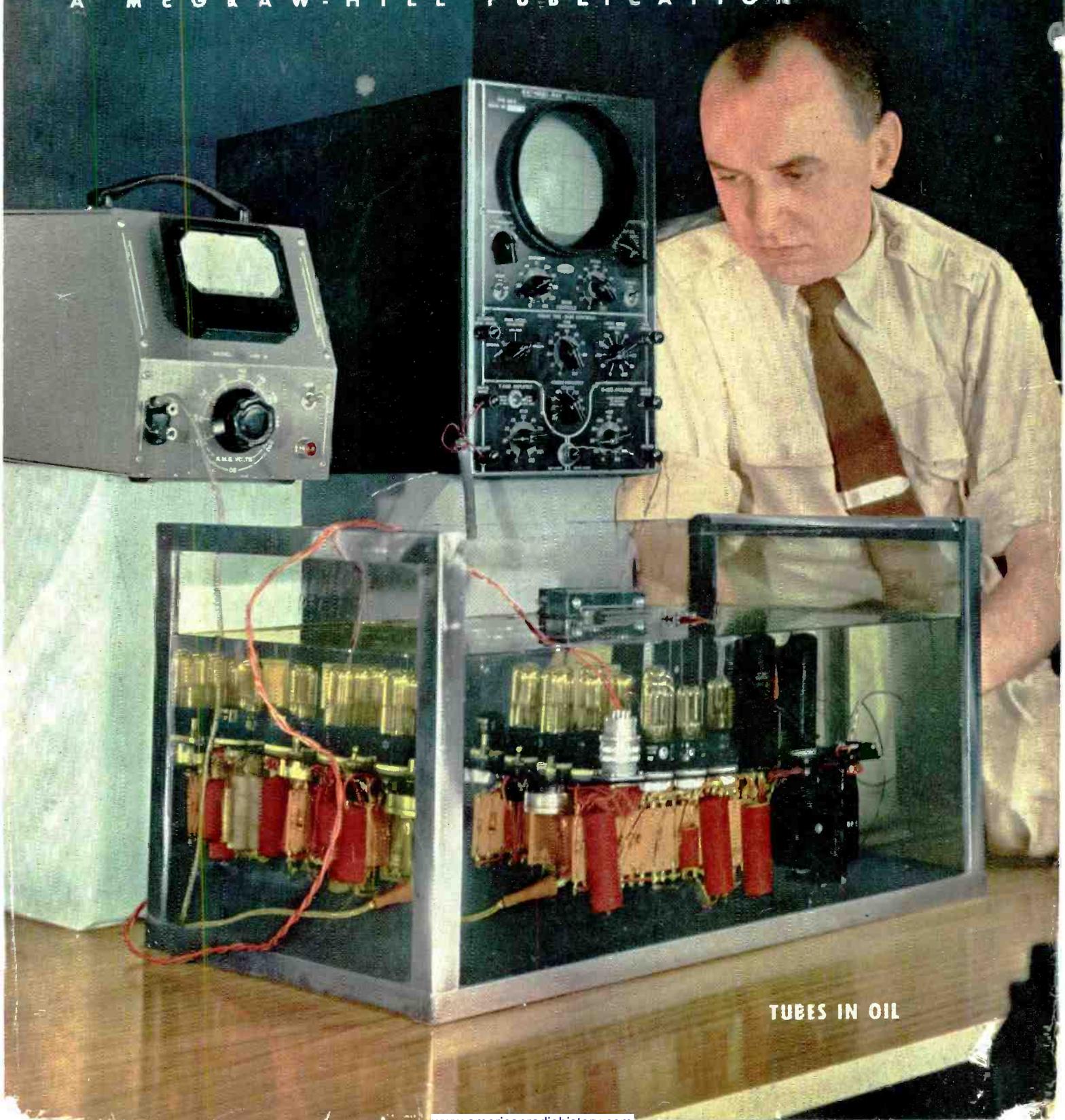


MARCH · 1948

electronics

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TUBES IN OIL

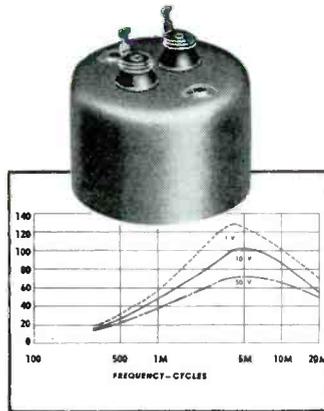


for HIGH Q TOROID INDUCTORS

There are many applications in the audio, carrier, and supersonic fields requiring inductors of high Q and great stability. The HQ series of units developed for these applications have remarkable characteristics, as illustrated below. HQA coils have high Q (100 at 5000 cycles) and are available in inductances from 5 MHY to 15 henrys. HQB coils have very high Q (200 at 4000 cycles) and are available in inductances from 10 MHY to 25 henrys.

HUM PICKUP is low due to the toroidal winding structure, 70 and 140 microvolts per gauss respectively for the HQA and HQB at 60 cycles.

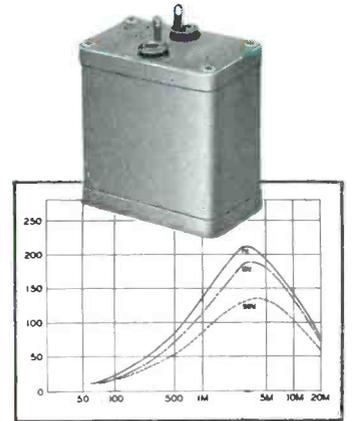
Stability is excellent. For the HQA-7 coil illustrated, inductance change is less than 1% for applied voltages from .1 to 25 volts 1000 cycles. For the HQB-5 coil illustrated, the inductance change is less than 1% for applied voltages from .1 to 50 volts 1000 cycles. Change in inductance due to DC current is approximately 1% per 10 MA linearly for the HQA unit illustrated and 3/4% for the HQB. All cased units are hermetically sealed. Standard inductance tolerance is 1%.



TYPE HQA

DIMENSIONS— $1\frac{1}{4}$ " Dia., x $1\frac{1}{8}$ " H.—
Wt. 5 ozs.

Inductance Value	Type No.	Net Price
5 mhy.	HQA-1	\$7.00
12.5 mhy.	HQA-2	7.00
20 mhy.	HQA-3	7.50
30 mhy.	HQA-4	7.50
50 mhy.	HQA-5	8.00
80 mhy.	HQA-6	8.00
125 mhy.	HQA-7	9.00
200 mhy.	HQA-8	9.00
300 mhy.	HQA-9	10.00
.5 hy.	HQA-10	10.00
.75 hy.	HQA-11	10.00
1.25 hy.	HQA-12	11.00
2. hy.	HQA-13	11.00
3. hy.	HQA-14	13.00
5. hy.	HQA-15	14.00
7.5 hy.	HQA-16	15.00
10. hy.	HQA-17	16.00
15. hy.	HQA-18	17.00



TYPE HQB

DIMENSIONS— $2\frac{3}{8}$ " L. x $1\frac{1}{8}$ " W. x $2\frac{1}{2}$ " H.—
Wt. 14 ozs.

Inductance Value	Type No.	Net Price
10 mhy.	HQB-1	\$20.00
30 mhy.	HQB-2	20.00
70 mhy.	HQB-3	20.00
120 mhy.	HQB-4	20.00
.5 hy.	HQB-5	20.00
1. hy.	HQB-6	22.00
2. hy.	HQB-7	24.00
3.5 hy.	HQB-8	25.00
7.5 hy.	HQB-9	26.00
12. hy.	HQB-10	27.00
18. hy.	HQB-11	28.00
25. hy.	HQB-12	29.00

UNCASED HIGH Q TOROIDS

We can supply any of the Toroids listed without case. Deduct \$1.50. Specify type and inductance value when ordering.



SPECIAL TOROIDS

Sizes other than those shown in our stock list can be supplied on special order at price of next highest value. Type HQC and HQD coils, having maximum Q at 50 kc and 100 kc respectively, are also available.

NEW ITEMS

CG-50 DYNAMIC NOISE SUPPRESSION INDUCTOR

Incorporates two accurately tuned high Q inductors of .8 hy. and 2.4 hy., respectively, for use in dynamic noise suppressor circuits. Write for Circular No. CG-50 for additional details. List Price \$16.00

CGE-1 UNIVERSAL INTERSTAGE EQUALIZER

This new UTC unit is the ideal device for any application requiring frequency response correction. Designed to be connected between two triode audio stages or will match a high impedance (5000 to 30000 ohms) source to grid. The CGE-1 equalizer is not a simple R-C tone control, but employs resonant circuits to permit low or high end equalization without affecting mid-frequencies.

Write for completely detailed manual.

CGE-1 Panel Dim. $2\frac{3}{8}$ x 4" List Price \$25.00



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MARCH • 1948

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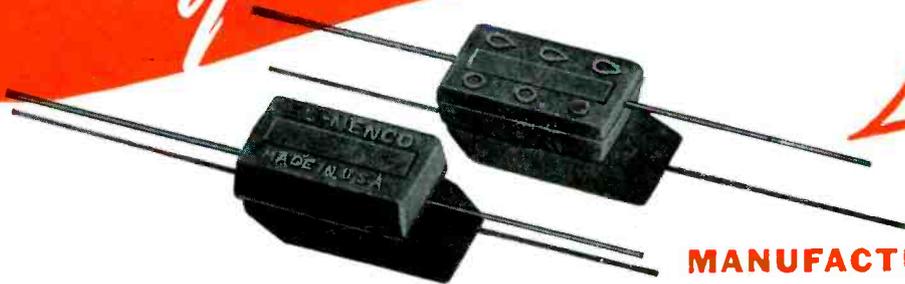


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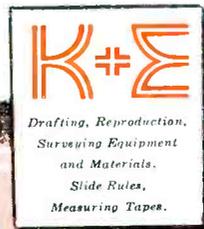
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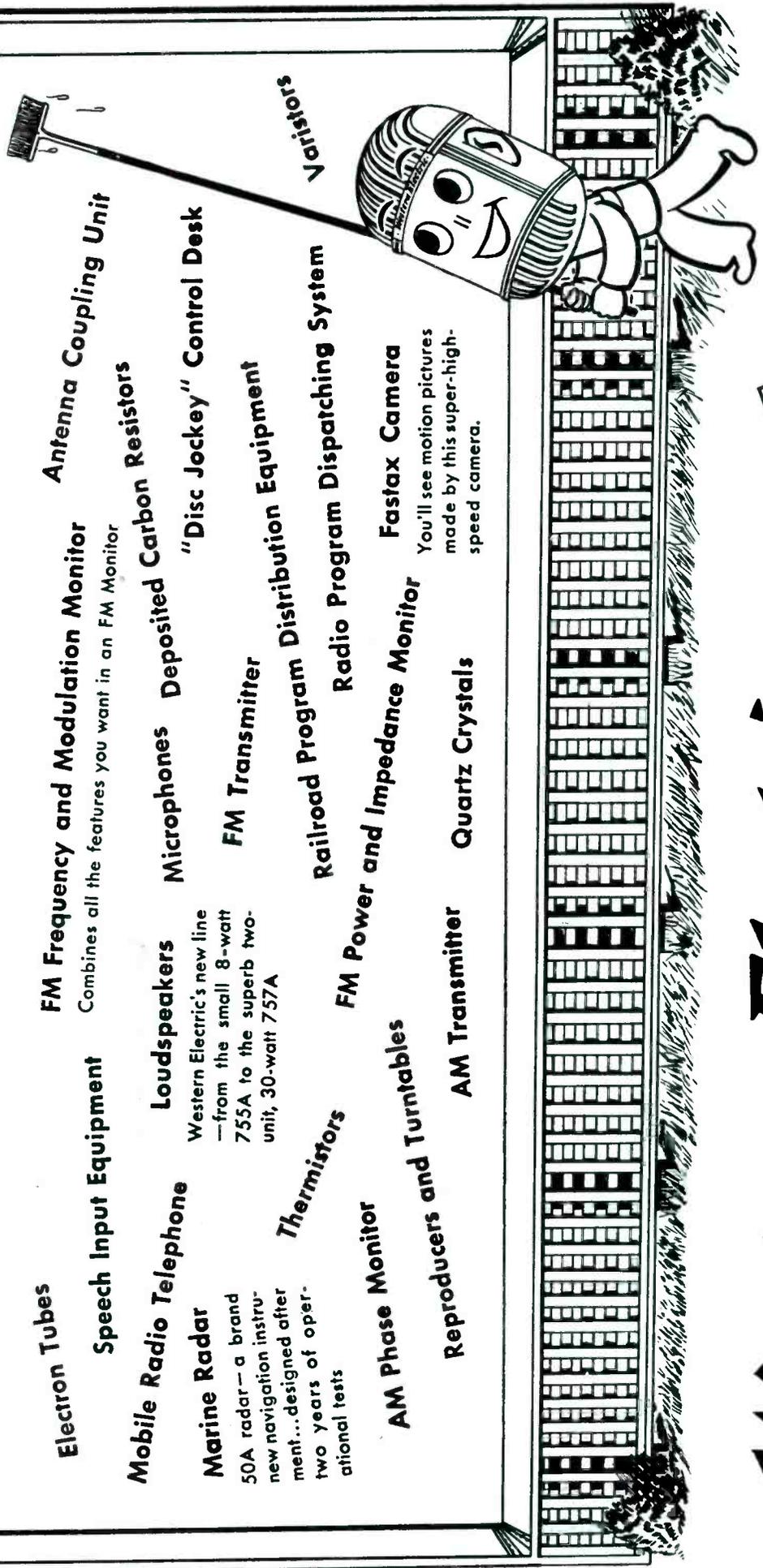
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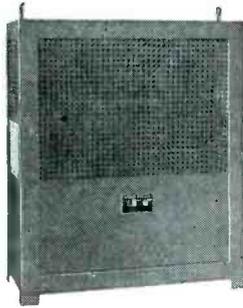
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• Harmonic Distortion on above models 3%.
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10,000*	1000-10,000	0.5%
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General Application

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250	25 - 250	0.2%
500	50 - 500	0.5%
1000	100-1000	0.2%
2000	200-2000	0.2%

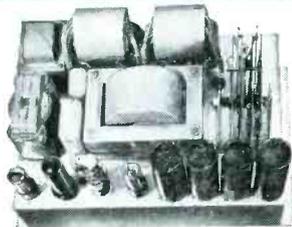


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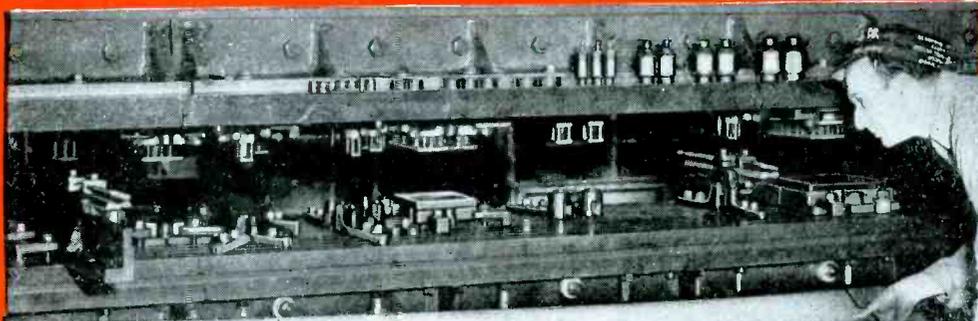
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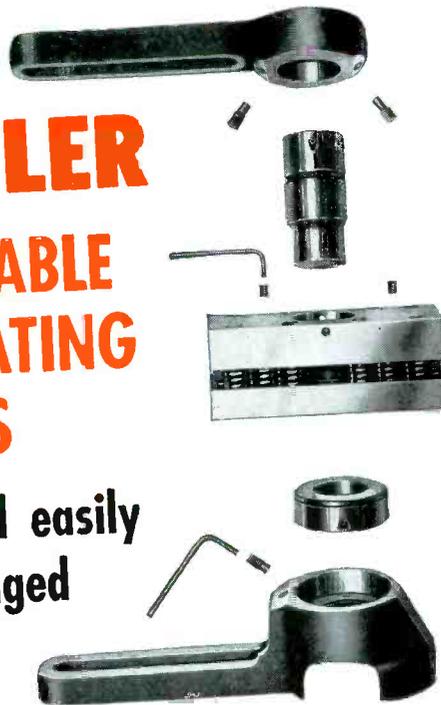
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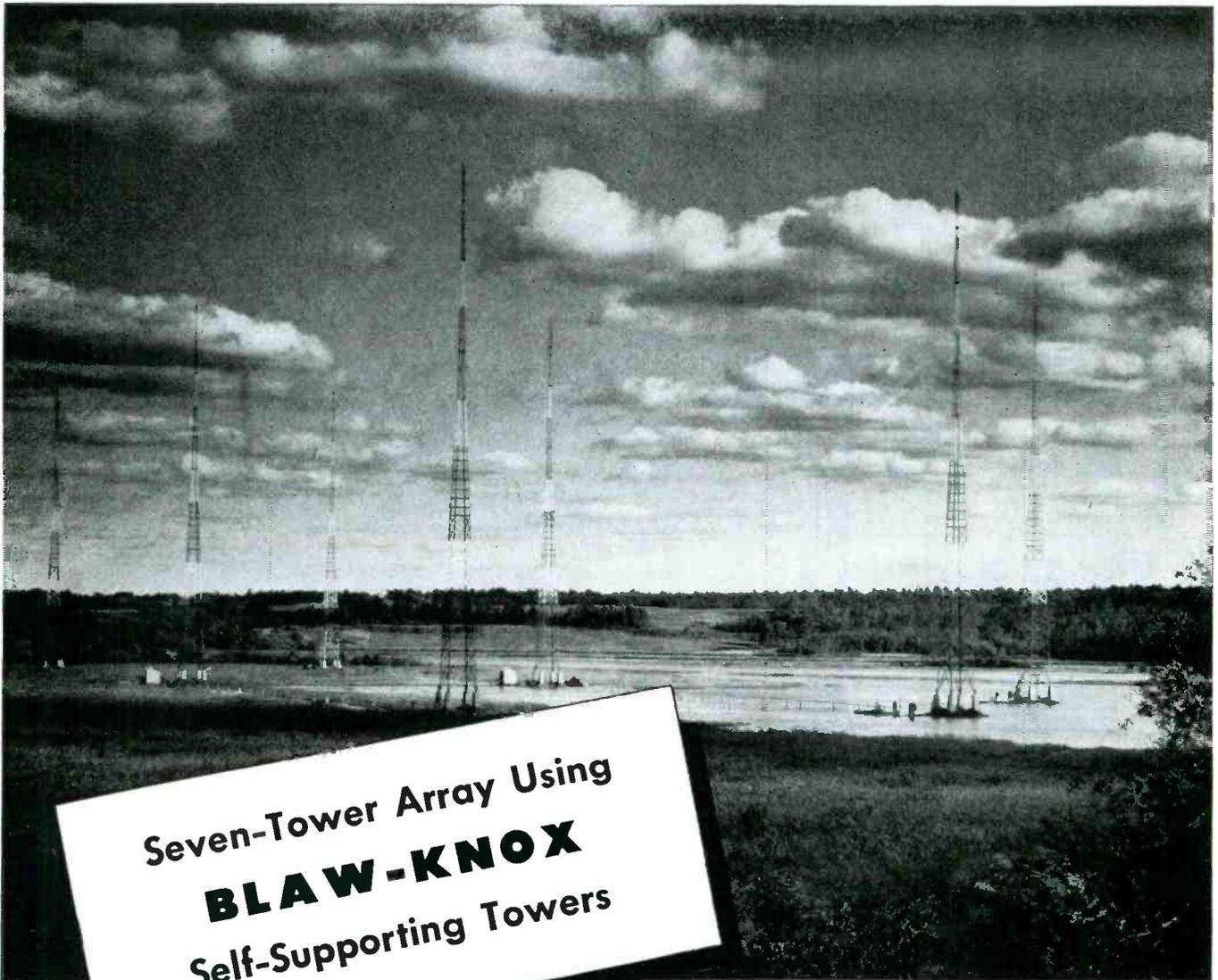
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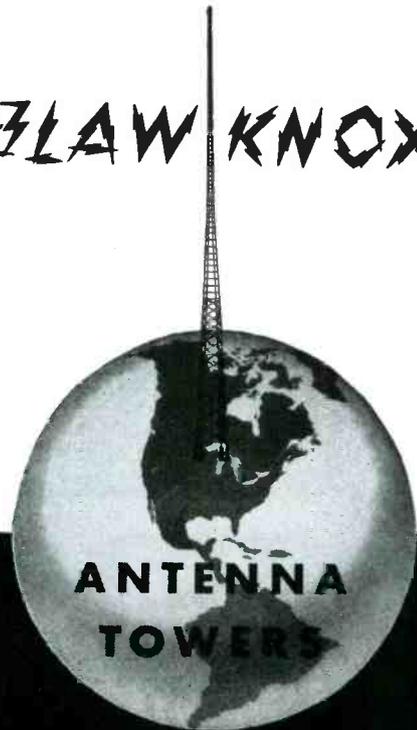


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Self-Supporting Towers

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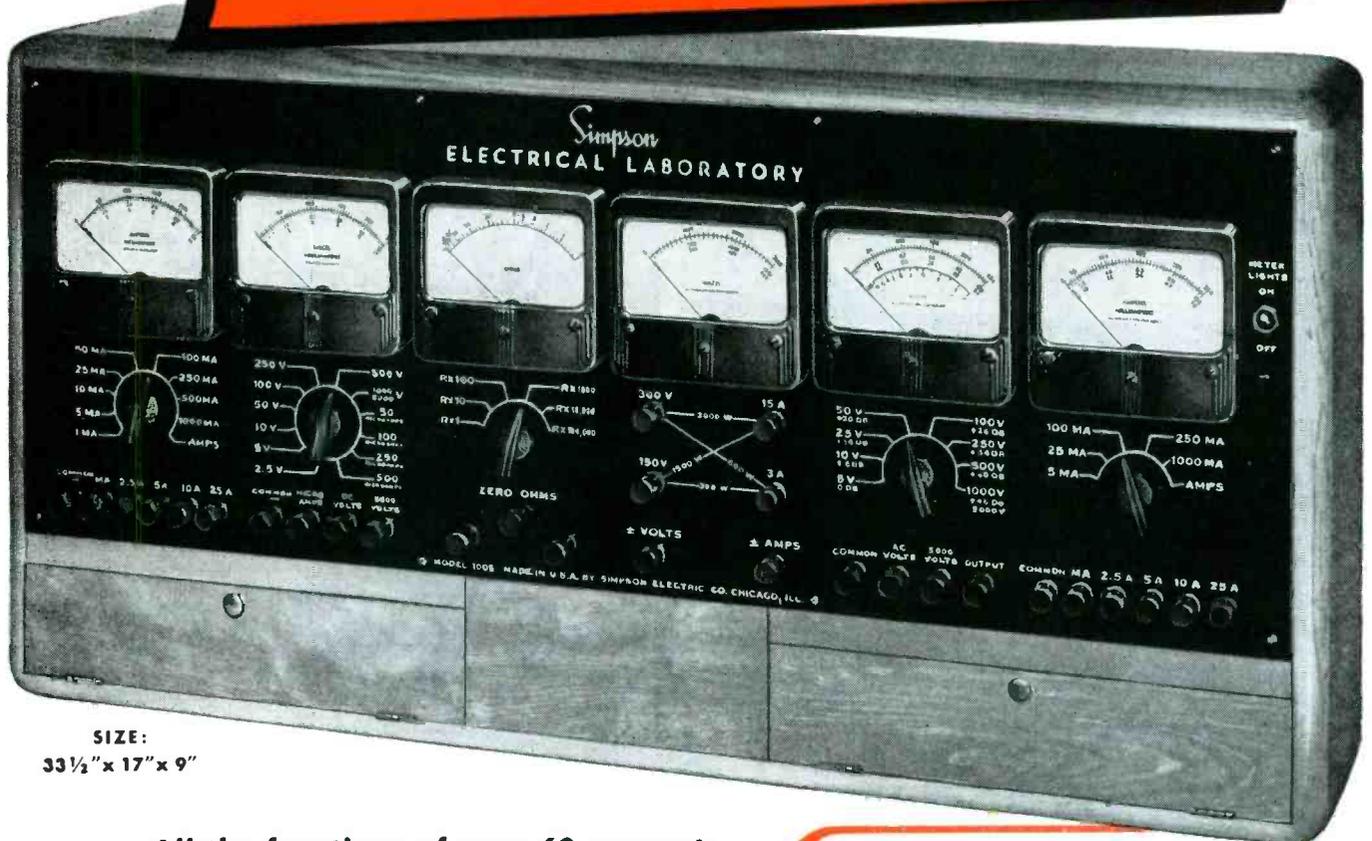
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SIZE:
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RANGES OF MODEL 1005

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0-1 MA. D.C.
0-5 MA. D.C.
0-10 MA. D.C.
0-25 MA. D.C.
0-50 MA. D.C.
0-100 MA. D.C.
0-250 MA. D.C.
0-500 MA. D.C.
0-1000 MA. D.C.
0-2.5 Amps. D.C.
0-5 Amps. D.C.
0-10 Amps. D.C.
0-25 Amps. D.C.

Meter No. 2 (D.C. Microammeter and Voltmeter)

0-2.5 Volts D.C.
0-5 Volts D.C.
0-10 Volts D.C.
0-50 Volts D.C.
0-100 Volts D.C.
0-250 Volts D.C.
0-500 Volts D.C.
0-1000 Volts D.C.
0-5000 Volts D.C.
20,000 ohms per volt
0-50 Microamps
0-100 Microamps
0-250 Microamps
0-500 Microamps

Meter No. 3 (Ohmmeter)

0-500 Ohms (5 ohms center)
0-5000 Ohms (50 ohms center)
0-50,000 Ohms (500 ohms center)
0-500,000 Ohms (5,000 ohms center)
0-5 Megohms (50,000 ohms center)
0-50 Megohms (500,000 ohms center)

Meter No. 4 (Wattmeter)

0-300 Watts A.C.
0-600 Watts A.C.
0-1500 Watts A.C.
0-3000 Watts A.C.

Meter No. 5 (A.C. Voltmeter, Output and DB meter)

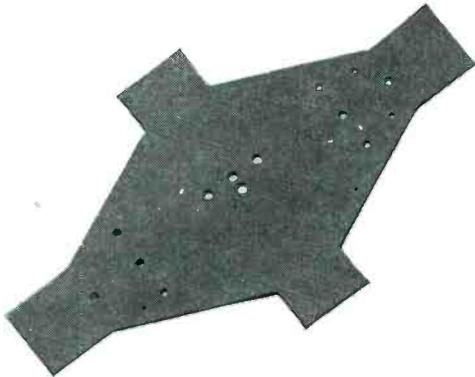
0.5 Volts A.C.
0-10 Volts A.C.
0.25 Volts A.C.
0.50 Volts A.C.
0-100 Volts A.C.
0-250 Volts A.C.
0-500 Volts A.C.
0-1000 Volts A.C.
0-5000 Volts A.C.
Rectifier type
1000 Ohms per volt
DB Ranges
-10 to +54
Output Ranges
same as volts
except 5000
Volt Range

Meter No. 6 (A.C. Milliammeter and Ammeter)

0-5 MA. A.C.
0-25 MA. A.C.
0-100 MA. A.C.
0-250 MA. A.C.
0-1000 MA. A.C.
0-2.5 Amps. A.C.
0-5 Amps. A.C.
0-10 Amps. A.C.
0-25 Amps. A.C.

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FOR Complex PARTS



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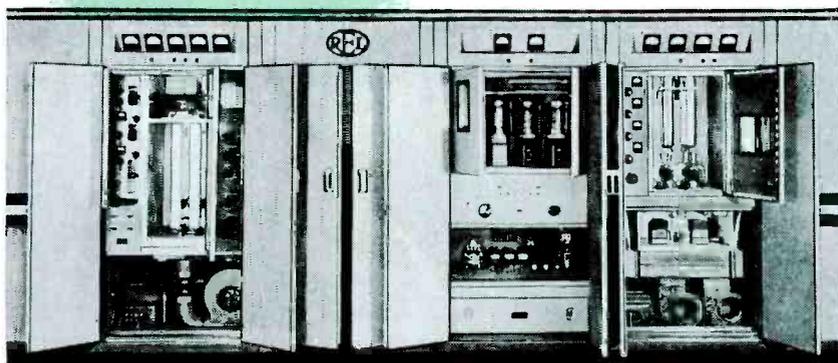


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DO FM TRANSMITTER COSTS MEASURE UP TO THE REL YARDSTICK?

Before you make commitments on any FM Broadcast Transmitter, check the performance record of REL tetrode powered FM Transmitters. These actual case histories of installations in all sections of the country offer convincing evidence of the lower first cost and lower operating cost of REL FM Broadcast Transmitters. They tell, in every instance, an equally important story of maximum operating convenience, negligible maintenance, low tube cost and unmatched dependability.

These records provide a new and valuable yardstick for judging FM transmitter costs. If you are interested in applying the REL yardstick to your FM problem, simply call or write today. Complete information will be supplied and visits to operating installations can be arranged.



Front view of REL 10,000 watt FM Broadcast Transmitter. The four tube final amplifier employs internal anode tetrode tubes in the Quadri-line circuit.

REL cordially invites you to visit us at our IRE CONVENTION HEADQUARTERS at the Hotel Commodore, March 22 to 25, 1948

RADIO ENGINEERING LABS · Inc.
LONG ISLAND CITY 1, NEW YORK





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- Only 1 $\frac{3}{8}$ " x 2 $\frac{3}{8}$ " x 1 $\frac{3}{4}$ "
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Light Duty Multiple Contact



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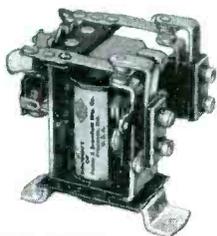


PLATE CIRCUIT



SENSITIVE



MULTIPLE LEAF



HEAVY DUTY POWER



MOTOR STARTING

P & B STANDARD RELAYS

Potter & Brumfield standard relays will meet most relay requirements and specials can be supplied if required. Our 14 years of experience in the manufacture of relays assures you that the type recommended for your job will give better service.

Write NOW for your copy of our new 1947 catalog, illustrating and describing in detail a complete line of standard relays.

● YOUR LOCAL ELECTRONICS PARTS DISTRIBUTOR STOCKS P & B PRODUCTS

POTTER & BRUMFIELD SALES CO.

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 FACTORY AT PRINCETON, INDIANA



Quality
Performance
Economy
Appearance

**GET ALL 4 WITH
 AUDIO
 EQUIPMENT**

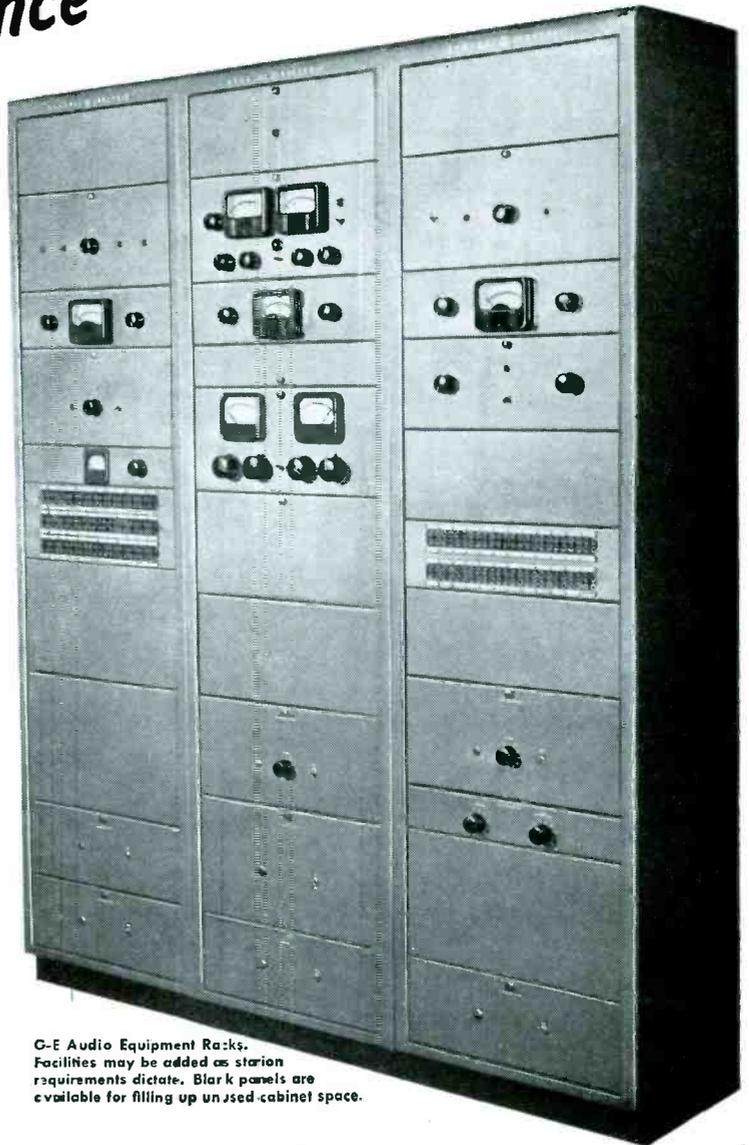


★ **Quick, Easy Maintenance.** All components instantly at hand without removal of any chassis. Hinged front panels open to permit access to installation. Panels are supported by concealed mounting screws—no troublesome trim strips to remove in a time-wasting operation.

★ **Long Life at Peak Performance.** Good ventilation is assured by special arrangement of chassis and vertical mounting of all units. No overheating—longer equipment life. New G-E circuits are designed to provide extended frequency response, lower noise and distortion levels. General Electric audio equipment meets every requirement in AM, FM, and TV service.

★ **Low Installation Cost.** With G-E equipment, your installation costs are held to a minimum. If desired, all wiring is completely enclosed in vertical ducts. It's easy to remove units and change positions because wiring ducts have snap-on covers—no cables to unlace.

★ **Neat Appearance.** Audio equipment is permanently mounted in handsome, blue-gray steel racks. The smooth finish of these cabinets is easily and quickly cleaned. No cracks or wrinkles to collect dust and dirt. Your Control Room becomes a showplace to impress your sponsors and please your listeners.



G-E Audio Equipment Racks. Facilities may be added as station requirements dictate. Blank panels are available for filling up unused cabinet space.



Your G-E broadcast equipment representative is nearby, ready to serve you fast. Call him, or write: General Electric Company, Transmitter Division, Electronics Park, Syracuse, N. Y.

WHY GENERAL ELECTRIC? Long a leader in AM, FM, and TV, General Electric continues to manufacture audio equipment with the same care that has made its transmitters renowned the world over. Behind every piece of radio equipment bearing the G-E monogram are the multiple research and engineering facilities of Electronics Park. Here, at the greatest electronics center in the world, science joins with industry in building for you reliable, up-to-date radio equipment for every broadcast need.

LEADER IN RADIO, TELEVISION AND ELECTRONICS

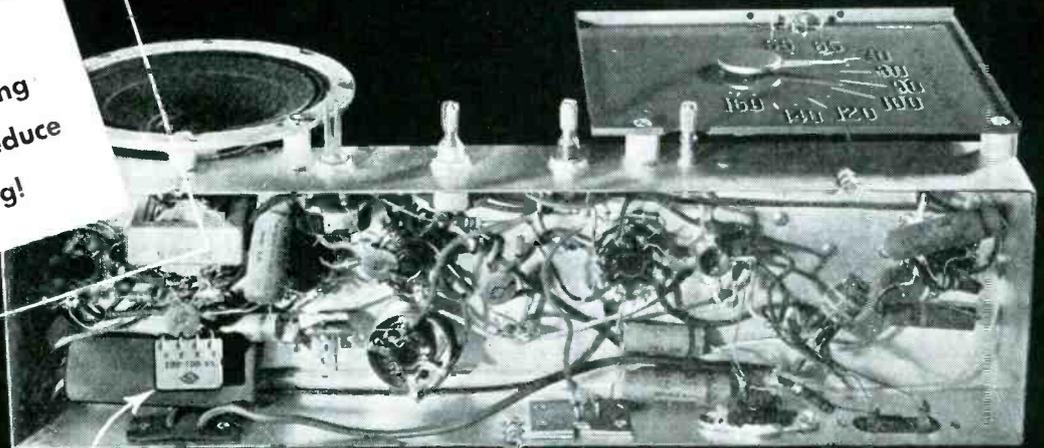
GENERAL  ELECTRIC

100-711-0814

Centralab reports to

MARCH 1948

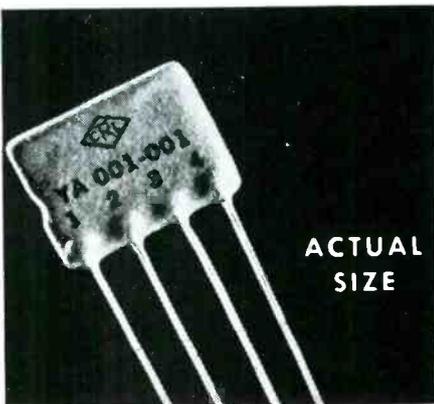
How Sonora Radio uses CRL Couplate to improve manufacturing efficiency, reduce servicing!



Sonora engineers take advantage of Couplate's long life, high efficiency, resistance to humidity and vibration. Result: more dependable performance, simplified production for Sonora Radios.

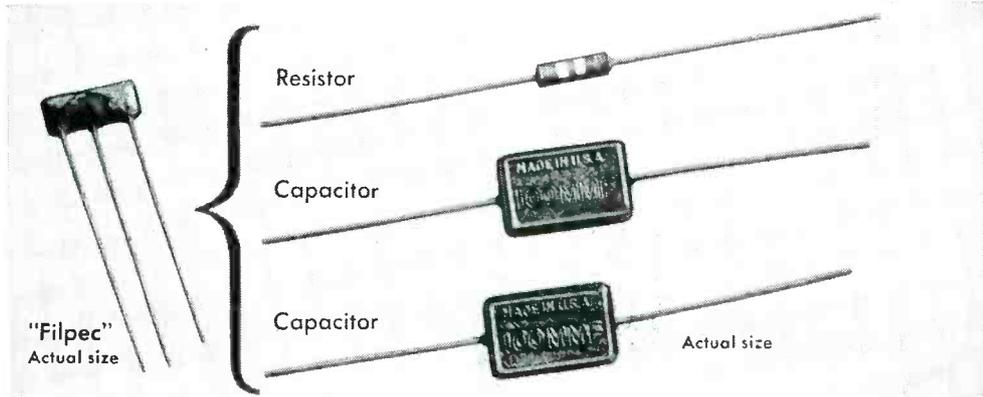
I First commercial application of Centralab's revolutionary "Printed Electronic Circuit"—the *Couplate* gives you four basic manufacturing advantages: 1) Requires only four soldered connections instead of eight; simplifies wiring and production. 2) Saves space

and mass weight, permits more compact and dependable finished equipment at lower cost. 3) Improves set performance by lengthening life, gives you a complete "printed" interstage coupling circuit. Chassis courtesy of Sonora Radio and Television Corp., Chicago.



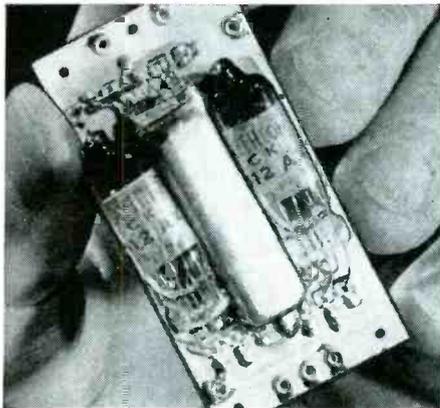
ACTUAL SIZE

2 CRL's *Couplate* consists of a plate load resistor, grid resistor, plate by pass capacitor and coupling capacitor. Write for Bulletin 943.

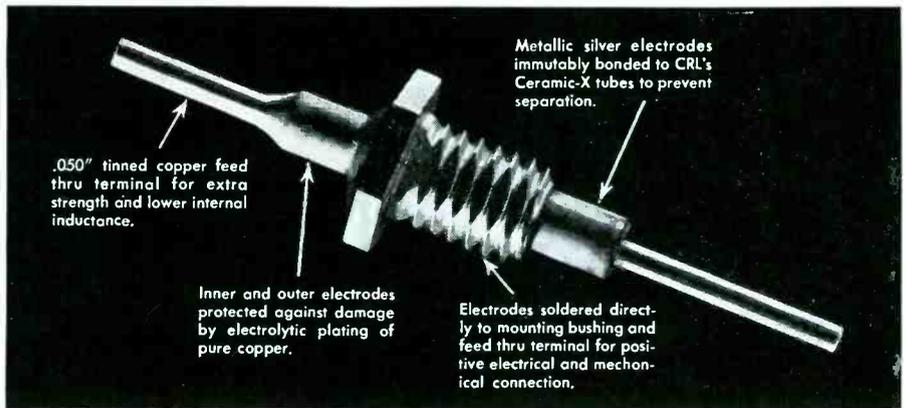


3 Another application of the "Printed Electronic Circuit" is Centralab's *Filpec*! Designed for use as a balanced diode load filter, *Filpec* combines up to three major components into one tiny filter unit, lighter and smaller than one ordinary capacitor. Available for other applications. Send for Bulletin 976.

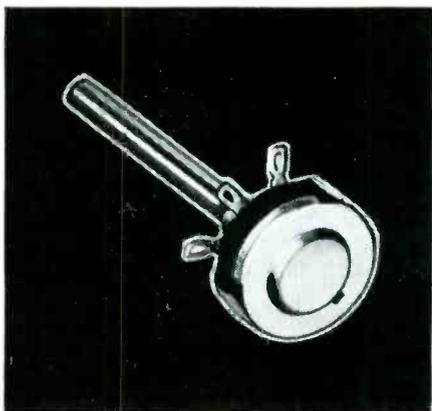
Electronic Industry



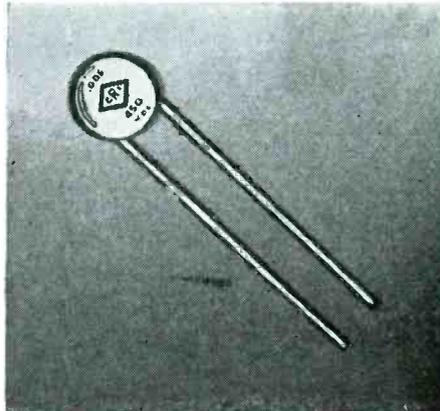
4 Newest development of the "Printed Electronic Circuit", CRL's *Ampec* is a complete 3-stage audio amplifier. Get complete facts in Bulletin 973.



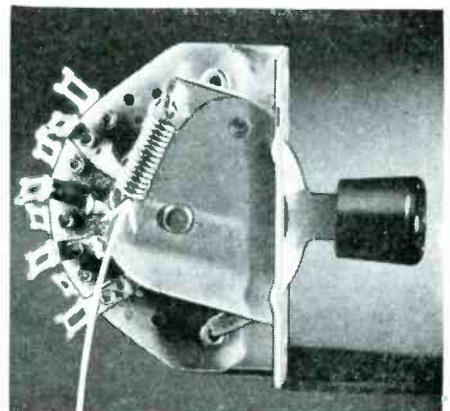
5 Made with Ceramic-X, CRL's new Feed-thru and Bushing Mounted Capacitors eliminate structural and electrical damage during installation. Two special bonds are reason: 1) between inner feed-thru terminal and inside diameter of tube, and 2) between mounting bushing and outside diameter of tube. Send for bulletin 975.



6 Wide range of variations in CRL's Model "M" Radiohm simplifies production and inventory. Bulletin 697-A illustrates convenience, versatility!



7 To CRL's line of high quality ceramic capacitors, these miniature disc *Hi-Kaps* have been added. Combine reliability, capacity. Order Bulletin 933.



8 In its new Lever Switch, Centralab guarantees a minimum life of 50,000 cycles. Reason: an exclusive new coil spring index. Write for Bulletin 970.

LOOK TO CENTRALAB IN 1948! *First in component research that means lower costs for the electronic industry. If you're planning new equipment, let Centralab's sales and engineering service work with you. Get in touch with Centralab!*

Centralab

DIVISION OF GLOBE-UNION INC., MILWAUKEE, WIS.

**DO YOU KNOW
WHAT THIS
SYMBOL
MEANS**



POWERSTAT 3PF 1126



It stands for a three-wire system, with the third wire grounded. It means added personal safety and insurance against shock from "hot" circuits.

A third wire grounded in a three-wire, single phase system is becoming a requirement in more and more communities . . . and POWERSTAT variable transformers are prepared for this transition. Standard models are available . . . wired for a three-wire, single phase system with one wire grounded.

Safety and versatility—two important features of The Superior Electric Company's dependable voltage control equipment has resulted in wide acceptance of these quality units for use in laboratory and industry.

POWERSTAT variable transformers are easily adapted to fit individual specifications. Let the experience of The Superior Electric Company's voltage control engineers assist in solving your specific problem. Request Bulletin 547 for complete voltage control engineering data.

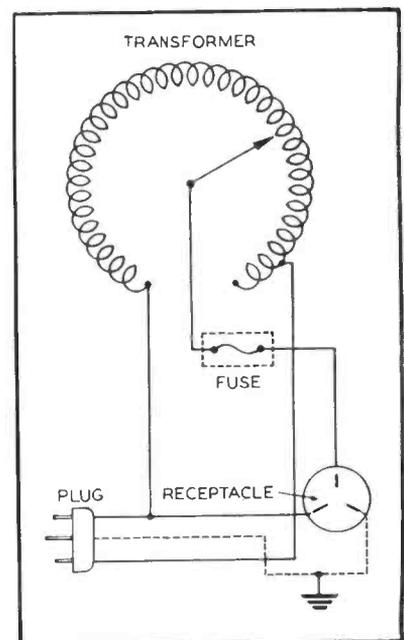
The schematic drawing shows a typical single phase, three-wire POWERSTAT variable transformer with the third wire grounded.

Write The Superior Electric Co., 403 Meadow St., Bristol, Conn.

THE SUPERIOR ELECTRIC CO.
BRISTOL, CONNECTICUT



Powerstat Variable Transformers • Voltbox A C Power Supply • Stabiline Voltage Regulators.

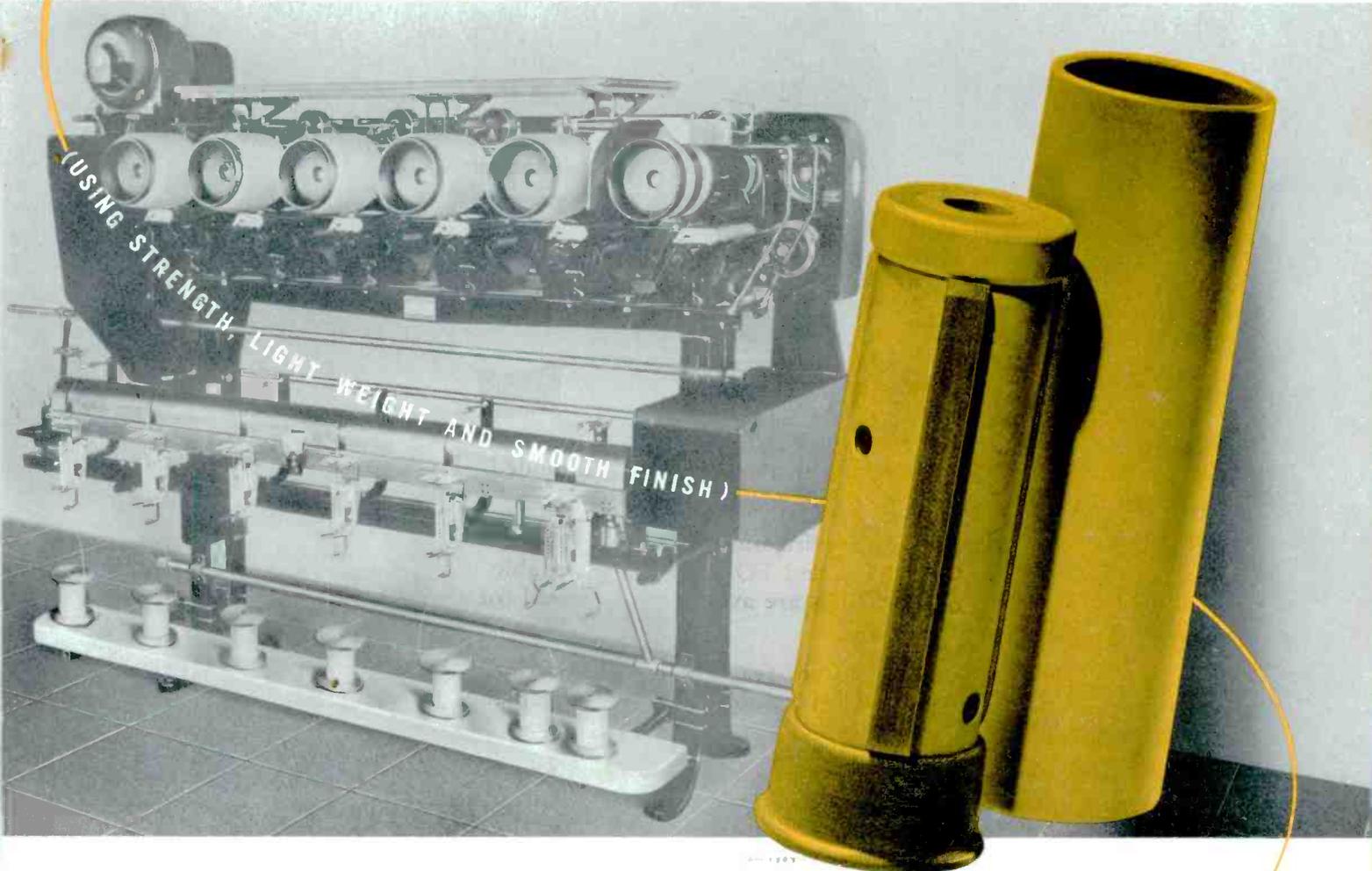


Plastics where plastics belong



Because of a unique combination of chemical, electrical, and mechanical qualities, Synthane laminated plastics can be applied to an endless number of practical purposes. Moisture and corrosion resistant, light-weight and structurally strong, Synthane has many collective advantages not readily found in any other material. One of the best electrical insulators known, Synthane is hard, dense, durable . . . quickly and easily machined.

Among the interesting occupations of our type of technical plastics are the redraw bobbin and chuck (below) used in winding fine denier nylon for women's hosiery.



Fine nylon filaments can be wound without pulling and sticking because of the smoothness of the bobbin. Light weight of bobbin and chuck allows the spindle to be started and stopped faster and with less effort. Greater crushing strength of tube permits larger amounts of nylon to be wound. This is an appropriate job for Synthane, an interesting example of using plastics where plastics belong.

If any of Synthane's many properties suggest a use for it in your plant, let us help you before you design. Write for our complete catalog of Synthane plastics today! Synthane Corporation, 6 River Road, Oaks, Pa.

SYNTHANE

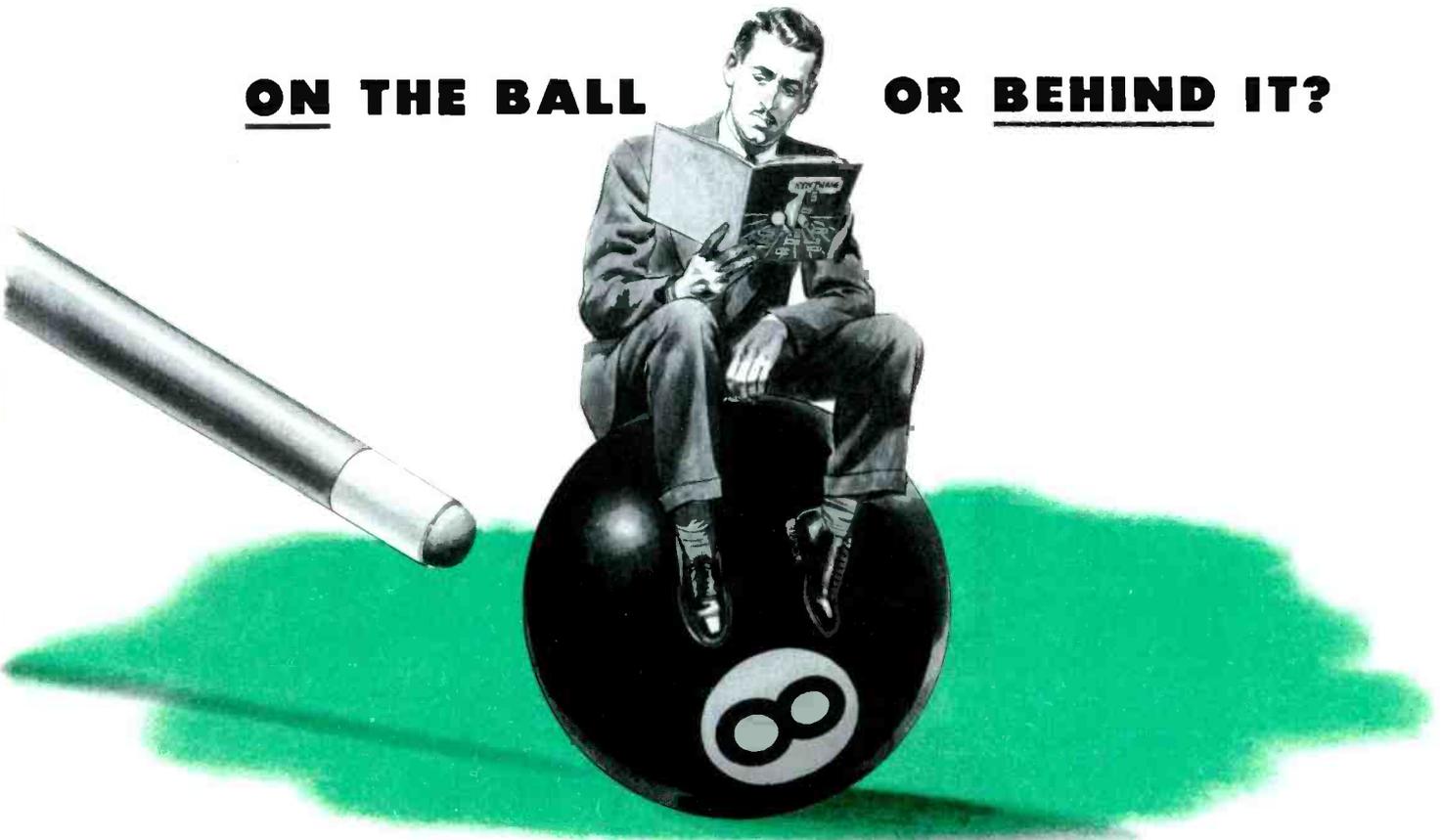
S

where Synthane belongs

DESIGN • MATERIALS • FABRICATION • SHEETS • RODS • TUBES
FABRICATED PARTS • MOLDED-MACERATED • MOLDED-LAMINATED

ON THE BALL

OR BEHIND IT?



With industry clamoring for better products, businessmen are leaving no material unexplored which suggests a better answer to their current requirements.

Our type of laminated plastics—Synthane—may be your answer to better products because it has not one, but many valuable properties *in combination*.



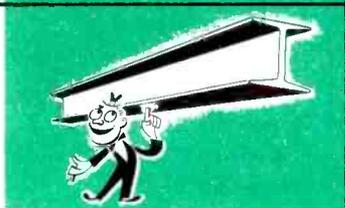
As an electrical insulator, Synthane is one of the best—high dielectric strength, low power factor, low dielectric constant. May be quickly and easily machined.

For example, you can depend on Synthane for tensile, compressive, flexural and impact strength. Compares favorably with metals on a strength-for-weight basis.



Synthane is the set plastic, stable over wide variations in temperature.

Light weight is one of Synthane's most useful properties. Weighs about half as much as aluminum, has ample strength for all electrical and most mechanical applications.



Perhaps one of these or other Synthane qualities suggest its use in your product. If so, let us help you before you design . . . we may be able to save you considerable time, trouble and money. Send for your free copy of the Synthane Plastics Catalog today!

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Gentlemen:

Please send me without obligation a complete catalog of Synthane technical plastics.

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Company _____

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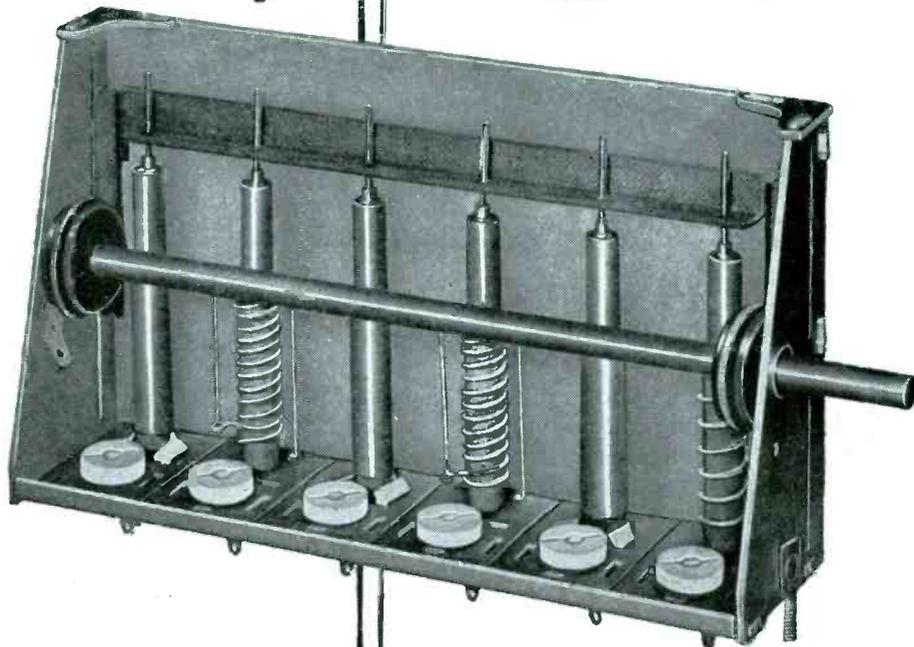
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PLAN YOUR PRESENT AND FUTURE WITH SYNTHANE TECHNICAL PLASTICS • SHEETS • RODS • TUBES • FABRICATED PARTS • MOLDED-LAMINATED • MOLDED-MACERATED

PMT

for

TV



- A Permeability Tuner of advanced design, incorporating a new tuning principle, the 770-TV unit provides full coverage of all television channels, with greatly increased gain and a worthwhile saving in cost.
- It is adaptable to either single-ended or push-pull circuits. It may be actuated by a rotary knob, with or without detent channel

positioning, or by a mechanical push button actuator.

- It permits the most advantageous layout of associated circuit elements, with extremely short connecting leads.
- Its compact, integrated design provides great flexibility to satisfy individual requirements of chassis and cabinet layout.

The services of Johnson Laboratories are available to manufacturers licensed under our patents.

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The Mantle Lamp Company
of America

DON'T IMPROVISE!

Rather use Du Mont Tubes in your cathode-ray oscillography because



only the
RIGHT TYPE
with the
RIGHT SCREEN
can do the
RIGHT JOB!

and here's why:

▶ Only Du Mont makes ALL types of tubes and all types of screens to serve the needs of ALL users—scientific, industrial, educational.

Regardless of what your oscillographic requirements call for, Du Mont has the *right tube* with the *right screen*. Tubes for high-accelerating potentials; multiple-gun tubes; tubes for low-accelerating or medium-accelerating potentials—all are included in Du Mont listings. And with each type there's a choice of screens for short, medium or long persistence; for photographic recording; for visual observation; for high-speed transients; for recurrent phenomena at any speed.

Definitely, for every oscillographic application there's one best tube to use — and only Du Mont provides that adequate choice. Why improvise?

As the outstanding specialist in this highly specialized technology, Du Mont maintains the highest standards of quality, precision design, and dependable craftsmanship.

DU MONT CATHODE-RAY TUBES AVAILABLE

3AP1-A	3JP11	5JP1-A	5LP11-A
3AP11-A	5BP1-A	5JP2-A	5RP2-A
3GP1-A	5BP11-A	5JP7-A	5RP11-A
3GP11-A	5CP1-A	5JP11-A	5SP1
3JP1	5CP2-A	5LP1-A	5SP2
3JP2	5CP7-A	5LP2-A	5SP7
3JP7	5CP11-A	5LP7-A	5SP11

DU MONT SCREENS AVAILABLE

- P1: Medium-persistence green. High visual efficiency. For general purpose applications.
- P2: Long-persistence blue-green fluorescence and yellow-green persistence. Long persistence at high writing rates. Short interval excitation.
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- P7: Blue fluorescence and yellow phosphorescence. Long persistence at slow and intermediate writing rates.
- P11: Short-persistence blue. For recording high writing rates.

DU MONT IS *always* YOUR BEST BUY!

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DU MONT Precision Electronics & Television

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for



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HI-Q components are uniformly superior because of rigid quality control throughout all stages of manufacture. Final individual inspection insures their conformance to electrical and physical specifications. When you specify **HI-Q** components, you can be sure they meet your most stringent requirements for precision, dependability, compactness and uniformity. Write for complete information and engineering data.

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HI-Q General Purpose Capacitors can be supplied in any size from .200 x .375 to .340 x 1.875, with capacity range from 5 to 33,000 MMF. They are insulated with a clear non-hydroscopic styrene coating. I.R. of 10,000 Megohms, working voltages up to 500 volts D.C. and power factor well under 3 per cent can be assured.

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**HI-Q COMPONENTS
BETTER 4 WAYS**

- PRECISION** Tested step by step from raw material to finished product. Accuracy guaranteed to your specified tolerance.
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- MINIATURIZATION** The smallest BIG VALUE components in the business make possible space saving factors which reduce your production costs . . . increase your profits.



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Plants: FRANKLINVILLE, N. Y. — JESSUP, PA.

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TO HELP YOU PICK THE BEST

Here are a few facts to help you choose the best: In approximately 90% of the new commercial mobile transmitter designs, you will find Hytron instant-heating tubes. Over 2,500,000 Hytron gaseous voltage regulators speak for themselves. Ratings of Hytron vhf tubes are CCS and based on actual equipment performance which you can duplicate. No other transmitting triode can touch the new all-purpose 5514 for economical versatility. Famed for transmitting tubes, Hytron also originated the popular "GT", and is the oldest manufacturer specializing in receiving tubes. You pick the best when you pick Hytron.

HYTRON TRANSMITTING AND SPECIAL PURPOSE TUBES CONTINUOUS COMMERCIAL SERVICE RATINGS

Description	Type No.	Filament Volts	Ratings Amps	Type	Max Plate Volts	Max Plate Ma	Max Plate Dis	Amateur Net Price
LOW AND MEDIUM MU TRIODES	10Y	7.5	1.25	Thor	450	65	15	\$1.95
	HY24	2	0.13	Oxide	180	20	2	1.50
HIGH-MU TRIODES	801A/801	7.5	1.25	Thor	600	70	20	3.00
	864	1.1	0.25	Oxide	135	5	--	1.50
VHF TRIODES	1626	12.6	0.25	Cath	250	25	5	1.60
	HY31Z §	6	2.55	Thor	500	150*	30*	5.50
	HY1231Z §	6	3.2	Thor	500	150*	30*	5.50
	5514*§	7.5	3	Thor	1500	175	65	4.95
BEAM PENTODES AND PENTODES	2C26A	6.3	1.15	Cath	3500	NOTE	10	7.75
	HY75A*§	6.3	2.6	Thor	450	90	15	4.70
	HY114B §	1.4	0.155	Oxide	180	12	1.8	2.25
	HY615	6.3	0.175	Cath	300	20	3.5	2.25
	955	6.3	0.15	Cath	200	8	1.8	3.10
	9002	6.3	0.15	Cath	200	8	1.8	2.15
ACORNS MINIA-TURES	2E25*§	6	0.8	Thor	450	75	15	5.50
	2E30 §	6	0.65	Oxide	250	60	10	2.25
	3D21A	6.3	1.7	Cath	3500	NOTE	15	7.50
	HY69 §	6	1.6	Thor	600	100	30	5.50
RECTIFIERS	807	6.3	0.9	Cath	600	120	25	2.30
	837	12.6	0.7	Cath	500	80	12	4.15
	HY1269 §	6	3.2	Thor	750	120	30	5.50
RECTIFIERS	1625	12.6	0.45	Cath	600	120	25	2.30
	5516 §	6	0.7	Oxide	600	90	15	5.95
RECTIFIERS	954	6.3	0.15	Cath	Sharp cutoff pentode			4.90
	9001	6.3	0.15	Cath	Sharp cutoff pentode			2.70
	Type No.	Filament Volts	Ratings Amps	Type Rect	Peak Plate Ma	Max D-C Ma†	Inv Peak Pot.	Amateur Net Price
RECTIFIERS	816	2.5	2.0	Mer	500	250	5000	\$1.25
	866A/866	2.5	5.0	Mer	1000	500	10000	1.75
	1616	2.5	5.0	Vac	800	260	6000	7.50
GASEOUS VOLTAGE REGULATORS	Type No.	Average Operating Voltage	Operating Ma	Av Volts Reg	Min Starting Voltage		Amateur Net Price	
	OA2	150	5	30	2	185	\$2.00	
	OB2	108	5	30	1	133	2.30	
	OC3/VR105	108	5	40	2	133	1.20	
OD3/VR150	150	5	40	3.5	185	1.20		

*Both sections of twin triode. NOTE: Special pulse tube, not recommended for c-w. consult Hytron Commercial Engineering Dept. for data. †Current for full wave. §Instant-heating.

For better reception, it's also Hytron — GT, G, lock-in, or miniature.



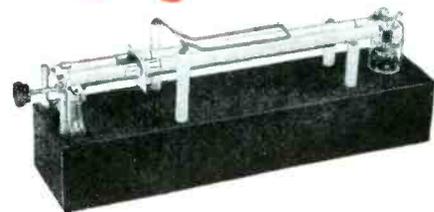
New data sheets: 2E25, 2E30, HY31Z, HY69, HY75A, HY1231Z, HY1269, 5514, 5516. Free.



Keep up to date with the Hytron Reference Guide for Miniature Electron Tubes. Free.



New transmitting and special purpose tube catalogue. It's yours for the asking.



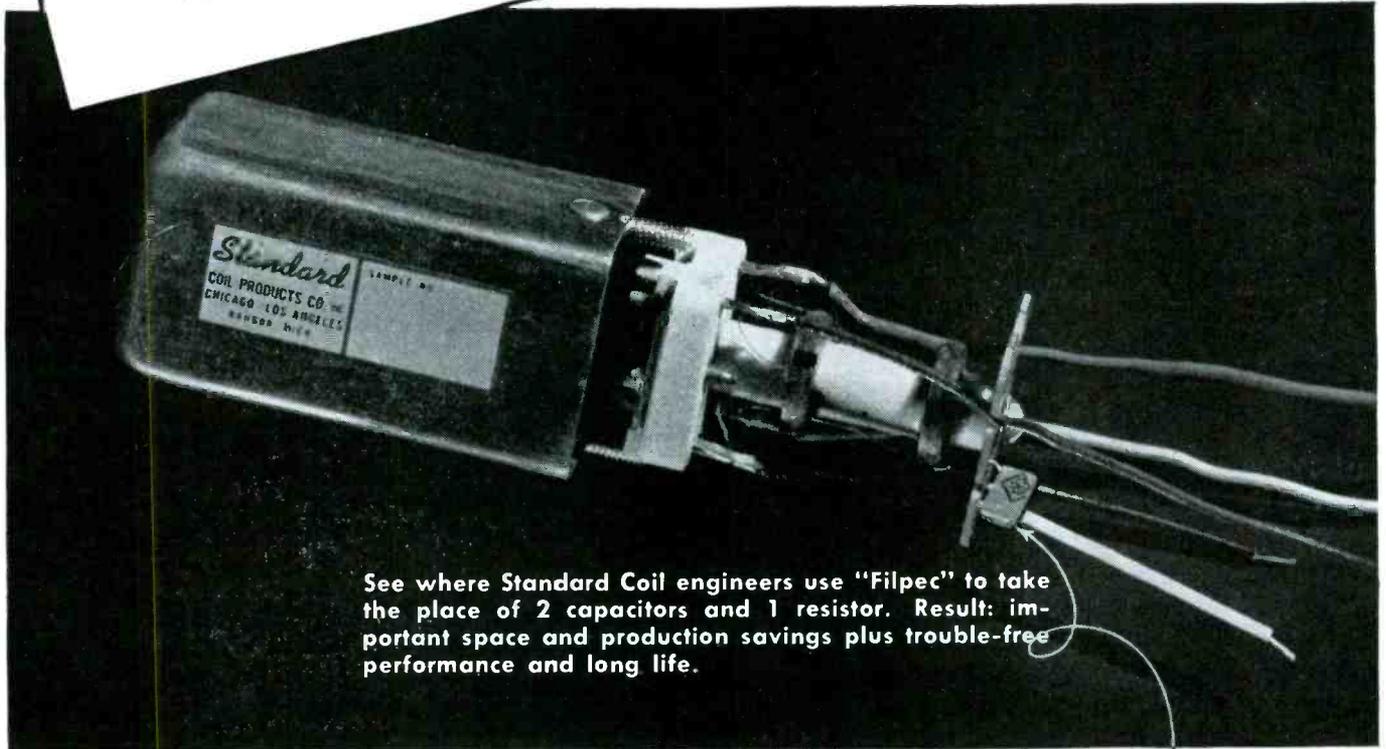
Simple, sure-fire vfo for 1½ or 2 meters. HY-Q 75 kit; unassembled, \$9.95; assembled, \$11.95.

HYTRON RADIO & ELECTRONICS CORP.

SALEM, MASSACHUSETTS

**PROGRESS REPORT
ON
P.E.C.***

**How Standard Coil uses
Centralab "Filpec"
to simplify production, save space on
I. F. Transformers**



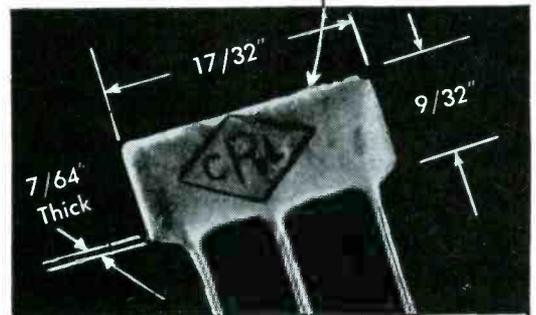
See where Standard Coil engineers use "Filpec" to take the place of 2 capacitors and 1 resistor. Result: important space and production savings plus trouble-free performance and long life.

I. F. Transformer courtesy of Standard Coil Products Co.

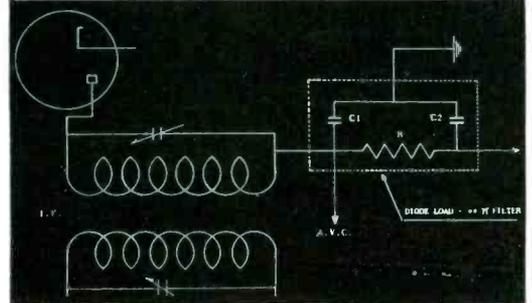
***Centralab's revolutionary Printed Electronic
Circuit — Industry's newest method
for stepping-up manufacturing efficiency!**

FOR SMALL SIZE, light weight and long life, there's nothing like Centralab's new *printed electronic circuit filter*! That's why the Standard Coil Products Co. uses "Filpec" in its new I. F. Transformers. And that's why you'll want to see how it gives you higher circuit efficiency, more dependable performance as well as a reduction of line operations in set and equipment manufacturing.

Filpec combines two capacitors and one resistor into one tiny balanced diode load filter unit, saves space, cuts inventory, is highly adaptable to a variety of circuits. Capacitor values from 50 to 200 mmf. Resistor values from 5 ohms to 5 megohms. Resistance rating: 1/5 watt. 100 WVDC. Flash test: 200 VDC. For complete information about *Filpec* performance, see your Centralab representative, or write for Bulletin 976.



"Filpec" gives you integral construction! Made with high dielectric Ceramic-X, CRL's *Filpec* assures long life, low internal inductance, resistance to humidity and vibration. Note schematic diagram below, showing typical application.



LOOK TO **Centralab** IN 1948!

Division of GLOBE-UNION INC., Milwaukee

miraglas

TAPES

TUBINGS

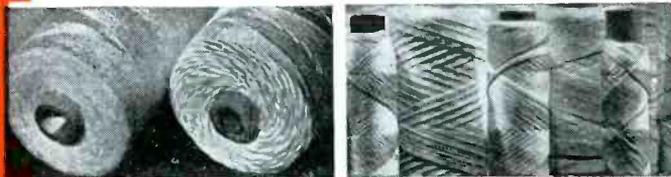
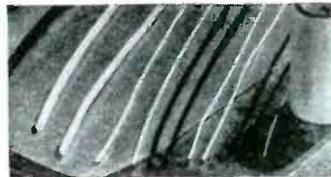
SLEEVINGS

CORDS

and

CLOTHS

treated and untreated



THE ELECTRICAL INSULATIONS WITH THE BUILT-IN STAMINA

...with the strength, power and energy to resist the destructive forces of overloading, extreme high and low temperatures, moisture, corrosion from vapors, fumes and acids, oils, grease, dust and dirt . . . the destroyers that play havoc with electrical equipment protected by ordinary insulations.

Miraglas Tapes, Tubings, Sleeveings, Cords and Cloths have the stamina that adds life to the electrical apparatus they protect . . . they feature fewer breakdowns, less maintenance, reduction of waste, savings in labor and materials . . . and in every way they prove the standing they have earned as the optimum in electrical insulation protection.

Take note of **MIRAGLAS ELECTRICAL INSULATIONS** . . . they stand for the ultimate in electrical insulations woven of Fibreglas Yarn . . . write today for details and characteristics.

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★

* ИНФЛЯЦИЯ?

★

We believe we have done our part to prevent inflation.

You, our customers, now pay only 15% more for Struthers-Dunn Relays than you did in 1941.

By your increased orders and our increased efficiency this has been accomplished.

We look forward with confidence to the months ahead.

* Russian for "INFLATION"

STRUTHERS-DUNN
5,348 RELAY TYPES

STRUTHERS-DUNN, Inc., 150 N. 13th St., Philadelphia 7, Pa.

Serving communications nation-wide!

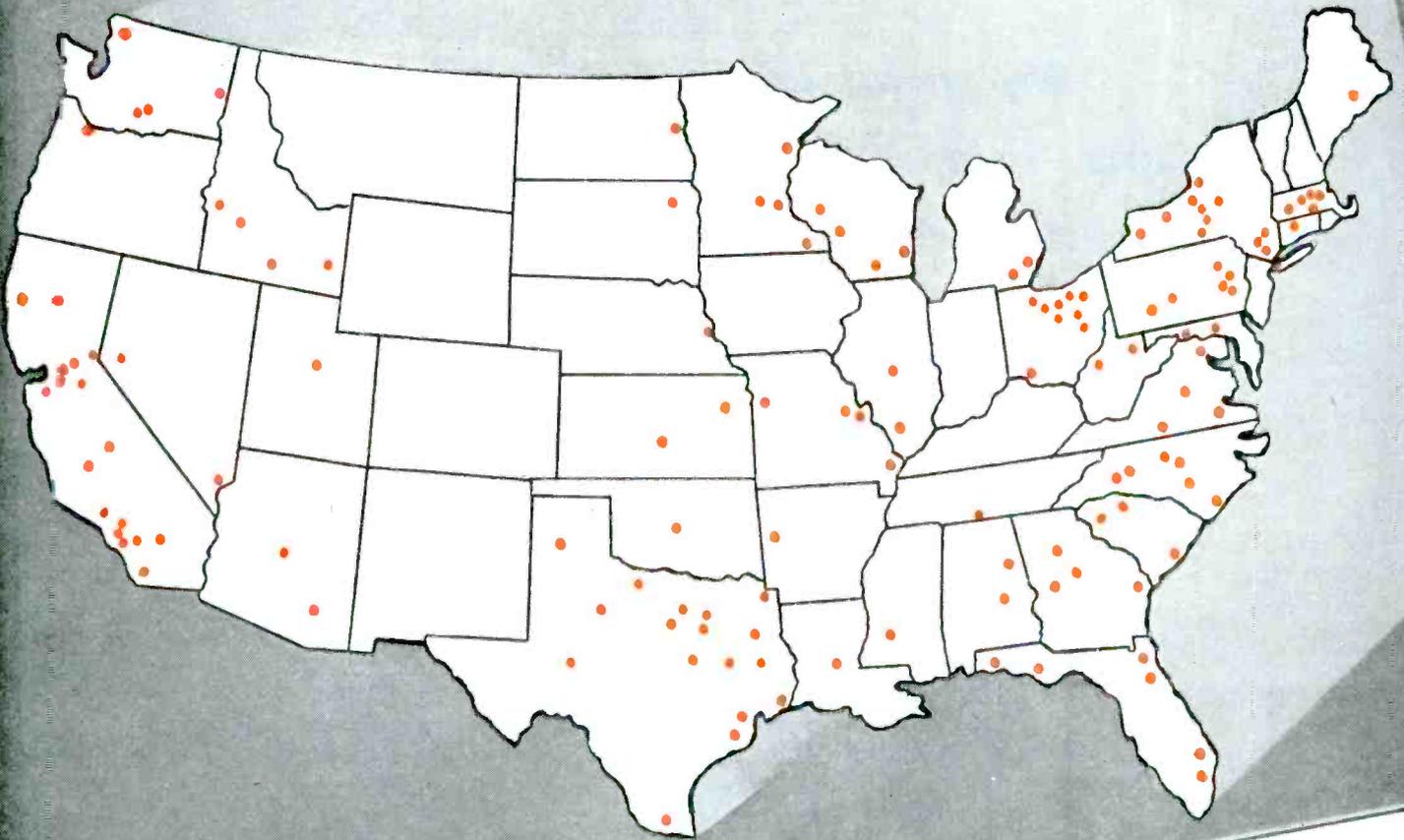


**CERTIFIED
PERFORMANCE**



Communications are vital. Meeting the high standards of this field is our business—our only business. For coaxial transmission lines and related accessories that are service-tested and proven dependable, follow the leaders using CP equipment.

Sold by RCA and GENERAL ELECTRIC. Distributed nationally through 98 service stations of GRAYBAR ELECTRIC COMPANY and distributed internationally by WESTREX CORPORATION.



**Trade Mark Registered*

COMMUNICATION

...with installation-proved

SEAL-O-FLANGE*

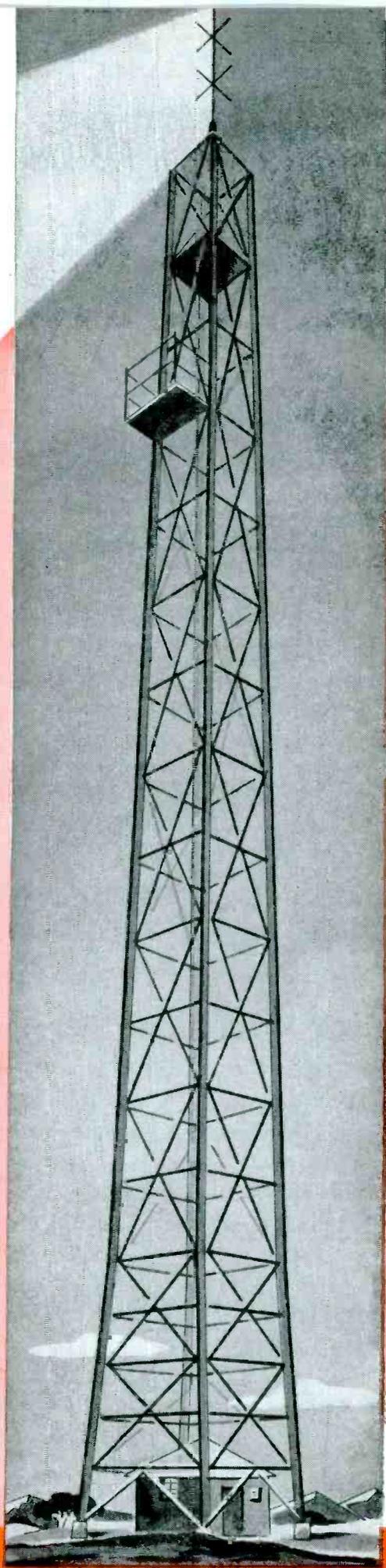
Coaxial Transmission Lines for

AM, FM and Television

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WAIM—Anderson, S. C.
WAJR—Morgantown, W. Va.
WAKR—Akron, Ohio
WATG—Ashland, Ohio
WBGE—Atlanta, Ga.
WBNY—Buffalo, N. Y.
WBOC—Salisbury, Md.
WBRE—Wilkes Barre, Pa.
WBTM—Danville, Va.
WCBS—Springfield, Ill.
WCIL—Carbondale, Ill.
WCOA—Pensacola, Fla.
WCOH—Newman, Ga.
WCOM—Parkersburg, W. Va.
WCRO—Johnstown, Pa.
WCSC—Charleston, S. C.
WCTS—Cincinnati, Ohio
WDAF—Kansas City, Mo.
WDEF—Chattanooga, Tenn.
WDLF—Panama City, Fla.
WDNC—Durham, N. C.
WDOB—Chattanooga, Tenn.
WEBC—Duluth, Minn.
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WEWS—Parma, Ohio
WFAA—Dallas, Texas
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WIBW—Topeka, Kans.
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WINX—Washington, D. C.
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KRIO—McAllen, Texas
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KROC—Rochester, Minn.
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KVCV—Redding, Calif.
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KWIK—Burbank, Calif.
KWRN—Reno, Nevada



PRODUCTS CO. INC

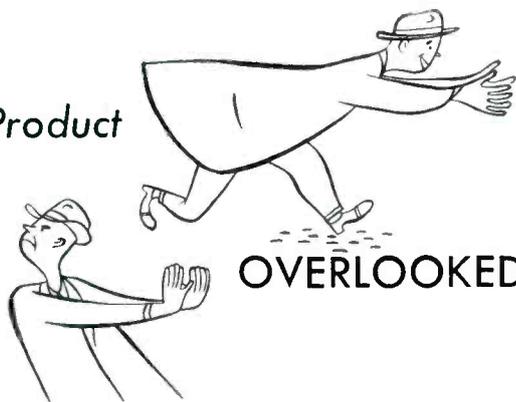
KEYPORT • NEW JERSEY

To Keep Your Product

SOUGHT-AFTER

Instead of an

OVERLOOKED HAS-BEEN . . .



REMEMBER: ROCKBESTOS WIRES and CABLES

RESIST HEAT, AGING, FUMES, FLAME and GREASE

The product you build today must be a better self-salesman than the one you built 12 months ago—because the U. S. consumer dollar is doing an increasingly more thorough value searching job, week by week and day by day.

Rockbestos wires, cables and cords will help you avoid repairs, servicing, replacements and customer dissatisfaction, as well as sales-killing publicity that soon means NO CUSTOMERS.

From airplanes to waffle irons, from calculators to locomotives, here are the advantages which go to buyers of Rockbestos-wired products:

Permanent insulation with impregnated felted asbestos.

No rotting, blooming or swelling from oil, grease or corrosive fumes.

No baking brittle from conductor-heating overloads.

No destructive and expensive wire-fires.

No deterioration from age or oxidation.

Stepped-up current carrying capacity via high heat resistance.

125 *permanently insulated* constructions—from Firewall Hookup Wire to 5000 Volt Rockbestos A.V.C. Power Cable—give you a wide range of failure preventing wires, cables and cords to select from. Write to our nearest district office or the address below for recommendations, samples or information.

ROCKBESTOS PRODUCTS CORPORATION 457 NICOLL ST., NEW HAVEN 4, CONN.

NEW YORK BUFFALO CLEVELAND DETROIT
CHICAGO PITTSBURGH ST. LOUIS
LOS ANGELES OAKLAND, CAL.



ROCKBESTOS FIREWALL HOOKUP WIRE

This heat, flame and moisture resistant wire, insulated with high dielectric tapes and impregnated felted asbestos and covered with color-coded, lacquered glass braid, has a maximum operating temperature of 125° C. Ideal for radios, television, amplifiers, calculators or small motor, coil, dynamotor and transformer leads. No. 22 to 4AWG in 1000 volt rating—No. 12, 14 and 16 AWG in 3000 volt rating.



ROCKBESTOS THERMOSTAT CONTROL WIRE

A multi-conductor control wire for fuel burner controls, safety pilots, intercommunications and signal systems. Its asbestos insulation and steel armor assure trouble-free circuits. Sizes No. 14 to 18 AWG in two to five conductors with .0125", .025" or (for 115 volt service) .031" of impregnated asbestos insulation.



ROCKBESTOS A.V.C. MOTOR LEAD CABLE

Use this 600 volt apparatus cable for coil connections, motor and transformer leads exposed to overloads and high ambient temperatures. Insulated with impregnated felted asbestos and varnished cambric, and covered with a heavy asbestos braid, it is heat-proof and resistant to oil, grease, moisture and flame. Sizes 18 AWG to 1,000,000 CM.

A few of the 125 permanently insulated wires, cables and cords developed by Rockbestos to protect product performance and give lasting service in 300 to 5000 volt applications.

ROCKBESTOS



The Wire with Permanent Insulation



GOOD SOLDER, AND ALL THIS TOO!

In Federated solder you get the exact metal you specify, PLUS all these intangible ingredients. These background factors mean service and security...they mean that you get *consistently* better solder to help you do a *consistently* better job.

For any size, form, or composition of solder—bar, pig, body, drop, foil

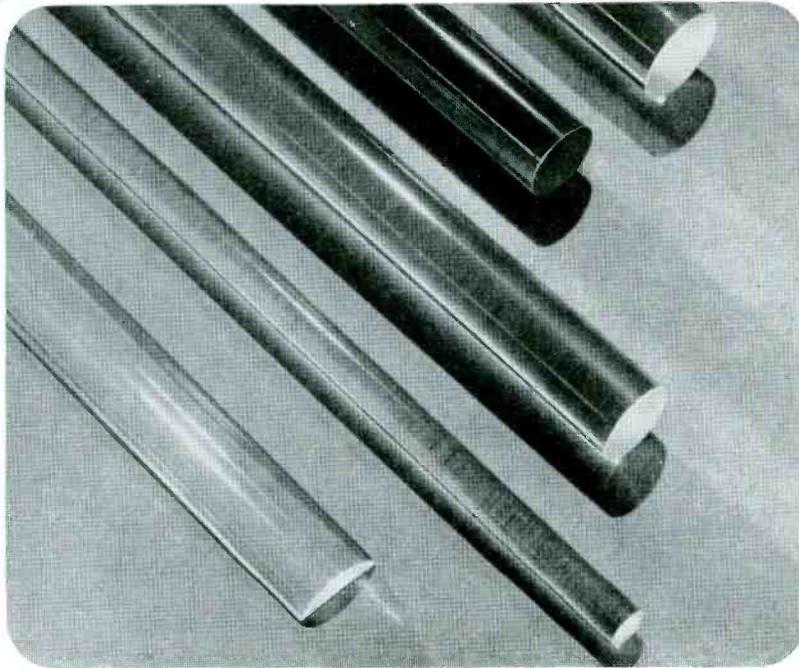
and ingot; acid core, rosin core and solid wire; triangle, strip, wiping and segment — see Federated first.

Federated
METALS DIVISION

AMERICAN SMELTING AND
REFINING COMPANY
120 BROADWAY, NEW YORK 5, N. Y.



YOU MAY NEED THESE TWO RODS



You may be searching at this moment for a material that will help you enhance the appearance of a product . . . add sparkle to a novelty or display . . . or handle an insulating job on high frequency equipment. Turn your attention to Plax polystyrene or methacrylate rod.

Both of these Plax products are enjoying wide usage in a variety of fields. Plax poly-

styrene rod, available in round, square or twisted shapes, is used in high frequency insulation, chemical applications, novelties, display pieces and for many general industrial purposes. Plax methacrylate rod also offers a diversity of applications.

Make sure you have the complete story about what these and other Plax products can do to improve your products.

CHART ON "HOW TO USE PLASTICS"

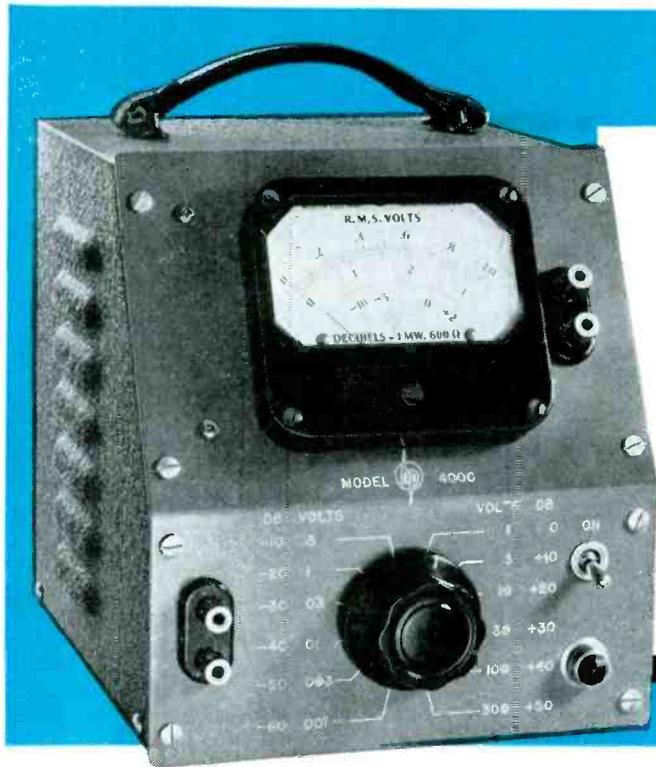
Now available for the asking is a table of properties for six materials available from Plax in various forms and formulae. This has been incorporated in the Plax catalog, which also contains helpful information on the primary uses of each material.

A copy will be sent promptly upon receipt of your request.

Between the resources of Shaw Insulator Company, Irvington 11, N. J., and Plax Corporation, Hartford 5, Conn., you can find help on virtually every material and method in plastics today.



P. O. BOX 1019 ★ HARTFORD 1, CONNECTICUT
In Canada — Canadian Industries, Ltd., Montreal



VOLTAGE RANGE:

3,000,000 to 1

READINGS:

.1 mv to 300 v

FREQUENCIES:

20 cps to 2 mc

THE NEW *-hp-* 400C VACUUM TUBE VOLTMETER

Increased sensitivity. Wider range. Easy-to-read linear scale. Space-saving, time-saving versatility! Those are but a few of the many advantages of the new *-hp-* 400C Vacuum Tube Voltmeter.

30 times more sensitive than the *-hp-* 400A voltmeter, the new *-hp-* 400C accurately determines voltages from .1 mv to 300 v. Its measuring range is broad and new—3,000,000 to 1. And with it you can make split-hair measurements all the way from 20 cps to 2 mc!

The big, clearly-calibrated linear scale reads directly in RMS volts or db based on 1 mw into 600 ohms. Generous overlap makes possible more readings at mid or maximum scale, where accuracy is highest. A new output terminal lets you use the *-hp-* 400C as a wide-band stabilized amplifier, for increasing gain of oscilloscopes, recorders and measuring devices. As a voltmeter, the new instrument has still wider applicability—for direct hum or noise readings, transmitter and receiver voltages, audio, carrier or supersonic voltages, power gain or network response.

Naturally the new *-hp-* 400C includes the familiar advantages of the *-hp-* 400A voltmeter. Range switch is calibrated in 10 db intervals providing direct readings from -70 dbm to +52 dbm. Overall accuracy

is $\pm 3\%$ full scale to 100 kc. High input impedance of 1 megohm means circuits under test are not disturbed. And the rugged meter movement is built to safely withstand occasional overloads 100 times normal.

In every respect, the convenient, durable *-hp-* 400C is the ideal new voltmeter for precision work in laboratory, plant or repair shop. Complete details are available at no obligation. Write today!

Hewlett-Packard Company
1556A Page Mill Road • Palo Alto, Calif.

CHECK THESE SPECIFICATIONS

VOLTAGE RANGES:

12 ranges. Full-scale readings.

.001 v	.100 v	10.0 v
.003 v	.300 v	30.0 v
.010 v	1.00 v	100. v
.030 v	3.00 v	300. v

FREQUENCY RANGE: 20 cps to 2 mc

ACCURACY:

$\pm 3\%$ full scale 20 cps to 100 kc
 $\pm 5\%$ full scale 100 kc to 2 mc

INPUT IMPEDANCE:

1 megohm shunted by 15 uuf, on .01 v to 300 v ranges.

1 megohm shunted by 25 uuf, on .001 v to .003 v ranges.

METER SCALE:

3" linear. Voltage ranges related by 10 db steps. Db calibrated -12 to +2 db. Zero level 1 mw into 600 ohms.

OUTPUT CIRCUIT:

Maximum 0.5 v full scale. Internal impedance 1000 ohms.

POWER SUPPLY:

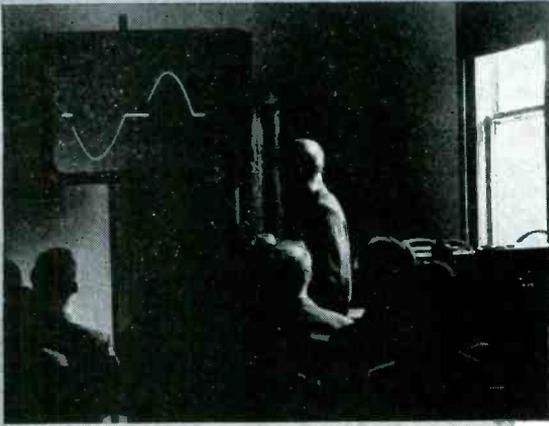
115 v, 50/60 cps, 45 watts.

CABINET SIZE:

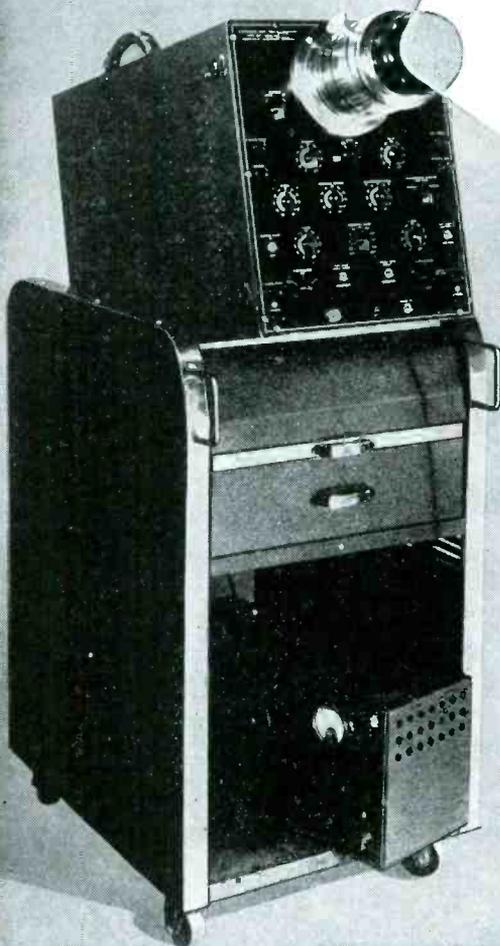
8" high, 7½" wide, 9" deep.

hp laboratory instruments
FOR SPEED AND ACCURACY

Power Supplies Frequency Standards Amplifiers Electronic Tachometers Frequency Meters
UHF Signal Generators Square Wave Generators Audio Frequency Oscillators Attenuators
Audio Signal Generators Noise and Distortion Analyzers Wave Analyzers Vacuum Tube Voltmeters



When projection lenses are available, you can project the oscillogram in a well-lighted room with perfect visibility, as in this unretouched photograph. Note open window.



© ALLEN B. DU MONT LABORATORIES, INC.

PHOTOGRAPHS, PROJECTIONS,
HIGH-SPEED TRANSIENTS ARE

Clear

if it's a

DU MONT Type 247-A
CATHODE-RAY OSCILLOGRAPH

► Modified from the Type 247, this new Du Mont Type 247-A is such a startling success that phenomena hitherto totally invisible can now be easily seen. Such modification extends the range of the instrument tremendously in the field of transient studies or high-speed photographic applications.

The modification utilizes the new Type 5RP Cathode-Ray Tube operable at voltages up to 30 KV, producing sufficient brilliance for direct projection, if required.

Other features are: automatic beam blanking; choice of single or continuous sweep; sweep rates available from .5 cps to 50,000 cps; Z-axis amplifier with choice of output polarity; soundly engineered electrical and mechanical design.

► Further details on request.

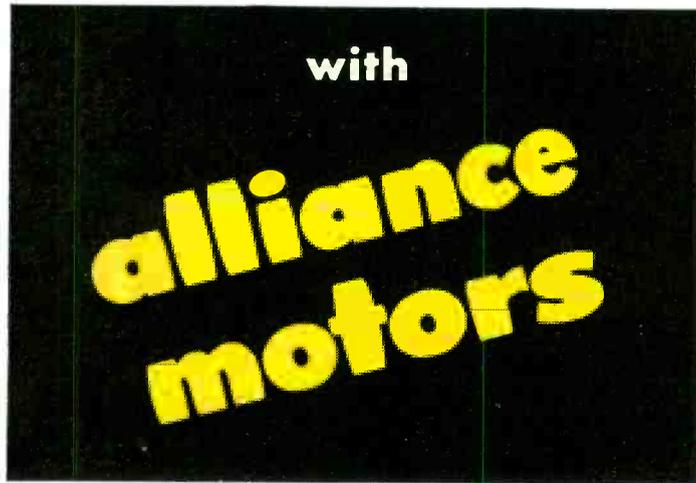
DUMONT

Precision Electronics & Television

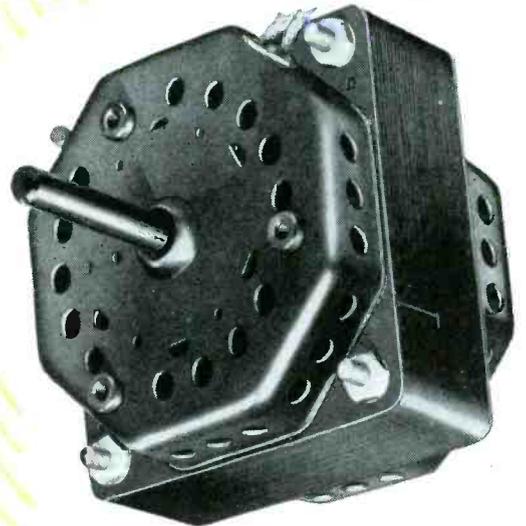
ALLEN B. DUMONT LABORATORIES, INC., PASSAIC, NEW JERSEY • CABLE ADDRESS: ALBEEDU, PASSAIC, N. J., U. S. A.



DRIVE RECORDERS . . . FANS . . . and other devices



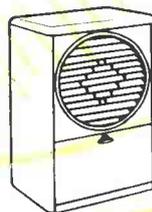
● It pays to use Alliance Motors for sound recorders, fans and many other devices. Mass produced at low cost, they're engineered for each job. Motors for continuous or intermittent duty can be supplied semi-enclosed or completely enclosed, with oilers. Coming in varying stack thicknesses to provide the right amount of power, the entire power range runs from about 1/400th h.p. up to 1/20th h.p. Also, speeds from 1550 rpm down to 500 rpm provide a versatile line of shaded pole induction motors designed for quiet, efficient operation—for economy and long life!



AIR CONDITIONER



AIR CIRCULATOR



ROOM HEATER

ALLIANCE MODEL B SPECIFICATIONS 4-pole shaded induction motor. Motor as illustrated is 3 3/8" square with a 1 1/4" stack thickness. Other standard stacks are 3/4" and 1 3/4"—squirrel cage rotor—semi- or fully-enclosed construction.

Operates on 115 volts, 60 cycles, single phase.

Weight as shown 4 1/2 lbs. Starting torque approx. 40% of torque at full load rating. Can be made with single or double 5/16" shaft. Construction is simple but rugged throughout.

Model B is ideal for operating sound recorders, fans, heaters and many other devices.

WHEN YOU DESIGN—KEEP

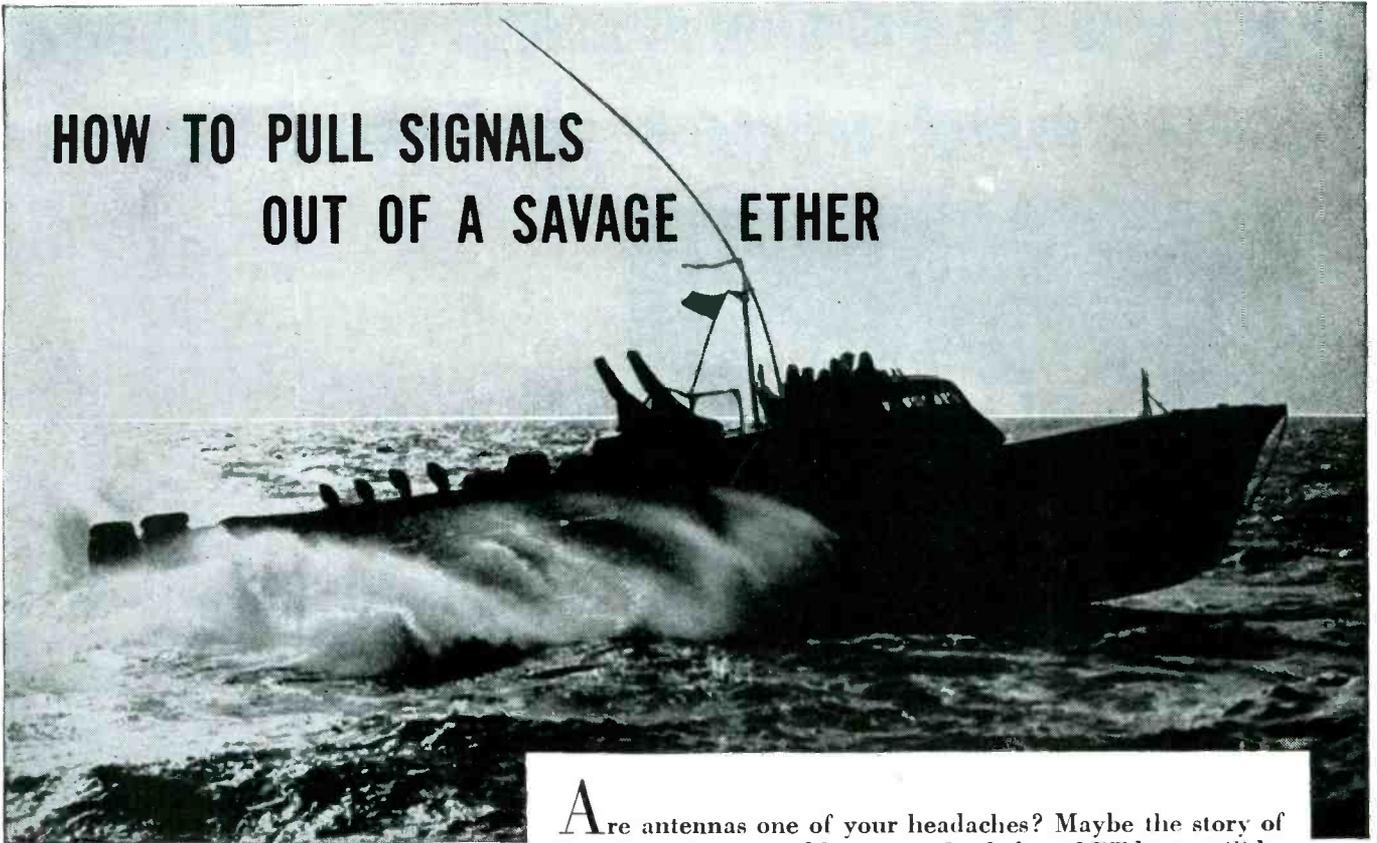
alliance motors

IN MIND

ALLIANCE MANUFACTURING COMPANY • ALLIANCE, OHIO

Export Department: 401 Broadway, New York 13, N. Y., U. S. A.

HOW TO PULL SIGNALS OUT OF A SAVAGE ETHER



Roaring into action on fighting PT boats, Premax Monel antennas defied salt spray, weather, and whipping wind.

Are antennas one of your headaches? Maybe the story of how the antenna problem was solved aboard PT boats will be of some help to you.

PT antennas had to fight corrosive salt air and water. They needed strength and stiffness to withstand whipping winds and plunging boats. They had to function in arctic cold and tropic heat.

An answer was worked out for the Navy by Premax Products Division of Chisholm Ryder Co., Inc., Niagara Falls, N. Y. It consisted of telescoping tubular antennas, made of sections of seamless tubing furnished by the Superior Tube Co., Norristown, Pa.

The metal that met the combination of conditions?—Monel.* To quote Premax engineers:

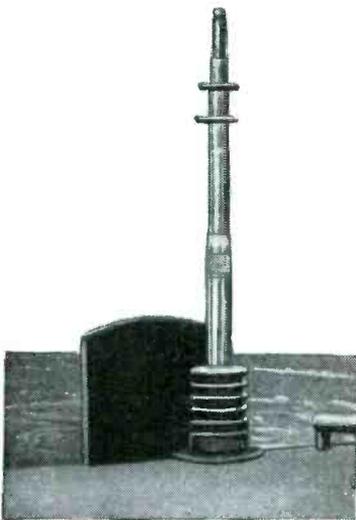
"Monel has been found to be the most practical material for radio antennas. Sudden shocks do not affect its toughness . . . its fatigue strength exceeds the limits of mild steel or all brasses and bronzes.

"Rigid tests by both Government and private agencies have shown Monel antennas to be dependable and satisfactory under all conditions."

Do you have an electrical problem that can be solved by the combination of properties obtainable in Monel . . . or the other INCO Nickel Alloys?

All are strong, tough, and corrosion resistant. In addition, each has special properties needed for special jobs. Write us describing your problem. Our technical assistance is yours whenever you ask for it.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.



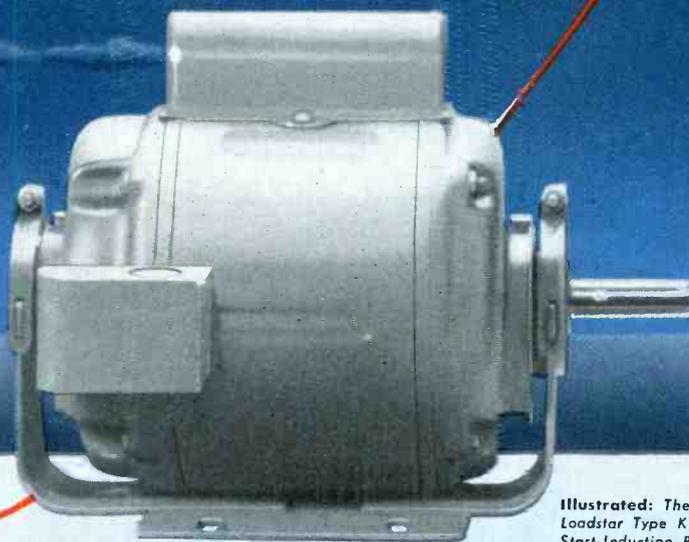
Premax Monel Antennas are built in multiple sections of tough, cold-drawn Monel tubing, telescoped one inside the other. Above illustration shows antenna in fully telescoped position.

Monel*

EMBLEM OF SERVICE
NICKEL  **ALLOYS**

MONEL* • "K"* MONEL • "S"* MONEL • "R"* MONEL • "KR"* MONEL
INCONEL* • **NICKEL** • "L"* NICKEL • "Z"* NICKEL *Reg. U.S. Pat. Off.

Set your Sales by the Leland **LOADSTAR**



Illustrated: The Leland Loadstar Type KL Capacitor Start-Induction Run Motor



COOL-RUNNING! Internal fan air-cooling, and newly developed ventilation features.



QUIET! Exceptionally close tolerances eliminate vibration, prolong motor life. Engineered throughout for smooth, silent operation under most exacting conditions.



SELECTION! 1/8 to 3 HP. Types—ball bearing and sleeve bearing; open and enclosed, horizontal and vertical. Thermomatic control optional. Special-purpose motors built to specifications.

LOADSTAR-POWERED, your product will encounter smoother sailing at the point of sale. However high your production and performance standards—you'll find the self-same qualities in Leland Loadstars. Thus, the Leland nameplate—on hushed, sweet-running, cooler motors—becomes an important factor in the service of your product and in the satisfaction it is built to render. Specify Leland Loadstars for HP per cubic inch as high as any—for HP per pound higher than most. Write for complete descriptive folder.

THE LELAND ELECTRIC COMPANY, DAYTON 1, OHIO. Branches in all principal cities.

LELAND LOADSTAR MOTORS

MOTORS OF ALL TYPES—ENGINEERED TO INDUSTRY'S SPECIFIC NEEDS

Nº3

WHAT MAKES A GOOD RECORDING BLANK GOOD?*

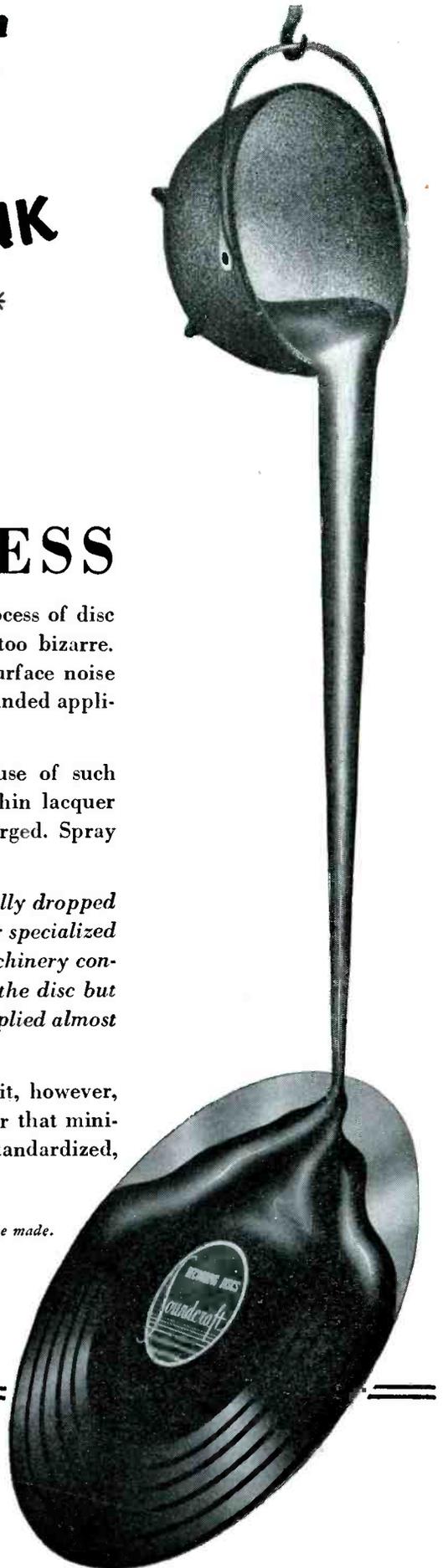
The COATING PROCESS

So secret have some disc manufacturers kept the actual process of disc coating that even the crude method illustrated might seem none too bizarre. The development of the Soundcraft disc coating to combine low surface noise with high mechanical strength (quietness with high response) demanded application of heavy viscosity (fine grain) lacquer.

- To coat smoothly such a molasses-like liquid precluded the use of such common processes as dip-coating wherein layer upon layer of thin lacquer built up the required thickness as the disc rotated half submerged. Spray build-up was also out of the question.
- The answer was flow-coating, a method by which lacquer is virtually dropped on the disc. To obtain uniform distribution by flow-coating, highly specialized equipment was developed. So accurately does this Soundcraft machinery control not only the direction and rate of flow of lacquer as it hits the disc but also the movement of the aluminum base, that the heavy film is applied almost as though a dry plastic were being laid over the aluminum.
- To visualize such a process is often difficult. Final evidence of it, however, is the precision surface of your Soundcraft disc—one more factor that minimizes uncertainty and establishes disc recording anew on a standardized, predictable basis.

**Watch this space for succeeding ads in this informative series on how Soundcraft discs are made.*

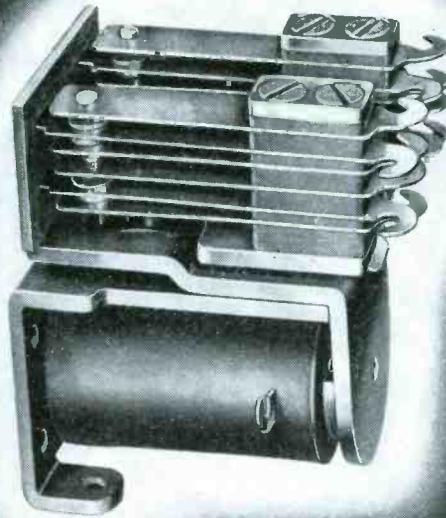
REEVES **Soundcraft** CORP.
10 EAST 52nd STREET • NEW YORK 22, N. Y.



The 'Broadcaster' The 'Playback' The 'Audition' The 'Maestro'

THE ALLIED "PR"

*A COMPACT
Power Relay
for a WIDE range
of applications*



The new Allied "PR" Relay meets the demand for a small versatile relay.

This new addition to the Allied line of precision relays has been designed to simplify your relay problems. Its availability in 1, 2, 3, or 4-pole, double-throw, normally-open or normally-closed and in double-break contact arrangements make it suitable for use in an even wider range of applications than the well-known "CR" type which it replaces.

These are some of the important reasons why this small relay is equipped to do a big job:

- Contact Rating—10 amperes, or 30 amperes for double-break contacts, at 24 volts D.C. and 110 volts

A.C. non-inductive with standard silver contacts. This rating is attained by high contact pressures which usually are obtainable only in a much larger relay.

- Coil Rating—D.C.—up to 120 volts. A.C.—up to 220 volts with a maximum contact arrangement of double-pole, double-throw.

- Mounting—horizontal or vertical mounting frame for maximum adaptability.

- Terminals—easy-to-wire contact and coil terminals are conveniently located.

These features plus the skillful workmanship and superior materials that

go into the manufacture of every Allied precision relay mean better relay performance . . . longer relay life in your equipment. Write for complete information on this and other Allied relays.

HERMETICALLY SEALED TYPE PR RELAYS

TYPE PRH—Solder terminals. Up to four-pole, double-throw.

TYPE PRHO—Standard octal plug-in base. Up to three-pole, single-throw, normally open or closed or any combination of six contact arms.



ALLIED CONTROL COMPANY, INC.

Dept. A, 2 East End Avenue • New York 21, N. Y.

AL-113

ZIRCON INSULATION CEMENT FOR ELECTRIC HEATERS

TAM zircon cement 31568-H has been developed to meet all five major requirements of insulation cements: 1—easy application: 2—refractoriness: 3—certain limiting values to current leakage at operating wattage, under humid conditions; and under an externally applied stress voltage: 4—stability of insulation and structure through a 1000 hour-life test: 5—reasonable cost. Performance indicates an outstanding group of compositions, both electrically and ceramically. The results listed below apply to a particular structure for cement applied in a specific manner. Any variation may alter results.

DRY PRESS FLAT IRON

CEMENT	OPERATING LEAKAGE	HUMIDIFICATION LEAKAGE	RETURN TO NORMAL
31568-H	0.002 M. A.	0.2	15 to 30 seconds

In dry press work insulation thickness is relatively greater than other assemblies which accounts for the very low values obtained.

STRIP HEATERS

Operating Leakage	= 0.002 M. A.
Heater cold stress voltage 700	0.1 M. A.
Heater cold stress voltage 1500	0.7 M. A.
Heater hot stress voltage 700	0.00 M. A.
Heater hot stress voltage 1500	0.4 M. A.

MUD CAST RANGE ELEMENT

Leakage at operating wattage	= 0.055 M. A.
Leakage after humidification	3.2 M. A.
Returns to normal in 15 to 30 seconds after current is turned on.	

TAM

TITANIUM ALLOY MANUFACTURING COMPANY

Executive Offices: 111 Broadway, New York City General Offices and Works: Niagara Falls, N. Y.



YOU GET A SQUARE DEAL AT OUR ROUND TABLE

When you bring your sheet metal fabrication problems to KARP, you immediately set in motion a "round table" board of experts whose combined specialized skill and experience is without an equal in the field. This group includes the president, chief engineer, chief draftsman-designer, chief toolmaker, plant superintendent, production manager and cost accountant.

These men make a detailed study of your special requirements. They plan, design and engineer the job with your needs and uses in mind. They determine the best manner of producing it, utilizing KARP'S superior equipment and facilities to your greatest advantage.

When your job is finished, it will be correctly designed for its application, handsome, rugged and built for long service life. You will have no costly problem of assembly . . . no need to spend additional time and labor on finishing touches. The job will be COMPLETE, ready for the installation of your electrical or mechanical operating parts with ease and simplicity. No matter how many units you order, every last detail will be absolutely uniform.

This custom service not only gives your product added value, but under KARP methods may often save you money.

Consult us for cabinets, housings, chassis, racks, boxes, enclosures or any type of sheet metal fabrication.

Write for Our New Catalog.

Karp METAL PRODUCTS CO., INC.

Custom Craftsmen in Sheet Metal

124 - 30th STREET, BROOKLYN 32, NEW YORK



*Your Toast, Sir!
Thanks to this Sleaving*



It's the clock that makes an automatic toaster pop up at exactly the right second. High heat . . . current leakage . . . abrasion and wear—these are some of the clock lead insulation problems that make "never fail" insulation a necessity.

In the new Universal Automatic Toaster, the leads from the clock assembly to the heating element are protected with double braided BH Fiberglas Sleaving, special treated for heat resistance up to 1200° F.

"We have found BH Fiberglas Sleaving to be the precise answer to an application requiring resistance

against heat and current leakage, and dependability over a long period of time." So say the makers of Universal Toasters.

Try BH Fiberglas Sleaving in your own plant, in your own product. See how it stays flexible as string, cuts without fraying. Compare it with ordinary saturated sleaving. Learn why leading manufacturers of home appliances, radios and industrial equipment have standardized on BH Fiberglas Sleaving.

BENTLEY, HARRIS MFG. CO., CONSHOHOCKEN, PA.

BH *Fiberglas** SLEEVINGS

*BH Non-Fraying Fiberglas Sleavings are made by an exclusive Bentley, Harris process (U. S. Pat. No. 2393530). "Fiberglas" is Reg. TM of Owens-Corning Fiberglas Corp.

-----USE COUPON NOW-----

Bentley, Harris Mfg. Co., Dept. E-20, Conshohocken, Pa.

I am interested in BH Non-Fraying Fiberglas Sleaving for _____ (product)

operating at temperatures of _____°F. at _____ volts. Send samples so I can see for myself how BH Non-Fraying Fiberglas Sleaving stays flexible as string, will not crack or split when bent.

NAME _____ COMPANY _____

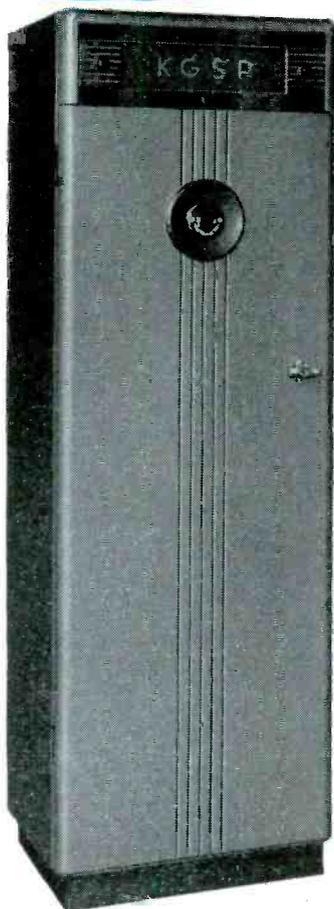
ADDRESS _____

Send samples, pamphlet and prices on other BH Products as follows:

- Cotton-base Sleaving and Tubing
- Ben-Har Special Treated Fiberglas Tubing

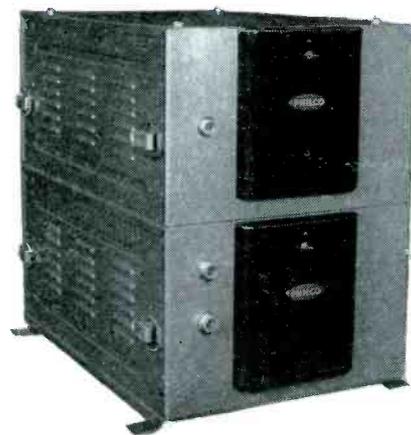
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these specifications for
**152-162 Mc-FM Radiophone
 Communication Systems**



by

PHILCO
 the leader



• specifications

RECEIVER	152-162 Megacycles
Dimensions	8 1/4 x 12 x 19 1/4"
Sensitivity	0-.5 microvolts for full audio output
Selectivity	Band width 40KC at 6 Db down. Adjacent channel (60KC) —60 Db minimum. Alternate channel (120KC) —106 Db minimum.
Spurious response	—60 Db minimum.
Squelch	0.3 microvolts minimum 6.0 microvolts maximum
Power supply	Synchronous vibrator
Frequency range	152-162 megacycles
TRANSMITTER	
Modulation characteristics	±20KC at 3,000 cycles equal 100%
Frequency stability	±.005%
Spurious emission	—60 Db minimum
Power supply	Dynamotor
Antenna relay	Built-in for transmit-receive operation
Temperature range for normal operation	—30° C to 60° C

• Philco Radiophone Systems are Available for Operation on All Frequencies Assigned for Mobile Communication.

• Free Engineering Consultation Service.

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Dept. J-2, Industrial Division
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Gentlemen:

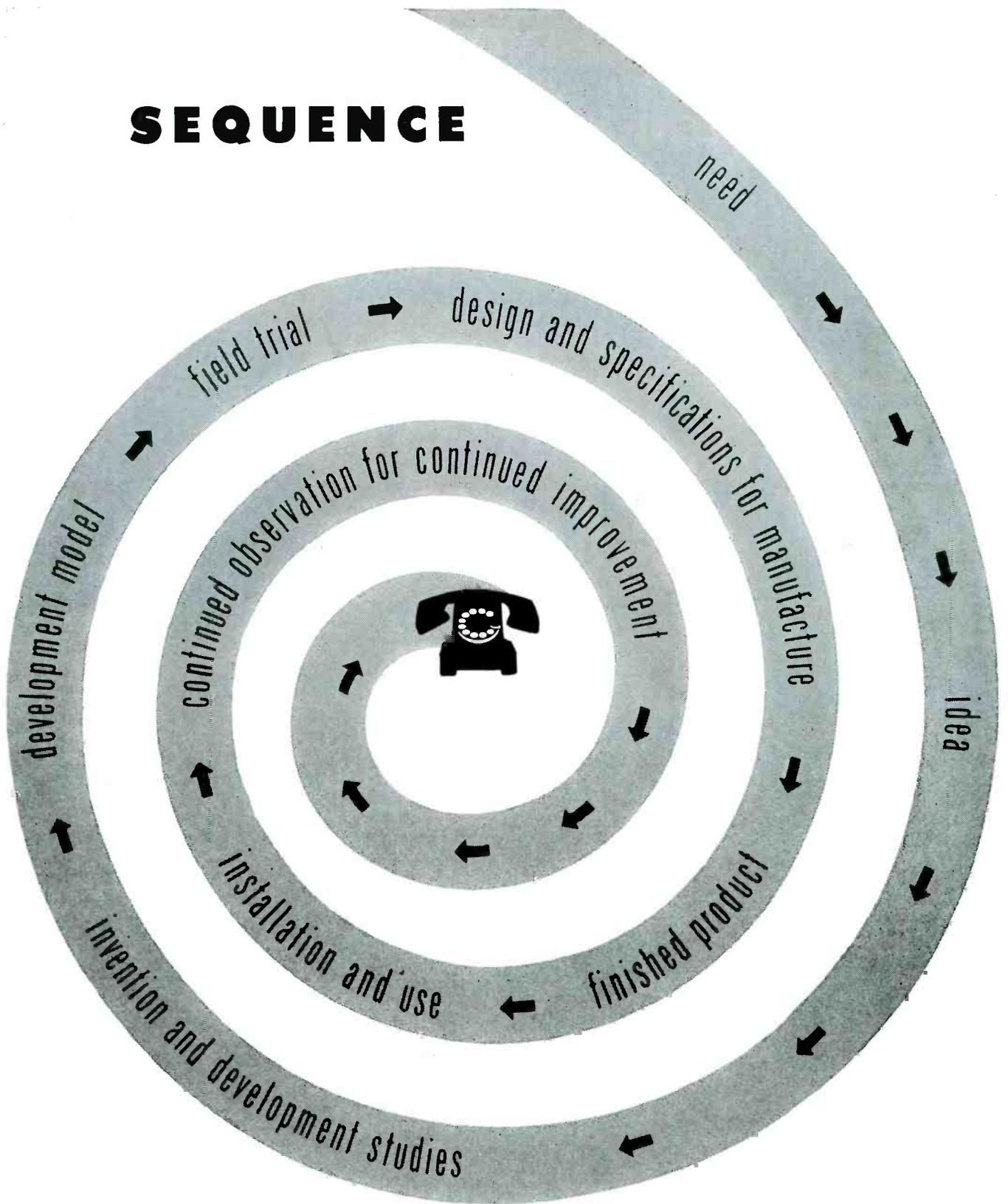
Please send me information about the new
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 System.

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CITY _____

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At Bell Telephone Laboratories, more than 2300 scientists, engineers, and their associates are continually exploring and inventing, devising and perfecting for improvements and economies in telephone service.



BELL TELEPHONE LABORATORIES

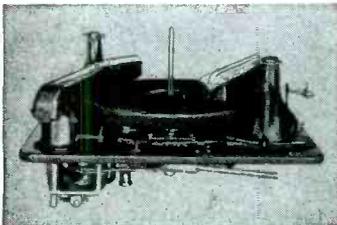
HERE'S
*Smooth
 Power*
**TO PLEASE YOUR
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**QUIETER . . .
 MORE COMPACT . . .
 LONGER LASTING . . .**



**Model LX Rim Drive Constant Speed
 Electric Phonomotor**



**Model RC-130 Combination Record-
 Changer Recorder**



**Model R-90 Dual-Speed, Home
 Recording and Phonograph Assembly**

© Yes, it's your customers who will appreciate the plus features of General Industries' Model MX Phonomotor — *split-second pickup to full constant speed . . . dependable, quiet operation . . . and a full measure of famous GI Smooth Power.*

In this up-to-date motor, no detail which could contribute to increased customer satisfaction has been overlooked. Scientific noise elimination through accurate balancing and improved cushioning . . . superior idler arrangement which positively eliminates vertical wobble . . . anti-friction bearing construction for long trouble-free service . . . are but some of the reasons why the MX stands out as the top-quality value for top-quality phonographs and record-changers.

From the drawing board to the final inspection line, the MX has been designed, engineered and built to be the finest phonomotor of its type available. Plan NOW to give your customers the extra quality that's inherent in every General Industries' phonomotor, recorder and combination record-changer recorder. Complete information is available upon request.

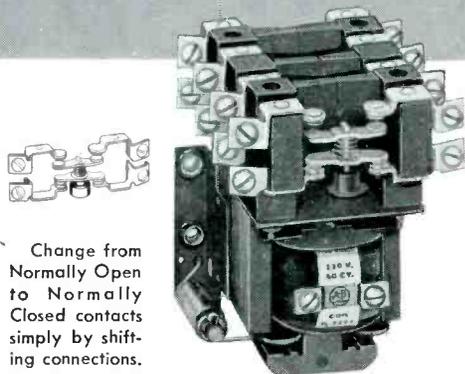


The GENERAL INDUSTRIES Co.

DEPARTMENT B • ELYRIA, OHIO

RELAYS • CONTACTORS • LIMIT SWITCHES

for ELECTRONIC APPLICATIONS



Change from Normally Open to Normally Closed contacts simply by shifting connections.

Dimensions 3 3/4 in. x 3 in. x 3 3/4 in.



BULLETIN 700 UNIVERSAL RELAYS have two banks of contacts for quick changes from Normally Open to Normally Closed contacts . . . or vice versa. Available in 10-ampere rating with 2, 4, 6, and 8 poles; double break, silver alloy contacts need no maintenance. No pins, pivots, bearings, or hinges to bind or stick.

A-B TIMING RELAYS



BULLETIN 848 TIMING RELAYS are ideal for any service requiring an adjustable, delayed action relay. Have Normally Open or Normally Closed contacts.

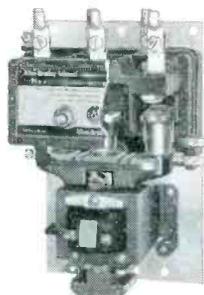
Magnetic solenoid core is restrained from rising by the piston in fluid dashpot. Adjustable valve in piston regulates time required to pull piston through fluid seal and trip the contacts, which open or close with quick, snap action. Ideal for transmitter plate voltage control.

• • •

A-B HEAVY DUTY CONTACTORS

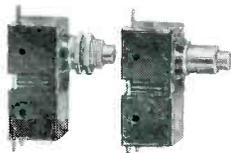
BULLETIN 702 SOLENOID CONTACTORS for heavy duty ratings up to 300 amperes. Arranged for 2- or 3-wire remote control with push buttons or automatic pilot devices.

Enclosing cabinets for all service conditions. Double break, silver alloy contacts require no maintenance. Solenoid mechanism is simple and trouble free. These Allen-Bradley solenoid contactors can be furnished in a variety of enclosures to meet any service requirement. Write for Bulletin 702, today.



A-B LIMIT SWITCHES

for Radio Transmitter Cabinet Doors



Precision Limit Switches with solder lugs or screw terminals.



Push Type. Slow action. N. O. or N. C. contacts.



Spring return roller type limit switch. Setting is adjustable.

Limit switches serve many electronic applications. Those shown above may be used for safety interlocks on transmitter cabinets. They serve as pilot controls for actuating Allen-Bradley 702 Heavy Duty Contactors which will disconnect all electrical apparatus in the cabinet if the doors are opened.

Limit switches are also used for electrical sequence switching; restricting machine motions; starting, stopping, and reversing motors, etc. The Allen-Bradley line of limit switches fills a 70-page catalog. Let us send you a copy.

Allen-Bradley Company
110 W. Greenfield Ave., Milwaukee 4, Wis.



ALLEN-BRADLEY

RESISTORS RELAYS

QUALITY

NEW!

LAPP GAS-FILLED CONDENSERS

- ✓ SMALLER DIMENSIONS
- ✓ LOWER LOSSES
- ✓ HIGHER CURRENT RATINGS
- ✓ HIGHER EFFECTIVE VOLTAGE RATINGS
- ✓ GREATER SAFETY FACTORS
- ✓ TUNING SHAFT AT GROUND POTENTIAL



For capacitance at high voltages or high currents, the Lapp Gas-Filled Condensers have long been known for their operating dependability and space-saving design. Now these condensers are offered in a new design, about 70% of the previous size, with current paths only one-third as long. Fixed or variable capacitors are available, as standard, in five voltage ratings up to 58 Kv peak, 1 mc. current ratings up to 390 amperes, capacitances to 30,000 mmf. Higher capacitances and ratings on special design order. Write for new descriptive bulletin No. 265.

Lapp

LAPP INSULATOR COMPANY, INC., LE ROY, NEW YORK

What's your problem?

Fine Wire? Tungsten? Molybdenum?

Problem 1

Mr. Hi Hott needed molybdenum sheets for forming into parts. High hot strength and good ductility were required. North American Philips supplied him with Elmet Molybdenum sheets that met his specifications exactly.



Problem 2

Mr. N. O. Emission, II, required plated grid wires. He solved his problem with a call to Fine Wire Headquarters. We shipped him some gold plated tungsten and molybdenum wires. Result: no secondary emission.

Problem 3

Mr. Insulate needed enamelled fine wire. So he ordered from Fine Wire Headquarters, and received fine enamelled copper wire made to his specifications.



the answer

WHY not call Fine Wire Headquarters when you have a question about fine wire? We can't do the impossible, but we can do lots of things that can bring you the right fine wire for the job.

So—when you have a problem on Fine Wire, Tungsten or Molybdenum—wire, phone or write to North American Philips, makers of NORELCO Fine Wires, and ELMET Tungsten and Molybdenum products.

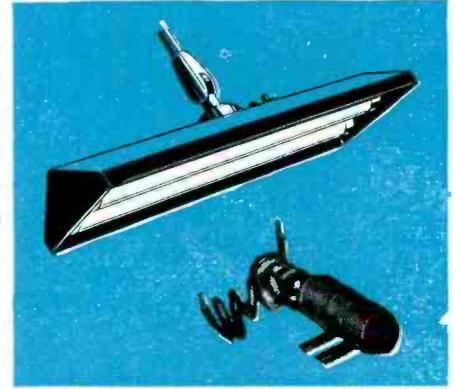
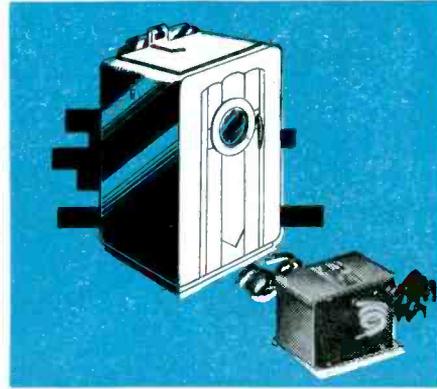
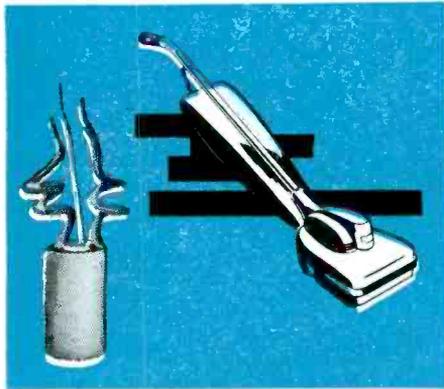
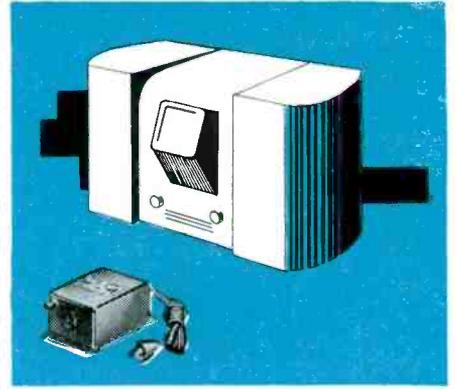
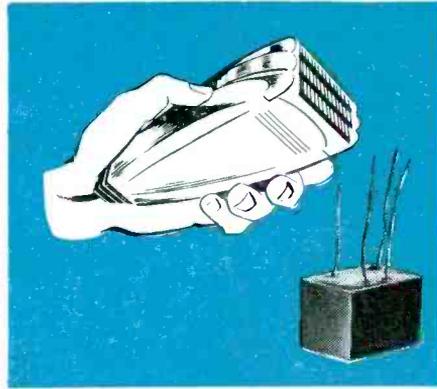
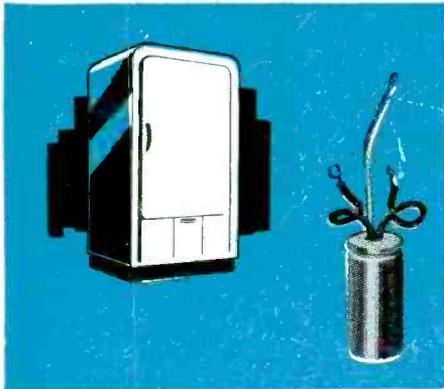
NORTH AMERICAN PHILIPS COMPANY, INC.

Dept. E-3, 100 East 42nd St., New York 17, N. Y.

YOUR PRODUCT, TOO

CAN BE RADIO NOISE-PROOFED WITH C-D

Quietones
Reg. U.S. Pat. Off.

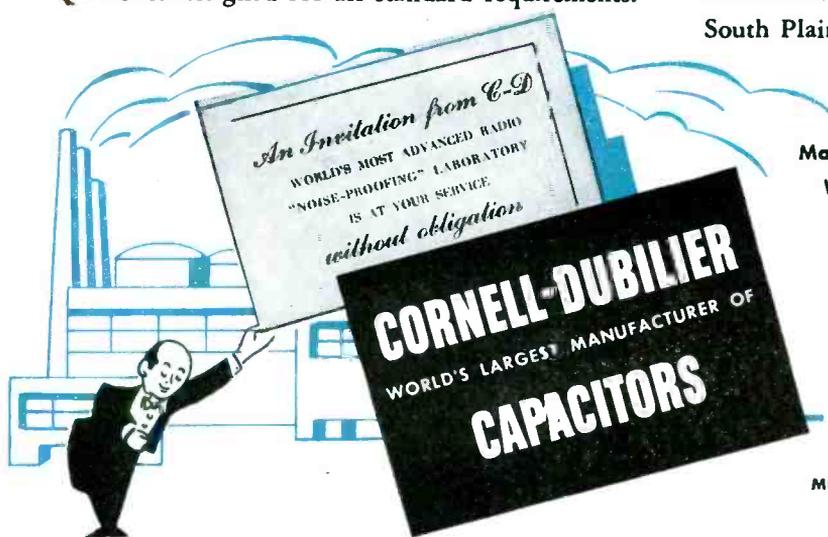


When we say Radio Noise-Proofed—we mean Radio Noise-Proofed. It's no trick at all to build a filter with high attenuation at 150 kc or 100 mc . . . but to build one which filters at 150 kc and 100 mc—as well as all points in between—is a horse of a different color. We know because we've done it. It is only one of hundreds of available types of C-D Quietones designed for all standard requirements.

Among these stock types there may be one which will bring the interference level of your product down to the level of a rabbit's bark. If not, we invite you to make full use of our Radio noise-proofing laboratory and our engineers for the development of a unit designed for your specific needs.

Your inquiries are cordially invited. Address: Cornell-Dubilier Electric Corporation, Dept. K-3, South Plainfield, N. J. Other large plants in New Bedford, Worcester and Brookline, Mass., and Providence, R. I.

Make Your Product More Saleable
With C-D Quietone Radio Noise
Filters and Spark Suppressors



MICA • DYKANOL • PAPER • ELECTROLYTIC

PROFESSIONAL PERFORMANCE — that keeps the original sound alive!

**Make Each
Record a**

**"Personal
Appearance!"**



—with precision control of recording quality



Listen critically: Your station is on the air. There's your announcer's voice . . . the opening music . . . the song . . . the chatter. Is it a 'live' or a 'recorded' program? Not even your trained ears should be able to tell!

Today, truly professional recording reproduces all of the quality and natural beauty of music or speech with full naturalness. It keeps the original sound alive.

You can sum up the reasons for the unexcelled 'live' performance of the Fairchild Unit 523 Studio Recorder in one simple statement: It provides a maximum flexibility of mechanical operation that permits the operator to secure unexcelled quality of reproduction. Fairchild provides instant, infinite variation of pitch from 80 to 160 lines-per-inch by means of a unique planetary-driven lead screw. Operation is controlled by a single, easily accessible knob, as illustrated at the left. This makes it possible to record a very loud passage at 90 lines-per-inch and to follow it with soft passages at 120 or 130 lines-per-inch without dial twisting or the danger of overcutting the next groove.

Timing is accurate to a split-second. Operation is 'WOW'-free. Turntable noise, rumble and vibration are non-existent. And the performance of the Fairchild Unit 541 Magnetic Cutterhead — which is standard equipment on the Unit 523 Studio Recorder — has been engineered for full dynamic range; minimum distortion content and broad frequency range. Want more details? Address: 88-06 Van Wyck Blvd., Jamaica 1, N. Y.



Studio Recorders
Magnetic Cutterheads
Transcription Turntables
Portable Recorders
Lateral Dynamic Pickups
Unitized Amplifiers

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Fairchild CAMERA

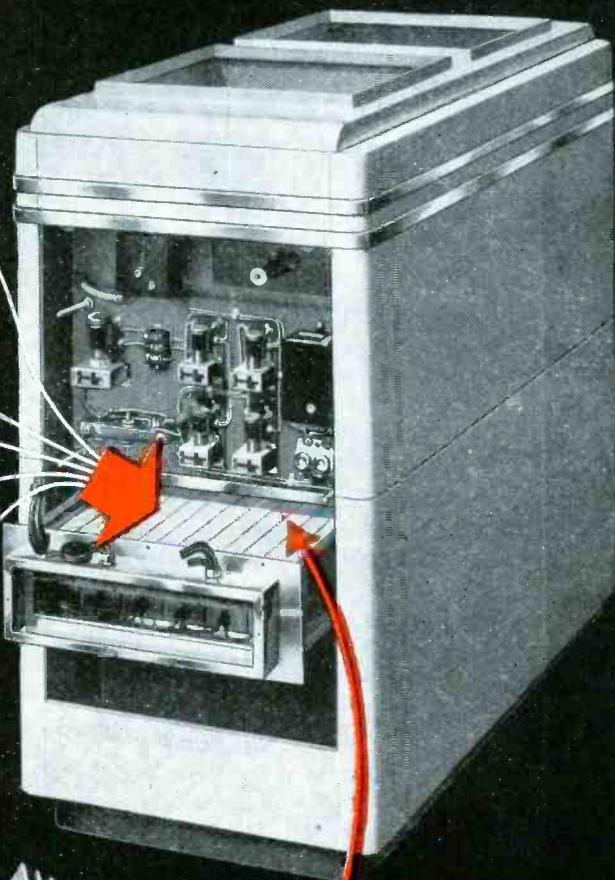
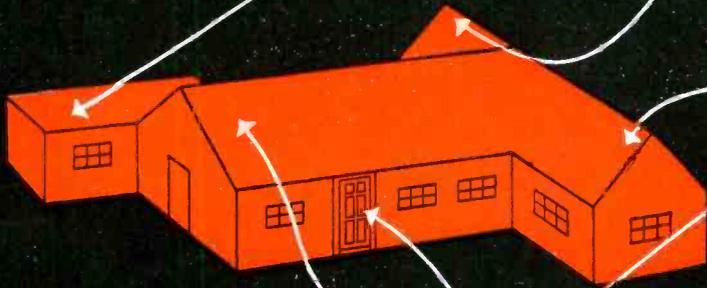
AND INSTRUMENT CORPORATION

SOUND EQUIPMENT



March, 1948 — ELECTRONICS

Fireless Furnace



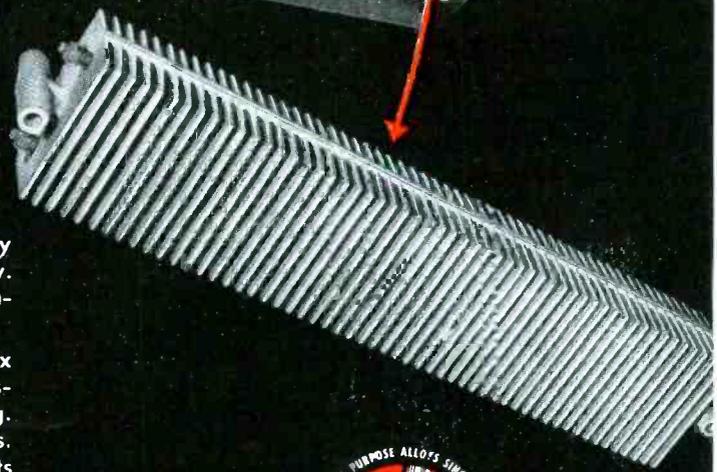
Heats Homes the Modern Way with **NICHROME***

This new, fireless home-heating furnace, manufactured by Electromode Corporation, heats a house noiselessly by electricity. No dust, no ashes . . . no fuel storage tanks, no elaborate installations.

The furnace, which is only 40" x 26 1/2" x 58", contains six heating elements, each consisting of an insulated NICHROME resistor wire in metal sheath, embedded in a finned aluminum casting. A master thermostat inside the house controls two of the units. The four remaining units are controlled from exterior thermostats set at various temperatures. As outside temperature falls, additional heating units are cut "in" as the various thermostat settings are reached; conversely, when outside temperature rises, units are cut "out". Thus maximum heating flexibility is combined with economical operation. Room temperatures vary only about 3° from floor to ceiling.

In developing this heating equipment, the Electromode Corporation encountered the problem of providing electrical heating elements efficient enough to heat an entire home yet sufficiently compact to fit into a space-saving outer cabinet. They selected NICHROME as the resistance wire for this exacting job, in order to assure top-level performance and a life-time of trouble-free operation.

Whatever your product, if it requires a resistance element combining high efficiency with long life, specify NICHROME. And remember, there are more than 80 Driver-Harris electrical resistance alloys specifically designed to fill the numerous requirements of the Electrical and Electronic Industries . . . get in touch with us for expert advice.



Driver-Harris COMPANY

Exclusive Manufacturers of Nichrome
HARRISON, N. J.

BRANCHES: Chicago • Detroit • Cleveland
Los Angeles • San Francisco • Seattle

THE B. GREENING WIRE COMPANY, LTD.
Hamilton, Ontario, Canada

*Trade Mark Reg. U. S. Pat. Off.

REVERE ALUMINUM TUBE for Home Antennas

Problems encountered in the manufacture and erection of home antennas for television and FM receivers are most easily solved by using Revere Aluminum Tube. Note these features:

Strength. Revere 61S-T6* Aluminum has high strength for masts. Typical properties are 40,000 p.s.i. yield strength and 45,000 p.s.i. tensile strength.

Workability. Revere 61S-T4* Aluminum can be easily bent if desired for the formation of dipoles. Both this and 61S-T6* are easily cut, drilled, and threaded. Typical properties of 61S-T4* are 21,000 p.s.i. yield and 35,000 p.s.i. tensile.

Lightness. Aluminum tube, being only about one-third the weight of steel, reduces transportation charges and facilitates installation work.

Beauty. Aluminum can be anodized and given almost any desired color. Most people, however, prefer it in its silvery beauty without adornment.

Revere Aluminum Tube is available in practically any size that might be required, and thus each design can be engineered to its own requirements. Revere and any Revere distributor will gladly quote you prices and delivery dates on your requirements. The Revere Technical Advisory Service will cooperate with you on technical matters concerning the use of aluminum tube or any other Revere Metal. Revere supplies the radio industry with many non-ferrous metals and alloys, in such forms as tube and pipe, rod and bar, sheet and plate, extruded shapes and forgings.

REVERE

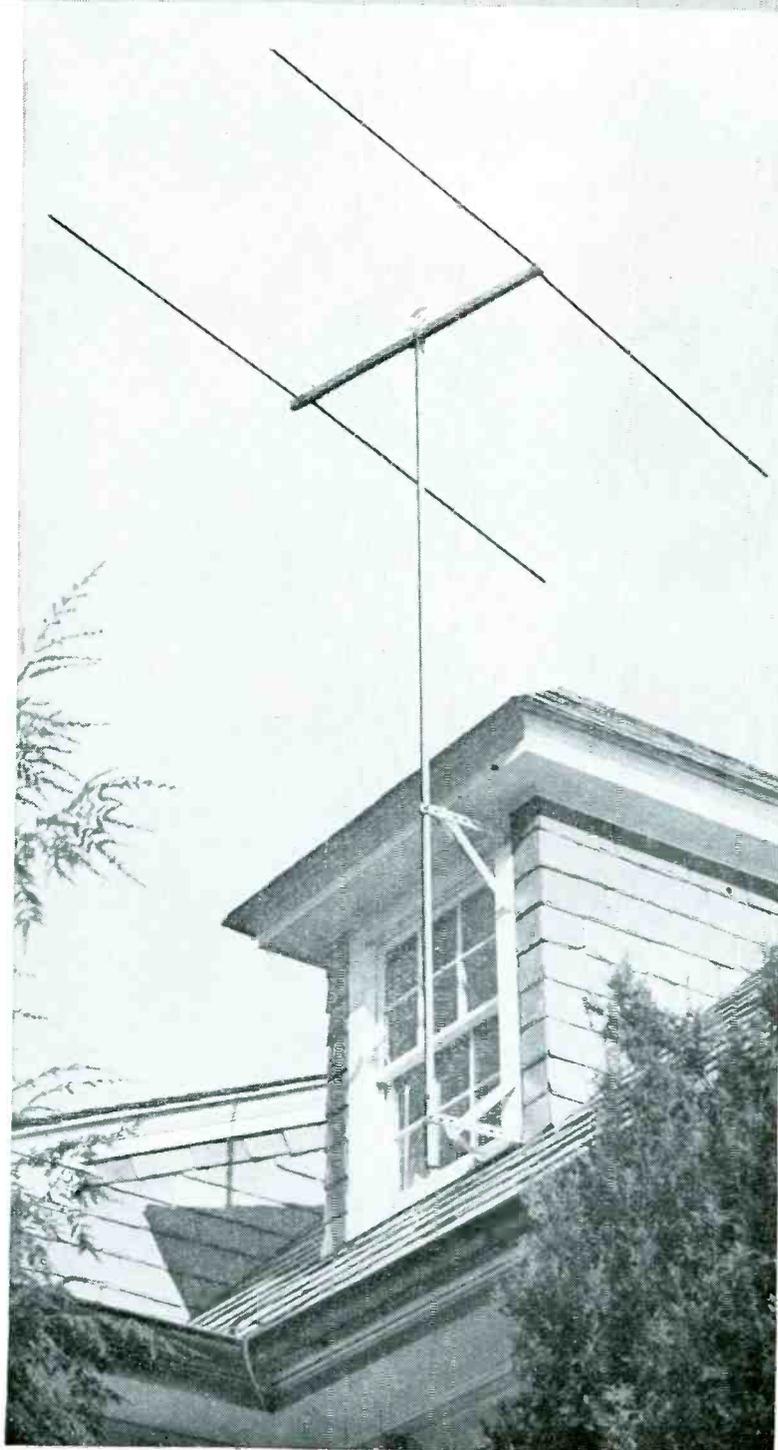
COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

230 Park Avenue, New York 17, New York

*Mills: Baltimore, Md.; Chicago, Ill.; Detroit, Mich.;
New Bedford, Mass.; Rome, N. Y.
Sales Offices in Principal Cities.*

*These are new temper designations effective January 1, 1948.
Formerly 61S-T6 was designated 61S-T and 61S-T4 was 61S-W.



RCA Television and FM receiving antenna, using Revere Aluminum Tube

**From this package
come the finest recordings
in the world**

Presto

GREEN LABEL DISCS

ALSO AVAILABLE—

Presto Brown Label discs. They're one-side perfect... with a flaw on the other side you probably couldn't find. Perfect for one-side recordings, reference recordings and tests, and at greatly reduced cost.

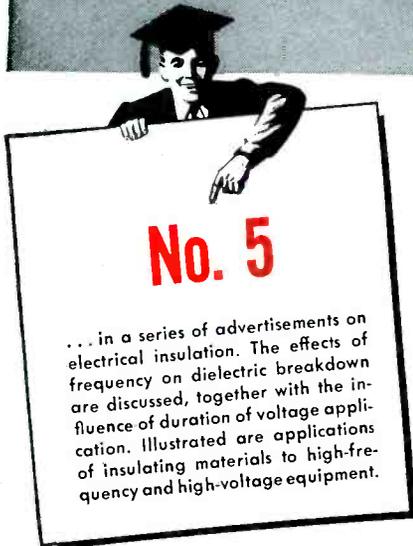
FREE! Presto will send you free of charge a complete bibliography of all technical and engineering articles on disc recording published since 1921. Send us a post card.



PRESTO

RECORDING CORPORATION
246 WEST 55TH STREET
NEW YORK 19, N. Y.

Frequency Effects Must Be Considered



In selecting electrical insulating materials, it is important to understand the effects of frequency on dielectric breakdown voltage. While present-day knowledge has not fully explained these effects (which are closely related to time, temperature and other conditioning factors) certain useful generalizations can be made.

DIELECTRIC STRENGTH vs. FREQUENCY

As a rule, an increase in frequency lowers breakdown voltages of electrical insulation, all other conditions being equal. The typical curve

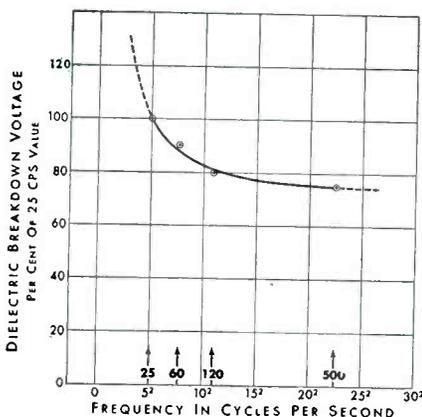


Figure 1: Effect of frequency on dielectric breakdown of transformer insulation. (Curve is based on findings of F. W. Peek)

in Figure 1 shows a sharp drop in breakdown voltage with increasing frequency gradually leveling off at higher frequencies. The rate of lowering of breakdown voltage varies from one insulating material to another.

Frequency effects are related to thermal effects. Through a given time interval, higher frequencies usually produce greater dielectric loss, though the loss per cycle may not be constant as frequency increases. The dielectric loss increases the temperature of the insulating material, which in turn lowers its dielectric strength.*

FREQUENCY AND DURATION OF APPLICATION

The time-voltage relationship in frequency effects is an important factor in dielectric breakdown.

As the time of voltage application is extended, for example, breakdown voltage is lowered. The curves in Figure 2 indicate that this drop is rapid for shorter time of application, then more gradual as duration of voltage application is extended.

Another illustration is afforded by the breakdown of insulation materials under impulse tests. Impulse breakdown voltage is higher than normal-frequency alternating-current breakdown for most insulation (see Table 1). The ratio of impulse breakdown to normal-frequency breakdown is called the "impulse ratio," and is greater than unity for most materials.

Comparisons of impulse breakdown with direct-current breakdown are inconclusive. Material thickness affects results, direct-current breakdown values being higher for thicker samples. Impulse tests of

comparatively long duration also give breakdown values lower than direct-current tests. Particularly useful information for comparing insulation materials is provided by impulse tests employing a standard

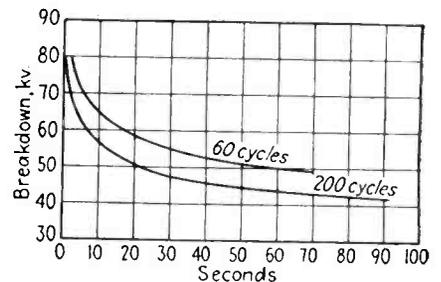


Figure 2: Effects of frequency and time. Press-board in oil at 25° C. (S. Whitehead)

impulse wave-form similar to that of lightning.

The factors of frequency, temperature and duration of voltage application are thus intimately related, and any evaluation of electrical insulating materials must be based on a knowledge of their combined effects.

*See advertisement No. 4 of this series.

Source	Crest Kv. per Mm.
Single impulse (equivalent to 200,000 cycles or 2.5 microsec. to crest) ...	108
D.c.	85
60 cycles (short-time)	53
60 cycles (1 min.)	46
90,000 cycles (1 min.)	17.6

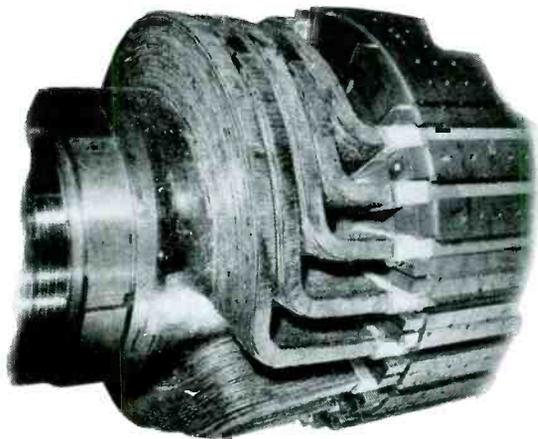
Table 1: Comparison of various voltage forms on the breakdown of two layers of varnished cloth, total thickness 0.60 mm. (F. W. Peek)



in Selecting Electrical Insulation

MICA INSULATOR PRODUCTS FOR HIGH-FREQUENCY AND HIGH-VOLTAGE REQUIREMENTS

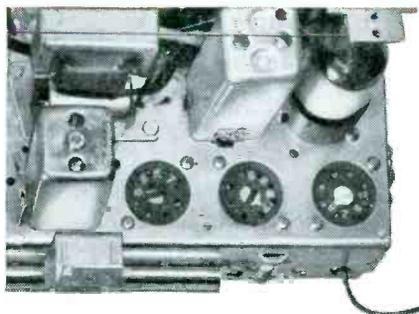
The successful performance of high-frequency and high-voltage equipment depends in large part upon the quality and properties of the electrical insulating material selected. The homogeneity, high dielectric strength and excellent physical properties of Mica Insulator Company products have contributed to unusual efficiency in many applications.



EMPIRE

Varnished Fiberglass Tapes, Micanite sheets and mica tapes are the materials used for coils and core insulation on the rotor for 43,750-kva, 13,800-volt, 80%-pf turbine generator. These materials provide dependable insulation that withstands dampness and high temperature and protects equipment against overload.

Experience counts in the selection of insulating materials for exacting applications. Mica Insulator Company has specialized in this field for more than fifty years, and has developed a complete line of electrical insulation to meet every requirement. Bring your insulation problems to our Technical Service Department for accurate and unbiased recommendations.



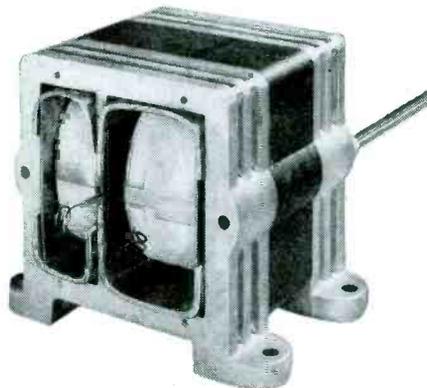
LAMICOID

tube socket bases provide strong mechanical support as well as the low dielectric loss and high dielectric strength characteristics well suited to the protection of electronic equipment. Lamicoid sheets, rods and tubes are used for many applications in radio and electronic equipment.



MICA

stampings, accurately punched for use as vacuum tube element separators, provide unusually high dielectric strength and temperature resistance for electronic and radio equipment. Mica is so basic an insulating material that it finds application in virtually every type of electrical and electronic equipment.



MICANITE

in transformers provides the extra margin of protection needed against surges or impulse voltages caused by lightning or switching. The exceptional dielectric strength of mica is secured in minimum space in a highly flexible plate which is easy to install, since it may readily be bent over small radii at room temperature.

Insulator COMPANY

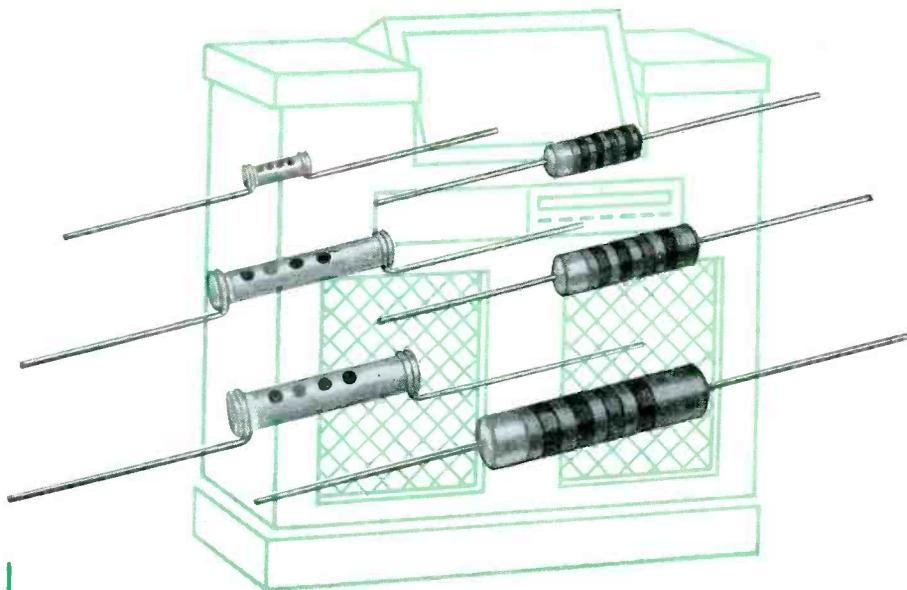
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Los Angeles • Milwaukee • New York • Philadelphia • Rochester • St. Louis • San Francisco



Trade-mark

Erie "GP" Ceramicons*



Going Places

... in FM and Television

The basic, simple construction of ERIE "GP" Ceramicons give them higher resonant frequencies, which make them the ideal condensers for FM and Television applications.

The same basic, simple construction makes possible the mass production which accounts for the surprisingly economical cost of high quality condensers. They are designed for practically all applications in which the condenser is not definitely frequency determining.

ERIE "GP" Ceramicons are not only cheaper to buy—they are cheaper to use than other types of condensers. Their wide range of adaptability reduces the number of condensers necessary to stock. Their compact tubular form and their sturdy construction make them easy to install on the assembly line.

ERIE "GP" Ceramicons are made in insulated styles in popular capacity values up to 5,000 MMF, and in non-insulated styles up to 10,000 MMF. If you are not already using them, write for detailed information.

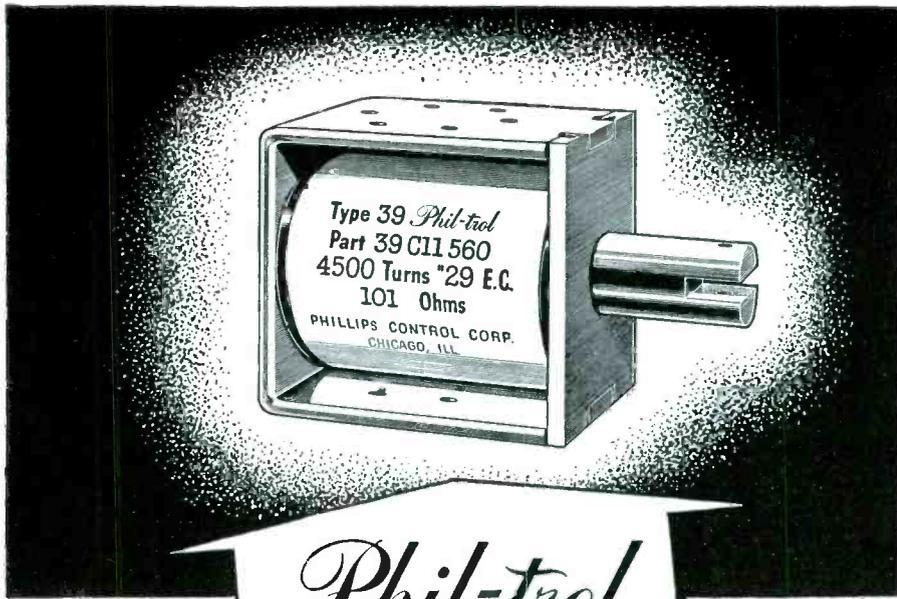


*Ceramicon is the registered trade name of silvered ceramic condensers made by Erie Resistor Corporation.

Electronics Division

ERIE RESISTOR CORP., ERIE, PA.

LONDON, ENGLAND • TORONTO, CANADA



Phil-trol

ACTUATORS

... Designed for POWER

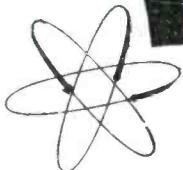
For maximum power, reliable operation and efficient performance, specify Phil-trol Actuators. Exclusive design features incorporated in one-piece solid frame construction make Phil-trol Actuators strong, durable units for a wide range of solenoid uses.

Outstanding construction features include: One-piece 1/8" iron frame, dovetailed and staked into end plate for a secure bond and extra strength; Plunger and plunger stops are made from specially processed steel and are available in three types of end shapes; Standard coils are fiber bobbins wound with enameled copper wire, and impregnated with insulating varnish; Entire frame and plunger stop are cadmium plated and plunger is chrome plated for smooth operation.

Five standard sized Phil-trol Actuators are available in either A. C. or D. C. desired voltage. Designed for "pull" application, they may be converted to "push" with but slight efficiency loss.

Phillips engineers, located in cities listed below, will be glad to assist you in determining solenoid requirements. Special Phil-trol Actuators are designed to specification.

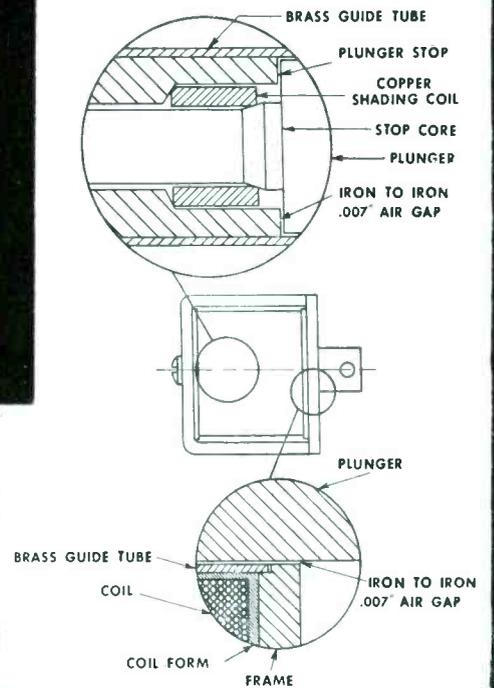
Send for Phil-trol Actuator Bulletin



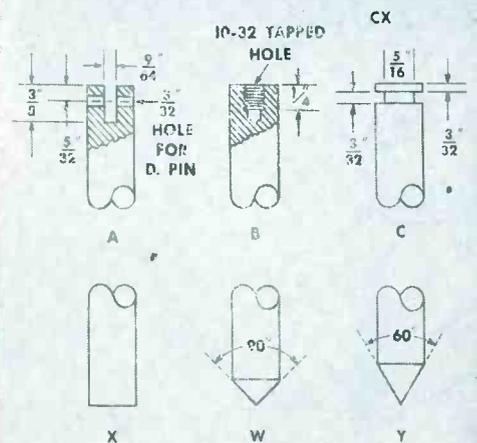
Phil-trol PRODUCTS

Relays, Actuators, Solenoids, Contactors, Starting Switches, Focus Coils, Ion Traps and Special Process Control Assemblies.

Phil-trol AC-DC END PLATE DESIGN AC PLUNGER STOP DESIGN



Phil-trol STANDARD PLUNGERS



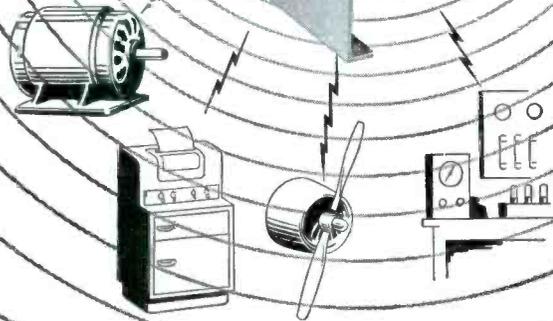
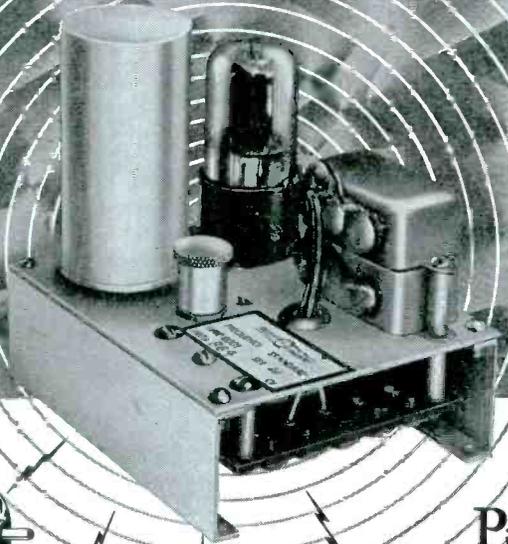
Type 27

Phil-trol RELAYS:

There is a complete line of Phil-trol Relays, all engineered to the highest standards, for electronic and industrial control, signal and traffic control, radio, communication, aircraft and other applications. Send for new Relay Catalog.

PHILLIPS CONTROL CORPORATION • 612 N. MICHIGAN AVENUE • CHICAGO 11, ILLINOIS
PLANT: Joliet, Illinois • SALES OFFICES: New York, Boston, Philadelphia, Buffalo, Cleveland, Charlotte, St. Louis, Kansas City, Los Angeles, Toronto

PICK A NUMBER
 ANY FREQUENCY FROM 10 TO 1,000



Pictured here is a tuning-fork frequency standard with accuracy guaranteed to one part per million per degree Centigrade. The fork is temperature-compensated and hermetically sealed against variations of barometric pressure. This standard, when combined with basic equipment, facilitates accurate speed and time control by mechanical, electrical, acoustical or optical means.

The unit is available separately or in conjunction with complete timing instruments. Our engineers are ready to cooperate on any problem.

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American Time Products, Inc.

580 Fifth Avenue

New York 19, N. Y.

OPERATING LINDER PATENTS OF THE WESTERN ELECTRIC COMPANY



NEW SEALED IGNITRON FOR RECTIFIERS UP TO 1,000 KW



- **400-amp continuous capacity at 300 v d-c.**
- **Will control voltage as well as convert power—through phase shifting of the ignition impulse.**
- **Cathode spot is stabilized during low-current intervals by an auxiliary anode.**
- **Two ignitors (only one is needed for ignition) protect against current-reversal accidents.**
- **Of standard stainless-steel-jacket ignitron construction, proved sturdy, efficient, and long-lived in thousands of installations.**

GENERAL ELECTRIC again breaks new ground in electronic-tube design with Type GL-5564/GL-507. This modern, big-capacity tube is right in step with today's march toward ignitrons for power rectification. Designed for the 125-, 250-, 600-, and 900-volt fields, it converts a-c power into controlled-voltage d-c for major applications such as:

- Mining equipment
- Electric railways
- Large industrial motors, or groups of smaller motors operating together, with variable-

voltage speed-control drive. Electro-chemical processes.

Wherever substantial amounts of d-c power are needed, check the advantages of Type GL-5564/GL-507, in rectifier banks up to 12 tubes with output up to 1,000 kw. No moving parts; no mechanical maintenance; long service life under exacting conditions... *economy!*

More detailed information gladly will be supplied to you on request. Phone your nearest G-E electronics office, or write *Electronics Department, General Electric Company, Schenectady 5, N. Y.*

GL-5564/GL-507

RATINGS

Max inverse and forward anode voltage	2,100 v	
Max anode current, amperes at	300 v d-c	600 v d-c
Instantaneous	3,600	2,400
Average:		
continuous	400	300
2-hour	600	450
1-minute	800	600
Surge (0.15 sec max)	25,000	19,000

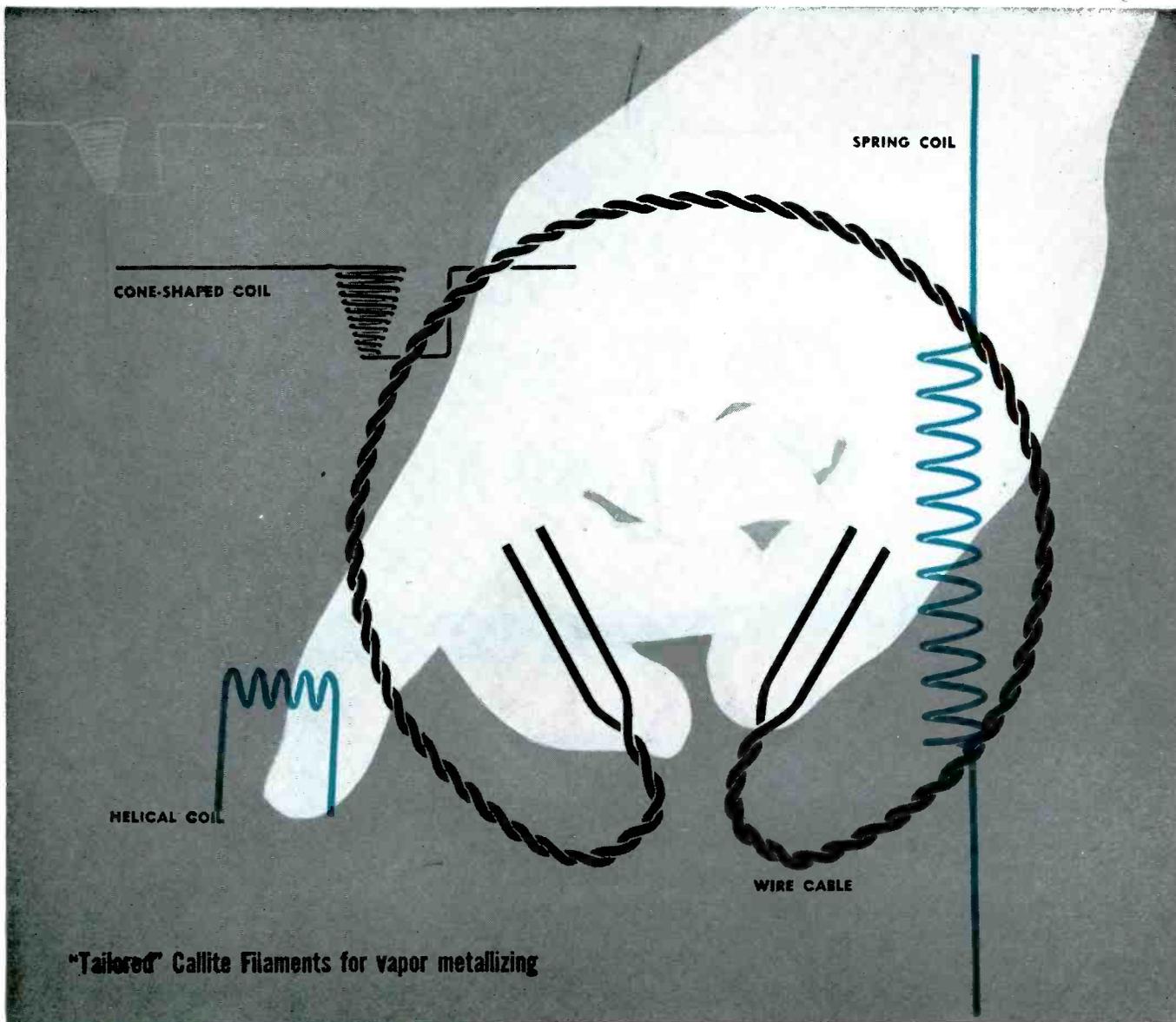
POWER-CONVERTER APPLICATION DATA

Kilowatt output at	No. of tubes	Circuit	
			300 v	600 v
400	750	6	Delta six-phase double-wye
500	1,000	6	Delta six-phase double-wye
750		12	Delta twelve-phase quadruple-zigzag
1,000		12	Delta twelve-phase quadruple-zigzag

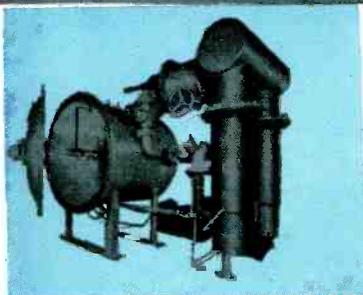
GENERAL ELECTRIC

161-026-0880

FIRST AND GREATEST NAME IN ELECTRONICS



"Tailored" Callite Filaments for vapor metallizing



another coating problem solved!

it's elementary...

when you use Callite heating elements to coat metals or plastics

Leading metallizers have discovered that Callite tungsten or molybdenum heating elements provide the simplest, quickest and most economical solution to their specific problem of coating materials by the vacuum evaporation process. Electrically heated, the filaments evaporate the coating metal — in pellets or wound on heater — and spread a smooth, uniform coat . . . often in a matter of seconds.

Let our many years of varied field experience help you, too, improve your metallizing operations. Skilled Callite engineers will gladly design special filaments — "tailor-made" to your specifications; to fit your current equipment; or to meet your production cost schedules. Prompt deliveries of all types. Callite Tungsten Corporation, 544 Thirty-ninth Street, Union City, New Jersey. Branch Offices: Chicago, Illinois; Cleveland, Ohio.

Callite

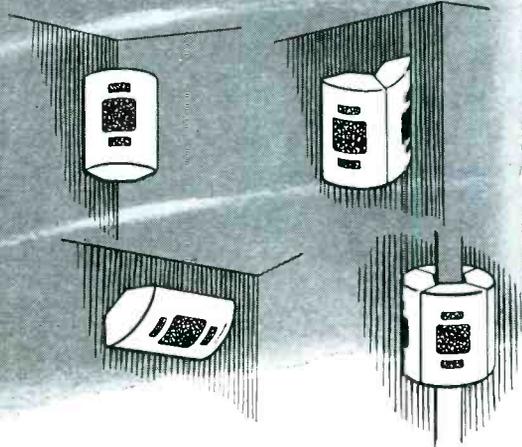
METALLURGY



Tungsten, molybdenum, silver, platinum, palladium and alloys of these metals. Callifex Thermostatic Bi-Metals; Callinite Facing Material. Bulletins on request.

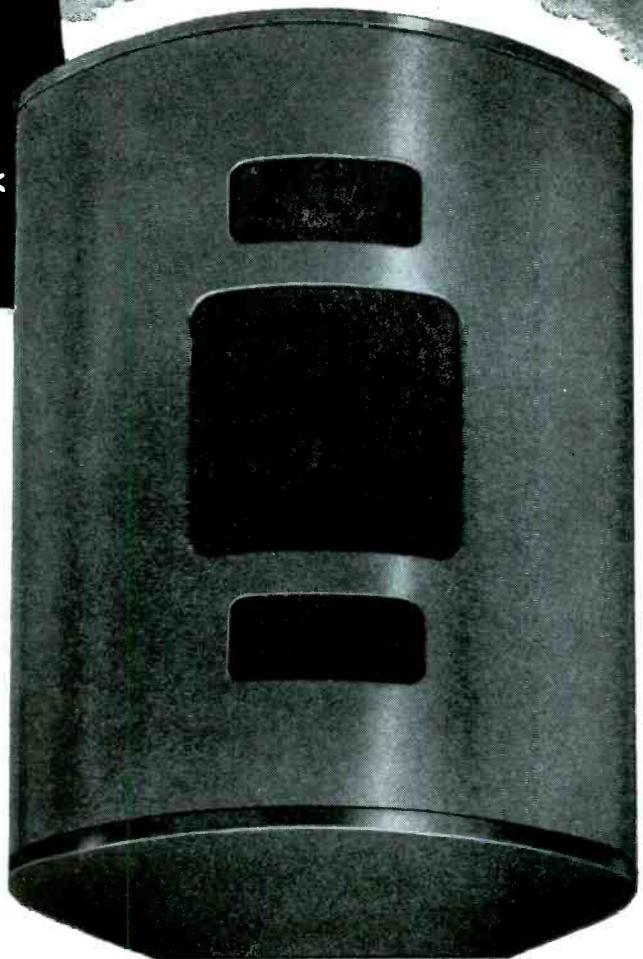
Jensen "SECTOR" CABINET WITH Bass Reflex*

for 8-inch Speakers



They fit anywhere — in 90-degree corners — flat on walls — or in clusters to give wide-angle distribution. Perfectly adapted for nearly all interior sound installations, because of their economy, small size and, above all, the high quality performance of JENSEN speakers in Bass Reflex enclosures. Use with any JENSEN 8-inch speaker. Model P8-SH is recommended for high fidelity as required by many wired music installations.

Type H Sector Cabinets are built around a frame of solid wood with wood composition replacing the conventional plywood panels.



Model H-81 Sector Cabinet (ST-141) List Price \$22.50

Finish is brown opaque lacquer although covering colors may be applied on the job if desirable to match environment. Size: Height 22½", width 17¾", depth 8½" Furnished with mounting brackets and screws.

JENSEN MANUFACTURING COMPANY
6607 South Laramie Avenue, Chicago 38

In Canada: Copper Wire Products, Ltd., 11 King St., W., Toronto

*Trade Mark Registered

OTHER Jensen CABINETS

BASS REFLEX



IMPERIAL TYPE D
D-151 (15-inch)
D-121 (12-inch)



UTILITY TYPE B
B-151 (15-inch)
B-121 (12-inch)
B-81 (8-inch)

PERI-DYNAMIC



WALL TYPE J
J-61 (6-inch)

Jensen

SPEAKERS
WITH ALNICO 5

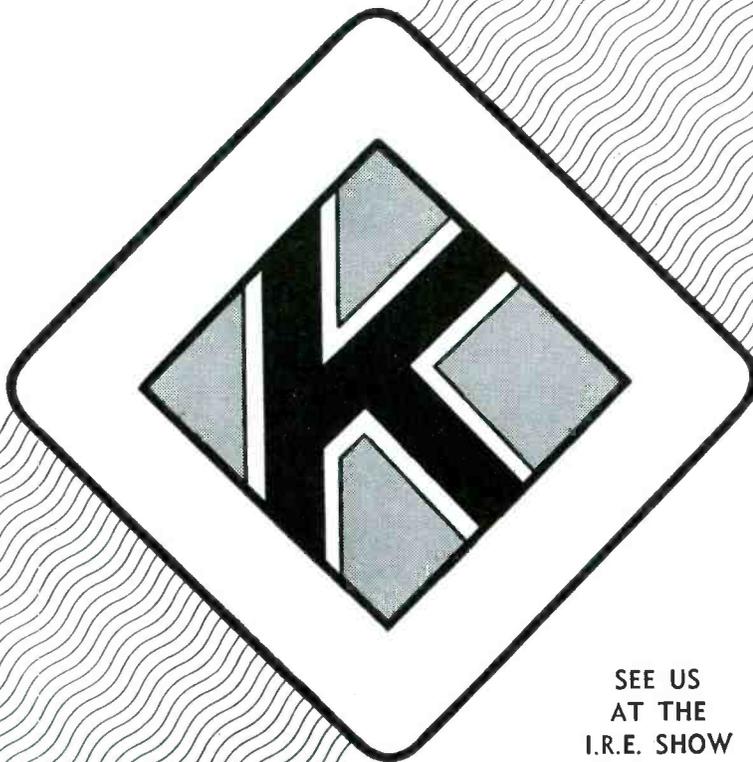


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of Fine Acoustic Equipment

Sign of Transformer Reliability

KENYON

For over 20 years, the KENYON "K" has been a sign of transformer reliability. Ever since the cat's-whisker, crystal-set days, KENYON has pioneered high quality transformers. Skillful engineering, progressive design and sound construction have resulted in dependable, conservatively-rated transformers with an enviable record for minimum field rejections. Cut engineering and replacement costs. Improve products. Insure repeat business. Specify KENYON!



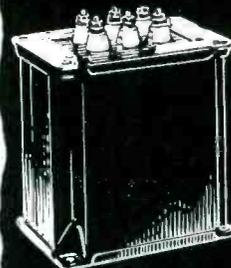
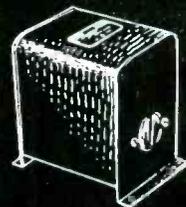
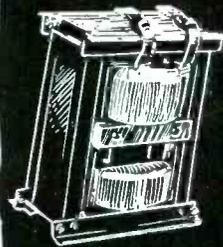
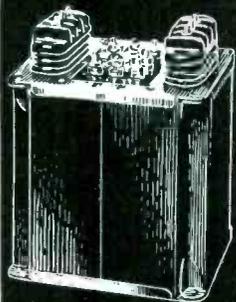
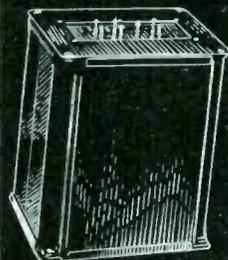
SEE US
AT THE
I.R.E. SHOW

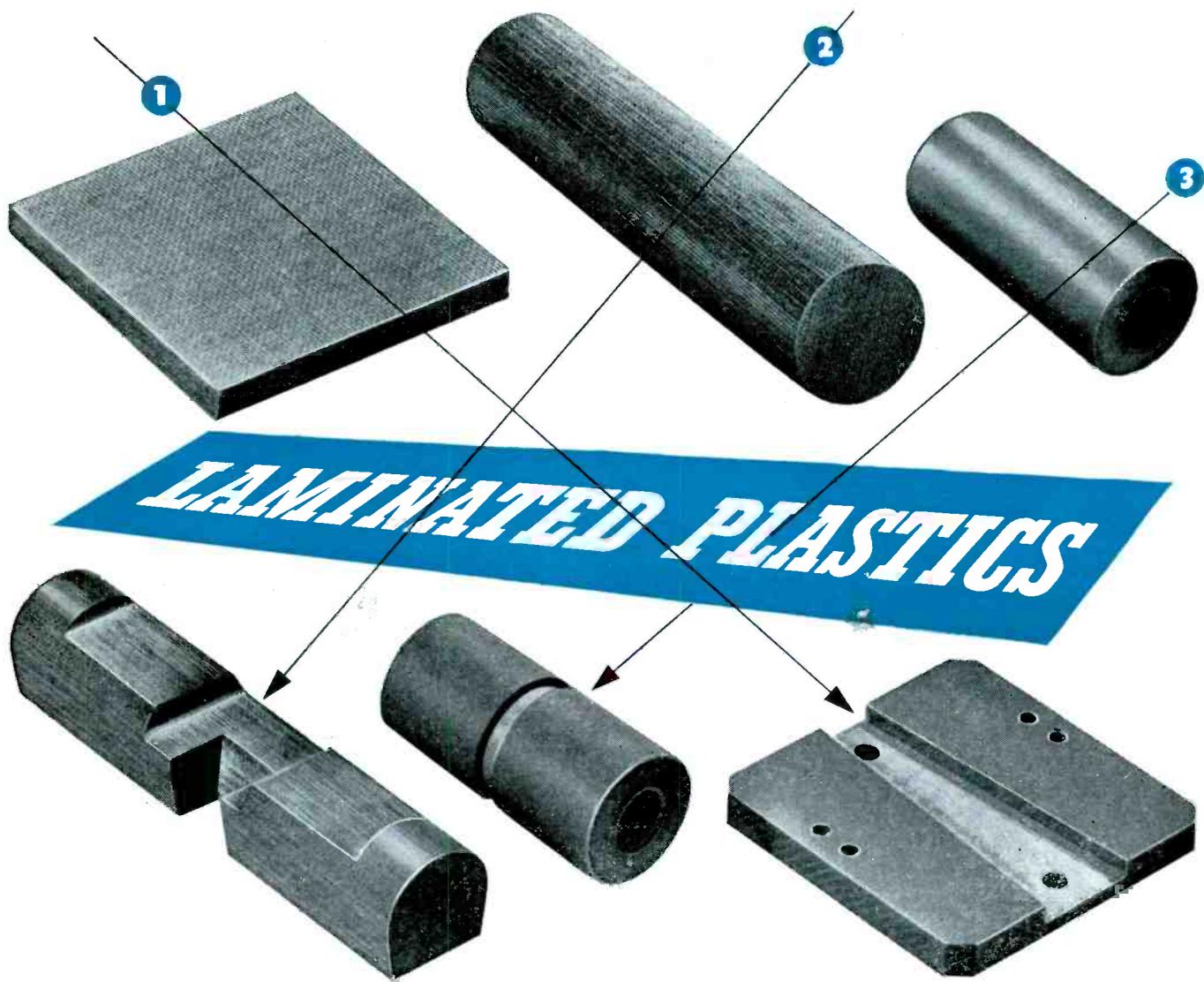
Consult KENYON

About Your Transformer Problems

KENYON TRANSFORMER CO., Inc.

840 BARRY STREET
NEW YORK 59, N. Y.





Thousands of Fabricated Parts from Taylor's Sheets, Rods, Tubes

1 Sawed, milled, and drilled piece, fabricated from fabric-base, Taylor Phenol Fibre sheet stock. Combines strength with good insulating qualities.

2 Part designed and machined using Taylor Phenol Fibre rod as the basic shape. Rods supplied either ground from sheet stock or molded.

3 Switch spacer, made from paper base grade of Taylor Phenol Fibre tubing. Fine machineability, dimensional stability, and electrical properties are characteristics of Taylor tubes. Supplied either rolled or molded.

From sheets, rods, and tubes of Phenol Fibre or Vulcanized Fibre, Taylor makes thousands of different fabricated parts, turning them out by the millions and doing it quickly, accurately, and economically.

Almost every one of these parts is specially designed for a special purpose and calls for a laminated plastic with special characteristics. Their common feature is light weight with great strength. In addition, they have insulating, electrical, and dielectrical properties unequalled by any other material.

Having been in this business for more than fifty years, Taylor also has a stock of standard tools for turning out such things as plain washers and shoulder bushings in so many different sizes that the chances are good that the size you need is in stock and your fabricated part can therefore be made more quickly and more inexpensively.

Whatever your problem, our engineers will gladly tell you, without obligation, exactly what Taylor Laminated Plastics can contribute to its solution. Write us today, sending sketch or blueprint.

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LAMINATED PLASTICS: PHENOL FIBRE • VULCANIZED FIBRE • Sheets, Rods, Tubes, and Fabricated Parts

NORRISTOWN, PENNSYLVANIA

Offices in Principal Cities

Pacific Coast Plant: LA VERNE, CALIFORNIA



Note the New Look in Power Transformers



Typical Motorola FM two-way radiotelephone receiver utilizing Sealed in Steel Chicago Transformers.

With CT's Famous Sealed in Steel Construction

The clean, streamlined appearance and compactness of CT's new *Sealed in Steel* construction contribute immeasurably to the trim, precision-like effect of any electronic equipment.

In addition, CT Transformers provide "steel wall" protection against atmospheric moisture, efficient magnetic and electro-static shielding, unsurpassed strength and rigidity to withstand shock and vibration, and unusual convenience of mounting.

Two base styles are available for most of the units in this catalog line, one with clearly identified solder lugs in a phenolic terminal board, the other with RMA color coded leads, stripped and tinned for easy soldering.

The design of these new power transformers assures maximum performance with minimum physical size and minimum temperature rise in accordance with RMA standards.

The wide range of carefully selected ratings achieves maximum flexibility of application, close matching with today's preferred types of tubes, and conformance with all industry standards.

Write direct for catalog illustrating, describing and listing the complete line, or contact your nearest radio parts jobber at once.

PLATE AND FILAMENT SUPPLY TRANSFORMERS

Primary 117 Volts, 50-60 Cycles

Catalog Number	For CAPACITOR INPUT SYSTEMS					
	HIGH VOLTAGE SECONDARY			FILAMENTS		
	A.C. Volts	D.C. Ma.	D.C. Volts Output	Rectifier Volts Amps.	No. 1 Volts Amps.	No. 2 Volts Amps.
PC-55	270-0-270	55	260	5 2	6.3CT 2	.....
PC-70	335-0-335	70	320	5 2	6.3CT 3	.....
PC-85	330-0-330	85	320	5 2	6.3CT 3	.....
PC-105	345-0-345	105	320	5 2	6.3CT 3.5	.....
PC-120	375-0-375	120	380	5 3	6.3CT 4	.....
PC-150	370-0-370	150	390	5 3	6.3CT 4	6.3CT 1
PC-200	385-0-385	200	390	5 3	6.3CT 4.5	6.3CT 1
For REACTOR INPUT SYSTEMS						
PR-55	350-0-350	55	260	5 2	6.3CT 2	.....
PR-70	425-0-425	70	320	5 2	6.3CT 3	.....
PR-85	440-0-440	85	325	5 2	6.3CT 3	.....
PR-105	445-0-445	105	325	5 2	6.3CT 3.5	.....
PR-120	500-0-500	120	400	5 3	6.3CT 4	.....
PR-150	505-0-505	150	400	5 3	6.3CT 4	6.3CT 1
PR-200	520-0-520	200	410	5 3	6.3CT 4.5	6.3CT 1
PR-300	550-370-75-0 -75-370-550	300	425	5 6	6.3CT 5	6.3CT 1

Also available in the *Sealed in Steel* constructions:

FILTER REACTORS with current ratings to match power transformers above.
FILAMENT TRANSFORMERS to meet a wide range of modern tube requirements.

AUDIO TRANSFORMERS—Input, Output, Driver, and Modulation—that provide uniformly high fidelity response in three frequency ranges: 30-15,000 cycles, 50-10,000 cycles, and 200-3,500 cycles.

CHICAGO TRANSFORMER

DIVISION OF ESSEX WIRE CORPORATION

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“What a lucky man I am to have this free G. A. & F. booklet! Now I know that SF Carbonyl Iron Powder is perfect for permeability tuning of the FM band. That it gives remarkably low loss and uniformity. What’s more, this same SF powder is ideal for adjusting television circuits. Imagine!”



FREE! This easy-to-read booklet that can save money — *real* money — for every radio engineer and electronics manufacturer!

Ask your core manufacturer — he’s an authority on the use of G. A. & F. Carbonyl Iron Powders.

*®



G. A. & F.

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General Aniline & Film Corporation

Clip this coupon — Mail it today!

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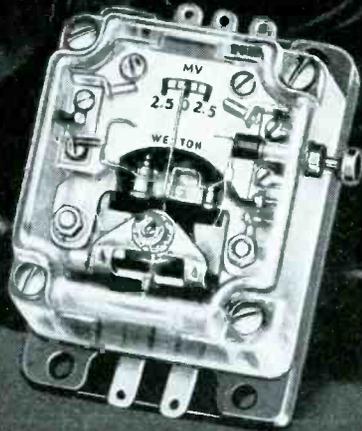
Please send me a free copy of:

G. A. & F. Carbonyl Iron Powders Polecron dielectrics

Name _____

Address _____

TINY... BUT SO SENSITIVE... SO TOUGH!



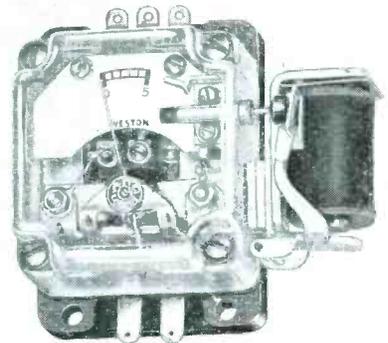
This **WESTON** [MODEL 813] * *Sensitrol Relay*

- provides positive control on 2 microamperes
- handles up to 50 milliamperes at 120 volts AC or DC
- resists extreme shock and vibration

Here is a sensitive relay whose unique characteristics stir the imagination... suggesting to design engineers vast possibilities for *new* product development, and for simplification and improvement

of existing products. To assist in their proper application, consult our representatives, or write... WESTON Electrical Instrument Corporation, 618 Frelinghuysen Ave., Newark 5, New Jersey.

* SENSITROL—A registered trade-mark designating the contact-making instruments and relays, as manufactured exclusively by the Weston Electrical Instrument Corporation.



Solenoid reset type (illustrated directly above) or manual reset types available.

WESTON *Instruments*

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For Truly Fine Recording and Reproduction



Professional Recordists Use—
Professional Recordists Recommend—

audiopoints*

THE NEWLY EXPANDED LINE of Audiopoints now covers the full range of recording and playback needs. There are Audiopoints that fully meet the requirements of the most exacting professional recordists. There are also Audiopoints which these engineers unhesitatingly recommend to the non-professional and the general public.

RECORDING AUDIOPOINTS

Sapphire #14. Long recognized by recording engineers as the best recording stylus obtainable. Manufactured to rigid specifications. Discussed on a recording machine just before packaging. List price **\$7.25.**

Sapphire #202. A fine quality brass shank stylus, ideally suited for those recordists not requiring the super quality of Sapphire Audiopoint #14. List price **\$5.25.**

Stellite #34. Favorite with many professional and non-professional recordists. Though moderately priced, it is the very best stellite stylus produced. List price **\$1.75.**

Diamond-Lapped Steel #50. Most practical stylus for home recordists when "first cost" is important. Being diamond-lapped, it cuts a quiet, shiny groove. List price **3 for \$1.00.**

PLAYBACK AUDIOPOINTS

Sapphire #113. Materials, workmanship and design make this playback point the finest made for original recordings and vinyl transcriptions. For years the outstanding choice of professional recordists. List price **\$6.50.**

"Red Circle" Sapphire #103. With straight dural shank and fine polished jewel point. Excellent for original recordings, vinyl pressings and phonograph records. List price **\$2.00.**

"Red Circle" Sapphire #303. Bent dural shank sapphire needle that is tops for phonograph records. *For the first time a phonograph needle with a resharpening feature.* List price **\$2.00.**

Steel Transcription Needle #151. The ideal all-purpose transcription needle for original recordings, vinyl pressings and phonograph records. Quality performance is assured since each point undergoes a shadow-graph test. List price **20 for 25¢.**

³Reg. U. S. Pat. Off.

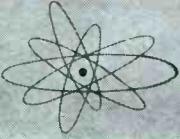
RESHARPENING SERVICE

Established years ago, our resharpening service gives real economy in the use of Audiopoints #14, #202, #34, #113, #103 and #303.

Write for new dealer discounts and our folder "Audiopoints."

Audiopoints are a product of the manufacturers of Audiodiscs.

AUDIO DEVICES, INC., 444 Madison Ave., New York 22, N. Y.

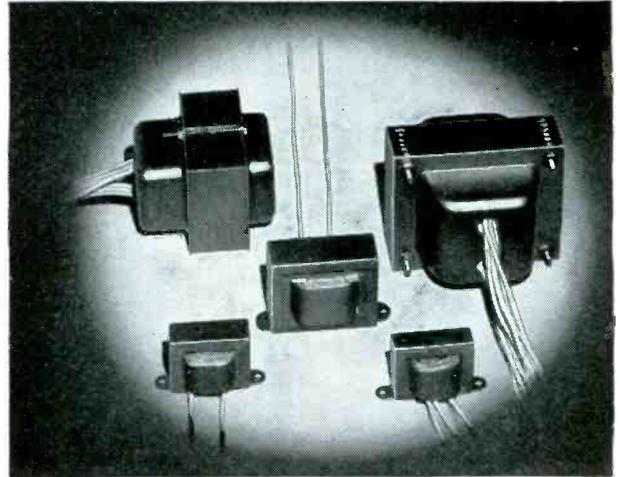


Designers

Television Transformers...tailored to your needs

1. Line supply voltage and frequency
2. High voltage d-c required
3. D-c milliamperes required
4. Filament volts and amperes
5. Sub-panel or above-panel mounting
6. Description of rectifier circuit
7. Winding insulation voltage required
8. Maximum ambient temperature

TELL US THESE **WE SHIP THESE**

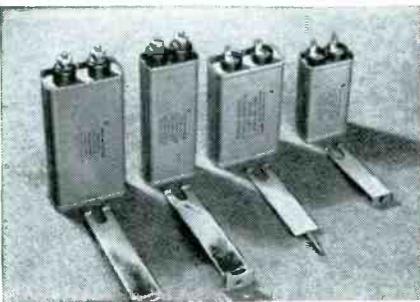


Whatever your transformer needs—power units like these, or special designs for deflection yokes, horizontal or vertical sweeps, or oscillators—General Electric can supply them . . . and quickly. G.E. offers its facilities and engineering

“know-how” to television manufacturers in tailoring these transformers to their requirements. Just tell us your specifications and we will meet them to your complete satisfaction. Power-supply transformers are available now in core-

and-coil and enclosed-case styles as standard units designed for television applications. Units for other uses are tailor-made from standard parts. Ask your G-E representative for more information; you'll be pleased with the prices and shipments he will offer you.

NEW PYRANOL CAPACITORS SAVE SPACE, WEIGHT, MONEY



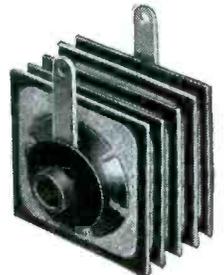
If you have been using 600-volt d-c capacitors on circuits rated 400 volts or less, you're in for a substantial saving in weight, size and cost by specifying General Elec-

tric's new 400-volt Pyranol units. Compared with 600-volt ratings, these new, standard, 400-volt capacitors will save you from 24 to 51 per cent in volume, 23 to 33 per cent in weight, and approximately 10 per cent in cost. They are available in 2-, 4-, 6-, 8- and 10-muf ratings with solder-lug or screw-thread terminals optional on the four larger sizes; the 2-muf size comes with solder-lug terminals only.

New developments, such as silicones and new paper, are continually improving the quality of G-E capacitors. They also permit our engineers to handle your new requirements to your complete satisfaction. Write for quotation on any

capacitor needs, or check Bulletin GEA-2621 for more information on the new d-c line described above.

NEW, SMALLER SELENIUM RECTIFIER



This new General Electric selenium rectifier, less than one inch long and one inch square, is available now for receiver and other elec-

GENERAL ELECTRIC

Digest

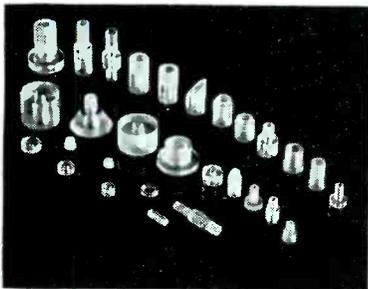
TIMELY HIGHLIGHTS ON G-E COMPONENTS



tronic applications. It costs little and mounts in places where a rectifier tube and socket won't fit. Tests prove that this new selenium rectifier will outlast several 117-volt rectifier tubes. Installation is easier too—only two soldering operations and a minimum of mounting hardware are required.

These rectifiers have an exceptionally high inverse-peak rating, and the inverse current is extremely low even with peak voltages up to 350 volts. At rated current output, the forward drop is five volts or less. Ratings are based on ambients of 50 to 60 C. Check Bulletin 21-127 for more information on this and other General Electric radio rectifiers.

NEW MACHINABLE PLASTIC FOR UHF INSULATION

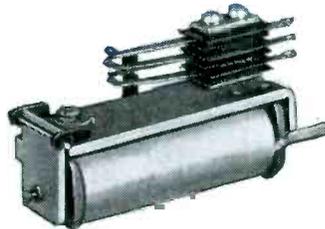


A new arrival in the plastics insulator field is G-E No. 1422, which offers characteristics of advantage in the manufacture of ultra-high-frequency equipment, television, FM, radar, and radio sets, and many other electronic applications. Possessing a dielectric constant of 2.5 to 2.6 with a power factor of .0006 to .0009 at 3000 mc, G-E No. 1422 exhibits unusual heat resistance and excellent machinability.

Indicative of its machinability is the industrial production of r-f con-

ductor beads from G-E No. 1422 on automatic and semi-automatic screw machines. As a low-loss dielectric in the hands of the electric-equipment designer, it affords an excellent low-cost means of producing experimental models and small production quantities through the use of standard machine shop tools. Check coupon for technical report.

HANDLES 12 CIRCUITS SIMULTANEOUSLY



This new telephone-type relay is capable of handling as many as 12 circuits in a wide variety of contact combinations. Designed for multi-purpose use in industrial electronic apparatus, communications and signaling equipment, these devices have service lives measured in millions of operations. Working from five basic contact arrangements, combinations can be stacked to satisfy intricate circuit switching requirements. Silver, palladium, or tungsten contacts can be supplied; the choice depends on rating and life specifications.

More than 500 different coils are available, with ratings ranging

from 1 to 250 volts, and 0.1 to 26,000 ohms. This varied selection of coil ratings makes it possible to match closely the coil voltage and resistance with the rating of the energizing circuits. Check Bulletin GEA-4859 for full details.

TO MEASURE TUBE LIFE



Now available for immediate delivery, General Electric Type KT time meters are ideal for inclusion in transmitters and other electronic equipment where knowledge of tube "on time" is important. They can record operating time in hours, tenths of hours, or minutes, and are built in four forms: round or square for panel mounting, portable with attached base, or for conduit mounting. Those designed for panel mounting are housed in small Textolite cases that harmonize with other panel devices.

Telechron motor drive assures an accurate record of tube operation over a long period of time. They can also be used on electronic production tools, such as resistance welders, to keep an accurate record of machine operating time. Researchers use them for measuring time intervals, verifying circuit operation, and life testing. Bulletins GEA-3299 and GEA-1574 have full details.

GENERAL ELECTRIC COMPANY, Section F-642-16
Apparatus Department, Schenectady 5, N. Y.

Please send me:

- | | | |
|-----------------------------------|------------------------|--|
| <input type="checkbox"/> GEA-2621 | } 400-v D-c Capacitors | <input type="checkbox"/> 21-127 Selenium Rectifier |
| <input type="checkbox"/> GEA-3299 | | <input type="checkbox"/> GEA-4859 Telephone-type Relay |
| <input type="checkbox"/> GEA-1574 | | Report on G-E No. 1422 Plastic |

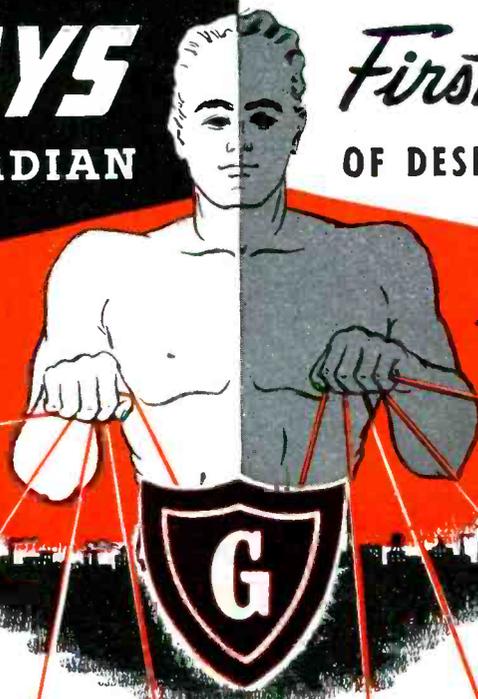
NOTE: More data available in Sweets' File for Product Designers.

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First Choice
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Series R Stepper

Three basic types of A. C. and D. C. operation: continuous rotation, add and subtract, electrical reset. First two types have 40 active positions, electrical reset has 36 contacts. All three types follow 10 pulses per second with in rated voltage range.



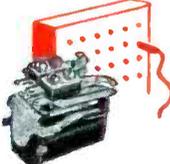
Series A-300 Relay

Designed for low loss antenna change-over. Straight line position of screw terminals and contact springs maintains equal spacing thru relay from transmission line to transmitter. Reduces impedance mismatch to minimum.



T-110 Time Delay

Provides delayed operation from 10 to 60 seconds using a resistance wound bi-metal strip. In radio it prevents damage to rectifiers and tube filaments by retarding plate current until tubes are sufficiently heated. Used widely in industry to change circuits after a predetermined interval.



Series 595 D. C. Relay

Midget telephone type unusual for amount of power provided. Size only 1 7/16" x 1 3/8" x 1". Three outstanding features—frictionless pivot—proper copper-iron balance—capacity to carry up to 8 single pole, single throw contact combinations.



Series 220 A. C. Relay

Capable of breaking currents up to 20 amps at 230 v., 60 c., A. C., non-inductive load. Bakelite contact block tests 1500 v. breakdown to ground. 5/16" dual contacts minimize arcing.



Series 600 Relay

Small, compact, low cost. Size: 2 1/8" x 1 1/2" x 1 1/8". Contact combinations up to 4 P. D. T. Power consumption, 6 V. A. Max. cap., 8 amps, 3 v. to 230 v. A. C., or 3 v. to 110 v. D. C. Coil and contact assemblies interchangeable.



Series 100 A. C. Relay

Used successfully in automatic home washing machines. It is incorporated in many new household appliances now on drafting boards.



Series 12 A. C. Solenoid

For intermittent and continuous duty. Rated at 6 v. to 230 v., 60 c., A. C. Stroke ranges from 1/8" up to 7/8". Series 6 D. C. rated 6 v. to 230 v. Stroke 1/8" up to 2".

Faced with responsibilities for the design and successful performance of their companies' products, American design engineers are eagerly turning to Guardian Electric first for relays and complete control assemblies. They find at Guardian a vast wealth of application and performance data, an expert engineering staff with more than a decade of specialized experience solving the most complex and widely diversified control problems. Such experience offers design engineers an *extra bonus value* thru practical suggestions and valuable specific recommendations given without cost or any obligation. Should your design call for a "special" control, Guardian has probably built the self-same principle you seek into one of its large line of *basic type* units. When such a *basic type* unit becomes the "special" you need thru slight variations, the savings in time and money are substantial, you circumvent die costs and beat delivery schedules in the bargain! Should special engineering be required, our staff is at your disposal. Write — call on Guardian for these excellent controls designed by Guardian engineers for engineers. Expert advice is yours for the asking to help you design better products thru improved techniques which are now so vital to meet competition.

GUARDIAN  **ELECTRIC**

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A COMPLETE LINE OF RELAYS SERVING AMERICAN INDUSTRY

1949 —

Can Be a Good Year Too

You can expect good business to run on well through 1948.

But old-time competition is close upon us.

And 1949 will be a critical year for all of us — making lower taxation imperative NOW.

These are the main conclusions drawn from a nation-wide survey of industry's plans for new plants and equipment which McGraw-Hill has just completed. Here are the major findings:

1. Capital expenditures in 1948 may be a little lower — but at the most only 8% lower — than in 1947.
2. In 1949 capital expenditures may decline. 1949 plans are still fluid. However, those which have been projected now show a falling off. (Washington planners, please note: Current official attempts to discourage capital expansion may turn out to be superfluous — or downright dangerous.)
3. Industry's initial postwar rebuilding will be 85% complete at the end of 1948. When this first wave of deferred maintenance and expansion is finished, American industry will have more than half again the capacity it had in 1939. This does not mean the end of needed capital expenditures. Business will need to invest much more. (President Truman sets an investment goal immediately ahead of \$50 billion.) But it does mean that tough competition is returning fast.

• IF YOU WANT full details of the McGraw-Hill survey of Capital Expenditures, which is summarized in this editorial, write to the Economics Department, McGraw-Hill Publishing Company, 330 West 42nd Street, New York 18, N.Y.

These are solid facts, based on plans which are firmly made by a broad cross-section of American industry and which the McGraw-Hill survey revealed.

The greatest contribution of this survey is the information it supplies on business plans for the purchase of new plants and equipment. What business planned to do about such expenditures was by far the biggest unknown element in the 1948 outlook. For, if business planned to slash its outlays for plants and equipment this year, that fact alone could bring a sharp downturn in business.

In making this survey, McGraw-Hill researchers all over the nation personally interviewed top executives of companies selected to make up a scientific cross-section of industry. Each executive was asked to give, *not his opinion* about general business trends, but *factual details* about his company's plans for 1948. By adding together the plans of the companies interviewed, McGraw-Hill has secured, for the first time, a reliable picture of what business plans to do in the months ahead.

Here are plans for 1948 and 1949, as revealed by the survey:

1. Industry still needs more than a year to finish its initial postwar maintenance and rehabilitation program.

Among manufacturing industries, top executives report that 64% of their program for the immediate postwar period is now complete. According to present plans, 85% will be installed by the end of this year even though some manufacturing industries still have a long way to go. For instance, oil companies will complete only three-quarters of their presently planned expansion program by the end of 1948.

2. Business may spend less on new plants and equipment this year than the record \$16.1 billion spent last year. But the decline

probably will be negligible and certainly will not be great enough to bring on a business recession.

At the time McGraw-Hill interviewed top executives, some companies had not yet approved their 1948 capital budgets. Under the extreme assumption that those particular companies will make no capital expenditures in 1948, industry's 1948 bill for new plants and equipment will run to \$14.9 billion, or 8% below last year's record figure. Under the more realistic assumption that those companies will cut their capital investment only as much as the companies which had already drawn up their plans for 1948, industry's 1948 capital budget will run to almost \$15.8 billion, a decline of only \$300 million from 1947.

Thus the over-all conclusion of the McGraw-Hill survey is that capital expenditures by business will be only slightly lower this year than last.

3. Business executives will not slash their 1948 capital budgets unless they are convinced that a real slump is in the offing — and they are not convinced now.

Almost two-thirds of all manufacturing companies say they would not cut capital budgets sharply even if business activity declined 20%. What is more, even a 15-20% boost in wage rates would have little effect on projected capital budgets. If wages go up, 57% of manufacturing companies would not change their capital budgets, 26% would increase them, and 17% would cut them.

4. Most executives look for an increase in their company's sales this year.

More than half of all manufacturing companies are planning on a sales increase over last year of 10% or more. A third of them say sales will be about the same as in 1947. And fewer than 10% look for lower sales.

5. Manufacturing companies will finance much of their purchases of new plants and equipment in 1948 from funds set aside out of past or current earnings.

Utilities and railroads, on the other hand, must go to the securities markets or commercial banks to finance most capital expenditures.

Although manufacturing companies say they can

finance this year's capital expenditures in large part from current profits and past savings, all evidence indicates that, to do so, they will use up most of the funds they earmarked during the war for this purpose. So in 1949, industry must go to the capital markets or to the commercial banks if it is to continue to spend for capital purposes. If the securities markets continue to lie in the doldrums, *as they will under present tax laws*, only companies with triple A credit ratings will be able to raise funds that way.

6. Purchases of new plants and equipment may fall off in 1949.

The McGraw-Hill survey collected all available evidence on plans for 1949 capital budgets. Fewer than 40% of all manufacturing companies now have definite plans for 1949. Of those that have plans, 45% intend to spend less than in 1948, 30% plan to spend the same amount, and a quarter expect to spend more. These preliminary decisions would seem to indicate that capital investment may fall off in 1949.

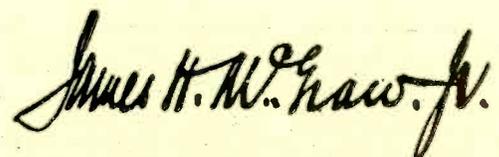
7. Industry's production capacity in 1949 will be far above prewar.

Manufacturing capacity will be more than 50% greater than in 1939 once the present wave of postwar building is complete. Almost a third of all manufacturing companies report that their capacity will be double or more than double the prewar figure. Thus, 1949 may see a huge increase in production of many things that now are hard to buy.

The last two points in this summary mean that 1949 will be a critical year. We must forestall a sudden drying up of capital expenditures in that year. We must be able also to absorb a great outpouring of production both of capital and consumer goods.

What will happen to business in 1949, therefore, will depend on how successful we are this year in dealing with such momentous problems as taxation, foreign aid and prices. But 1949 *can* be a good year too.

The next editorial in this series will discuss the pivotal problem of taxes.



President, McGraw-Hill Publishing Company, Inc.

Anyone can make accurate SOUND LEVEL TESTS...



...with this dependable, portable

Western Electric Sound Level Meter

THIS instrument—available in a-c line or battery operated models—is small and light, simple to operate, ruggedly built, adaptable to many noise measuring problems. And it's modestly priced!

The Western Electric Sound Level Meter has built-in calibration circuits to permit rapid, accurate adjustment to A.S.A. standard reference levels. Negative feedback in the amplifier contributes to utmost stability.

The frequency range of this meter is 20 to 10,000 cps. It can be used alone—or in conjunction with an associated Filter Set which enables the meter to measure sound in selected frequency bands between 50 and 4800 cycles.

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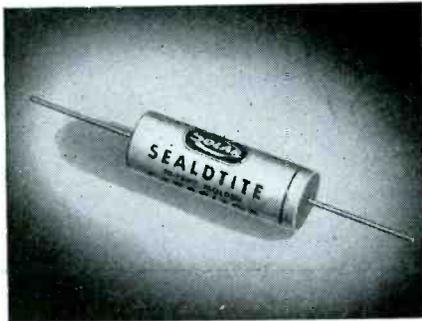
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ALL-PURPOSE HI-TEMP SEALDTITE* TUBULARS



Sealdtite Capacitors, the molded tubulars first pioneered by Solar in 1939, are now truly all-purpose capacitors. The recent introduction of a new Hi-Temp molded jacket makes Sealdtite Capacitors a universal choice for both automobile and home radio applications.

More than a year's field trials of over 5,000,000 Hi-Temp molded Sealdtites in automobile and export receiver applications have proven the superior quality of this latest Solar development in the capacitor art.

Securely sealed against atmospheric moisture by a tough molded armor, Sealdtite Capacitors maintain their exceptionally high insulation resistance throughout their extremely long life. Unlike conventional tubulars, Sealdtites have no cardboard tubes to grow soggy, or internal voids to collect moisture.

Hi-Temp Sealdtite Capacitors have attractive labels in bold, easy-to-read type. Their smooth surface attracts no dust and drips no wax.

Hi-Temp Sealdtite tubulars are available with either Halowax-impregnated or mineral-oil impregnated sections to fit your application requirements. Eleven mold sizes make for maximum space economy. Complete dimensions for standard ratings are given in Catalog Bulletin SPD-200.

All-purpose Sealdtite Capacitors are available for prompt delivery at no increase in price.

Investigate today!

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★ Trade Mark



BUSINESS BRIEFS

By W. W. MacDONALD

Buyers' Guide Issue idea hinted at on p 69, February, has now jelled. We are going to include a special editorial section giving the electrical, mechanical and other characteristics of materials important to designers of electronic equipment and the components used in such gear.

Included will be such things as *insulating materials, plastics, ceramics, glass, metals, magnetic materials, chemicals, gases, radioactive materials, crystals, acoustic materials, and finishes.*

The special issue will reach readers around the middle of June, between the times they receive the regular June and July numbers.

Take A Piece Of Paper, sandwich it between a thin sheet of Lucite and a similar sheet of celluloid. Place sandwich on insulated surface and rub hard with dry cloth. Flip sandwich over.

Remove top sheet. Dip small, pointed artist's brush in nonconducting dye. Hold tip of brush an inch above paper and write in the air. You will find that static electricity attracts the dye to the paper in a fine spray and that what you have written in the air appears on the paper, much as if it had been written with a pen.

Here's a principle that appears to have many important applications, particularly in the publishing and textile industries. We're on top of it, watching completion of a demonstration machine and awaiting erection of a pilot plant. When these are ready there'll be technical details in our feature pages, probably sometime this summer.

Tea Would Taste Better in restaurants if the water used to make it was brought to precisely the right temperature during preparation. But it is hard to maintain water at this temperature with existing equipment.

The Tea Association thinks the problem might be solved by designing 10 or 15-cup commercial units employing electronic heating

to bring water up to the proper temperature in a matter of seconds. We ourselves suspect that electrical rather than electronic heating might provide the answer, but if any of you out there feel differently and want to take a fling at the job, write committee chairman George N. Wicc at the National Urn Bag Company, 3408 Northern Boulevard, Long Island City 1, N. Y.

FCC Licenses, at the end of 1947, were as follows:

Broadcast Stations	
A-M	1,962
F-M	1,010
Remote Pickup	590
TV (exp.)	91
TV	73
Educational	40
International	37
Other	31
3,834	
Non-Broadcast Stations	
Amateur	75,000
Aeronautical	20,818
Marine	14,254
Public Safety	4,653
Land Transportation	2,447
Industrial	2,028
Miscellaneous	1,307
120,507	

Licensed radio operators were listed as follows:

Commercial	341,000
Amateur	81,000
Special Aircraft	61,999
483,999	

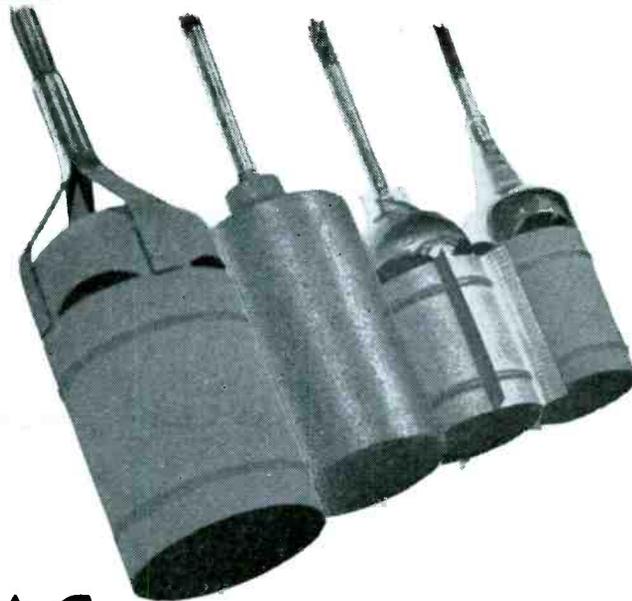
Personal And Business interests clash when we spend a quiet evening at home listening to f-m. On the one hand, the chief attraction of the service for us is freedom from announcements. On the other, we keep wondering how long this lovely music can play on, like Muzak, without advertising support.

We hope the programs stay as they are. And we hope the stations begin to make money. A spot for a Jekyll and Hyde, if we ever saw one.

If There Is Any Doubt in your mind about the speed with which f-m receivers are being sold watch the rooftops in towns that have stations when passing through by car, bus, or train.

The number of dipole-reflector rigs we spotted on a run to St.

there IS a difference.



PYROVAC the new Eimac plate material makes a better vacuum tube anode . . . on all counts.

- 1** **LIFE** . . . Tubes with tantalum plates formerly giving 3000 hours of service, now, with Pyrovac plates operate in excess of 15,000 hours . . . a 400 percent increase.
- 2** **OVERLOADS** . . . With Pyrovac plate, 65 watt tubes have dissipated 900 watts—a 1280 percent momentary overload—without indication that the eventual life of the tubes or their characteristics were affected. In normal service these tubes are still going strong. Excessive plate dissipation due to tuning procedure and circuit failure normally won't mean the loss of your tube.
- 3** **MECHANICAL CHARACTERISTICS** . . . Pyrovac is easily welded, enabling rugged shock-resistant mounting. It is a "black body" radiator and possesses excellent characteristics as an electrical conductor.
- 4** **COSTS** . . . Pyrovac plates in Eimac tubes cost you no more, yet since they enable longer life you actually get more for your vacuum-tube-dollar.
- 5** **PROVEN IN SERVICE** . . . Pyrovac is the result of millions of hours of life tests. The universal acceptance of the 4-125A and the 4-250A in all fields of electronic endeavor can, in part, be attributed to Pyrovac for contributing overload resistance, life, and a general ability to "take it."

THESE ARE THE TUBES WITH PYROVAC PLATES

EIMAC TUBE TYPES	PLATE DISSIPATION watts
TETRODES	
4-65A	65
4-125A	125
4-250A	250
4-400A	400
4-1000A	1000
TRIODES	
25T	25
3C24	25
35T	50
35TG	50
75TH	75
75TL	75
100TH	100
100TL	100
152TH	150
152TL	150
250TH	250
250TL	250
304TH	300
304TL	300
450TH	450
450TL	450
750TL	750
1000T	1000
1500T	1500
2000T	2000

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193 San Mateo Ave., San Bruno, California

Export Agents: Frazar & Hansen 301 Clay St., San Francisco, Calif.

1st LINE PERFORMANCE *Proved in* ADC 2nd Line Transformer

An ADC 115A (Industrial Series) impedance matching transformer, picked at random from stock, was submitted to tests to compare its performance with that of other makes of 1st line transformers. Here are the results. Compare performance of the ADC transformer with that of other makes.



Receiver Production by RMA members in 1947 is estimated at 17,695,677 units. Breakdown by months:

January	1,564,171
February	1,379,966
March	1,377,269
April	1,759,723
May	1,316,373
June	1,213,142
July	1,155,456
August	1,265,835
September	1,339,980
October	2,002,303
November	1,615,541
December	1,705,918

Included in the figures are 3,029,637 auto radios, and 178,571 television sets. Some 72 percent of all home radio receivers made were table models, 13 percent consoles, and 15 percent portables.

In addition to the radio and television receivers tabulated above, members made 291,410 phonographs and 224,945 record players.

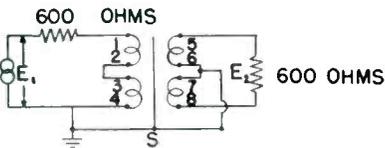
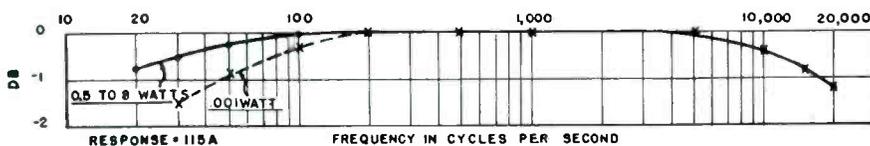
Projection Television is about to get another shot in the arm, the needle being wielded this time by designers up at the North American Philips lab.

Nearly ready for sale to tele set manufacturers, in more or less packaged form, is an extremely compact unit comprising a stubby c-r tube having a high-intensity screen just a little larger than two inches in diameter, an optical system, and a mirror that shoots the picture up to any conventional translucent screen. A high-voltage power supply using fewer than the usual number of tubes is also involved.

A detailed technical description of the system is in preparation and will soon appear in ELECTRONICS.

Associate Editor Zeluff has an idea worthwhile passing along. He thinks lots of people who have television sets with small screens will soon want larger pictures, largely so that more can watch. So, how about auxiliary cathode-ray tube units that can be attached to such sets and used simultaneously some place else in the same

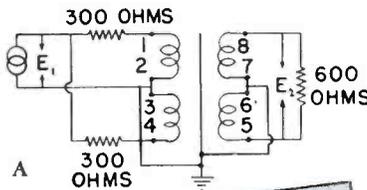
FREQUENCY RESPONSE



It may be noted that altho the permeability of magnetic materials drops at low flux densities, the ADC transformer has sufficient reserve inductance to allow for this even at low power levels. At 40 db below maximum power level it exceeds the response guarantee. Insertion loss at 1,000 cps was 0.75 db.

LONGITUDINAL BALANCE

The most common interference voltages encountered in telephone line transmission are longitudinal; that is, the induced voltages in both wires are in phase with respect to ground. These can be removed from the signal voltage only by means of a well balanced line transformer. Illustration "A" shows the test circuit used to measure the degree of removal of these interference voltages. Level reduction on the ADC 115A transformer was 67 db at 100 cps and 56 db at 10,000 cps.



CONSULT ADC for your engineered transformer where exacting specifications require positive results. ADC's policy assures you the finest available materials and workmanship to give you the very best electronic components.

ADC QUALITY PLUS TRANSFORMERS
Finest transformer made. For AM and FM broadcast stations and recording studios. ± 1/2 db 30-15,000 cps.

MANUFACTURERS, JOBBERS:
Write today for catalog of ADC electronic components or for information on units engineered to your requirements.



Audio Development Co.
2835 13th AVE. S., MINNEAPOLIS 7, MINN.
"Audio Develops the Finest"

room? And, if and when they become available at reasonable cost, auxiliary units with larger screens?

Hotel installations using the central receiver and remote cathode-ray tube system are already being made. Why not apply the idea to homes?

Transmitter Equipment Sales by RMA members exceeded \$97,000,000 during the first half of 1947.

Makers of broadcast transmitting and studio equipment shipped \$9,253,358 worth. A-m transmitter sales totalled \$2,319,006, f-m transmitter sales \$1,820,633. A-m and f-m studio equipment sales went to \$2,205,382. Antenna equipment for both types of broadcast service brought in \$433,767. Television station equipment of all kinds totalled \$1,354,633.

General communications equipment sales totalled \$2,589,468 for vhf equipment and \$746,902 for medium frequency. Aviation radio gear went for \$4,061,072. Marine transmitting equipment sales were \$1,677,703. Sales of piezo-electric quartz crystals hit \$456,137, of which \$315,169 worth went to equipment manufacturers.

The U. S. Government received delivery of \$78,347,341 worth of gear in the first half of 1947.

Test Equipment can be made smaller and lighter by using miniature tubes, batteries and component parts. Some instruments hitherto limited by size and weight to laboratory use could be made sufficiently compact for field applications, thus broadening their market.

An Indian Radio Company has ordered 100,000 two-tube sets produced by the Sargrove method. In case you've forgotten, that's the method employed to turn out the machine-made radio appearing on the cover of *ELECTRONICS* for February.

One Way To Find Time: Studying in his cell from books furnished by his mother, a Cranston, R. I. man is said to have become an electronic expert while serving a 35-year sentence for the second degree murder of his fiancee.

New! **INDISPENSABLE ALL INCLUSIVE! COMPLETE!**

GEIGER-MÜLLER LABORATORY COUNTING RATE METER

MODEL - RM4
A COMBINED COUNTING RATE METER AND COUNTER SET

Direct reading counting rate meter with FOUR full scale ranges of 5, 50, 500 and 5000 pulses per second.

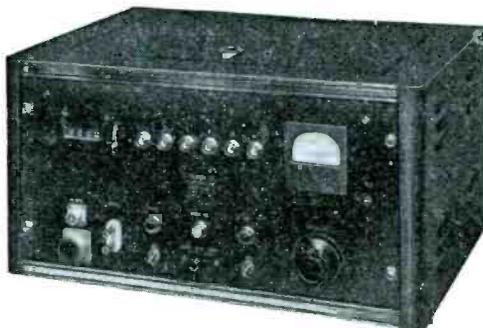
Provision for connection of external 5 m. a. recording milliammeter. Recorder circuit for operation of impulse register (recording clock). Regulated high voltage power supply for counter tube. Built-in loud-speaker for aural monitoring. Pulse equalizing and sharpening stages. Operates with self-quenching OR non-self-quenching counter tubes. Provision for connecting scaling circuit, impulse register, oscilloscope, recording milliammeter and calibrating input signal. Price only \$350 less counter tubes and recording clock. For complete description send for Bulletin No. 471.



HIGH SPEED GEIGER-MÜLLER LABORATORY SET

MODEL LS64

CHECK THESE OUTSTANDING FEATURES:



All of the newest circuits—simplified and modernized—reliable and fool-proof. Uses the famous Higinbotham Scaling

Circuit—SCALE OF 64 (Used under license agreement with U. S. Atomic Energy Commission). Build-in recorder clock of zero reset type—counts up to 9999 before recycling. Regulated high voltage power supply for counter tube, with front panel voltmeter. Suitable for use with self-quenching or non-self-quenching counter tube. Bank of neon indicator lamps for interpolation of count and indication of proper scaler operation. Small, compact, light in weight—constructed completely on one 13"x17" chassis with 8-3/4" rack type front panel. PRICE ONLY \$360.00 complete with tubes and built-in recording clock. Send for Descriptive Bulletin No. 472.

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MANUFACTURERS OF SPECIALIZED ELECTRONIC APPARATUS

MALLORY ORIGINATED ELKONITE* METALS—

ELKONITE

**and only Mallory has the years of
experience with their complex fabrication**

ELKONITE is the registered trade mark for a series of metals originated by Mallory which derive their effectiveness from the skillful compounding that Mallory has developed through many, many years of pioneering in the field of powder metallurgy.

Elkonite metal proved so dependable under the most severe conditions that it quickly became standard on most heavy duty circuit interrupting equipment. It also proved indispensable in the field of resistance welding and in countless applications requiring its particular characteristics.

The success of Elkonite metal is so well established that the trade mark has been mistakenly applied to materials that are sold with the implication that they will match the performance of true Elkonite metal.

Mallory has made true Elkonite metals for years. Only Mallory can guarantee the correct formulation that gives hardness, high electrical conductivity, resistance to mechanical wear and to sticking and erosion by arcing—the qualities that have made the word Elkonite a symbol of dependability.

ONLY MALLORY MAKES AND SELLS GENUINE ELKONITE METAL

*Reg. U. S. Pat. Off.

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MALLORY ELECTRICAL
CONTACTS & CONTACT ASSEMBLIES

P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA



CROSS TALK

► **ALEX . . .** Out near the end of Long Island stand several monuments to one of the grand figures of electronics. Here are antennas the like of which the younger generation of experts has never seen. They are a mile long and 400 feet high. They operate in the region of 15 kc and they get their power, several hundred kilowatts of it, from huge generators rotating at high speed.

The genial figure who has thus created his own monument is E.F.W. Alexanderson, just retired after 45 years with General Electric. "Alex" not only produced the alternators which bear his name but had much to do with the multiple-tuned antennas which launch the energy into the ether. His contributions to electronics, however, are not confined to dot-and-dash techniques. The industry still remembers with awe television demonstrations in Schenectady where his giant scanners made possible theater-size images. Industrial electronics, too, has felt his handiwork. And above all, Alex has the human touch, so often missing in those who deal primarily with machines—and big machines at that.

► **STANDARDS . . .** Recent changes in two basic physical standards remind us that arbitrarily defined units of measurement are subject to alteration. From W. F. Meggers of the National Bureau of Standards comes news that a new and better standard of length is available. It is a spectrum line, of green color, produced by mercury 198. This isotope of mercury does not occur in nature, but is produced by neutron bombardment of gold. The wavelength of this line is, according to Dr. Meggers, superior to the long-established standard red line in the spectrum of cadmium, and far easier to reproduce than the standard meter bar now preserved in Paris. So nuclear technology provides a new standard, measurable to an accuracy of one part in 100,000,000.

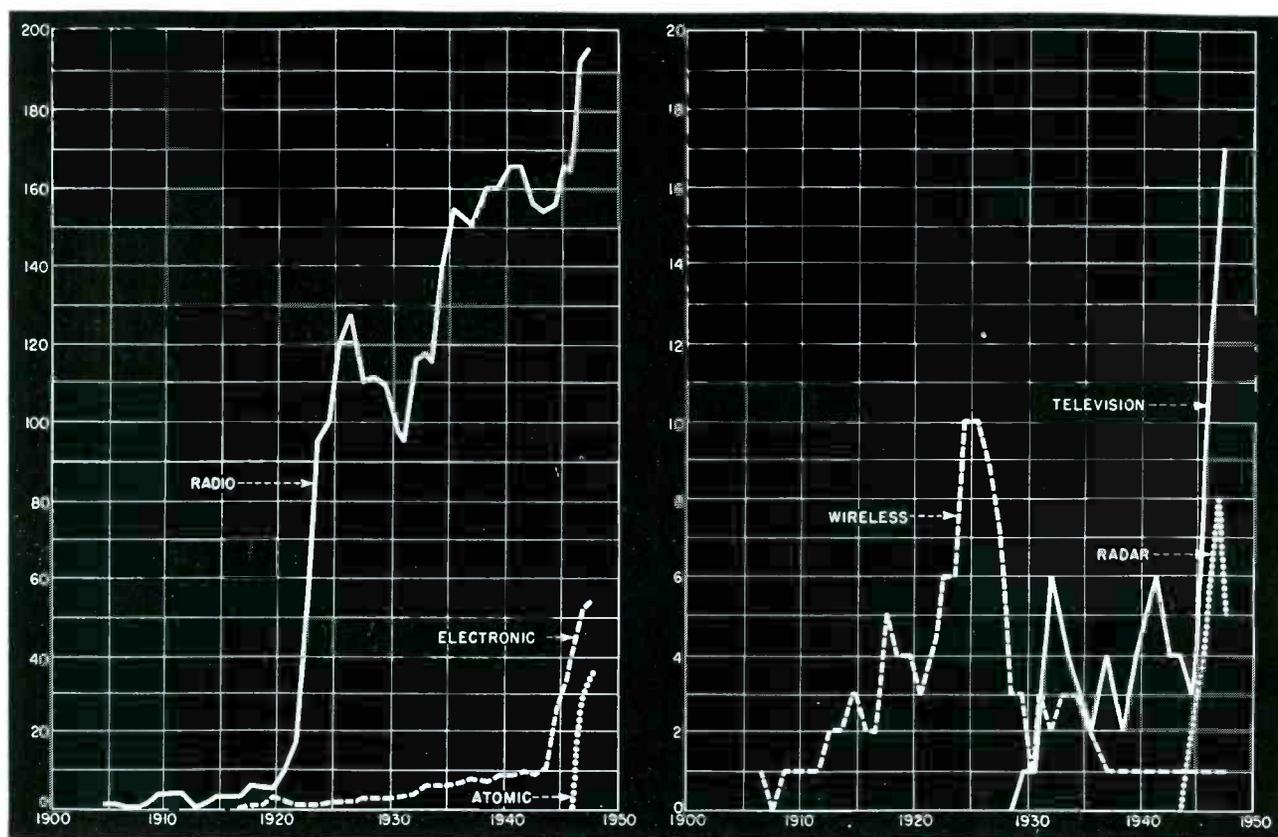
The other change is less exciting, but perhaps of equal practical importance. Effective this year, the standard ohm becomes about 1/20th of a percent smaller than formerly. The formerly used international ohm was 1.000495 absolute ohm. The absolute ohm is the newly defined standard. The practical effect is that precision resistors, whose tolerance is 0.1 percent or better, must be made to the new

standard. For all other practical purposes, we are glad to report, we may cleave to the obsolete (non-absolute) ohm.

► **OVERSUPPLY . . .** While busily engaged in trying to control the inflationary aspect of our feast-and-famine economy, we may lose sight of a similar oscillation in the supply of electrical engineers. Through a now-recognized defect in the draft policy of the last war, we virtually stopped production of young engineers for nearly five years. Meanwhile we vastly enhanced the attraction of the electrical industry, particularly the electronics part of it, by introducing radar and similar wonders to vast numbers of soldiers and sailors. So students, largely G.I.'s, have since flocked to the electrical departments of colleges throughout the land. The committee on manpower of the American Society for Engineering Education has surveyed this rush and sounds a warning. By 1949, there will be an oversupply of electrical engineers, by 1950 an "exceedingly high" oversupply, or so the A.S.E.E. experts claim. Perhaps so. But in 1948 we still have a shortage of young men, as well as experienced men. If the products of electrical science continue to command an increasingly large portion of the national income, as they have since prewar years, our industry will absorb all the good men offered.

► **MICROSCOPE . . .** The electron microscope has climbed in magnifying power to 300,000 diameters and, like telescopes of new power, is revealing hitherto unknown worlds. The latest adventure has been reported at Philadelphia by Dr. James Hillier, speaking before the Electron Microscope Society of America. Microscope pictures taken at the RCA Princeton Laboratories show viruses attacking bacteria and destroying them. Both virus and bacteria were killed by the passage of the electron beam in the microscope, but they preserved their relative positions at the instant of exposure and so showed, in successive pictures, the advance of the attack. This direct insight is of the greatest importance in studying the nature of virus diseases. A new double electron lens did the trick, revealing bodies only one four-hundred-millionth of an inch in diameter.

NEW WORDS



When a new technical word having popular appeal is publicized into the language, businessmen frequently ride on its coat tail and incorporate the word into the names of their firms. Sometimes these firms are engaged in the field so intimated, sometimes not

THE NAMES of new advances in science are often employed in connection with business ventures. Their use as part of company names tells an interesting story.

The trend is easily traced by an examination of telephone directories of past years. Such a search of New York (Manhattan) telephone directories since 1904 reveals the growth and sometimes the decline of several words in our field. It also discloses the extent of their popular appeal over the years.

The words chosen for this study were *Radio*, *Wireless*, *Electronic* (including *Electron* and *Electronics*), *Television*, *Radar* and *Atomic*. The 1904 starting date was chosen as directories back to that date were conveniently available. This date also pretty well antecedes the common use of most of the words.

The number of listings in the telephone directory is plotted in the accompanying chart. (Note that the fluctuations do not follow at all closely the boom of the late twenties or the depression of the thirties.)

Radio

Strangely enough, the word *radio* appears two years before the word *wireless*.

In 1904 and 1905 there was a single entry, the Radio Chemical Company. The next two years showed no use but in 1908 it reappeared, one listing being a radio telephone company. In 1910 a radio wireless station was listed. In 1912 the word disappeared, but it returned the following year. By 1917 there was a total of six in use, but none of them were really applicable to the science of radio as we know

this very popular word today.

The Radio Corporation of America showed up in 1920, and in 1931 the completion of Radio City swelled the list considerably. The period of most rapid growth was between 1919 and 1924, when the number of mentions increased from five to 100. Use of the word is now pushing the 200 mark.

The publicity value of the word *radio* caused it to be used in connection with many enterprises such as awnings, grills, picture frames, meat shops, slippers, neckwear, and wet wash.

The term *radionic* has not so far made a great deal of progress.

Wireless

The word *wireless* first made real news in this country as a result of the reception of Marconi trans-

COME and GO

By W. C. WHITE

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atlantic signals on December 12, 1901. However, it did not appear in the New York telephone directory until 1906. It was not represented in 1907, which year incidentally was the only one covered by this survey that yielded no entry of any of the words chosen.

It is rather prophetic of the early era of wireless that the first entry in 1906 was for the Wireless Securities Exchange, which proved to be short-lived, at least under that title.

The word *wireless* was back again in 1908 with the well-remembered and relatively long-lived Wireless Specialty Apparatus Company.

Another big boost in the news value of the word occurred in connection with the wreck of the S.S. Republic, in 1909, and to an even greater extent as a result of the Titanic disaster in 1912. However, its use in connection with business enterprises did not seem to be immediately affected. The number of appearances in the telephone directory reached a maximum in 1924 and 1925 with 10 entries.

As in the case of the word *radio*, many of the listings were not really connected with the science.

By 1937 the listings were down to one entry, and this one and only entry has remained up to the present. It is for a printing company. Incidentally, in 1926 there was a Wireless Radio Corporation in Brooklyn.

Electronic

Although none of the words stemming from *electron* appeared until 1917, the word *elektron* was listed in 1904 and 1905, applied to an elevator company. The word *electron* appeared first in 1917 in connection with a chemical company. The number of entries varied slightly but never reached over four until after 1932.

The word *electronic* first showed up in 1926 and *electronics* in 1930 in connection with this publication. The magazine remained the sole representative of this form of the word in the telephone directories until 1944.

For some reason not entirely evident, the three words based on *electron* have been applied appropriately to a much greater extent than *radio* or *wireless*. A rapid increase occurred between 1943, with 11 entries, and the latter part of 1946, with 52 entries. Use apparently is still on the increase.

Television

The word first was used in the telephone directory in 1929, in connection with a television-radio shop. There was an increase from a single entry in 1930 to six entries in 1931. Then it varied back and forth between these limits until 1944, when it started a rapid and continuous increase, reaching 17 in the latest issue.

As in the case of *electronic*, listings under television are largely connected with the actual industry.

Radar

The word *radar* made its first appearance in 1944 with two entries, one a paint and one a novelty company. It appears to have reached a maximum of eight mentions in 1946, none of them having any apparent connection with the science. Typical firms listed dealt in blouses, novelties, restaurant supplies, paints, and slippers.

The use of this word in the telephone directory will probably decrease and may well disappear after a few years.

Atomic

The 1945 fall directory was probably well along in preparation when

REPEAT PERFORMANCE

THE EDITORS almost let this article slip through their fingers. So unusual was the theme, and so light the treatment, that it seemed not to fit a serious technical publication.

BUT a good story will not die. The editors re-read it, and again enjoyed it. Why keep it from readers? Editors can get too serious. So here it is.

BILL WHITE, by the way, is not only a charter subscriber to ELECTRONICS but is a charter contributor as well. An article appeared under his signature in our first issue, back in April 1930

the atom bomb was dropped over Hiroshima so there were no listings containing the word *atomic* in that issue. But in the next issue, in the spring of 1946, it appeared 19 times. None, of course, were directly applicable to the scientific development.

The great popular appeal of the word is indicated by the fact that it showed more listings in the issue of its first appearance than any of the other words did after a growth of ten years. The listings showed activity in handbags, pleating, rainwear, and surgical supplies. By the 1946 fall issue, the number had grown to 30 and added lines were neckwear, undergarments, podiatry, art studios, food, and jewelry.

By the fall of 1947, the number had grown to 35. One appropriate entry did appear then, the Atomic Energy Commission.

Nucleonic

To date the word *nucleonic* has not appeared. It offers a wonderful opportunity if you are going into neckwear, novelties, etc.

You may have the field to yourself for at least one issue of the Manhattan directory if you start now.*

* ED. NOTE. You will not. See "Nucleonics," a McGraw-Hill Publication.

Electronic Preservation of Food

Experiments indicate that foods of many varieties can be preserved over long periods, without alteration in appearance or taste, by exposing them in their sealed containers to ultra-short-time pulsed cathode rays from a capacitron. Sterilization of drugs without decrease in potency is also possible

By **WOLFGANG HUBER***

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THE IMPORTANCE of electrons moving within evacuated tubes has been amply demonstrated. By contrast, comparatively little has been done with electrons released from the confinement of tubes, particularly in the field of food preservation.

In 1894 Lenard¹ brought cathode rays out through a window in the wall of a tube. But the cathode-ray tube remained a low-voltage, low-current device until 1926 when Coolidge² developed a tube capable of operation at several ma and up to 350 kv. With this type, electron beams of sufficient intensity to permit practical experimentation with chemical and biological objects were obtained.

Still higher electron velocities were obtained by the subsequent development of cascaded cathode-ray tubes. Many investigators³ used this method to expose a wide variety of materials of inorganic as well as organic origin to the action of electrons. The results of the biological experiments were not very encouraging, however. Micro-organisms within the penetration range were killed, but irradiated prod-

HEATLESS

Energy developed by the capacitron is cold energy. Thus limitation of micro-organism and enzyme activity may be accomplished while food is in any physical state . . . frozen, raw, partly or fully cooked

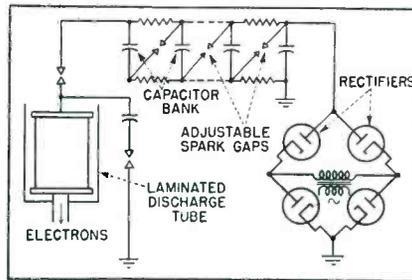


FIG. 1—Basic circuit of the electronic impulse generator

ucts showed pronounced changes in taste, odor and appearance.

Capacitron Development

Biological and medical experiments undertaken by Brasch and Lange⁴ in cooperation with Beck and Haelberstaedter opened new possibilities. These men used a capacitron, an apparatus which produces high voltages and great electron intensities during ultra-short-time periods. It was indicated that the release of high intensities during ultra-short-time periods killed micro-organisms in much the same way as continuous current-voltage generators but without radically changing taste, odor or appearance.

Initial experiments were carried out by the utilization of voltage produced by lightning.⁵ This source of voltage was obviously unreliable and further progress was intimately connected with the development of an impulse generator developed by E. Marx⁶ and shown in Fig. 1. A number of capacitors are charged in parallel, through resistors, from a rectifier unit. Discharge of the capacitors in series is accomplished by means of gaps which spark over at predetermined voltages.

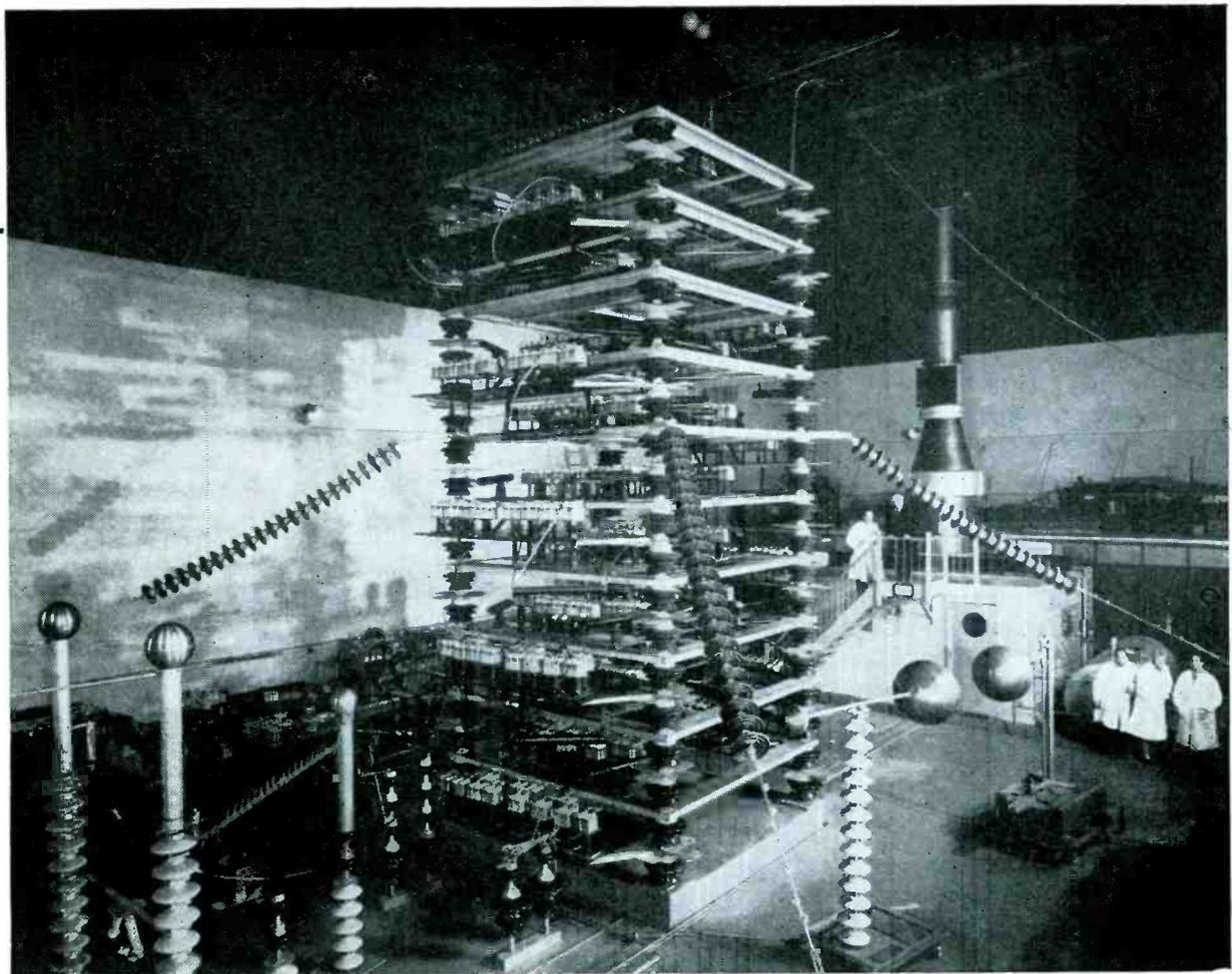
The availability of impulses of several million volts from a generator now made it imperative to develop discharge tubes that would handle these voltages continuously and without breakdown. Brasch and Lange⁷ determined that the breakdown voltage depended not only on the status of the vacuum and the construction of the electrodes but also upon the type and structure of the wall of the discharge tube. Breakdown troubles were reduced by lamination of the tube wall and by increase in the lengths of surfaces which were prone to cause gliding discharges. This led in 1930 to the development of the so-called laminated tube illustrated in Fig. 2. It consists of alternate stainless steel or nickel, insulating resin, and rubber discs.

In order to avoid excessive bombardment of the walls with electrons it is important to construct the tube in such a way that the relation of length to width is not materially in excess of 8 to 1. In large capacitrons the ratio may be as low as 2 to 1. To avoid flashovers the tube is immersed in oil.

Practical Design

Experimental work by A. Brasch and the author⁸ has so far been carried on with the experimental capacitron pictured in these pages. Line voltage is transformed to 100,000 volts and converted into d-c by a set of rectifier tubes. Induction coils used in lieu of resistances permit a capacitor-bank charging fre-

* From a paper presented before the 1947 National Electronics Conference in Chicago.



Experimental capacitron used in the tests

quency of 50 to 100 times per minute. The generator itself consists of capacitors arranged in 30 banks of 100,000 volts each, thus giving a peak output voltage of 3,000,000.

The intensity of each individual impulse is of the order of thousands of amperes and the release time of the order of 10^{-6} second. The electrons reach the open through a window device which consists of a grill supporting a thin metal foil. Foils of beryllium alloys, which have the best strength and ductility characteristics, are not yet available. Therefore, we are at present using 0.05-mm foil of a hard aluminum alloy. The efficiency of the device, as compared with other corpuscular accelerators, is relatively high. According to calorimetric determinations, about 35 percent of the surge generator intensity is converted into electrons.

The simplicity of capacitron design permits the attainment of practically unlimited voltages and in-

tensities, particularly if the entire surge generator together with the discharge tube is immersed in a liquid insulating material contained in a grounded tank. The general design of such a unit, which will be a prototype for commercial uses, is shown in Fig. 3. In this unit, the capacitor banks and the discharge

tube are immersed in oil in a submerged concrete pool, with only the pumping equipment, the exit window and the conveyor belt above ground in a separate concrete housing. The spark gaps are hermetically sealed in compressed gas and the beam of electrons is bent around by a system of magnets to facilitate

Table I—Penetration Range of Electrons in Water

Velocity*	Accel. Pot. (kv)	Max. Range (mm)	High Intensity Range†	Depth of Max. Intensity (mm)
0.55	100	0.03	.....	.....
0.70	204	0.83	.....	.....
0.78	300	1.40	.....	.....
0.80	340	1.60	.....	.....
0.90	662	2.46	.....	.....
0.91	1,000	5.20	.....	.....
0.97	1,600	7.70	0-2.7	1.3
0.985	2,400	12.50	0-4.5	3.0
0.993	4,000	21.00	0-7.5	6-7
0.998	8,000	42.00	0-14.0	10-12
0.999	12,000	62.00	0-22.0	16-18

*Expressed as fraction of velocity of light

†Higher than at surface

the use of conventional conveyor equipment and to eliminate x-rays.

The penetration range of electrons depends on the accelerating voltage and the density of the target. Table I illustrates this, using water as a target, as well as the fact that electrons exercise more intensity at a certain depth than on the surface. The latter effect is due to the phenomenon that with increasing electron speed scattering will be predominantly in the forward direction. This is of considerable practical importance, since it avoids unduly high energy absorption in any container wall.

Penetration in water with 5,000,000 volts is about 25 mm. After electrons pass through the discharge-tube air exerts a bushing effect upon them. In 5 inches distance from the window, for example, an area of at least 380-mm diameter is covered. With a penetration range of 25 mm it is thus possible to process with one impulse 2.83 liters of one particular material. If we assume an average discharge frequency of only 30 impulses per minute this would be equivalent to a capacity of 85 liters per minute and about 5,100 liters, or 5.5 tons, per hour.

Table II indicates the nature of changes in several substances when subjected to continuous radiation

and, by comparison, to ultra-short-time radiation. Using ultra-short-time impulses with intensities far above maximum continuous radiation values recommended in the literature, we note no formation of vitamin D in ergosterol. Our interpretation of this fact is that the first step in the photoactivation of ergosterol, namely, the isomerization of the angular methyl group on C-10, has a reaction time considerably in excess of 10^{-6} second.

Preservation of Foods

Table III illustrates the effectiveness with which foods are preserved by means of capacitron radiation. For example, slices of raw beef, veal and pork were put into thin-walled glass containers which were sealed off under air and exposed for four impulses. The energies applied were far in excess of the minimum sterilization dose.

Tests for sterility were made directly after irradiation and at the end of the storage period, which was in some few instances coincident with perceptible change in appearance but in most cases arbitrary. Experiments are continuing, so it is difficult to estimate the extent of ultimate storage stability for many samples. In the protein series, for example, we feel that we are nowhere near the limit.

Table II—Comparison of Continuous and Ultra-Short-Time Radiation

Substance	Continuous Radiation	Effect	Capacitron Impulses of 10^{-6} Sec
Ergosterol	u-v, α , β	vitamin-D formation	no change
Casein, Egg Albumen	β , γ	decomposition, oxidation	no change
Butane, Heptane	α , β	H ₂ , CH ₄ evolution, polymerization	no change
Styrene	u-v, α , β	polymerization	no change
Castor, Linseed, Tung Oil	u-v, β	polymerization, change of ref. index, iodine no. and color	development of slight flowery odor
Acetone	β	condensation, gas formation	no change
Hemoglobin	u-v, α	inhomogenization, low molecular breakdown products	small % of methemoglobin
Rubber Plant	β	discoloration, drying, latex formation	no change

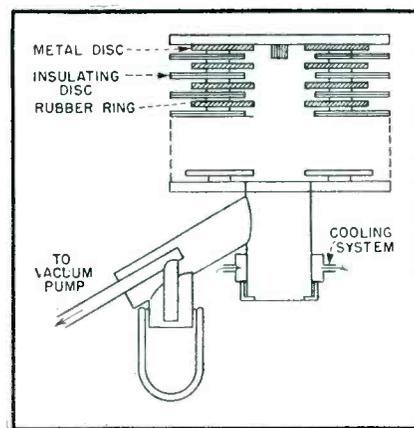


FIG. 2—Laminated discharge tube used in the system

Boiled ham showed decomposition after 63 days, whereas raw fat pork exhibited no change after 207 days. This had us puzzled until we found that the discrepancy was due to differences in packing. The boiled ham samples were packed in double bags of 0.004-inch polyethylene foil, considered ideal because of its low density, and heat-sealed. Decomposition of the sample started around the areas closest to the sealed edges, indicating need for a foolproof, fully airtight plastic container.

Ultra-short-time impulses do not always eliminate all side effects. In the case of butter as well as other products containing butter fat a definite taste change occurs which cannot be classified as any of the previously known taste changes. We call this change irradiated taste. It can be considerably reduced by critical variation of the irradiation conditions, and also by prolonged storage. In the case of cream cheese, irradiated taste completely disappeared after 66 days of storage at room temperature in the original tin-foil wrapper.

Considering the most common use of castor oil, it was rather amusing to find that under radiation this household standby developed a fragrant odor much like that of daisies.

Table III also illustrates the behavior of capacitronized vegetables. The days of storage for the products in plastic containers are somewhat deceiving, since these samples were opened regardless of appearance when we discovered the unsuitability of heat-sealed polyethylene bags for our purpose.

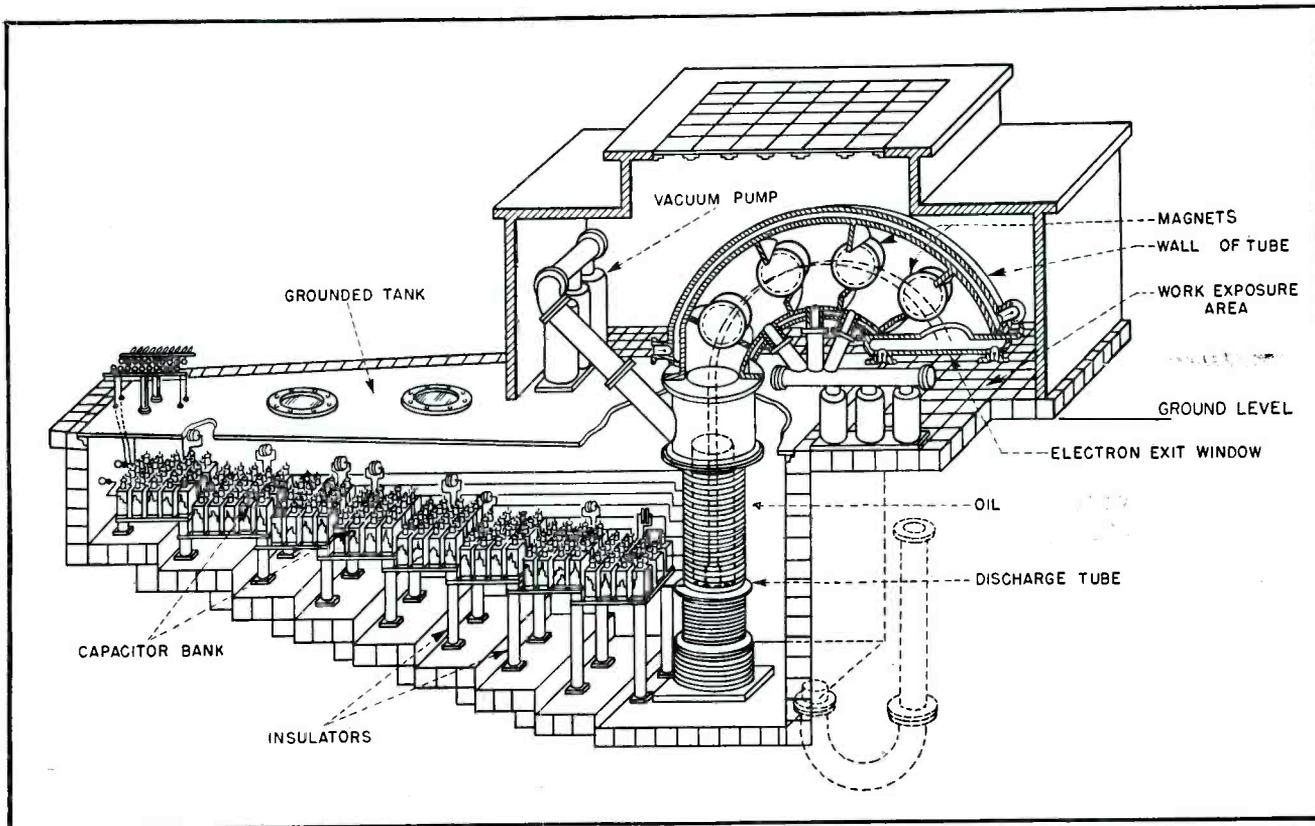


FIG. 3—Prototype of a commercial capacitron

By contrast with the color of substances of animal origin, some plant dyes were found to be much less stable under our conditions of storage. Bleaching is not a radiation effect but develops slowly on storage. It can be reduced by storage away from light. On the other hand, attempts to preserve lettuce have so far been a failure, with the detrimental effects undoubtedly due to irradiation. We do not yet know why.

The color of all except one of the fruits so far tested was well preserved after radiation. The notable exception is strawberries. Indications are that special treatment and storage conditions as well as more rigidly controlled impulse dosages may overcome the undesirable effects.

Surface Sterilization of Foods

All the experiments discussed so far were undertaken for the purpose of studying the maximum extent of preservation obtainable with penetrating electrons of ultra-short-time duration. If, however, only a moderate extension of shelf life is needed then the capacitron can be readily utilized for a process which

we have called surface sterilization. In this procedure the irradiation conditions are adjusted in such a way that the electrons penetrate just through the surface of the foodstuff.

We have found that the elimination of micro-organisms from the surface affords a considerable extension of the life of fresh food products, particularly of those that have a rather thick or tough skin, such as apples, peaches, melons, corn, nuts and eggs. That this should be so seems logical if one remembers that except for insect infestations the surface is the main portal of entry for micro-organisms.

We have been able to preserve fruits such as melons, peaches, pears and corn on the cob, wrapped in plastic envelopes, over periods of several weeks at room temperature. Controls kept under identical conditions started to decay after several days.

Another interesting application of the capacitron is the preservation of partly or wholly dehydrated foodstuffs, particularly when the dehydration has been achieved by freeze-drying. And this discussion

of preservation of foods would not be complete without mentioning commodities which serve in one way or another as raw materials, intermediates or additives in the preparation of finished food products. These highly diversified products include grains such as wheat, corn and rice, as well as the corresponding flours, beans, nuts, spices, plant extracts, protein fractions and many others. We have achieved preservation of these commodities by elimination of micro-organisms of all types as well as infestations caused by insects, insect eggs or larvae.

Before concluding the discussion of food preservation, I would like to say a few words about capacitron preservation in relation to preservation by refrigeration, particularly by deep freezing. We do not hold the opinion that preservation with penetrating electrons of ultra-short-time duration will be a potential antagonist to deep-freezing techniques. Quite the contrary, we feel that the process can offer great advantages to the processor of frozen foodstuffs. The capacitron offers a means for heatless sterilization and enzyme inhibition. To this, refrig-

eration can add preservation of color and texture. In addition, and this is probably even more important, capacitronized frozen products can be kept without loss at about 10 F for very long periods of time, thus providing considerable reduction of freezing costs and elimination of many of the headaches of transport.

Sterilization of Drugs

The last topic of this discussion deals with the sterilization of drugs. Some of the results are illustrated in Table IV.

It can be seen that vitamins such as thiamin, riboflavin, pyridoxine, niacin, and pantothenic acid either alone or in mixture are readily sterilized without loss in potency, even with large impulse dosages. Similar data was obtained when testing fat-soluble vitamins, such as vitamin A and vitamin D. The same also holds true for hormones, and even such a mixture of complicated protein molecules as pituitary hormone can be readily sterilized without any loss in potency. Another remarkable result is the radiation stability of antibiotics such as penicillin and streptomycin. They withstand even higher impulse dosage than those given in the table without any loss of antibiotic activity.

To illustrate in this table the sterilization of individual enzyme preparations as well as their sensitivity to penetrating electrons of ultra-short-time duration, I have selected three examples, namely, hyaluronidase, clarase, and trypsin. Two facts are outstanding. First, the margin between sterility dose and activity loss, although rather narrow, is still wide enough to achieve sterilization with little or no potency loss. Second, there are appreciable individual differences in enzyme sensitivity to capacitron radiation.

The sensitivity of individual enzymes as well as isolated enzyme systems to penetrating electrons of ultra-short-time duration is at present under more detailed investigation.

Summary and Acknowledgments

Summarizing the salient features of penetrating electrons from a capacitron as they apply to heatless

Table III—Effects of Capacitron Radiation on Foods

MEATS, FISH, EGGS						
Food	Impulses (10 ⁻⁶ Sec)	Storage Conditions*		Appearance, Taste, Odor	Un- treated Sample Decay (days)	Con- tainer
		Temp (°C)	Time (days)			
Beef	4	room	264	unchanged, raw and fried	2	glass
Veal	4	room	238	unchanged, raw and fried	3	glass
Pork, fat	4	room	207	unchanged, no rancidity	2	glass
Flounder, filet	4	room	127	unchanged, no rancidity	1	glass
Roast Beef, red	4	room	94	unchanged except for darkening of color	2	plastic
Ham, boiled	4	room	63	fair, slight decomposition	2	plastic
Bacon, smoked	6	room	156	unchanged, no rancidity	6	aluminum
Chicken a la King	6	+4	74	unchanged	4	plastic
Hamburger	4	+4	83	unchanged	5	plastic
Eggs, pigeon	4	room	194	unchanged	18	card-board
FATS and OILS						
Butter	5	room	97	preserved, but off taste; no rancidity	3	glass
Margarine	4	room	79	preserved, but off taste; no rancidity	3	glass
Lard	4	room	182	unchanged, no rancidity	8	glass
Olive Oil	6	room	204	unchanged	10	glass
Cream Cheese	2	room	66	unchanged; off-taste after irradiation disappeared in storage	4	tin foil
Camembert	4	room	82	preserved, ripening process arrested; taste more like cheddar	2	tin foil
VEGETABLES						
Peas	6	room	184	unchanged, except for slight bleaching	5	glass
Beans, cut	6	room	184	unchanged, except for some bleaching	6	glass
Carrots, diced	6	room	117	considerable bleaching, some loss of texture	5	glass
Potatoes, diced	4	room	64	unchanged, except for some browning	4	plastic
Lima Beans	6	room	227	unchanged	5	glass
Cabbage, diced	4	room	234	unchanged	9	glass
Broccoli, diced	4	room	42	unchanged, except for some bleaching	2	plastic
Spinach, chopped	4	room	83	unchanged, except for some bleaching	3	plastic
Mushrooms	4	room	33	unchanged, except browning of stem and slight loss of texture	1	plastic
Lettuce	3	room	2	soggy, flat tasting and considerable bleaching	1	plastic
Cauliflower, diced	4	room	234	unchanged, slight yellow discoloration	6	glass

*In air and light.

FRUITS						
Food	Impulses (10 ⁻⁶ Sec)	Storage Conditions*		Appearance, Taste, Odor	Un- treated Sample Decay (days)	Con- tainer
		Temp. (°C)	Time (days)			
Pineapple, sliced	4	room	94	unchanged	4	plastic
Coconut, sliced	4	room	86	unchanged	3	plastic
Peaches, sliced	4	room	83	well preserved, but slight loss in texture and some browning	1	glass
Apples, sliced	4	room	101	unchanged, except for some browning	2	glass
Blueberries	4	room	65	unchanged, except for slight loss in texture	2	plastic
Raspberries	4	room	69	unchanged, except for slight loss in texture	2	plastic
Strawberries	4	room	41	preserved, but marked loss in texture and color	1	plastic
Cherries, sweet	4	room	64	unchanged	2	plastic
Orange Juice	4	room	128	preserved, but some loss of aroma and sweetness	1	glass
Orange-Grapefruit Juice	4	room	129	unchanged	1	glass
Grapefruit Juice	4	room	134	unchanged	2	glass

*In air and light.

Table IV—Capacitron Sterilization of Drugs

Drug	Impulses (10 ⁻⁶ Sec)	Contami- nation	Potency		Container
			Untreated	Treated	
Thiamine HCl	2-4	unknown	4.6 mg/cc	4.4 mg/cc	glass
Protein Hydrolysate	2	GNB, GPC	.....	.....	aluminum
Penicillin-Na	3	B. subtilis fungi spores	220,000 U	220,000 U	glass
Streptomycin-H ₂ SO ₄	4	B. subtilis	100,000 U	100,000 U	glass
Testosterone	4	B. subtilis	100%	100%	glass
Prolactane	4	.....	100%	110%	glass
Pituitary Hormone	2	unknown	3800 I. U.	4000 I. U.	plastic
Hyaluronidase	2	unknown	100%	97%	plastic
Clarase	2	unknown	100%	87%	aluminum
Trypsin	2	unknown	100%	100%	aluminum
Yeast	2-4	B. subtilis	.....	.....	plastic
Riboflavin	.....	.....	0.07mg/gm	0.07mg/gm	.....
Pyridoxine	.....	.....	0.04mg/gm	0.04mg/gm	.....
Pantothenic Acid	.....	.....	0.10mg/gm	0.10mg/gm	.....
Niacin	.....	.....	0.35mg/gm	0.35mg/gm	.....

preservation and sterilization:

While the energy is cold energy it is of very considerable intensity. The use of such cold energy makes it possible to treat products at temperatures well below freezing and in any physical state—raw, partly or fully cooked.

The application of high intensities for ultra-short-times accomplishes the selective elimination of micro-organisms and enzyme activity which, under such conditions, in many cases runs ahead of undesirable side reactions.

Highly accelerated electrons penetrate to a considerable depth, depending upon the voltage. Furthermore, they release more energy underneath the surface than on the surface. These characteristics permit the treatment of ready-packed items without breakage of the container and with minimum energy loss within the wall of the container, provided the density and the wall thickness of the container materials are kept within reasonable limits.

High accelerating voltages, necessary for the preservation of bulky materials, will not give rise to nuclear reactions, thus eliminating the danger of artificial radioactivity.

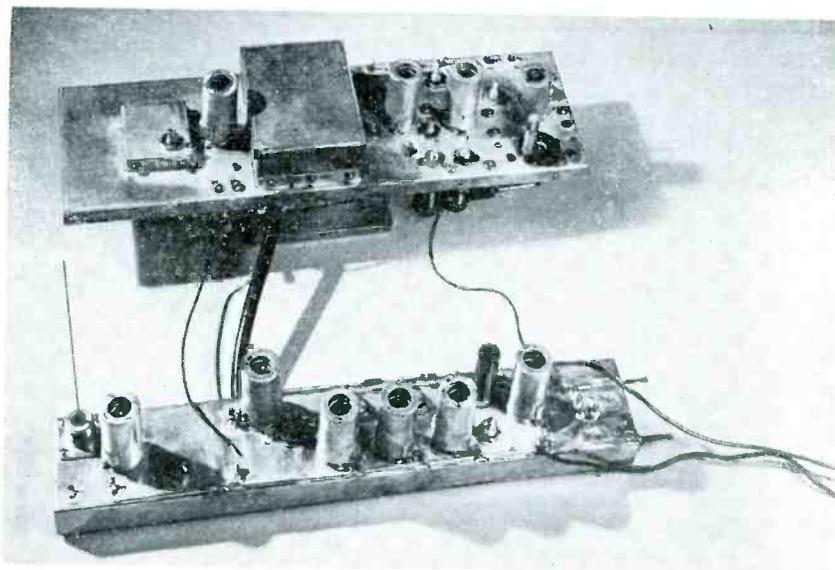
The possibility of large-volume processing, due to the high discharge rate and good efficiency, make commercial application of the capacitron feasible and attractive in many fields.

The author gratefully acknowledges the assistance rendered by the staff of Electronized Chemicals Corporation in carrying out this work. In addition, he is indebted to Alexander Astrack Jr., who conducted many of the food experiments.

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Part II of a Series



Transmitter and receiver for 465 megacycles. The quarter-wave receiving antenna is at the lower left. Local oscillator power for the receiver (bottom) is taken from the transmitter (top)

RECEIVER for the

A RECEIVER operating in the 460–470 mc band is ultimately limited in sensitivity by the thermal noise associated with the antenna resistance and circuit components, and the shot noise due to the tubes. A satisfactory receiver for the Citizens Service should limit on noise and have a good noise figure.

Figure 1 shows the block diagram upon which the present design was based. The preamplifier was used in the interest of improved noise figure, but also improves image rejection and reduces local oscillator radiation. The following assumptions were made:

- (1) 10-db gain in the preamplifier.
- (2) Unity power gain in the converter.
- (3) 250-kc effective bandwidth to receive the 200-kc channel width allowed by FCC specifications. This allows for the ± 0.02 percent tolerance for class-A operation and ± 25 -kc deviation of the carrier.
- (4) 10-db noise figure.
- (5) 10,000-ohm converter plate load.

The available thermal noise power is 4.1×10^{-21} watt per cycle per second.¹ For our bandwidth, the thermal noise power is 1.025×10^{-16} watt. On the assumption of 10-db preamplifier gain, 10-db noise figure, and unity power gain in the converter, the noise voltage across the 10,000-ohm converter plate load is 32 microvolts.

This noise must be amplified to the 1-volt level in three i-f stages. The required gain is 31,200 overall or 31.5 per stage. This gain is readily obtained at 15 megacycles using tubes of the 6AU6 type.

Typical operation for the 6AU6 is as follows: $E_b = E_{c2} = 100$ volts, $E_{c1} = -1$ volt, $I_b = 5.2$ ma, $I_{c2} = 2.0$ ma., $G_m = 3,900 \mu\text{mho}$. Using these parameters, the load resistance for a gain of 31.5 is 8,090 ohms.

Four tuned circuits enter the bandwidth considerations. These are the converter plate tuned circuit and the three i-f amplifier tuned circuits. The converter plate tuned circuit will be considerably broadened by the plate resistance of the

6J4 converter and the last i-f tuned circuit by the loading action of the limiters. From these considerations, only the first two i-f amplifier tuned circuits determine the total bandwidth.

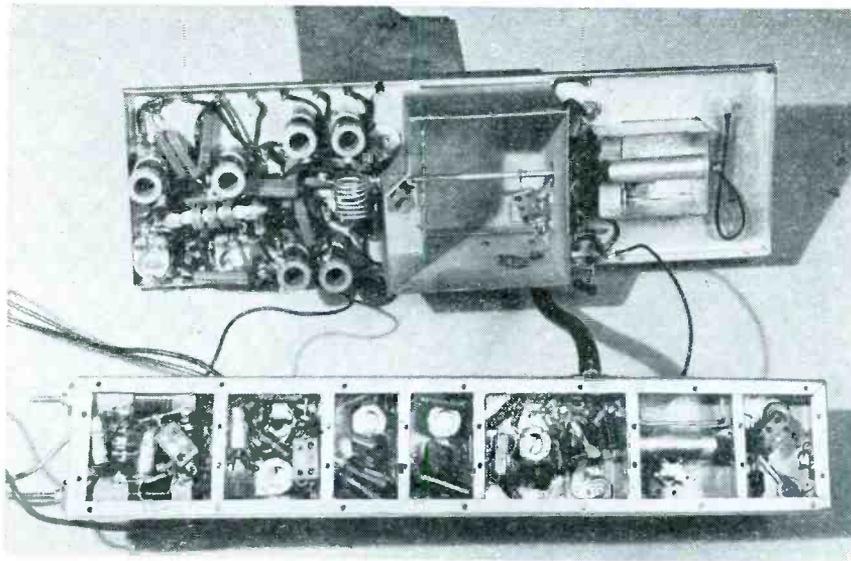
For two single-tuned circuits, the bandwidth factor for 3-db down is 0.64, making the bandwidth per stage 390 kc.² This requires a circuit Q of 38 and a capacitance of 50 μmf per stage for the desired bandwidth and gain.

Circuit Details

Limiting is accomplished by two 1N35 germanium diodes biased at 0.5 volt. The limiter clips both positive and negative peaks exceeding 0.5 volt. This circuit is about equivalent to two stages of conventional limiting.

The limited signal then is fed into another 6AU6 i-f amplifier which drives a Foster-Seeley discriminator employing 1N35's as detectors. An inverse frequency network is included for reception of a phase-modulated carrier.

Figure 1 shows the complete



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Underview of transmitter and receiver, showing coupling to transmitter doubler cavity resonator for receiver local-oscillator power. The two coil forms at left of the receiver (bottom) form the discriminator transformer

Citizens Radio Service

Circuit operation and construction details for a 465-megacycle superheterodyne receiver for operation in conjunction with the transmitter described in November 1947 *ELECTRONICS*. Grounded-grid input, cavity resonators, and crystals in limiter and discriminator aid in design of a small-size unit for portable operation

block diagram of the receiver and Fig. 2 is the schematic diagram, without the audio system. The received signal is fed in the receiver from the antenna coaxial transmission line to the input jack, J_1 . The input is tuned by L_1 a short length of transmission line, and the tube input capacitance. No tuning adjustment is required as the Q of the input circuit is extremely low due to the low driving impedance of the 6J4 grounded-grid amplifier V_1 .

Impedance matching is accomplished by tapping down the line,

* The equipment described was produced by Mr. Hollis as an independent consultant to the McGraw-Hill Publishing Company. For a full account of *ELECTRONICS* Citizens Radio Project, see p 80 of the November 1947 issue.

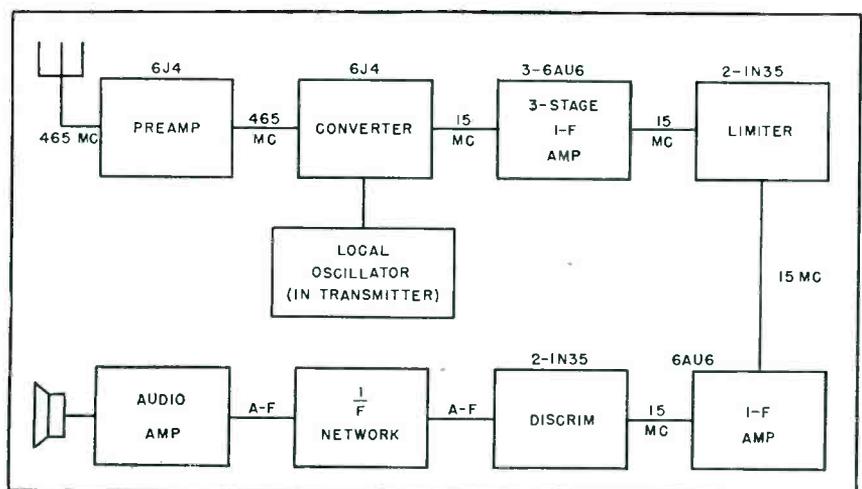
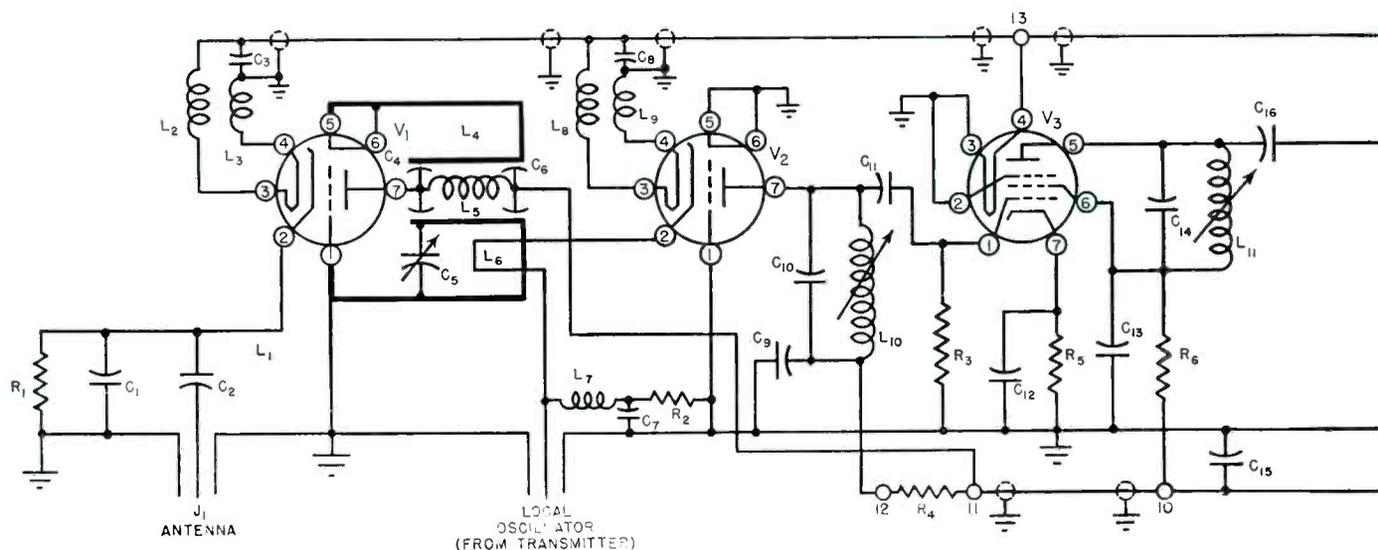


FIG. 1—Block diagram of the receiver. Power supply and a-f circuits are separate from the chassis illustrated in the accompanying photographs



R_1, R_{14}, R_{16} —100, 1/2 w, Allen-Bradley
 R_2 —390, 1/2 w, Allen-Bradley
 R_3, R_{15}, R_{24} —470,000, 1/2 w, Allen-Bradley
 R_4 —1,000, 1/2 w, Allen-Bradley
 R_5, R_8, R_{11}, R_{18} —130, 1/2 w, Allen-Bradley
 R_6, R_9, R_{12}, R_{19} —7,500, 1/2 w, Allen-Bradley
 $R_7, R_{10}, R_{17}, R_{20}$ —50, 1/2 w, Allen-Bradley
 R_{13} —30,000, 1 w, Allen-Bradley
 R_{21} —22,000, 1/2 w, Allen-Bradley
 R_{22}, R_{23} —100,000, 1/2 w, Allen-Bradley

$C_1, C_3, C_4, C_6, C_7, C_8, C_{37}$ —1,000 μmf , Erie button mica, Type 370BB
 C_2 —10 μmf , silvered mica
 C_5 —3–15 μmf , E. F. Johnson, type 160–107
 $C_9, C_{12}, C_{13}, C_{15}, C_{17}, C_{18}, C_{20}, C_{22}, C_{23}, C_{24}, C_{27}, C_{28}, C_{29}, C_{30}, C_{31}, C_{33}$ —5 μmf , Centralab Type D6–502
 C_{11}, C_{14}, C_{19} —36 μmf , silvered mica
 $C_{11}, C_{16}, C_{21}, C_{26}, C_{32}$ —430 μmf , silvered mica
 C_{25} —20 μmf , silvered mica
 C_{34} —3 μmf , silvered mica
 C_{35}, C_{36} —100 μmf , silvered mica

FIG. 2—Detailed circuit of the receiver showing values of compo-

L_1 . Capacitor C_2 is provided for d-c blocking when used with an antenna or signal generator having a d-c return.

The plate resonator circuit for the grounded grid preamplifier consists of L_4 and C_5 . These constitute a resonator similar to that used in the transmitter and shunt fed through L_5 , C_4 , and C_5 . Grid bias is supplied by R_1 , bypassed by C_1 . Chokes L_2 and L_3 , bypassed to ground by C_3 , place the filament at cathode potential.

The converter, V_2 , is another 6J4 operated with grounded grid. The amplified signal is inductively coupled from the preamplifier plate resonator through coupling loop L_6 . Local oscillator power is fed in series with the amplified signal.

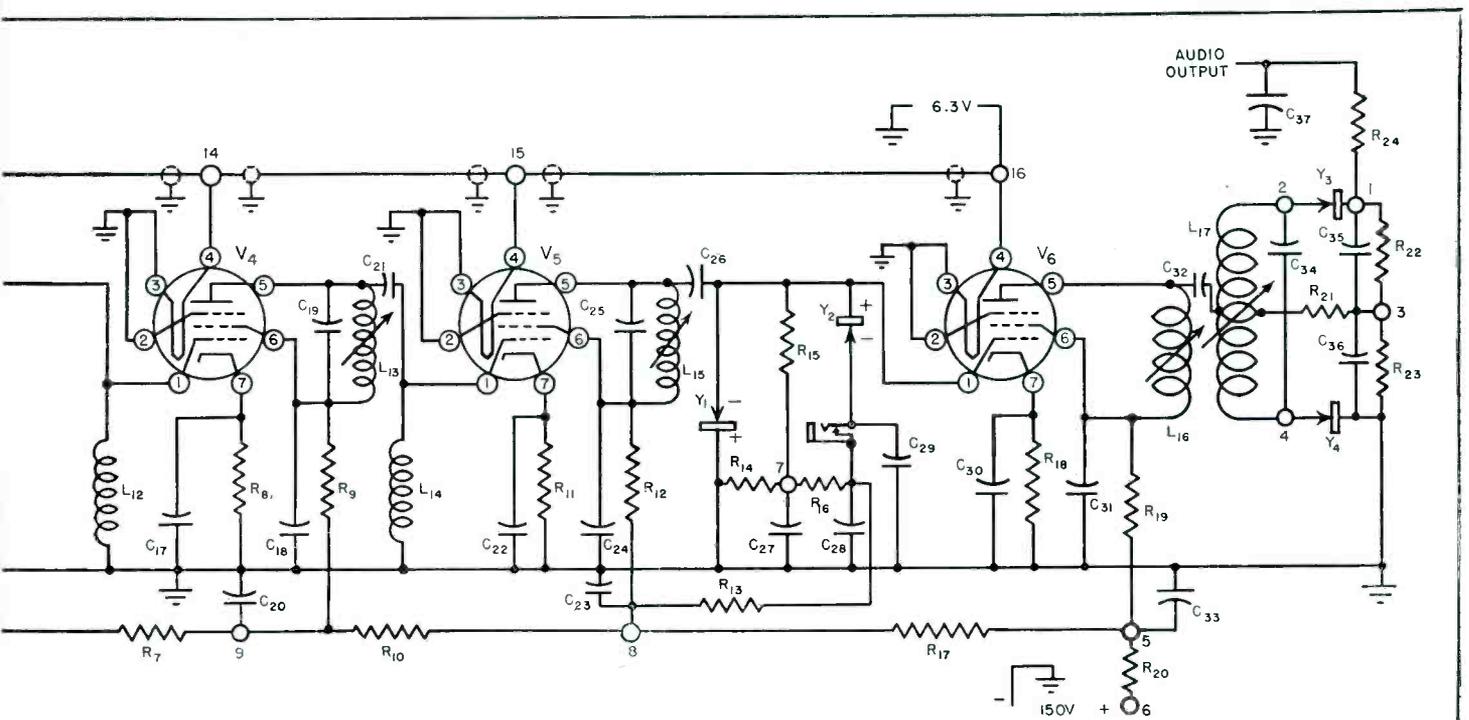
The oscillator voltage is developed across self-resonant choke, L_7 . Grid bias is developed across R_2 , bypassed by C_7 . Local-oscillator power is fed in at half frequency (225 mc) and doubling is accomplished in the converter.

The intermediate frequency of 15 mc is developed in the plate resonant circuit, L_{10} , C_{10} . Plate decoupling is accomplished by R_1 , C_9 . The i-f signal is coupled into the grid of the first i-f amplifier, V_3 through C_{11} , R_3 . Tube V_3 is a 6AU6 operating as a normal pentode amplifier. The amplified i-f signal is developed across L_{11} , C_{14} . Plate decoupling is accomplished by R_6 , C_{13} ; grid bias is developed across R_5 , bypassed by C_{12} . Coupling to the second i-f stage is through C_{10} , L_{12} .

The second and third i-f stages, V_4 and V_5 are identical with the first. Inductors L_{12} and L_{14} are self-resonant grid chokes employed to provide zero audio gain to overcome a troublesome audio oscillation due to feedback through the plate decoupling networks.

The signal level in the third i-f plate circuit L_{15} , C_{25} is sufficient for limiting. The limiter is coupled through C_{26} and R_{15} , and consists of two 1N35 diodes oppositely biased to 0.5 volt through the voltage drop across R_{14} and R_{15} , bypassed by C_{27} and C_{28} respectively. A dropping resistor R_{13} limits the current to 5 ma. A closed circuit jack is used for limiter current monitoring; C_{29} bypasses it to ground.

The fourth i-f amplifier, V_6 , is



L_1, L_4, L_6 —see text
 L_2, L_3, L_5, L_8, L_9 —12 turns No. 22 enameled, close-wound on 1/2-watt Allen-Bradley resistor, 100,000 or larger, dipped in Glyptal
 L_7 —15½ turns No. 22 enameled, close-wound on 1-watt Allen-Bradley resistor, 100,000 or larger, dipped in Glyptal
 $L_{10}, L_{11}, L_{13}, L_{15}$ —16 turns, No. 30, heavy Formvar, close-wound on Millen form No. 69041
 L_{12}, L_{14} —100 turns, No. 34 heavy Formex close-wound on Stackpole G-Y

core, 0.25 x 7/8", coated with Glyptal
 L_{16} —24 turns, No. 22 enameled, close-wound on National XR-50 form
 L_{17} —Bifilar winding, each winding 10 turns No. 26 heavy Formvar, double spaced
 Feed-through terminals 1 to 16—Vitro-seal Corp. Terminal No. 1901-9-L-HT
 J_1 —UG-58/U r-f jack
 J_2 —Closed-circuit phone jack
 V_1, V_2 —6J4
 V_3, V_4, V_5, V_6 —6AU6
 Y_1, Y_2, Y_3, Y_4 —1N35 crystal

nents. At current net prices, the cost of parts is approximately \$40

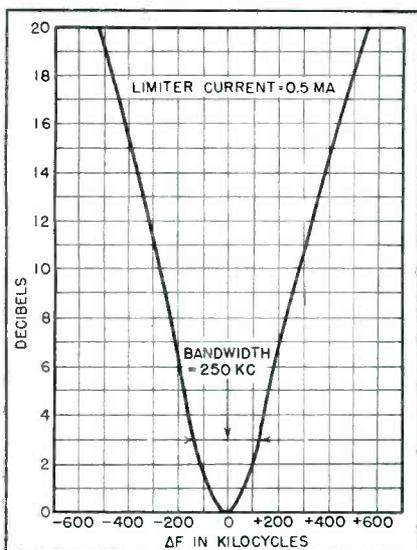


FIG. 3—Bandpass characteristic of the receiver i-f stages

driven by limited voltage. The output voltage is developed across L_{16} . This output voltage drives a Foster-Seeley discriminator consisting of $L_{17}, C_{35}, Y_3, Y_4, R_{22}, R_{23}, C_{30}, C_{37}$, and coupling elements C_{34} and R_{21} . Units Y_3 and Y_4 are 1N35 diode detectors. Opposing output voltages are developed across R_{22} and R_{23} . An inverse frequency network for reception of a phase-modulated carrier is formed by R_{24} and C_{37} .

Plate decoupling between stages is accomplished through $R_{17}, C_{23}, R_{10}, C_{20}, R_7, C_{16}$, and R_4, C_9 . The filter formed by R_{20} , and C_{33} effectively decouples any resonance in the plate supply.

As shown in the photographs the receiver chassis measures only

12¼ x 2¼ inches. All tubes and components are miniature. Each stage is individually shielded and the preamplifier plate resonator is built into the chassis. All i-f coils are slug-tuned and accessible for tuning from the top of the chassis, except for the discriminator coils which are accessible from the rear.

Performance

The assumed preamplifier and converter gain were not achieved. For the optimum adjustment of the r-f portion of the receiver, there are at least four interacting parameters to adjust. These are (1) output loop size, L_6 , which directly affects (2) the tap position on L_1 , and (3) local-oscillator drive power, a function of (4) the con-

verter cathode resistor, R_2 .

Another difficult-to-determine parameter is the impedance reflected at the signal frequency by the local oscillator across the choke coil, L_7 . The length of transmission line (5 inches) was chosen so that under assumed maximum limits of terminating loop inductance (tap on first doubler resonator), the input impedance at 465 mc would be a short circuit or a capacitive reactance. As choke L_7 presents a capacitive reactance at 465 mc, an inductive reactance presented at input to coaxial cable could produce resonance and absorb much signal power.

The r-f stages were adjusted in the following manner: A Measurements Corp. model 84 signal generator was connected through a coaxial cable to the input jack J_1 , and an 0-1 milliammeter plugged into J_2 . A loop size was chosen for L_6 and the local oscillator adjusted to produce a computed bias of 5.8 volts across R_2 . With sufficient output voltage from the signal generator to produce limiter current, the preamplifier tuning adjustment, C_5 , was adjusted for maximum limiter current. The local oscillator tuning was then adjusted for maximum limiter current. Several tap positions were then tried and the signal generator level for minimum detectable limiter current noted. This process was repeated for other loop sizes for L_6 . This process admittedly adjusts for maximum gain, not signal to noise ratio.

A loop size of $1\frac{1}{2}$ by $\frac{3}{8}$ inch made of No. 14 tinned copper wire for

L_6 was determined as a reasonably good adjustment. For this size loop, the antenna was tapped directly to the cathode terminal of V_1 . A bias voltage of 3.5 volts across R_2 was optimum and a detectable limiter current was observed from an input of 10 microvolts. An image rejection of 30 decibels was observed. A bench-to-bench talking test using a bread-board version of the transmitter described in the November issue of *ELECTRONICS* showed highly intelligible reception.

With no i-f regeneration, the gain was insufficient to obtain limiter current on noise. It was found, however, that the receiver was critical as to the grounding of the shield cover. The receiver is normally quite stable, but at times it was possible to obtain a slight amount of regeneration which brought the noise up to a readable level. Under these conditions, assuming no decrease in i-f bandwidth, the noise figure measured 20 decibels above theoretical.

Figure 3 shows the i-f bandpass characteristic. This was measured by feeding an i-f signal in at the local oscillator input. Under this condition, the converter stage operates as an i-f amplifier. This has a minor effect due to differences in the plate resistance between converter and amplifier operation. For this measurement, the limiter current was maintained constant at 0.5 ma. The ratio of input voltage expressed in decibels is plotted against deviation from the center frequency. The bandwidth for 3-db down is 250 kc, the objective.

Figure 4 shows the limiter characteristic. Output voltage as measured across R_{23} is plotted against limiter current. It is seen that effective limiting occurs above 0.1-ma limiter current. Increasing limiter current to 1.0 ma produces only 3.3-db more in output.

Figure 5 shows the discriminator characteristic taken at 0.5 ma of limiter current. The characteristic is essentially linear over ± 100 kilocycles. The slope at resonance is 0.08 volt per kilocycle, producing 2 volts peak for 25-kilocycle deviation, which is sufficient to drive a low-power audio amplifier.

Constructional Details

Figure 6 shows chassis details. The chassis is constructed entirely of 1/32-inch sheet brass. Each stage is enclosed within its own shield formed by partitions soft-soldered into the chassis. Each partition has a cut-out to clear the tube socket. The preamplifier plate resonator is formed by two partitions, into one of which a $1\frac{1}{8}$ -inch length of $\frac{1}{2}$ inch \times 1/32-inch wall brass tubing is soldered.

A shield cover of 1/32-inch sheet brass is securely fastened to the chassis with 3-48 screws. Two screws are used in each partition to produce a complete electrical shield between each stage. The chassis and cover are cadmium plated to resist corrosion.

Button mica capacitors and feed-through terminals are soft-soldered into the plated chassis. Units C_4 , L_6 and C_5 are then assembled into the center conductor of the resonator. Capacitor C_5 is mounted

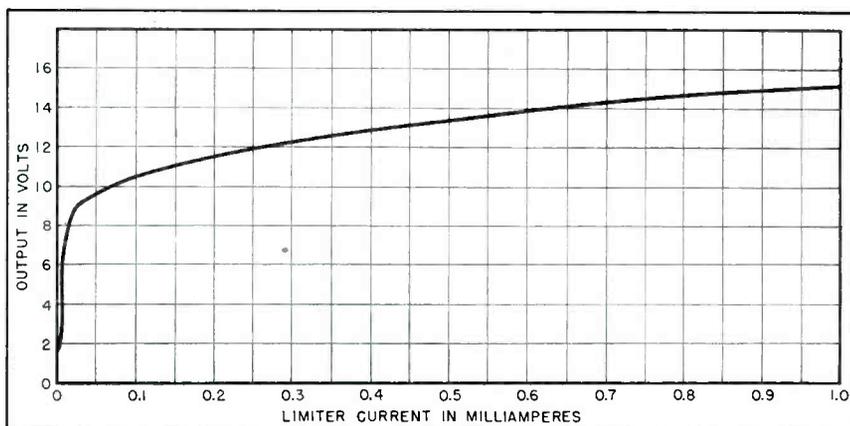


FIG. 4—Output voltage across R_{23} in the discriminator load circuit (Fig. 2) plotted against limiter current

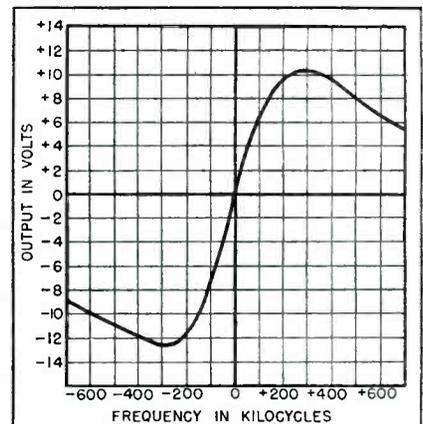


FIG. 5—Discriminator characteristic when limiter current is 0.5 milliampere

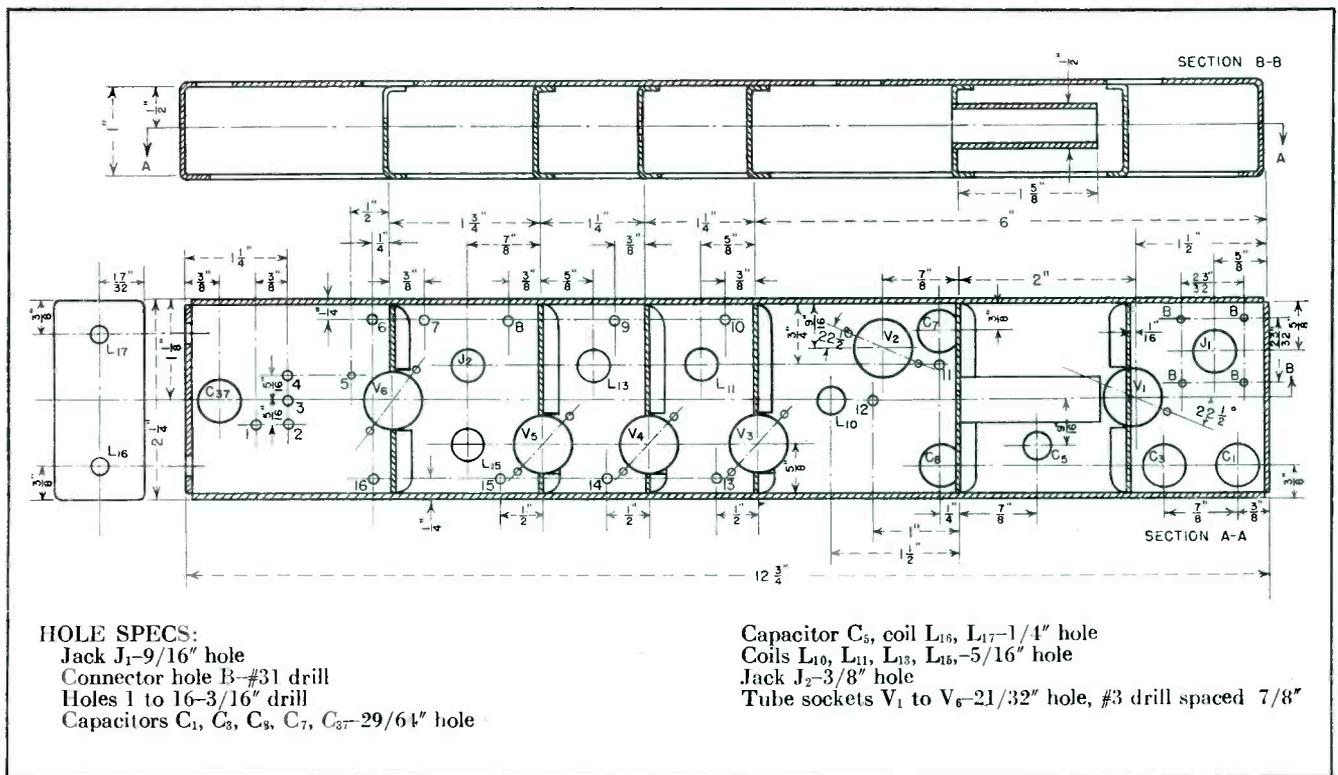


FIG. 6—Mechanical details of receiver chassis, including those of shield partitions. Section A-A at the right is the plate resonator of the r-f preamplifier stage

on the chassis and the uprights soldered to the center conductor. Coil L_1 is a length of No. 14 tinned copper bus wire spanning the cathode terminal of V_1 and the terminal on C_1 . It is spaced about $\frac{1}{4}$ inch above the chassis.

The components should next be mounted and the receiver wired in the normal manner. All grounds are made to the same point within each stage; for example, C_{12}, C_{13}, C_{16} , and L_{12} are all grounded to the same point as terminals No. 2 and No. 3 on the tube socket for V_8 , grounded to shield partition.

The secondary winding of the discriminator transformer, L_{17} , consists of two interlaced windings spaced one wire diameter. One set of opposite ends of the winding are tied together to form the center tap. The other set of opposite ends feed the 1N35 crystal diodes. This construction automatically permits the tuning slug to affect both windings nearly equally, thus maintaining an approximate inductance balance.

All shielded filament and plate leads are covered by copper-shielded wire, Precision Tube Co., No. 22 Lenz Aeroglas, in 0.101 OD by 0.009 wall tubing.

A signal generator tuned to 15 mc is connected to the local oscillator cable. Care must be taken to carefully shield this lead. A 0-1 ma meter is plugged into J_2 . Coils L_{10}, L_{11}, L_{13} , and L_{15} are tuned for maximum meter current. A high resistance d-c voltmeter is next connected from terminal No. 3 to ground and L_{16} tuned for maximum deflection. The voltmeter lead is then moved from terminal No. 3 to No. 1 and L_{17} adjusted for a null. This completes the i-f alignment.

A signal generator is next connected through a coaxial cable to the input jack, J_1 . Local oscillator power at 225-mc (4,166.667-kilocycle crystal) is fed in through the local oscillator coaxial cable by tapping the center conductor of the cavity resonator of the first doubler stage of the transmitter through a 10- μ f. mica capacitor, see Fig. 2.

The local oscillator power is adjusted to produce 3.5 volts across R_2 by adjusting the tap position or tuning of the first doubler of the transmitter.

One possible improvement, requiring no circuit change, is a reduction in the resistance of R_2 . The value of 390 ohms was computed on the basis of maximum

second harmonic space current at a d-c cathode current of 15 ma. An optimum bias voltage of 3.5 corresponding to 9-ma cathode current was observed. This indicates increased conversion transconductance could be achieved by reducing the value of R_2 , staying within maximum plate dissipation (2.25 watts) of the 6J4.

Another relatively simple improvement would be to change the 6J4 converter into a 15-mc grounded-grid amplifier. The input impedance would present approximately the optimum load for a silicon crystal converter which could be incorporated into the preamplifier resonator.

Acknowledgments

The author wishes to thank Herbert Hardy for his assistance in the mechanical construction of the chassis. Thanks are also due Gilman Andrews for his suggestions and criticisms during the design and test of the receiver.

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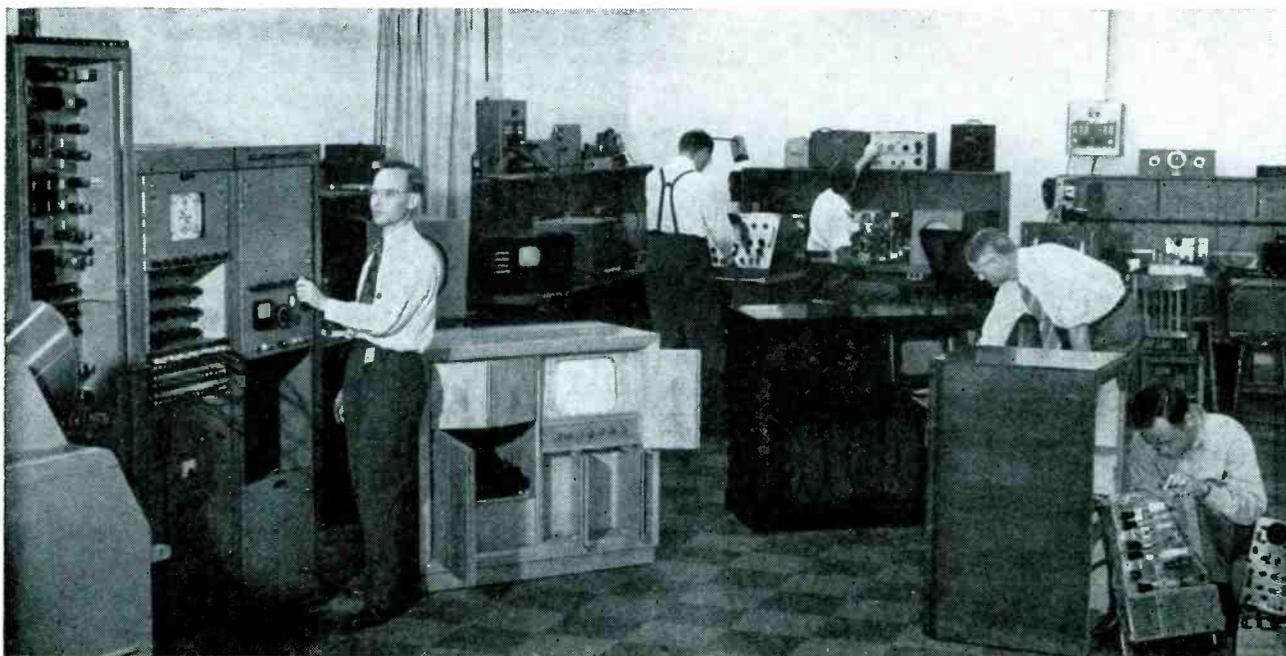


FIG. 1—In this view of the laboratory, the central test equipment racks illustrated in Fig. 2 appear at left. The line-isolation amplifiers are mounted on the walls

Television Receiver Laboratory

Design of test facilities, shielding, and filtering for a development laboratory. An oscilloscope adapter, line-isolating amplifiers, safety boxes for c-r tubes and the construction of the shielded room are among the features

IN THIS PLANT, the television receiver development program is carried out in part in the general laboratory area, with the main activity taking place in a special receiver room, a small camera room, two shielded rooms, and an adjacent space with impedance-measuring lines suitable for use at 40 mc to 250 mc.

The main television room is shown in Fig. 1. In addition to a number of 7, 10 and 15-inch direct-view receivers and one 10-inch indirectly-viewed experimental receiver, one 15 and two 10-inch diameter

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cathode-ray tubes may be seen on the benches in safety boxes. These are plywood boxes with sloping fronts, having a safety-glass window the full size of the tube screen. They are provided with readily adjustable deflection-yoke and focus-coil mounts.

In one safety box, a second focus

coil and deflection yoke have been mounted remote from those around the neck of the tube. By switching from one set of coils to the other (with brightness control turned down to avoid burning a spot on the screen) the undeflected, unfocused spot can be conveniently observed. This is of interest in studying asymmetry of the spot or proper adjustment of the ion-trap magnet. Connections to a receiver chassis can be made by using either binding posts or a multiple-pin connector mounted on the side of the box. The front section of the box is hinged and held

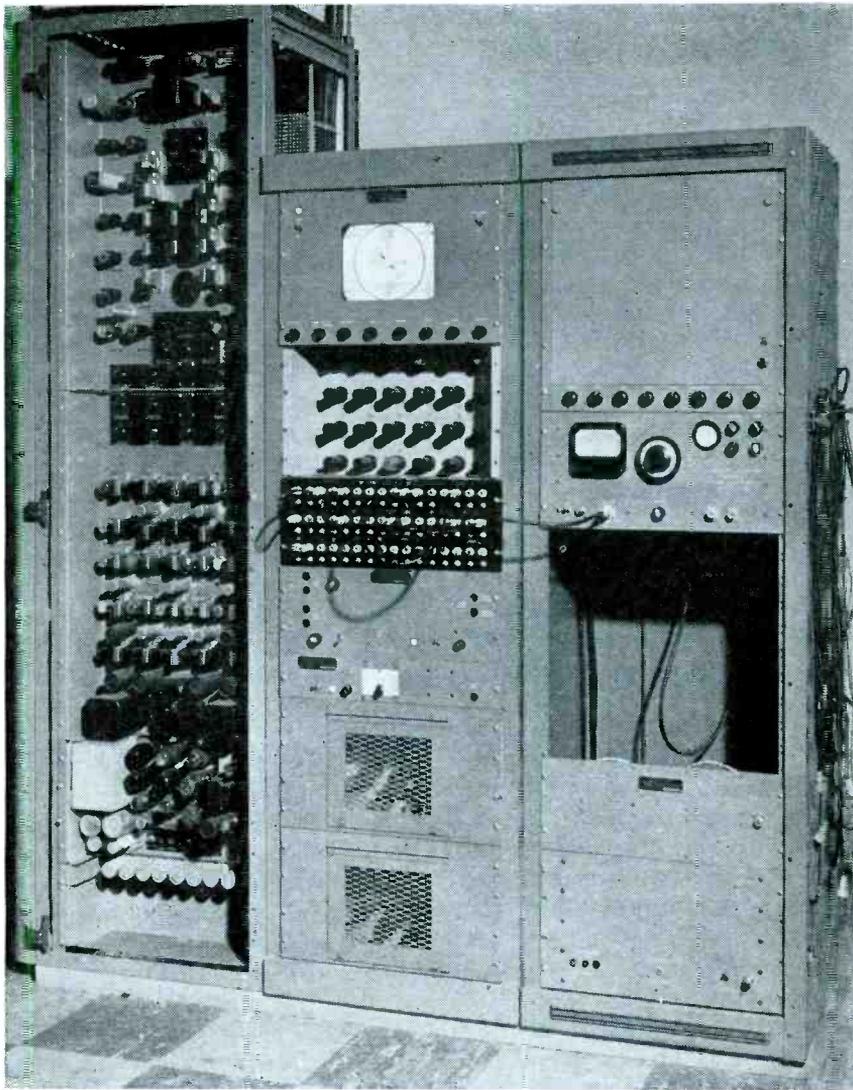


FIG. 2—Central receiver test equipment. The rack at left contains the sync generator. In the center rack are the laboratory picture monitor, distribution and line amplifiers, a linearity test generator, and picture monitor and monoscope camera power supplies. The right-hand rack mounts the monoscope, a transmitter, a noise generator, and line-isolation amplifier power supply

in place by convenient snap catches to facilitate changing tubes.

Curtains are provided for darkening one end of the room without affecting the rest of the laboratory. Fluorescent ceiling units provide over 20 foot-candles of illumination. Lights behind the curtains can be turned off separately, and, if desired, an incandescent unit in that area can be adjusted from its maximum light output to any lower brightness by means of a Variac.

Test Instruments

The first essential equipment of a television laboratory is a television synchronizing generator, preferably one complying with RMA standards¹. The second major requirement is a dependable source of picture signals such as those obtained from a monoscope or other test pattern which remains fixed while adjustments are made and

which can always be used to observe the geometric distortion, resolution, contrast, focus and general quality of the received picture.

An electrical bar or grating pattern generator is needed to accurately and rapidly adjust sweep linearity. The pattern generator signals provide a grating of horizontal and vertical bars accurately spaced in time. Thus their distances apart on the picture screen show the sweep speed averaged over each time interval between bars. The pattern can be chosen so as to produce squares when the aspect ratio is correct and then the linearity and amplitude of the sweeps can be quickly adjusted.

A monoscope camera (such as the one at the top of the right hand rack in Fig. 2) generally includes an amplifier which mixes blanking signals with the picture signal. Either its output or that of some

other camera or picture signal source is then put into a line amplifier where sync pulses are added to produce a standard RMA² composite picture signal. This composite video signal should then be monitored by a laboratory picture monitor and a waveform monitor. For complete receiver testing, a laboratory television transmitter is necessary if locally broadcast picture signals are not available.

A noise generator to provide a known and controllable amount of various types of noise, such as thermal noise, but more particularly impulse noise similar to ignition noise, is also needed to permit study of noise limiting and sync interference and other important receiver characteristics.

In Fig. 2, the RMA sync generator occupies the left-hand rack. Its outputs are made available both on the central racks and at seven line-isolation amplifiers mounted in boxes on the wall above the benches at convenient locations around the laboratory. These locations are connected through RG 59/U coaxial lines to the central racks. The coaxials and d-c power connections for each line-isolation amplifier are run in ducts mounted along the walls near the ceiling with branches down to each box. From each box two coaxial cables run directly to the central jack panel shown at the center of Fig. 2. Signals can be sent from any part of the room to any other location by making a suitable connection at the jack panel. This saves time and avoids having lines remain on the floor.

The picture on the monitor at top center of Fig. 2 is not retouched. The actual picture resolution and contrast as viewed directly are excellent, even with the room brightly lighted. An aluminized 10-inch cathode-ray tube is used at about 14 kilovolts, giving about 200 foot-lamberts brightness in the high-lights. A neutral density filter in

the safety glass over the tube has only 40-percent light transmission. The ambient room illumination is thus attenuated before it strikes the screen. Thus the picture still looks bright and the contrast is not appreciably impaired when the room is fully lighted.

A small broadband scope near the racks is used as a waveform monitor and doubles as a test oscillograph. However, it is desirable to have a rack-mounted waveform monitor which is always available when needed.

The test transmitter shown on the right-hand rack in Fig. 2 is crystal controlled for the desired channel. The output stage uses a grid-modulated 832A tube with a 2-inch c-r monitor directly connected to the plate coil. A balanced mutual-inductance type attenuator is used, giving a continuously adjustable output from 100,000 to 1 microvolt with a direct-reading dial. This balanced output appears on two coaxial jacks, at an impedance level of 50 ohms to ground from either side, or 100 ohms from side to side. This is very convenient in receiver testing.

Line-Isolation Amplifiers

The line-isolation amplifiers shown in the schematic of Fig. 3 have five type 6J6 tubes, one for each of the five independent circuits. Both plate and cathode-coupled outputs (either polarity of the applied signal) are available at coaxial jacks on the front of the box. The first three circuits are intended for pulse signals such as sync, blanking, camera driving, and the last two for

composite picture signals or camera output signals. Slightly different circuit values were used for convenience.

The polarity of the input signals on the first and last circuits are black negative so the output jacks are marked - on the cathode and + on the plate to indicate the output signal polarity. The middle three circuit jacks are marked with the + on the cathode and - on the plate to indicate whether the output is the same or the opposite polarity from the applied input.

The maximum output level is about 0.5 volt peak-to-peak if compression is to be avoided. This level is often insufficient, but a few booster amplifiers used on the bench as needed have been found satisfactory. Other engineers may prefer to use more distribution amplifiers whose outputs can be patched from central racks to any location desired. This line-isolation amplifier system provides a multiplicity of outputs always available at each location. Larger output tubes were not used because the total B current drain of the isolation amplifiers would become excessive.

The coaxial line to the amplifiers is looped into one after another, the amplifier inputs being simply bridged across the line except at the last amplifier, where the line must be accurately terminated to avoid reflections which may become serious if there is an appreciable mismatch. A small coaxial cable of the length used here has about 3-db loss at 5 mc. The output of the amplifiers is practically flat to beyond 5 mc except for the line loss, which is

not serious since the phase response is excellent.

Oscilloscope Adapter

An oscilloscope adapter is shown in Fig. 1 on the rear bench at the left-hand side. It may be conveniently used with any broad-band oscilloscope to increase its utility in television development work. Its schematic diagram is shown in Fig. 4. The adapter is used to supply a 60-cycle calibrating voltage to the input probe to compare in amplitude with the signal under test, and to supply a variable sweep voltage to provide sufficient sweep velocity to view only a few lines of a television signal. This is also adjustable in phase; any desired portion of the signal may be expanded for close examination. The unit also provides a double trace on the oscilloscope at a 30-cycle rate for study of the interlace of a television signal, and provides a broadband (6-mc) video mixing amplifier with two inputs.

The sweep-voltage waveform is a trapezoid, produced from a 60-cycle sine wave which is adjustable in phase over about 360 degrees. The slope or velocity may be varied to allow only a few lines of a television signal to be viewed if desired. Blanking for the oscilloscope is produced by differentiating the sweep to avoid bright spots on the screen where the beam would otherwise dwell during the time between the fast sweep intervals.

In using the unit, compression of the positive trace may occur due to nonlinearity in the amplifier if the trace separation is widened too far. The phase shifter is quite satisfactory but an autosyn resolver would give even more constant output amplitude and make it possible to adjust the phase continuously in any direction. The present arrangement is limited to 360 degrees and has a slight variation in amplitude with phase.

Shielded Rooms

The screen rooms are somewhat unusual in that hardware cloth with $\frac{1}{4}$ -inch mesh is used for both the inner and outer screens on the usual wooden 2 x 4 frames. The relatively open mesh permits excellent interior illumination by

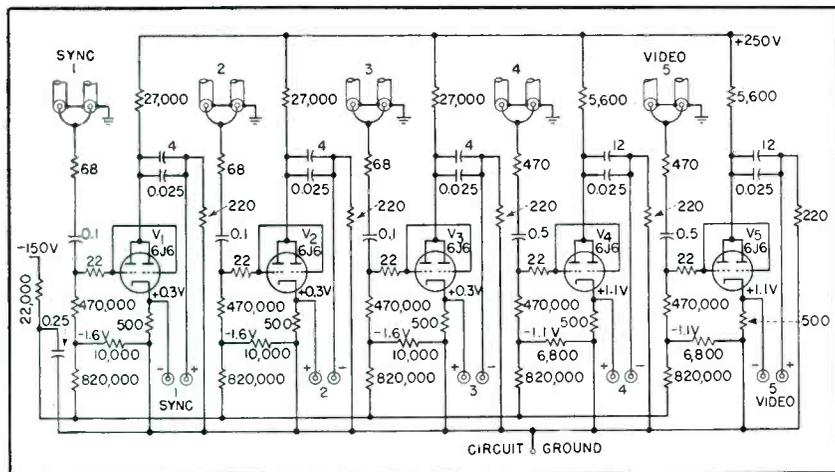
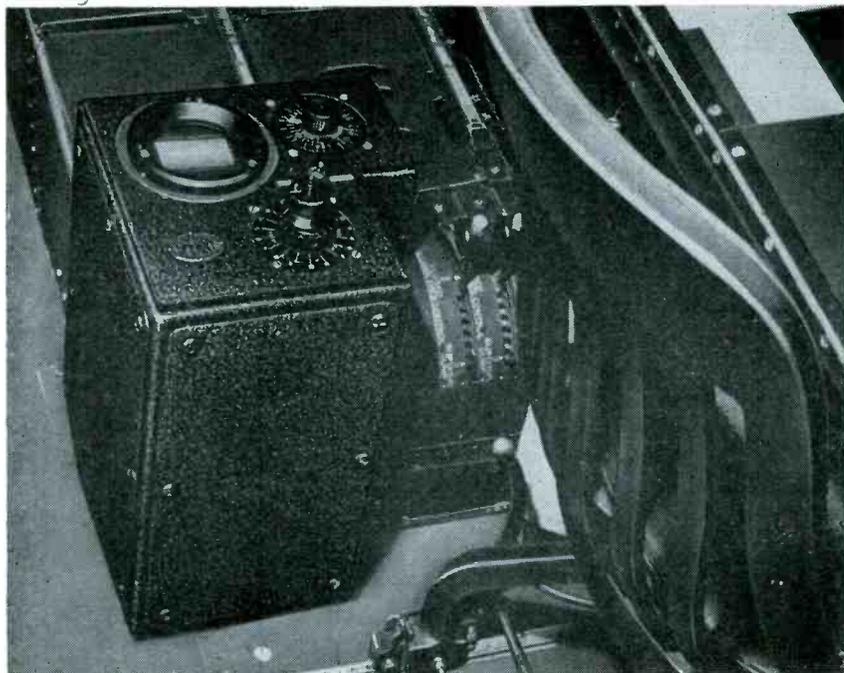


FIG. 3—Circuit of line-isolation amplifier

Airborne Engine Analyzer

Electronic instrumentation for aircraft engine trouble shooting insures greater safety and efficiency of operation. Special circuits provide cathode-ray display of ignition and vibration patterns regardless of engine speed



Engine analyzer installed in plane at rear of pilot's seat near flight engineer's desk

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fication of what might be termed vibration faults, such as detonation, incorrect valve clearances, and valve bounce. Records show that approximately 50 percent of all engine faults are caused by ignition troubles alone.³

It should be noted that the engine analyzer is installed as a permanent part of the aircraft's flight equipment and consequently is available not only to the maintenance crews while the ship is on the ground, but is also constantly available to the flight engineer so that he can check the power plant whenever he has an opportunity or whenever he believes a fault is developing. Experience has shown that checks made during actual flight often reveal faults not detectable by ground test methods.

Ignition Check

To understand how ignition faults are revealed it is necessary to discuss the operation of a typical aircraft-engine ignition system.

Without considering the details involved, we can state that at the instant the magneto breaker points are opened by the engine-driven magneto cam mechanism, a high value of magnetic flux has been built up in the iron core structure of the magneto by the action of the magneto's permanent magnet rotor. Then as the breaker points separate, this magnetic field suddenly collapses, generating a very high voltage in the secondary winding of the magneto which is connected to the

ALTHOUGH many engine malfunctions are not serious enough to prevent aircraft from flying, present-day commercial practice requires that all engines on even multi-engine ships be in as nearly perfect condition as possible before the plane is permitted to take off.

As a result of these high standards of maintenance, and because no easy, accurate, and rapid method has been devised to enable maintenance crews to quickly locate engine malfunctions, airlines have often found it necessary to withhold an aircraft from active service for many hours and even days because one or more causes of engine irregularities could not be located.

Estimates of the loss in revenue to an airline caused by the grounding of a large ship range as high as \$37,000 per day.¹ Although in some cases this constitutes merely a

paper loss it is none the less true that the dollar loss caused by an aircraft being grounded is considerable, and when added to the passenger ill-will invariably incurred when flights are delayed or cancelled the situation becomes of considerable importance to any first-class airline.

The importance of the problem has been recognized for some time, and much work has been done in the development of methods designed to expedite maintenance work to the utmost.

Functions Performed

The two principal functions of the engine analyzer² are: the location and identification of engine ignition system malfunctions such as fouled plugs, faulty magneto capacitors, and grounded high-tension leads; and the location and identi-

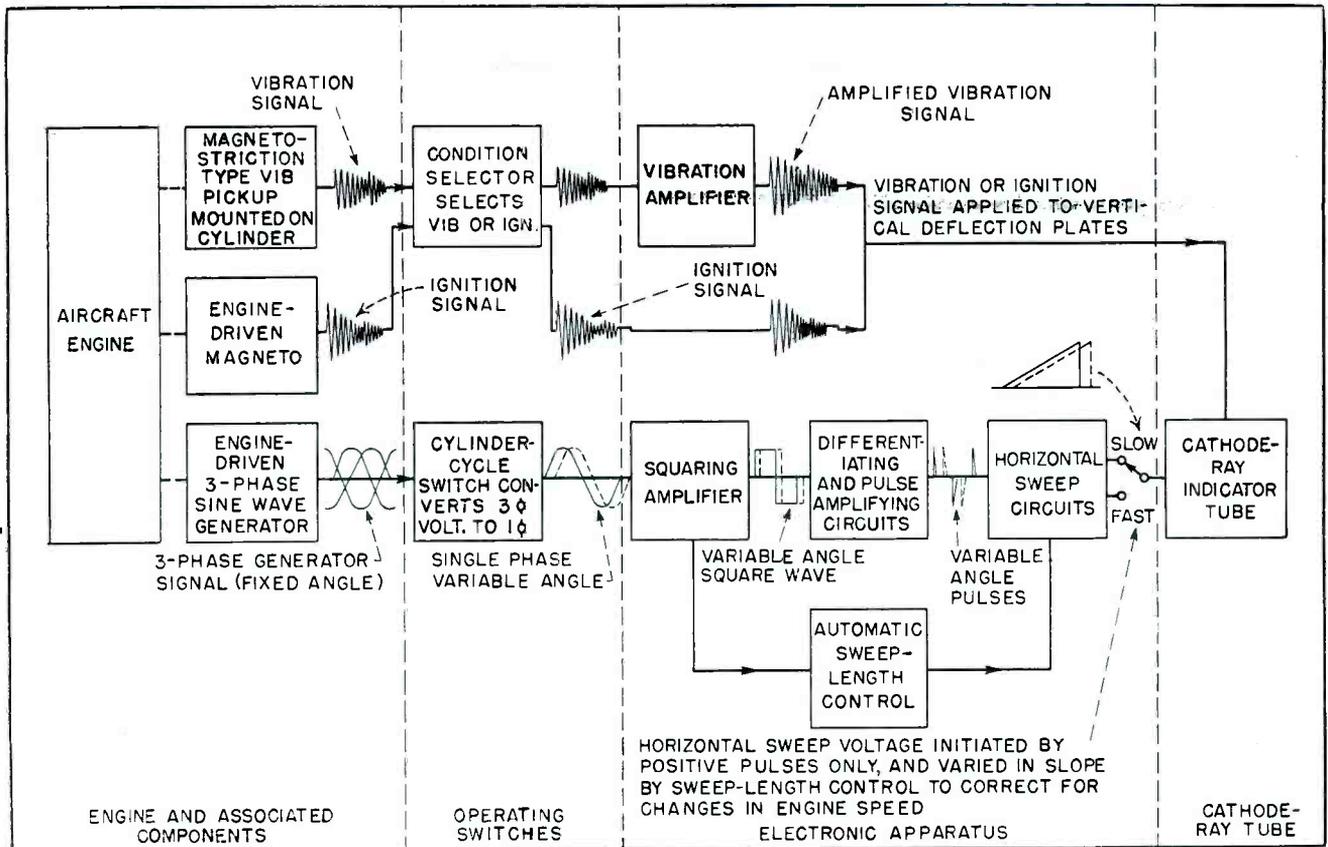


FIG. 2—Block diagram of engine analyzer

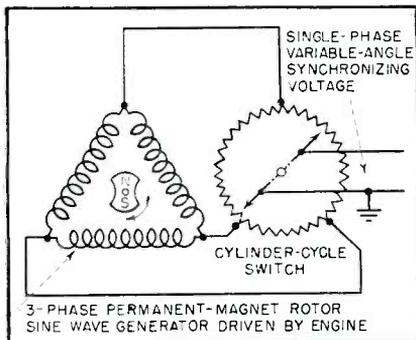


FIG. 1—Simplified circuit diagram of synchronizing voltage generator

spark plugs through the distributor. It is this voltage that fires the spark plugs.

During the time that the breaker points are open and the spark discharge is taking place the engine analyzer makes its analysis of conditions existing in the ignition system. The spark discharge sets into motion a highly oscillatory circuit. This circuit comprises the resistance and inductance of the magneto primary as well as the primary capacitance located in parallel with the breaker points. The circuit also

includes the resistance, inductance and stray capacitance of the secondary circuit, including the effect of ionization in the spark-plug gap, and the breakdown and extinction voltages of the plug. The characteristics of the oscillation will be determined by these quantities and it follows that if one of them, say the secondary resistance, should change from its normal value to some higher or lower value, then the resulting oscillation would suffer a change in one or more of its characteristics such as its frequency, or rate of damping.

It has been found that in ignition systems nearly all of the common malfunctions are accompanied by some significant change in one or more of the electrical parameters constituting the oscillatory circuit. Consequently, it is necessary only to establish the oscillation characteristics occurring in a completely normal engine, and then to establish, similarly, the characteristics produced by the various ignition malfunctions. The effect of the malfunctions upon the oscillation

characteristics have been studied by building in various faults such as fouled plugs on a test engine.

Breaker-Point Voltage

In order to study the oscillations, it is necessary to specify a method of measuring them. In the engine analyzer this is done by measuring the voltage appearing across the breaker points during the time they are open, and the actual evaluation of the characteristics is made visually by observing the resulting ignition patterns on a cathode-ray type indicator. The voltage across the breaker points is chosen because it rarely exceeds 200 volts.

It should be noted that an isolating resistor of several thousand ohms value is placed between one of the magneto breaker points (the other breaker point being grounded in a normal engine installation) and the analyzer. This resistor prevents any short circuit or ground condition that might occur inside the analyzer from affecting the operation of the magneto.

Analysis of vibration faults re-

quires use of a magnetostriction-type vibration pickup. The essential parts of this device are a small permanent magnet surrounded by a winding of many turns of copper wire, and a suitable housing to contain the magnet and coil. One end of the winding is connected to the case of the pickup which is subsequently grounded, while the other end is brought out by means of a helical spring connector and shielded cable arrangement. The entire unit is mounted on the outside of the cylinder, the threaded pickup stud being located in a hole tapped into the thermocouple boss. The stud does not go through the cylinder wall into the cylinder itself, but extends a short distance into the mounting boss.

As the engine operates, vibrations are set up in the cylinder walls; these vibrations in turn cause the entire magnetostriction pickup to vibrate since it is attached to the cylinder. The vibrations set up in the pickup produce stresses in the permanent magnet, and since this magnet is made of a highly magnetostrictive metal, these stresses cause the magnetic flux of the magnet to vary in intensity, inducing a voltage in the winding surrounding the magnet. This voltage is equal in frequency to the frequency of the vibration, and proportional in amplitude to the amplitude of the vibration. Consequently, by its strategic location on the engine cylinder, the pickup is able to produce a voltage which is characteristic of cylinder vibrations caused by detonation and valve bounce.

Sweep Requirements

To understand the operation of the analyzer it should be noted that there are two voltages that must be displayed on a cathode-ray tube screen. These are the voltage from the magneto breaker points, and the voltage from the vibration pickup. Each of these signals is applied to the vertical deflection circuit of the cathode-ray tube. This leaves only the horizontal circuit of the cathode-ray tube to be considered.

In order to examine either the ignition or vibration voltages, it is clear that the patterns formed by these voltages must appear sta-

tionary on the cathode-ray tube.

Each complete pattern for a given cylinder, whether it be due to ignition or vibration, occurs once during each cycle of engine events. The initiation of the horizontal sweep of the cathode-ray tube is synchronized with the rotation of the engine. As the engine rotates through one complete cycle of events (two revolutions) the horizontal sweep is initiated, and the pattern appears stationary. Furthermore, if the sweep speed is such that during two revolutions of the engine the electron spot moves from the left to the right side of the tube, then it is clear that the ignition patterns for all the cylinders will appear one after the other along the tube face.

The patterns will begin at the left with the pattern for the cylinder whose firing corresponds to the angular position of the crankshaft at the instant of initiation of the sweep. That ignition patterns for all the cylinders will appear on the screen is seen from the fact that in two revolutions of the engine the magneto breaker points must open a number of times exactly equal to the number of cylinders. One vibration pattern for one cylinder will occupy the entire length of the trace, since one complete vibration pattern requires two engine revolutions for its completion.

Figure 1 shows the circuit used in generating the signal which is ultimately used for initiating the sweep in proper synchronism with the engine. The generator is a small 3-phase permanent magnet alternator that is connected to one of the engine's auxiliary tachometer drives. The alternator is wound as a two-pole machine and hence delivers one complete cycle of alternating voltage per revolution of its rotor. Since the tachometer drive operates at half the engine speed, the frequency of the resulting 3-phase voltage in cycles per second is numerically equal to half the speed of the engine in revolutions per second. This 3-phase voltage is applied as shown to a continuous resistor wound uniformly in a circular configuration. The continuous resistor is arranged so that it is contacted at two points 180 degrees apart by two contact arms. These

contacts are insulated from each other electrically but are arranged so that they can be rotated around the continuous resistor as a single unit, one arm always remaining 180 degrees from the other.

Phasing Control

It can be shown that with an arrangement of this sort a single-phase voltage will appear across the two contact arms, the frequency of this voltage being equal to that of the 3-phase voltage and the phase angle with respect to the 3-phase voltage being dependent only upon the angular position of the two contact arms on the continuous resistor.

The contact arms are attached to a shaft equipped with a detent mechanism so arranged that as the shaft is rotated by means of a knob the contact arms are moved around the circular resistor in discrete steps. A dial used in connection with the knob is inscribed with numbers spaced over the 360-degree travel of the knob, one number for each cylinder. The numbers of the cylinders appear around the dial in the sequence of the particular engine's firing order. By turning the knob from one cylinder number to the next, the phase angle of the single-phase voltage across the contact arms is shifted with respect to the 3-phase generator voltage, or what is the same, with respect to the angular position of the crankshaft, by an amount equal to the number of crankshaft degrees between the occurrence of an event in one cylinder and the occurrence of the same event in the next cylinder.

The circular resistor, the contact arms, and the knob and dial arrangement are assembled as one unit known as the cylinder-cycle switch. For a given setting of the cylinder-cycle switch, the phase angle of the single-phase voltage with respect to the crankshaft will remain fixed regardless of variations in engine speed. This requirement obviously must be met in the present application, and represents the principal reason for using this type of circuit rather than one of many possible arrangements in which the phase shift would be dependent not only upon the setting of one or more circuit parameters,

but would also be a function of the varying frequency supplied by the generator as engine speed varies.

Block Diagram

The block diagram of Fig. 2 shows the complete operation of the analyzer.

Three signals entering the analyzer from the engine are the vibration, ignition, and 3-phase generator voltages. The vibration and ignition signals go into the condition-selector switch, where either one or the other is chosen by the operator. If ignition is selected, the signal is passed to the vertical deflection circuit of the cathode-ray tube. Since the amplitude of the voltage appearing across the breaker points is sufficient to produce ample deflection when applied directly to the cathode-ray tube, no amplification of the ignition signal is necessary. If the vibration signal is selected, it is passed through the vibration amplifier and then to the cathode-ray tube. Amplification is necessary because the normal output of the vibration pickup is only a small fraction of a volt.

The single-phase sine wave developed from the 3-phase generator enters a squaring amplifier followed by a differentiating and amplifying circuit that converts the square waves into one positive and one negative pulse each cycle. The positive pulses are used to trigger the horizontal sweep circuit once each cycle, or once for every two revolutions of the engine. These pulses trigger a conventional sawtooth sweep voltage that is applied to the horizontal circuit of the cathode-ray tube. In actual operation the generator is mounted on the engine in such a position relative to the angular position of the tachometer drive shaft that the resulting pulses derived from the cylinder-cycle switch and pulse-forming circuits will trigger the horizontal sweep at exactly the instant the magneto breaker points open to fire, say, the number one cylinder if the cylinder-cycle switch is set to that cylinder. In a like manner, setting the cylinder-cycle switch to any other cylinder will shift the position of the pulse in one direction or the other by the amount necessary to cause

initiation of the sweep to occur just as the breaker points open to fire that cylinder.

Having achieved the ability to initiate the sweep just as the desired ignition pattern is beginning to form, the sweep circuit has two adjustments such that instead of causing the electron spot merely to move across the tube face in two revolutions of the engine it will also move much more rapidly. Thus instead of seeing the ignition patterns for all the cylinders one after another, only the pattern of the cylinder being examined will be visible; but now the pattern will be greatly expanded horizontally (and may, indeed, be made to occupy the entire width of the tube face) thus facilitating analysis. The fast sweep is used mostly for ignition analysis where it is desired to expand the patterns considerably, while the slow sweep is used mainly for vibration analysis where it is more desirable to view the pattern for the entire cycle of cylinder events as one pattern rather than to have it broken up into a number of expanded sections. The slow

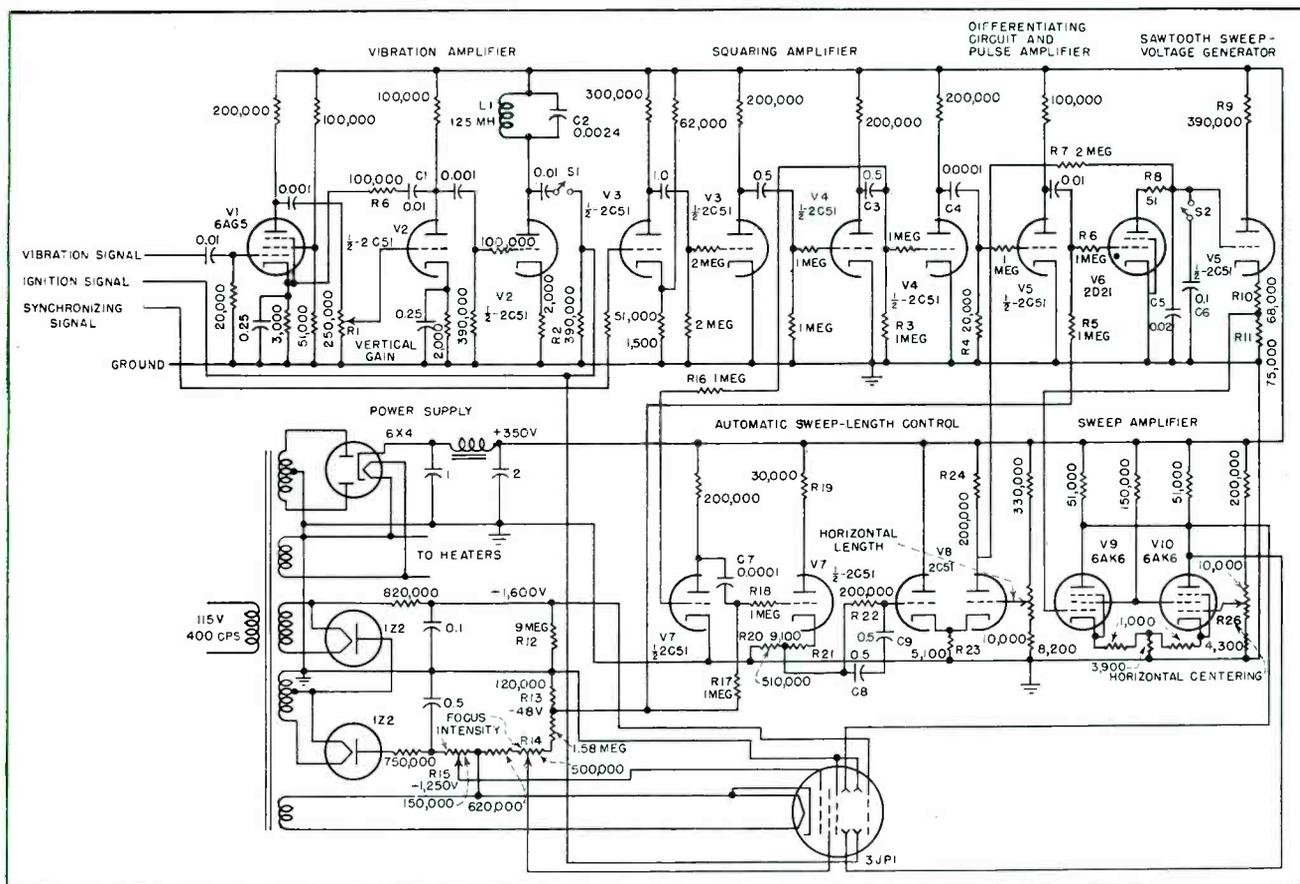


FIG. 3—Diagram of engine analyzer circuits. Value of capacitor C₁ is varied for different engines

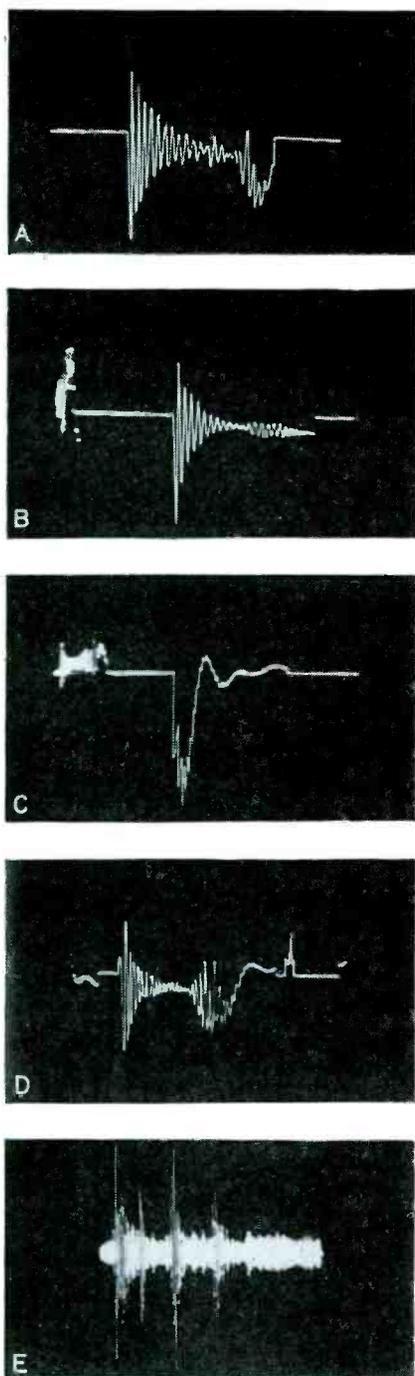


FIG. 4—Typical ignition patterns for (A) normal conditions, (B) fouled plug, (C) open secondary, (D) magneto breaker-point bounce, and (E) vibration pattern of a normal cylinder

sweep setting consequently provides a sweep requiring two revolutions of the engine for its completion.

If the sweep speed is maintained constant at either the fast or slow value the length of the horizontal trace will decrease as the engine speed increases. This effect results from the time between initiation of successive sweeps being inversely proportional to engine speed. For example, a 3-inch trace at 1,000 rpm

would shrink to 1-inch length at 3,000 rpm. To remedy this condition an automatic sweep-length control is included. In effect this circuit measures the speed of the engine by measuring the frequency of the 3-phase generator voltage and adjusts the sweep speed accordingly. As the engine speed increases the sweep speed increases correspondingly to maintain the length of the patterns constant.

Electronic Circuits

A simplified diagram of the electronic apparatus used in the engine analyzer is shown in Fig. 3. All the electronic circuits with the exception of the cathode-ray tube, which is located remotely are contained in one box measuring approximately $8 \times 10 \times 9$ inches.

The vibration signal is amplified by tubes V_1 and V_2 . The amplified signal appearing across R_2 is then applied directly to one of the vertical deflection plates of the cathode-ray tube, the other plate being grounded. The amplifier is entirely conventional except for the circuit consisting of inductance L_1 and capacitor C_2 . This circuit is tuned to resonate at about 10,000 cycles, causing the amplifier to peak at this frequency. It has been found that the cylinder vibrations associated with detonation and valve events occur in the band of frequencies lying between 5,000 and 15,000 cycles. The gain is adjustable from zero to approximately 10,000 by means of R_1 . Feedback between the first and second stages is provided by R_6 and C_1 . The switch S_1 is provided to disconnect the amplifier from the upper end of R_2 when the analyzer is used for ignition analysis; this is necessary since the ignition signal entering the electronic unit is conducted to the cathode-ray tube by the same circuit used for the vibration signal. In the actual analyzer this switch takes the form of a small relay which is operated by the condition-selector switch.

Considering now the single-phase variable-angle sine wave coming from the cylinder-cycle switch and entering the electronic apparatus, the voltage is amplified in the first section of V_3 and subsequently converted into a square wave by the

second section of V_3 and by the two sections of V_4 which follow. Capacitor C_4 and resistor R_4 serve to differentiate the square waves, producing positive and negative pulses. These pulses are amplified by the first section of V_5 , resulting in positive pulses of approximately 50 microseconds in duration and 150 volts in magnitude, and also negative pulses that serve no useful purpose. The positive pulses are used to fire the thyatron V_6 and are applied to its control grid through R_5 and R_8 . One end of R_5 is returned to R_{13} as shown. A potential of about 48 volts is developed across R_{13} and serves as the negative bias which maintains the thyatron in a non-conducting condition until a positive firing pulse arrives.

Sweep Length Control

The first section of V_7 is supplied with square waves from V_4 , the frequency of these square waves being equal to the frequency of the 3-phase generator. The square waves are amplified by the first section of V_7 and then differentiated by C_7 and R_{17} . The resulting pulses, both positive and negative, are applied to the grid of the second section of V_7 . Since one end of R_{17} is connected to R_{13} , the grid of the second section of V_7 is biased well beyond cutoff except when a positive pulse arrives. Since the positive pulses are about 150 volts in magnitude, the second section of V_7 is forced to conduct fully during the time the pulses are applied. This current flow through V_7 charges the combination of C_8 and R_{20} to a voltage the average of which is determined by the frequency of the pulses. Resistor R_{22} and capacitor C_8 serve to filter the voltage appearing across R_{20} , resulting in a smooth d-c voltage that is almost exactly proportional to the frequency of the pulses, or in other words, proportional to engine rpm. The time constant of this filter is about two seconds. The values R_{19} and R_{21} are so proportioned as to prevent the voltage between the cathode and heater of V_7 from exceeding 100 volts, which is the limit specified by the tube manufacturer. With this arrangement it has been found that the d-c voltage appearing across C_8 is virtually independent of varia-

tions in the tube characteristics.

The purpose of tube V_8 is to amplify the voltage appearing across C_5 . By properly choosing the values of the components used with V_7 and V_8 , it has been possible to make the voltage at the plate of the second section of V_8 almost exactly proportional to engine speed over a range of speeds from 1,000 to 3,000 rpm, and it is this voltage that controls the sweep length. This effect is accomplished as follows: the voltage at the plate of V_8 is applied through R_7 to capacitors C_5 and C_6 . Assuming these capacitors to be uncharged at the start, they will charge through R_7 in the usual exponential manner. The voltage appearing across C_5 and C_6 is applied to the cathode-follower circuit of the second section of V_8 . The output of this cathode follower is used to drive the sweep amplifier consisting of tubes V_9 and V_{10} , the plates of which are connected to the horizontal deflection plates of the cathode-ray tube. Two capacitors C_5 and C_6 , provide the fast and slow sweep speeds mentioned above. When the fast sweep is desired only C_5 is used, whereas when the slow speed is needed, switch S_2 is closed, adding C_6 . The velocity of the sweeps is inversely proportional to the value of capacitance in the circuit. Because only the linear initial portion of the exponential charging characteristic is required to effect the complete sweep from left to right, the sweep speed is nearly uniform and proportional to the voltage appearing at the plate of the second section of V_8 , which in turn is proportional to engine speed. Thus the sweep speed is proportional to engine speed and, since the time for one sweep is inversely proportional to engine speed, it follows that the trace length will remain constant even though the speed of the power plant varies.

As the capacitors charge and the sweep reaches the end of its travel, the engine completes the two revolutions started at the time the sweep was initiated, and the thyatron V_6 is fired by the pulse discussed earlier. The thyatron discharges C_5 and C_6 through current-limiting resistor R_8 and the process of charging repeats; thus a linear sawtooth sweep voltage is generated. Since

it is desirable to be able to adjust manually the actual length of the sweep that is to be maintained by the automatic control, resistor R_{25} is provided. By adjusting the potential of the grid of the second section of V_8 at some convenient engine speed, the plate voltage of that tube is set to give the desired length at that speed, after which the automatic action compensates for higher or lower speeds.

Horizontal centering of the entire trace is accomplished by adjusting R_{21} .

It should be noted that the components comprising the sawtooth generator, cathode follower and sweep amplifier were chosen so that: (1) the minimum voltage ever appearing on C_5 and C_6 at the end of the sweep would be sufficient to insure reliable firing of the thyatron when the pulse arrives; (2) the maximum voltage ever appearing on C_5 and C_6 would not cause excessive current to flow through the thyatron; (3) the maximum energy ever appearing on C_5 and C_6 would be low enough that it could be dissipated by V_9 and R_8 in a time that is very short compared to the shortest sweep time; (4) the sweep voltage applied to the cathode-ray tube would be linear under all conditions; (5) the maximum voltage between the cathodes and heaters of V_9 , V_8 and V_{10} would never exceed 100 volts; and (6) the maximum ratings of all components would not be exceeded under any condition.

The power supply used in this apparatus is conventional.

The focus and intensity of the cathode-ray tube are adjusted by R_{14} and R_{15} respectively.

Typical Results

The results obtained by use of the engine analyzer can best be shown by means of photographs of the cathode-ray screen while the analyzer was in operation.

Figure 4 (A through E) shows ignition patterns as they appear under various engine conditions. Space does not permit a detailed discussion of each photograph; however it has been possible to explain nearly all the patterns in terms of the electrical parameters of the ignition system. These photographs apply to a high-tension system, and

while the corresponding patterns for a low-tension system are somewhat different in form, they too can be analyzed and used in the identification of faults. While only photographs showing normal ignition, fouled plug, open secondary, and breaker-point bounce have been included, numerous other patterns are available showing such conditions as shorted secondary, large plug gap, small plug gap, shorted primary capacitor, no combustion, and magneto mistiming. Breaker-point bounce, (Fig. 4D) shows a pattern almost exactly like the one for normal ignition, except for the sharp pip near the end of the trace indicating that the points bounced open at that time after closing an instant earlier.

Figure 4E shows a typical normal cylinder vibration pattern. It will be noted that there are four distinct points at which the vibration rises to values considerably higher than the rest of the pattern. Counting from the left, these points represent (1) the closing of the exhaust valve; (2) the injection of the fuel; (3) closing of the intake valve; and (4) vibration due to combustion. When any of these cylinder events become abnormal, the particular portions of the pattern change greatly in magnitude. Thus when a cylinder detonates (knocks) the combustion portion of the pattern increases in height considerably. With a little practice, one can distinguish at a glance nearly any vibration abnormality.

Acknowledgment

The author wishes to acknowledge the helpful suggestions given him in the writing of this paper by J. W. Wheeler and R. W. Brown of the Engineering and Publicity departments, respectively, of the Sperry Gyroscope Co., and to thank Charles Plate of the Sperry Design department for his work in preparing the illustrations.

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Space-Charge Tetrode Amplifiers

Performance of developmental space-charge audio output tetrodes is compared with that of 6K6 pentodes, 6V6 beam pentodes, and 45 triodes in push-pull output stages of high-quality amplifiers. Developmental tubes not only outperform other types, but also require less costly components and simpler circuits

IN THE AUGUST 1947 issue of *ELECTRONICS* W. S. Brian described a space-charge grid power output tube that he had developed. In cooperation with Brian, a number of tests were made in which the performance of these tubes in a high-quality amplifier was compared with that of some standard tubes. It is the purpose of this article to report the results of these tests.

An amplifier was constructed in which provision was made for changing the output tubes, everything else remaining the same. Four

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sets of output tubes were tested—the 6K6 as representative of a pentode, the 6V6 as a beam tetrode, the 45 as a triode, and the new space-charge tubes under discussion. The 6V6 and the 45 were used, rather than the 6L6 and 2A3, because their power capacity is of the same order as that of the space-charge tubes available.

The standard type tubes were

quite well matched; the space-charge tubes were quite badly mismatched, one tube having about twice the power output of the other. This circumstance was accidental, having arisen from the fact that two tubes of the better type were not available among the experimental models constructed. Therefore, the results for the space-charge tubes, while significant, are by no means optimum.

The nominal rating of the space-charge tubes used was 2 watts per tube. Since these tubes are operated strictly as class-A amplifiers, the push-pull amplifier was rated at 4 watts. The 6V6 tubes are rated in the tube manuals at 14 watts under the conditions used in these tests, 6K6's at 9.8 watts, and the 45's at 12 watts. In these experiments, even when allowance was made for the losses in the output transformer, the pentodes and beam power tubes failed to deliver rated power.

Measurements were made on all four amplifiers of both harmonic and intermodulation distortion versus power output. The optimum load resistance was first determined experimentally and that value used for the measurements. In the case of the three standard tubes, the load resistance thus determined agreed very closely with the published values. The push-pull, space-charge-tube amplifier gave the greatest power at the lowest distortion with a plate-to-plate load of 20,000 ohms.

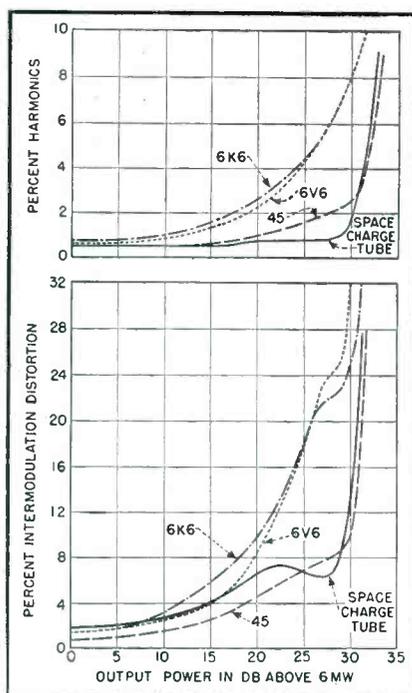
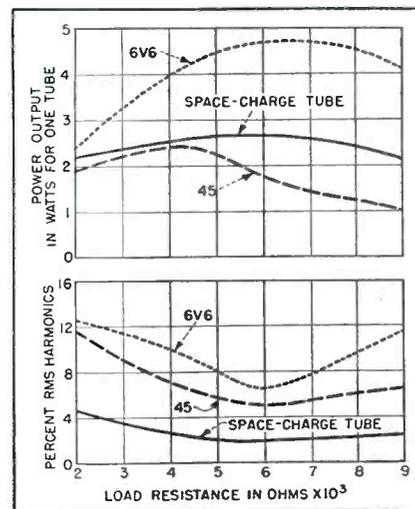
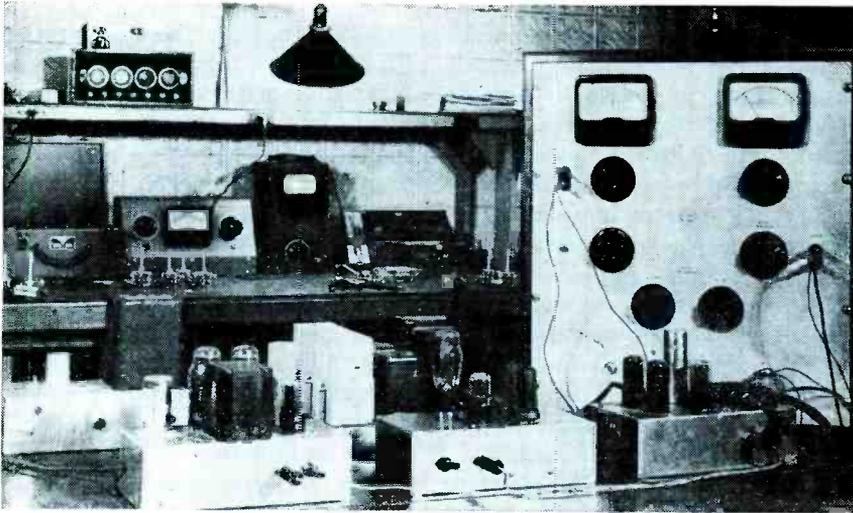


FIG. 1—Harmonic and intermodulation distortion versus output for resistive load

FIG. 2—Power output and harmonics show less variation for space-charge tubes





Three amplifiers undergoing comparison tests

Harmonic distortion was measured at 300 cycles by means of the high-pass filter method. The filter used to remove the fundamental had an attenuation of 60 db at 300 cycles, and less than 1 db at 600 cycles and above. The harmonic content was indicated on a vacuum-tube voltmeter reading rms volts. No attempt was made to analyze the harmonic content of the output waveform. Since the filter and vacuum-tube voltmeter were both flat to well above 20kc, it was assumed that all significant harmonics were included in the summation.

Intermodulation was measured on a Pickering Model 502 Intermodulation Distortion Meter. In this instrument, measurements are made at 100 and 7,000 cycles, with the low-frequency signal 12 db above the high-frequency signal. The percent intermodulation is specified as the degree of modulation of the 7-kc carrier after the low frequency has been filtered out.

It is felt by some engineers that harmonic distortion and intermodulation distortion measurements give essentially the same results, and therefore that there is no point in making both measurements. It is true that with a complete wave analysis and hours of laborious computation the intermodulation in an amplifier can be predicted. A simple harmonic distortion measurement, however, cannot indicate anything about the intermodulation, since the latter is dependent on the order as

well as the magnitude of the harmonics.

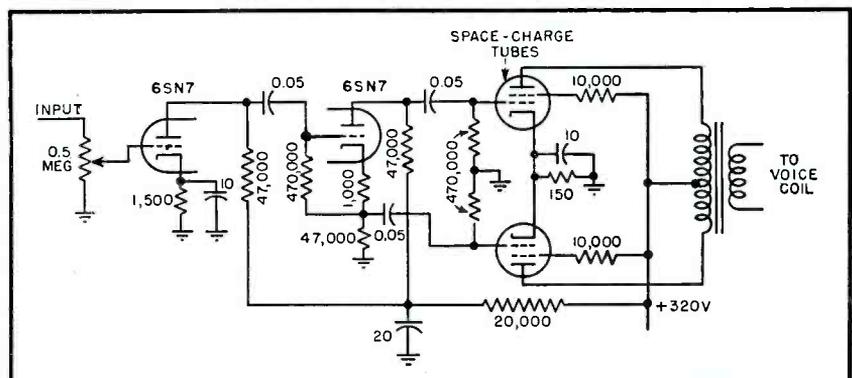
A word should be inserted here about the permissible limits of harmonic and intermodulation distortion for good quality amplifiers. For many years 5 percent harmonic distortion has been accepted as the tolerable limit for good amplifiers. This limit was found to be far too lenient for even medium-quality equipment, especially that using beam-power or pentode tubes, since 5 percent harmonics from these tubes is much more objectionable than 5 percent harmonics from triodes. Instead, it seems more practical to define a fair-quality amplifier as one having 2 percent total harmonics and 10 percent intermodulation, and a good amplifier as having 2 percent harmonics and 5 percent intermodulation. Judged by these ratings, many commercial amplifiers look pretty feeble.

Figure 1 shows the curves for harmonic distortion and intermodulation distortion in the four types of tubes. The bumps in the curves for the space-charge tubes are caused by the mismatch of the two tubes. It must be emphasized that these curves were plotted with the tubes working into a resistive load, with each pair working into its own best load resistance. To evaluate the performance of the amplifier working into a reactive load, such as a loudspeaker or cutting head, more extensive tests were made.

Comparison of Tubes

Characteristics of the four types of tubes used in these tests are given in Table I. Several interesting conclusions emerge from this comparison. Dynamic plate resistance, transconductance, amplification factor and plate supply voltage are listed merely to describe the tube and its condition of operation. The design engineer will find greater interest in the fifth heading, which shows that the drain on the power supply is greatest with the space-charge tubes. However, since these tubes are strictly class-A amplifiers, there is no rise of plate current toward full power output, the quiescent plate current being the maximum plate current; in the three other types of amplifier there is a plate current rise of from 10 to 30 ma at full power output. This plate current variation necessitates a power supply having fairly good regulation. The supply to the space-charge tubes can have a fairly high impedance without appreciable detrimental effect upon performance.

The ultimate power output repre-



Simplicity and low cost are features of this high-quality space-charge tetrode amplifier

sents the power that the load connected to the tubes must withstand in the event of accidental overload. Much more significant is the grid voltage required to obtain this power. Here the triodes compare badly, while the space-charge tubes are found to be even better than the pentodes and beam tubes, which are notably easy to drive.

The efficiency of an audio amplifier has been defined as the ratio of the power output with 5 percent harmonic content to the d-c power input.

The figures for power output at a given percentage of harmonic distortion are greatly at variance with the published literature on the standard tube types. These measurements were carefully made, and all recommended operating voltages adhered to very closely. It is felt that these conditions often prevail in practice regardless of the results obtainable in the tube laboratory.

At low values of harmonic distortion, the space-charge tubes are about twice as good as the triodes. The others are not even close to this standard of performance. However, from the intermodulation standpoint, the triodes are about 1 db better which indicates that the small amount of harmonic distortion in the space-charge tubes is of a higher order.

The figures for practical efficiency are rather remarkable, because they show the triode to be the most efficient.

The effective amplification highlights the weakness of the triodes, and also brings out the astonishing fact that the 6V6 with an amplification factor of 230 provides a useful gain of only 13.3. The space-charge tube, on the other hand, realizes a net gain of 16.6 with an amplification factor of 20. This is another advantage of low plate resistance.

The effective generator impedance, or damping factor, is a most important characteristic of a power amplifier that is used to drive a loudspeaker. This impedance should be low because the electromagnetic damping of a loudspeaker depends on circulating currents through the generator impedance. Furthermore, it is desirable, when working into a reactive load, to develop as nearly as possible a constant voltage. To

satisfy this requirement would demand a zero-impedance output stage, which is ordinarily impossible. In practice, however, a generator impedance equal to the nominal load resistance is satisfactory; a generator impedance less than this value is even better. The effective output impedance was measured by first observing the open-circuit voltage and then loading the amplifier until the voltage was reduced 6 db, or 50 percent. At this point the load resistance and generator impedance are equal.

Table I shows that the effective generator impedance is five times the load resistance for the beam-power tube, four times for the pentode, only 80 percent for the triode, and 50 percent for the space-charge tubes. This property of the space-charge tube makes the bass response cleaner and free from hang-over. It also prevents the voltage rise at high frequencies which is characteristic of the pentodes and beam-power tubes. It is primarily to obtain this damping effect that negative feedback is used with the latter types of tubes. To obtain the same damping effect with the 6V6 tubes which is inherent in the space-charge tubes 20 db of feedback is required.

Practical Amplifiers

Three complete amplifiers were constructed using push-pull 6V6's, 45's and space-charge tubes. Every effort was made to make each of the amplifiers of as high quality as possible. A great deal of difficulty was

experienced with the driver stage for the triode tubes. It was found impossible with ordinary voltage-amplifier tubes to drive the grids of the output tubes with a resistance-coupled phase inverter or even a resistance-coupled amplifier stage without having the driver overload before the output tubes did. Therefore, transformer coupling was used, adding considerably to the cost of this amplifier. Experience indicates that overloading of the driver is a common problem in triode amplifiers.

The output-transformer primary inductance is in shunt with the load, and at low frequencies increases the loading on the amplifier tubes. This effect reduces the amount of useful power applied to the load, and in the case of the triode and beam-power tubes, substantially increases the distortion at low frequencies. Figure 2 shows the manner in which power output and distortion varies with load for the three types of tube. The ability of the space-charge tube to ignore variations in

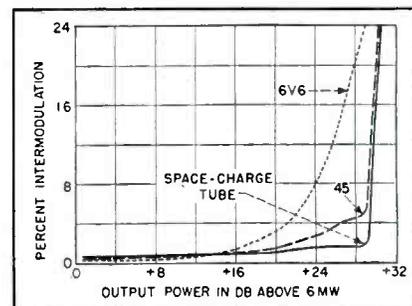


FIG. 4—Intermodulation distortion as a function of power output is shown for three amplifiers

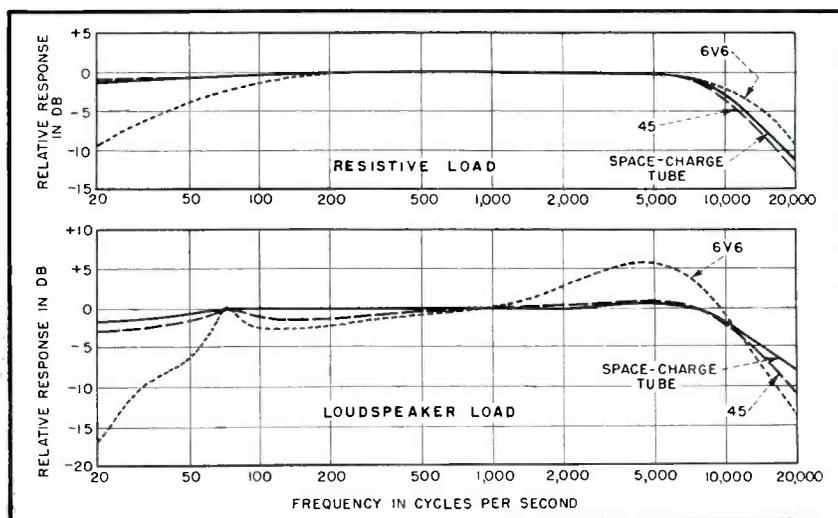


FIG. 3—These frequency response curves were obtained from amplifiers using three types of tubes with both resistive and loudspeaker loads

load impedance is an important advantage. No more primary inductance in the output transformer is required for the space-charge tubes than for the triodes. A value of 10 henries is quite adequate for response within 1 db to 30 cycles. The beam-power tubes, on the other hand, require at least twice the inductance for equivalent bass response into a resistive load. For the same core structure, the transformer for the space-charge tubes will have the same number of primary turns and half the number of secondary turns as the triode transformer. This construction will reduce the cost of labor and materials, at the same time reducing the I^2R losses in the secondary winding and reducing the leakage reactance. This is a case where something is had for nothing.

The measured frequency response of the three amplifiers with both resistive and loudspeaker loads is shown in Fig. 3. The same output transformer was used on all three amplifiers, the secondary taps being changed to match the various load impedances. The primary inductance was 15 henries, which is more than necessary for the space-charge and triode amplifiers, and less than desirable for the beam power tubes. The effect of a low generator impedance when working into a loudspeaker load can be seen clearly.

In order to conduct listening tests with any degree of similarity between pairs of amplifiers, it was necessary to equalize the 6V6 amplifier so that it had about the same high frequency response as the other amplifiers. This was accomplished by connecting a 10,000-ohm resistor in series with a 0.05- μ f capacitor from plate to plate of the 6V6 tubes. Little could be done about the low-frequency peak.

Another effect which showed up when switching from one amplifier to another was an apparent change in relative volume at low and high levels. When all amplifiers were adjusted for the same loudness at low levels, the space-charge amplifier sounded louder at high levels. Conversely, when adjusted on loud passages to the same loudness, the 6V6 amplifier was loudest at low levels. Measurements showed that the 6V6 amplifier departs from lin-

Table I—Comparison of Tube Characteristics

Tube Type	6V6	6K6	Space Charge	45
Dynamic plate resistance R_p at quiescent operating point, ohms	65,000	75,000	4,000	1,700
Transconductance g_m at quiescent operating point, micromhos	3,600	2,100	5,000	2,050
Amplification factor μ ($R_p \times g_m$)	230	150	20	3.5
Plate supply voltage E_b	285	285	325	325
Total cathode current I_c , milliamperes	74	62	110	92
Total d-c power supplied to tubes, ($E_b \times I_c$) watts	21.2	17.7	35.7	29.8
Optimum load resistance R_L , ohms	8,000	12,000	20,000	5,000
Ultimate power output, watts	12.5	8.5	11.0	13.5
Peak grid-to-grid volts for ultimate power output	42	54	36	150
Power output at 5 percent harmonics, watts	2.4	2.4	10.7	12.0
Power output at 2 percent harmonics, watts	0.32	0.50	6.6	3.8
Power output at 10 percent intermodulation distortion, watts	0.76	0.61	4.8	6.0
Efficiency as a-f amplifier, percent	11.3	13.5	30.0	40.0
Gain—actual amplification, $\mu R_L / (R_L + R_p)$	13.3	11.1	16.6	2.6
Effective generator impedance, ohms, 500 ohms load	2,500	2,000	250	400

earity almost 10 db below its peak voltage input. The space-charge tubes, on the other hand, are linear to within about 3 db of maximum input. The triodes depart from linearity somewhere between these levels. Naturally, this effect is closely related to distortion, because a nonlinear device is by definition both a harmonic generator and modulator.

It is interesting to examine the intermodulation distortion of the three amplifiers with loudspeaker load, shown in Fig. 4. Observe that the space-charge tubes, because of their ability to work well into a load of variable impedance, show the lowest intermodulation percentages. The triodes are very nearly as good, but the 6V6 tubes are considerably worse.

Comparison of Amplifier Costs

To perform as well as the triodes and the space-charge tubes, the 6V6's require at least 20 db of feedback. For this feedback, an additional stage of amplification is required and careful attention must be paid to phase shift within the feedback loop. In addition to these expensive modifications, the circuit requires a costly output transformer having a frequency range far in excess of the useful passband, in order to prevent oscillation. There is the additional point that

the same amount of feedback applied to an amplifier using space-charge tubes will improve it by the same factor.

The expense of the driver stage makes it difficult to construct a low-cost amplifier using triodes, even though the output transformer is less expensive than that for the beam power tubes.

Since inverse feedback is hardly necessary with the space-charge tubes, a high-quality amplifier can be built that is capable of supplying full power output over a wide frequency range from a grid input signal of 30 millivolts. Such an amplifier would need only three stages including the output tubes. Savings in the power supply result from reduced heater-winding capacity on the power transformer, and a reduction in the amount of plate-supply decoupling necessary. A suitable output transformer could be made for a retail price of about four dollars. The retail cost of the parts required to build a completely satisfactory amplifier, flat within 1 db from 30 to 15,000 cycles, with intermodulation of less than 5 percent at 10 watts, is less than twenty-five dollars, including tubes and power supply. The only drawback at present is the fact that the tubes are not yet available. It is hoped that they will be in production before too long.



Sensing element of the leak detector, a diode of unusual design employing positive ion rather than negative electron emission and operating in air

Leak detector with supersensitive nose, one example of an instrument utilizing a long-neglected principle to simulate another of man's senses



Electronics Simulates Sense of Smell

Platinum, heated to incandescence, freely emits positive ions in air and does not readily oxidize. Emission is increased when halogen vapor compounds, of which Freon and carbon tetrachloride are good examples, are present. Use is made of this principle to detect leaks

THE SCIENCE of electronics has provided instruments which, in a practical way and to a remarkable degree, give responses similar to the human senses. Examples of this are the microphone, which performs like the ear; the loudspeaker and its similarity to the voice; the phototube and the eye, and a number of instruments equivalent to the sense of touch.

The sense of smell, as the human nose operates in air, has to date not been well duplicated, although for certain specialized cases very sensitive detectors¹ have been developed. The device to be described is thermionic in its nature and is sensitive to a large variety of halogen compound vapors and air-suspended particles. It thus extends man's ability to simulate the sense of smell.

Engineers working with electron tubes understand negative electron emission. On the other hand, the emission of positive ions from a red-hot metal is not as well known, and little use has been made of this phenomenon.

Unlike electrons, which are simply basic units of negative electricity, ions are positively charged particles of some specific substance.

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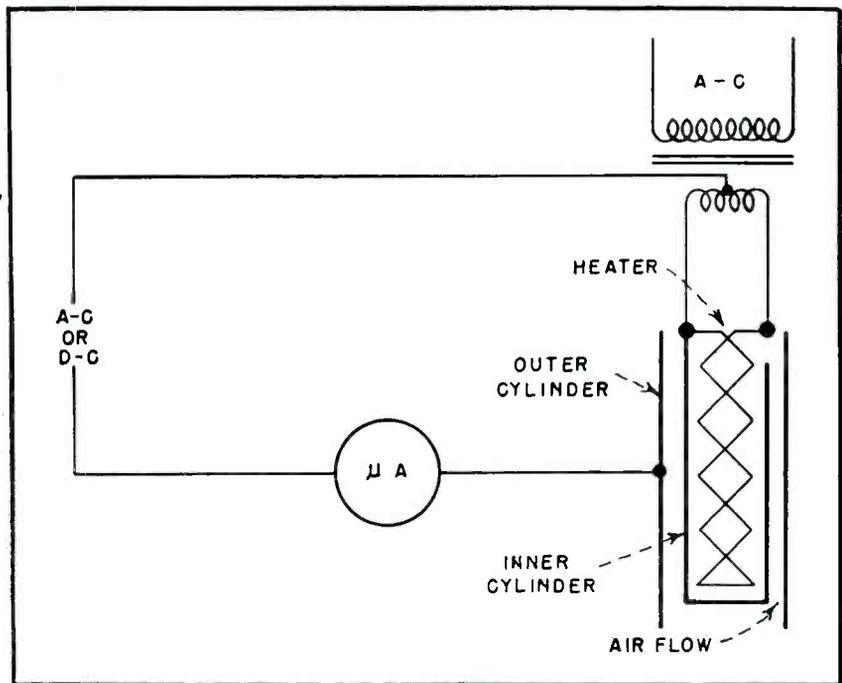


FIG. 1—Basic circuit of the new device

In general, emission of ions means a loss of material from the cathode emitting them. One unique feature of ion emission, however, is that it can be made to occur readily in the air.

Owing to the fact that platinum can be operated at a red heat with little oxidation and loss from evaporation, this metal is very useful as an ion-emitting source. The volume of ion emission from platinum varies greatly, depending upon temperature, area and nature of the surface, and purity of the metal. Ion emission current drops slowly with time, eventually reaching, however, a small but finite equilibrium value.

Twenty-five to fifty years ago, some scientific work was done on this phenomenon², but with the coming of electron tubes in their evacuated, sealed envelopes conduction in air was neglected for the newer, more intriguing, and simpler phenomenon of electron emission in a high vacuum. When early reports on conduction in air are studied it is soon realized that the experimental results obtained were very conflicting and the theories contradictory. In part this was due to the fact that electrical conduction through air is more complicated than in a high vacuum. There was also a less developed experimental

technique available to early workers.

Operating Principle

It has been found by C. W. Rice that the steady emission of ions in air is increased to a marked extent when certain vapors strike the electrode surfaces. In the presence of even a small amount of a halogen compound vapor there is a marked increase in ion current. There is also a marked increase in current when suspended particles, such as smoke, containing a halogen compound contact the electrode surface.

Thus the essential elements of a halogen compound vapor detector, shown in Fig. 1, are:

(1) A two-element sensing structure, one suitable arrangement being in the form of concentric cylinders. The vapor to be detected is passed between these two closely spaced cylinders. The inner cylinder or cathode is kept red hot by an internal platinum-wire heater and the outer cylinder or anode is operated at a negative potential.

(2) A means of forcing air containing the vapor to be detected between the cylinders at a constant low velocity.

(3) Low-voltage a-c for the heater and another supply delivering a few hundred microamperes at somewhere between 50 and 500

volts a-c or d-c for use as the inter-electrode potential.

(4) Sufficient amplification to make a small increase in d-c current due to ion emission variation readily detectable.

General Characteristics

One of the characteristics of the device under operating conditions is the small amount of current that flows even in the presence of pure dry air. This current is usually of the order of 1 to 10 microamperes. In the presence of an air-diluted vapor of a chemical element or compound to which the device is sensitive this current will increase several fold.

Sensitivity to a halogen compound vapor varies with the velocity of air flow between the two cylinders. With an air flow of the order of one inch per second or less there is an extreme sensitivity to some vapors of about one part in a million. With an air flow of more than one foot per second the sensitivity and response are reduced to a point where there is little response.

The device is very sensitive to carbon tetrachloride, chloroform and Freon (dichlorodifluoromethane). At room temperature it does not respond to Pyranol (chlorinated phenol) but, if the Pyranol is heated to 60 C or more the vapor

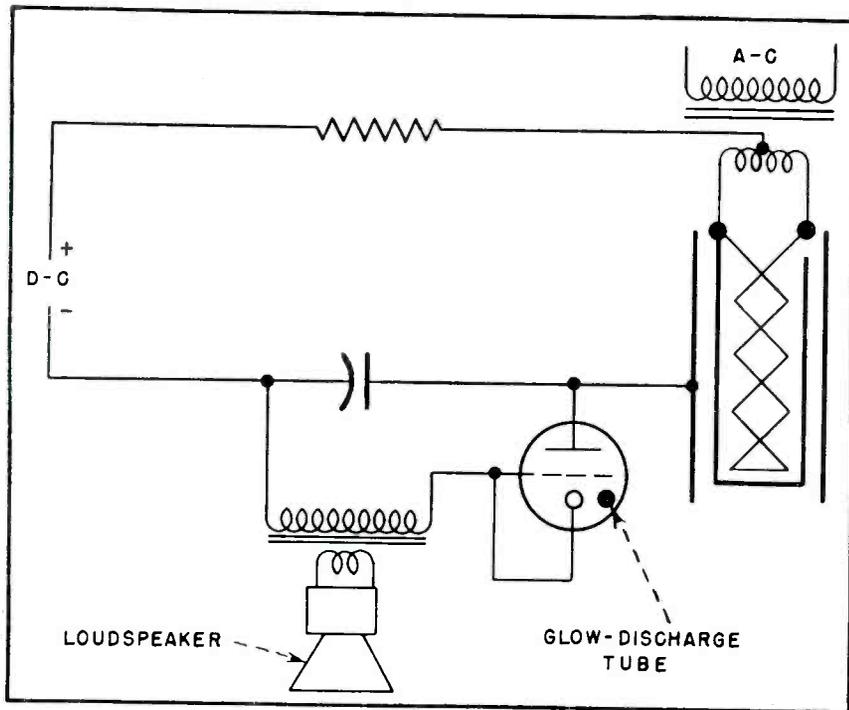


FIG. 2—Method of producing an audible response when the leak detector encounters halogen vapor compounds, or solid particles containing them, in the air

pressure becomes sufficiently high to give a response. It also responds to solid particles of the iodides, chlorides, bromides and fluorides. Therefore, it detects smoke from burning materials containing such compounds.

The detector is suitable in its present form for exposure to vapors, provided this exposure is limited to a relatively short time. If the sensing element is exposed to a halogen vapor for too long a time, or to a too highly concentrated vapor, it may lose its sensitivity. Long operation at full temperature in a current of pure air and with voltage between electrodes will restore its sensitivity if the contamination has not been too great. If the contamination has been too great it may be necessary to clean or replace the electrodes. The ease of contamination varies greatly from one compound to another. For instance, carbon tetrachloride contaminates the electrodes more easily than Freon.

If the sensing element has been hot for some time in the absence of an interelectrode voltage a heavy transient current flows when voltage is applied. The time taken to return to normal is dependent upon the time the element has been hot. A similar transient rush of ion current occurs if the interelectrode

voltage is interrupted momentarily and then reapplied.

The device is quite sensitive to variations in air flow. If the air flow is too rapid then the vapor apparently has only limited opportunity to strike the hot cathode and dissociate. The sensitivity of the device therefore decreases as the air flow is increased. Part of the decreased sensitivity is also due to the additional cooling of the cathode with the increased air flow. On the other hand, if the air flow is at too low a rate the device will be extremely responsive to vapors to which it is sensitive but considerable time will elapse before the current returns to its normal no-vapor condition even after the inlet is again given a supply of pure air.

The response of the sensing element increases markedly with temperature over a narrow range. Below approximately 850 C, the emission current is too small to be easily utilized, and over approximately 950 C it becomes unstable and random fluctuations will hide any signal.

It is necessary to keep the space between the electrodes free from dust, cotton lint, or other particles that may be sucked in by the air flow. Such particles would short-circuit the electrodes and give false

indications. It is usually desirable to filter the incoming air.

Indicating Methods

There are several ways by which the increase of current due to exposure to a vapor may be indicated. The simplest is by means of a microammeter or a galvanometer. Another method is to utilize the change in voltage across a high resistance to operate an amplifier which in turn operates a relay.

A third method is to add a relaxation-type of circuit incorporating a capacitor and glow-discharge tube, with a loudspeaker as an indicating element, as shown in Fig. 2. The current through the sensing element builds up a charge in the capacitor. When the voltage is sufficiently high the glow-discharge tube operates and the pulse of current resulting from the discharge of the capacitor produces a click in the loudspeaker. The repetition rate of the clicks is an indication of the amount of current passing.

With any circuit used, it is desirable to include a protective resistor to prevent injury to the sensing element and indicating device resulting from an overdose of vapor or a short circuit between electrodes. This may be of the order of 100,000 ohms.

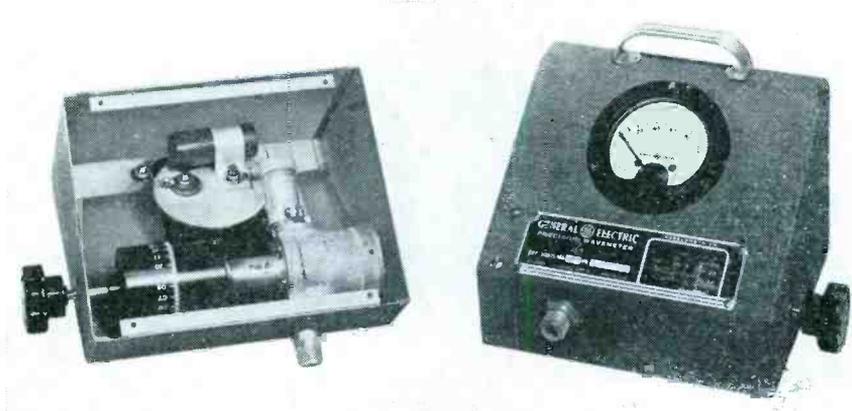
Use as a Leak Detector

The device is very convenient for detecting leaks in pressure systems of tanks, pipes, valves and flanges. In the case of a refrigerating system utilizing one of the Freon compounds under pressure, the operation consists of moving the intake nozzle of the unit near spots where a leak is suspected. For other closed systems a little Freon or other suitable halogen compound vapor is introduced as a tracer gas and air pressure is applied.

It is believed that this device will find wide application in industry due to the many products which must be made free from leakage before being used. Many other uses of the principle are anticipated.

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- (1) T. T. Woodson, Industrial Mercury-Vapor Detector, *Industrial Medicine*, p 22, April 1941.
- (2) O. W. E. Richardson, "Emission of Electricity from Hot Bodies," Longmans, Green & Co.



Postwar re-entrant line short-circuit type of wavemeter for use in the frequency range from 8 to 12 cm, as described below

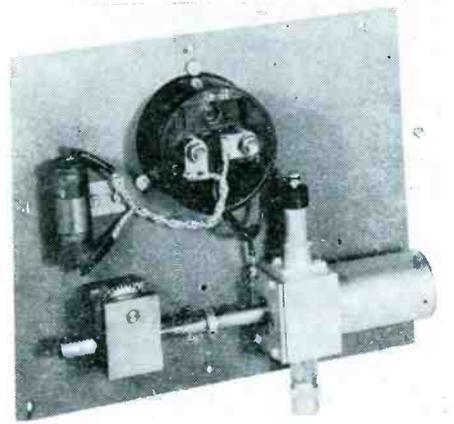


FIG. 1—A 5 to 30-cm searching wavemeter with finger contact to inner conductor

Direct-Reading WAVEMETER DESIGN

Construction details of direct-reading wavemeters for the range from 2 to 75 cm (15,000 to 400 mc). Theory behind maintaining linearity of wavelength-change-to-conductor-displacement is given for cavity devices of finger-contact and re-entrant line short-circuit type

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THE development of wavemeters for use in the centimeter-wavelength range was accelerated after 1939, before which Lecher wires were probably in greatest use. Development of resonant coaxial transmission line and resonant wave guide cavity types followed.

All forms of the Lecher wire wavemeter require that two or more observations of resonance be made and that the distance of motion of a short-circuiting bar or plunger between points of resonance be measured to get data from which the signal wavelength can be calculated. A 5- to 30-centimeter searching wavemeter was developed to replace the various forms of Lecher wire device in order to conserve space and man-hours.

The back-panel appearance of the direct-reading 5- to 30-cm searching wavemeter is shown in Fig. 1. The device will agree with a primary standard of wavelength of frequency within 0.1 cm and will repeat a reading made using a crystal-controlled signal source within 0.05 cm.

A cross-section of the resonant cavity of this wavemeter is shown in Fig. 2. A coaxial transmission line resonator operates in its quarter-wave mode. Finger contacts are used on the inner conductor, the length of which is adjustable by means of a rack and pinion. The visual indication of resonance is obtained by converting a small amount of microwave energy to direct current with either a thermocouple or a crystal rectifier and applying it to

a d-c microammeter. An input of approximately 20 milliwatts is required for full-scale deflection with a thermocouple and approximately one milliwatt when a crystal rectifier is used.

In order to obtain better accuracy and precision in another equipment, the size and shape of the contacting fingers were chosen to cause a minimum departure from a linear characteristic over a range from 30 to 75 cm. In addition, the coupling loops were adjusted to give uniformly good sensitivity over the whole range together with a characteristic sufficiently linear to allow the direct reading scale to be guaranteed accurate to within 0.5 percent.

In order to increase the effective

scale length, the wavelength dial is rotated nearly two revolutions. The slope of wavelength versus conductor displacement was adjusted so that one set of graduations could be used with two sets of color-coded numerals. The correct scale is indicated by a colored target near the upper left edge of the dial.

Shielding for Accuracy

Experience with the 5- to 30-cm wavemeter showed a need for shielding against extraneous fields. Any r-f voltage induced in the nominally d-c path between crystal and microammeter is rectified to give a deflection. A combination bypass capacitor and instrument connection, together with grounding the input coupling and tuning shaft to the case, provided adequate shielding in the vicinity of high r-f fields.

A design similar to that of the 5- to 30-cm wavemeter has been made for the 2- to 8-cm range with the scale direct reading to within 0.05 cm between 3 and 8 cm.

Precision Wavemeters

An early form of laboratory wavemeter built for the dual purpose of investigating the characteristics of quarter-wave resonators as wavemeters of high precision in the 8- to 12-cm wavelength band and of measuring the output spectra of magnetron oscillators is shown in Fig. 3. Since the existence of discrete narrow spectra was suspected, a vernier tuning control shown at

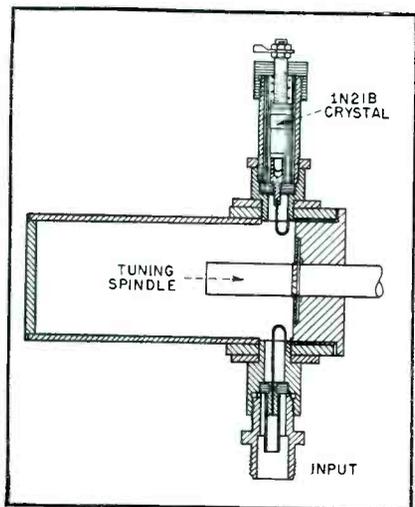


FIG. 2—Cross-section of 5 to 30-cm searching wavemeter

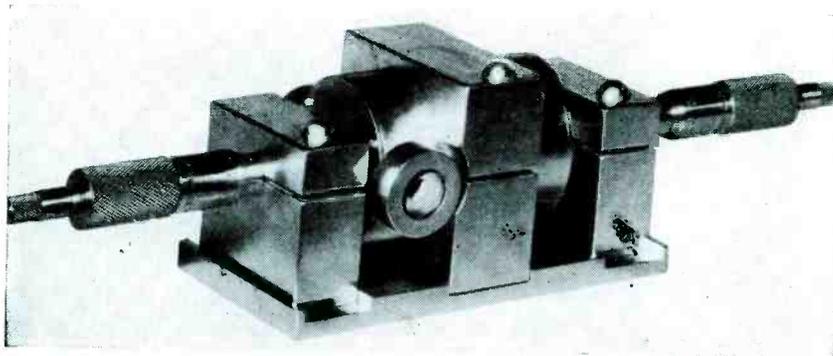


FIG. 3—A developmental 8 to 12-cm precision wavemeter with conductors for coarse and fine tuning

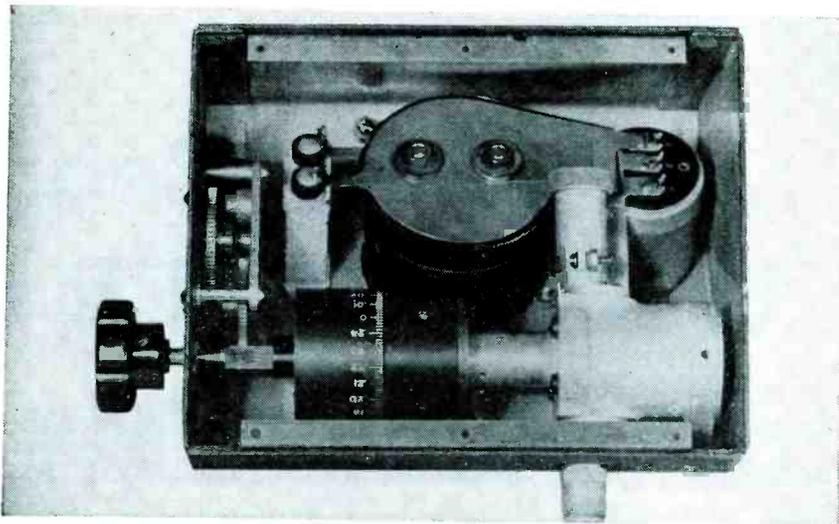


FIG. 4—Field type precision wavemeter. Indicating meter is at upper center

the right was included. However, the main tuning control proved adequate and tests showed that the resolution obtainable with a coaxial resonator employing a silver-plated micrometer spindle as adjustable center conductor was sufficient for all but the most specialized measurements in the 8- to 12-cm range.

Quantitative analysis and test of the performance of this laboratory wavemeter provided guidance in the design of wavemeters for field use. Improvements were made in the coupling loops, the contact between the micrometer-head mounting plate and the body of the wavemeter, the contact between the mounting plate and the micrometer spindle and in the body of the wavemeter itself. The measuring equipment had good sensitivity, full scale deflection for approximately 1 milliwatt input, and a wavelength versus displacement characteristic linear within 0.05 percent over the wavelength range of 8 to 12 cm. Positive

low resistance contact is necessary both between the micrometer-head mounting plate and the body of the wavemeter as well as between the mounting plate and the micrometer spindle. It was found that the stiffness of a wavemeter body made of standard brass tubing was inadequate. Changes as great as 0.03 percent in tuning were caused by pressure on the clamp that held the body to the base.

In field wavemeters satisfactory contact between the micrometer-head mounting plate and the body of the wavemeter resulted from the combination of silver plating both parts and turning a lip approximately 0.005 inch high on the body of the wavemeter at its inner edge.

A satisfactory contact between the mounting plate and the micrometer spindle was obtained by making the micrometer spindle of sterling silver and the finger contacts of silver-plated phosphor bronze or beryllium copper. Motor driven

accelerated wear tests indicated that a year of trouble free performance could be expected from this combination. However, the re-entrant transmission line type of short-circuit which is described below is superior to the finger-type contact in having low manufacturing cost and more uniform and stable electrical characteristics.

Adequate stiffness in the wavemeter body has been obtained by means of a sturdy bronze casting, silver plated for high conductivity, shown in Fig. 4. This casting is securely bolted to the sloping panel to provide a sturdy mount for the input jack, output coupling loop, crystal rectifier unit, and tuning control.

Re-entrant Short Circuit

One of the most valuable features of the field type precision wavemeter is the re-entrant transmission line short circuit between inner and outer conductors of the resonator, shown in cross-section in Fig. 5. This accomplishes the same purpose as the finger contacts of earlier designs but without a mechanical contact between conductors of the main resonant cavity. The re-entrant portions of the cavity are proportioned so that the reactance at the input to the re-entrant line is zero at some intermediate wavelength in the band. At other wavelengths, the reactance is small in proportion to that of the main cavity. The rotating joint between micrometer spindle and head is at a low current point, so that the effect of this variable resistance contact on the wavemeter performance is negligible.

This design has resulted in an ideal working condition for the micrometer screw, since there is no load on the spindle. The construction provides a close approximation to the ultimate in uniformity and stability of both electrical and mechanical characteristics.

Further features of the field-type precision wavemeter are the direct-reading wavelength scale, accurate within 0.1 percent and resettable within 0.002 centimeter, and the combined shielding and bypassing that protect the wavemeter from

strong radio-frequency fields and prevent responses to other than the impressed signal.

The appearance and construction of a postwar 8- to 12-cm precision wavemeter for general laboratory use is illustrated on the first page of this paper. Comparison with Fig. 4 will show that the gear-stop and sensitivity control of the field type have been omitted and that a less expensive bypass capacitor has been used across the microammeter, but that the primary structural and shielding features have been retained. The electrical characteristics of the two wavemeters are identical. Many of the benefits that accrue in designing for field use are not visible, but require a comparative study of the designs developed here and in England.¹ It is believed that the use of friction to hold the positions of the drum, the thimble, and the extension piece fixed relative to the spindle is indication that field use was considered secondary during the British development. The use of a 0.002-inch clearance for a distance of from $\frac{1}{8}$ to $\frac{1}{4}$ inch in the noncontacting plunger type also points in the same direction.

It is interesting to note the differences in electrical design, also. In the designs described herein the cavity beyond the end of the adjustable inner conductor has been chosen to be below cutoff for all operating wavelengths; whereas in the British design, the cavity is in the pass band for operating wavelengths. This difference apparently

resulted from considering the direct-reading feature more important than width of tuning range while developing these designs.

A 12- to 17-cm precision wavemeter operating on the same principles as those for the wavelength range 8- to 12-cm has the same quality of performance as detailed in Table I.

The precision type wavemeters are unusually well adapted for field service where extreme conditions of temperature, humidity, high-power radio-frequency fields in and out of the wavemeter range, vibration and shock are encountered. For example, the micrometer heads have been lubricated with a special oil which allows free movement at -60 C and yet does not evaporate at 50 C. Extensive use of these wavemeters for several years has shown that the wavelength calibration is maintained well within the 0.1 percent specification.

The devices have also been used as power indicators without modification, as receivers after connecting an audio amplifier across the crystal rectifier, and even as tunable band-pass filters after removing the crystal rectifier and connecting directly to the output loop.

Theory

The most important property of direct-reading wavemeters is the linearity of wavelength change to conductor displacement. The underlying theory of this property is presented below for those wavemeters employing finger contacts and those with a re-entrant transmission line short circuit.

It is an experimental fact that properly designed wavemeters having a resonator of the type shown in Fig. 6A have the property that a one centimeter increase in the length of the center conductor changes the fundamental resonant wavelength by four centimeters. It may at first seem obvious that this is the case, since the wavemeter is resonant in its quarterwave mode. Actually, however, the line is considerably shorter than a quarter wavelength because of the end-loading capacitance of the inner to outer conductor. This foreshortening may

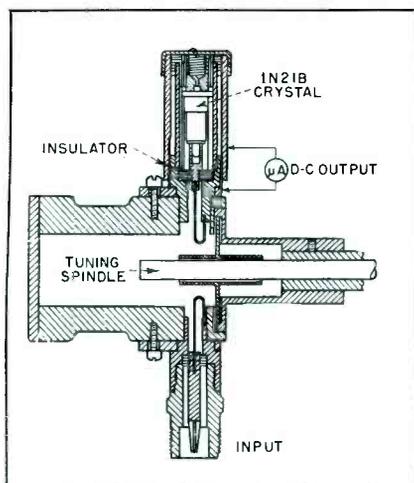


FIG. 5—Cross-section of re-entrant transmission line short circuit type

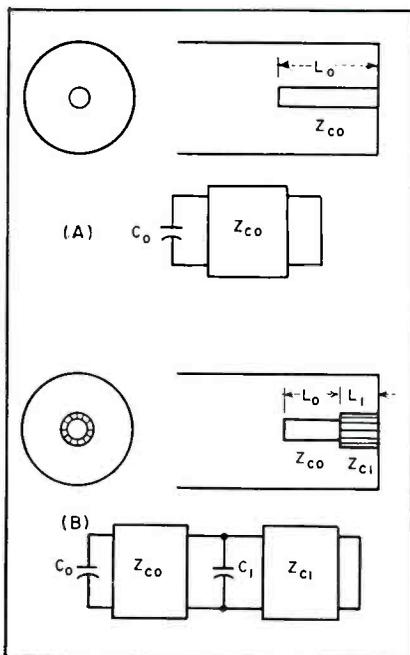


FIG. 6—Cross-section and equivalent circuit (A) of finger-contact type and (B) re-entrant type wavemeter

be as great as 18 percent of the quarter wavelength, and yet the rate of change of wavelength to conductor displacement is within 1 percent of the four-to-one relation.

It is difficult to make a good disc-type electrical contact of the kind needed in the resonator although such a contact was used in the early designs. The cylindrical type shown in Fig. 6B has been used in more recent designs requiring finger contacts because of its simpler construction. Resonators having a contact of this kind depart from the four-to-one relation and are not linear over the complete range of extension of the center conductor, but can be made direct reading within a fraction of one percent over a two-to-one wavelength range.

The resonator of Fig. 6A is a special case of that shown in Fig. 6B, the analysis of which is given below. The equivalent circuit for the latter consists of two cascaded sections of transmission line of characteristic impedances \$Z_{c1}\$ and \$Z_{c0}\$. The former is short-circuited at its input end, and the latter is terminated in an equivalent end-loading capacitance \$C_0\$, representing the effect of the fringing field between the end of the center conductor and outer conductor. A

capacitance \$C_1\$ is added to account for the step in the center conductor.²

The electrical length \$\theta_0 = \beta L_0\$ of the extensible portion of the center conductor can be related to the frequency and constants of the circuit. Referring to Fig. 6B, resonance will occur when the reactance of the parallel combination of line \$L_1\$ and fringing capacitance \$C_1\$ is the conjugate of the reactance of line \$L_0\$ terminated in the equivalent discontinuity capacitance \$C_0\$.

The input reactance of line \$L_1\$ is

$$X_{L1} = Z_{c1} \tan \theta_1$$

where \$Z_{c1}\$ and \$\theta_1\$ are the characteristic impedance and electrical length, respectively, of line \$L_1\$.

Combining with the capacitive reactance \$X_{c1} = 1/\omega C_1\$,

$$X_1 = \frac{X_{L1} X_{c1}}{X_{c1} - X_{L1}} = \frac{(Z_{c1} \tan \theta_1) (1/\omega C_1)}{(1/\omega C_1) - Z_{c1} \tan \theta_1}$$

The input reactance of line \$L_0\$ terminated in the capacitance \$C_0\$ is

$$X_2 = -\frac{1/\omega C_0 - Z_{c0} \tan \theta_0}{1 + (1/\omega C_0 Z_{c0}) \tan \theta_0}$$

where \$Z_{c0}\$ and \$\theta_0\$ are the characteristic impedance and electrical length, respectively, of line \$L_0\$.

The condition for resonance, \$X_1 = -X_2\$, gives for \$\theta_0\$ the relation

$$\tan \theta_0 = \frac{\frac{X_{c0} - Z_{c1} \tan \theta_1 (C_1 + 1)}{Z_{c0}}}{1 - \frac{Z_{c1} \tan \theta_1 (Z_{c0} - X_{c0})}{Z_{c0} X_{c1}}} \quad (1)$$

The relation for the special case of Fig. 6A is obtained from Eq. 1 by setting \$\theta_1 = 0\$, in which case

$$\tan \theta_0 = \frac{X_0}{Z_{c0}} = \frac{1}{\omega C_0 Z_{c0}} = \frac{\lambda}{2\pi C_0 Z_{c0}} \quad (2)$$

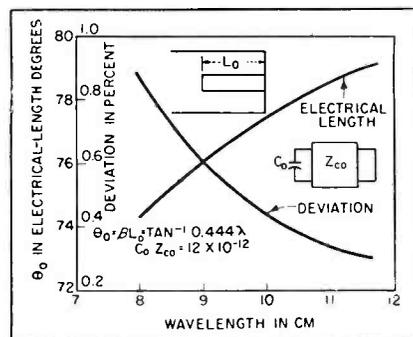


FIG. 7—Electrical length and deviation from the 4-to-1 slope in a finger-contact wavemeter

where \$v\$ is the velocity of propagation and \$\lambda\$ the wavelength in cm.

If it were possible to eliminate end-loading so that \$C_0 = 0\$, the electrical length \$\theta_0\$ would be 90 degrees. The magnitude of the effect of end-loading capacitance can be seen from Fig. 7, in which values of \$\theta_0\$ are plotted for a wavemeter operating in the 8- to 12-cm range.

Of more importance is the expression for the rate of change of conductor displacement with wavelength, which can be found by differentiating the expression for the length \$L_0\$ of the extensible line.

$$L_0 = \theta_0/\beta = (1/2\pi) (\theta_0 \lambda)$$

$$\frac{dL_0}{d\lambda} = \frac{\theta_0}{2\pi} + \frac{\lambda}{2\pi} \frac{d\theta_0}{d\lambda} \quad (3)$$

The second term is obtained from the expression for \$\tan \theta_0\$,

$$\frac{d\theta_0}{d\lambda} = \frac{1}{D} \left[\frac{dN}{d\lambda} - \frac{N}{D} \frac{dD}{d\lambda} \right] \cos^2 \theta_0 \quad (4)$$

where \$N\$ is the numerator and \$D\$ the denominator of Eq. 1.

For the case in Fig. 6A, the expression for the rate of change of wavelength to conductor displacement reduces to

$$\frac{dL_0}{d\lambda} = \frac{\theta_0 + 1/2 \sin 2\theta_0}{2\pi} \quad (5)$$

Let

$$\theta_0 = \frac{\pi}{2} - \epsilon$$

Then

$$\sin 2\theta_0 = \sin(\pi - 2\epsilon) \cong 2 \left(\epsilon - \frac{2}{3} \epsilon^3 \right) \quad (6)$$

for \$\epsilon < 0.5\$ radian.

Therefore,

$$\frac{dL_0}{d\lambda} \cong \frac{1}{4} - \frac{\epsilon^3}{3\pi} \quad (7)$$

The percent deviation from a

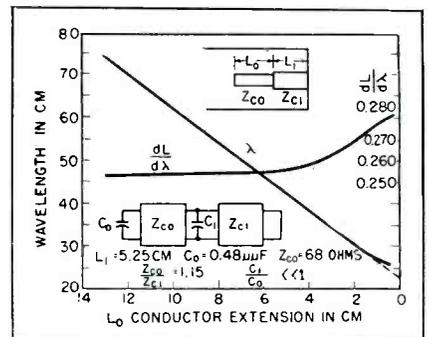


FIG. 8—Resonant wavelength versus conductor extension and slope for a re-entrant type wavemeter

4-to-1 slope has been calculated from Eq. 7 and plotted in Fig. 7 for the 8- to 12-cm range.

When the projecting type of contact is used, the rate of change is no longer four to one. The slope versus wavelength for a 30- to 75-cm wavemeter, and conductor length versus wavelength, have been plotted in Fig. 8. This wavemeter employed a contact line 5.25-cm long. The ratio of characteristic impedances Z_{c0}/Z_{c1} was 1.15. A reduction in the length of the contact line to 3.2 cm made the characteristic linear to within ± 0.5 percent over the range of 30 to 75 cm.

A cross section of a cavity type used in the 8- to 12-cm and 12- to 17-cm wavemeters is shown in Fig. 9. The main part of the cavity consists of two transmission lines, one having the variable length AB as inner and MN as outer conductor, the other having JK as inner and LM as outer conductor. The former line is terminated in a fringing capacitance from A to the outer conductor; the latter line is shorted by the plate KL .

The re-entrant portion of the cavity consists of the short-circuited line HI , GF , and the line CD , FE . The two parts of the cavity are connected by the choke line BC , JI . The center conductor rotates in its bearing at point D , this being the only point of mechanical contact between the outer shell and center conductor. The electrical quality of this contact is not important, since it is at a low current point relative to the current in plate KL .

An equivalent circuit for the cavity can be drawn, showing the interconnection of the five different transmission lines having characteristic impedances Z_{c1} , Z_{c2} , Z_{c3} , Z_{c4} , Z_{c5} and the discontinuity capacitances. The capacitance C_{12} represents the fringing capacitance from the end of the center conductor to the shell. Capacitances C_1 , C_2 , C_3 , C_4 , C_5 are those associated with the discontinuities at the junctions of the various transmission lines. These capacitances can be calculated from the dimensions.²

The following procedure is followed in calculating the wavemeter characteristic. The reactance ap-

Table I—Characteristics of 12- to 17-cm Wavemeter Calculated From Equivalent Circuit

λ	$\Delta\lambda/\Delta L_2$	I_{05}/I_{01}	P_1	P_2	P_3	P_4	Q
12		0.046	8.8	1.8	11.0	0.10	2250
13.25	3.540						
14.50	3.566	0.073	8.6	3.5	10.3	0.15	2260
15.75	3.550						
17.00	3.555	0.104	8.3	5.3	9.7	0.22	2280

$\Delta\lambda/\Delta L_2$ = slope of wavelength versus conductor displacement
 I_{05}/I_{01} = ratio of current through rotating joint to maximum current
 $P_{1,2,3,4}$ = power loss in various portions of cavity shown in Fig. 9
 Q = Q -factor of overall resonator

pearing between terminals S and T due to the combination of networks 1, 3, 4, and 5, where each network consists of a transmission line and associated discontinuity capacitances, is calculated, ignoring losses. The electrical length of line of characteristic impedance Z_{c2} necessary to give the conjugate reactance across these two points is then determined. This calculation is carried out for several wavelengths over the band of operation to obtain the characteristic of extension AB versus wavelength. Matrix formulation simplifies the procedure of calculation.

The equivalent circuit can also be used to calculate other properties of the resonator. The ratio of current I_{05} in the rotating joint at D to current I_{01} in the short-circuiting plate KL is of importance in the design. Distribution of loss in various parts of the cavity and the Q value of the resonator can also be calculated.

Table I gives values of slope of wavelength versus conductor displacement, $\Delta\lambda/\Delta L$, current ratio I_{05}/I_{01} , Q , and loss distribution for a 12- to 17-cm cavity.

In order to make the wavemeter direct reading, utilizing a standard micrometer screw thread, a slope of $\Delta\lambda/\Delta L = 3.543$ was required. The dimensions of the cavity were varied in initial trial calculations until the following series was obtained in which all dimensions are the same except the diameter of the center conductor of line L_1 .

diameter (inches)	$\Delta\lambda/\Delta L$ (average)
0.320	3.58
0.330	3.55
0.340	3.53

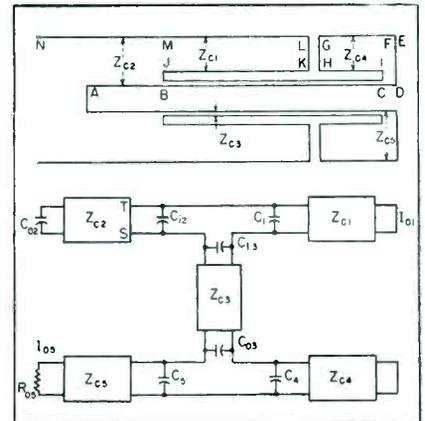


FIG. 9—Equivalent circuit for re-entrant type wavemeter

The experimental value of average slope for the final design with a diameter of 0.330 inch was 3.536. The calculated value is in error by less than 1 percent. The experimental value is somewhat affected by the coupling loops, so that better agreement could hardly be expected.

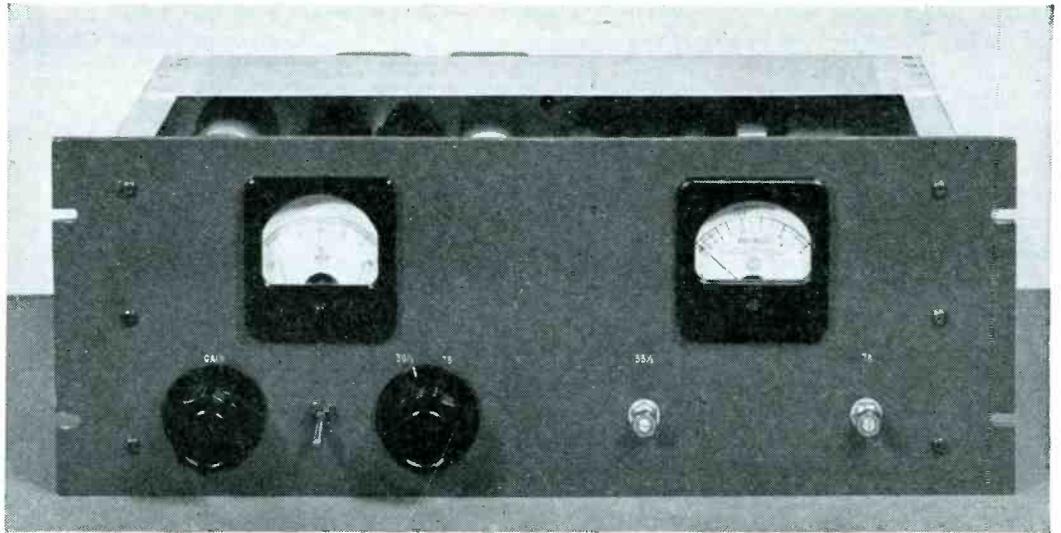
It should be pointed out that the analysis is valid only for loose coupling, since over coupling can greatly change the calculated characteristics.

Acknowledgement

The authors take this opportunity to acknowledge P. E. Hosegood's contribution of the expanded scale feature to the precision wavemeters, F. J. Moles' development of the 5- to 30-cm and 2- to 8-cm searching wavemeters, and E. D. Cook's encouragement during the course of these developments.

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Electronic equipment used with the turntable tone generator

WOW METER for Turntable Testing

A toothed wheel rotating between two pickup coils connected for maximum output generates a tone. Output is fed through a peak clipper to a discriminator and rectifier. Instantaneous speed variation is shown directly on a calibrated meter

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IN DISC RECORDING a common but annoying fault in reproduction is instantaneous speed variation of the turntable commonly called wow. Everyone is familiar with the discordant quavering of sustained piano or bell tones that are encountered in the reproduction of phonograph music. This is the direct result of turntable speed variation.

Wow can be detected by the listener when it occurs at a relatively low cyclic rate. One to three cycles per second in variation of frequency at 1,000 cycles seems to give the most noticeable wow at that frequency. The amount of wow that is detectable varies with frequency. A

small amount is noticeable at high frequencies but only larger amounts at low; that is, a larger percentage of variation in frequency is tolerable when a low frequency is being reproduced.¹ In general, three-tenths of one percent instantaneous speed variation is the maximum that can be tolerated at any frequency without introducing noticeable frequency change in the reproduced tone.

Causes of Variation

There are a number of reasons for wow in turntables and these may be classified by the type of drive used.

In the rim-driven turntable eccentricity of the spindle, oval shape of the turntable, line frequency or between the spindle and the surface of the turntable, line frequency or voltage fluctuation, as well as variations in friction of any part of the driving mechanism during a portion of a revolution result in wow. In the spindle-driven turntable, out-of-round shaping of the turntable does not cause wow, but eccentricities in the driving gears or an eccentric spindle drive contribute to wow. Again, nonuniform bearing friction, variations in line frequency and voltage, and any inaccuracies in the drive mechanism

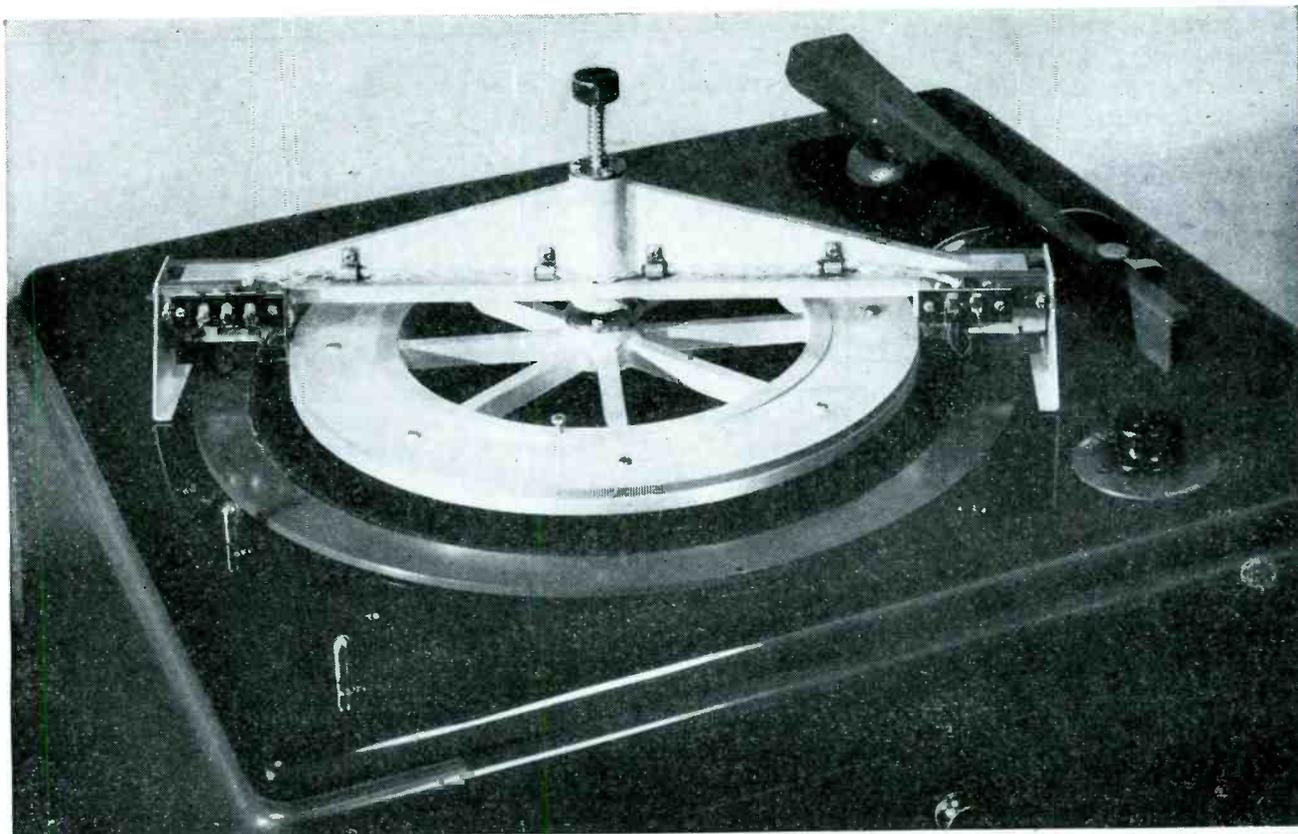


FIG. 1—Toothed-wheel tone generator centered on the turntable

tend to produce speed variation. Another factor that is somewhat difficult to control on the spindle-driven turntable is mechanical damping of the mechanism as the turntable is started. Frequently the turntable comes up to speed and overshoots slightly, then oscillates about the desired speed for a short time before it settles down to its constant-speed operation. In both types of turntable, variation in groove amplitude of the record causes a variation in torque that results in instantaneous speed variation if the drive motor does not have sufficient power or if the inertia of the turntable and its associated mechanism is not sufficient to carry through the momentary periods of greater torque requirements. This effect is similar to the problems involved in the design of a flywheel to maintain a required stability.

Since the requirements for constancy of speed in the phonograph turntable are so rigorous, it is important that a convenient means be devised for measuring instantaneous speed variation.

There are a number of methods

by which the wow of a turntable might be measured.

Testing Methods

A method that comes to mind immediately is the familiar stroboscopic disc which is viewed in a 60-cycle light source. By observing the position of the dots or lines on the disc as the turntable is rotated, it is possible to check the average speed of the turntable. This method, however, is not practical for checking the instantaneous speed variation with an accuracy which is necessary in order to have a quantitative measure of turntable performance. It is true that the stroboscopic disc does show up variations in turntable speed in the advancing rotation or reverse rotation of the virtual marks of the stroboscopic disc; but the motion is not easily measured because it ordinarily varies at a rate equal to that of turntable rotation. Since this method necessarily involves visual inspection, the observer errors are large.

Another method is to play a constant-tone record on the turntable using a conventional pickup, ampli-

fier, and a frequency measuring system. There are a number of reasons why this is not entirely practical except as a rough approximation. This system must necessarily include any wow which is present in the original recording. It also includes wow contributed by any eccentricity of the record owing to off-center stamping of the blank or clearance in the center hole. These contributions to instantaneous frequency variation may add to or subtract from that present in the turntable being tested.

Another suggested means is to use a purely mechanical differentiating speedometer to measure instantaneous speed variation. This would be a rather difficult mechanical problem because the mechanism of the wow meter itself must be better at all times than the mechanism of the turntable. Building any measuring device to measure to within one-tenth of one percent is a major design problem. The differentiating speedometer must contribute no friction to the turntable itself and it must have low inertia so that it does not reflect into the turntable a

speed variation which is not present normally.

The most practical means by which the instantaneous speed variation of a turntable can be measured seems to be the method suggested by H. E. Roys² in which a gear blank is cut with a suitable number of teeth so that by using magnetic pickup from the teeth a convenient tone is generated. This tone is fed into an amplifier and a frequency measuring circuit that operates a meter indicating the instantaneous speed variation. A gear is admirably suited for the generation of a constant tone because it is possible to machine the teeth accurately so that the errors in tooth spacing contribute very little to the error of measurement. The centering of the gear can be accurately maintained because the inside framework is constructed of metal as shown in Fig. 1.

Gear Dimensions

The gear wheel is cut from a plate of cold-rolled steel and mounted on an aluminum wheel having its center at the center of the turntable. The gear has a pitch diameter of 13.750 inches, and a diametral pitch of 56, giving an output of 1,004 cps at 78 rpm and 427 cps at 33½ rpm. A center-drilled shaft brings about alignment of the centers of the tone wheel and the turntable record-centering pin. Three screws are used for leveling the wheel on the turntable so that the pole piece of the pickup coil is in horizontal alignment with the teeth of the tone wheel.

At first thought it might seem that a single magnetic pickup from the tone wheel would be satisfactory. This, however, is not true. A single pickup coil would introduce a variation in tone generated by the gear itself owing to eccentricities that might be present. This effect is shown in Figs. 2A and 2B, in which the center of the tone wheel and the center of the turntable do not coincide. With the turntable and the tone wheel in the position 2A, the peripheral velocity at coil 1 is equal to the average speed of the turntable, while at 2B it is seen that because of the decreased radius the peripheral velocity adjacent to coil 1 is lower than

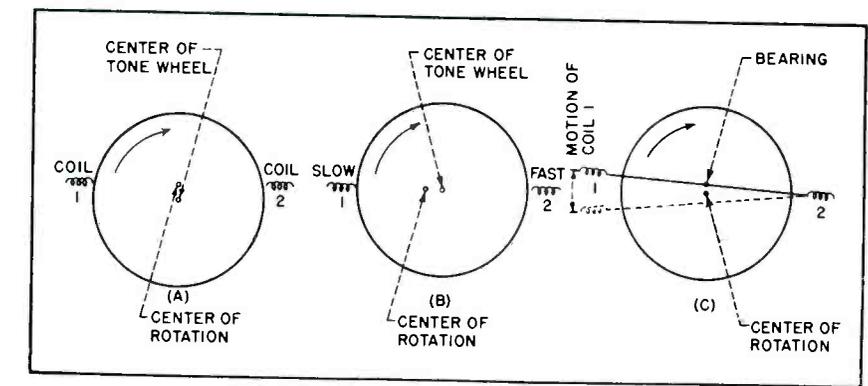


FIG. 2—Effect of wow on a single pickup coil (A and B) and upon a pair bearing on the center of the tone wheel (C)

the average. At coil 2 the velocity and hence the tone is higher than the average.

This effect suggests the spacing of two pickup coils at diametrically opposite points in the circumference of the tone wheel, so phased that a double voltage is obtained. Assuming a sinusoidal voltage from the coil (the output is actually very close to a sine wave), then the voltage from coil 1 is $E_{max} \sin(\omega t + \theta)$ and the voltage from coil 2 is $E_{max} \sin(\omega t - \theta)$ where θ is a variable which varies throughout the revolution. The two expressions for the voltage output from the pickup coil are seen to be phase modulated and the voltage from either of the coils would therefore result in an erroneous answer from any simple form of indicating circuit. If the two voltages are added together the sum is $2E_{max} \sin \omega t \cos \theta$. This operation demonstrates that the phase modulation drops out, leaving an amplitude term $\cos \theta$. Thus by using two coils an output voltage is obtained, the frequency of which is directly proportional to the speed of rotation of the turntable.

Originally, for the sake of convenience, the pickup coils were suspended on a bearing at the center of the tone wheel with one end of the pickup coil assembly prevented from rotating with the turntable by abutment with a fixed stop. In Fig. 2C is shown the result of having the pickup coil assembly eccentric with regard to the center of rotation of the turntable. If coil 2 is fixed in space, coil 1 oscillates between the solid and the dotted positions indicated in Fig. 2C, resulting in a variational output that is not balanced

out even through the addition of the two coil output voltages.

The coils are made from number 30 wire, scramble wound, approximately 1,500 turns. A pole piece of cold-rolled steel projects through the pickup coil and is magnetically coupled to a permanent magnet of the type used in a moving coil meter and to the teeth of the gear. The exact magnetic structure of the pickup coil assembly is not important, since a satisfactory output is obtained with no difficulty.

Centering the Assembly

At the center of the assembly is a tapered centering shaft that is pressed down to engage with the center hole of the tone wheel so that the pickup coil assembly is properly positioned. Upon release of the centering shaft, the pickup coil assembly is supported at its extremities from the surface of the turntable cabinet. Adjusting screws are provided so that the pole pieces and pickup coils can be shifted slightly to obtain maximum voltage from the system. A maximum voltage is secured when the two coils are in corresponding positions with regard to gear teeth, giving an output voltage from each coil so phased that they combine additively.

Electronic Components

A wow meter developed by the writers for production testing of transcription turntables is built for mounting in a standard speech rack and is self-contained except for the power supply. Provision for checking the turntables at both 33½ and 78 rpm is included. At the left of the instrument (illustrated) is a

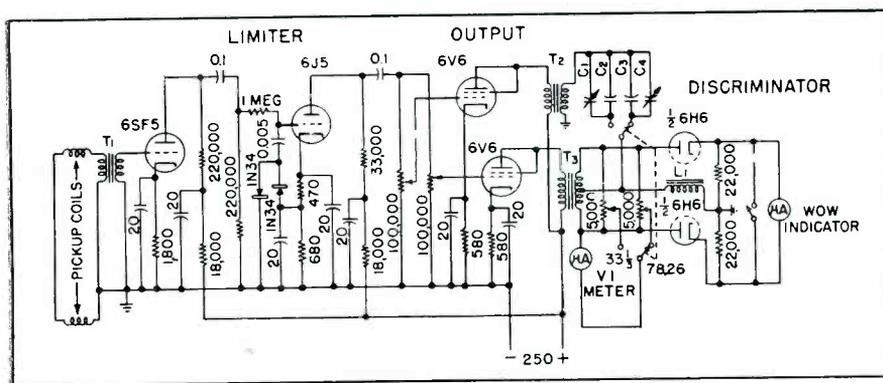


FIG. 3—Schematic circuit diagram of the wow meter. Shorting switch across the indicating meter prevents damage when turntable is started

meter directly calibrated in percent wow. On the right is a volume indicator for establishing the proper level for satisfactory operation. Below the volume indicator are two locking potentiometers for zeroing the volume indicator at both frequencies of operation. Below the wow indicating meter on the left is a meter shorting switch and the master gain control, as well as the 33½ and 78 rpm changeover switch.

In the schematic diagram of Fig. 3 may be seen a conventional voltage amplifier upon which no particular effort was expended to secure extended frequency response beyond 1,000 cycles and below 400 cycles. The input transformer matches the output of the pickup coils to the input grid with an impedance ratio of approximately 250 to 30,000 ohms. The first stage of the voltage amplifier uses a high- μ 6SF5 tube. The audio is then fed into a limiter circuit of the biased-diode type using germanium 1N34 diodes. This is in reality a peak clipper in which the diodes are biased with a voltage obtained from the cathode circuit of the second amplifier stage. A series grid resistor of 1 megohm provides a high impedance source so that effective peak clipping occurs whenever the peak a-c voltage exceeds the bias provided by the cathode circuit. The second amplifier stage consists of a 6J5 feeding the two output tubes. Since high frequency response is not required, it is satisfactory to feed the two 6V6 grid circuits in parallel. One 6V6 feeds the push-pull and the other the series portion of the discriminator circuit. A single 6H6 serves as a

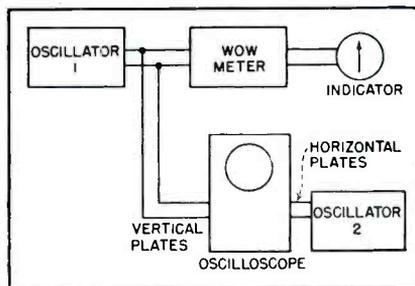


FIG. 4—Method of calibrating the meter by Lissajous figures

discriminator rectifier feeding a zero-center microammeter with an undamped movement. Two sets of capacitors, C_1 and C_2 for 33½ and C_3 and C_4 for 78 rpm, makes possible a more flexible wow meter for use with both turntable speeds. The variable portions of this tuned circuit C_3 and C_4 are high-capacitance variable ceramic capacitors that are convenient in this application. A volume indicator is connected across the output of one of the 6V6 tubes so that the proper voltage may be fed into the discriminator for satisfactory operation. This meter is switched with the variable capacitors used to tune the discriminator. Two 5,000-ohm potentiometers are used to adjust the volume indicator to zero at the level at which calibration was made. A shorting switch must be provided to protect the meter as the turntable comes up to speed. With a sensitive circuit such as must be used to detect wow of 0.1 percent, excessive deflection occurs with large frequency differences that are present before the turntable reaches its correct operating speed. Without the shorting switch severe pinning of the meter occurs during the starting of the turn-

table. The resonant circuit of the discriminator must use a high-Q audio coil at L_1 to secure adequate sensitivity. Since the inductance of L_1 varies with the a-c voltage present across it, it is necessary to hold the level into the discriminator at a value corresponding to that which was used during calibration.

Standards of Calibration

The block diagram in Fig. 4 shows a method by which the wow meter can be calibrated. Oscillator 1 is fed into the wow meter and the vertical plates of an oscilloscope, while oscillator 2 feeds the horizontal plates of the scope only. With the two oscillators at the same frequency, the usual circular pattern is observed on the screen.

Before indicating how to measure minute frequency variations accurately, the fundamental relationship of Lissajous figure should be reviewed. The figure seen when there is a slight variation in frequency between the two input voltages applied to an oscilloscope progresses from a circle to a straight line, to a circle to a straight line, and so on. The figure passes through two straight line portions a second for a frequency difference of one cycle a second. By using a stop watch and counting for a period of a half minute or so, it is possible to measure the frequency of the oscillator accurately even to a portion of a cycle a second as is required in practical wow measurements. In a like manner, for each frequency difference at which the meter is to be calibrated the reading of the discriminator is recorded. This plot of readings gives an accurate calibration of the wow meter. By repeating the process it is possible to calibrate the meter to read both at 78 and 33½ rpm. Since the microammeter used is undamped, the meter swings up and down scale in synchronism with the wow frequency during the operation of the instrument. The peak wow is half the total deflection plus and minus from the average position of the meter.

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Shoran ground station antenna installation near lighthouse in Caribbean area

Shoran for Surveying

AAF tests indicate that shoran has advantages over ground triangulation and astronomic control for many geodetic survey, photo mapping, and geophysical prospecting jobs.

Operating principles, circuits, and application techniques are given

THE shoran (SHOrt RANge Navigation) system of two ground stations or beacons, together with associated shoran-equipped aircraft, was developed primarily as a precision bombing device. As such it was used with extremely accurate results during the latter phases of the war. Shoran now appears to be one of the few military electronic developments to have practical postwar uses, and is therefore worthy of consideration as a new tool of industry.

Principle of Shoran

A shoran-equipped aircraft carries a transmitter which radiates pulses in alternate groups at two different carrier frequencies. One of the two ground stations is tuned to one carrier frequency and the other station to the remaining frequency. Reception of a pulse from the aircraft causes a ground station to act as a transponder and relay a pulse on a different frequency back to the aircraft, where it is received and displayed, and the distance to that station recorded. Since the

ground beacons, called Rate and Drift stations, transmit on a common frequency, the system utilizes three different radio frequencies, all in the neighborhood of 250 mc.

Since radio waves travel in approximately straight lines at 250 mc, the theoretical maximum measurable distance from the aircraft to any one ground station will vary with the height of the plane. This distance varies from about 100 miles with the aircraft at 5,000 feet to about 280 miles at an altitude of 50,000 feet. Maximum separation of the two ground stations is thus from about 350 to 500 miles, depending upon the type of survey.

The airline distances from aircraft to ground are converted to actual point-to-point distances on the ground by mathematical formulas. Estimated probable error with unmodified shoran equipment is ± 50 feet.

As a system for accurately positioning an aircraft with respect to two fixed stations, the commercial importance of shoran becomes enormously significant. In the field of

geodesy, for instance, it is often necessary to determine accurately the distance between two ground points. Use of shoran for this purpose has been successfully investigated by the 7th Geodetic Control Squadron, 311th Reconnaissance Wing, AAF, and techniques are still under development.

Shoran bombing equipment was not sufficiently accurate for geodesy. Possible sources of error were therefore studied and a knowledge of their magnitude led to more accurate determination and control of system delay times.

The path length of the radio wave traveling between ground station and aircraft is affected by weather conditions. Accurate weather data is consequently obtained and corrections made in the value used for velocity of radio wave propagation.

For surveying with shoran, the aircraft is flown to a previously specified area under the direction of the navigator. The navigator then directs the aircraft on a line perpendicular to one drawn between the two ground stations. The pilot

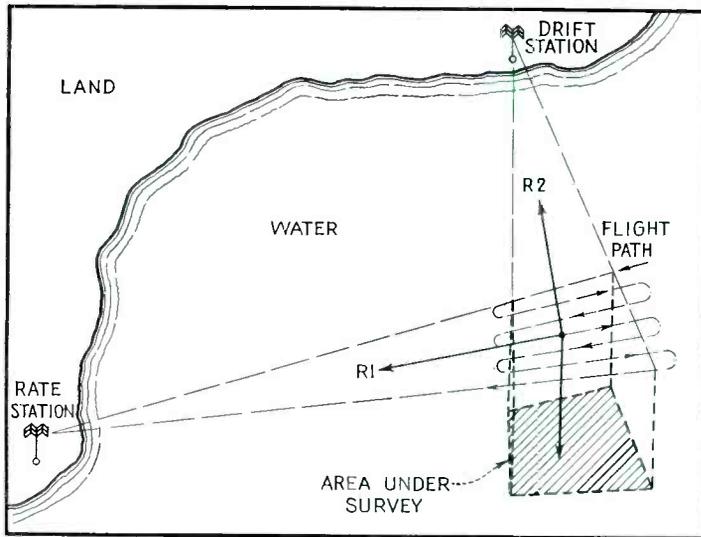


FIG. 1—Use of shoran for aerial photographic surveys. Indicator on aircraft shows airline distance to each ground station, and operator uses this data to determine deviation from desired flight path

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guides the plane on this line with the aid of a PDI (pilot direction indicator). Meanwhile the flight team operates the shoran equipment and the various data recorders. At a predetermined point the pilot turns the aircraft to a new line at an angle of approximately ten degrees to the line between the stations and now controls the aircraft with the autopilot. Necessary data for computations is then recorded on film every three seconds as the airplane continues on course. The plane then starts a crossing in the reverse manner, completing a figure-of-eight path over the center of the line between stations.

Somewhere in the accumulated data appears the minimum air-to-ground distance to the stations. This minimum is determined by fitting a curve to the various consecutive distances plotted against time by a method of least squares.

A complete geometrical figure of five ground station points is flown, measuring all sides and diagonals of the pentagon thus produced. After all network distances are measured and corrected for errors, a further least squares adjustment is made of the entire network, to obtain the most probable set of consistent distances.

Cost of Shoran Surveys

Careful operation of ground station and airborne equipment by qualified technicians, combined with

accurate equipment calibration and mathematical computations, has resulted in measured distances comparable to ground survey by usual first-order triangulation methods. Further study and investigation will undoubtedly increase efficiency and reduce operation costs.

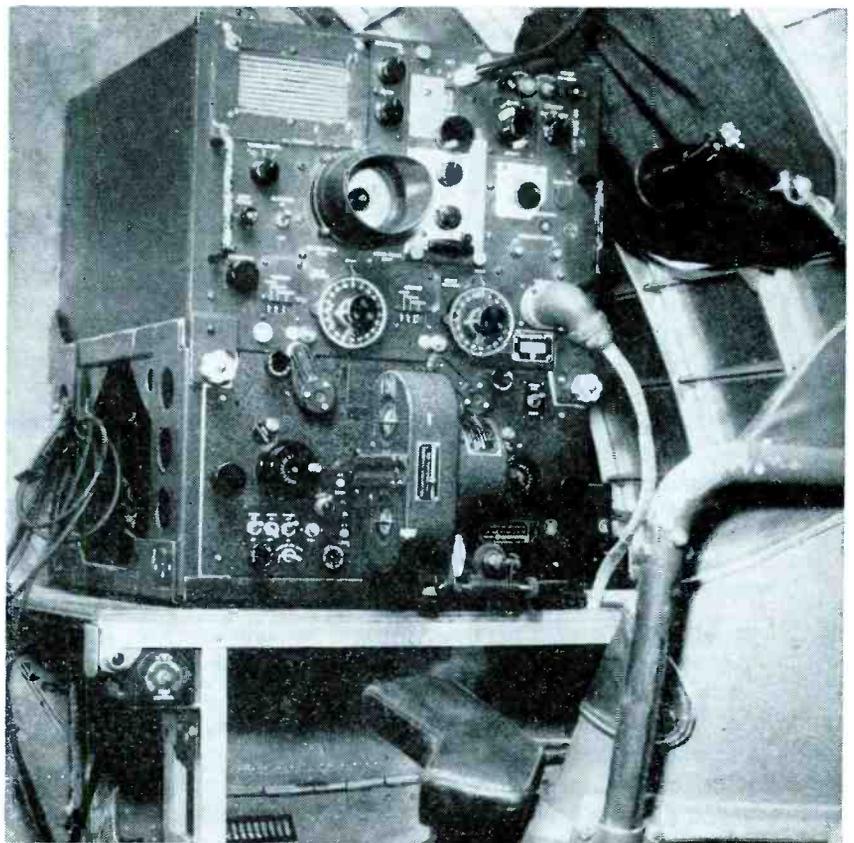
Shoran can be used cheaply to make maps up to 1-25,000 in

scale, but because shoran stations are so far apart, monumenting of the surveyed area cannot be done. Then again, in island areas where locations between points cannot be seen because of great distance, or where anomalies exist that preclude accurate use of astronomic control, good surveys cannot be made quickly by any other method.

Astronomic control can be used for scales as large as 1-250,000 and no larger. Ground triangulation with monumentation becomes very expensive when the scale is of the order of 1-25,000 or larger.

Perhaps the most general commercial use of shoran is its combination with photogrammetry for aerial surveys and mapping. A possible survey of this type is shown in Fig. 1.

The usual method of photo map-



Airborne indicator and recorder for shoran

ping involves taking a series of photographs as the aircraft proceeds along a predetermined course. Successive course lines are flown with about a 60 percent forward lap and a 30 percent side lap of photographs taken. Photo charts are then made from the series of overlapping individual photographs. The resultant chart is only as good as the accuracy with which the aircraft is flown on course.

Using shoran, course lines of the aircraft are plotted in advance, the operational team guides the aircraft along the desired course through the use of the PDI and operation of the shoran equipment, and all necessary data on position and altitude is recorded photographically while map photos are being taken.

Two general types of course lines have been flown. With reference to Fig. 1, consider the aircraft in space at the point shown, with a distance of R1 to the rate station and R2 to the drift station. As the aircraft flies its path, these distances change constantly if the path is a straight line as diagrammed. If the plane were to fly a series of arcs over the given area, one distance from a station would remain constant and the other would vary. In either case a PDI is driven from the shoran equipment to show course deviation. Both types of flight path have been used with success.

Photographs taken with shoran guidance can be used with multiplex equipment to make accurate maps quickly with scales as large as 1-25,000. These maps can be as accurate as any other existing maps of the area if the ground stations are installed carefully and tied to existing monumentation by either shoran or usual ground triangulation methods.

Geophysical Prospecting

Another outstanding wartime device, the magnetic airborne detector (MAD), was developed to locate submarines. This device, used with shoran, an aerial camera, and a radio altimeter, will allow accurate contour mapping or reduce costs of geophysical reconnaissance. The technique therefore has application

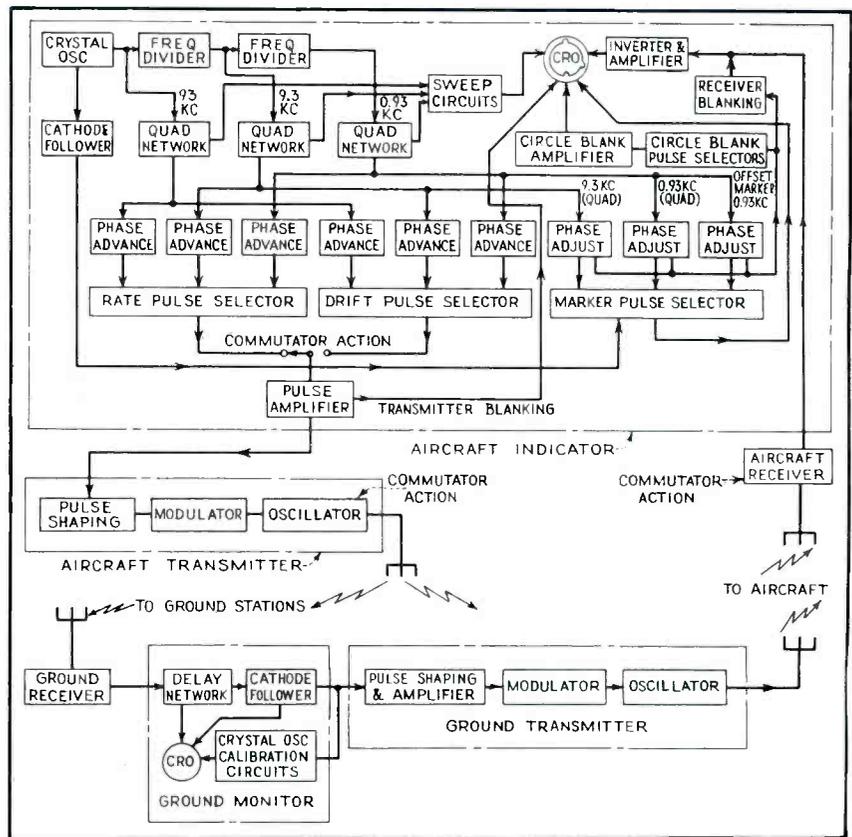


FIG. 2—Simplified block diagram of shoran system as used for aerial surveying

in the oil and similar industries. Aircraft-locating requirements for magnetic surveys are adequately met by shoran.

The camera used with MAD is a 35-mm Sonne, with image stabilization added, that records a continuous film strip of the terrain. Correlation with the magnetic record is achieved through serial numbers and edge marks on the film. The aircraft is flown on arcs from one ground station through PDI control, and deviations from course are noted on tape. A recording radio altimeter provides continuous information of the aircraft altitude. Resultant magnetic readings can therefore be plotted to a space of approximately a 100-foot cube, and the complete survey made quickly and economically. The value of such a system becomes obvious when otherwise inaccessible areas or water and island areas are considered for survey.

Shoran has also been successfully used in locating the position of ships off shore, providing the distances do not exceed line of sight from antenna to antenna. Thus accurate positioning of the craft is

provided, while the desired hydrographic or geophysical surveys proceed with other associated equipment.

Technical Details

The block diagram in Fig. 2 shows the major units in airborne shoran equipment and in one of the two identical ground stations. The associated photo recorder, remote indicator, radio altimeter, and similar devices are not shown for simplicity.

Aircraft Indicator

The aircraft indicator is the heart of the entire unit. It is here that the pulses are generated and recorded, and the distances to the stations shown.

The crystal-controlled tuned-plate oscillator circuit uses a 6AC7 tube with capacitive feedback, tuned to approximately 93 kilocycles. This frequency gives a maximum directly indicated distance of 100 miles; greater distances up to line of sight require appropriate interpretation of indirect readings. The time for a 200-mile round trip of a pulse is 1,074 microseconds, hence

the pulse repetition rate must not be greater than 930 pps. Since the final indication is to be a pip alignment on a circular cathode-ray oscilloscope (cro) screen, the sweep frequency should also be 93 kc. Accuracy of alignment is facilitated by two higher sweep speeds, 9.3 kc and 0.93 kc, providing ten- and one-mile ranges.

The crystal oscillator is followed by two regenerative frequency dividers, each of which divides by ten. Referring to Fig. 3, two frequencies beat in the nonlinear 6V6, providing the output at one-tenth the input frequency. The output phase is stable, and correlated with that of the input.

The three sinusoidal output signals of the oscillator-frequency divider chain are fed to three separate quadrature networks, each designed to produce at its own particular frequency two sinusoidal signals of equal voltage, but in quadrature. One set of these signals goes to the sweep circuits, and then to the cro for generation of the circular motion of the luminescent spot at the correct rate for the scale chosen. The other outputs are fed to the variable phase advance circuits, with the 9.3- and 0.93-kc quadrature signals going also to the phase adjust circuits.

The phase advance circuits feed into rate and drift pulse selector sections, which generate the rate and drift pulses used to drive the aircraft transmitter. The phase adjust circuits feed the marker pulse selector which generates the pulses that serve as a time base, producing outward deflections of the circular sweep at the top of the cro screen.

The rate and drift received pulses also appear as deflections of the circular base line of the cro.

When the shoran operator superimposes the marker, rate, and drift deflectors, the indicator dials read the distance to each station in miles.

The transmitted rate and drift pulses must be advanced in phase with respect to the marker pulses by an amount exactly equal to the time in transit of the signal to the stations plus the time delays of the equipment. This phase advancing is accomplished by accurately calibrated goniometers of the continuous type, in which the two quadrature inputs are applied to two stator coils oriented so their planes intersect at an angle of 90 degrees. The output is taken from a rotor coil, the angle of which determines the relative phase of the output through 360 degrees. There is a phase advancer for each frequency and hence range; the drift advancers and three rate advancers are separately ganged, so the resultant in-

dicating dials connected thereto read the required distance.

Pulse Selector Circuit

The pulse selector circuit for the rate and drift channels, shown in Fig. 4, is representative of the type of circuit used in the unit as a whole. Pulse selection is a means of blocking the passage through a signal channel of all but one of the positive sine-wave peaks of the 93-kc sine-wave train which occurs during each 0.93-kc wave. The one peak passed forms a short pulse with a repetition rate of 0.93-kc or 930 pulses per second. The method allows accurate selection of the pulse desired, or accurate phasing of the pulse produced without use of complicated high-accuracy circuits.

The 6SA7 pulse selector receives three inputs from phase advance circuits. The grids are biased beyond plate current cutoff so that no current will flow unless all three grids are made more positive by a considerable amount. The output at the plate of the tube therefore consists of pulses at a repetition rate of 930 pps with a pulse width of two microseconds.

We thus have a continuous output of pulses from the selectors of the rate and drift channels. The amount of phase advance for each channel will depend upon the distance of the aircraft from the station in question, and some means must be incorporated for the transmitter following to differentiate between the rate and drift pulses. This differentiation is accomplished by a motor-driven commutator which performs a complete sequence of switching operations every one-tenth second. Actually, the two pulse outputs are used alternately for periods of 1/40 second, with periods of 1/40 second interspersed between them. This means that during one period about 23 rate pulses are transmitted, and 23 drift pulses go out the next time the aircraft transmitter is pulsed.

A pulse amplifier feeds the commutator output pulses to the aircraft transmitter. This amplifier, using a 6AC7 tube, also feeds a short blanking pulse to the control grid of the cro with such polarity

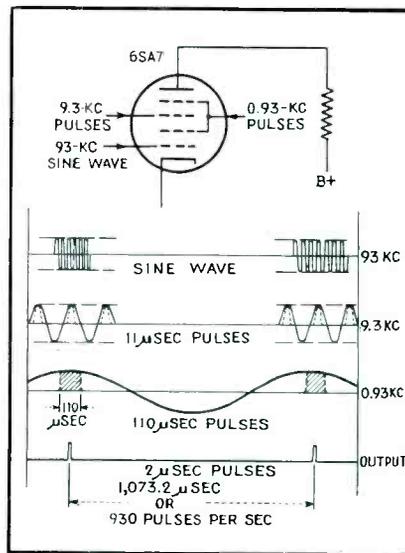


FIG. 4—Operating principle of pulse selector tube, which passes a single output pulse in its plate circuit whenever the three different pulses applied to the three grids are all reaching positive peaks at the same instant

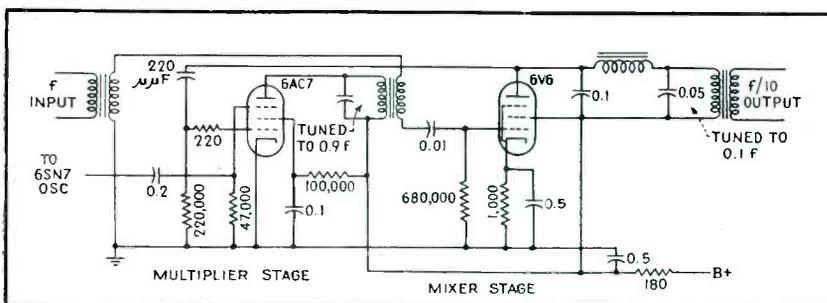


FIG. 3—Typical regenerative frequency divider circuit used in shoran equipment

as to cut off the beam current momentarily until the transmitted pulse has time to leave the antenna. This prevents the pulses sent out by the transmitter from appearing on the cathode-ray oscilloscope.

The phase adjust network consists of a potentiometer across diagonally opposite points of the quadrature network. Varying the potentiometer varies the phase of the signal over a 180-degree range.

The 93-kc signal for the marker pulse selector is taken from the crystal oscillator through a phasing capacitor and cathode follower. The lead is coaxial cable. The cathode follower prevents the large and variable capacitance of the cable to ground from detuning the oscillator.

Since the marker pulses have a frequency of 930 pps, one marker pulse would appear on the cro for every sweep of the 100-mile range, but only one marker for every ten sweeps on the ten-mile range, and one for every hundred sweeps on the one-mile range. Obviously the same condition would exist with respect to the received pulses. The applied solution is the use of a circle-blanking pulse selector (6SA7) and a blanking amplifier (6SN7) which blanks out all sweeps except those during which the marker and received pulses occur, and at the same time intensifies the desired sweep.

Noise voltages would be displayed on all portions of the sweep if the aircraft receiver output were fed to the cro at all times. For this reason, the receiver output is disconnected during the display of the marker pulses. This is accomplished by screen and suppressor modulation of the inverter and amplifier tubes. Blanking pulses are obtained from the offset marker network, and supplied through the receiver blanking amplifier and blocking capacitors in negative polarity with respect to the inverter and amplifier tubes so as to cut off plate current in these tubes.

If the marker pulse and the received rate and drift pulses occur on the same sweep, alignment of the two pulses would be difficult since they would tend to become additive the closer they were brought in alignment, and it would be hard to discern the three pulses. The

marker and the received pulses should occur on different sweeps, since the latent image on the tube is sufficient for alignment purposes. On the 100-mile sweep the marker occurs on each sweep, so separation is not possible. On the 10-mile and one-mile range, the marker pulse is offset by one and by ten sweeps respectively. This is accomplished through a differently phased 0.93-kc source for the generation of marker pulses in these positions, known as the offset marker.

Aircraft Transmitter

The successive rate and drift pulses are delivered to the aircraft transmitter for transmittal to the respective ground stations. In the pulse shaping section of the transmitter the pulses are amplified and steepened and their tops flattened without changing the timing of the leading edges.

The modulator driver and the modulators are of conventional design. The driver is a 3E29 twin-pentode tube with the sections connected in parallel, while the modulator consists of two tubes of the same type with all four sections paralleled.

The oscillator is a tuned-grid tuned-cathode push-pull circuit in which the grid and cathode circuit tanks are resonant transmission lines. The plates are at zero r-f volt-



Shoran ground station

age with respect to ground, and hence the stage does not oscillate except during the time when positive pulses are supplied from the modulator to provide plate voltage.

Oscillator tuning is adjusted by varying the electrical length of the grid line with a movable shorting bar. Another bar is used to short-circuit the line closer to the tube. A vacuum relay, excited by commutator action, switches the output from one line condition to the other, producing two output frequencies differing by 15 to 30 mc and used for triggering rate and drift station receivers respectively.

The ground station and airborne antennas are identical and are essentially vertical quarter-wave antennas working against ground. The antenna is placed directly on the aircraft, but at the ground station it is mounted on a fifty-foot plywood mast and backed by a 90-degree corner reflector.

Ground Station Receiver

The frequency range of the uhf superheterodyne receiver at the ground station is from 210 to 230 mc, with a band width of 4 mc, measured from points on the selectivity curve at which gain is 70 percent of maximum. Sensitivity is 2.5 microvolts, or 9 db above the thermal noise level. The i-f circuits are single-tuned, with their resonant frequencies stagger-tuned to the middle and both edges of the 30-mc i-f pass band. Converter and oscillator circuits are tuned to rate or drift carrier frequency by a variable transmission line controlled manually from the front panel.

Ground Station Monitor

The monitor at the ground station is interposed between the receiver for incoming pulses and the ground transmitter that sends them back to the aircraft. It provides a standard signal to the aircraft as a frequency standard for the system, and also provides a means for checking the delay of the station through fixed time delay networks.

The output pulses of the ground receiver go to the variable delay network. This artificial transmission line allows the operator to



Typical shoran ground station as set up by surveying crew, using 50-foot plywood mast to support a vertical quarter-wave antenna backed by 90-degree corner reflector

standardize the overall delay of the ground station at a predetermined value.

A cathode follower stage provides impedance transformation between the relatively high impedance of the variable delay circuit and the low impedance of the cable line to the transmitter.

The accuracy of the entire system depends upon the accuracy of the fundamental frequency of the crystal oscillators. The oscillator circuit in the aircraft is subject to drift, hence the 93.109-kc crystal oscillator of the monitor is used as a standard. The output of this oscillator passes through a frequency-dividing chain in which its frequency is divided by 100. The resulting 931.09-cycle signal is converted into short pulses of suitable power and shape, and the pulses are used to key a uhf oscillator operating at very low power. This

oscillator is tuned to the same frequency as the receiver (in the 210- to 230-mc range), and the pulses are fed through a transmission line and coupling loop into the path of the received pulses. The standard pulses are also used for measuring overall ground station delay.

Ground Station Transmitter

Pulses leaving the monitor enter the shaping and amplifying stages of the transmitter. The general purpose of these stages is to eliminate noise in the signal, amplify, and shape the pulses for use by the modulator and oscillator stages.

The modulator driver and modulator are of conventional design, incorporating 3E29 tubes with the sections paralleled.

The oscillator consists of two type 4C28 triodes in a push-pull tuned-grid tuned-cathode circuit, in which the grid and cathode cir-

cuit tanks are resonant parallel-conductor transmission lines. The plates are grounded with respect to r-f, so the stage will oscillate only when pulses are supplied from the modulator. Frequency is adjusted by varying the electrical length of the grid line through the use of a movable short-circuiting bar across it. The cathode tank can also be tuned through the use of a similar shorting bar.

Aircraft Receiver

The returned pulse is accepted by the aircraft receiver (identical with ground station receiver), and the receiver output is sent to the inverter and amplifier stages in the indicator. Here the polarity of the received pulses is reversed intermittently by a polarity-reversing switch phased with the commutator action in such a way as to have the received rate pulses produce an outward deflection of the cro trace, and the drift pulses an inward deflection. This circuit also terminates the receiver blanking system.

If the shoran airborne operator operates the indicator so that the marker, drift, and rate pulses are superimposed, the mileage dials will accurately show the distance to each station in miles, tenths, and hundredths.

Installation and Maintenance

Practically speaking, the ground station equipment can be installed in about eight hours, including auxiliary living, radio, and associated equipment, by a crew of five men. It can then be operated by two men, one on the monitor and the other in radio contact with the aircraft and other stations in the net. All equipment can be carried in a jeep and trailer, making for reasonable maneuverability in rough terrain.

The aircraft equipment should be mounted in a plane having stable flying characteristics. Most Air Forces work has been done in the B-17 type.

Although not completely perfected at the present writing, shoran has definitely shown its practicability in its present state as a new tool of industry.

RADIO RECEIVERS, to be sufficiently stable in the very high frequency portion of the spectrum, require crystal control. However to provide separate crystals for each channel is often impractical.

The need for simplicity is especially great in aircraft equipment operating in the 108 to 132 megacycle band, in which such navigational facilities as localizers and omnidirectional ranges, and such communicational facilities as tower and airways channels and domestic and international operational stations are located. An aircraft flying from coast to coast in the United States can use as many as forty frequencies in this band, if it stays on the same company airway; if the plane is interchanged between companies at terminal points on the way, more frequencies would be used. All these frequencies should be crystal controlled.

To minimize the required number of crystals both to reduce production cost and simplify servicing, a crystal saver circuit has been devised for use in the Bendix MN-85 vhf navigation system receiver.

Circuit Principle

The basic problem to be solved in aircraft receiver design is to provide crystal control on the 120 channels spaced every 200 kilocycles throughout the 108 to 132 mc band. Each frequency must be maintained to better than 0.01 percent. Control must be established using a small number of self-contained crystals, retaining simplicity of design, and providing ease of maintenance and reliable performance. To meet the requirements of frequency stability, a superheterodyne receiver is necessary. This discussion is concerned only with producing the required number of crystal-controlled local oscillator frequencies to obtain the desired number of channels, and does not consider overall receiver design problems.

Consider Fig. 1; the variable oscillator is the receiver local oscillator. It is a free oscillator, capable of being tuned over the frequency band required. The radio-frequency tuning circuits are ganged and tracked with the local oscillator tuning. The actual frequency-rotation curve is

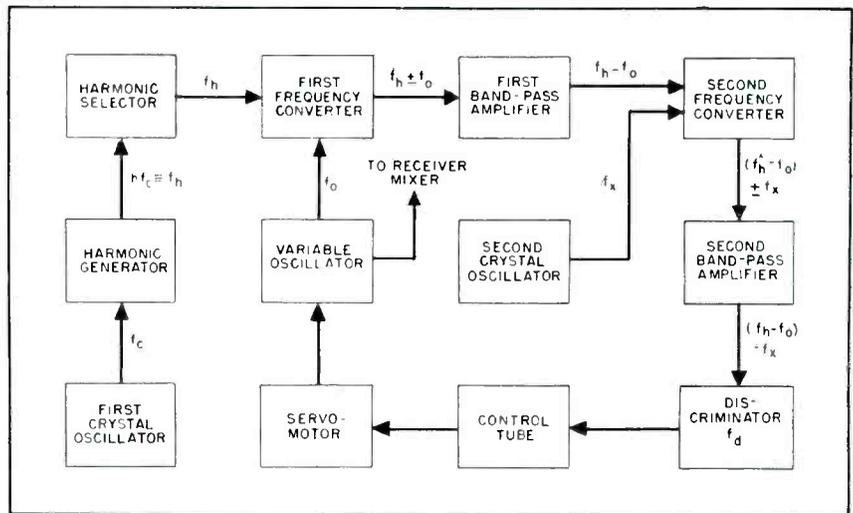


FIG. 1—Variable oscillator of receiver is stabilized on any one of 120 channels in the vhf aircraft band by means of this crystal saver circuit

Few Crystals

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unimportant, but an approximation to straight-line frequency-rotation is helpful in stabilizing tuning motor control circuits.

Some of the output of the variable oscillator is fed to the first frequency converter where it is combined with the output of the first crystal oscillator from which one harmonic is selected by means of fixed tuned selective circuits. The first band-pass amplifier passes the difference frequency of the output from the first frequency converter on to the second frequency converter into which is also fed the output from the second crystal oscillator. This oscillator may be at any one of a number of frequencies as determined by its crystal selector. The second band-pass amplifier passes the difference frequency of the output from the mixer second frequency converter. Output from this band-pass amplifier is fed to a number of fixed tuned discriminators, of the Foster-Seeley type, to obtain d-c output which

feeds the control tube. The latter, in turn, operates the servomotor.

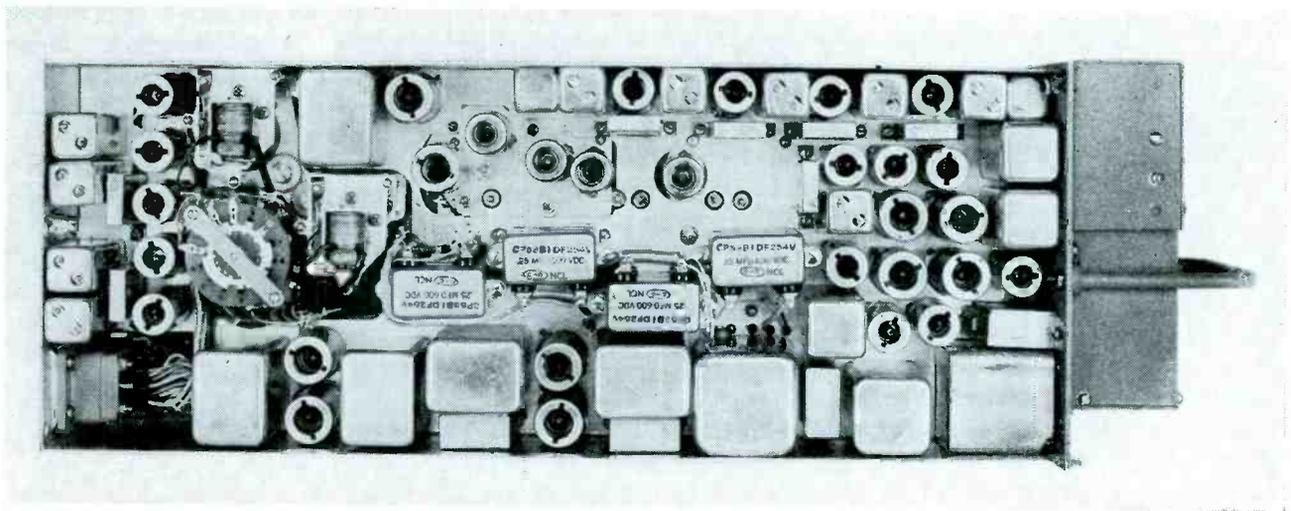
Output from the discriminator provides intelligence for frequency correction and for initial tuning. If f_o is the frequency of the variable oscillator, f_h is the frequency of harmonic selected, f_x is the frequency of second crystal oscillator, and f_d is the frequency of discriminator, then

$$f_o = f_h + f_x \pm f_d \quad (1)$$

when the system is balanced by being on frequency. Either the plus or the minus sign can be selected as the stable frequency position by changing the sense of the servomotor. Thus by a few changes of several variables, many frequencies can be crystal controlled.

Servomotor Control

To explain the motor control circuit it is helpful to examine a simplified form such as is shown in Fig. 2, which shows only a variable oscillator driven by a motor, with a discriminator to determine the



Omnidirectional range and communications receiver has the frequency monitoring circuit described in this article at the left of the chassis. The r-f and i-f circuits occupy the upper center and right, navigation circuits extend along the lower side of the chassis. Two crystal ovens are in cans on the underside of the chassis

Control Many Channels

Local oscillator of multichannel superheterodyne receiver used for aircraft communication and navigation is crystal controlled on 120 channels by only 10 crystals. Conditions for minimum number of crystals, frequency spacing, and stability are described

oscillator frequency. The direction of motor rotation is determined by relay contacts HC, LC, their coils being energized from the output of the discriminator, through the control tube. Normal plate current of the control tube without discriminator output is sufficient to energize LC only, in which condition the motor will not run.

The discriminator output will reverse in polarity depending on whether the oscillator frequency is above or below the discriminator frequency. If discriminator output is negative, plate current in the control tube will decrease and LC will drop out, causing the motor to run in one direction. If discriminator output is positive, plate current in the control tube will increase and both HC and LC will be energized, causing the motor to run in the opposite direction. Thus the oscillator frequency is maintained equal to the discriminator frequency.

Figure 3 shows the next step in expanding the system, and

shows how the plus or the minus sign for the discriminator frequency is chosen. The discriminator, instead of being fed directly from the oscillator, is fed from the output of a frequency converter. The converter mixes the output of a crystal oscillator, and the oscillator to be controlled. A low-pass filter in the converter plate circuit passes the difference frequency. If the oscillator frequency differs from the crystal frequency by the discriminator frequency, the motor does not run. The oscillator frequency may be either greater or less than the crystal frequency to obtain this result. But only one position is stable, depending upon the motor polarity. For, if the oscillator frequency is the smaller, then an increase in oscillator frequency decreases the difference between oscillator and crystal frequencies, while if the oscillator frequency is the greater an increase in its frequency will increase the difference between oscillator and

crystal frequencies. Thus, by reversing motor polarity, two stable oscillator frequencies are obtained for each crystal used.

In tuning a system of this type, normal procedure is to start the local oscillator tuning from one limit of the frequency band, and to allow it to sweep the band. As its frequency changes, it will pass a position where Eq. 1 will be satisfied; here the servomotor will stop. If for any reason the frequency of the local oscillator changes, the motor again will drive to retune the local oscillator.

In order to save wear and tear on the motor, it has been found advantageous to control frequency only coarsely by the motor tuning, and to obtain fine frequency control by means of a reactance tube operated by the output from the discriminator. Whenever the range of control of the reactance tube is exceeded by slow frequency drifts, the motor restores mechanical tuning to the center of the range of control

into the values of f_h , f_s , and f_d over the frequency band. From Eq. 10

$$f_{d \min} = (x/2)(1 + DX - D) \quad (12)$$

Then, if $D \geq 1$

$$f_{d \min} = (x/2)DX \quad (13)$$

From Eq. 4 $f_h = 2XDx$; therefore

$$f_{d \min} < \Delta f_h/4 \quad (14)$$

indicating that Δf_h must be considerably less than the absolute frequency f_s , because f_h is only a part of f_s . Also $f_{d \min}$ must then be only a very small part of f_s , because it is less than $\frac{1}{4}\Delta f_h$, as shown in Eq. 14. Thus very large percentage errors in the absolute value of f_d will cause only very small percentage errors in f_s .

The principal frequency error, therefore, will be that owing to errors in f_h and f_s . These frequencies are crystal controlled, and can be held to ± 0.005 percent individually by means of temperature controlled ovens. The resultant frequency error due to f_h and f_s collectively will also be ± 0.005 percent because these frequencies are of the same algebraic sign in Eq. 1.

Considerable research into the construction of fixed frequency discriminators has revealed a method of construction which provides frequency compensation for temperature changes by means of choice of materials having the proper thermal coefficients of expansion to hold the relative positions of active parts fixed over a very wide temperature range. This construction avoids the use of temperature coefficient capacitors to obtain temperature compensation; by it and because of the high Q obtained, only ± 0.2 percent of the discriminator center fre-

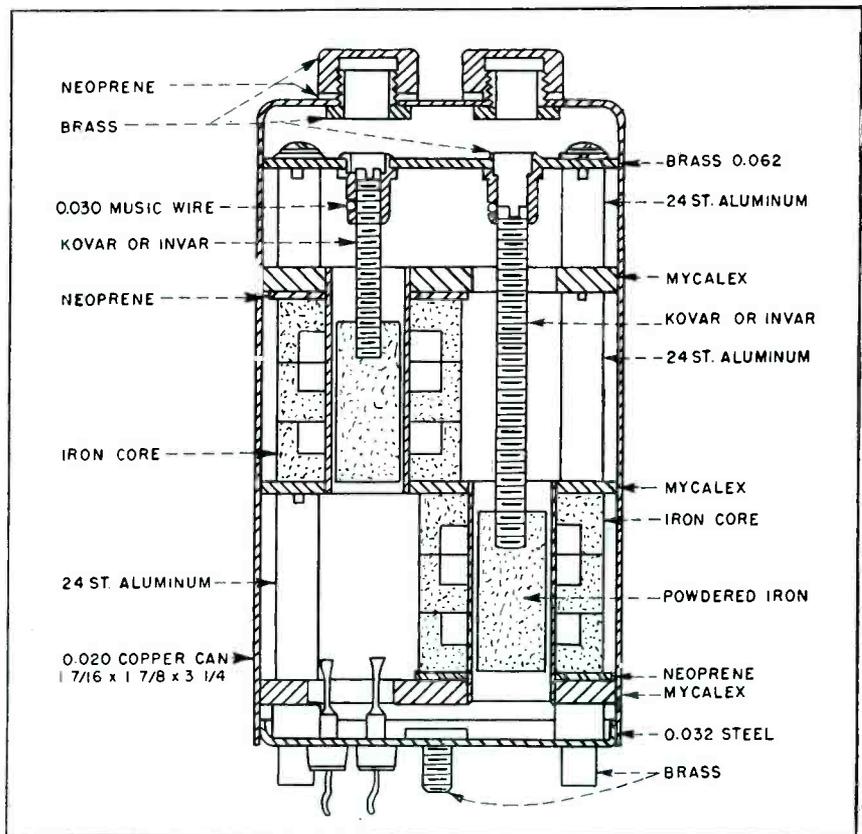


FIG. 4—Discriminator is constructed of compensating materials to insure stability

quency need be allowed for center frequency drift plus reactance tube control. This error will be not greater than ± 0.002 percent of the local oscillator frequency. The reactance tube will allow ± 2 percent of the band covered in mechanical detuning before affecting output frequency by more than the allowable deviation. Figure 4 shows the discriminator construction.

Under the worst conditions, using ± 0.005 percent crystals and a

± 0.2 percent discriminator, a final frequency stability of better than ± 0.007 percent can be obtained by this circuit over a very wide range of frequencies.

The above circuit lends itself quite readily to remote control over a very few wires. The description of a radio frequency channel is accomplished by the selection of one harmonic, one crystal, and one discriminator. This effectively breaks channel selection down into successive steps, each step being finer than the one preceding. If it is desired to effect a remote choice of ten possibilities, then ten leads plus a remote switch can be used. In the case at hand, if there were four each harmonics, crystals, and discriminators, then four leads for each variable plus one ground lead, and three remote four-position switches will suffice for the control of 128 channels. In the practical case for the 108-132 megacycle receiver, 7 harmonics, 10 crystals, and 2 discriminators are used. The switches in this case are arranged coaxially for conservation of space and ease of reading.

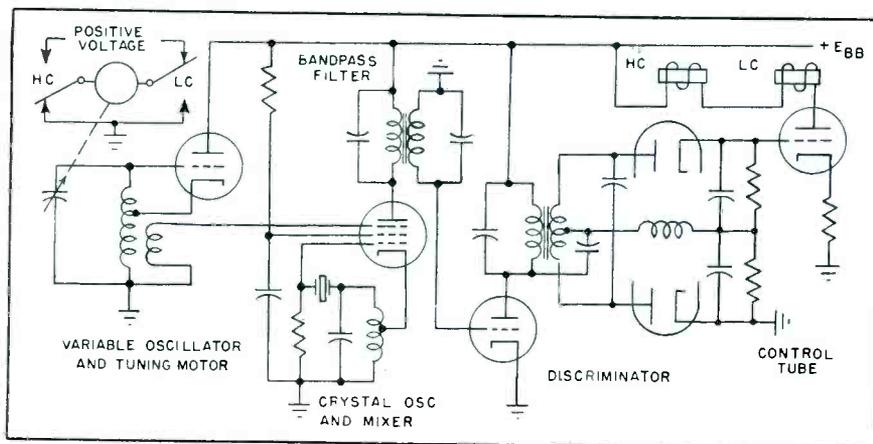
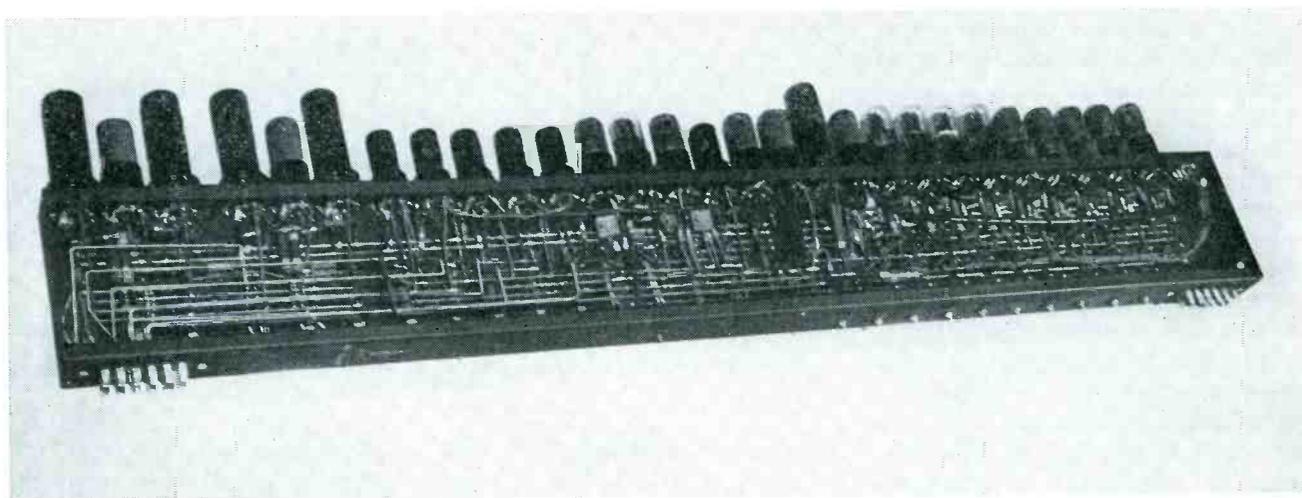


FIG. 3—Frequency stabilization is obtained by beating variable oscillator against crystal oscillator; compare with Fig. 2

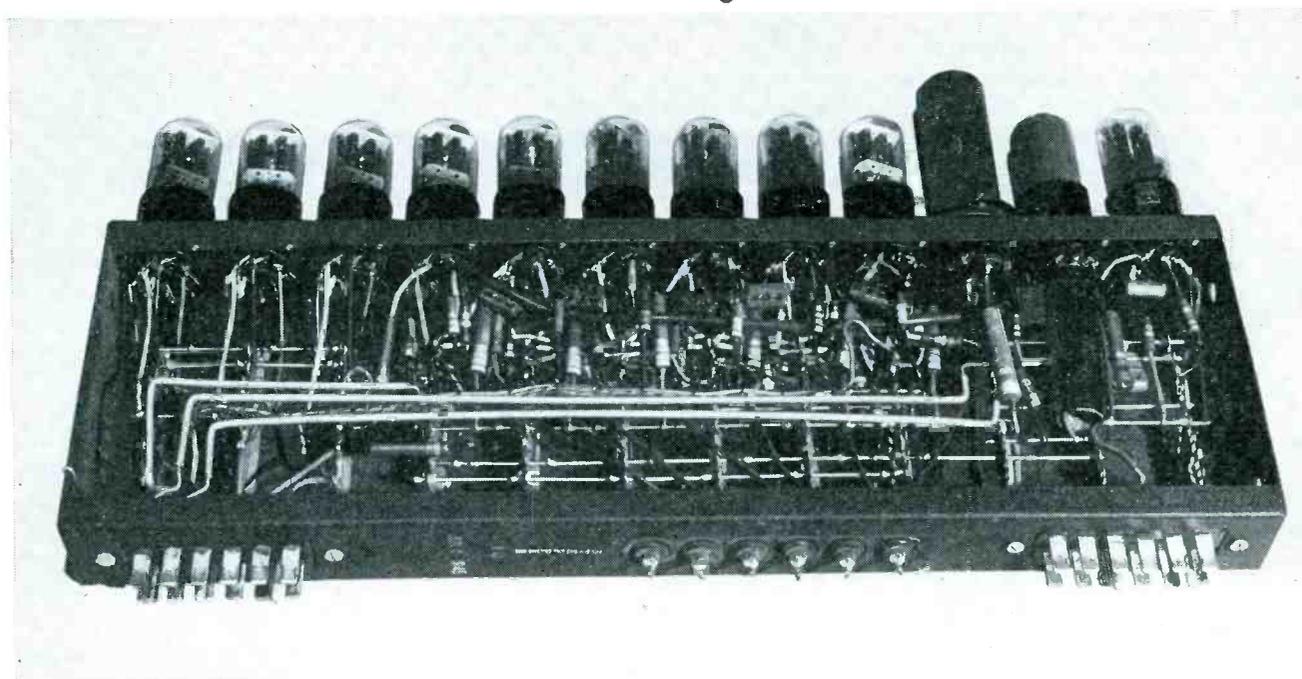
High-Speed N-SCALE COUNTERS

By T. K. SHARPLESS*

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Ten stages at right form counter in this plug-in decade unit; other circuits are for carryover and transmission of count



This stepping switch unit incorporates a six-stage counter. Three tubes at right are part of input pulse-forming circuit

Basic flip-flop and scale-of-two circuits are reviewed, and extension of techniques to the design of ring and chain counters of higher scale is given. Cathode-pulsed n-scale circuit described requires no complex indicating schemes, eliminates counting errors and operates at speeds as high as 180,000 pulses per second

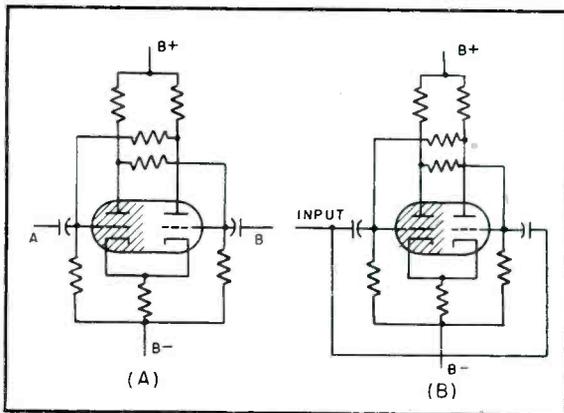


FIG. 1—Flip-flop circuit (A) is tripped by a negative pulse at input A and is reset by negative pulse at input B. Basic scale-of-two circuit (B) has two operating states, alternating from one to the other as successive negative pulses are fed to input

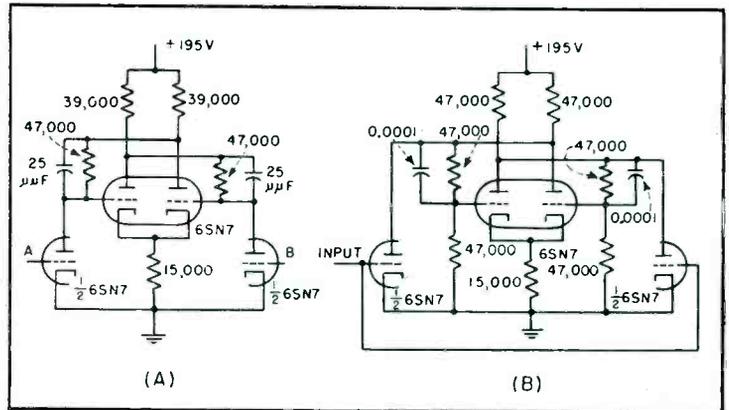


FIG. 2—Flip-flop (A) and scale-of-two (B) circuits used in ENIAC. Negative pulses are used to trip the flip-flop circuit; positive pulses trigger triodes which deliver negative pulses to plates of scale-of-two counter. This example illustrates the fact that trigger pulses of suitable shape can be applied to points other than the grids

ELECTRONIC counters have been known for a number of years and have found extensive use in physics laboratories. In these applications, their major function has been to scale down rapidly occurring pulses to a frequency suitable for the operation of mechanical counters. The fact that such scaling circuits have been used mainly for the study of radiation phenomena has meant that, in the past, electronic counters were regarded solely as laboratory equipment. In recent years, however, the application of these counters to many other problems has resulted in the production of several of them for the general market by a number of manufacturers.

The first publication of a counter circuit intended for commercial production was made in 1944 by Potter.¹ In 1939, Perry Crawford,

* Developments reported were made while the author was Technical Director of the Digital Computing Program at Moore School of Electrical Engineering, University of Pennsylvania.

in a thesis written at MIT, proposed the use of such counters in a computing device. RCA Research Laboratories, in 1941, examined such applications in a computer for a gun director.

Counter Applications

The ENIAC, first large-scale, practical, computing device making use of electronic counter circuits, was designed and built at the Moore School of Electrical Engineering of the University of Pennsylvania and put into operation in December 1945. This machine, involving 300 electronic counters, was built for the Army Ordnance Department and marked a tremendous advance in the art of computing.

Electronic counters are usually derived from two basic types of trigger circuit, the flip-flop and the scale-of-two counter. Both of these circuits are examples of the Eccles-Jordan trigger circuit, first published in 1919.²

To explain the operation of the

flip-flop, Fig. 1A, assume the left-hand triode section to be conducting, and let this condition be designated as state 1. A negative pulse appearing at A will cut off the left-hand triode; the positive signal appearing at its plate will cross over to the opposite grid and turn on the righthand section. The negative signal from this plate is fed back to the lefthand triode and keeps it cut off. The circuit is now in state 2. A subsequent negative pulse on A will have no effect. However, a negative pulse appearing at B will reset the circuit to state 1.

Pulse Dodging

The scale-of-two counter is shown in Fig. 1B. It will be seen that a negative pulse applied to the input tends to hold the righthand triode cut off while the positive signal from the plate of the lefthand tube is trying to turn it on. Thus, in converting a flip-flop to a scale-of-two counter, the problem arises of producing in the crossover a signal

that will override the externally applied signal. This problem can be called the pulse-dodging problem. It is apparent that the shape and magnitude of the tripping pulse in a counter are of utmost importance, although in flip-flop applications such is not the case.

Figure 2 shows the flip-flop and scale-of-two counter circuits actually used in ENIAC. Note that the flip flop is designed to operate with negative pulses applied to inputs *A* and *B* while the counter operates with positive pulses on its single input. Moreover, the counter circuit shows that tripping pulses need not be applied to the grids but can be applied to any suitable point. Application of pulses to the plates of the trigger circuit, in the case of the counter, helped considerably in solving the pulse-dodging problem mentioned above. A number of practical circuits for both flip-flop and scale-of-two counter applications have been devised.³

Once a counter having a scale of two has been designed, the extension of the scale to higher numbers

immediately suggests itself. Scale-of-*n* counters can be made by merely cascading stages of scale-of-two counters, as done by Wynn-Williams.⁴ With this arrangement, *n* can only be a power of two unless special tricks are resorted to as in the Potter counter.¹ As a result, the conducting triode combinations are not linear, so that it is difficult to display the numerical counts simply.

Lewis⁵ designed a circuit of one tube per stage which behaves essentially like the basic Eccles-Jordan circuit, in that one conducting tube is sufficient to keep the others cut off. A five-tube example of this circuit is shown in Fig. 3.

The plate of each tube is connected to the grid of every other tube, giving the circuit stable states in which *n*—1 tubes are turned off and one on. Proper progression of carryover in the counter is achieved by use of capacitance coupling between any one stage and the next, in parallel with the direct resistance coupling which is used to hold the circuit in its particular state. Since the last tube is connected to the first

in this same manner, the circuit is called a ring counter.

The major objection to counters of this sort is that each plate and each grid is loaded by *n*—1 resistors. Thus, as the number of stages increases, the device becomes quite complex. Moreover, this loading of each stage results in a reduction of gain around the loop formed by the *n* stages. Since this gain must be greater than unity for the counter to step, it can be seen that counters of this type are limited in the number of stages that may be used. With presently available vacuum tubes, five stages are about all that seem practicable.

Counter circuits of this type can also be built with *n*—1 tubes conducting and 1 tube cut off. Although this arrangement provides more current for cutting off the one tube, it has the disadvantage that the circuit may run away, for there may exist one moment when all tubes are on and the phase shift around the loop may be some multiple of 360 degrees at a particular frequency so that oscillation can occur.

Lewis combined a scale-of-two with a scale-of-five counter of the type described above, to produce a scale-of-ten counter. Such arrangements have the disadvantage that the operating state of the circuit at any moment is not directly indicated but can be known only by reference to its binary and quinary parts.

n-Scale Counters

In ENIAC, *n*-stage counters are formed using two triodes per stage in standard trigger circuits. Such counters are found in scales of six, nine, ten, fourteen, and twenty.

Figure 4 shows this type of circuit generalized for *n* stages. Consider the circuit to be operating with the shaded tube sections conducting as shown. The counter is now in its first stable state with a positive potential at the lefthand plate of the initial or 0th stage. This condition is indicated by the lighting of the 0th neon glow lamp. No other lamp is lit since the currents drawn through the conducting lefthand tubes are sufficient to drop the plate potentials below the ignition point of the glow lamps. The application of a negative pulse

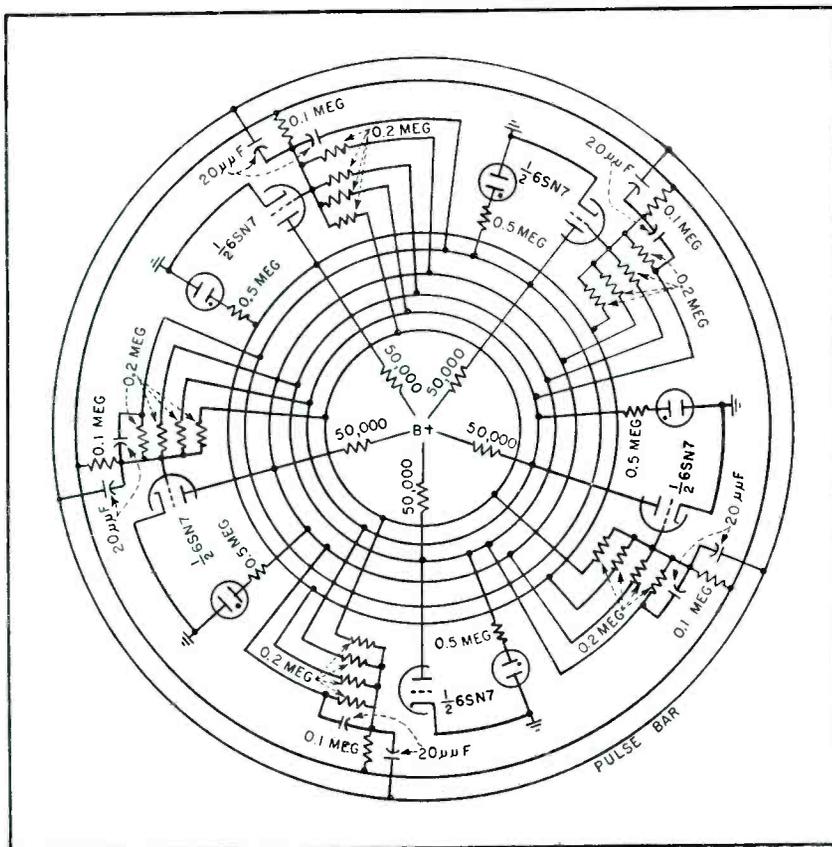


FIG. 3—Lewis five-stage ring counter. Successive pulses fed to pulse bar step the counter through five states; on sixth pulse the counter recycles

to the lefthand cathode of the 0th stage turns that triode on and the trigger action of the stage cuts off the righthand triode producing a positive signal at its plate. This signal, transferred through C_2 , turns on the righthand section of stage 1, thus triggering this stage into the condition that previously existed in stage 0. Successive pulses applied to the pulse line produce similar stepping from stage to stage down the line. If, as shown in the diagram, the last stage is connected back to repeat the cycle, a ring counter results.

As in all previously mentioned counters, the pulse-dodging problem is present, for the negative pulse on the cathode which turns on the lefthand side of an abnormal stage also tends to keep on the lefthand side of the subsequent stage which it is desired to change. That this does not occur is due to the fact that the crossover signal through C_2 is of such amplitude and duration as to override the effect of the negative input pulse. For this overriding action to take place, it is necessary that the applied pulse shape be maintained and its amplitude controlled within quite close limits. This pulse shape and amplitude control is achieved by incorporating as part of each counter the pulse standardizing circuit of Fig. 5.

The fact that each tube in a counter is operated as a binary device, thus having only two states: conducting and nonconducting, is used to advantage. Though the applied pulse, circuit parameters, or bias voltages may vary considerably in amplitude, so long as the grid is driven to cutoff on the one hand and to zero or a slightly positive value on the other, the plate current has only two values. This principle is of basic importance in counter design, since reliability of operation is achieved by minimizing the effect of changing circuit parameters.

Design Considerations

A counter circuit should be so designed that coupling between stages is effected without the use of extra tubes or buffers. Furthermore, it is desirable to arrange the circuit so that there is a minimum

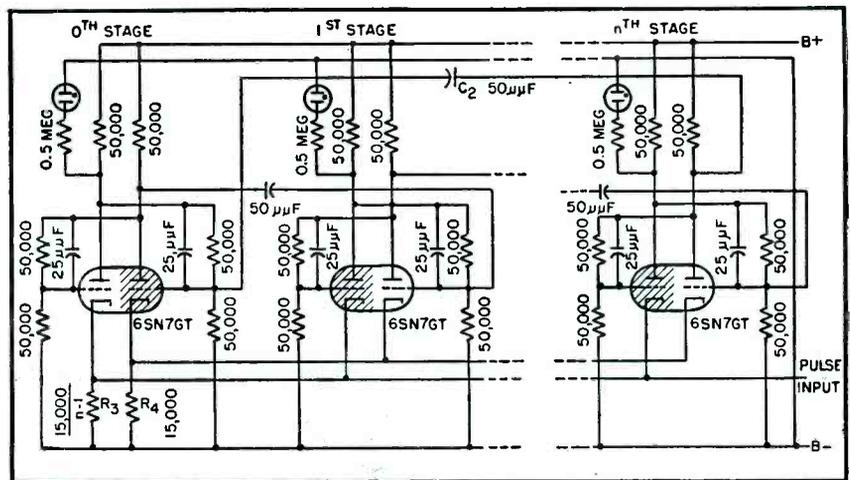


FIG. 4—N-stage counter differs from cascaded binary systems in that cathodes of trigger circuits are interconnected with pulse input causing successive stages to trip in linear sequence

of connections and so that not too many of these go to any one element of the tube, such as the grid. There must be in the decade counter, for example, internal coupling, connections between stages, connections to the pulse bar, connections to the neon indicating lamps, static output connections, and reset connections for clearing the counter. One disadvantage in grid pulsing lies in the fact that the grids are already used for the internal connections so that using them also for the pulse bar connections loads them too heavily.

A counter circuit may be so arranged that it can operate in modes other than the one desired. Thus, if a stable state of a decade counter consists of 9 tubes off and 1 tube on, it may be that the counter can also operate with 2 tubes on and 8 tubes off. If a counter is expected to operate in the first mode, but happens to get started operating in the second mode, then though the circuit will count, the output voltages will be incorrect and the counter useless. The counter of Fig. 4 is capable of only one mode of operation because of the relation between R_3 and R_4 .

In computing machine applications, a counter must be completely reliable, that is, it cannot be permitted to lose a single pulse. Some 300 counters of the type shown in Fig. 4 have been used in ENIAC for the past year and have met this criterion of reliability. Production models operate at a maximum count rate of 180,000 pulses per second or

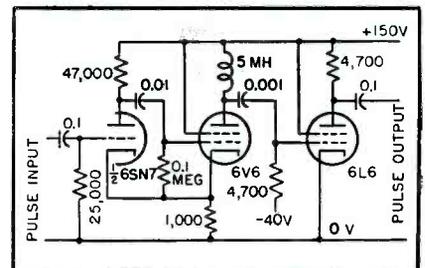
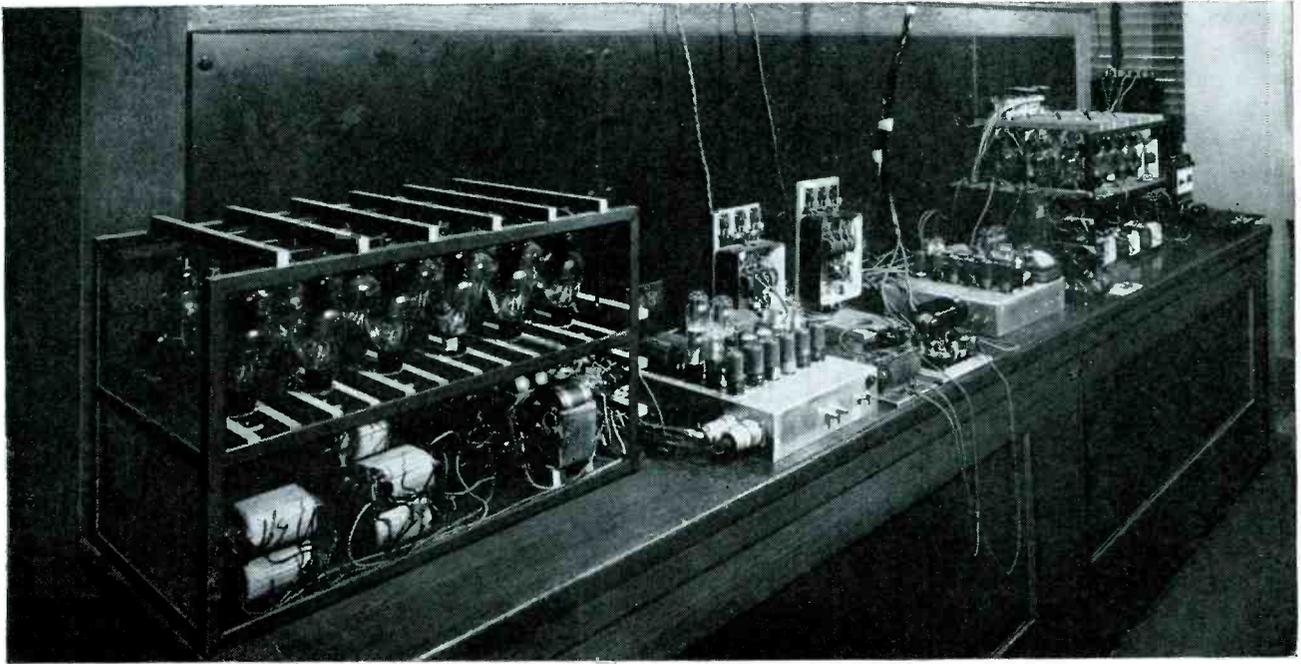


FIG. 5—Pulse-forming circuit for cathode-pulsed counter of Fig. 4. This circuit controls shape of input pulses to insure correct pulse-dodging action

better and count at 100,000 pulses per second with applied voltage ranging from 90 to 500 volts. They are quite insensitive to variations in circuit parameters and particularly to changes in tube characteristics. Indeed, tubes of twice the plate resistance of 6SN7's have been inserted with the result that the counters operated at about 140,000 pulses per second. Since they are designed to operate at 100,000 pulses per second, their use was not impaired. Present electronic computing machine research has produced a number of counting circuits that are reliable at rates up to 2 or 3 million pulses per second.

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Frequency-changer power circuits include parallel-inverter type, left, and cycloconverter, extreme right. Frequency and phase control units are in the center. Connections between control circuits synchronize the two systems to permit parallel operation

THYRATRON Frequency Changers

Designed to permit parallel operation of three-phase aircraft alternators driven at unequal and varying speeds, the converter and control circuits described here produce three-phase power having constant frequency and regulated voltage. Characteristics of two types of power units are compared

By **O. E. BOWLUS** and **P. T. NIMS**

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ONE OF THE interesting problems in connection with modern large aircraft is the provision of adequate electrical power. The number and size of electrical loads increases yearly as new models of gun turrets, radar, automatic controls, and radios are installed. The present systems use 24 volts d-c, but for weight saving with these increased loads, there is considerable interest in 120-volt 3-phase a-c systems.

A major obstacle to a-c operation of the heavier motor loads is the

difficulty of obtaining large blocks of power economically. For fuel economy, it is desirable that aircraft generators be driven by the main engines, and for reliability the power should be available from any or all of the engines of a multi-engined aircraft. This implies that the outputs of several main generators be paralleled at the load bus. Paralleling is difficult, as even with the airplane's engines synchronized well enough to reduce vibration the generators are still a long way from the exact synchronism demanded.

As the generator horsepower is only a small part of the total engine output, the synchronizing torques of the generators are inadequate to hold the system together. In addition, the engine speed for most efficient operation varies with flight conditions and would seldom be that required to give the desired 400-cycle output from the generator.

This situation calls for some method of obtaining synchronization and correct frequency in the electrical system. Mechanical or

hydraulic methods might be used to give a constant-speed drive for the alternators, or the alternators could be directly connected to the aircraft engines and the necessary frequency change obtained electronically. The latter method was chosen as the basis for some experimental work which Chrysler Corporation Engineering Division was asked to do on 4-kva units for the parallel operation of aircraft type alternators. Two units were built and successfully operated in parallel at 400 cycles with input frequencies varying from 300 to 900 cycles¹. The photograph shows the two units set up for bench test. The electronic frequency changer used consisted of a power circuit using eighteen grid-controlled gas-filled rectifiers and a frequency-control circuit with fourteen assorted receiving type tubes. The control circuit provided three-phase, 400-cps, square waves.

Two power circuits were tested, one of the parallel-inverter type², the other of the cycloconverter type³ and certain differences in their operation noted. For three-phase operation, the cycloconverter offered advantages in weight, efficiency, and power factor of the generator. If only single-phase 400-cps power is needed the parallel inverter has possibilities.

Cycloconverter Power Circuit

The complete power circuit of the 4-kva test unit is shown in Fig. 1. The alternator available was rated at 30 volts output, so that a delta-wye connected step-up transformer was used to supply approximately 200 volts to the tubes. The current from one phase of this transformer passes through a load-division current transformer, one of the six tubes connected to it, half of a reactor, a series capacitor, and one phase of the load. As the neutrals are not interconnected, the current

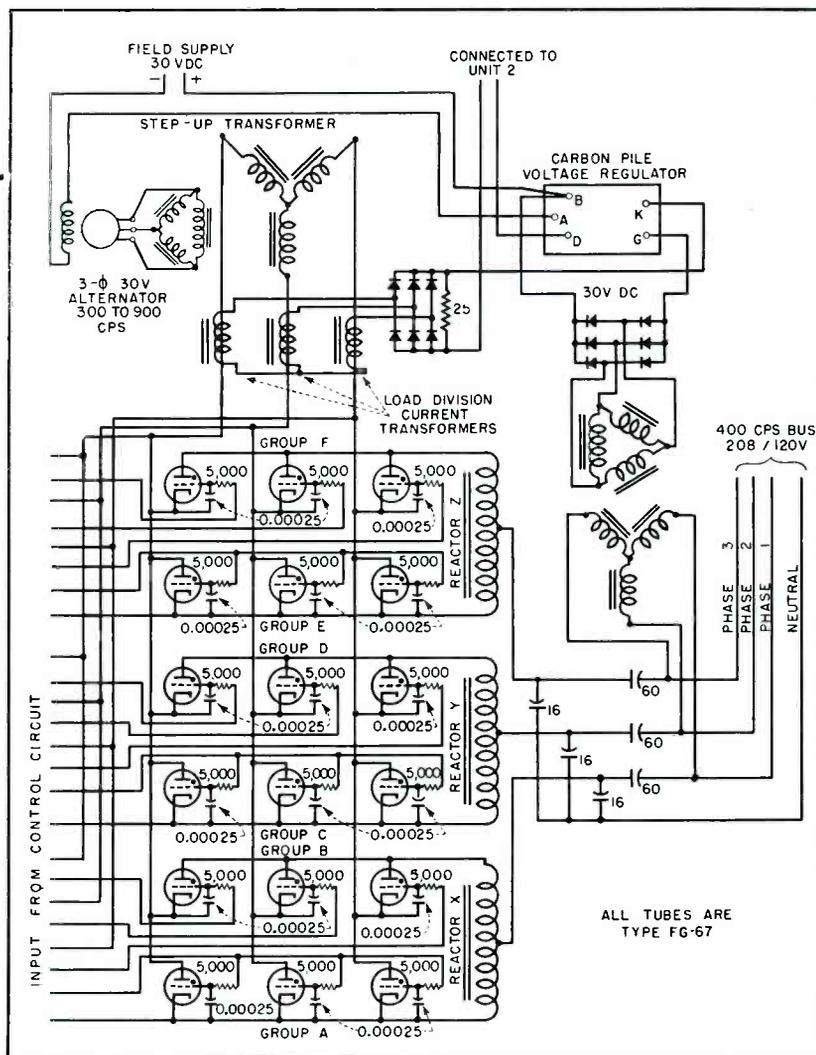


FIG. 1—In the cycloconverter, each phase of the step-up transformer secondary supplies voltage to three pairs of thyratrons. Output frequency is held at 400 cycles by auxiliary control circuit that determines thyatron firing sequence

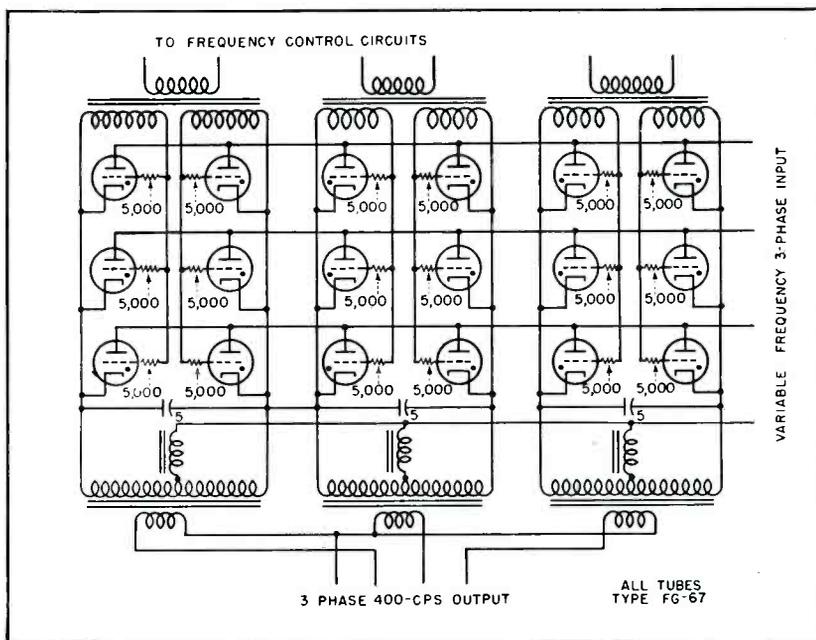


FIG. 2—Three-phase parallel-inverter shown here consists of three interconnected single-phase units with phase sequence determined by circuit of Fig. 4. Losses in transformers and chokes make this circuit less efficient than cycloconverter

returns through another load phase, a series capacitor, half of its reactor, one of the three tubes connected to the end of the reactor, and the phase winding of the transformer.

Operation of the tubes is controlled by the square-wave voltage applied to the grids by the control circuit and by the input voltage applied to the plates and cathodes as shown. Consider group *A* and group *B* for example, which together supply one phase of the load. The tubes of group *A* have their cathodes tied together and their grid bias supplied from a common point in the control circuit. If the grid voltage is positive, then the tube having the most positive plate potential will conduct and raise the common cathode potential high enough to cut off the other tubes. As the input voltage varies through its cycle, another tube anode in group *A* becomes more positive and it conducts, cutting off the previously conducting tube.

When a half cycle of the 400-cycle output frequency is completed, the grids of group *B* are made positive relative to their cathodes. Since the group *B* anodes are connected together, the tube with its cathode connected to the most negative input line conducts and also prevents conduction in the other two tubes.

Commutation

Commutation between groups, that is, extinguishing a tube of group *A* when a tube of group *B* fires, is produced by reactor *X* in the following manner. When a tube in group *A* is conducting, the cathode end of reactor *X* is positive relative to the center tap. However, when a tube of group *B* fires, it instantly makes the anode end of the reactor positive relative to the center tap, and the cathode end is made temporarily negative due to the autotransformer connection of the reactor. The duration of the negative swing is dependent upon the size of the series and shunt capacitors in the output circuit. The negative swing must last long enough to permit the tubes to deionize. This deionization appears to be hastened by the negative grid voltage applied during the off cycle for group *A*^{4, 5}.

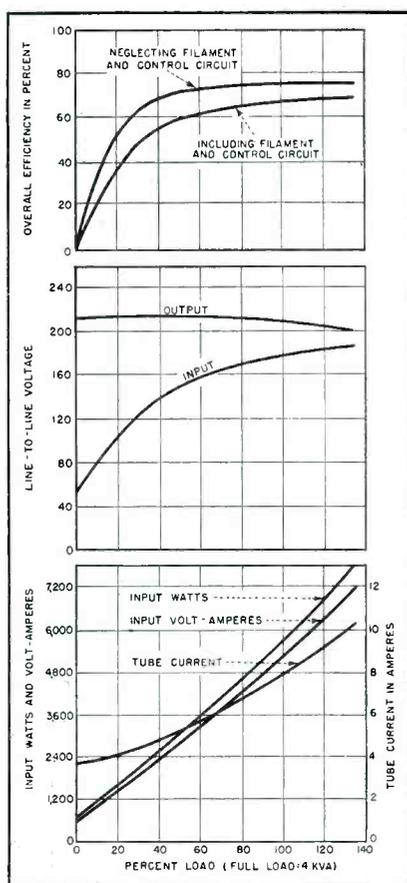


FIG. 3—Performance curves for cycloconverter power circuit

It is interesting to note that for the special case when the input frequency exactly equals the output frequency, six of the eighteen power tubes will be completely inoperative. If sustained operation is possible under this condition, then either the tubes should be chosen with ample capacity or some provision made to shift the output frequency slightly to prevent sustained operation.

Parallel Inverter

When operated as a frequency changer, the parallel inverter is basically a device using 3-phase input at one frequency to give single-phase output at another frequency. The anodes of six tubes are connected in pairs to the source, and the cathodes in two groups of three to the output transformer. Figure 2 shows how three such units are connected to give 3-phase output and shows also the neutral return for the supply lines. Tests on this circuit showed satisfactory operation but larger I^2R losses in the various transformers and chokes. The circuit also required

an output transformer as well as the series reactor.

The overall efficiency, input voltage variation and power input of the cycloconverter are shown in Fig. 3.

Parallel Operation

The two types of frequency changers operate well in parallel, with load division on the alternators controlled by the voltage regulators as in a d-c system. Heavy resistive loads, even to the point of short circuiting the output terminals, were carried with ease. Inductive loads require correction to nearly unity power factor for satisfactory operation, because of effects on both wave form and commutation. One-quarter hp motors start and operate normally. A 3-hp motor will start and operate normally, provided there is ample resistive load on the bus to stabilize the system.

Control Circuit

The control circuit, as mentioned, supplies a 3-phase 400-cycle square wave for the power tubes. It is these control circuits which are synchronized for parallel operation of two frequency-changer units as shown in Fig. 4. The basic frequency is determined by an 884 gas triode which discharges 2,400 times per second. These pulses are fed to the grids of three 6J5 triodes connected in a ring-of-three counter circuit⁶. Each 6J5 goes through an on-off-on cycle 800 times per second, and each tube operates 1/2,400 of a second after its predecessor in the ring. This gives 3-phase voltages at 800 cycles.

The final stage of the control circuit comprises three pairs of 6V6GT pentodes connected in a modified Eccles-Jordan circuit. The cathode, grid, and screen of each tube are in the flip-flop circuit and the anode is connected to the transformer which forms the output connection of one phase of the control. The tubes in each pair conduct alternately and thus produce in the transformer a 400-cps square wave of voltage. The vacuum tubes used in these counting circuits operated with much more stability than the gas triodes first used.

Output frequency is determined

by a single-tube inverter circuit. Referring to Fig. 4, capacitor C_1 is rapidly charged through tube V_1 to somewhat above line voltage by virtue of the inductance of the primary of transformer T_1 . Since the cathode at this instant is positive with respect to plate and the grid is held negative with respect to cathode, the tube is extinguished. Capacitor C_1 then discharges through resistors R_1 , R_2 , until the combination of plate-to-cathode and grid-to-cathode voltages are such as to fire the tube. Capacitor C_1 is

again rapidly charged. The cathode voltage has a sawtooth waveshape with sharp rise and slow decay.

The sawtooth voltage is fed through capacitors C_2 , C_3 , C_4 at the grids of tubes V_2 , V_3 , V_4 in the three-tube switching circuit. These tubes are biased in such a manner that at any instant two are conducting while the third is cut off. Each pulse of the sawtooth voltage causes the tube which is cut off to conduct and causes one of the other two tubes to cease conducting. The cut-off condition passes from one tube

to the next in definite sequence.

In Fig. 4, assume tube V_2 to be nonconducting and tubes V_3 and V_4 to be conducting. The plate of tube V_2 is near supply potential and, by means of the voltage dividing resistors R_1 and R_7 , tends to hold the grid of tube V_3 at or above cathode potential. Also, by means of resistors R_{11} and R_8 , the plate of tube V_2 tends to hold the grid of tube V_4 at or above cathode potential. Tubes V_3 and V_4 are held conducting. When conducting, the plate potential of tubes V_3 and V_4 is approxi-

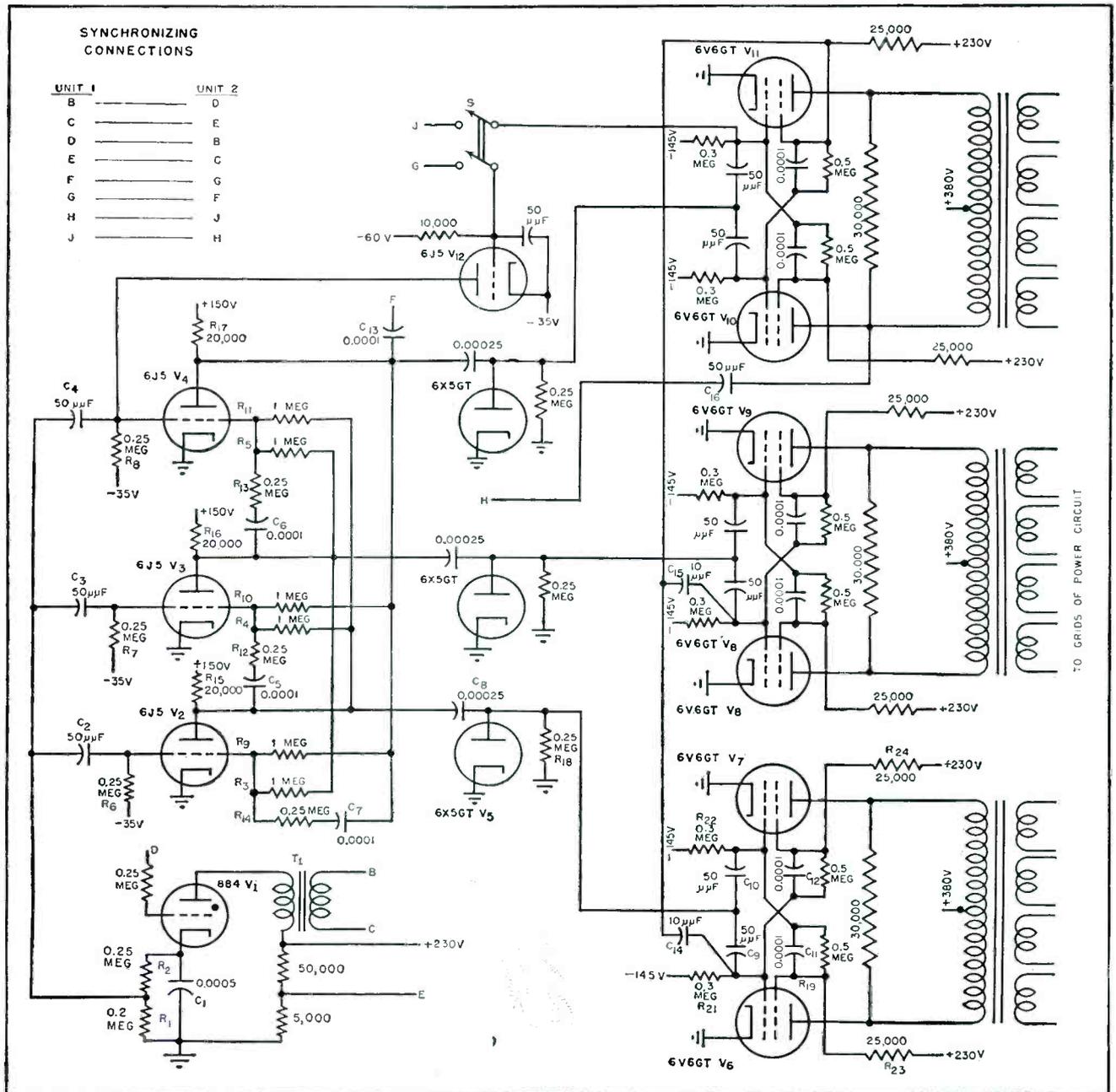


FIG. 4—In the control circuit, a 2,400-cycle relaxation oscillator drives a ring-of-three counter that develops three 800-cycle square-wave output voltages having 120-degree phase relationship. Each of these voltages drives a flip-flop circuit coupled to the thyatron

mately one-third the supply-to-cathode voltage. By means of resistors R_3 , R_9 , and R_8 , the grid of tube V_2 is held sufficiently negative with respect to cathode to block the flow of plate current. When the next upward sawtooth voltage pulse is transmitted through capacitors C_2 , C_3 , and C_4 to the grids of all three tubes, the grid of tube V_2 is made less negative with respect to cathode causing plate current to flow. As soon as plate current flows, the plate voltage drops by virtue of resistor R_{16} . This drop, being transmitted to the grids of tubes V_3 and V_4 , tends to reduce the plate current in these tubes. At the same time, the grid of tube V_3 is given an additional downward kick by capacitor C_5 and resistor R_{12} . Consequently, the plate voltage of tube V_3 rises faster than that of V_4 . Tube V_3 assumes control by holding tubes V_2 and V_4 conducting. The next upward sawtooth voltage pulse renders tube V_3 conducting and tube V_4 is selected by capacitor C_6 and resistor R_{13} to become nonconducting. The next pulse renders tube V_2 nonconducting, and the process continues in this manner.

The plate-to-cathode voltage from tube V_2 is clipped to form an inverted saw-tooth wave. The clipping circuit consists of tube V_6 , capacitor C_8 , and resistor R_{18} . On the positive swing of the input voltage, tube V_6 , being a diode rectifier, passes current causing capacitor C_8 to be charged with the input side positive. On the downward swing of the input, a voltage suddenly appears across resistor R_{18} . During the horizontal portion of the input voltage, the charge on capacitor C_8 gradually leaks off through resistor R_{18} . The cycle repeats on the next upward swing of the input voltage.

The inverted sawtooth voltage is transmitted to tubes V_6 and V_7 through capacitors C_9 and C_{10} . In the flip-flop circuit comprising tubes V_6 and V_7 , consider first the part connected to screen grid, control grid, and cathode. The tubes are so biased that, in the steady state condition, one tube blocks current while the other passes current. Each input pulse from the clipper circuit reverses the condition on the tubes, that is, the one which was blocked is made to pass current and

the one which was passing current is made nonconducting.

Assume tube V_6 blocked and tube V_7 conducting. Then the screen grid of tube V_6 is near line potential and the control grid of tube V_7 is held at or above cathode potential by means of the potentiometer circuit consisting of resistors R_{19} and R_{20} . Likewise the screen grid of tube V_7 , because of the drop across resistor R_{21} , holds the control grid of tube V_6 below cutoff by means of resistors R_{20} and R_{21} . The next negative pulse from the input voltage drives the control grid of tube V_7 negative, reducing the flow of screen current. The rise in screen voltage transmits a positive kick through capacitor C_{12} to the control grid of tube V_6 . The resulting rise in screen voltage on tube V_6 is transmitted through capacitor C_{11} to the control grid of tube V_7 . The process once started, continues until the current is transferred from one tube to the other. A square voltage wave is obtained between screen grid and cathode.

The primary of a center-tapped transformer is connected between the plates of tubes V_6 and V_7 with the centertap connected to positive d-c line voltage. By connecting a resistor across the primary, a square output voltage can be obtained. Four secondary windings are provided for connection to the control grids of the FG-67 power tubes.

It will be noted there are three separate flip-flop circuits. Action of the other two is identical to that of the one explained.

Synchronization

The secondary of transformer T_1 in the plate circuit of tube V_1 transmits a transient pulse through connector pins B and C to connector pins D and E in control circuit 2. This pulse is further transmitted to the control grid of tube V_1 in control circuit 2, in such a manner to fire the tube, unless, of course, it is already conducting. Likewise, the secondary of transformer T_1 in the plate circuit of tube V_1 in control circuit 2 transmits a transient pulse to the control grid of tube V_1 in control circuit 1. Whichever tube fires first fires the other. The tube with the shortest period will

determine the output frequency.

Tube V_{12} is used to synchronize the three-tube switching circuits in the two control circuits. Capacitor C_{13} , attached to plate of tube V_4 in control circuit 1, transmits a pulse to grid of tube V_{12} in control circuit 2 when synchronizing switch S is depressed. When tube V_4 in control circuit 1 is blocked, tube V_{12} in control circuit 2 is made conducting. Tube V_{12} holds the grid of tube V_4 in control circuit 2 below cutoff. In this manner, tube V_4 in control circuit 2 is made to be nonconducting during the same period tube V_4 in control circuit 1 is nonconducting. Once the circuits are brought into step, switch S may be opened.

In the flip-flop circuit, the tubes must fire in the following sequence: V_9 , V_8 , V_{10} , V_7 , V_9 , V_{11} . Capacitors C_{14} and C_{15} hold them in this sequence. Three of the six tubes are conducting at any given instant. From the above sequence it may be seen that when tube V_{11} becomes conducting, tubes V_6 and V_8 must be nonconducting. When tube V_{11} fires, a downward pulse is transmitted through capacitors C_{14} and C_{15} to the control grid of tubes V_6 and V_8 , rendering the tubes nonconducting if they are not already in that condition.

There still remains a possibility of the flip-flop circuit in control circuit 2 being 180 degrees out of phase with the flip-flop circuit in control circuit 1. To bring them in step, a small capacitor C_{16} is connected from the plate of tube V_{10} in control circuit 1 through switch S to the grid of tube V_{11} in control circuit 2.

The three-tube switching circuit and the six-tube flip-flop circuit are synchronized by the same switch S . Both control circuits are connected so that either may be synchronized to the other.

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Filter Ripple Chart

Where choke input is used, output characteristics are readily predetermined. Curves are given for 50 and 60-cycle, half-wave and full-wave, and single and three-phase rectifiers. A rectifier attenuation table is included

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WHEN USING choke-input filters, the output ripple of rectifier-type power supplies can be predetermined from the accompanying chart.

It is necessary to know the inductance value, in henrys, and the capacitance, in microfarads, for each filter section. Knowing the product of these two terms,

the amount of attenuation in db for each filter section can be read directly on the chart. Curves are given for 50-cycle (dashed lines) and 60-cycle (solid lines) power, for the four types of supplies most often used in industrial equipment.

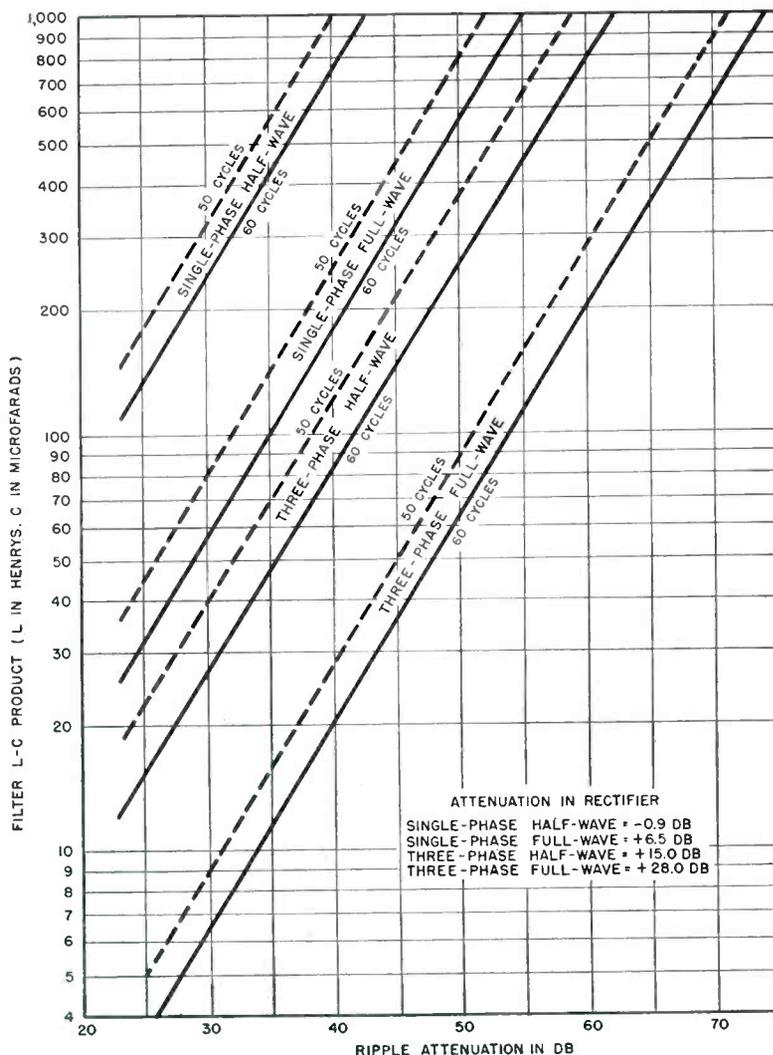
To obtain the total output ripple in db below the d-c level, the equivalent rectifier attenuation must be added to that of the filter sections.

Practical Example

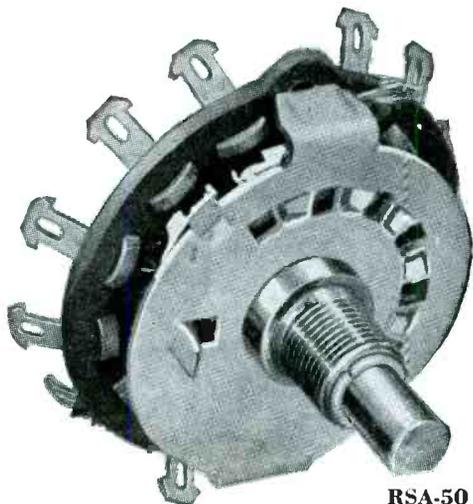
The following example will illustrate the use of the chart. Assume that a single-phase full-wave rectifier operating from a 60-cycle supply has a two-stage choke-input filter. One of the filters consists of a 2-henry choke and 15- μ f capacitor. The other filter consists of a 2-henry choke and 20- μ f capacitor.

For the first filter, with an L-C product of $2 \times 15 = 30$, the attenuation is read as 24.5 db. The second filter has an L-C product of $2 \times 20 = 40$ and the attenuation is read as 27 db. From the table the equivalent rectifier attenuation of a single-phase full-wave rectifier is given as + 6.5 db.

The total resulting ripple attenuation is the sum of that of the individual filter sections plus that of the rectifier. In this case, the total is $24.5 + 27 + 6.5 = 58$ db rms below the d-c level.



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THE FRONT COVER

THE CHASSIS shown on this month's cover combines three amplifiers, one modulator, and pulse shaping and clamping circuits, of the Ludwig electronic-hydraulic high speed industrial computer. This unit solves continuously a differential equation involving error, integral of error and derivative of error.

The computer has been developed to solve problems of register in web processing, any manufacturing or converting operation involving a continuous sheet of material, as in printing, cutting, slitting, winding, and rolling. Processing registration accuracies up to and beyond 0.0001 inch on any web can be built into a control which will be fully automatic over a web speed range of ten to one.

The computer on the cover, shown with inventor John W. Ludwig, was adapted to multicolor registration on high-speed rotogravure presses. It holds color register to 0.0001 inch at web speeds ranging from 100 ft per min to 1,000 ft per min. Errors are corrected within 0.15 second. In the case of slow gradual errors, corrective control is thus anticipatory. Comparable accuracies and correction times are engineered into controls governing metal rolling, sheet metal processing, cutting, slitting, roll wind and rewind, fabric and synthetic web processing.

which may be selected by a switch as a band-pass filter of 1,500-2,500 cycles or a high-pass filter of 6,500 cycles. This signal is amplified by both halves of a 2C51 to produce an output of the high-frequency signal modulated by the low-frequency signal to a degree dependent upon the amount of intermodulation in the input signal.

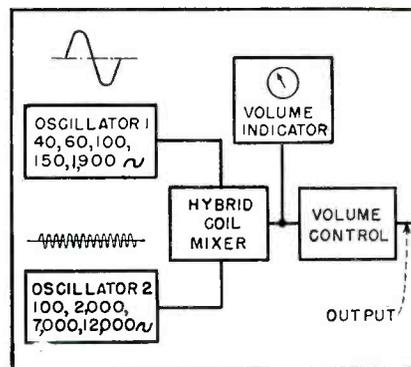
The output of the high-frequency amplifier is rectified and filtered through a low-pass filter with a terminating resistor of 2,400 ohms, R_{25} . The amplitude of the low-frequency voltage impressed on this resistor is relative to the degree of intermodulation in the input signal, while the average current passing through R_{25} indicates the amplitude of the high-frequency input signal.

The low-frequency component from the low-pass filter is impressed upon the primary of transformer T_3 , the secondary of which is connected to a variable attenuator which has provision for settings of 5, 15, 50, and 100-percent intermodulation, allowing full-scale intermodulation readings. The output of the attenuator is amplified by one-half of a 2C51 and this output rectified by the 6AL5 full-wave rectifier.

The voltage developed across R_{25} is applied to the grid of the other half of the 2C51 used in the low-

frequency amplifier—a space-saving feature made possible by the shielding of the individual sections within the tube—and the triode used as a vtvm in connection with M_2 , on which the percentage intermodulation is read directly. In the preceding rectification, the voltage polarity developed is always such as to make the grid negative with respect to ground. The cathode voltage is adjusted by a control on the front panel so that M_2 will read zero percent intermodulation by applying positive d-c voltage to the grid, increasing plate and cathode voltage.

Since the output of the rectifier V_1 is such as to make the grid of the vtvm more negative as the amount of intermodulation increases, the plate current and cathode voltage



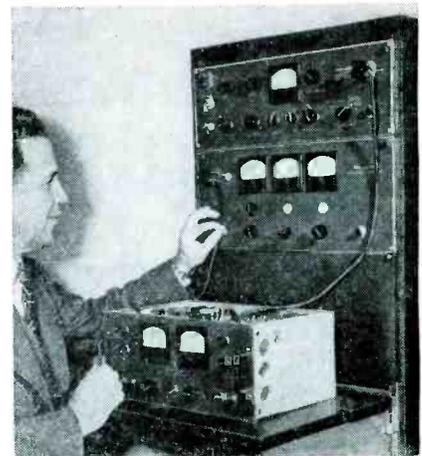
Essential stages of the system for measuring intermodulation distortion

decrease with intermodulation increase, causing the pointer of M_2 to move.

Although the new system will be of value in many fields where audio frequencies are used, it will be of particular importance in the measurement of intermodulation on variable density sound track where intermodulation occurs not only during recording, but within the film itself.

Application

To determine optimum processing and recording techniques, the output of the signal generator is adjusted so as to modulate the light valve about 1.5 db below the clash point, or the point at which the two ribbons of the light valve overlap in the path of the light beam, thereby providing the maximum safe modulation. Recordings are then



The signal generator and analyzer mounted on the rack form the two units of the Western Electric intermodulation test set for measuring audio-frequency distortion caused by intermodulation

made at several recorder lamp intensities and the negatives processed for various values of gamma. Positive prints are next made for each negative at several printer light values in a region which past experience has shown to be acceptable.

Each of the several positives is then run on a suitable reproducer and the output fed into the intermodulation analyzer. The print which gives the optimum reading in terms of intermodulation percentage is then used as a guide in making further, more specific tests by

(continued on p 150)

Get the facts on Western's miniatures!



Western Electric is now offering a group of miniature tubes, including 2 twin triodes and 6 pentodes. They were developed by Bell Telephone Laboratories...are manufactured by Western Electric to the high standards of quality for which

all Western Electric tubes are noted. Data sheets on all these miniatures are available for your design files. Send the coupon for sheets on the types you are interested in—or call your Graybar Representative for full information.

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6AS6	Pentode	6.3	175	180
6AK5	Pentode	6.3	175	180
6AJ5	Pentode	6.3	175	180
5590	Pentode	6.3	150	180
5591	Pentode	6.3	150	180
408A	Pentode	20	50	180
2C51	Twin Triode	6.3	30	300
407A	Twin Triode	20 (parallel) 40 (series)	100 (parallel) 50 (series)	300



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6AK5 5590 408A 407A

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City _____ State _____

Western Electric

—QUALITY COUNTS—

THE ELECTRON ART

Edited by FRANK ROCKETT

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Theoretical Requirements for Communication Systems

ADDITIONAL LIGHT was shed on new methods for determining effectiveness of communication systems in utilizing frequency spectrum, transmission time, and transmitter power to convey information from point to point in the presence of noise by W. G. Tuller, Project Engineer of Melpar Inc., before 120 members of the Princeton Section of the IRE on January 8 at Princeton University. After philosophizing as to whether communication systems convey information or intelligence, Mr. Tuller presented criteria by which such systems can be evaluated. The concepts, reported below, are extensions of the Hartley Law, which has been recently modified to include the effect of signal-noise ratio (ELECTRONICS, p 72, Jan. 1948).

Elements of Communications

To determine efficiency with which a communication system, the essential feature of which is usually the modulation, utilizes its transmission medium, the fundamental laws of communications need to be known. Knowing these laws, their influence on specific systems can be determined. However, here the interest is limited to the laws themselves.

Consider the simplified com-

munication system of Fig. 1A. Laws governing this system can be deduced most directly by considering its abstract (mathematical) properties. Thus, the transmitter can be considered to map the information signal S from its two-dimensional (time and amplitude) aspect or space to the modulated carrier C in its multidimensional space, with a one-to-one correspondence between S and C . The receiver reconverts C to S . The information occupies a bandwidth F and continues for a time T . The carrier occupies a bandwidth B and (in this discussion) is transmitted for time T . White thermal (completely random) noise N unavoidably enters the system.

If there is any known correlation between parts of the signal of higher probability than between parts of the information that is to be transmitted, it should be removed before modulation; the signal will then have the same characteristic as white noise passed by the same bandwidth. (What is meant by the mathematical concepts of the foregoing statement can be illustrated by a typical example. An operator, in copying telegraphy through strong interference, is able to fill in unintelligible letters by knowing what the words ought to

be. He correlates what precedes and follows portions of the signal to find out what the garbled portions are. In this case more letters are transmitted than the probability of the receiving operator's deducing them necessitates. Not all the letters needed to be transmitted in the first place for the operator to have deduced the complete message.) For example: because the amplitudes for the frequency components of speech decrease with increasing frequency, whereas the amplitudes of all the frequency components of noise are equal, pre-emphasis should be used to remove the amplitude-frequency correlation of speech.

At the receiver output, because of the noise, there is a region of uncertainty about the amplitude of the signal as shown in Fig. 1B. The noise N fixes the depth of this region. (The system must be designed to provide a maximum amplitude of the signal so that the signal-noise ratio meets the requirements of whatever service the channel is to be used for.) Therefore only $(1 + S/N)$ discrete amplitudes of signal can be distinguished. (The "one" arises from the fact that, if a line is cut by M intersections, it is divided into $1 + M$ segments, counting the ends as well as the segments between intersections.) The amplitude dimension of the signal is thus broken into a series of discrete levels. The signal is said to be quantized because of the parallel to the quantum theory. Quantization is done at the amplitude intervals that can be just distinguished in the presence of the finite noise.

It is unnecessary to transmit a continuously varying signal. Therefore the quantized signal can be sampled at the fastest rate at which it is expected to exhibit a distinguishable change in amplitude because of its finite bandwidth, as

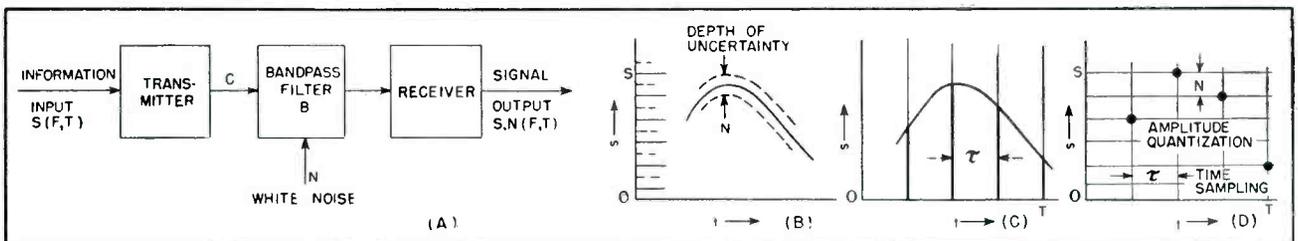
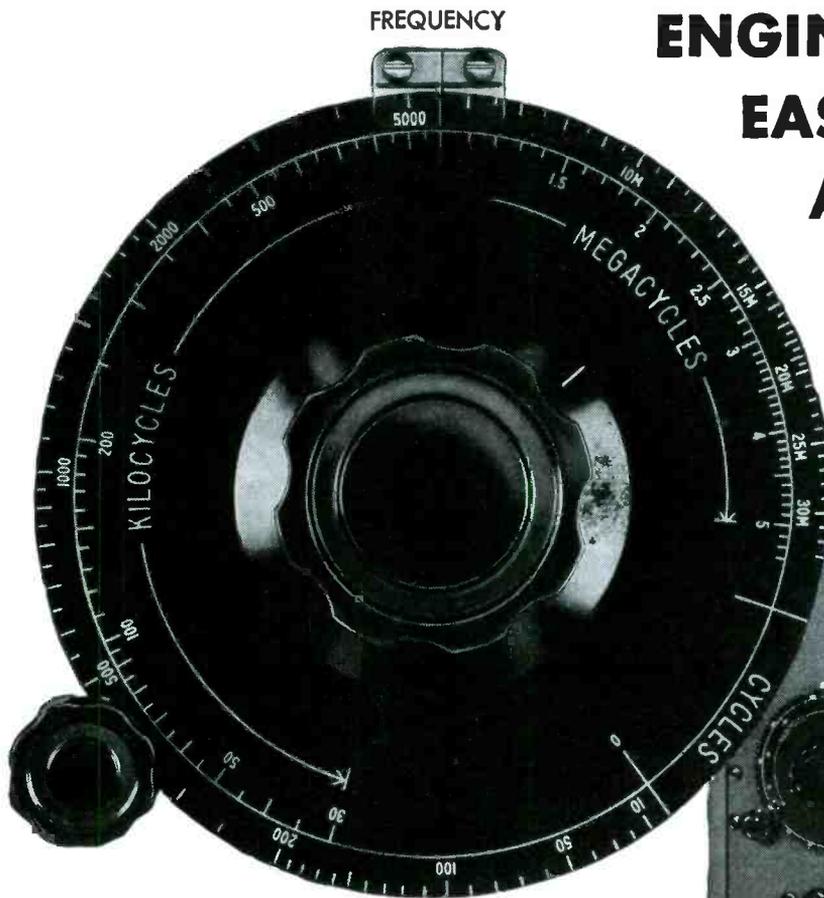


FIG. 1—Basic elements of simple communication system indicate that transmission can be by two-dimensional points

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THE BEAT FREQUENCY GENERATOR TYPE 140-A



AN IMPORTANT FEATURE

of this instrument is the large dial scale which has been planned for maximum readability and rapid setting—the overall dial scale length from 20 cycles to 5 megacycles exceeds 22 inches. The low frequency scale overlaps the high frequency scale at 30 kc, permitting continuous frequency coverage over the entire audio spectrum without bothersome range switching.

One of the most valuable instruments in the laboratory is a generator of signal voltage. Boonton Radio Engineers in designing the Type 140-A Beat Frequency Generator have provided an instrument of wide frequency coverage, capable of supplying accurate output voltages ranging from several microvolts to 30 volts and having a variety of output impedances from 20 ohms to 1000 ohms.

A 1-inch cathode ray tube has been provided to standardize the low frequency range against the power line frequency and to allow multiples of this frequency to be set with excellent accuracy by means of the cathode ray tube pattern.

An output attenuator having five decimal steps permits accurate setting of voltages as little as 1 millivolt. Engineers making gain or sensitivity measurements will particularly appreciate this feature.

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FREQUENCY RANGE: 20 cycles to 5 megacycles in two ranges. Low range: 20 to 30,000 cycles. High range: 30 kc to 5 megacycles.

FREQUENCY CALIBRATION: Accuracy ± 2 cycles up to 100 cycles, $\pm 2\%$ above 100 cycles.

STABILITY: About 5 cycles drift below 1000 cycles. On low range, drift becomes negligible percentage with increasing frequency. On high range, drift is 3% or less.

ADJUSTMENT: High and low ranges have individual zero beat adjustments. Low range may be checked against power line frequency with front panel 1-inch cathode ray tube.

OUTPUT POWER AND IMPEDANCES: Rated power output: One watt, available over the low frequency range from output impedances of 20, 50, 200, 500, 1000 ohms, and over both high and low frequency ranges from an output impedance of 1000 ohms.

DISTORTION: 5% or less at 1 watt output, 2% or less for $\frac{1}{2}$ voltage output.

VOLTMETER ACCURACY: $\pm 3\%$ of full scale reading.

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DESIGNERS AND MANUFACTURERS OF THE "Q" METER . . . QX-CHECKER . . . FREQUENCY MODULATED SIGNAL GENERATOR . . . BEAT FREQUENCY GENERATOR . . . AND OTHER DIRECT READING TEST INSTRUMENTS

shown in Fig. 1C. Sampling produces T/τ samples in time T at intervals of τ , $\tau = 1/2F$, where F is the highest frequency component in the signal. The result of amplitude quantization and time sampling is a series of signal points as shown in Fig. 1D.

Because all information-bearing signals can be reduced to such points, the series of random points is the most general form of signal. Only the coordinates (time and amplitude) of these points need be considered in communication theory. In practice these coordinates are transmitted in any convenient way such as carrier amplitude modulation, frequency deviation, or binary pulse code. At the receiver the particular modulation process is performed in reverse.

Characteristics of Systems

The foregoing treatment shows that the number of two-dimensional information points is $2FT$, and that each one occurs at random from a set of $(1 + S/N)$ possible points. Therefore, to handle this signal, an area capable of handing $(1 + S/N)^{2FT}$ total signals is required, or the capacity H of the information signal space is

$$H = (2FT) \log (1 + S/N) \quad (1)$$

whereas heretofore the basic communication law has stated that the capacity was proportional to the product of the bandwidth and the time FT .

In a similar manner, the capacity for containing information of the carrier space is $(2BT) \log (1 + C/N)$. In designing a communication system, the capacity of the information space is made equal to that of the carrier space, so that $(2FT) \log (1 + S/N) = (2BT) \log (1 + C/N)$. To simplify the mathematics, assume that both information and carrier signals are well above the noise, so that the equation reduces to

$$(S/N) \approx (C/N)^{B/F} : \text{Case I}$$

where the "less than" is necessary because of the immediately foregoing simplifications. In Case I the transmitter sends more or less than one point for each information point; that is, it maps into a higher or lower order space, as in pulse code modulation in which each information point is transmitted as

several pulses of the code group.

If the transmitter sends one point for each point from the information signal, mapping into the same order space, the relation is the familiar

$$(S/N) \approx (B/F) (C/N) : \text{Case II}$$

applying to a-m, p-m, and f-m. The characteristics of any communication system can be expressed by one of these two relations.

Examples of Realization

These theoretical considerations can be used to study properties of any method of modulation, or to determine minimum requirements for a given service. For example; if B/F is to be smaller than unity, when transmission occupies less bandwidth than the information, C/N must be large to maintain a useful S/N . Or in general, the capacity of the two portions (information and transmission) of the system are made equal by adjusting the signal-noise ratio to compensate for changes in bandwidth. In Case I the exchange of signal-noise ratio for bandwidth is exponential, in Case II the exchange is simply multiplicative.

To visualize how wideband information can be transmitted in a narrow band, consider a generalized signal that consists of an amplitude-modulated pulse train. The amplitudes of three consecutive pulses of the train are 3, 5, and 7 units, the peak possible amplitude being 10 units. Instead of transmitting these three sharp pulses in rapid sequence, they can be converted, by complex terminal equipment operating along the lines of digital computers, into a single pulse 357 units in amplitude. This pulse can then be transmitted in the same time that the three would have required, and it can be much wider than any one of the original three. The transmitted bandwidth is thus reduced. If the amplitudes of the three original pulses are to be recovered to an accuracy of one part in ten, $S/N = 10$, the C/N will have to be 1,000. Because three information points are transmitted as only one point, this is a Case I system. The transmitted bandwidth would be about a third the information bandwidth.

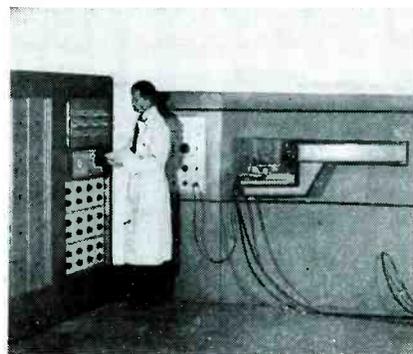
Unfortunately, in Case II sys-

tems, bandwidth can be reduced only by increasing transmission time because, as originally postulated, each information point is transmitted as a single transmission point. The most obvious example of a narrower band Case II system is that based on recording the message and transmitting the record at low speed. This method requires consideration of message duration, the law for which has long been known and need not be reviewed here. In general, Case II systems are best used to improve signal-noise ratio by increasing bandwidth, as is done in frequency modulation. In this instance $(S/N) = \sqrt{3}(C/N)$, the $\sqrt{3}$ arising because a rectangular spectrum is assumed in the derivation, but is not used practically.

Although terminal equipment for such systems is costly, being both more complex and requiring higher transmitter power, it may be justified by the necessity to provide facilities for the growing volume of communication to be handled in the available frequency spectrum.

Recording Spectrometer

QUANTITATIVE ANALYSIS of low-alloy steels can be made quickly with a direct reading spectrometer containing 12 light receivers. The instrument comprises a conventional exciter for producing a high intens-



Industrial materials can be analysed in a minute with this direct-reading

ity spectrum from the metallurgical sample to be analysed, and a grating spectrometer producing a long focal curve. To obtain direct indications of percentages of alloys present, 12 light receivers with in-

(continued on p 174)

This amazing WARD aerial sells FM better than 10,000 words!

THE SMARTEST WAY TO MERCHANDISE FM

Every FM receiver needs an outdoor dipole aerial and, when you hear the amazing difference this new Ward Magic Wand* makes in FM reception, you'll be sold solid. For, then you'll agree there's only one way to sell, or buy, FM . . . that's with aerial installation included. Equally efficient from all directions, this new broad band turnstile folded dipole continues to get all stations in your area regardless of how many more are yet to come on the air. Equal in signal strength to a high-gain folded dipole, it has a quarter-wave phasing loop which places elements 90 degrees apart electrically. Construction is all-metal, weather-proof. Complete fittings for installation included. Stock it, demonstrate it and sell it to present owners, and future purchasers, of FM radios!

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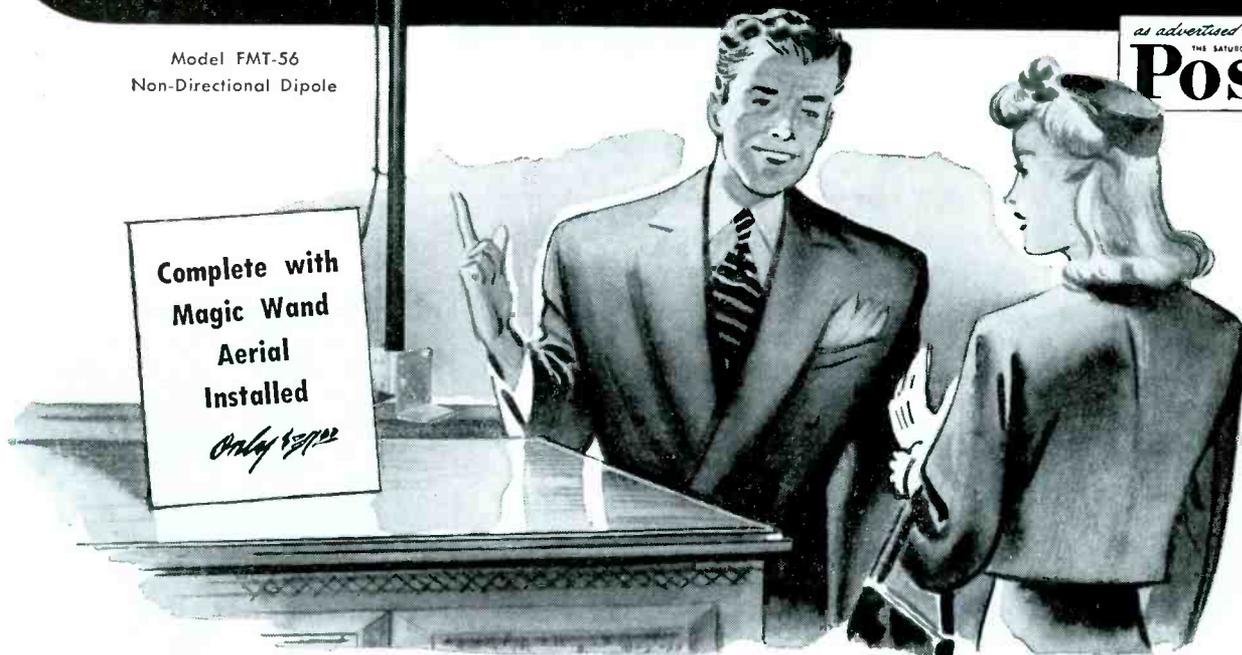
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NEW PRODUCTS

Edited by A. A. McKENZIE

New equipment, components, tubes, testing apparatus and products closely allied to the electronics field. A review of catalogs, handbooks, technical bulletins and other manufacturers' literature

oscilloscope includes special features for various industrial and research applications. Provision is made for internal calibration of sweep circuits. Accelerating potential of 4,000 volts produces a clear trace. Sweep speeds from 4 to 4,500 microseconds can be selected in 6 ranges, while expanded and delayed portions of the above sweep are also available at speeds of 4, 10, or 25 microseconds. There are other special features.

Television Camera (1)

GENERAL ELECTRIC Co., Syracuse, N. Y. The 56-pound television camera is ten inches wide, ten inches high and twenty inches long. Designed primarily for studios, it



is mounted on a mobile dolly and may be operated with fingertip control. Acceptable pictures can be obtained at 50 foot-candles and f/3.5.

Sweep Calibrator (2)

BROWNING LABORATORIES, INC., Winchester, Mass. Model GL-22 sweep calibrator is a pulsed timing



marker oscillator designed for use with standard oscilloscopes for the accurate measurement of time intervals on either triggered or recurrent sweeps. Markers available are 0.1, 0.5, 1.0, 10, and 100 microseconds. Operation of the calibrator can be by use of external synchronizing triggers or from its own trigger generator.

Industrial CRO (3)

ALLEN B. DU MONT LABORATORIES, INC., 2 Main Ave., Passaic, N. J. The new type 256-D cathode-ray



Noise Suppressor Amplifier (4)

FISHER RADIO CORP., 41 East 47th St., New York, N. Y. A new wide-range amplifier that embodies the



Scott dynamic noise suppressor shows only 1 percent distortion at 20 watts output, has less than 0.5 percent intermodulation distortion at 5 watts output, and exhibits uniform response within plus or minus 1 db from 20 to 20,000 cycles. The amplifier is priced at \$254.50.

Talking Ads (5)

MAGNECORD, INC., 304 W. 63rd St., Chicago 21, Ill. AudiAd is a magnetic tape recorder that plays back a total of more than 60 seconds of speech or other sound, either continuously or in brief segments, after being tripped by a light-beam



USING THE NUMBERS

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Place the number (appearing to the right of the heading) of one item in which you are interested in a circle and then fill out the balance of the card according to directions appearing on the colored sheet. Unnumbered items listed at the end should be procured direct from the manufacturer or publisher upon payment of the fee noted.

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Inside this Probe (actual size)...

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This WESTON Instrument, employing the small probe, pictured, provides a stable vacuum tube voltmeter with a range up to 300 megacycles. Combined with this in the one instrument is a volt-ohm-milliammeter and a high impedance electronic volt-ohmmeter.

The handy sized probe permits ready measurement of high frequency potentials in restricted spaces. Its convenience in use and the stability and broad frequency range of the Instrument may be attributed in part to the use of the Type CK 606 BX Raytheon Subminiature Tube.

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2. **Plug Into Standard Sockets.** All Raytheon Subminiatures can either be soldered in or plugged into readily available sockets.
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and eight years continuous production of long-life Subminiature Tubes.

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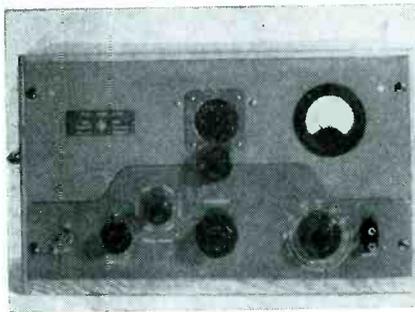
RAYTHEON

Leadership in Electronics

or similar switch. Interchangeable magazines of magnetic tape can be recorded with advertising copy or the individual user can make his own recordings on the spot.

High Altitude Tube (6)

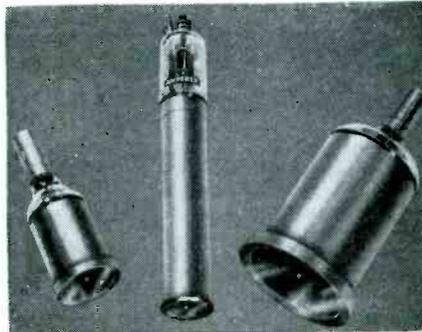
AMPEREX ELECTRONIC CORP., 25 Washington St., Brooklyn, N. Y. Developed for the Army Air Forces for use at high altitudes is a half-wave rectifier rated at 14,000 peak inverse volts. It delivers an average plate current of 125 ma and a peak current of 750 ma. The special tube-socket combination will handle voltages as high as 35,000 volts peak. Base of the tube is tapered and ground to fit the socket like a glass bottle stopper.



1 db from 10 cycles to 10 mc, and a voltage range of 0.00003 to 3 volts. Output impedance is 600 ohms or 6 ohms with output voltage divider.

G-M Counter Tubes (9)

AMPEREX ELECTRONIC CORP., 25 Washington St., Brooklyn 1, N. Y. Physically redesigned for standard-



ized production the new series of Geiger tubes includes counter tubes for beta, gamma, and x-rays. Featured herein are direct bonds between mica and metal and mica and glass.

Multiple Power Supply (10)

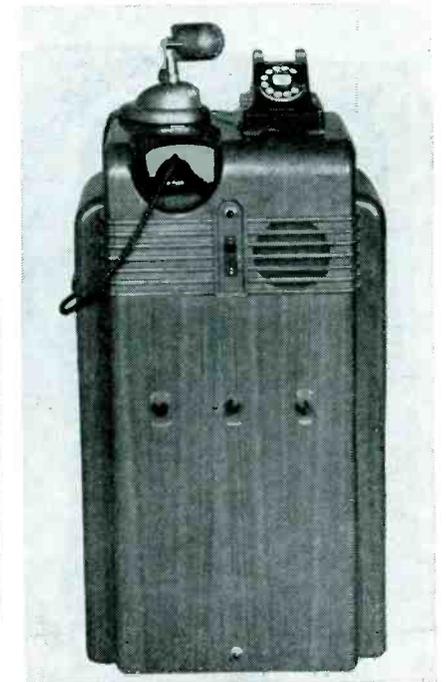
KEPCO LABORATORIES, INC., 142-45 Roosevelt Ave., Flushing, N. Y. Model 103 multiple power supply was developed to supply four commonly used voltages from a single compact unit. The power supply contains two continuously variable



B supplies delivering from 0 to 300 volts at currents up to 120 milliamperes, one variable C supply delivering from - 50 to + 50 v at 5 ma, and one heater supply delivering 6.3 volts at 5 amperes.

Group Telephone (11)

JORDANOFF AVIATION CORP., 595 Madison Ave., New York, N. Y. has begun limited production of the



Jordaphone, a device which permits group telephone conversations without individual headsets. It consists of a regulation telephone, console cabinet and microphone. Impulses in the receiver are picked up by a coil in the console and amplified. In transmitting, the talker's voice is heard without amplification. A built-in receptacle cuts out all outside noises from both ends of the handset.

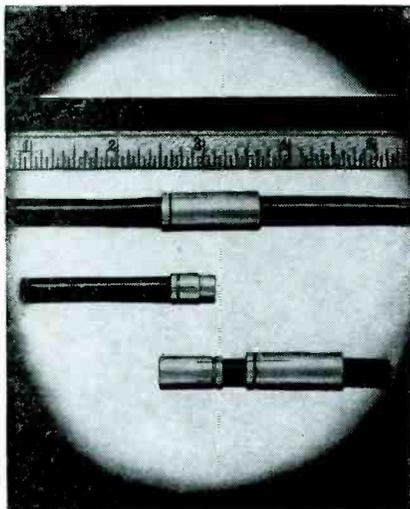
Well Sounder (12)

KEYSTONE DEVELOPMENT CORP., 2813 Westheimer Road, Houston, Texas. Sonolog is an instrument for the acoustic determination of the fluid level in the annular space between the casing and the tubing of an oil well. A small chamber attached to a casing at the surface

(continued on page 198)

Miniature Connectors (7)

H. H. BUGGIE & Co., 2145 Madison Ave., Toledo 1, Ohio, manufacture a connector with an overall diam-



eter of 23/64 inch. It has a voltage rating of 500 volts peak with a low loss. The unit is solderless and requires minimum cable preparation.

Resistance-Tuned Oscillator (8)

HEWLETT-PACKARD Co., 395 Page Mill Road, Palo Alto, Cal. Model 650A resistance-tuned oscillator is a wide-band precision instrument which provides output flat within

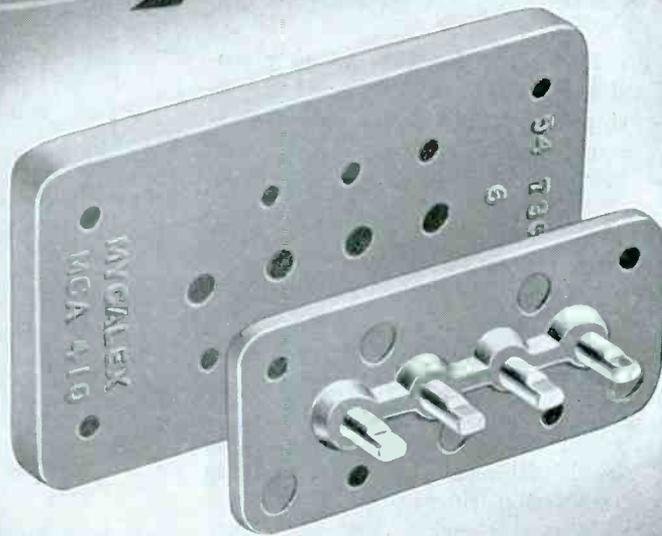
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insulation



In television seeing is believing . . . and big name makers of television sets are demonstrating by superior performance that MYCALEX 410 molded insulation contributes importantly to faithful television reception.

Stability in a television circuit is an absolute essential. In the station selector switch used in receivers of a leading manufacturer, the MYCALEX 410 molded parts (shown here) are used instead of inferior insulation in order to avoid drift in the natural frequency of the tuned circuits. The extremely low losses of MYCALEX at television frequencies and the stability of its properties over extremes in temperature and humidity result in dependability of performance which would otherwise be unattainable.

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2. High dielectric strength
3. High arc resistance
4. Stability over wide humidity and temperature changes
5. Resistance to high temperatures
6. Mechanical precision
7. Mechanical strength
8. Metal inserts molded in place
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NEWS OF THE INDUSTRY

Edited by JOHN MARKUS

New WWV time signal schedule; Marine Corps starts electronic warfare training; reviews of 11 new technical books

Television Receiver Symposium

EIGHT technical papers dealing with television receivers are scheduled for presentation Feb. 28, 1948 at an all-day symposium sponsored by the IRE New York Section, in the main auditorium of the Engineering Societies Building in New York City.

The program is as follows:

- 10:00 a.m.—Television Receiving Antennas, by Andrew Alford of Boston, Mass.
- 10:30 a.m.—Television Antenna and R-F Distribution Systems for Apartment Houses, by Heinz Kallman of New York City.
- 11:00 a.m.—Automatic Frequency Control of Television Sweep Circuits, by E. L. Clark of RCA Victor.

- 11:30 a.m.—Standards for Testing Television Receivers, by D. G. Fink of ELECTRONICS.
- 2:00 p.m.—Intermediate Frequencies for Television Receivers, by Paul F. G. Holst of Crosley Division, AVCO Mfg. Co.
- 2:30 p.m.—I-F Amplifiers for Inter-carrier System of Sound Reception, by S. W. Seeley of RCA Laboratories.
- 3:00 p.m.—Television Tuners, by Alarico Valdetaro of Bloomington, Ind.
- 3:30 p.m.—Standardization of Transient Response of Television Transmitters and Receivers, by G. L. Fredendall of RCA Laboratories.

Moderator for the morning session is Arthur Loughren of Hazeltine Electronics Corp., and moderator for the afternoon session is Murray Crosby of Paul Godley Co.

Eta Kappa Nu Honors Young Electrical Engineers

ACTIVITIES in the field of electronics appear frequently in the biographical sketches of the six Eta Kappa Nu Recognition Award winners and the fifteen winners of honorable mention. Suspended during war years because security regulations prevented divulging the work of many candidates, the resumption of awards this year cites one outstanding young engineer and a number of honorable mentions for each of the years 1942 through 1947.

Achievements considered in making the selections stress cultural development and contributions to community, state, and national welfare as well as professional achieve-

ment. The name of each award winner is engraved on a bronze bowl displayed in AIEE headquarters in New York City and each winner is given a miniature replica of the bowl. Honorable mention winners received certificates.

Winners, with colleges from which they graduated and present business affiliations, are as follows:

RECOGNITION AWARDS

- 1942 John R. Pierce; California Institute of Technology, 1933; Bell Telephone Laboratories, Inc., New York, N. Y.
- 1943 Nathan I. Hall; West Virginia University; Hughes Aircraft Company, Culver City, Calif.
- 1944 Richard W. Porter; University of Kansas, 1934; General Electric Co., Schenectady, N. Y.

- 1945 James M. Wallace; University of Pittsburgh, 1935; Westinghouse Electric Corporation, Pittsburgh, Pa.
- 1946 Everard M. Williams; Yale University, 1936; Carnegie Institute of Technology, Pittsburgh, Pa.
- 1947 Richard R. Hough; Princeton University, 1939; Bell Telephone Laboratories, Inc., Whippany, N. J.

HONORABLE MENTIONS

- 1942 Gilbert D. McCann, Jr.; California Institute of Technology, 1934; California Institute of Technology, Pasadena, Calif.
David B. Smith; Massachusetts Institute of Technology, 1933; Philco Corporation, Philadelphia, Pa.
- 1943 Armig G. Kandoian; Harvard University, 1934; International Telephone and Telegraph Company, New York, N. Y.
James W. McRae; University of British Columbia, 1933; Bell Telephone Laboratories, Inc., New York, N. Y.
- 1944 William E. Ingerson; Hardin-Simmons University; Bell Telephone Laboratories, Inc., Murray Hill, N. J.
Ernst H. Krause; University of Wisconsin, 1934; Naval Research Laboratory, Washington, D. C.
Donald W. Pugsley; University of Utah, 1935; General Electric Company, Bridgeport, Conn.
- 1945 Wallace A. Depp; University of Illinois, 1936; Bell Telephone Laboratories, Inc., New York, N. Y.
Jack A. Morton; Wayne University, 1935; Bell Telephone Laboratories, Inc., New York, N. Y.
Edgar A. Post; University of Illinois, 1936; United Air Lines, Chicago, Ill.
- 1946 Benjamin B. Bauer; University of Cincinnati, 1937; Shure Brothers, Inc., Chicago, Ill.
Albert C. Hall; Agricultural and Mechanical College of Texas, 1936; Massachusetts Institute of Technology, Cambridge, Mass.
Donald L. Waidelich; Lehigh University, 1936; University of Missouri, Columbia, Mo.
- 1947 Marvin Camras; Illinois Institute of Technology, 1940; Armour Research Institute, Chicago, Ill.
Jerome B. Wiesner; University of Michigan, 1937; Massachusetts Institute of Technology, Cambridge, Mass.

AIEE Tube Conference

NEED for tubes having longer life and closer tolerances, for use in electronic instruments, has resulted in an AIEE tube conference to be held March 29 and 30 at the Benjamin Franklin Hotel in Philadelphia. Instrument and tube manufacturers, as well as engineers from industrial, commercial, and



1942
J. R. Pierce



1943
N. I. Hall



1944
R. W. Porter



1945
J. M. Wallace

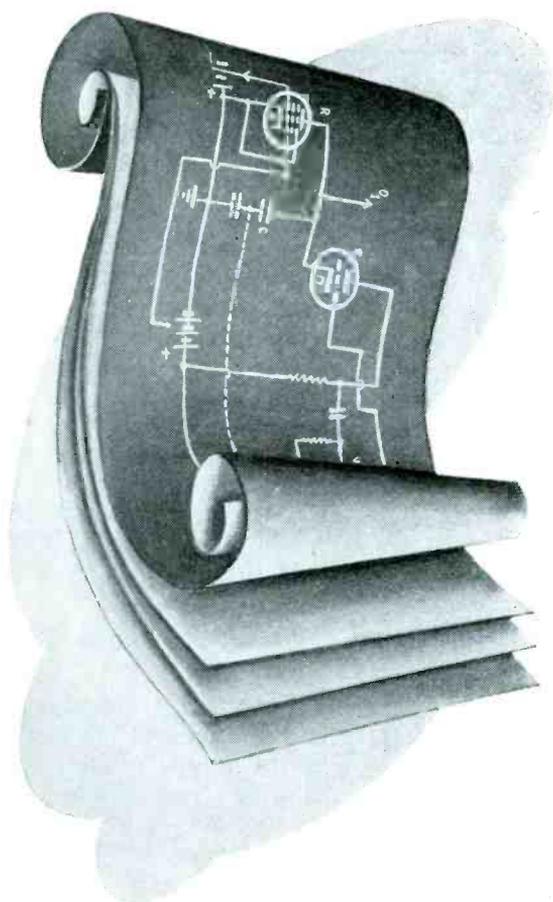


1946
E. M. Williams



1947
R. R. Hough

Specialized Knowledge and Equipment for **UHF DESIGN**



● The phenomena encountered in the UHF field are in many cases so decidedly different from those true of lower frequencies that many manufacturers find themselves in urgent need of specialized UHF knowledge, in order to develop equipment that will handle certain specific conditions.

● Since we are specialists in UHF engineering, we are equipped not only to render technical advice, but also to follow through in the actual production of equipment in our shops.

● If you are contemplating a new product, or have a problem involving ultra high frequency with present production, our specialized knowledge should be invaluable for quick, accurate, low unit cost. There is no cost or obligation involved in talking this over.



Larvie Laboratories

RADIO ENGINEERS AND MANUFACTURERS
MORGANVILLE, N. J.

Specialists in the Development and Manufacture of UHF Equipment

university laboratories will convene. AIEE members will be admitted free, and the fee for non-members is \$2.00. Requests for invitations should be addressed to C. C. Wilson, AIEE Headquarters, 33 W. 39th St., New York 18, N. Y.

Chicago Scientific Center

THE WESTERN Society of Engineers has signed an agreement with the John Crerar Library in Chicago, leasing three floors in the Taylor building, which adjoins the Library, and establishing a science and technical center for the use of professional persons, students, and others interested in the advancement of science. Included in the center is an auditorium seating 300.

The Western Society's 20,000-book collection is being coordinated with the 700,000-volume Crerar Library, largest free public library in the world devoted exclusively to science and technology.

Development of the new science center will cost the engineering society about \$100,000.

New WWV Schedules

EFFECTIVE Jan. 30, 1948, time announcements from radio station WWV of the National Bureau of Standards were advanced one minute with respect to the former announcement scheme (see WWV Schedules, *ELECTRONICS*, p 87, May

1947). With the new system the audio frequencies are interrupted at precisely one minute before each hour and at each succeeding five-minute period, and are resumed precisely on the hour and each five minutes thereafter. The time announcement, in International Morse Code, refers to the end of the announcement interval (the instant when the audio tone frequencies are resumed), as indicated by the ac-

MEETINGS

- FEB. 28: IRE Television Receiver Symposium, sponsored by New York Section; main auditorium, Engineering Societies Bldg., technical papers all day, starting at 10:00 a.m.
- MARCH 22-24: Chicago Technical Conference, Stevens Hotel; meetings and exhibits; sponsored by 51 societies, including IRE, SMPPE, and AIEE.
- MARCH 22-25: IRE Convention and Radio Engineering Show, Hotel Commodore and Grand Central Palace, New York City.
- MARCH 29-30: AIEE conference on electron tubes for instrumentation and industry, Benjamin Franklin Hotel, Philadelphia, Pa.
- APRIL 1-3: AIEE Great Lakes District Meeting, Des Moines, Iowa.
- APRIL 7-9: Midwest Power Conference, Sheraton Hotel, Chicago, Illinois. Three papers on supervisory control and telemetering at 2 p.m. April 9.
- APRIL 17: IRE Engineering Conference, Chicago Section, Illinois Institute of Technology, Chicago.
- APRIL 24: Spring Technical Conference of IRE Cincinnati Section, featuring television papers, at Engineering Society Headquarters.
- APRIL 26-28: IRE-RMA spring meeting on transmitters, Syracuse Hotel, Syracuse, N. Y.
- APRIL 28-30: AIEE North Eastern District Meeting, New Haven, Conn.
- MAY 3-5: URSI-IRE joint meeting, Washington, D. C.
- MAY 9-14: 1948 Radio Parts Show, Hotel Stevens, Chicago.
- MAY 11-16: Engineering Progress Show, Franklin Institute, Philadelphia, Pa.; exhibits and two evening lectures.
- JUNE 21-25: AIEE Summer General Meeting, Mexico City, Mexico.
- AUG. 24-27: AIEE Pacific General Meeting, Spokane, Wash.
- SEPT. 13-17: Third Instrument Conference and Exhibit, Convention Hall, Philadelphia, Pa.
- SEPT. 27-Oct. 2: Third National Plastics Exposition, Grand Central Palace, New York City.
- SEPT. 30-Oct. 2: Pacific Electronic Exhibition and IRE west coast Annual Convention, Biltmore Hotel, Los Angeles, Calif.
- OCT. 5-7: AIEE Middle Eastern District Meeting, Washington, D. C.
- OCT. 11-12: FM Association Second Annual Convention, Sheraton Hotel, Chicago.

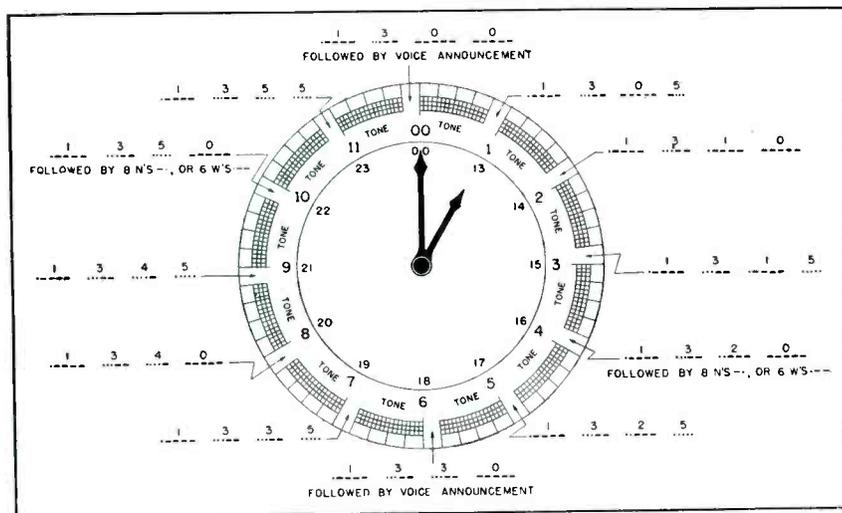
companying clock-face diagram.

These time signals are now broadcast continuously day and night on all of the eight carrier frequencies in use: 2.5, 5, 10, 15, 20, 25, 30, and 35 mc. A 440-cycle audio tone is transmitted on 2.5, 5, and 30 mc along with pulses at intervals of precisely one second. Both 440 and 4,000 cycle tones are transmitted on 10, 15, 20, and 25 mc along with the time ticks. Further details of WWV broadcast services are given in bulletin LC886, available on request from the National Bureau of Standards, Washington 25, D. C.

Other Time Signal Services

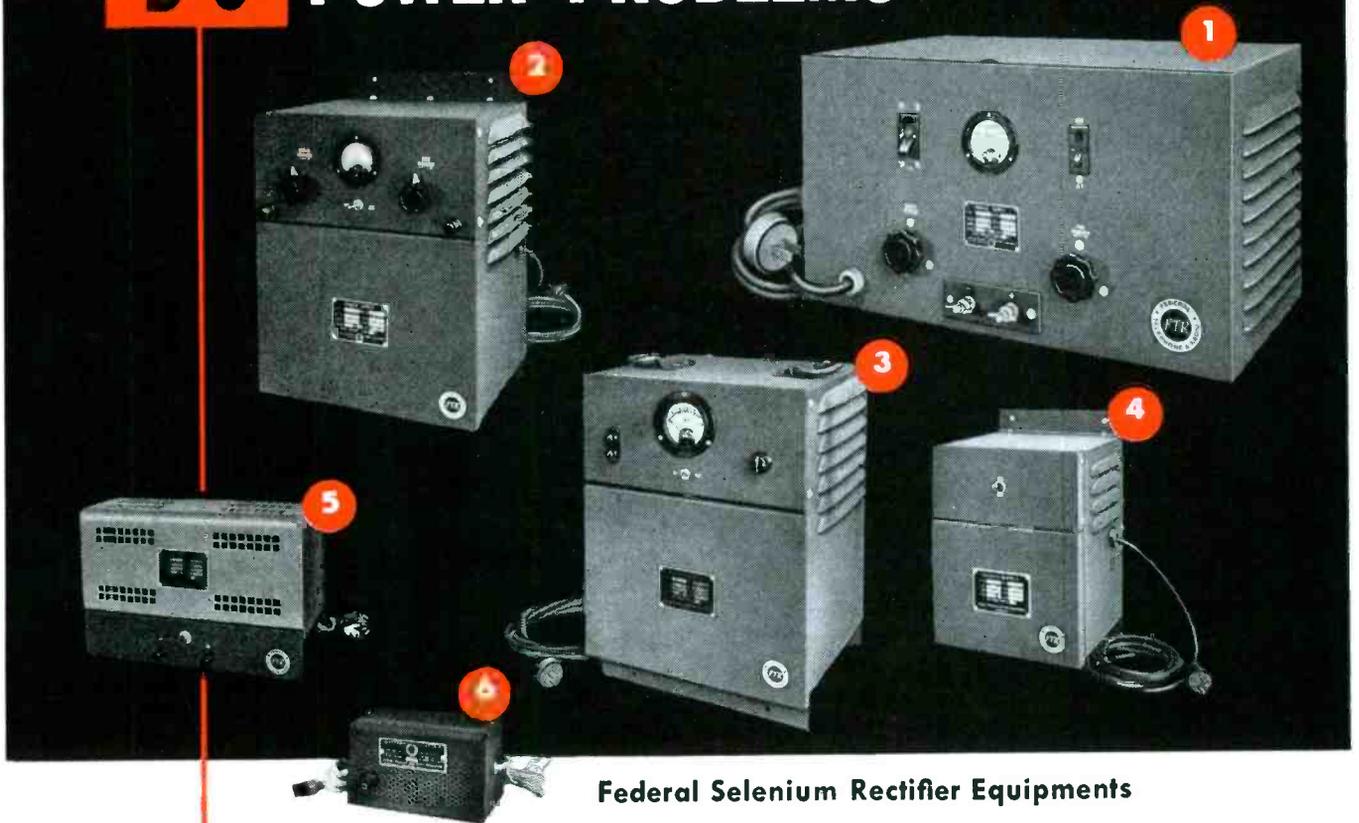
The Naval Observatory, U. S. Navy Department, broadcasts time signals at regular intervals on the following frequencies: NSS (Annapolis, Md.)—122, 4,390, 9,425, and 12,630 kc; NPG (Mare Island, Calif.)—115, 9,255, 12,540 kc; NPM (Pearl Harbor, Hawaii)—16.68, 56, 4,525, 9,050, 13,575, 17,370 kc; NBA (Balboa, Canal Zone)—148, 5,005, 11,080 kc. Detailed information

(continued on p 246)



Example illustrating new schedule of time announcements by station WWV. Hour illustrated is 1 to 2 p. m., or 1300 to 1400 in 24-hour time for Eastern Standard Time

SIX SOLUTIONS TO YOUR D-C POWER PROBLEMS



Federal Selenium Rectifier Equipments

HERE'S FEDERAL'S line of standard D-C Power Supplies which offer you a convenient, economical and always *dependable* source of direct current for a wide range of industrial and laboratory applications.

These attractively styled, compact and efficient units are completely self contained—ready to connect to your a-c power supply—ready to supply d-c power wherever and whenever you want it. Because they are powered by Federal's long-life Selenium Rectifiers, their service life is practically unlimited—with no expendable parts which require frequent replacement. These equipments are conservatively rated, using the new heavy-duty stacks which assure a wide margin of safety to withstand momentary heavy overloads.

For complete information on these new d-c power supplies, write to Federal today—Dept. E 313.

Available for IMMEDIATE DELIVERY

- 1 FTR 3300-DS** D-C Output—2-32 volts, 50 amperes
A-C Input—115 volts, 1-phase, 60 cycles
- 2 FTR 3339-BS** D-C Output—6-24 volts, 18 amperes
A-C Input—115/230 volts, 1-phase, 50/60 cycles
- 3 FTR 3128-BS** D-C Output—22-30 volts, 10 amperes (filtered and regulated)
A-C Input—115 volts, 1-phase, 60 cycles
- 4 FTR 3341-AS** D-C Output—28 volts, 5 amperes
A-C Input—115 volts, 1-phase, 50/60 cycles
- 5 FTR 3246-BS** D-C Output—6 volts, 10 amperes (filtered)
A-C Input—115 volts, 1-phase, 60 cycles
- 6 FTR 1342-AS** D-C Output—6 volts, 4 amperes (3 cells 6-3 amperes)
A-C Input—115 volts, 1-phase, 50/60 cycles



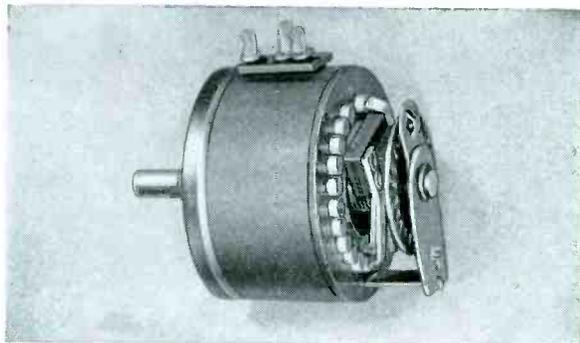
KEEPING FEDERAL YEARS AHEAD... is IT&T's world-wide research and engineering organization, of which the Federal Telecommunication Laboratories, Nutley, N. J., is a unit.

Federal Telephone and Radio Corporation

SELENIUM and INTELIN DIVISION, 900 Passaic Ave., East Newark, New Jersey

In Canada:—Federal Electric Manufacturing Company, Ltd., Montreal, P. Q.
Export Distributors:—International Standard Electric Corp. 67 Broad St., N. Y.

Shallcross ATTENUATORS

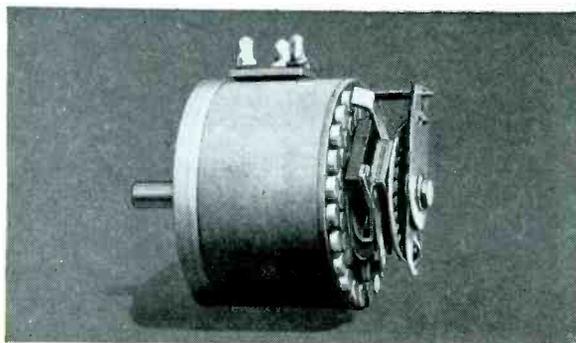


BRIDGED 'T' ATTENUATOR Type 410-4B1

10 steps, 4 db/step.
Linear attenuation
with detent. 2 1/8" di-
ameter, 2 1/8" depth.

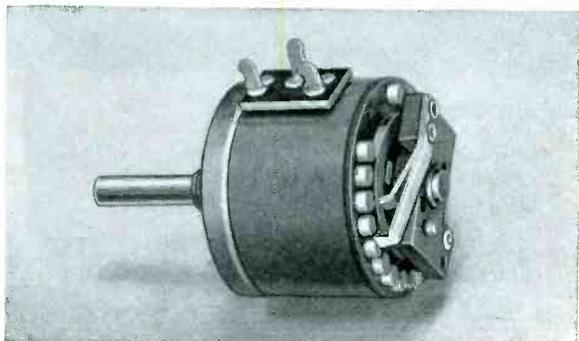
BRIDGED 'T' ATTENUATOR Type 420-2B2

20 steps, 2 db/step.
Linear attenuation with
off position and detent.
2 1/8" diameter, 2 1/8" depth.



POTENTIOMETER Type C720-2A3

20 steps, 2 db/step,
tapered on last three
steps to off, composi-
tion resistors. 1 3/4" di-
ameter, 1 3/4" depth.



These Shallcross Features Mean Better Performance— Better Value!

Off position attenuation well in excess of 100 db.

25% to 50% fewer soldered joints.

Noise level ratings that are factual. (130 db. or more below zero level.)

Non-inductive Shallcross precision resistors used throughout assure flat attenuation to and beyond 30 kc.

Types and sizes engineered for all needs. Attenuation accuracies of 1%, Resistor accuracies of 0.1%, on special order.

SHALLCROSS ATTENUATORS

Shallcross variable attenuators have proved their remarkable quietness and serviceability in dozens of applications for leading users in all parts of the world. Such important details as the use of spring-temper silver alloy wiper arms, silver alloy collector rings and contacts, non-inductive precision resistors, and sturdy, substantial mounting plates have made possible the high standard of performance attributed to Shallcross.

Standard types include ladder and bridged T mixer controls, bridged T and straight T master gain controls and V.U. meter multipliers, wirewound and composition potentiometers for grid control. Cueing attenuators, and fixed pads, both composition and wirewound, in all circuit configurations are also available.

Write for Catalog and Attenuator Specification Sheet

SHALLCROSS MANUFACTURING COMPANY

Department E-38, Collingdale, Pa.

TUBES AT WORK

(continued from p 136)

the same method, with printer light values and values of gamma of the negatives only a small amount greater or smaller than those previously found most satisfactory.

High-Frequency Crystal Voltmeter

By B. F. TYSON

*Hazeltine Electronics Corporation
Little Neck, N. Y.*

A CRYSTAL voltmeter is useful in measuring the gain and response characteristics of the r-f and i-f circuits in f-m and television receivers. Such an instrument is physically small, and when built in probe form can be easily connected to the point of measurement. Inherently, it has high sensitivity and when used with a 10-microampere meter will indicate r-f voltages as low as 0.05 volt.

The voltmeter described here uses a type 1N28 crystal rectifier connected as shown in the circuit diagram of Fig. 1. Other crystals such as types 1N21 or 1N25 can also be used. On the input side, load resistor R_1 and a ceramic d-c blocking capacitor C_1 are built into the probe. On the output side, the r-f components of the rectified current are bypassed to ground through a button mica capacitor C_2 and the direct current to the microammeter is filtered by resistor R_2 and a button mica capacitor C_3 .

The physical arrangement of the various parts is shown in the cross-section assembly view of Fig. 2. The smaller diameter half of the probe has the ground and high potential input tabs and contains the blocking capacitor and load resistor. The shielded microammeter lead is brought out of the other half which houses the button-type bypass and filter capacitors and the filter resistor. Note that the large end of cylinder B is made to slide fit into cylinder A and a clip from

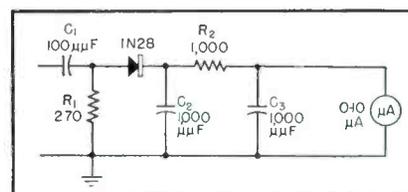
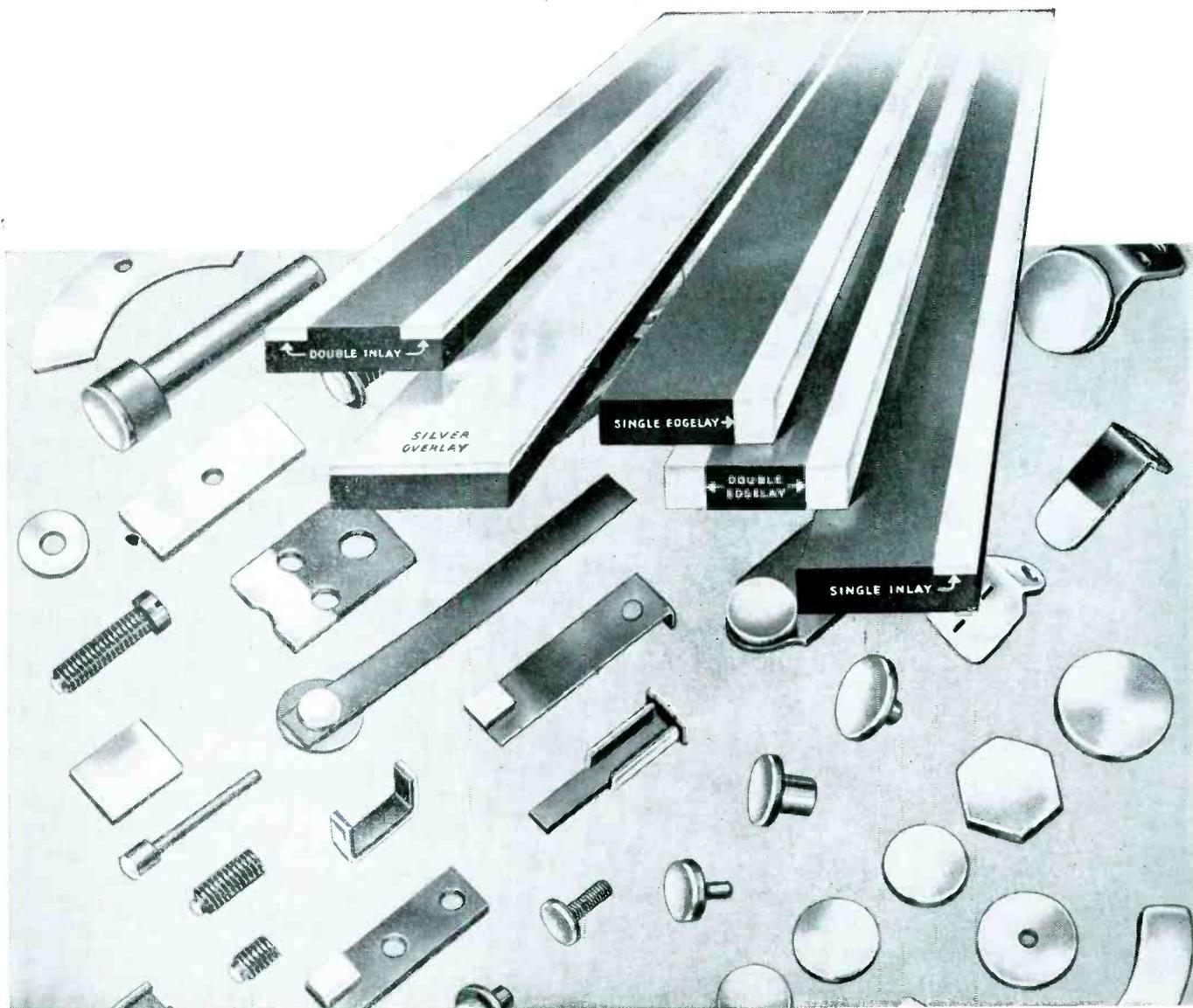


FIG. 1—Circuit diagram of crystal voltmeter



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PLUS ECONOMY WITH GENERAL PLATE
LAMINATED SILVER METALS AND CONTACTS**

The big advantage of General Plate Laminated Silver metals and contacts is that they give you solid silver performance at a fraction of the cost of solid silver. Why—because General Plate permanently bonds a thin layer of silver to suitable inexpensive base metal, thus providing a contact face of high electrical conductivity at the point of actual contact.

General Plate Laminated silver metals, for your own fabrication, are available

with silver bonded to base metal in the following stock... overlay, single or double inlay and single or double edge lay. General Plate contacts and fabricated parts are made to customers specifications. Laminated contact buttons, rivets and screw type contacts are also available. Advantages include—long contact life, greater strength, easier fabrication, and easier soldering, brazing or spot welding.

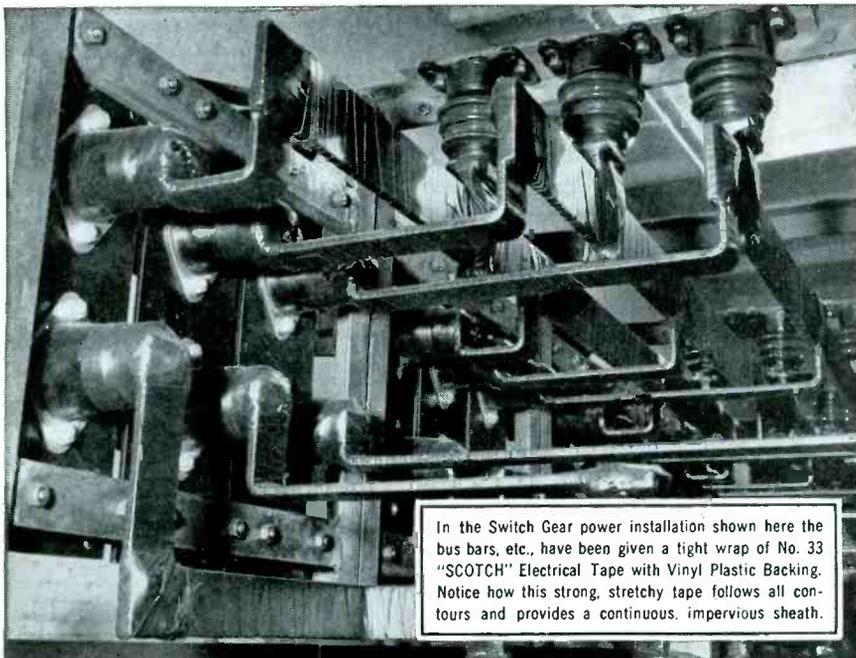
Write, specifying your problems.

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of Metals & Controls Corporation

ATTLEBORO, MASSACHUSETTS

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In the Switch Gear power installation shown here the bus bars, etc., have been given a tight wrap of No. 33 "SCOTCH" Electrical Tape with Vinyl Plastic Backing. Notice how this strong, stretchy tape follows all contours and provides a continuous, impervious sheath.

ARE YOU TAKING ADVANTAGE OF THIS BRAND NEW TIME SAVER for Insulating and Protecting Electrical Installations?

One Tape, No. 33 "SCOTCH" Electrical TAPE with Vinyl Plastic Backing, and one operation, replace two tapes, rubber and friction, and two application operations.

The thin caliper of No. 33 "SCOTCH" Electrical TAPE makes possible a neat, tight wrap that takes up minimum room, and insures a snug job that will stay that way and render full electrical protection; remain oil tight and moisture tight.

No. 33 "SCOTCH" Electrical TAPE will not soften or crack even when exposed to oil, acids, alkalis. Superior outdoor aging qualities prevent cracking and checking.

Used for wrapping wire harnesses on a Segur Taper, No. 33 "SCOTCH" TAPE goes on at high speed, makes a snug flexible harness. Can be applied in an open spiral or in an oil proof, moisture proof sheath.

All this, of course, cuts maintenance costs and saves a lot of money. Write today for a sample roll and complete information.

No. 33 **SCOTCH** Electrical TAPE

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TUBES AT WORK

(continued)

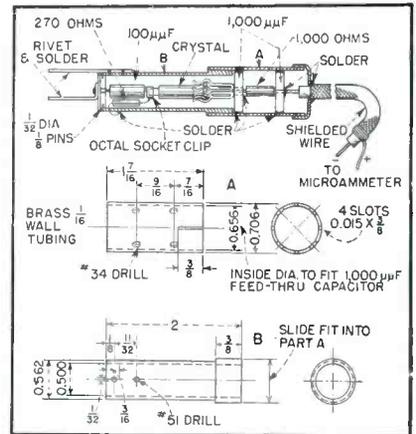


FIG. 2—Crystal probe assembly consists of two cylinders machined so the end of one slides inside the other for rapid replacement of crystal cartridge

an octal socket is soldered to the end of the 100- $\mu\mu\text{f}$ Ceramicon capacitor to receive the contact of the crystal. The larger, probe end of the crystal is held firmly by a finger contactor. Thus, the entire probe is separable near its center for easy insertion of the crystal cartridge.

Fig. 3 is a typical calibration curve of the crystal voltmeter using a 1N28 crystal. Measured characteristics of several 1N28 crystals indicate that their sensitivities are in the order of 700 to 1,200 micro-amperes per volt squared and that they have square-low input-output characteristics only for inputs up to approximately 0.1 volt. The compact construction of the probe, minimizes lead inductances and stray capacitances, and the low value of load resistance, 270 ohms, serve to maintain an input-output characteristic substantially independent of frequency from 50 mc to at least 250 mc. At frequencies below 50 mc, the response falls off gradually.

The crystal voltmeter has been checked for susceptibility to burn-out. Peak surges of 500 volts d-c or 180 volts, 60-cycle a-c have shown no effect on the calibration. Likewise, it has been determined that the crystal can withstand r-f voltages to produce approximately 1 ma of direct current, without effect on calibration. Higher r-f voltages, or mechanical shocks may, of course, cause a change in calibration or permanent damage.

The crystal voltmeter is intended for observation of r-f voltage across low impedances such as the output terminals of a signal generator or

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Northern Communications Co. are design and manufacturing specialists. We do not make standard items. Each transformer, coil, saturable-core reactor or other assembly item produced in our plant is made either to customer's specification or designed by us to fill the customer's special needs.

With abundant experience, before, during and since the war Northern can help you with many an electronic problem. Write us fully, wire or phone.

Northern Communications products are being used as follows:



67% Airborne: Commercial, Air Force and Experimental Aircraft service in Radar Control and Servo-Mechanism assemblies.



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Because we are specialists and geared to produce "specials," many manufacturers rely on us in order to keep their costs down, yet maintain their quality.

Northern Communications Manufacturing Company

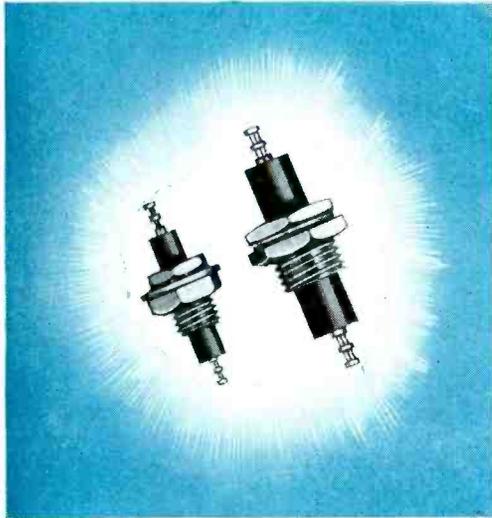
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C.T.C. Custom-Engineers

The Solution To

a tricky feed-thru problem

Feeding an R. F. potential through the wall of a cavity oscillator presented many difficulties. Not only was space at a premium, but extreme changes in humidity, temperature and other service conditions had to be met.



THE ANSWER

C.T.C. 1795B Insulated Feed-Thru Terminals fulfilled every requirement. Design-features like these show you why: *Rugged construction that withstands loosening under vibration or shock . . . approved phenolic insulating material, JAN type LTS-E-4 . . . brass bushings, cadmium plated . . . brass thru-terminals, silver plated for easy soldering.*

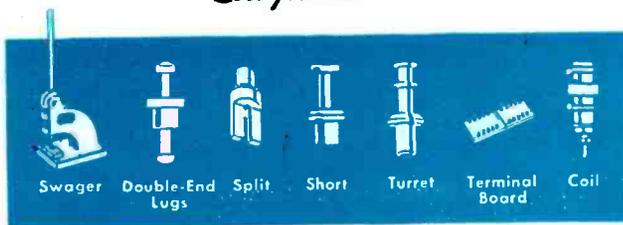
SPECIFICATIONS

The 1795B mounts in a $\frac{1}{4}$ " hole, and has an over-all length of approximately $\frac{7}{8}$ ". C.T.C. Feed-Thru Terminals are available in additional sizes. The 1795A is similar to the 1795B, but with an over-all length of 1". Also similar in design and function are X1771A and X1771B, but larger in size and mounting in a $\frac{3}{8}$ " hole. Breakdown voltages, at 60 cycles R.M.S., are:

1795A . . . 3800V X1771A . . . 8200V
1795B . . . 3200V X1771B . . . 6000V

Catalog No. 200 contains details of C.T.C. standard electric and electronic components, together with full information on our custom-engineering service. Write for it today.

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IRE National
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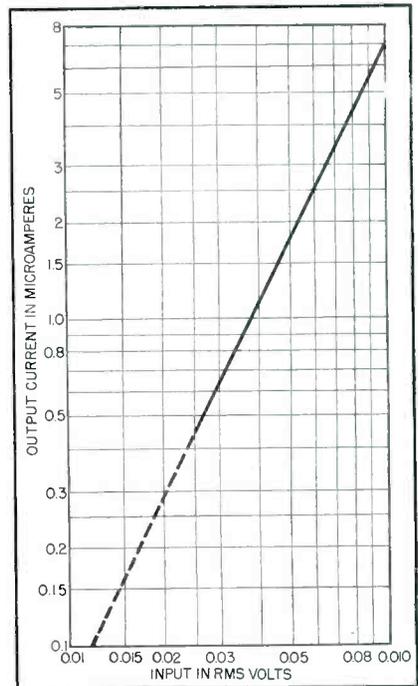


FIG. 3—Typical calibration curve of the crystal voltmeter using a 1N28 crystal

a low-resistance plate load of an amplifier tube. Care should be exercised in connecting the probe for high radio-frequency measurements to avoid excessive lead length and the addition of stray capacitance. When making measurements at low frequencies, say below 50 mc, it should be remembered that the 100- $\mu\mu\text{f}$ d-c blocking capacitor has appreciable series reactance. It will be observed that the action of the microammeter needle is somewhat sluggish due to damping by the crystal resistance. A short time should therefore be allowed for the needle to come to rest before reading the meter.

X-Ray Thickness Gage

GAGING without physical contact with the material under test, and access to areas never before gaged, are features of a new x-ray technique that consists of irradiating the material and measuring the drop in intensity through that material. Designed by Westinghouse engineer W. N. Lundahl for measuring the thickness of cold-rolled steel sheet and cold-rolled copper, the instrument should also prove applicable for use on hot materials like metal and glass sheet, and fragile materials like foil and paper. Readings are unaffected by

Wilco Announces A new and positive method of bimetal identification!



Clearly etched markings on each strip of Wilco Thermometal prevent confusion of high with low expanding side . . . positively identify the type of metal as well. Another achievement by a leading pioneer in thermostatic bimetal developments.

LOOK at this strip of WILCO "Morflex."

Its clearly etched characters instantly identify the *low expanding side* of the thermometal. For only the low expanding side shows these markings. (The high expanding side is left unmarked.)

STUDY this thermometal strip more closely, and you will note a second safeguard against confusing it with the high expanding side . . . the frequent repetition of "LE", signifying low expansion.

NOTE, too, the frequently repeated abbreviation, "MORF", indicating "Morflex", the Wilco thermometal for devices or instruments requiring extremely high sensitivity from 50° to 350° F. Also the Wilco trademark displayed at various points to remind you that "Morflex" is a product of the H. A. Wilson Co., pioneer in the thermostatic bimetal field.

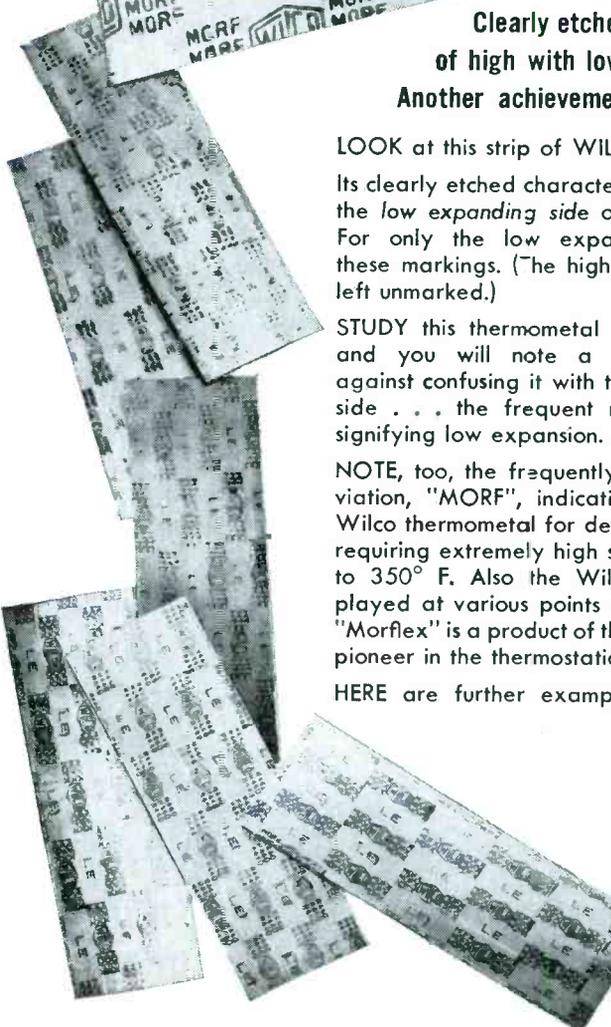
HERE are further examples that show the

consistency with which Wilco carries this clear-cut method of identification throughout the entire line of 29 Wilco Thermometals, precluding any possibility of mistaking one type for another.

Another Wilco pioneering achievement

The H. A. Wilson Company is an American pioneer in the design and development of thermostatic bimetals. WILCO supplies these materials as sheet or strip, in partly or completely fabricated form, and as parts of assemblies for thousands of applications. All temperature ranges, deflection rates and electrical resistivities.

Now Wilco—which for 34 years has majored in the development and widespread application of thermostatic bimetals—pioneers again with an etching process that will help to make these Wilco products more than ever *precision products*.

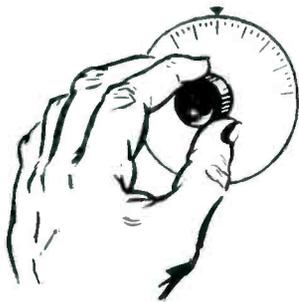


THE H. A. WILSON COMPANY

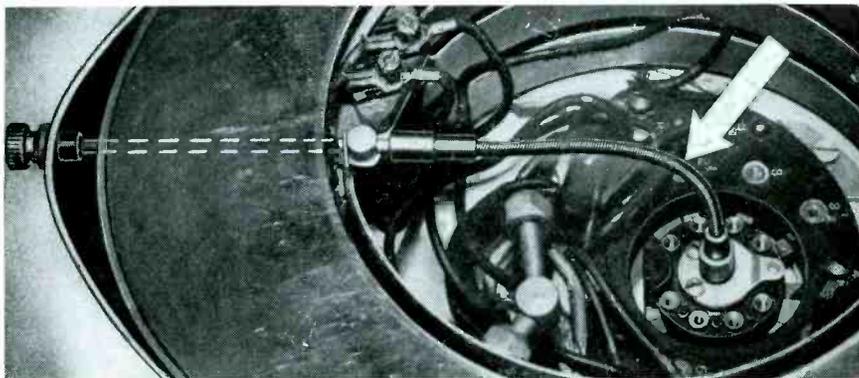
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FINGERTIP CONTROL FOR VARIABLE ELEMENTS with **S.S. WHITE** FLEXIBLE SHAFTS



WHEN you design equipment with variable elements you naturally want to provide those elements with fingertip control. This means, control that is located at the operator's fingertips, and control that is so smooth and effortless it can be operated with the fingertips.

With S.S. White flexible shafts of the type specially designed for this service, you can satisfy both requirements. A typical example is illustrated. It's a top view, with cover removed, of the accessory table of a costly, intricate dental unit. For reasons of assembly and wiring, the designer wanted the rotary switch in the position shown. And he wanted the control knob where it is, because that was the most desirable location for operation. Placing them in these positions created no problem—thanks to the flexible shaft. Consider the picture for a moment and you can appreciate that this use of flexible shafts to couple variable elements and their controls, removes practically all restrictions as to location and gives greater freedom in design.

SEND FOR THIS FLEXIBLE SHAFT HANDBOOK

Its 260 pages have facts and information about flexible shafts and their application. Just ask for it on your business letterhead and mention your position.



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THE S. S. WHITE DENTAL MFG. CO. DEPT. E 10 EAST 40th ST., NEW YORK 16, N. Y.



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fluttering of the sheet, surface coatings like lacquer, or atmospheres heavy with steam, water, or palm oil.

The gage consists of two x-ray sources and one phototube pickup. Relative to the two x-ray sources, the pickup is actually at the apex of a right angle but is illustrated for simplicity in Fig. 1 as being aligned vertically with the two x-ray sources. Radiation from the lower source is directed up through the sheet being gaged so that the transmitted rays will strike the pickup. Rays from the upper source are directed horizontally through a

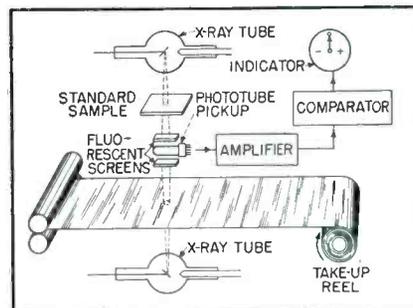


FIG. 1—Simplified schematic showing arrangement of units so that two x-ray beams strike the phototube pickup for comparison

standard sample of correct thickness to the same pickup. Radiations are emitted 180 degrees out of phase so that the rays alternate in striking the pickup and are compared in intensity after a large part of their radiation has been absorbed in the standard sample or test sheet.

Difference in the intensities of the rays is registered on the indicator instrument. At full deflection of the indicator needle a red light on the instrument goes on and a throw-out or other mechanism is actuated through electronic circuits.

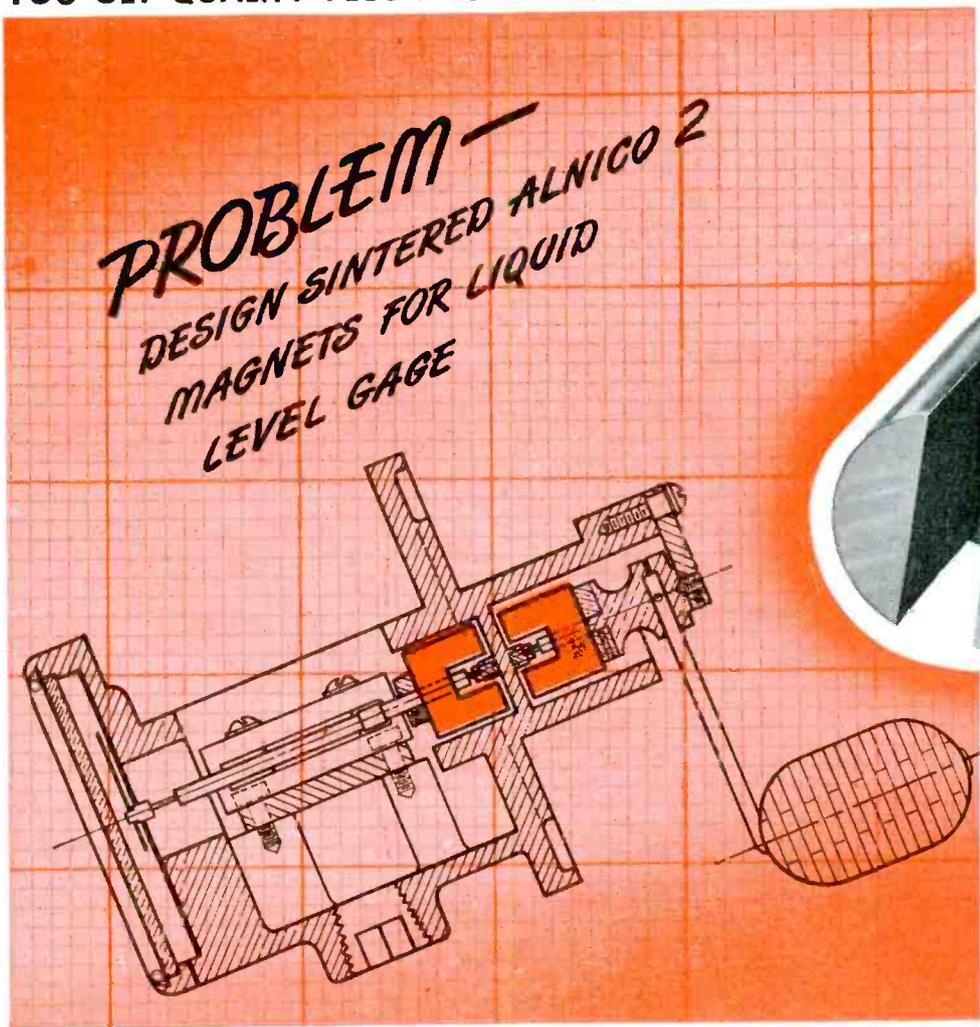
Measures Glass Thickness

Equipment has recently been constructed for measuring the wall thickness of glass containers. In this system, the pickup is inserted within the container as shown in Fig. 2. It consists of a brass tube with one end opening to a housing containing the phototube and the other end cut on a 60-degree angle axially with respect to the tube. This diagonal cut has a fluorescent screen mounted in its plane. Thus the phototube looks down through the tube at the fluorescent screen.

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TUBES AT WORK

(continued)

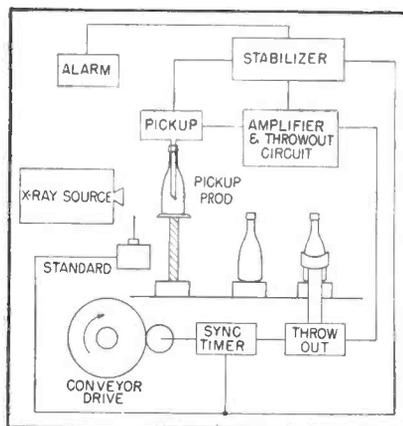


FIG. 2—A method of using the x-ray gage for measuring the thickness of a glass bottle

glass container up around the pickup tube, rotating the bottle at the same time. Thus a point on the container describes a helix and the bottle wall is effectively scanned. If the wall thickness at any point is less than a predetermined minimum value, the gaging circuits operate to discard the defective container.

The phototube pickup consists of a photomultiplier surrounded by a fluorescent screen and enclosed in a light-proof cover. Absorption of x-radiation in the fluorescent screen excites the compound of the screen to visible luminescence which is picked up by the phototube and converted into current pulses. The latter vary in amplitude according to the thickness of the material.

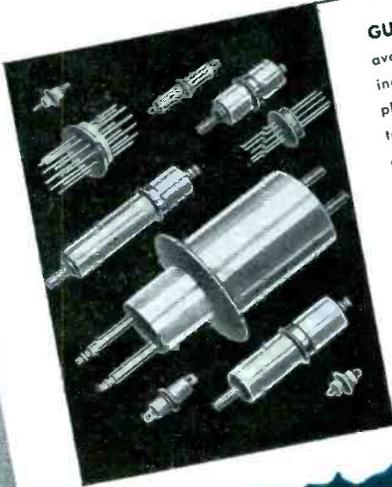
Gage Circuits

The gage circuit (see Fig. 3) consists essentially of a 6SJ7 amplifier, a 6H6 clipper and base line restorer, a 6AC7 saw-tooth converter, and a pair of 6AG7's used in a comparator circuit. A 6AC7 photomultiplier stabilizer, a 6AC7 amplifier for a cathode-ray indicator, and a 6H6 duplex diode rectifier for a bias supply are also located in the gage chassis.

The output signal obtained from the anode of the 931A photomultiplier is applied to the control grid of the 6SJ7 through conventional capacitive coupling. The photomultiplier anode is maintained approximately 255 volts d-c above ground through 1.5 megohms resistance from the power supply of the gage circuit. The amplified signal from the 6SJ7 is then applied to the 6H6 clipper. The anode of this clipper is maintained at a

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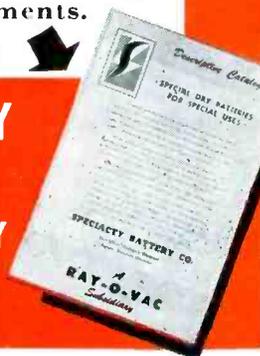
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TUBES AT WORK

(continued)

negative potential with respect to the cathode. Thus, a positive pulse for the 6SJ7 will not be conducted across the 6H6 unless the pulse amplitude overcomes the bias between the elements on the clipper. Thus, by varying this d-c bias, the amplitude of the pulse as it may be applied to the next stage can be controlled.

The action of this tube also protects the indicating instrument in the event of thickness differentials

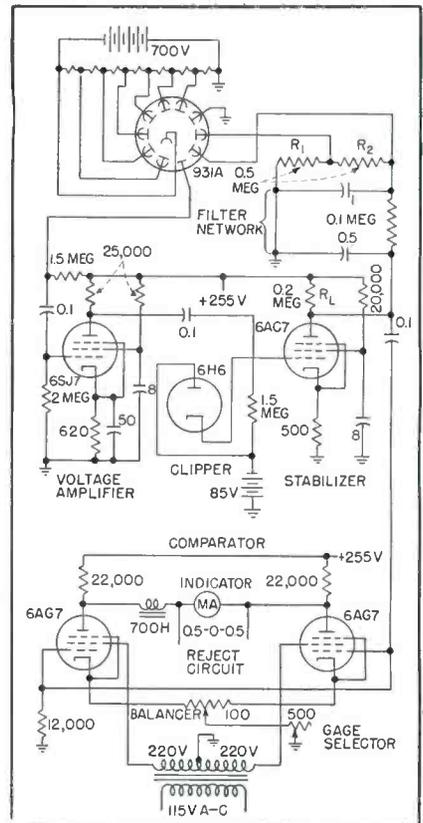


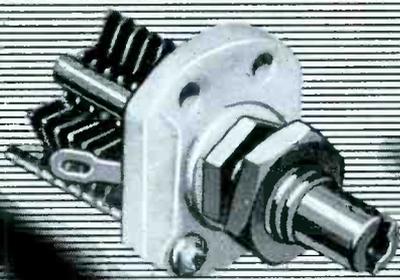
FIG. 3—Values of components and stages of the gaging circuit. The 6AC7 stabilizes the 931A photomultiplier

greater than 150 percent or complete removal of the test sheet. In either event one pulse becomes too small to pass the diode, and thus the pulse differential on the comparator is no longer proportional to the actual thickness difference. The indicating instrument will consequently never be subjected to much more than 150 percent of rated current.

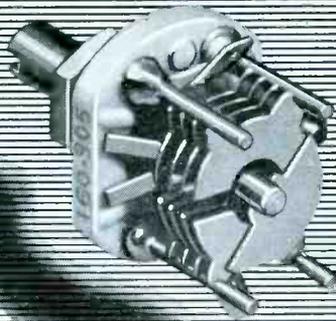
The cathode of the 6H6 clipper is coupled to the control grid of the following 6AC7, which is a saw-tooth converter. This stage in effect adds area to the pulses. This effect is accomplished by shunting the tube with a 1- μ f capacitor.

The control grids of the two

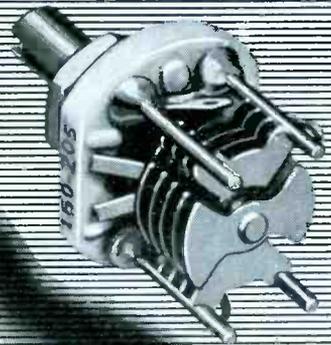
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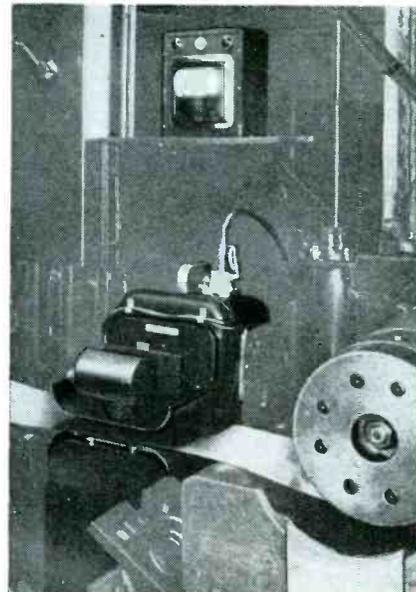
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TUBES AT WORK

(continued)



Setup of the x-ray thickness gage for checking copper strip in a cold reduction mill

tubes in the comparator circuit of Fig. 3 are in parallel. The cathodes are grounded through a potentiometer balancer and a gage-selector rheostat located on the control panel. The screen grids are connected to the transformer so that the applied potentials are 180 degrees out of phase. Each tube thus conducts only when its screen grid is positive. The magnitude of the plate current during conduction depends on the magnitude of the pulse applied to the grid by the x-ray tube channel that is operating during that same half cycle. For equal pulse amplitudes on both half cycles, as occurs when sample and unknown are equal in thickness, the voltage drops across the two 22,000-ohm plate load resistors will be equal and there will be no voltage acting on the meter. For differences in thickness, the zero-center meter will indicate the deviation in thickness by deflecting in the proper direction. The high-reactance choke prevents a-c voltage from acting on the meter.

Photomultiplier Stabilizer

Phototube output is held constant despite inherent drift of secondary-emission tubes by automatically controlling the dynode potentials and in effect controlling the amplification of the phototube. The output pulse due to visible light emitted by the fluorescent screen is amplified by the phototube and by the 6SJ7. The amplified pulse is



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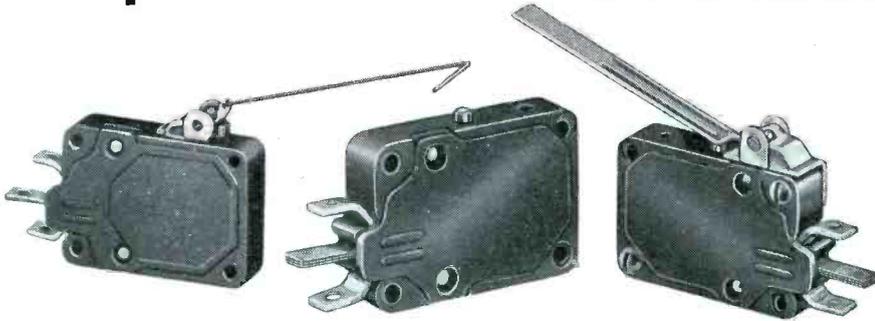


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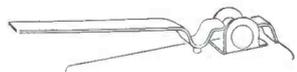
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applied to the grid of the 6AC7 stabilizer which is biased far beyond cutoff and will not conduct unless the signal pulse amplitude nearly equals the d-c bias. If the stabilizer tube plate current increases due to an increase in pulse amplitude, the average drop across R_L increases and the drop across R_1 and R_2 decreases. This lowers the voltage on photomultiplier dynodes 8 and 9 sufficiently to counteract the increase in signal pulse amplitude due to drift.

Operating Conditions

At times, signal amplitude increases to quite high values due to thin test material or complete removal of the test material. The diode serves to clip off the lower portion of the signal, reducing the average a-c value and preventing excessive positive grid swings that might damage the stabilizer tube.

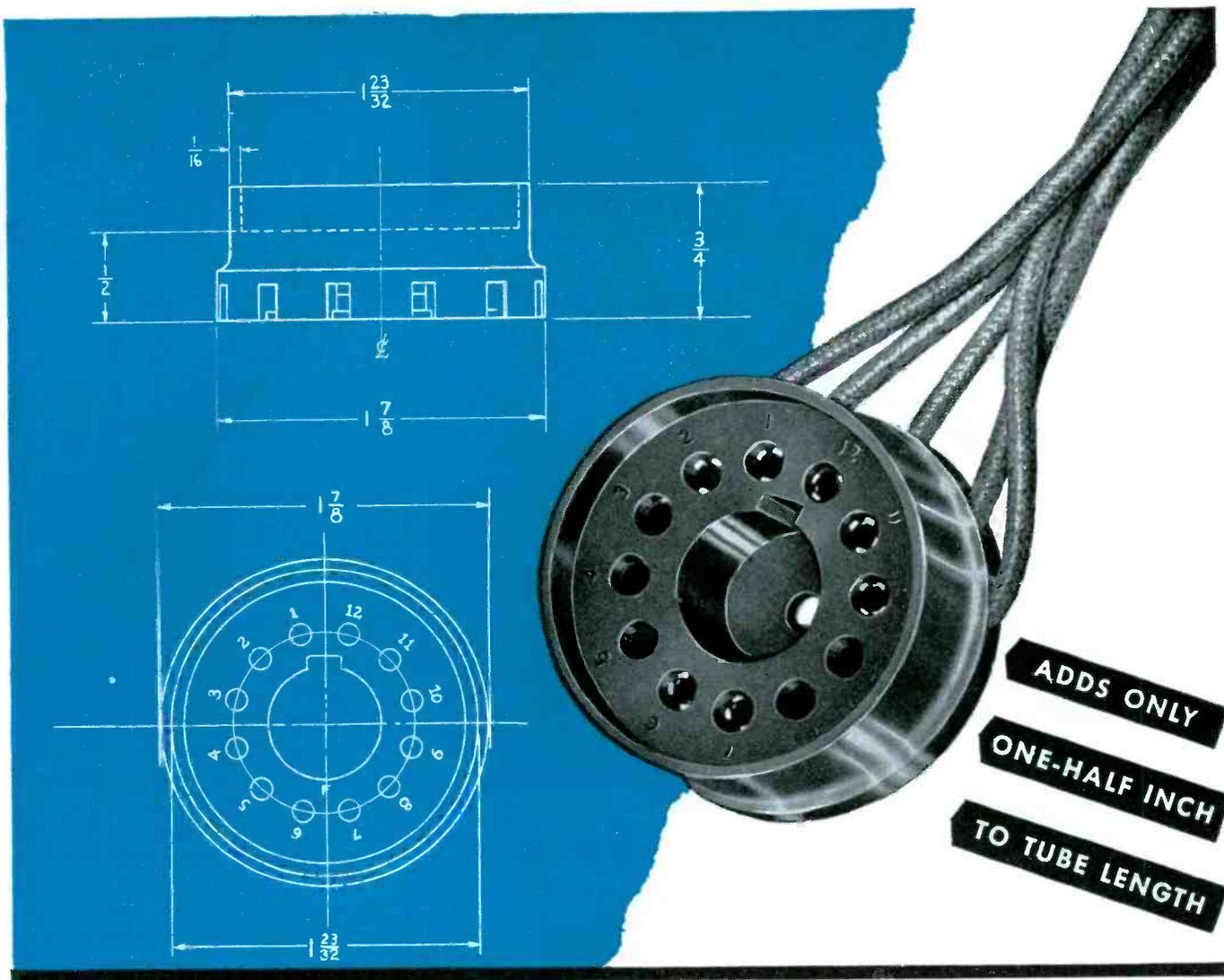
Signal input to the phototube is set originally so that an optimum signal current flows through the stabilizer tube. This sets the voltage across R_1 and R_2 at its midvalue, as required for drift compensation in either direction.

The operator may select the gage of stock to be run by making a simple adjustment of a calibrated rheostat connected in the cathode circuit of the comparator and located at the remote control panel.

Optimum conditions include use of a fluorescent screen causing highest photomultiplier response, restriction of the x-ray beam to that small area on the fluorescent screen most effective in causing photomultiplier response, use of x-ray wavelengths for which absorption in the fluorescent screen is nearly complete, and use of a refined 931A phototube for maximum light sensitivity.

X-Ray Tube Stabilizer

Operation of the x-ray sources without stabilization results in undependable gage indication. X-ray tube current is dependent upon filament temperature. If tube currents in the two heads are originally set at equal values, it is unlikely that they will still be equal an hour later. To maintain automatically identical current magnitudes at all times, the tandem milliamperere stabilizer circuit shown in Fig. 4 is



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TUBES AT WORK

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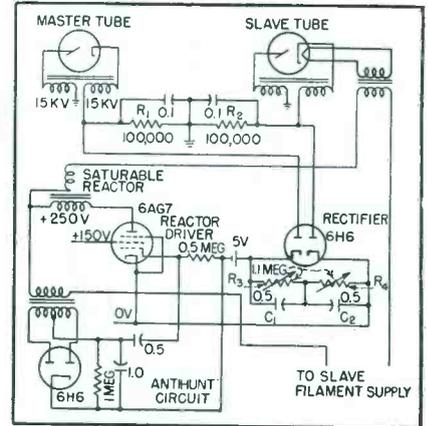


FIG. 4—In the x-ray tube stabilizer, the anode current of the master tube controls the filament current of the slave tube

provided. This circuit uses current of one tube (the master) as reference and makes the current of the slave tube follow it.

The cathode currents of the x-ray tubes cause voltage drops across resistors R_1 and R_2 and these are applied to a 6H6, charging C_1 and C_2 to voltages proportional to the respective x-ray tube anode currents.

Rheostats R_3 and R_4 adjust the time constants of the two R-C circuits, enabling the operator to vary the magnitude of the slave current. The bias on the control grid of the 6AG7 pentode is the algebraic sum of the two capacitor voltages and the bias battery voltage. Plate current of the pentode flows through the d-c winding of a saturable reactor. The greater the plate current, the smaller the a-c voltage drop across the reactor and the higher is the filament current in the slave tube, and vice versa. An anti-hunt arrangement using a feedback transformer and a duplex-diode rectifier, capacitance-coupled to the grid circuit, prevents oscillation that might otherwise result from high sensitivity and quick response.

Other Applications

Applications for an x-ray thickness gage include measurement of the thickness of linoleum, laminated plastics, sheet glass, many types of sheet metal, and paper and cardboard. One interesting application that wouldn't work was counting of bundles of banknotes to determine exactly how many bills above and below the standard number (100, 500, or 1,000) were in a given bundle. It sounded simple, until a trial showed the thicknesses of in-

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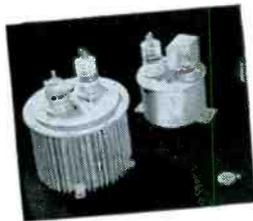
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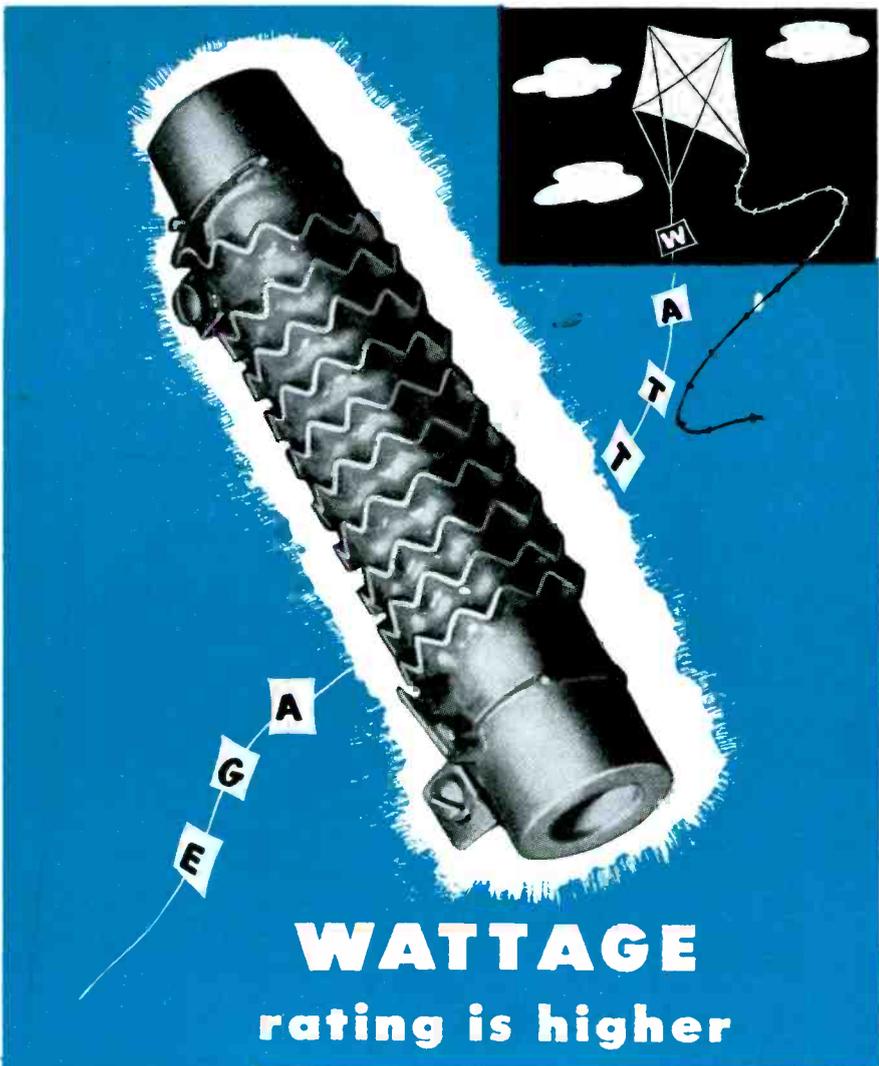


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RESISTORS • RHEOSTATS • RELAYS • CONTROL DEVICES



dividual bills varied as much as 10 percent.

The photograph illustrated on page 162 shows the instrument as it is installed in a cold reduction mill. The Westinghouse x-ray thickness gage checks copper strip as it passes to the take-up mandrel at right. Mounting the x-ray generators as shown (below the moving strip and above and to the rear) permits the necessary right-angle relation with respect to the photo-tube pickup in the cylinder above the strip.

Ultraviolet Flame Detector

IN DEVELOPING counter tubes to measure the intensity of soft x-rays, physicists at the Naval Research Laboratory observed that these tubes were sufficiently sensitive to ultraviolet radiation to make practical the construction of a counter, highly sensitive to ultraviolet radiation from an open flame, and thus having advantages for fire alarm equipment.

The basic Geiger-Muller counter tube, of which this unit is a variation, consists of a cylindrical cathode and a centered anode wire all enclosed in a glass envelope as shown in Fig. 1. The tube is filled

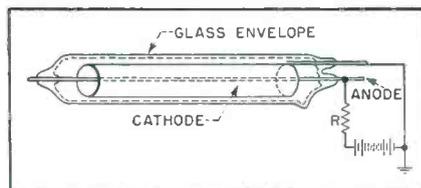


FIG. 1—Construction of basic Geiger-Muller counter tube. To sensitize tube to ultraviolet, surface of copper cathode is slightly oxidized and tube is filled with mixture of argon and alcohol vapor at low pressure. Quartz window in the glass envelope admits ultraviolet radiation

with a single gas or a combination of gases at low pressure, and a potential of the order of 1,000 volts is applied across the two electrodes. This voltage is carefully adjusted so that the tube is operating just below the point where self-sustained discharge can occur. Under these conditions, when a single electron is introduced into the tube, a momentary discharge is triggered. Proper design of the counter and its associated circuit permits the discharge to be rapidly quenched. The elec-

for MORE POWER



*The trade name VARIAC is registered at the U. S. Patent Office. VARIACS are manufactured and sold under Patent No. 2,909,013.

• The Type V-20 VARIAC* with new materials and improved design delivers over 140 percent more power per pound than its predecessor, the Type 100-Q. The V-20 is rated at 20 amperes, with a 30 ampere maximum; the V-20H, 8 amperes with a 10 ampere maximum.

These new VARIACS are provided with heavier barrier terminals in a box equipped with knockouts for standard 3/4-inch BX or conduit. The new combination knob and handwheel makes it much easier to vary voltage. The V-20 dials have extra large calibration figures, easy to read at a distance.

As with all other VARIACS, output voltages are continuously adjustable from zero to 17% above line voltage.

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	TYPE V-20	TYPE V-20H
LOAD RATING (KVA)	3.45	2.3
Input Voltage	115	230 or 115
Output Voltage	Zero to 115 or 135	270 or 230
Rated Current (Amperes)	20	8
Maximum Current (Amperes)	30	10
PRICE	\$55.00	\$55.00

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XL-3-14N Recept.
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trons causing the discharges can originate as the result of various forms of radiation. In a light-actuated counter, they originate as a result of photoelectric emission from the cathode.

To permit the use of the counter in a lighted place, it is necessary that it be particularly sensitive to those components of the spectrum that are produced by radiation from a flame, and that it be relatively insensitive to the spectral components of sunlight. For this purpose, the counter must have a threshold of sensitivity less than 2,900 angstroms. A counter tube having a copper cathode surface will meet this requirement provided that this surface is oxidized slightly. The introduction of a small amount of alcohol vapor in the counter tube also helps to reduce the wavelength at which the sensitivity threshold occurs.

Construction of Counter

Based on the principles outlined, an ultraviolet counter tube was constructed with a copper cathode having a slightly oxidized surface, and a 5-mil tungsten wire anode. The anode was centered by means of two punched mica discs. A quartz window cemented in the glass wall with Glyptal admits ultraviolet radiation. The tube was filled with a mixture of alcohol vapor at 4 mm and argon at 4 cm (mercury-pressure).

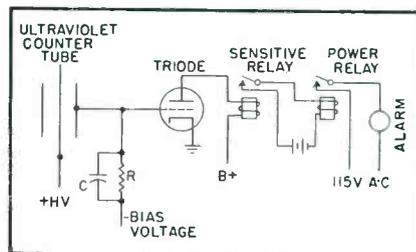
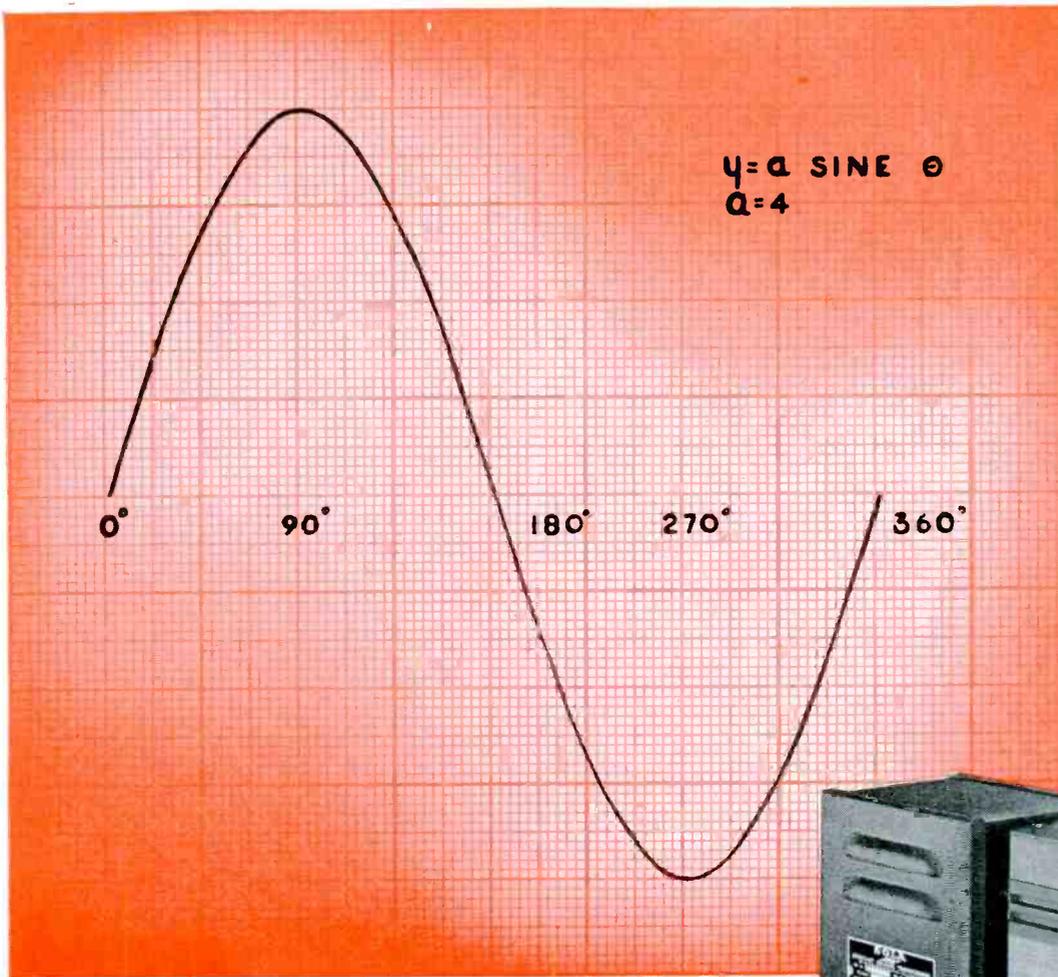


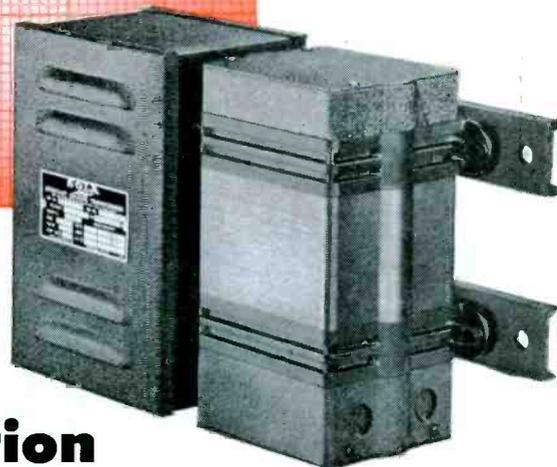
FIG. 2—Simple ultraviolet counter fire-alarm circuit

The counter tube was connected as shown in Fig. 2 to the input of an amplifier. The R-C input circuit was chosen to have a time constant of about five seconds. Thus, infrequent aperiodic discharges of the counter, occurring for small intensities of radiation, are smoothed out to produce steady currents. With the time constant so chosen,



$$y = a \text{ SINE } \theta$$

$$Q = 4$$



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TYPE CVH, an important newcomer in a famous line—a SOLA CONSTANT VOLTAGE Transformer designed for use with equipment that requires a source of undistorted voltage. These new transformers, available in 250, 500 and 1,000 VA capacities, provide all of the voltage stabilizing characteristics of the standard SOLA Constant Voltage Transformer, with less than 3% harmonic distortion of the output voltage wave.

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DCVH-136—complete electrical and mechanical characteristics of the new Type CVH Constant Voltage Transformers.

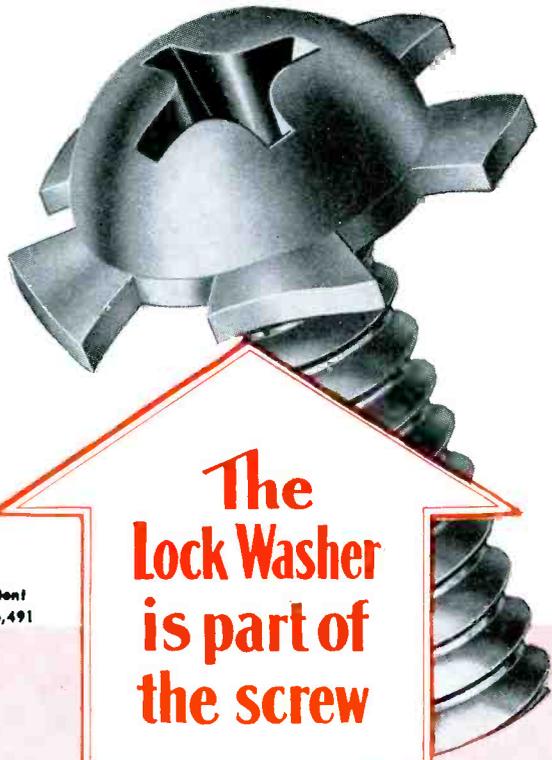
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U. S. Patent
No. 2,226,491

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Mass., U.S.A.

TUBES AT WORK

(continued)

the relay operated when the input current exceeded 10 photoelectrons per second. An alternative circuit arrangement using a thyratron is shown in Fig. 3.

If it is desired to operate the device from the 110-volt a-c line, a transformer and voltage doubler can furnish the required high voltage. Stabilized voltage can be picked off a bank of ¼-watt neon lamps connected in series across the d-c output. Alternatively, with an amplifier using a low-current triode such as the 1G4-G, a pack of miniature aircraft B batteries can be used to produce the necessary voltage.

Performance

In a one-minute run, the counter described can detect a photocurrent of only five electrons per minute against the normal background count inherent in the device. This small electron flow corresponds to a current of the order of 10^{-20}

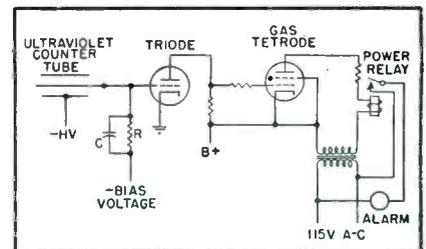
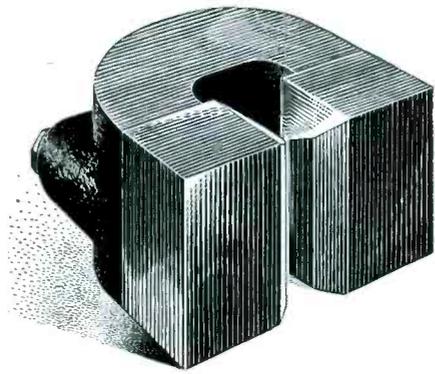


FIG. 3—Sensitive relay required in circuit of Fig. 2 is eliminated by use of thyratron

ampere. The most sensitive type of photocell can measure photocurrents of the order of 10^{-18} ampere.

In testing thermal alarms, the Bureau of Standards has used a standard flame obtained by igniting five square feet of alcohol in a flat pan. In one series of tests, this source was ignited in a room measuring roughly 13 feet high and having about 2,000 square feet of floor space. With detector elements on the ceiling and the fire pan on the floor in the center of the room, it generally required more than a minute to actuate the alarm. With a similar source, the ultraviolet counter triggers the alarm in a few seconds when mounted 200 feet from the fire pan. Its response is independent of room shape or ventilation and is limited only by the cone of vision.



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Electrocardiographs

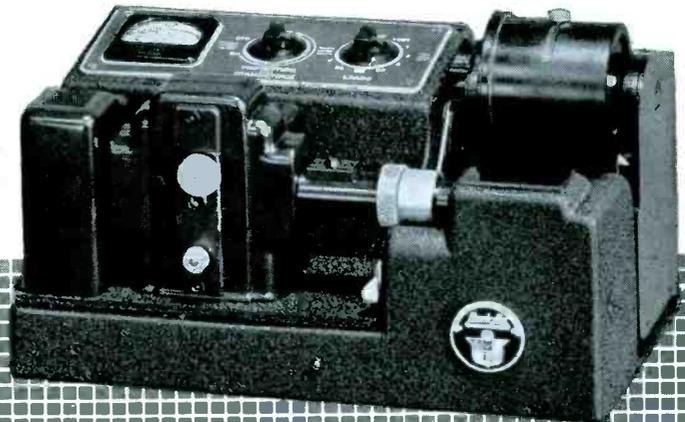
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3. Reduce weight of complete unit.
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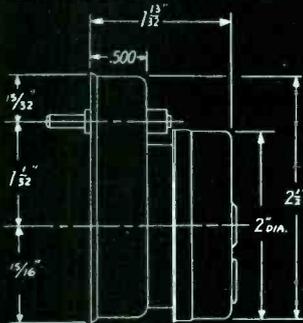
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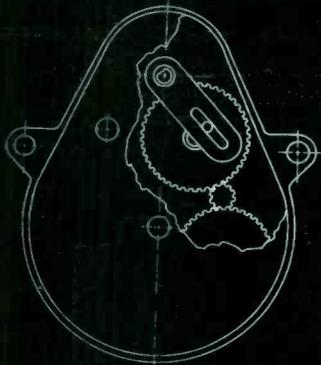
MAT'L: SYNCHRONOUS MOTORS

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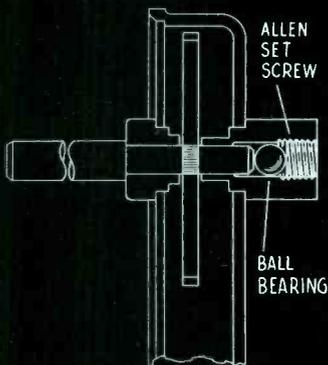
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THE ELECTRON ART

(continued from p 140)

dividual slits are arranged on tracks along the focal curve. The receivers can be positioned as necessary on tracks to monitor lines from elements of interest. Each receiver of the Quantometer built by the Applied Research Lab. consists of a photomultiplier tube (supplied from a single high-voltage rectifier in common with the other receivers) and an integrating amplifier (with individual power supply). A separate, multiple-channel recording console punches tapes from which, after calibration, the chemical percentage of each element can be read. Once set up, the meter determination has an average deviation of only 0.012 percent.

Development and Applications of the Skiatron

BY G. WIKKENHAUSER

Technical Director, Schophony Ltd.
Wells, Somerset, England

DISLOCATION of electrons in or from their atoms in crystal lattices usually results in coloration. This effect, recently utilized in x-ray treatment and inspection of gems, is used to produce the visible image

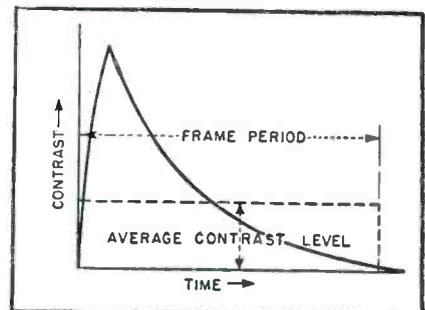


FIG. 1—Density-time characteristic of electron opacity phenomena

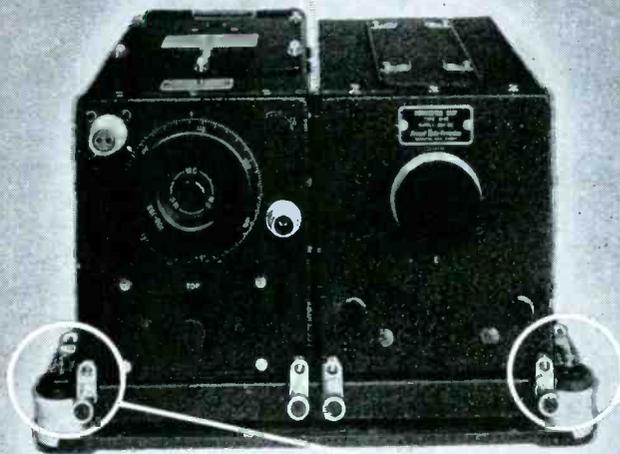
in the Skiatron type cathode-ray tube. Although experimentally developed for use in television, this tube offers several advantages for radar indicators, especially its long persistence with concomitant discrimination against noise by signal integration.

Development and Characteristics

Intense coloring of various alkali halide crystals that results from cathode-ray bombardment, discovered in 1894 by E. Goldstein, and further studied by Pohl, Mott, and Gurney, is used to produce opacity in the tube screen. When a thin layer of these crystals is so bom-

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3

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FIG. 2—Large-screen plan position indicator used by British Admiralty

barded, some electrons are displaced from the halides and occupy positions in the faults of the crystal lattice where they vibrate at characteristic frequencies. Because the frequency of vibration lies in the visible spectrum, and because these displaced electrons can absorb light at their characteristic frequencies, a dark pattern is produced on the originally semitransparent crystal layer. The color of the pattern is the complementary color of the absorption.

The most commonly used material is potassium chloride whose absorption is in the green region of the spectrum, thus the dark pattern appears magenta. In potassium bromide the absorption is in the bluish range, so that the pattern is brownish; sodium chloride gives an orange trace. As the electrons absorb further energy either from light or heat rays they return to their stable positions and the dark trace disappears.

This phenomenon was applied to television tubes by A. H. Rosenthal in 1938, but, although he obtained television images on Skiatrons of the BBC 405-line interlaced transmission, it was realized that much work was required to perfect the technique. The images lacked sufficient contrast because of the relatively long persistence of the trace. Time required for a trace to disappear is a function of the degree of discoloration, dark traces dissolving most slowly. To obtain fast enough decay for reproducing 25 pictures per second, the darkening had to be limited to very faint traces. Figure 1 shows a typical buildup-decay characteristic. De-

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GL-8008
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GL-857-B

GL-869-B

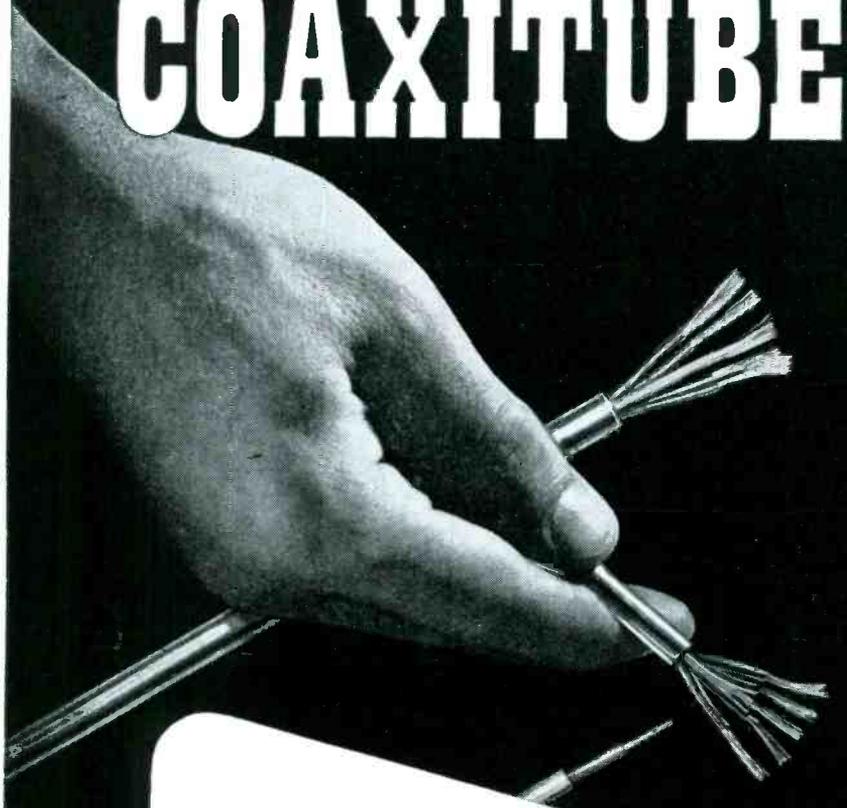
GL-673
(also available with 50-watt base as Type GL-575-A)

Type	Cathode voltage	Cathode current	Anode peak voltage	Anode peak current	Anode avg current
GL-866-A	2.5 v	5 amp	10,000 v	1 amp	0.25 amp
GL-8008	5 v	7.5 amp	10,000 v	5 amp	1.25 amp
GL-673	5 v	10 amp	15,000 v	6 amp	1.5 amp
GL-869-B	5 v	18 amp	20,000 v (*15,000 v)	10 amp	2.5 amp (*5 amp)
GL-857-B	5 v	30 amp	22,000 v	20 amp (*40 amp)	5 amp (*10 amp)

(* Quadrature operation)

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THE ELECTRON ART

(continued)

spite these limitations, the fact that the tube could be used as a light valve, controlling an auxiliary light source, recommended it for use in projection systems for producing large television images.

Application to Radar Indicators

In applications other than television, where the trace could remain for some time, the characteristic of the Skiatron screen is desirable. One such application is to ppi instruments, especially the projection type of Fig. 2, on which shore lines and other fixed objects build up to high contrast and paths of aircraft and ships are shown. To cancel the trace the screen is irradiated with heat and light.

Parallel developments were made by several German firms including Lorenz and Telefunken. To cancel the trace on these tubes, heat was applied directly. The halide screen was formed on a thin sheet of mica on which was also a tungsten film thin enough to be transparent to visible light but yet electrically conductive. When the trace was to be erased, current was passed through the tungsten film producing a sufficiently high temperature to dissolve even a very dark trace in from 5 to 10 seconds. The metal

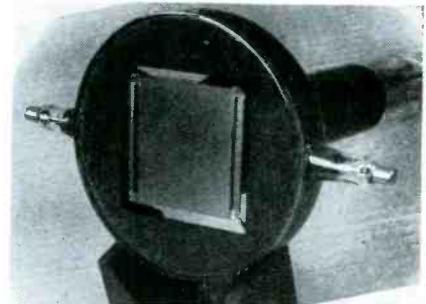


FIG. 3—Dark-trace tube developed in Germany contains erasing heater

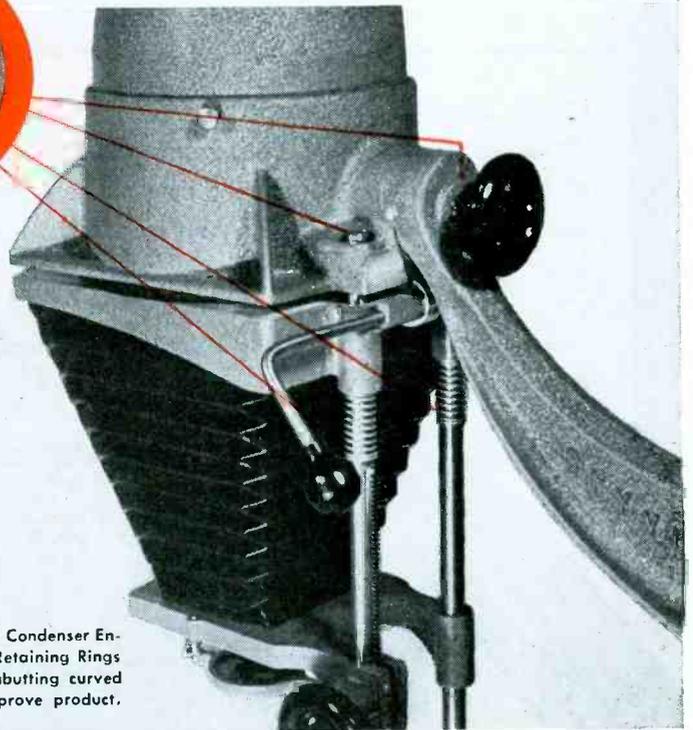
caps at the sides of the tube shown in Fig. 3 provide connection to the tungsten film.

Other applications utilizing the long persistence characteristic of the Skiatron have been made. To track every plane within a 50-mile radius of the All-Weather Flying Center, Wilmington, Ohio, such a tube is being used. The transient recording oscillograph made by Scophony produces a persistent trace that can be studied or photographed without need for precise synchroni-

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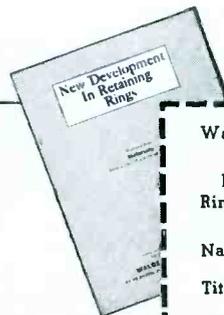
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FIG. 4—Dark trace persistence is such that trace remains after tube is unplugged

zation with the occurrence to be recorded. Figure 4 is a rather unique photograph of a British tube on which a damped 25-cps wave was recorded; the tube was then removed from the associated equipment and the photograph made, the trace still remaining on the screen. The British Services Electronic Research Laboratories have demonstrated a facsimile transmission and reception system in which a 500-line picture, scanned over a period of one second, is reproduced by this electron opacity technique.

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- (3) R. W. Pohl, Electron Conductivity and Photochemical Processes in Alkali-halide Crystals, *Proc. Phys. Soc. (London)*, p 3, Aug., 1937.
- (4) R. B. Hotz, Radar Traffic Control System Developed at All-Weather Center, *Aviation News*, Feb. 3, 1947.
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Measuring R-F Power with a Thermopile

By GUY P. WALKER

Naval Research Laboratory
Navy Department
Washington, D. O.

DETERMINATION of radio-frequency power produced by an oscillating vacuum tube or lost within it or its associated circuit is difficult. Closely coupling measuring equipment to the circuit may change the operating conditions. Although the optical pyrometer method does not disturb the tube or circuit, it is subject to error from the nonuniform distribution of temperature over the anode during calibration (calibration usually being done with d-c in



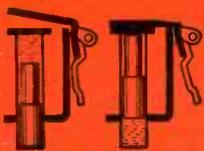
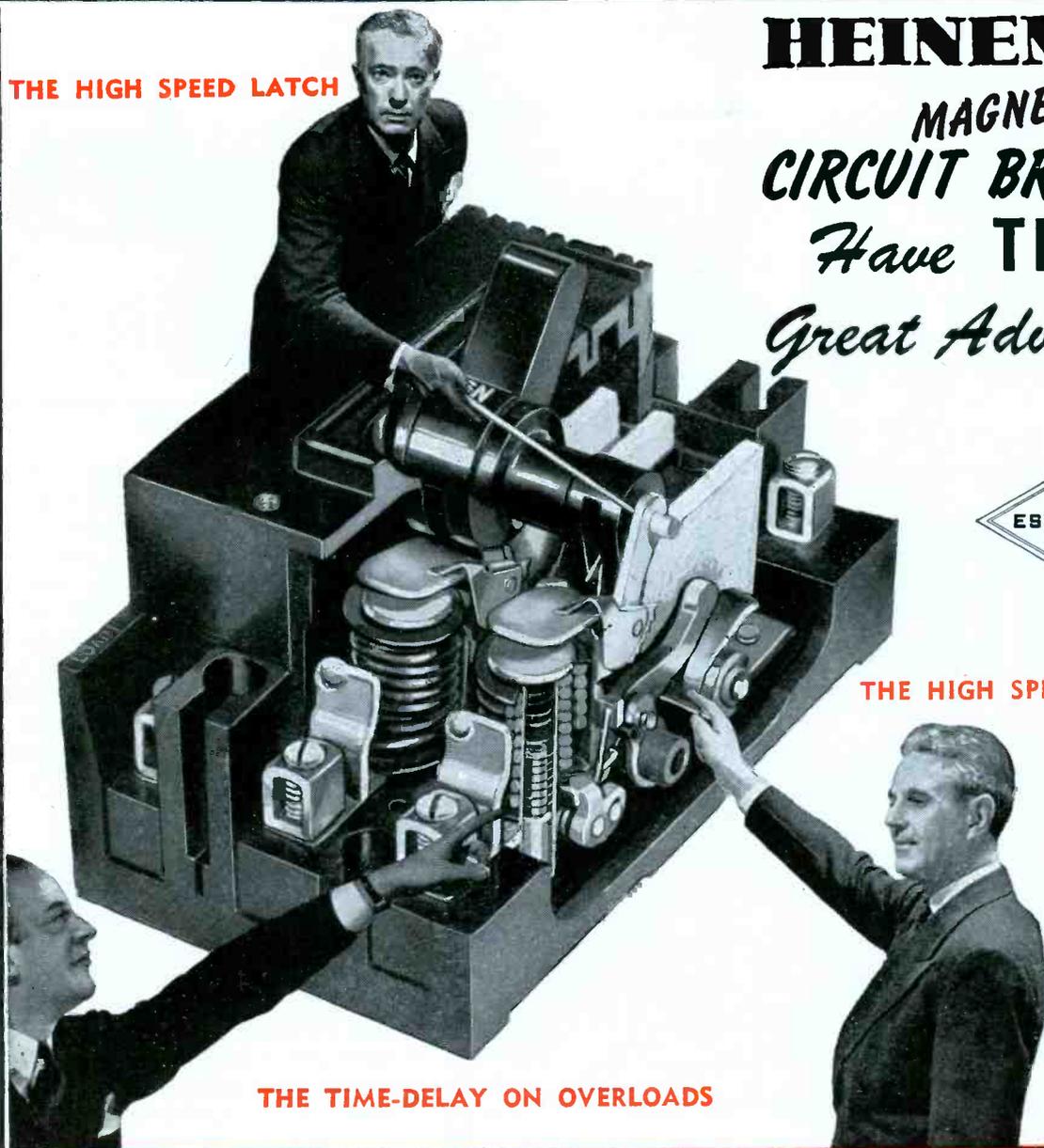
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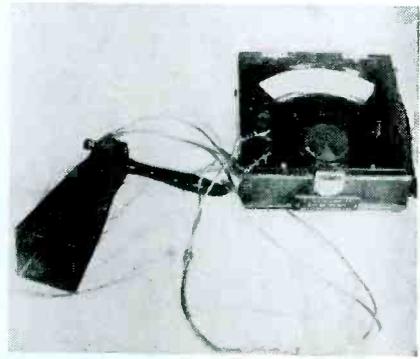


FIG. 1—Thermopile in horn operates indicating meter

which case the grid shadows on the anode are well defined; during operation, when the grid voltage is swinging, these shadows are less defined). Furthermore, the optical pyrometer can only be used with tubes whose anodes show color during operation. The thermopile, by measuring radiated heat rather than light, is free from these limitations, and retains the advantage of not disturbing the circuit.

Method of Use

In a self-excited oscillator, d-c input power to the tube is consumed in (1) tube losses, (2) circuit losses, and (3) useful power output. Circuit losses and useful power output taken together make up the total r-f power output. Because d-c input power to the tube is readily obtained, if tube loss can be measured, subtracting this loss from d-c input power gives total r-f power output. A lumped value of the various circuit losses can be obtained if both tube loss and useful power output are measured and the useful power output subtracted from total r-f power output.

A sensitive but rugged and inexpensive thermopile located at the focus of a horn whose interior is highly polished has been found to be sufficiently directional to respond to the heat radiated from a given tube toward which it is aimed and to exclude small quantities of heat radiated from sources outside the area seen by the orifice of the horn. However, the horn covers a large enough area of the anode not to make the equipment sensitive to localized temperatures. Figure 1 is a photograph of this equipment and its associated meter. The horn and shielded meter leads prevent interference from r-f fields produced by

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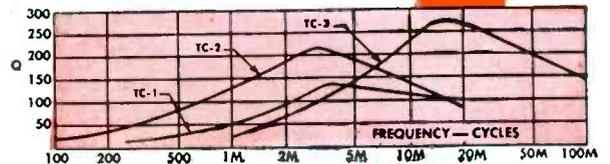
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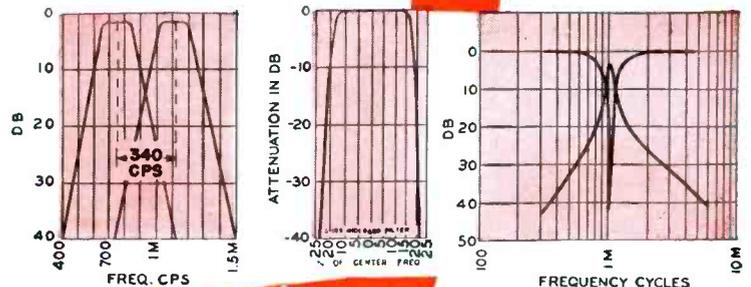
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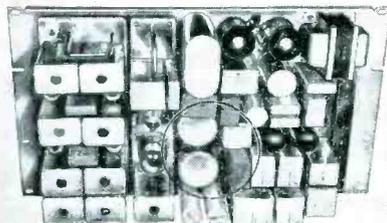
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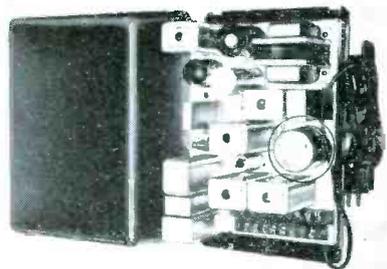
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the circuit under test. The meter used with the thermopile is a sensitive d-c microammeter whose resistance should be such as to produce a reading of at least half scale under the prevailing conditions of radiation being received by the thermopile.

A calibration curve is made of d-c input power vs thermopile reading with the tube operating statically. As would be expected, current from

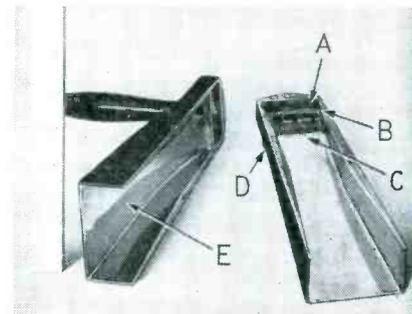


FIG. 2—Open horn shows internal shape and location of thermal junctions. There are 19 cold junctions (A) and 19 hot ones (C), the latter being blackened and located along the focus of the horn. The Thermopile is insulated (B) from the polished aluminum horn (E) and leads brought out to terminal posts (D). The equipment is available through Central Scientific Co., Chicago

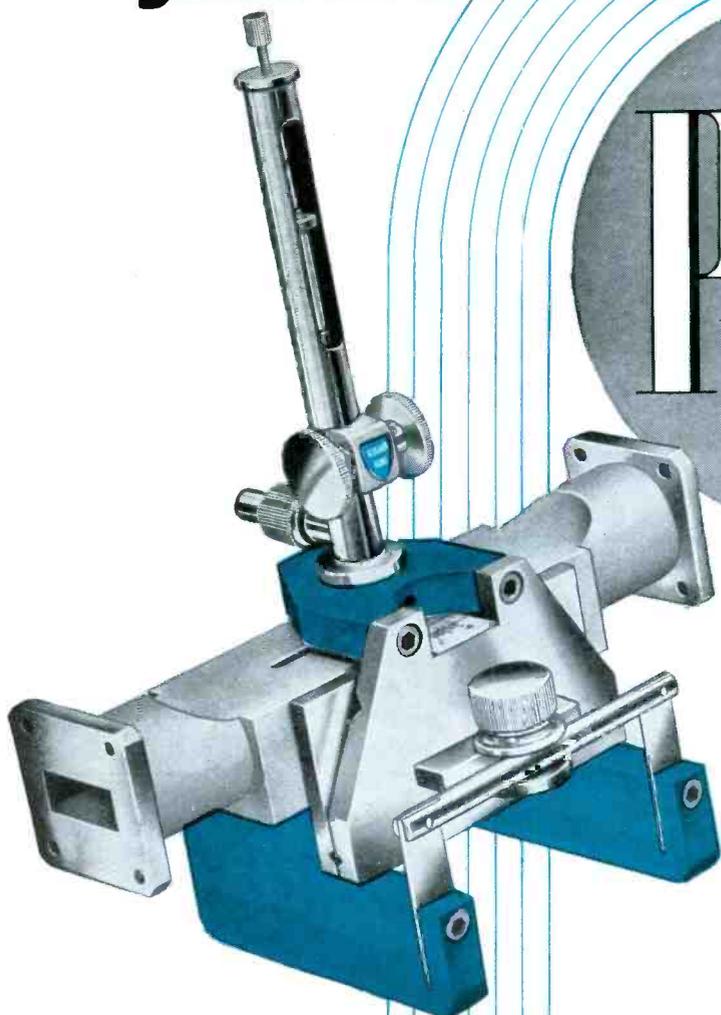
the thermopile varies linearly with respect to the power dissipated within the tube. During calibration the tube dissipation is considered to be the sum of the plate and screen input powers. Filament power is neglected because it is considered to be constant throughout calibration and operation, its only effect being to produce a finite intercept of the calibration curve. Control grid power for most tubes is negligible during calibration and in self-excited oscillators is furnished by the anode supply. After calibration, the tube circuit is adjusted for the oscillating condition without disturbing the distance between tube and thermopile or their positional relationship. However, the same thermopile and meter can be used to measure a wide range of power by varying the distance between thermopile and radiating tube, making suitable calibrations at these distances.

With the tube oscillating, a thermopile reading is obtained and, by reference to the calibration curve the power dissipated within the tube is determined. As indicated above, subtraction of this value

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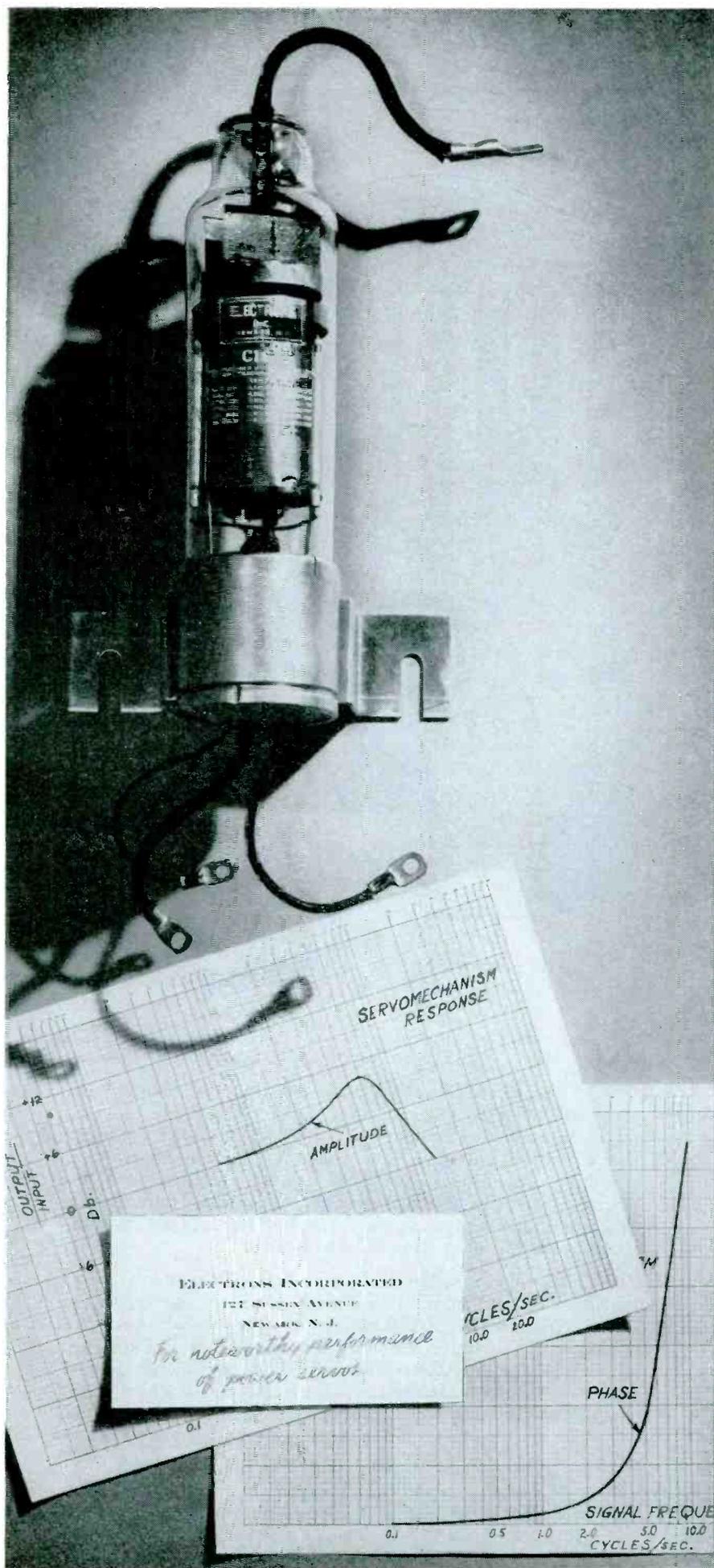
from the d-c input power gives the total r-f output or, in other words, gives the sum of circuit losses and useful power output. Measurement of the useful power output by a lamp and photocell or by a lamp or other load and the thermopile enables one to arrive at a lumped value of circuit losses. By supporting the thermopile on a pivot, it can be rotated to aim it at either the tube to measure tube loss or at the load to measure useful power output. Separate calibration curves are necessary because of the dissimilarity in the two sources of radiation. Figure 2 shows constructional features of the horn and thermopile.

Accuracy of Technique

Using a 4E27, which has a tantalum anode, the relationships of watts dissipated within the tube to thermopile current and optical pyrometer reading in degrees centigrade were simultaneously determined. Then, with the tube oscillating, readings were taken on both instruments as a check of one method against the other to give the following tabulation

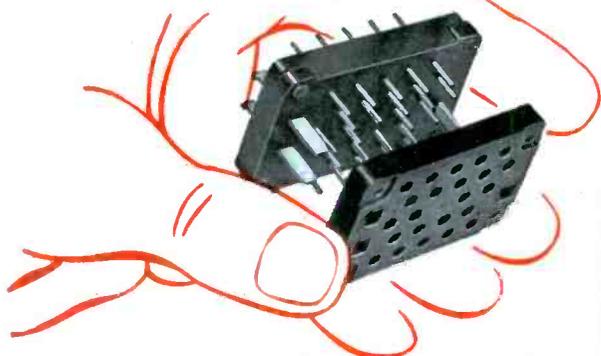
<i>Optical Pyrometer</i>	<i>Thermopile</i>
<i>Tube loss in watts</i>	
37	44
49	51
57	52
80	79
<i>Total r-f power in watts</i>	
117	110
138	136
168	173
220	221
<i>Circuit losses in watts</i>	
21	14
20	18
30	35
29	30

In general, the readings agree with each other within a few percent. However, scattered readings are in considerable disagreement. The fact that the disagreements are not consistently in the same direction indicates that the personal element may be an important factor. Because matching colors of a small area of the tube anode and of a heated filament within the optical pyrometer is more difficult than



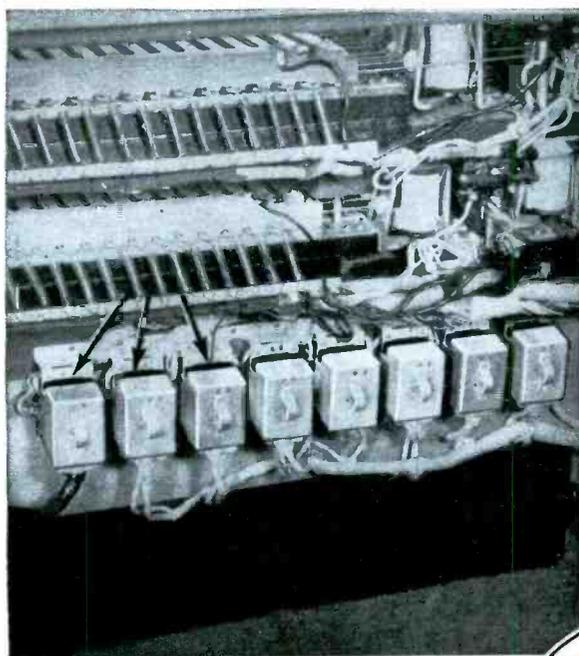
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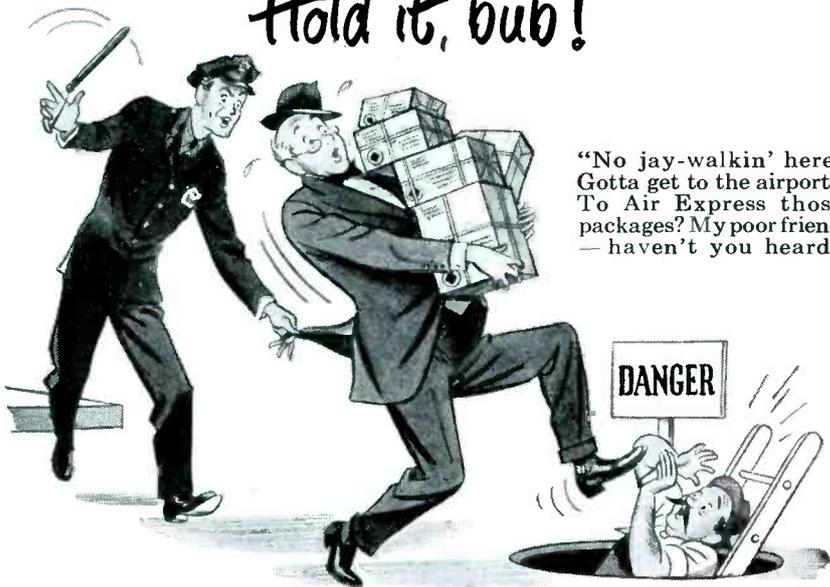


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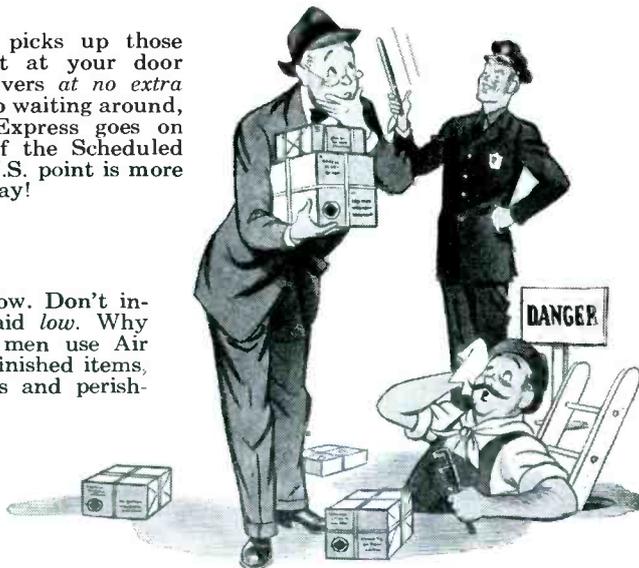
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reading a 5-in. meter scale, the disagreements in readings are most likely due to inaccuracies in reading the optical pyrometer than to errors in the thermopile. Therefore the thermopile is at least as accurate as other commonly used equipment for measuring r-f power.

Because tubes warm up slowly, approaching their stable temperatures asymptotically, readings cannot be taken quickly. A 50-watt tube requires about 8 minutes to reach a point where reasonably accurate readings can be taken. When making readings with the thermopile, ambient temperature should not change widely. Changes in direction or velocity of air currents near the tube or thermopile can introduce errors. However, as the data presented indicates, the thermopile with its directive horn is a very useful instrument, especially in the laboratory where tubes can be held at equilibrium long enough for the reading to have meaning.

Directly Coupled Phase

Inverter

BY E. JOHNSON
Brooklyn, N. Y.

DIRECT-CURRENT symmetry and stability of output are obtained from the phase inverter shown in the accompanying diagram. Because of these properties, the circuit is useful in handling flat-topped pulses, low frequencies and the like. The indicated values of the components, although considered optimum for the specific application for which this circuit was developed, should be taken as suggestions rather than absolutes.

Operating Conditions

The upper half of the inverter is recognizable as a cathode-coupled amplifier^{1,2}. The output of this half is in phase with the inverter input.

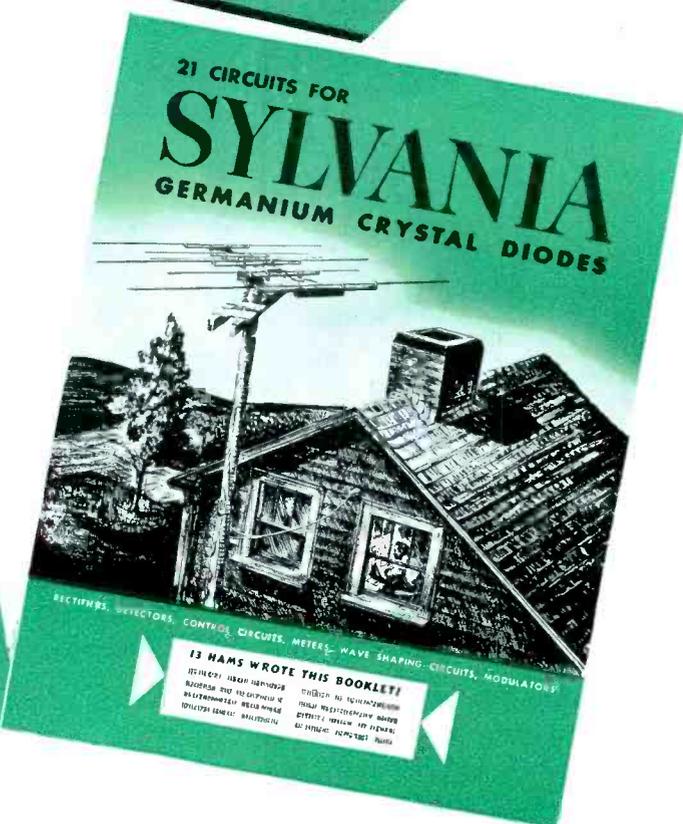
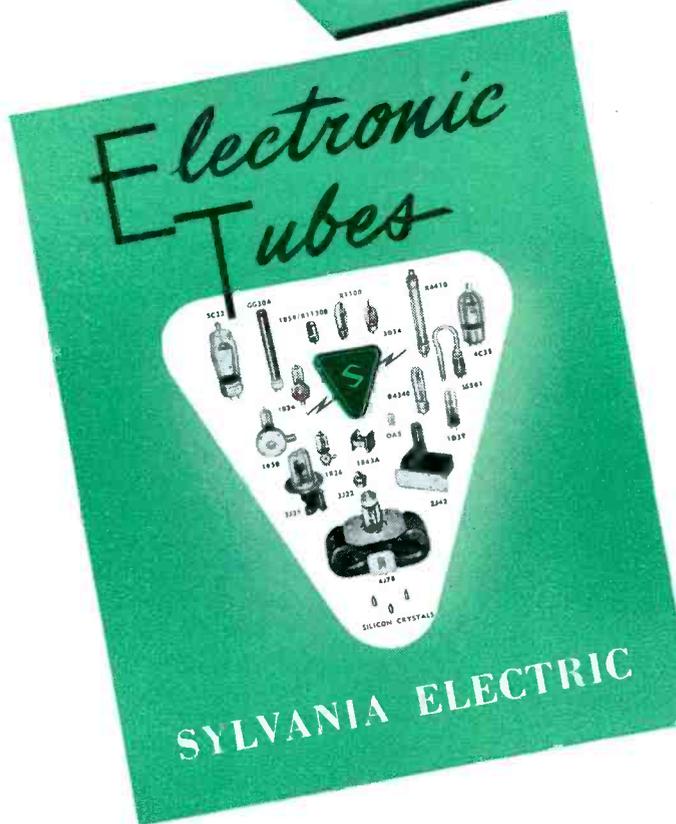
The lower half is the same as the upper half but with its grids interchanged. With respect to quiescent conditions, the lower half of the circuit behaves identically to the upper half. However, the output of the lower half is 180 degrees out of phase with the inverter input. The inherent gain

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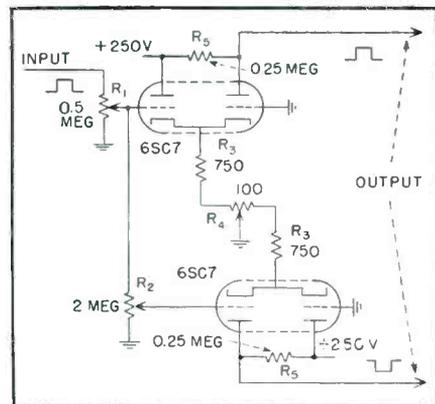
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Phase inverter is directly coupled

of the lower half is about half that of the upper half so that an adjustment of the potentiometer R_2 is necessary to equalize the outputs of the two halves. Overall gain of the inverter is controlled by R_1 .

Potentiometer R_4 is adjusted to make the d-c output voltage of each half of the circuit equal, the adjustment being made in the absence of signal and before R_2 is adjusted. The subsequent adjustment of R_2 does not necessitate any further adjustment of R_4 , making the circuit very easy to balance. Essentially, each half of the circuit operates independently of the other half so that there is no tendency towards regenerative drifting and critical adjustment that characterize many comparable circuits.

With the typical values of components as shown, the circuit has a voltage gain of about 20 and handles inputs up to two volts without appreciable distortion. Use of 6SN7's would have reduced the gain to about seven. Graphical analysis offers a convenient means of investigating the performance of the circuit and provides a guide for selecting the components³

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- (1) G. C. Sziklai and A. C. Schroeder, Cathode-Coupled Wide-Band Amplifiers, *Proc IRE*, p 701, Oct. 1945.
- (2) K. A. Pullen, The Cathode-Coupled Amplifier, *Proc IRE*, p 402, June 1946.
- (3) M. S. Rifkin, A Graphical Analysis of the Cathode-Coupled Amplifier, *Communications*, p 16, Dec. 1946

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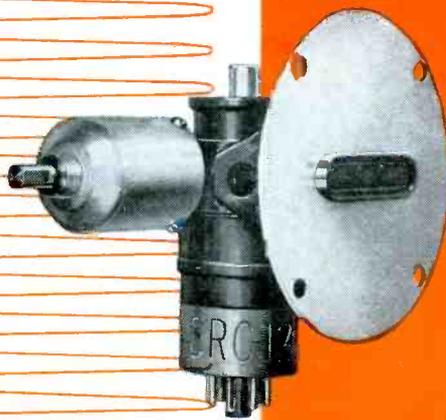


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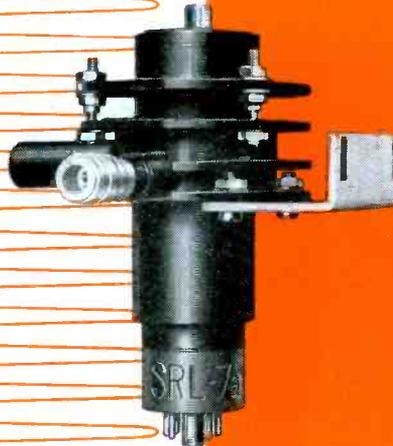
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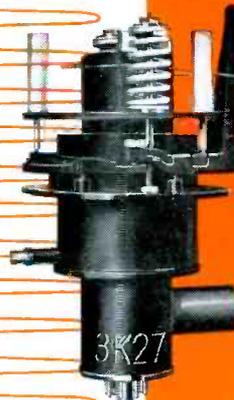
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Information based on an interview with Dr. Krambeer, chief filter designer of Siemens Halske Labs.,

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Fishing reel gears must operate smoothly at a speed of 3000 revolutions per minute or more, when a cast is executed. These gears must also withstand the strain of hauling in a fighting fish of unpredictable size and strength, thus rendering a dual purpose: speed and velvety smoothness in one direction—strength and durability in the other.

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Aircraft controls, dental drills, electric clocks, gauges, indicators, heat controls, machine tools, radar, radios, washing machines and motion picture projectors are but a few of the many conveniences of modern progress which depend upon the heartbeat of Quaker City Gears. Your gear problem is our business, our large productive capacity is at your service.

YOUR INQUIRIES WILL RECEIVE PROMPT ATTENTION

The heart of the Outdoorsman Castomatic reel illustrated above is but one of many gear trains developed by our engineers and produced in our fully equipped plant.



Quaker City Gear Works

INCORPORATED

1910 N. Front Street, Philadelphia 22, Pa.

ERSIN

Multicore



**IS THE ONLY THREE CORE SOLDER
IN THE WORLD WHICH IS MADE WITH
EXTRA-ACTIVE NON-CORROSIVE
ERSIN FLUX**

which gives you guaranteed flux continuity and ensures a high standard of precision soldered joints. Three cores of flux in Ersin Multicore Solder give quick melting and more rapid soldering. The Multicore construction ensures flux continuity and the correct proportion of flux to solder. If you would like to know more about Ersin Multicore please write to us for detailed technical information.



Ersin Multicore Solder is made as standard in gauges between 10 and 22 S.W.G. (.128 — .028 ins., 3.251 — .711mm.) and in five standard antimony free alloys. Other gauges or alloys can be supplied to order. Only the finest tin and lead are used in the manufacture of Ersin Multicore Solder.

**ERSIN MULTICORE SOLDER GIVES YOU HIGH SPEED
PRECISION PRODUCTION — THE SECRET IS IN THE
ERSIN FLUX (EXCLUSIVE TO MULTICORE) COMBINED
WITH MULTICORE CONSTRUCTION.**

Address U.S.A. and Canadian inquiries to
BRITISH INDUSTRIES CORP., 315 Broadway, New York 7, N. Y.

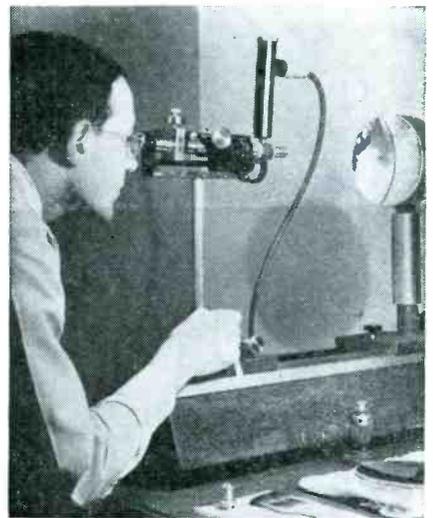
Inquiries regarding other territories to
MULTICORE SOLDERS LTD., Mellier House, Albemarle Street, London, W.1, England.
Cables: Dustickon, Piccy, London.

VISIT OUR BOOTH
at the
I. R. E. SHOW

and contained in an exchange report prepared by the British Intelligence Objectives Sub-Committee describes methods of designing channel, narrow band, and low and high pass crystal filters (PB-80572, microfilm \$1.00).

Electroacoustic measurements can be logarithmically recorded by techniques used in the Neumann damping recorder. The method is suitable for determining voltage differences in sound frequency generators such as receivers and microphones (PB-69125, microfilm \$1.00).

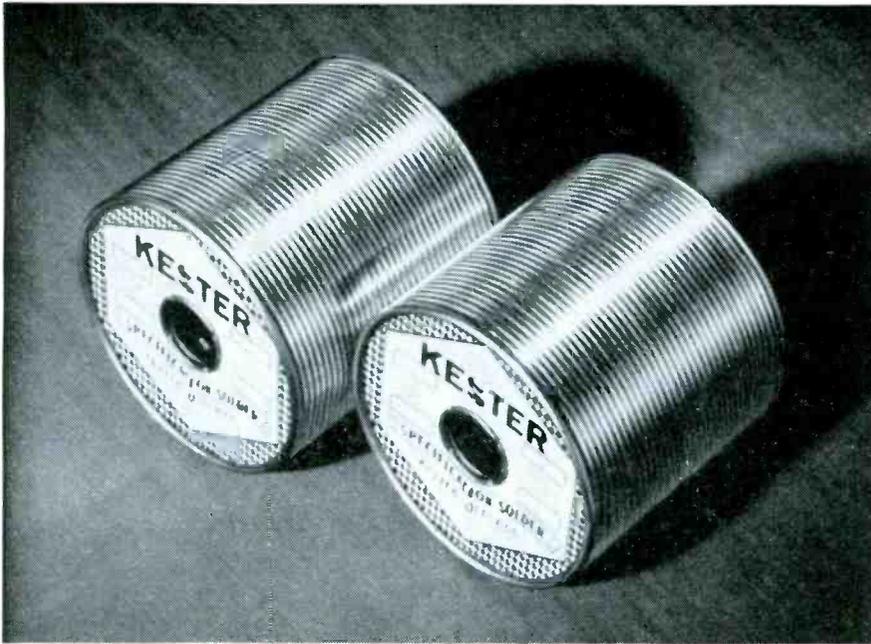
CONCENTRATED ARC LAMP (ELECTRONICS, p 202, Feb. 1947) is used as a point source in projecting a wide angle beam capable of covering the large spherical mirrors used in projection television receivers.



Optical laboratory instrument paves the way for production inspection of television projection mirrors

The technique is used at North American Philips Labs. to determine means for improving quality of mirrors. The image formed is examined by the same lens system that projects the light beam.

VERY DILUTE CONCENTRATIONS of colloids and bacteria can be compared in a pulse type penetrometer developed under OSRD and Army Service Forces contracts at Northwestern University by F. T. Gucker, Jr., H. B. Pickard, C. T. O'Konski, and J. N. Pitts, Jr. The penetrometer consists of a cell through which the stream (gas or liquid)



***Uniform in looks—
but ONE is best for You!***

All solders look alike but many will vary widely in performance. Speed up all soldering operations and eliminate trouble by using Kester Cored Solders with their uniform and dependable flux core.

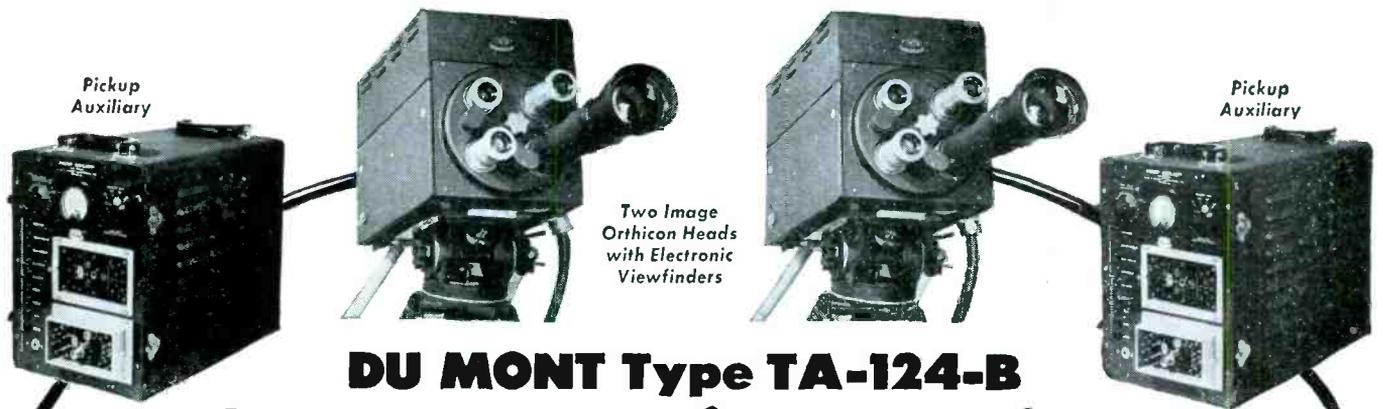
Consult our engineers, without obligations, on any soldering problem. One of our Cored Solders can be fitted to your needs.

KESTER SOLDER COMPANY

4204 Wrightwood Avenue, Chicago 39, Illinois

Eastern Plant: Newark, New Jersey Canadian Plant: Brantford, Canada





DU MONT Type TA-124-B *Dual Image Orthicon Chain*

► Split-second action through quick setup and finger-tip controls; accessibility for time-saving inspection and immediate maintenance; superlative image pickup with precise electronic viewfinder checkup; handy matched units for all required power, synchronizing, amplifying and monitoring functions plus latest camera effects—such explains the popularity of the Du Mont Type TA-124-B Dual

Image Orthicon Chain for studio and outdoor telecasts alike.

Whatever your telecasting plans or requirements—from modest start (Acorn Package) to most ambitious setup—whether local station or network—be sure to get the details of this outstanding camera equipment. From camera to antenna, it's DU MONT for "The First with the Finest in Television."

FEATURES...

Heavy-duty cables and "Jiffy" Connectors for trouble-free operation. Built in intercommunications.

Camera: Four-lens turret. Electronic viewfinder and camera integral assembly, but separately operable. Heater and blower for wide variation of ambient temperatures. Pan-handle operation of focus control. Remote iris adjustment from camera rear. No screwdriver controls. Factory-aligned peaking in video pre-amplifier.

Auxiliary: Pentode control of focus-coil current. Independent cable delay compensation for multiple camera hook-ups.

Power Supplies: Rugged construction. Super-regulating supplies for video circuits.

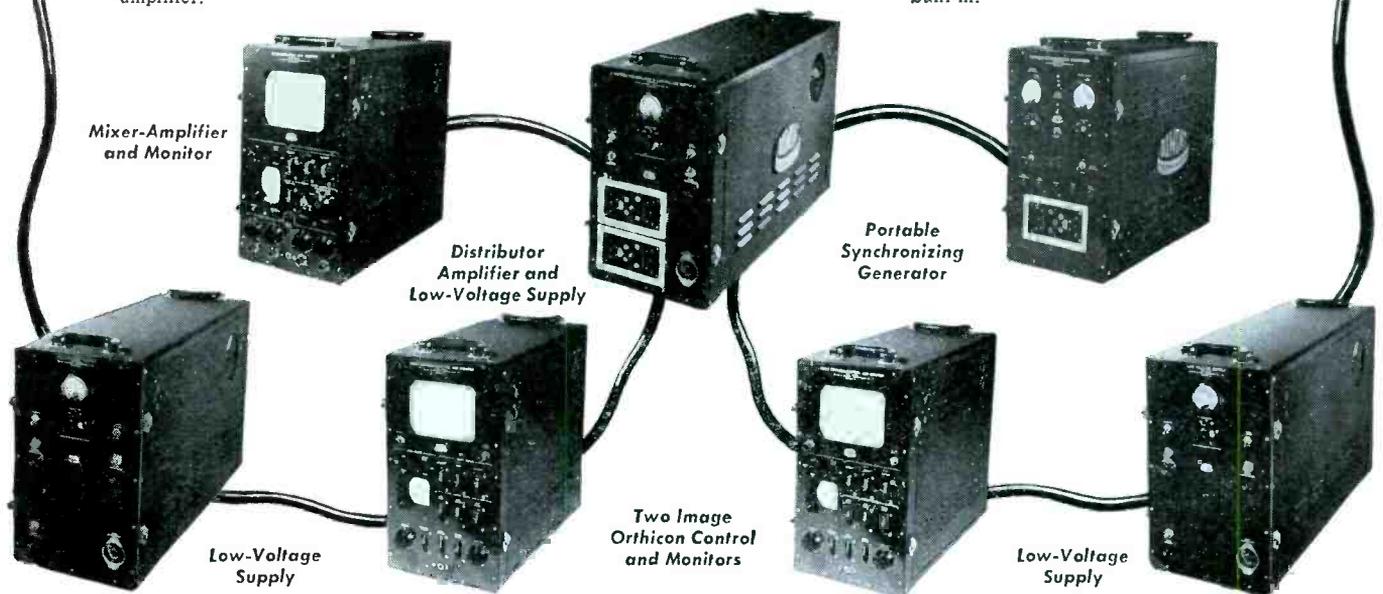
Control and Monitor: Thumb-wheel controls. Line-to-line clamp circuits. Single-camera chain operation if necessary.

Sync Generator: Smallest and lightest

portable unit extant. Better rise time of pulses and freedom from adjustments than most studio type sync generators.

Distribution Amplifier: Equipment set up to handle up to four cameras without use of junction boxes.

Mixer Amplifier and Monitor: Automatic lap dissolve and fading circuits (four speeds) applicable up to four channels. Normal manual mixing and fading, also built in.



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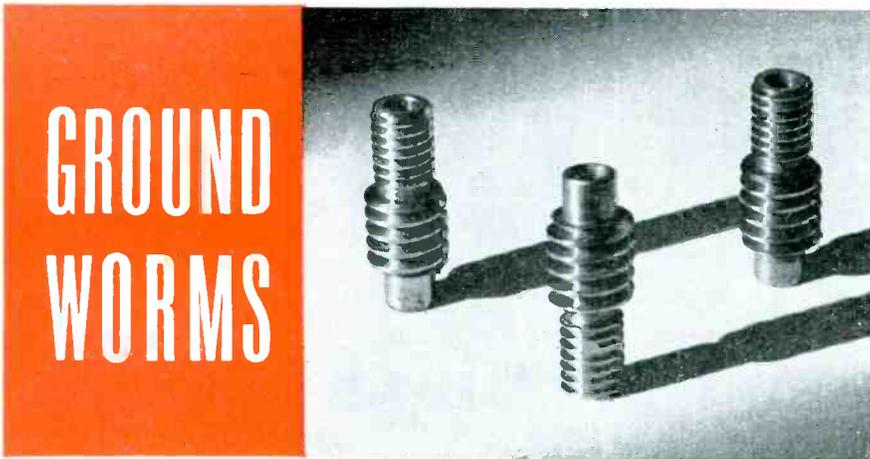
ALLEN B. DU MONT LABORATORIES, INC. • TELEVISION EQUIPMENT DIVISION, 42 HARDING AVE., CLIFTON, N. J.
SEE OUR DISPLAYS AT BOOTHS 244-248, I.R.E. NATIONAL CONVENTION

bearing the very dilute concentration to be measured passes an intense light-beam. Particles in the stream scatter light to a thalofide cell or photomultiplier tube which feeds an amplifier having a maximum voltage gain of 300,000. As a particle passes the beam, it scatters light to the photocell for about three milliseconds. A thyratron in the amplifier output is thus operated to actuate a mechanical counter. The count over a measured time interval is indicative of the particle concentration (PB-79150, microfilm \$1.).

STANDARD OF LENGTH might be made the green radiation of mercury 198, an isotope transmuted from gold by neutron bombardment. Because the human eye is more sensitive to this green line than to the red line of cadmium, used as a standard because of its greater stability and precision than the standard platinum-iridium meter bar, adjustment of interferometers with which lengths are measured is more readily done. Also this green line is stable, reproducible, sharp, and easily maintained, according to Dr. W. F. Meggers of the National Bureau of Standards.

CAPACITOR paper having densities from 1.25 to 1.30 were manufactured in Germany; highest density attained in America is 1.00. The high density paper is the result of using high-grade Finnish pulp, slow-speed paper making machines, carefully controlled wetting of the paper, and especially the final supercalendering on fine mechanical machines (mimeographed copies of 15 page PB 80394, "Supercalendering of Condenser Paper", are available from Office of Technical Services at \$0.50 each.)

VOLTAGE on power lines varies—In the District of Columbia, voltages at substations vary about 4 percent, according to National Bureau of Standards measurements. Considering the greater amount of heavy industry in other districts of the country, voltage drops in mains, distribution transformers, and plant wiring, the Bureau estimates that voltages in factories vary about 11 percent.



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Hard or soft worms, lead screws, etc. ground to your exact specifications in small lots or production runs. We invite you to submit your prints for quotation without obligation.

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- SPLINE
- HELICAL
- SPROCKET
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- GROUND THREADS

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Beaver Gear Works Inc.

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MODEL FR-1

with an **AUTOMATIC FREQUENCY RESPONSE RECORDER**

Why use the old fashioned, tedious point-to-point method of plotting, when modern equipment is available? The FR-1 is a laboratory apparatus of unsurpassed merits for making response characteristics of:

- AMPLIFIERS
- P-A SYSTEMS
- MICROPHONES
- SOUND INSTALLATIONS
- FILTERS
- EQUALIZERS
- LOUDSPEAKERS
- RECORDING HEADS
- REPRODUCERS

Literature on this unique instrument will be sent upon request

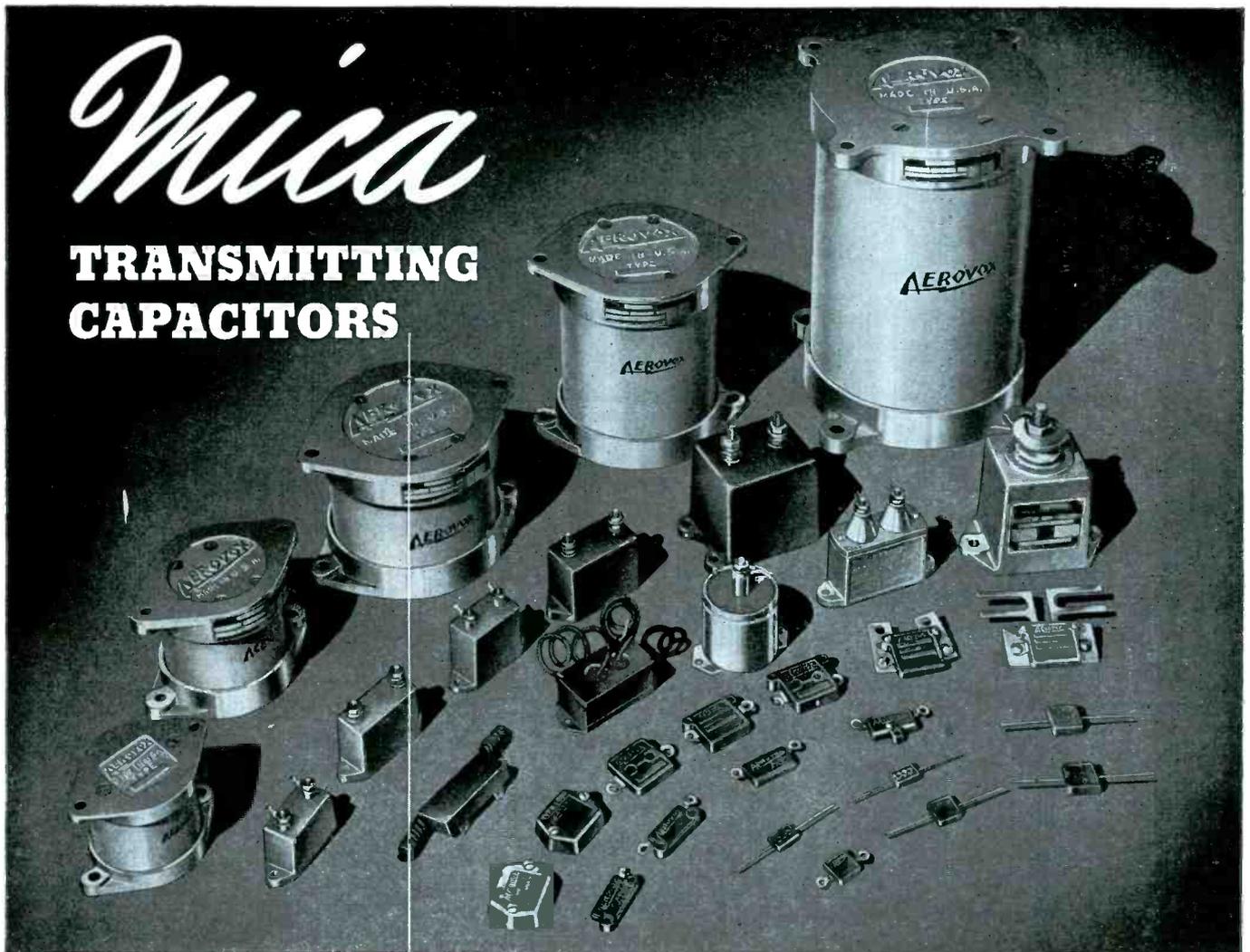


Sound APPARATUS Co.

233 BROADWAY (Woolworth Bldg.) NEW YORK 7, N.Y.
 CANADIAN REPRESENTATIVE: H. Pound, 2235 Acclington Ave., Montreal 28, P. Q.

Mica

TRANSMITTING CAPACITORS



An outstanding choice of bakelite-molded receiving and transmitting capacitors for widest range of requirements.

Bakelite-cased potted transmitting capacitors for greater load-carrying capacity. Aerovox current ratings insure the most satisfactory selection.

Stack-mounting heavy-duty capacitors for transmitting and other high-voltage applications.

Ultra-high-frequency molded-in-bakelite capacitors featuring high-voltage minimum-inductance characteristics.

Water-cooled oil-filled mica capacitors for higher KVA ratings and greatly reduced capacitor size for given power ratings.

• Be it tiny "postage-stamp" mica capacitor or large stack-mounting unit—regardless, it's a precision product when it bears the Aerovox name.

Only the finest ruby mica is used. Each piece is *individually gauged and inspected*. Uniform thickness means meeting still closer capacitance tolerances. Also, sections are of exceptionally uniform capacitance, vitally essential for those high-voltage series-stack capacitors. Meanwhile, the selection of perfect mica sheets accounts for that extra-generous safety factor so characteristic of ALL Aerovox capacitors.

Send us your capacitance problems . . .

Aerovox application engineering service is yours for the asking. Let us quote on your mica, paper, oil, electrolytic, ultra-high-frequency, power-factor and other capacitor needs.

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PRODUCT OF NATIONAL RESEARCH

NEW GRADE G-7-830
SILICONE FIBERGLAS LAMINATE

PHENOLITE
REG. U. S. PAT. OFF.
Laminated PLASTIC



Remarkable
HEAT RESISTANT
Material

*Possesses these
Exceptional Properties*

Tensile Strength	19,000 lbs./sq.in.
Flexural Strength	44,000 lbs./sq.in.
Compressive Strength	46,000 lbs./sq.in.
Water Absorption (1/16" thk. -24 hrs.)	0.15%
Power Factor, 10 ⁶ cycles—Dry	0.0012
Power Factor, 10 ⁶ cycles— (after 24 hrs. water immersion)	0.0086
Dielectric Constant, 10 ⁶ cycles	3.90
Dielectric Loss Factor, 10 ⁶ cycles . . . . .	.0048
Insulation Resistance	71,600 megohms
Dielectric Strength	485 volts/mil
Arc Resistance (ASTM method)	228 seconds

GRADE G-7-830 Phenolite combines high heat, flame and arc resistance. It is recommended for exacting low loss electrical applications and for insulation in transformers, motors and other applications subjected to elevated temperatures.

For full details call or write

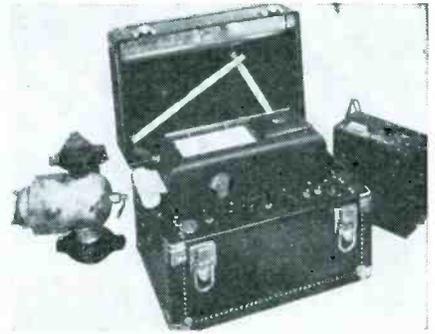
NATIONAL VULCANIZED FIBRE CO.

WILMINGTON 99,
Offices in the



DELAWARE
Principal Cities

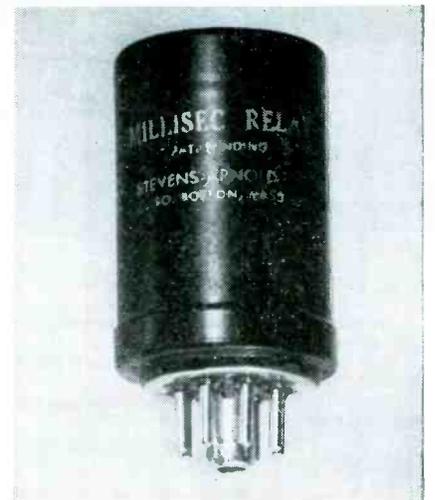
NEW PRODUCTS
(continued from p 144)



contains a microphone and a blank-cartridge gun. Sound of the initial explosion as well as the reflected pulses are picked up, amplified, and recorded.

High-Speed Relay (13)

STEVENS-ARNOLD INC., 22 Elkins St., South Boston, Mass. The new Millisec d-c relay has an operating



time as short as 1/3 millisecond. It is assembled in an hermetically sealed container, with an 8-prong octal base, and made in two sizes, either single-pole, double-throw, or double-pole, double-throw.

Sync Signal Generator (14)

ALLEN B. DU MONT LABORATORIES, INC., 42 Harding Avenue, Clifton, N. J. Model TA-107 A/B synchronizing signal generator furnishes horizontal and vertical driving pulses, blanking signals, and composite synchronizing signals required by studio and film cameras, camera control units, monitors

CHATHAM TUBES

Chatham also designs, develops and manufactures Electronic Equipment to exact customer specifications. Inquiries regarding this service are invited.

LOOK FOR US AT THE IRE SHOW
BOOTHS 252 and 253



CHATHAM 866-A RECTIFIER

A rugged half wave Mercury Vapor rectifier to withstand high peak inverse voltages. Heavy duty filament. Fil. 2.5 volts, 5.0 amp. . . . Peak inverse anode voltage 10,000 volts, .25 amp. average anode current.



CHATHAM 394-A THYRATRON

A Mercury Vapor and Argon filled thyatron for grid controlled rectifier service. . . . Amb. Temp. range of -40°C to $+80^{\circ}\text{C}$, Heater 2.5 volts, 3.2 amp. . . . Peak inverse anode voltage 1250 volts, 640 ma. average anode current.



CHATHAM 2051 THYRATRON

An Argon filled shield grid thyatron for grid controlled rectifier service. Permits use of high resistance in grid current. Heater 6.3 volts, 0.6 amp. . . . Peak inverse plate voltage 700 volts, 75 ma. average plate current.



CHATHAM 2050 THYRATRON

A Xenon filled shield grid thyatron for grid controlled rectifier service. Permits use of high resistance in grid current. Heater 6.3 volts, 0.6 amp. . . . Peak inverse plate voltage 1300 volts, average anode current 100 MA.



CHATHAM 884 THYRATRON

An Argon filled thyatron for use as a sweep circuit oscillator in cathode ray tube circuits. Stable oscillator. Heater 6.3 volts, 0.6 amp. . . . Peak forward plate voltage 300 volts, 75 ma. average plate current.



CHATHAM 4B32 RECTIFIER

A rugged half wave Xenon filled rectifier. Operates in any position throughout an ambient temperature range of -75°C to $+90^{\circ}\text{C}$ Fil. 5 volts, 7.5 amp. . . . Inverse peak anode voltage 10,000 volts, 1.25 amp. average anode current.



CHATHAM 2D21 THYRATRON

A Xenon filled shield grid thyatron for grid controlled rectifier service. Permits use of high resistance in the grid circuit. Heater 6.3 volts, .6 amp. . . . Inverse peak plate voltage 1300 volts, 100 ma. average plate current.



CHATHAM 5594 THYRATRON

Xenon filled thyatron. Operates through ambient temperatures from -55°C to $+90^{\circ}\text{C}$ without auxiliary equipment to maintain bulb temperature. Fil. 2.5 volts, 5.0 amperes. Peak inverse 5000 volts, anode current 0.5 amps, average, 2.0 amps peak.



CHATHAM 872-A RECTIFIER

A half wave Mercury Vapor rectifier to withstand high peak inverse voltages. Heavy duty filament. Fil. 5 volts, 7.5 amp. . . . Peak inverse anode voltage 10,000 volts, 1.25 amp. average anode current.



CHATHAM 885 THYRATRON

An Argon filled thyatron for use as a sweep circuit oscillator in cathode ray tube circuits. Stable oscillator. Heater 2.5 volts, 1.4 amp. . . . Peak forward plate voltage 300 volts, 75 ma. average plate current.



CHATHAM 17 THYRATRON

A Mercury Vapor thyatron for grid controlled rectifier and general application. . . . rugged filamentary cathode. Fil. 2.5 volts, 5.0 amp. . . . Peak inverse anode voltage 5,000 volts, 0.5 amp. average anode current.



CHATHAM 3B28 RECTIFIER

This rugged half wave Xenon filled rectifier will operate in any position and throughout an ambient temperature range of -75°C to $+90^{\circ}\text{C}$. Fil. 2.5 volts, 5.0 amp. . . . Inverse peak anode voltage 10,000 volts, .25 amp. average anode current.



CHATHAM 1Z2 RECTIFIER

A small bulb high voltage vacuum rectifier. Low cathode heating power and low dielectric losses make tube suitable for radio frequency supply circuits. Fil. 1.5 volts, .290 amp. . . . Inverse peak plate voltage 20,000 volts, 2 ma. average plate current, 10 ma. peak plate current.

WRITE FOR CATALOG! The informative CHATHAM catalog contains complete information and technical data covering CHATHAM rectifiers. For your free copy, write on company letterhead today.



CHATHAM ELECTRONICS

475 WASHINGTON STREET, NEWARK 2, NEW JERSEY

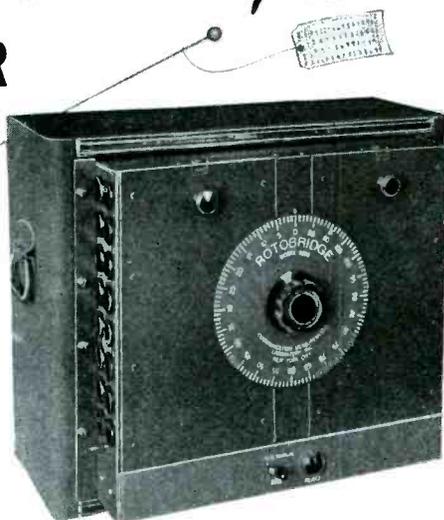
FOR TELEVISION MANUFACTURERS

The
NEW
MODEL
1010

ROTOBRIDGE *Automatic Circuit Inspector*

**PRODUCES BETTER
PROFITS**

- by 'PINPOINTING' THE TROUBLE
- TO SPEED PRODUCTION.
 - Enable Quick Correction of Rejects.
 - Save Time and Money all along the production line.
 - Capacity for the biggest TV chassis or the tiniest midget radio.
 - Pre-tests sub-assemblies to insure final assembly operation.



USED BY MAJOR MANUFACTURERS*

HIGH SPEED INSPECTION — Checks a circuit per second. Up to 119 circuits can be checked for resistance to tolerances of 5%, 10% or 20% as required. Shorts, open circuits, incorrect wiring or resistance values are detected and located accurately by circuit number.

QUICK JOB SET-UP — The Model 1010 RotoBridge takes only about 15 minutes to set up and so may be used with great advantage on either short or long production runs.

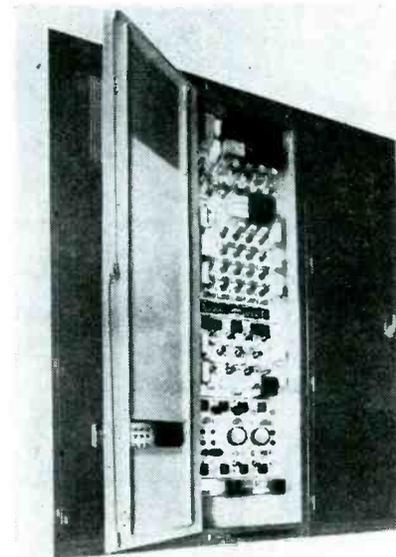
NO SKILL REQUIRED — An unskilled operator can make precise tests to your highest engineering standards and specifications and merely 'ticket' the trouble by number for follow-up service.

PROVED PRODUCTION TOOL — The result of 5 years of development work. Now used by some of the major low-cost producers of television and radio receivers.

PRODUCTION EXECUTIVES AND ENGINEERS:
Ask for descriptive literature and (if you have not already seen it) for a reprint of article entitled "Automatic Limit Bridge for Production Testing" from the Jan. 1948 ELECTRONICS.



*Names on request.



and other telecasting station equipment. Power consumption is 680 watts. Equipment conforms to all RMA and FCC specifications.

Tube and Set Tester (15)

SIMPSON ELECTRIC Co., Chicago, Ill. A new tube and set tester model 445 incorporates the well-known model 260 meter. The tube tester is the plate conductance type

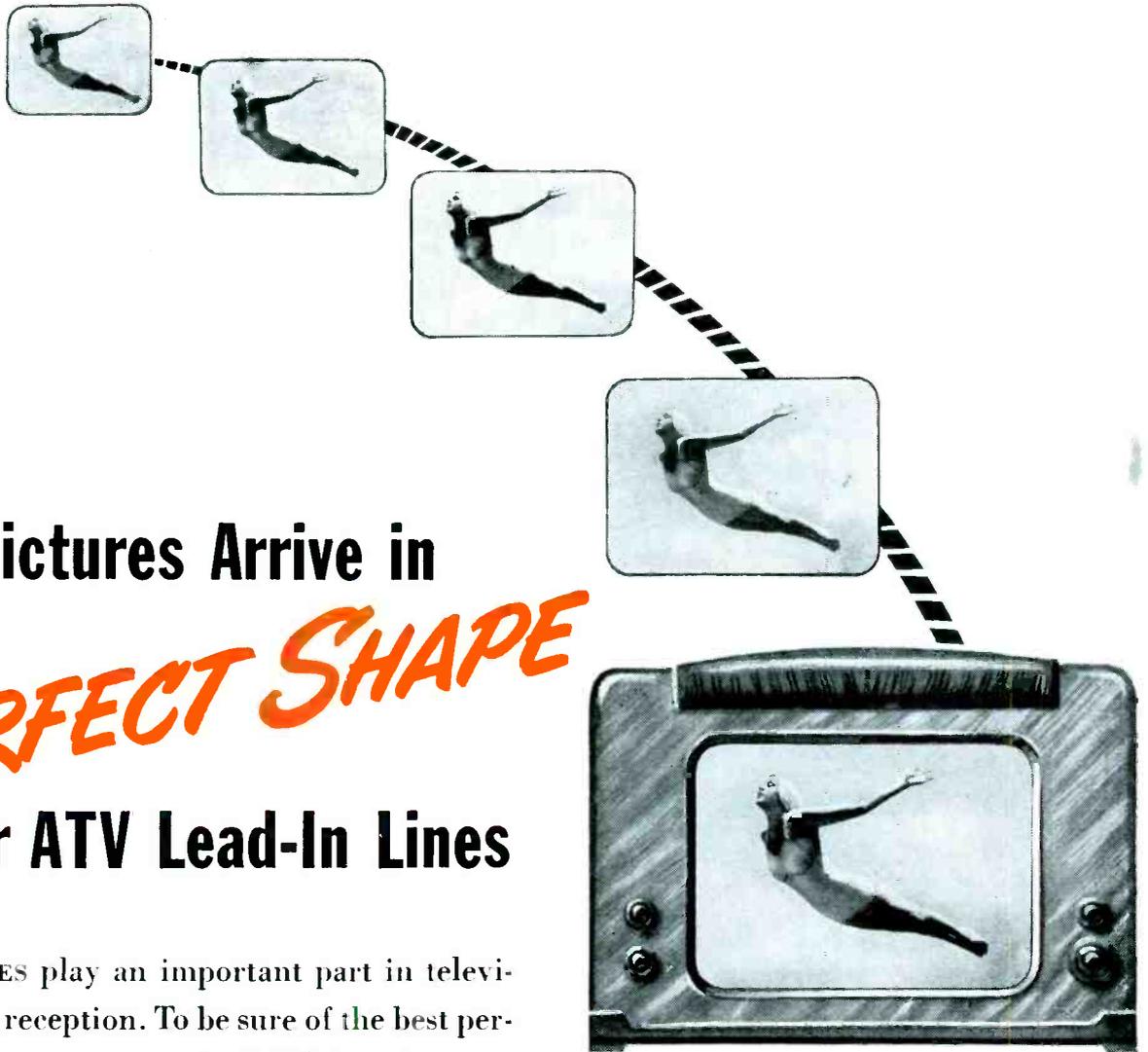


with an automatic reset mechanism that returns all switches to normal at the end of each test. Sockets for all types of tubes are provided.

X-Ray Tube (16)

WESTINGHOUSE ELECTRIC CORP., Bloomfield, N. J. A small x-ray tube designed for application in self-contained dental, portable and mobile oil-filled equipments for low current high detail radiographic work features a hooded anode and a getter. A relatively thin x-ray

COMMUNICATION MEASUREMENTS LABORATORY, INC.
120 Greenwich Street • New York 6, N. Y. • Cable: COMUNILAB, New York



The Pictures Arrive in *PERFECT SHAPE* Over ATV Lead-In Lines

LEAD-IN LINES play an important part in television and FM reception. To be sure of the best performance of your set, specify ATV* lines for your set.

The effects of attenuation and impedance mismatch on FM and Television reception are minimized by Anaconda Type ATV lead-in lines.

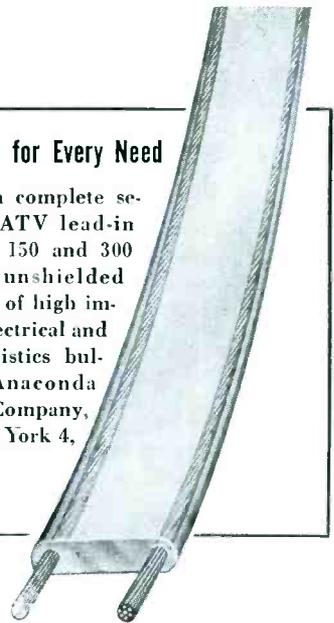
The satin-smooth polyethylene insulation of Type ATV line sheds water readily, thus avoiding subsequent impedance discontinuities. This material also has exceptionally high resistance to corrosion. Count on Anaconda to solve your high-frequency transmission problems—with anything from a new-type lead-in line to the latest development in coaxial cables.

48447

A Type ATV Lead-In for Every Need

Anaconda offers a complete selection of Type ATV lead-in lines for 75, 125, 150 and 300 ohms impedance unshielded and shielded lines of high impedance. For an electrical and physical characteristics bulletin, write to Anaconda Wire and Cable Company, 25 Broadway, New York 4, N. Y.

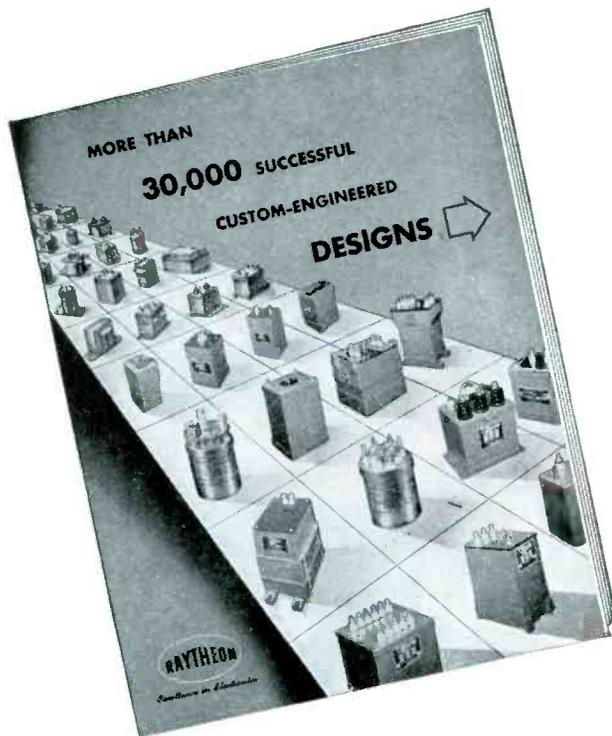
*An Anaconda Trade-Mark



Anaconda Wire and Cable Co.

25 Broadway, New York 4, N. Y.

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(CLIP THIS TO YOUR LETTERHEAD)

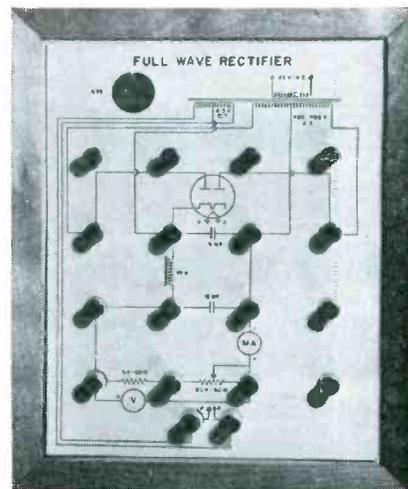
**Please Rush Our Copy
 Your New Special-Purpose
 TRANSFORMER BULLETIN
 DL-K-301 A**



window can be used because the hooded anode reduces the electron bombardment of the envelope. Information is available on several tubes that make up this new line.

Circuit Panel (17)

KEPCO LABORATORIES, INC., 142-45 Roosevelt Ave., Flushing, N. Y. Model 104 electronic circuit panel,



designed for fundamental laboratory experiments, aids in investigating the characteristics of vacuum and gas-filled tubes as well as the circuits using these tubes. It contains three octal tube sockets and eighteen binding posts mounted on a panel. Supplied with the unit are 23 keyed circuit diagrams and 3 master charts.

Lab Amplifier-Suppressor(18)

HERMON HOSMER SCOTT, INC., 385 Putnam Ave., Cambridge, Mass. Type 210-A laboratory amplifier is supplied with a matched variable reluctance pickup cartridge. The amplifier has less than 2 percent distortion at 20 watts output. Below 8 watts distortion falls to under 0.5 percent. Frequency range

TIME SAVING BASIC LABORATORY INSTRUMENTS by KAY . . .



The-**MEGA-MATCH** For VISUAL DISPLAY OF REFLECTED ENERGY

- 10 to 250 MC and up. Complete television and FM coverage.
- Completely electronic. No slotted lines, moving parts, bridges, or other frequency sensitive devices such as directional couplers.
- Precision frequency meter.
- Saves engineering time—Visual display presents instantly data which would take hours to tabulate.
- Can be adapted for balanced lines.

Completely Electronic

This unique instrument presents a visual display of REFLECTED energy over any band up to 30 MC. By the use of the MEGA-MATCH it is possible to instantly observe and measure mismatches. Thus this instrument will check transmission lines, antennas, input and output impedance of amplifiers, converters, transformers, etc.

Price: \$695 F.O.B. FACTORY

THE MEGA-MARKER

- Precision variable marker oscillator having a range of 19 to 29 megacycles for the television i. f. band.
- Crystal oscillator for the FM i. f. band (10.7 mc.)

A large easily read dial provides over 12 inches of calibrated scale length. Thus it may be read to accuracies of 0.02 megacycles.

Included in the MEGA-MARKER is a crystal controlled oscillator which provides accurate check points.

The MEGA-MARKER is a valuable accessory for FM and television applications of the MEGA-SWEEP and MEGA-MATCH. For absolute stability the regulated power supply of the MEGA-SWEEP or the MEGA-MATCH is used.

Weight 5 lbs., Size 7 x 10 x 6, Price \$60.00 F.O.B. factory

THE MEGA-PULSER

Recently developed instrument for generating ultra-short pulses. Its pulse characteristic (shortest pulse) is 0.05 Micro-seconds in length with a flat top of 0.03 micro-seconds duration. Impedance level 75 ohms. Pulse Amplitude is 150 volts.

KAY ELECTRIC COMPANY

23 MAPLE AVENUE

PINE BROOK, NEW JERSEY

Telephone Caldwell 6-3710



The **MEGA-SWEEP** WIDE RANGE SWEEPING OSCILLATOR

DISPLAYS PASS BAND

Continuous frequency coverage up through the color television bands



Shows at a glance the response of any network of amplifier. Eliminates the tedious point to point analysis. Saves engineering time and stimulates research. Valuable for television production alignment.

USES

Testing Television Systems and Components
Testing Radar Systems and Components.
Instructional Purposes in Schools and Universities.
Designing Wide-Band i.f. Amplifiers.
Designing Filter Networks.
Production Testing of F. M. and Television Equipments.
As a Signal Source of Extraordinary Range (Unmatched by any existing commercial signal generator.)
As a cw high frequency oscillator.
Self-contained. Regulated. Power Supply—117 Volt 60 Cycle.
Operation—Size 9" x 17" x 11"—Weight 35 Pounds.

FEATURES

CARRIER FREQUENCY
50 kilocycles to 500 megacycles & up.
FREQUENCY SWEEP
From 30 Megacycles to 30 kilocycles throughout the complete spectrum.
CONTINUOUSLY VARIABLE ATTENUATOR
LOW AMPLITUDE MODULATION WHILE SWEEPING
Less than 0.1 DB per megacycle.
PRECISION WAVEMETER

Price \$395 F. O. B. Factory

THE MEGA-PIPPER

The MEGA-PIPPER is a new production and service alignment instrument. By the use of this unit in conjunction with the MEGA-SWEEP or MEGA-MATCH it is possible to quickly and accurately align television receivers.

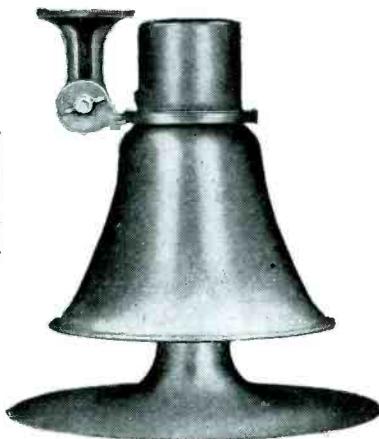
The MEGA-PIPPER gives four precise crystal controlled pips which are independent of the circuit under test. These pips establish the picture, sound carrier, and also the adjacent channel points. Thus the MEGA-PIPPER is an instrument which will save many hours of time spent in alignment. No switching or adjustment is necessary for frequency control. Inasmuch as the pips are fed directly into an oscilloscope the pips are visible at all times, even in the traps where the highest precision is desired.

Self contained power supply.
Weight 15 lbs. Size 8 x 16 x 8. Price \$150. F.O.B. factory.

EFFICIENCY More APPLICATIONS VALUE

by using these **NEW RACON
SPEAKERS and HORN UNITS**

Right—NEW RADIAL RE-ENTRANT SPEAKER, excellent for all types of industrial sound installations, provides superlative and complete 360° speech intelligibility by efficiently over-riding factory high noise levels. Frequency response 300-6000 cps. Handling capacity 25 watts continuous, 35 w. peak. Has mounting bracket. Size 12" wide by 12 3/4" high.



Left—NEW SMALL RE-ENTRANT HORNS, extremely efficient for factory inter-com and paging systems; for sound trucks, R. R. yards and all other industrial installations where high noise levels are prevalent. Watertight, corrosion-proof, easily installed. Two new models—type RE-1 1/2, complete with Baby Unit, handles 25 watts, covers 300-6000 cps; type RE-12, complete with Dwarf Unit, handles 10 watts, has freq. response of 400-800 cps.

Right—NEW SPECIAL PM HORN UNIT, having Alnico V magnet ring completely watertight, housed in a heavy aluminum spinning. Provides extremely high efficiency reproduction with minimum input. Handling capacity 35 watts continuous, 60 w. peak.



To the more than 60 different type and size speakers and horn units that already comprise the RACON line—these new models have been added. There is a RACON speaker and horn unit ideal for every conceivable sound system application. RACON has not only the most complete line, but also has the most preferred line. For over 20 years leading Soundmen have recognized and specified them because of dependability, efficiency and low-cost, and because the reproducers are trouble proof.

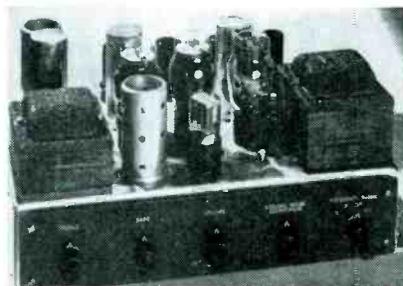
RACON ELECTRIC CO., INC.

52 E. 19th St.,

New York 3, N. Y.

Write for catalog describing
RACON'S Line of Horns,
Speakers, Units, Accessories,
Inc.

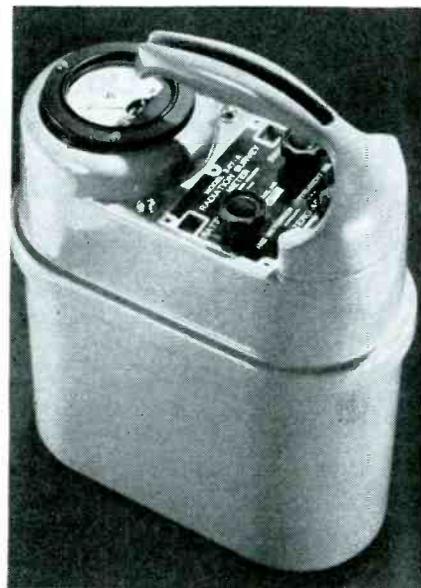
RACON



exceeds 20,000 cycles and with dynamic noise suppressor response is flat to 10,000 cycles. Bass and treble tone controls are provided. For a-m reception a whistle filter can be switched in.

Radiation Meter (19)

VICTOREEN INSTRUMENT Co., 5806 Hough Ave., Cleveland 3, Ohio. The portable 247A gamma ray survey meter is the ionization chamber



type that is hermetically sealed and watertight. Four ranges of sensitivity are provided to allow full-scale readings of 2.5, 25, 250, and 2,500 milliroentgens per hour. Total weight of the rugged instrument is 11 3/4 pounds.

Wire-Wound Resistors (20)

CLAROSTAT MFG. CO., INC., 130 Clinton St., Brooklyn, N. Y. announces the Greenohm Juniors, ceramic-cased midget wire-wound resistors for small spaces and for facilitating point-to-point wiring. Standard type C7GJ is rated at 7 watts,



... mean **105°C** continuous operating temperature

A NEW HIGH FOR EXTRUDED VINYL TUBING

Natvar 400 now has "four ridges equally spaced around the circumference, and running the length of the tubing." This marking was specified by Underwriters' Laboratories to distinguish it from tubings limited to lower temperatures.

It may now be safely used in many applications instead of varnished sleeving, with great savings in material and labor costs and reduced waste.

More and more users of extruded tubing are standardizing on Natvar 400 because, in addition to its remarkable heat and oil resistance, it is well balanced in other properties. E.T.L. and Underwriters' reports are available on request.



Natvar Products

- Varnished cambric—straight cut and bias
- Varnished cable tape
- Varnished canvas
- Varnished duck
- Varnished silk
- Varnished special rayon
- Varnished Fiberglas cloth
- Silicone coated Fiberglas
- Varnished papers
- Varnished tubings and sleeveings
- Varnished identification markers
- Lacquered tubings and sleeveings
- Extruded vinyl tubing
- Extruded vinyl identification markers

Ask for Catalog No. 21

THE NATIONAL VARNISHED PRODUCTS



TELEPHONE
RAHWAY 7-2171

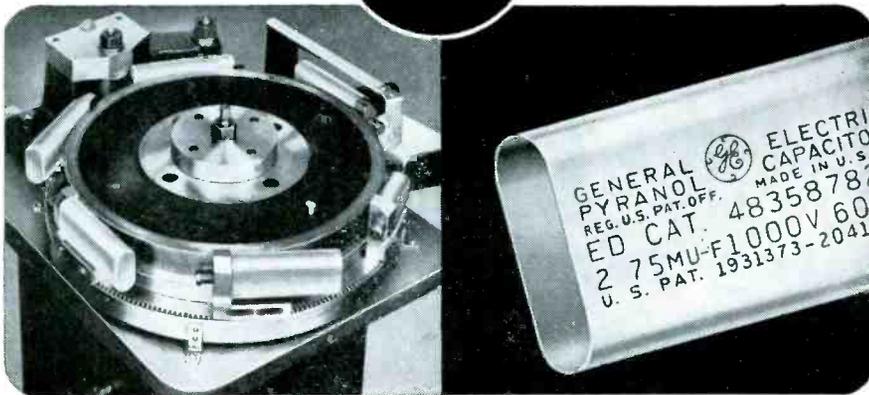
CABLE ADDRESS
NATVAR: RAHWAY, N. J.

201 RANDOLPH AVENUE ★ WOODBRIDGE NEW JERSEY

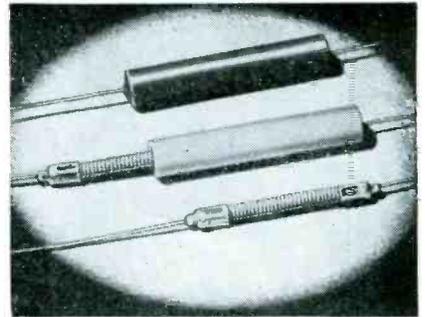
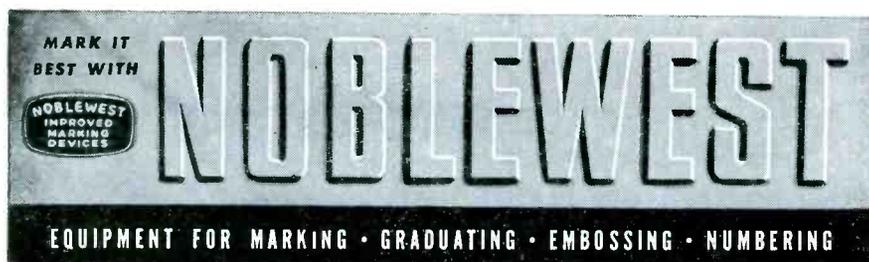
now
MARK
metal
or
plastic
parts



with
NOBLEWEST
rapid
production
marking
machines



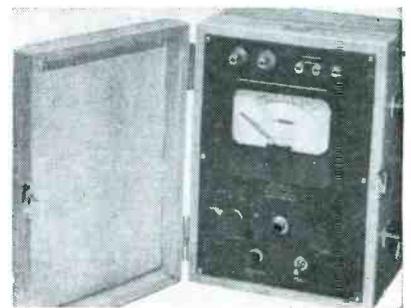
Are you using modern methods and equipment for marking the products you manufacture? Right now Noblewest Rapid Production Marking Machines are stepping up production and saving money for leading manufacturers of electronic products and their component parts. For example, Model No. 246, shown above, is tooled for marking GE capacitors. The inscription, shown at right, being permanently *rolled in*, lasts as long as the product itself. Noblewest equipment can be used for marking metal, plastic, hard rubber, etc. Marking speeds are practically unlimited. Every Noblewest Marking Machine is engineered to meet your specific requirements, and backed by the skill, experience and facilities of the world's leading manufacturer of rapid production marking equipment. Whatever your marking problem, Noblewest engineers will be glad to make time and money saving recommendations without obligation to you. A copy of our new catalog on Modern Marking Methods will be sent upon request. Write to Noble & Westbrook Manufacturing Company, 27 Westbrook Street, East Hartford 8, Conn.



and is available in values from practically zero to 5,000 ohms maximum; smaller type C4GJ is rated at 4 watts, with maximum resistance of 1,000 ohms.

Log Scale Megohmmeter (21)

MACLEOD & HANOPOL, Charlestown 29, Mass. Logarithmic scale dis-



tribution of this direct-reading megohmmeter gives the same accuracy over the whole range of 1 to 100,000 megohms, covered by six decade steps. Range can also be extended to 1,000,000 megohms.

Projection Television Components (22)

SPELLMAN TELEVISION CO., 2898 Jerome Ave., New York 58, N. Y. The 30 kv r-f power supply illustrated has a low voltage supply separate from the high voltage pack. Voltage can be varied from



.022

.0047

Funny Numbers?

... perhaps, but they are more evidence of **SPRAGUE LEADERSHIP!**

New Phenolic-Molded Sprague Tubular Capacitors Produced in Decade Ranges and Color-Coded!

With the recent introduction of its sensational new *molded* tubular capacitors, Sprague now announces standardized capacities, and color-coding for ready identification of these new units. For example, starting with the number 1, the next numbers in the 20% tolerance decade are 1.5, 2.2, 3.3, 4.7, 6.8 and on back to 10.

Established decade ranges and color-coding have proved their efficiency and acceptability in the resistor industry over a period of years.

Now, for the first time, this same practice will allow capacitor manufacturers the many advantages of standardized production—advantages which we feel will be cumulative through the years.

In the firm conviction that these steps toward standardization will prove mutually beneficial, Sprague Electric Company solicits your cooperation and invites your inquiries for information, samples and application data concerning the new **SPRAGUE MOLDED TUBULAR CAPACITORS. WRITE FOR ENGINEERING BULLETIN NO. 210A.**

THE FIRST TRULY PRACTICAL PHENOLIC-MOLDED PAPER TUBULAR!

Highly heat- and moisture-resistant • Non-inflammable • Conservatively rated for —40°C. to 85°C. operation • Small in size
Completely insulated • Mechanically rugged
Moderately priced.



SPRAGUE MOLDED TUBULAR CAPACITOR COLOR CODE

			Black	Brown	Red	Orange	Yellow	Green	Blue	Violet	Gray	White
1st BAND	Capacity in MMFD	First Significant Number	0	1	2	3	4	5	6	7	8	9
2nd BAND		Second Significant Number	0	1	2	3	4	5	6	7	8	9
3rd BAND		Decimal Multiplier			100	1000	10,000	100,000				
4th BAND	TOLERANCE		±20%			±30%	±40%	±5%				±10%
5th BAND	RESERVED FOR ARMED SERVICES											
6th BAND	Voltage in Hundreds (x 100)	First Significant Number	0	1	2	3	4	5	6	7	8	9
7th BAND		Second Significant Number	0	1	2	3	4	5	6	7	8	9

SPRAGUE ELECTRIC COMPANY North Adams, Mass.

CAPACITORS

SPRAGUE

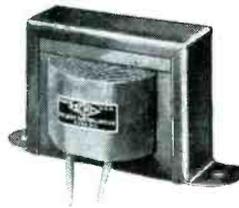
*KOOLOHM
RESISTORS

*Trademark reg. U. S. Pat. Off.

PIONEERS OF ELECTRIC AND ELECTRONIC PROGRESS

HOW TO BUY SPECIAL TRANSFORMERS from STANDARD PARTS

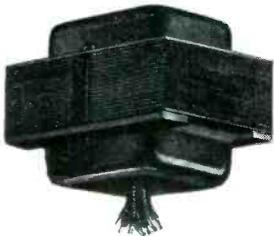
The special physical design or special electrical characteristic transformers you may need can probably be engineered from Acme Electric standard laminations and parts to the exact mechanical dimensions and electrical performance required. No need for special dies, tools or other expensive production materials. Here are a few of the Acme Electric designs available.



Mounting type 100. Available in ratings from 3 to 40 VA.



Mounting type 110. Available in ratings from 35 to 2500 VA.



Mounting type 130, 2 hole horizontal mounting lead holes on bottom or side of shell. Ratings 15 to 100 VA.



Mounting type 121. Available in ratings from 35 to 2500 VA. Taps to suit your needs.



Mounting type 131 with end bells. Leads out bottom or side. Ratings 35 to 500 VA.



Mounting type 150. 4 hole horizontal mounting. Lead holes on bottom or side of shell. Primary tap changer on top. Ratings 35 to 500 VA.

Write for Specification Transformer Bulletin 168.

ACME ELECTRIC CORPORATION
31 WATER STREET + + + CUBA, N. Y.

Acme Electric

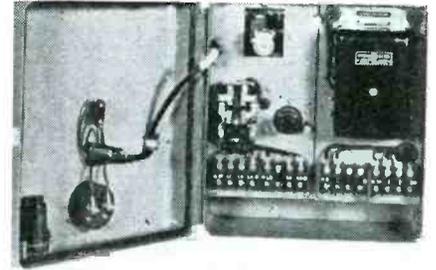
NEW PRODUCTS

(continued)

12 to 40 kv. A focus control is provided for use with type 5TP4 projection tube. Other components include projection lens, movable stand for equipment, and a number of screens.

Combustion Control (23)

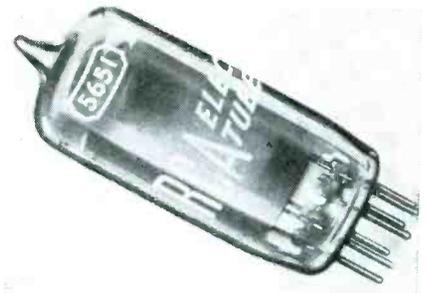
GENERAL ELECTRIC CO., Schenectady 5, N. Y. A new photoelectric



combustion control system for commercial oil burners comprises master, phototube, and electrode units. The system shuts off fuel flow immediately if oil fails to ignite or if the flame is extinguished after successful ignition. Write for bulletin GEA 4779.

Voltage Reference Tube (24)

RADIO CORP. OF AMERICA, Harrison, N. J. Type 5651 miniature glow-discharge tube maintains a d-c operating voltage of 87 volts, and has an operating current range of 1.5 to 3.5 milliamperes. Operating

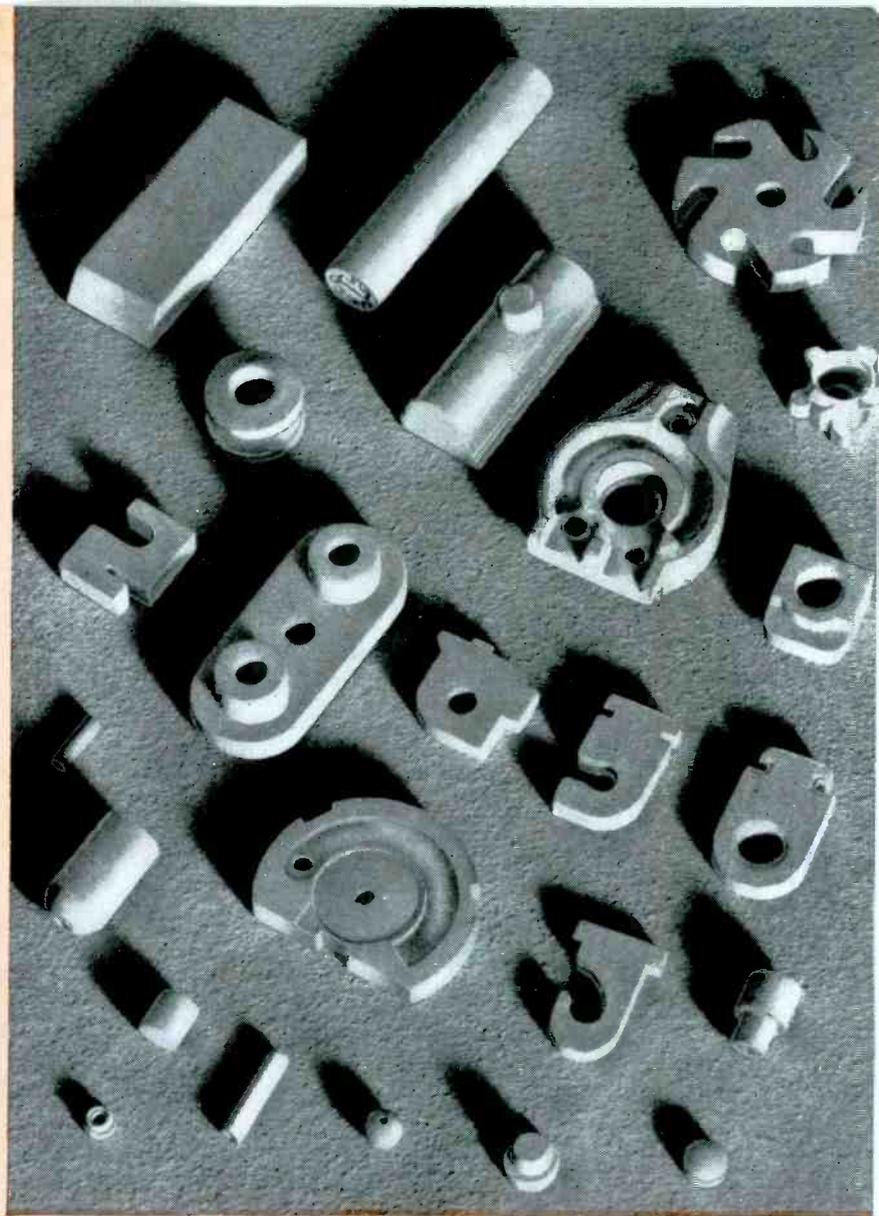


characteristics are essentially independent of ambient temperature. Complete information is contained in a reference sheet.

Hand-Desk Mike (25)

ASTATIC CORP., Conneaut, Ohio. Model 200 crystal microphone has a smooth frequency response from 30 to 10,000 cycles; model 241 is similar in range but with a rising characteristic between 1,500 and

Typical insulators produced by Alsimag
at very low cost



IN SOME INSTANCES

ALSIMAG

TRADE MARK REGISTERED U.S. PATENT OFFICE

INSULATORS ARE

lowest in cost

Some types of insulators can be produced by Alsimag at very low cost. Our files show many instances where Alsimag insulators are used simply because they are the lowest cost insulators that will do the job.

This comes as a surprise to many engineers and purchasing agents. They know that Alsimag materials are expensive, that Alsimag parts have dimensional accuracy and uniformity which facilitates assembly, that Alsimag has great mechanical strength, permanent rigidity, that it will not char or form electrical conduction paths and that it has a far greater dielectric efficiency than most insulating materials. Therefore it is natural that they would think that Alsimag components would be more expensive... However, in some instances, the greater cost of the Alsimag materials is more than offset

by production savings. Certain sizes and designs, usually small and relatively simple shapes, are produced in quantity on automatic production equipment at such low production cost that the final price is highly competitive. Many materials commonly regarded as "cheap" are actually more expensive in first cost because those cheap materials do not lend themselves to economical manufacturing processes.

This advertisement is not an announcement of "bargain" prices. The Alsimag price structure remains unchanged. It is simply a statement of fact and an invitation to submit your insulator problems to Alsimag for cost and design analysis. You may be surprised to find Alsimag production efficiency enables you to buy superior insulators at a price competitive with materials which you have always thought of as "cheap."

AMERICAN LAVA CORPORATION

46TH YEAR OF CERAMIC LEADERSHIP

CHATTANOOGA 5, TENNESSEE

SALES OFFICES: ST. LOUIS, MO., R. H. Geiser, Tel: Garfield 4959 • CAMBRIDGE, MASS., J. F. Morse, Tel: Kirkland 4498 • NEWARK, N. J., J. H. Mills, Tel: Mitchell 2-8159 • PHILADELPHIA, S. J. McDowell, Tel: Stevenson 4-2823 • CHICAGO, W. E. Glasby, Tel: Central 1721 • SAN FRANCISCO, F. S. Hurst, Tel: Douglas 2464 • LOS ANGELES, L. W. Thompson, Tel: Mutual 9076



Sensational "MIDGET" PHOTO CELL THAT DOES A GIANT'S JOB

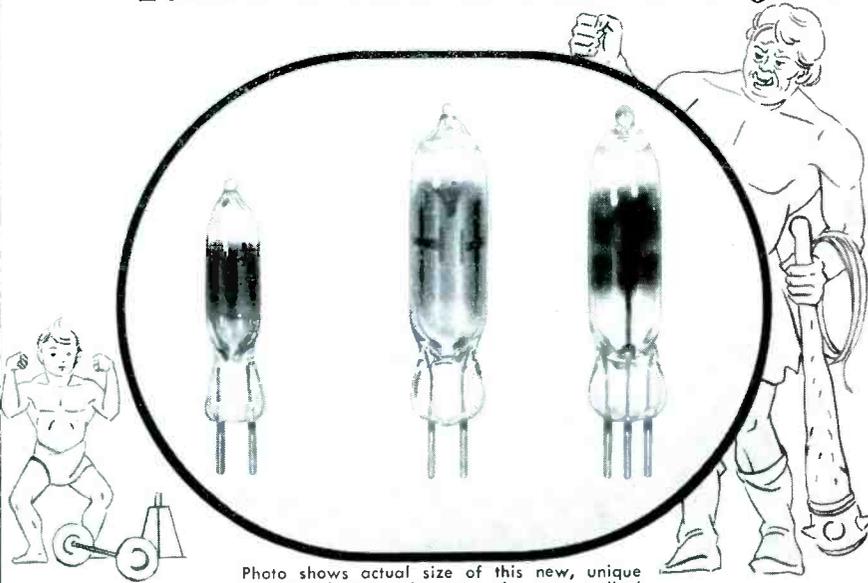


Photo shows actual size of this new, unique photo-conductive tube now the most talked about item in the tube industry.

ADVANTAGES

- ★ Miniature and sub-miniature sizes available.
- ★ Infra-red sensitivity up to 3 μ .
- ★ Better frequency response
- ★ Technical perfection, plus steady performance

CONTINENTAL'S new lead sulphide cell is the most revolutionary development ever accomplished in photo cell manufacturing history. Nothing like it has ever been successfully advanced before. Ultra compact—it's the smallest, practical tube ever made. Continental now offers it on a straight production schedule, the consistent high quality of each tube being positively assured. You can use this exclusive Continental item with much less supplementary equipment. It will mean a large economy because you save greatly on space and materials. This "Mighty Midget" does work comparable with tubes 3 and 4 times its size with no sacrifice in high response or sensitivity. Our engineers are ready to tell you how this "Mighty Midget" can go to work for you. Wire or write us today.

Continental leadership in the photo tube field has been acknowledged far and wide. Manufacturers of Top Notch Motion Picture Sound Equipment, Coin Operated Devices, Electronic Toys, Counting Devices, Automatic Pilots for Aeroplanes and Boats, Burglar Alarms, Fire Detection Apparatus and others have perfected their machines and kept operations smooth and consistent with Continental's highly engineered tubes. We are interested in the unusual and difficult and will welcome a challenge on your own tube problem.



CONTINENTAL ELECTRIC CO.

World's Leading Single Manufacturer of Photo Cell Tubes and Electronic Specialties

GENEVA, ILLINOIS



5,500 cycles. Either model supplied with or without switch has a quick-lock base so that it can be used as hand or desk mike or mounted on a floor stand.

10-Kw R-F Generator (26)

WESTINGHOUSE ELECTRIC CORP., 306 Fourth Ave., Pittsburgh 30, Pa. Designed specifically for the wood-working industry, the new 10-kw r-f generator operates semi-automatically. A single front panel control allows adjustment for large changes in electrode size. The generator is available in 5 and 13.6-mc units that operate on 230 or 460 volts, three-phase, 60-cycle current.

Modulator Unit (27)

BEE-BEE ELECTRONIC CO., 2692 W. Pico Blvd., Los Angeles 6, Calif. The model 500 narrow-band f-m modulator unit is a reactance type designed for direct coupling to the



MEASURE SONIC FREQUENCIES . . .
INSTANTLY . . . ACCURATELY . . . VISUALLY

WITH **Stroboconn**

Used effectively in industrial laboratories for checking the speed of rotating objects and for calibrating or checking tachometers, measuring natural frequencies, and calibrating oscillators, impulse generators and similar equipment. With the Stroboconn, you can speed up the job with full assurance of accurate results.



**A Notable Achievement
in Sonic Research**

The Stroboconn is essentially a logarithmic frequency meter of the Stroboscopic type, having an accuracy of frequency determination of 0.05%, in the continuous range of 32 to 4070 cycles per second. Ultra-sonic frequencies may be reduced to Stroboconn range by use of a frequency divider. The logarithmic scale is particularly advantageous in measuring ratios of two frequencies, with or without regard to the actual frequencies involved.

In use, the quantity to be measured is converted into an audio signal, amplified and fed to a discharge tube that produces flashes of light at the audio rate involved. A dial reading indicates the frequency of the input signal. Send for *free* folder and further information concerning the Stroboconn's adaptability to your particular problem.

PROVED PERFORMANCE

Among Stroboconn users are Harvard University, Bell Aircraft Corp., and Hamilton Standard Propellers. During the War, this instrument was used as a standard for checking equipment in the Army Air Forces Power Plant Laboratory, at Wright Field.



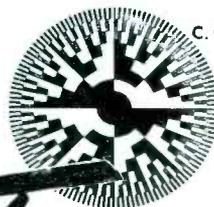
Send for Free Folder

Gives more complete information about operation and application of this amazing precision instrument. No obligation.



CONN BAND INSTRUMENT DIVISION

C. G. CONN LTD., DEPT. 312
ELKHART, INDIANA



Stroboconn



Present 3 clean-cut Advantages

1. EXTREME UNIFORMITY
2. SUPERIOR STAKING QUALITIES
... ends will roll without splitting.
3. BETTER FOR MOLDED PARTS
.. closed end keeps compound out.

If you use pins for vacuum tubes, adapters, fluorescent lamps, plugs, or electrical equipment of any kind, the chances are you'll save time, money and rejections by using these super-smooth, *seamless*, patented Radio Pins. They are available in a wide variety of styles and sizes, with staking end either closed or open. For a quotation, simply send a sketch, sample or description and state the quantity you need.

Radio or Radar Equipment?

In addition to Radio Pins, we produce large quantities of top caps, base shells and adapter shells for vacuum tubes; also a wide variety of other metal products including deep drawn shells and cups, blanks and stampings, ferrules, grommets, washers, vents, fasteners—and, for almost every manufacturing requirement, the world's largest assortment of eyelets. 47-420



THE AMERICAN BRASS COMPANY

Waterbury Brass Goods Branch

General Offices: Waterbury 88, Connecticut

Subsidiary of Anaconda Copper Mining Company

In Canada: ANACONDA AMERICAN BRASS LTD., New Toronto, Ont.

vfo or crystal socket of a conventional crystal-controlled pentode or triode oscillator.

Multi-Purpose Tester (28)

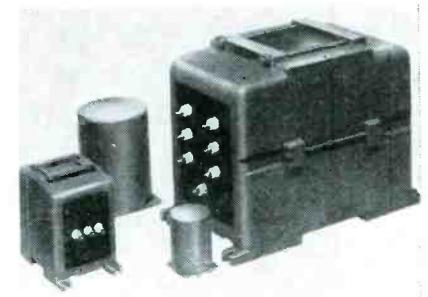
SIMPSON ELECTRIC Co., Chicago, Ill., announces the new model 1005 Electrical Laboratory, a test unit combining the functions of over 60



separate instruments. It is adaptable for testing all electrical appliances, small motors, circuits, radio sets and the like. Size is approximately 34 × 17 × 9 inches; and weight, 37 lb.

Transformers (29)

UNITED TRANSFORMER CORP., 150 Varick St., New York 13, N. Y. A



new series of commercial grade transformers includes audio grade transformers, input transformers, modulation, power, and filament transformers. They are fully described in catalog PS-408.

Dielectric Heater (30)

SHERMAN INDUSTRIAL ELECTRONICS Co., INC., 503 Washington Ave., Belleville 9, N. J. Sieco heater type SD-15 for heating plastic preforms, drying cloth, or setting glue has a

THORDARSON



DEPENDABILITY AND VERSATILITY FOR INDUSTRY

1. LOW VOLTAGE - LOW CURRENT
2. LOW VOLTAGE - HIGH CURRENT
3. HIGH VOLTAGE - HIGH CURRENT
4. HIGH VOLTAGE - LOW CURRENT

WHERE QUALITY IS A NECESSITY...

Thordarson has the answers to many electrical problems that daily confront industry. With a background of over 25,000 active specifications in their files, built up over 53 years of leadership in the field, Thordarson supplies the leaders with their large variety of stock types of transformers as well as the hundreds of special types built to customer specifications or resulting from recommendations of our own engineers upon studying the various requirements submitted to them by industry.

With this background, you know that your Thorardson equipment, purchased from stocks of a jobber or directly under special specifications, is of top-notch quality — sure to deliver unmatched performance. If you require the best, there is no unit either too large — or too small that Thordarson can't deliver.

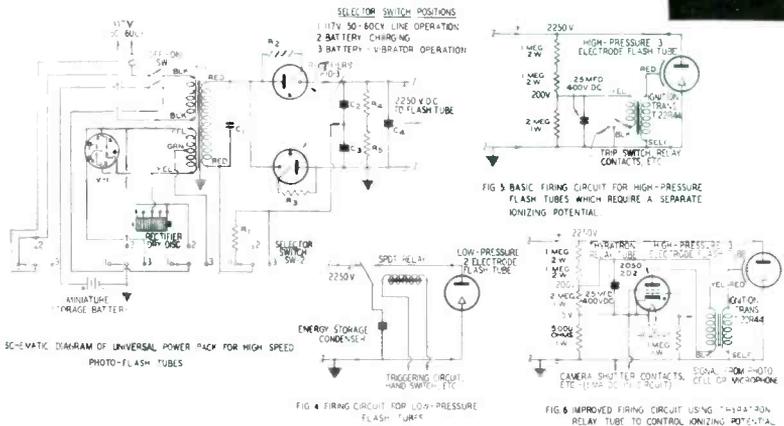


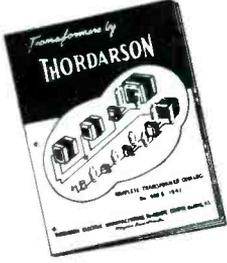
PHOTO FLASH POWER SUPPLY

Here is another Thordarson FIRST... a typical example of Thordarson engineering skill that has helped established leadership in the field. This circuit features:

- A.C. Line or Portable Battery Operation
- Charging Time — 10 to 15 Seconds
- A.C. Line Battery Recharge Feature
- Light Compact Low Drain Power Transformer
- Power Supply Output — 2250 V. D.C.
- Storage Condenser Delivers 75 Watt-Sec. Energy Element
- Adaptable Trigger Circuits for 2 or 3 Tubes
- Cold Cathode Rectifiers Employed in Voltage Doubling Circuit

OUR ENGINEERING STAFF IS AVAILABLE TO SOLVE YOUR PROBLEMS FOR YOU UPON REQUEST

Whatever your position in the field of electronics Thordarson can serve you better. Our large variety of stock types fill almost every need. For extraordinary conditions, send us your problems and our engineering staff will come up with the right answers.



The New Thordarson Catalog Is Now Available, Send For Your Copy Today.

THORDARSON

Manufacturing Quality Electrical Equipment Since 1895
 500 WEST HURON CHICAGO 10, ILLINOIS
 A Division of Maguire Industries
 Export — Scheel International Inc.

AMPHENOL



For installing metal industrial electron tubes on non-insulated surfaces

MEETS NEMA SPECIFICATIONS AND UNDERWRITERS' REQUIREMENTS

AMPHENOL TUBE MOUNTS, STAND-OFF INSULATORS AND FEED-THRU BUSHINGS

Amphenol tube mounts and stand-off insulators efficiently mount Thyatron 173, and similar metal industrial electron tubes, on non-insulated surfaces. Secure mounting and highest quality insulation are assured.

The use of steatite dielectric guarantees excellent heat resisting qualities, low-loss and high mechanical strength. Surface creepage distances of 2" safely accommodate high voltages. Exposed portions of stand-offs are glazed to facilitate cleaning in dusty industrial plants.

Types with steatite feed-thru bushings allow wiring back of the supporting panel. Additionally, these insulators serve as tie points, or feed-thru insulators, for tube element connections, or for passage of high voltage circuits through panels or compartment walls. Complete electrical, mechanical and pricing data immediately available on request. Write for it today.



THESE FEATURES ASSURE TOP PERFORMANCE

- Mounts in small panel area
- Adequate clearance between tube and panel permits cooling by convection
- Wing nut connections simplify assembly and wiring maintenance
- Steatite dielectric

Amphenol tube mounts and stand-off insulators are designed for use with the following metal tubes: GL-414, FG-172, FG-280, FG-190, FG-166, ELC16J, EL60B, EL16F.

AMERICAN PHENOLIC CORPORATION
1830 S. 54th AVE., CHICAGO 50, ILLINOIS
 COAXIAL CABLES AND CONNECTORS • INDUSTRIAL CONNECTORS, FITTINGS AND CONDUIT • ANTENNAS • RADIO COMPONENTS • PLASTICS FOR ELECTRONICS

NEW PRODUCTS

(continued)



continuous output of 15 kw and features pushbutton operation. No tuning or other manual adjustments are required. Frequency of operation is 27 mc.

50-kw Heater (31)

WESTINGHOUSE INDUSTRIAL ELECTRONICS DIVISION, Plant 4, Baltimore 3, Md. A 50-kw 450-kc r-f



generator and two-position work table are available for production heating jobs such as hardening gears and automotive parts. The generator operates on 230/460 volt 3-phase, 60-cycle current.

Variable Speed Motor (32)

GUERNET ELECTRICAL MACHINERY, INC., Box 196, Meriden, Conn. Designed to maintain constant maximum torque at all speeds, a new motor with $\frac{1}{2}$ hp rating is variable from 1,500 to 6,000 rpm. A lever at the side of the motor stops and starts the motor and mechanically

ARNOLD

PERMANENT MAGNETS

*Depend on them
for Uniformly
High Quality
in every
PHYSICAL, MAGNETIC
and METALLURGICAL
Characteristic*

You would find it hard to set a requirement on Arnold magnets that is not already exceeded in our regular production procedure.

All Arnold products are made on a basis of 100% quality-control at every step of manufacture. These rigidly maintained standards cover all physical, magnetic and metallurgical characteristics. . . you can place complete confidence in the uniformity and dependability of Arnold Permanent Magnets, and their resultant performance in your assemblies.

Remember, too, that Arnold's service covers all types of permanent magnet materials, any size or shape of unit, and any field of application. Our engineers are at your command—write us direct or ask any Allegheny Ludlum representative.

W&D 1098



THE ARNOLD ENGINEERING COMPANY

Subsidiary of

ALLEGHENY LUDLUM STEEL CORPORATION

147 East Ontario Street, Chicago 11, Illinois

Specialists and Leaders in the Design, Engineering and Manufacture of PERMANENT MAGNETS

Designed for



Application



90811

**90811 HIGH FREQUENCY
RF AMPLIFIER**

The No. 90811 RF Amplifier is the same unit as used in the No. 90810 complete 2-6-10-20 meter Ham Band crystal controlled transmitter. Can be panel or base mounted. Uses 829B or 3E29 tube with normal 75 watt output. (Higher output may be obtained by the use of forced cooling.) Provisions are made for quick band shift by means of the new 48000 series high frequency plug-in coils. Extremely compact. Chassis 4" x 7 3/4" exclusive of flanges. Over-all height 6 3/4".

**JAMES MILLEN
MFG. CO., INC.**

MAIN OFFICE AND FACTORY
**MALDEN
MASSACHUSETTS**



NEW PRODUCTS

(continued)

controls a pair of centrifugal vibrating contacts that accomplish the speed variation.

Control Unit (33)

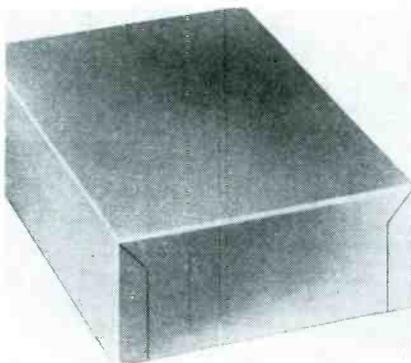
GENERAL ELECTRIC Co., Schenectady 5, N. Y. A new packaged ampli-dyne control unit for applications



where speed, current, or voltage regulation are required is now available. Indicating instruments are provided for ease in adjustment.

New Chassis (34)

E. F. JOHNSON Co., Waseca, Minn. A new line of chassis is so formed that no overlaps occur at the cor-

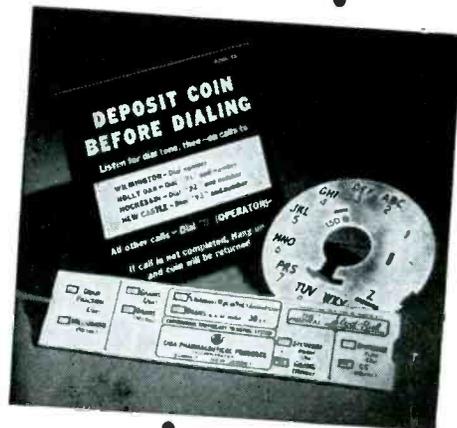


ners. The feature permits locating holes for volume controls and toggle switches all the way up to the corners. Rigidity is insured by welded tie bars on the inside of the turned under bottom edge.

Servicing CRO (35)

HICKOK ELECTRICAL INSTRUMENT Co., 10527 Dupont Ave., Cleveland

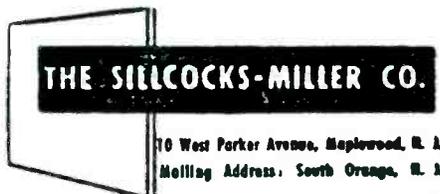
precision-
fabricated
**PLASTIC
PARTS**



**QUALITY and SERVICE
AT A PRICE
THAT'S RIGHT**

With more and more manufacturers switching to plastic parts to improve the appearance and performance of their products, it is significant that so many look to Sillcocks-Miller for the quality and service they want. This organization of specialists is recognized throughout the industry for its skill in fabricating plastic parts to close tolerances and its reputation for unvarying quality. With complete facilities to meet your requirements . . . no matter how large or small . . . Sillcocks-Miller offers you the dependable source you want for plastic parts and service, at a price that's right.

Write for illustrated booklet or phone South Orange 2-6171 for quick action.



**SPECIALISTS IN HIGH QUALITY, PRECISION-MADE
PLASTICS FABRICATED FOR COMMERCIAL,
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PLASTICON HIVOLT SUPPLIES

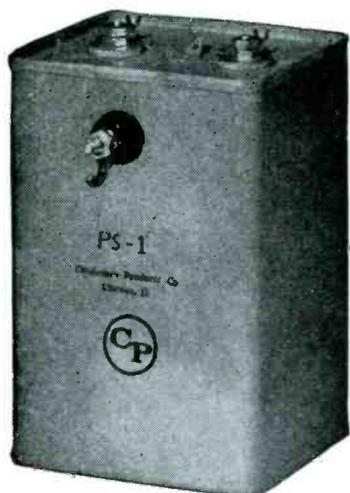
High Voltage - Low Current DC Power Supplies

for

Television—Radiation Counters—Photoflash Devices—Electrostatic Precipitators—Spectrographic Analysers, Oscilloscopes, Etc.

HiVolt Supplies are self-contained in hermetically sealed metal containers. They are designed to transform low voltage AC to high voltage - low current DC.

HiVolt PS-1



Specifications:

Volts Input: 118 VAC, 60 cycles.
 Volts Output: 2400 VDC (capacitor load)
 Current Output: .006 Amps., half-wave DC.
 Max. Watts Input: 15 watts.
 Type of Filter: Not filtered.
 Terminals: 8-32 screw and nuts.
 Insulation: 118 VAC—2 bakelite washers;
 2400 VDC—1 porcelain standoff;
 2400 VDC—lug spotwelded to case.
 Container: Terne plate steel—gray lacquer finish.
 Size: 3 $\frac{3}{4}$ " x 3 $\frac{3}{16}$ " x 5 $\frac{1}{2}$ ".
 Weight: 2.2 lbs.

List Price \$18.95 F. O. B. Chicago

NOTE: The PS-1 is designed to charge a parallel-wired bank of not more than 15 AOCOE-22C3 Plasticon Energy Storage Capacitors (48 mfd.).

HiVolt PS-2

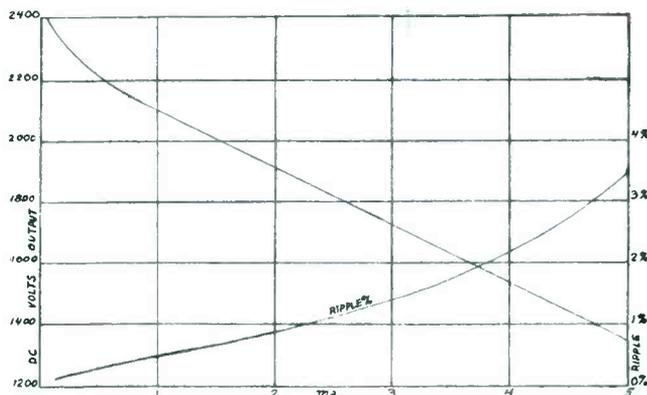
Specifications:

Volts Input: 118 VAC, 60 cycles.
 Volts Output: 2400 VDC, maximum.
 Current Output: .005 Amps. DC, maximum.
 Max. Watts Input: 10 watts.
 Type of Filter: R. C. Filter: 50,000 ohms, 2x.1 mfd.
 Terminals: 8-32 screw and nut.
 Insulators 118 VAC—2 bakelite washers;
 2400 VDC—2 porcelain standoffs;
 container neutral.
 Container: Terne plate steel—gray lacquer finish.
 Size: 3 $\frac{3}{4}$ " x 3 $\frac{3}{16}$ " x 5 $\frac{1}{2}$ ".
 Weight: 2.5 lbs.

List Price \$25.75 F. O. B. Chicago

NOTE: The PS-2 is similar in appearance to the PS-1 except that all four terminals are on the recessed top of the container.

Regulation and Ripple Curves



Condenser Products Company

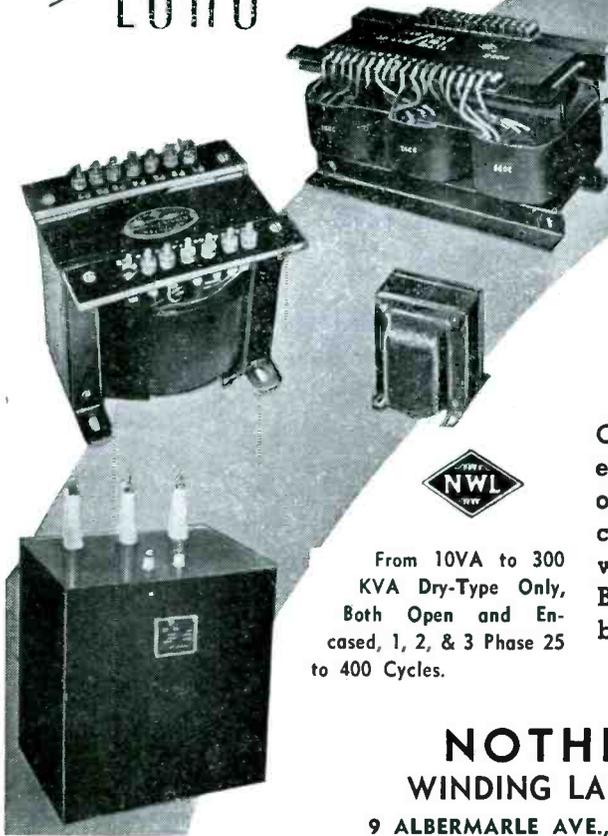
1375 NORTH BRANCH STREET • CHICAGO 22, ILLINOIS

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NEW PRODUCTS

(Continued)



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**CUSTOM-BUILT
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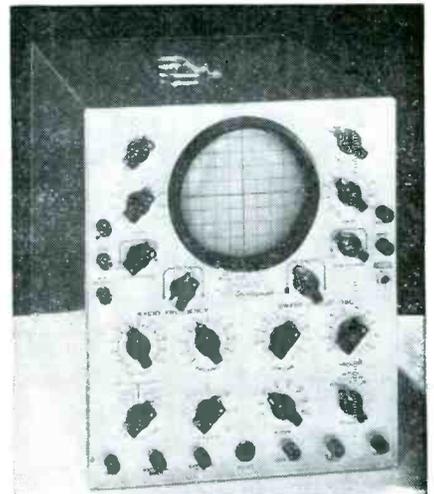
Over 25 years experience in the manufacture of specials at cost that compares favorably with standard types. Built-in quality proved by years of actual use.

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From 10VA to 300
KVA Dry-Type Only,
Both Open and Encased,
1, 2, & 3 Phase 25
to 400 Cycles.

**NOTELFER
WINDING LABORATORIES**

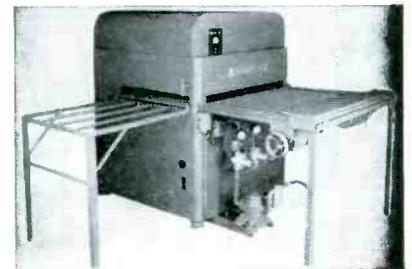
9 ALBERMARLE AVE., TRENTON 3, N. J.



8, Ohio. Model 505 cathode-ray oscilloscope has been designed for the visual analysis of receiver circuits and the signal-tracing technique in trouble shooting. The equipment generates an f-m signal so that it can be used for aligning i-f and r-f transformers and discriminator circuits.

H-F Gluing Machine (36)

ELECTRONIC HEATING ASSOCIATES,
75 Jefferson St., Newton 58, Mass.
The new high-frequency gluing

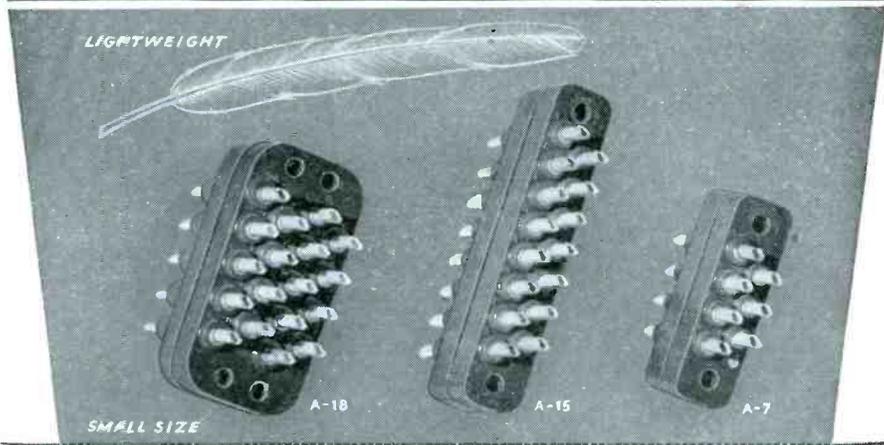


machine for woodworking, called Raybond, has a capacity from 400 to more than 1,200 square feet of edge-bonded blanks an hour. It requires only one operator and accommodates stock in thicknesses from $\frac{3}{8}$ inch to 2 inches with adjustable pressure as required. Average complete work cycle takes from 20 seconds to one minute. Several models are available.

Time Switch (37)

PALO-MYERS, INC., 81-83 Reade St.,
New York 7, N. Y. The new time
switch for laboratory and industrial
uses is a self-contained unit
incorporating equipment for turn-

WINCHESTER ELECTRONICS



RECTANGULAR CONNECTORS

Currently available with 18, 15 and 7 contacts, these lightweight connectors are designed for a minimum of weight and size while retaining typical WINCHESTER features such as MONOBLOC* construction, melamine insulation, precision machined contacts and long creepage paths. Strain relief cable clamps available. Send for Bulletin A.

*Trademark

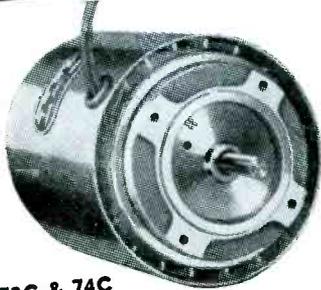
WINCHESTER ELECTRONICS COMPANY 6 East 46th Street, New York 17
(FORMERLY THE WINCHESTER CO.)



FRACTIONAL H.P. MOTORS

BLOWER UNITS

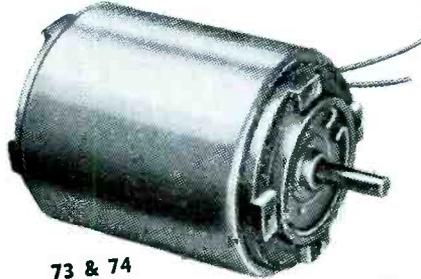
CONTROL COMPONENTS



73C & 74C SERIES

115-220 Volts—50, 60 and 400 cycles . . . Continuous duty. Sleeve Bearing . . . Fan Cooled . . . Totally Enclosed. Outside Diam. 3 1/8".

TYPE	H. P.	R.P.M. 60 Cy.
Capacitor	1/15, 1/20, 1/30	1600 & 3200
Shaded Pole	1/30, 1/50, 1/100	1500
Synchronous	1/50, 1/100	1800 & 3600



73 & 74 SERIES

115-200 Volts—50, 60 cycles. Fan or Intermittent duty . . . Sleeve Bearing . . . Totally Enclosed. Outside Diam. 3-5/16".

TYPE	H.P.	R.P.M. 60 Cy.
Capacitor	1/20, 1/30, 1/50	1600 & 3200
Shaded Pole	1/30, 1/50, 1/100	1500
Synchronous	1/50, 1/100, 1/200	1800 & 3600



71 SERIES

115-200 Volts—50, 60, 400 Cycles Continuous duty. Sealed Ball Bearings. Totally enclosed. Outside Diam. 3-5/16"—3 7/8".

TYPE	H. P.	R.P.M. 60 Cy.
Capacitor	1/15, 1/20, 1/30, 1/50, 1/100	1600 & 3200
Shaded Pole	1/30, 1/50, 1/100	1500
Synchronous	1/50, 1/100, 1/200	1800 & 3600



49 SERIES

115 Volts—50, 60 and 400 Cycles. Continuous duty . . . Ball Bearing. Totally enclosed. Outside Diam. 1 3/4".

TYPE	H.P.	R.P.M. 60 Cy.
Capacitor	1/100*, 1/250	2800 & 3100
Torque	5 Oz. In.	45° Only

*Intermittent Duty Only

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- Cameras and Projectors
- Chart Recorders
- Floor Fans
- Dispensing Machines
- Timing Apparatus
- Turntables
- Air Conditioning

Eastern Air Devices' units embody all of the important advances in design and construction made during the war. Included are such features as: replaceable "capsule" bearings, snap ring construction for easy disassembly, radically improved cooling means, insuring long life with minimum size and weight, etc. Let us fit an E. A. D. unit to your application.

EASTERN AIR DEVICES, INC.

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EAD Foreign Dept.-70 Pine St., N.Y.C. Tel Whitehall 4-8729



31 SERIES

115 Volts, 400 cycles, 1/25 to 1/100 H. P. Weight of units 15 oz. Diam. 1 5/16". Length 2 29/32".



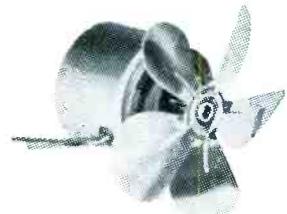
36 SERIES

D.C. Voltage Generators for Control and Tachometer applications . . . 2 Volts per hundred R. P. M. Permanent magnet field . . . weight, 20 oz. Diameter 2 1/4". Length 3".



ALTERNATORS

Special Alternators designed for any application. 20 to 1000 cycles up to 50 watts. Specialists in permanent magnet designs.



AXIAL FLOW BLOWERS

Numerous types for 50, 60 and 400 Cycle application. 170 to 800 C.F.M. (NEMA Code). 65 to 300 C.F.M. (NAFM Code). Designed for use in electronic or industrial equipment.



CENTRIFUGAL BLOWERS

Numerous Types for 50, 60 and 400 Cycle application. 60 to 110 C.F.M. For use in electronic or industrial equipment.



THE GE ELECTRONIC SWITCH

The General Electric Electronic Switch, Type YE-9, is a device which may be used with a conventional cathode ray oscilloscope for the simultaneous observation of two or more



wave phenomena on the screen of the oscilloscope. Since the cathode ray tube is essentially a single signal indicator, a device such as this is necessary for the observation of more than one signal. Thus, it permits the oscilloscope to be used as a multi-signal comparison device.

The two signals to be observed are applied to the two inputs of the Electronic Switch. The Electronic Switch then performs its function by delivering the individual signals to the output terminal, alternately. Due to the persistence of vision of the human eye, and the persistence of the fluorescence screen, the two signals appear on the oscilloscope screen simultaneously. While the employment of one Electronic Switch permits the simultaneous observation of two waveshapes on the oscilloscope screen, two switches used in tandem may be used to observe three waveshapes, etc.

The instrument requires no adjustment or calibration while in use. It is completely automatic in operation for any range of oscilloscope sweep frequencies from 10 to 12,000 cycles per second. The only controls are the individual Gain Controls for each signal and a Balance Control for separation or superposition of the two signals.

The most frequent uses to which the Electronic Switch may be put are the comparison of amplitude, waveform, phase, and frequency relationships between two signals. The signals under study may be those of an electrical or electronic device, or they may be sound or mechanical motion that are transformed into electrical functions.

TECHNICAL DATA

Input voltage.....	110-125 Volts, 50-60 cycle
Power drain.....	45 watts
Amplifier frequency response	4 cps to 450 kc (flat within 3 db)
Oscilloscope sweep frequency range...	will operate on any sweep frequency of from 10 cps to 12,000 cps, con- tinuously variable
Input impedance.....	100,000 ohms
Maximum signal input.....	250 volts rms
Length, overall.....	12 1/2"
Width, overall.....	7 3/8"
Height, overall.....	8 1/2"
Weight	14 lbs.

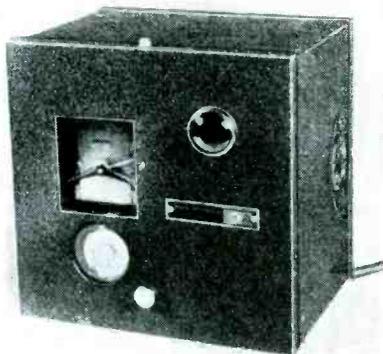
\$5950 Net, F.O.B.,
New York

Telephone: **hrc** Longacre 3-1800

HARVEY
RADIO COMPANY INC.
103 West 43rd St., New York 18, N. Y.

NEW PRODUCTS

(Continued)



ing apparatus on and off at a pre-determined time schedule. Operating at 110 volts a-c, the cycle repeats day after day as long as the clock is not disconnected.

Snap Switch (38)

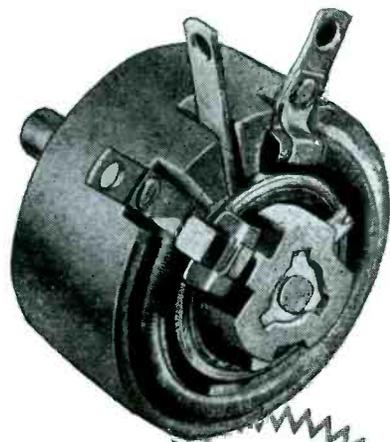
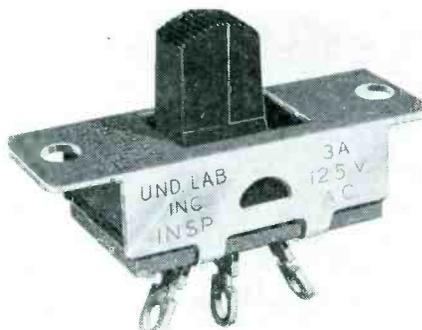
UNIMAX SWITCH CORP., 460 West
34th St., New York 1, N. Y. Type



SA-1 double-pole snap-action switch can be obtained in either double- or single-throw and is made up of two switches joined by an Adaptable. The switch is rated at 15 amperes 125 volts.

Snap-Slide Switch (39)

ELPAR CO., Bank & Marlton Ave., Camden, N. J. Type RS Underwriters' approved 3-ampere 125-volt a-c snap action slide switch has a low contact resistance. Max-



Just
plain
TOUGH!

POWER RHEOSTATS

The Clarostat kind stands up under the most trying service. Thousands in daily use. Insulated metal core supports resistance winding. Imbedded in cold-setting inorganic cement. Maximum heat dissipation.

Smooth rotation. Positive conduction. Minimum wire wear.

25- and 50-watt ratings. 1—5000 and 0.5-10,000 ohms, respectively.

Engineering Bulletin with details, specs, drawings, etc. on request. Let us quote on quantity needs.

CLAROSTAT

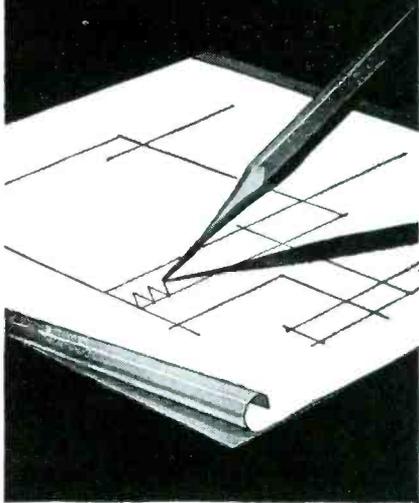


Controls and Resistors

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In Canada: CANADIAN MARCONI CO. LTD.
Montreal, P. Q., and branches

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Erasures are made easily, without damage. It gives sharp, contrasting prints of the finest lines. It resists the effects of time and wear, and does not become brittle or opaque.

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CLOTH**



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For high acoustical value, for a rich velvety finish at low cost, for ease and economy in application—you'll find Cellusuede Flock the ideal material for coating the turntables on phonographs. And this is only one of the thousand ways to use this versatile material! Cellusuede can be applied to almost any surface by spraying, and there is a wide selection of brilliant, eye-catching colors from which to choose. Rayon or Cotton Flock is available for immediate shipment.

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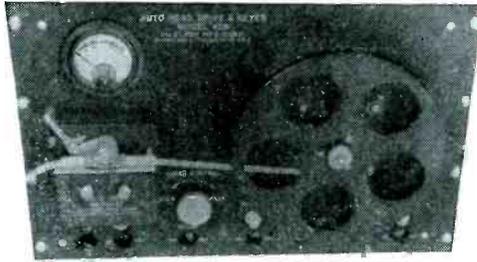
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Difficult Designs

DINION COIL COMPANY, INC. CALEDONIA
NEW YORK

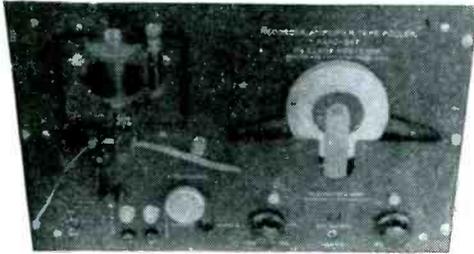


TERMINAL EQUIPMENT

by
McElroy



TYPE ADK



TYPE RAPC

**FOR HIGH SPEED
RECORDING
and
TRANSMITTING**

McElroy Manufacturing Corporation announces an entirely new line of high speed recording and transmitting terminal equipment. For the first time, McElroy makes available a mechanical Wheatstone keying head capable of continuous operation at 500 words per minute, and a compact undulator tape recorder which is tested at speeds up to 1500 words per minute, and capable of recording high speed Morse, teletype or other intelligence where a fast accurate pulse mechanism is required.

Illustrated are the new ADK and RAPC units. The ADK keys Wheatstone tape at any variable speed up to 500 words per minute and provides polar, voltage, relay, or tone output. The RAPC pulse type recorder will accept contact, tone, voltage and frequency shift input and record such inputs at speeds up to 1500 words per minute.

The heart of this equipment is the new McElroy variable speed drive, used in the units described above and in the new high speed tape pullers. Set arbitrarily at 60 words per minute, a Strobotac will reveal no variation in speed with any reasonable load.

See this new equipment at our booth at the I. R. E. Show, and let our engineers convince you of the new ease in operating possible with the new McElroy equipment.

McELROY MANUFACTURING CORP.

Made at...Telegraphers Lodge, Littleton, Mass.

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The Technical Materiel Corporation

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New York 19, N. Y.

imum travel is 0.16 inch, and the switch is selfactuating beyond the center of throw. Two mounting holes are required.

Ferrule Resistor (40)

MILWAUKEE RESISTOR Co., 700 West Virginia St., Milwaukee, Wis. A new ferrule-type line of resistors



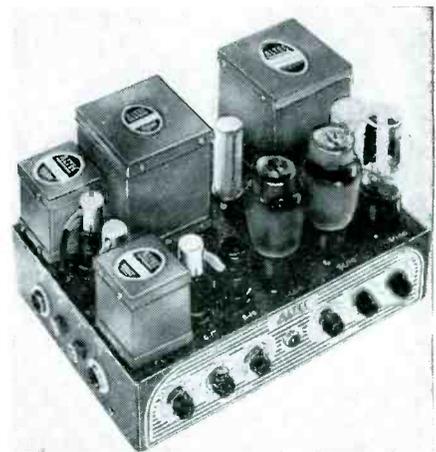
that eliminates separate tips by a technique in which the ends of the resistor core are copper coated substantially reduces production costs over conventional models.

Television Camera Tube (41)

RADIO CORP. OF AMERICA, Harrison, N. J. The new image orthicon, 5655, is especially recommended for studio use. It differs from the 2P23 in that its photocathode has practically no infrared sensitivity, and it has better resolution, signal-to-noise ratio, and more natural response to halftones.

Portable P-A Amplifier (42)

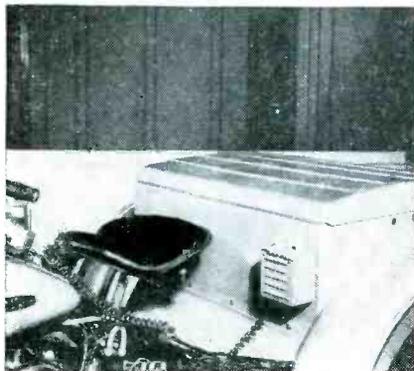
ALTEC LANSING CORP., 250 West 57th St., New York 19, N. Y. A new portable public address amplifier model A-324 is rated at 15 watts with an overall frequency response



flat within 1 db from 20 to 20,000 cycles. Four inputs are provided, two low impedance with 95-db gain and the other two with 72-db gain at high impedance. Variable controls are available for both bass and treble.

Motorcycle Dispatcher (43)

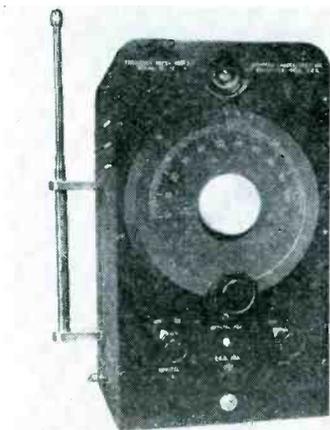
MOTOROLA INC., 4545 W. Augusta, Chicago 51, Ill. Designed for the 152-162 mc band, the new Dis-



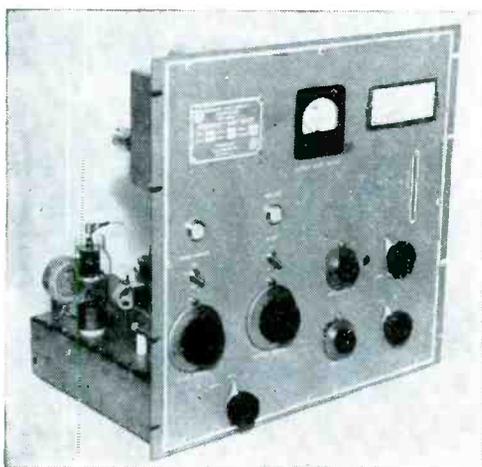
patcher unit is a compact mobile radiotelephone transmitter and receiver for motorcycle use with a power output of 7 to 10 watts. The crystal drift is held to less than ± 0.002 percent over a temperature range of -20 to $+80$ C.

Mobile Frequency Meter (44)

BROWNING LABORATORIES, INC., Winchester, Mass. Model S-7 frequency meter is particularly useful

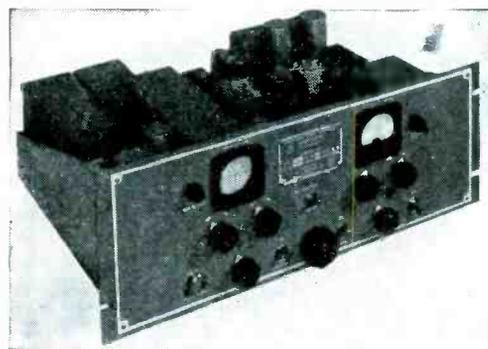


for measurements in the 72-76 and 152-162 mc bands. Accuracy of 0.005 percent is easily obtained, and with special precautions in the measurement technique, better than 0.0025 percent is possible. A whip



TYPE 105

A COMPLETE
FREQUENCY SHIFT
SYSTEM FOR
POINT-TO-POINT
COMMUNICATIONS



TYPE 107

From transmitting to receiving terminal, the Northern Radio Company supplies all of the equipment necessary for a complete frequency shift system for point to point communications, whether teletype, high speed Morse, facsimile or voice is the transmitted intelligence.

Illustrated are the Northern Radio frequency shifter type 105 and the converter type 107. However, also available are such units as complete transmitters, dual diversity receivers, line amplifiers, tone keyers and demodulators. Complete equipment for remote operation such as standard tone filters and link systems are also manufactured by the Northern Radio Company in order that complete matching systems may be installed.

We feel this equipment is far ahead of the field in its conception, and we invite discussion with our engineers on your particular problem.

See us at our booth at the I. R. E. Show

NORTHERN RADIO COMPANY, INC.

143 West 22nd Street

New York 11, N. Y.

SALES DEPARTMENT

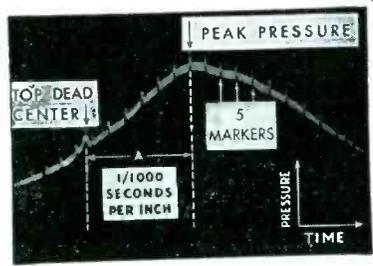
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New York 19, N. Y.

Have you ever seen the
INSIDE of an EXPLOSION?

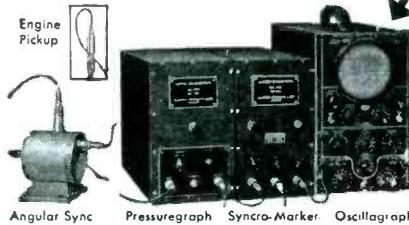
or the rate
of engine flame
propagation

Seeing now made
possible by remarkable
new electronic
features, embodied in



PRESSUREGRAPH with Syncro-Marker

Reproduces on oscillograph screen, accurate picture of pressures during and after explosion, relates pressure variations to time, top dead center, angular velocity, etc. Also accurate tracing of rate of flame propagation with relation to top dead center and peak pressure. See pressure-time characteristics of automotive, jet and Diesel engines, also compressors, pumps, etc. Operates over range from static up to 10,000 cycles at pressures from 0 to 10,000 lbs.



Send for description and full engineering data.

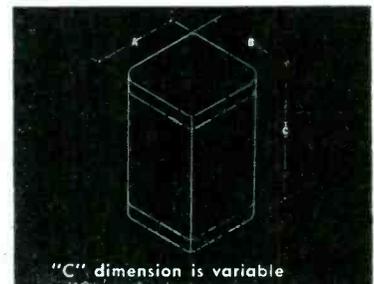
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549 W. Randolph St., Chicago 6, Ill. Phone ST ate 7444

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CORE	CASE	A	B	C
E1-21	1	1 3/8"	1 1/4"	2 3/16"
E1-A25	2	1 7/8"	1 3/8"	2 1/16"
E1-75	3	2 1/4"	2 1/8"	2 3/16"
E1-11	4	2 5/8"	2 1/2"	3 1/32"
E1-12	5	3"	2 1/8"	3 3/32"
E1-3A	6	3 1/4"	3"	3 1/32"
E1-112	7	3 3/8"	3 1/4"	4 1/32"
E1-125	8	3 3/4"	3 1/2"	4 1/32"
E1-137	9	3 7/8"	3 3/4"	4 3/32"
E1-13	10	4 1/8"	4 1/4"	5 1/32"
E1-151	11	5"	4 3/8"	5 1/32"
E1-36	12	5 1/8"	4 3/4"	6 1/32"

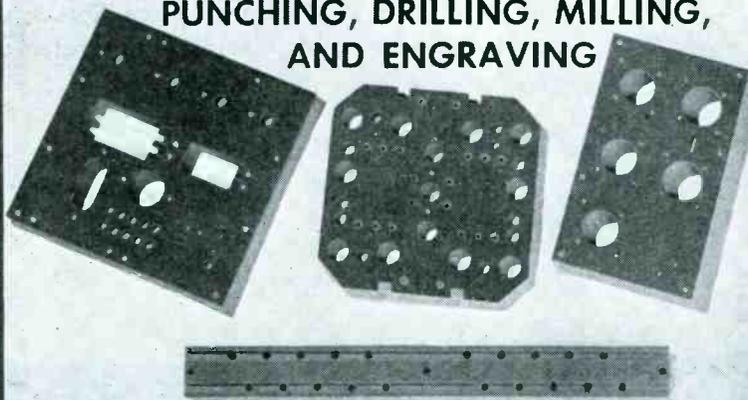
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LITERATURE and NEW PRODUCTS

Manufacturers' Literature as well as further information on New Products described in this issue are important "working tools" for design and production departments. To make it easy to keep up to date, ELECTRONICS will request manufacturers to send readers the literature in which they are interested. Just fill out card as shown in the filled-in sample (right), being particularly careful to write out in full all the information called for in each section of each card that is used.

<p>Write in circle number of item describing one item wanted → (14)</p> <p>Your Company Name <i>Jones Mfg. Co.</i> Address <i>3217 Lewis Ave.</i> <i>Chicago 13, Ill.</i></p> <p>Your Name <i>Geo. Smith</i> Your Title <i>Chief Engineer</i></p> <p>ELECTRONICS, 330 W. 42nd St., N. Y. 18</p>	<p>Write in circle number of item describing one item wanted → (22)</p> <p>Your Company Name <i>Jones Mfg. Co.</i> Address <i>3217 Lewis Ave.</i> <i>Chicago 13, Ill.</i></p> <p>Your Name <i>Geo. Smith</i> Your Title <i>Chief Engineer</i></p> <p>ELECTRONICS, 330 W. 42nd St., N. Y. 18</p>
<p>Write in circle number of item describing one item wanted → (37)</p> <p>Your Company Name <i>Jones Mfg. Co.</i> Address <i>3217 Lewis Ave.</i> <i>Chicago 13, Ill.</i></p> <p>Your Name <i>Geo. Smith</i> Your Title <i>Chief Engineer</i></p> <p>ELECTRONICS, 330 W. 42nd St., N. Y. 18</p>	<p>Write in circle number of item describing one item wanted → (49)</p> <p>Your Company Name <i>Jones Mfg. Co.</i> Address <i>3217 Lewis Ave.</i> <i>Chicago 13, Ill.</i></p> <p>Your Name <i>H. S. Towne</i> Your Title <i>Adv. Mgr.</i></p> <p>ELECTRONICS, 330 W. 42nd St., N. Y. 18</p>

**SAMPLE
CARD
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HOW TO ORDER:

1. There are two postcards, each divided into four parts. Each of the four parts contains a ○. You must write in this ○ the number that appears in this issue over the literature or new product item in which you are interested. Place one number only in each circle.

2. Fill out completely (name, address, etc.) for each piece of literature or new product information you desire.

Do not say "same" in lieu of writing out full information called for when requesting more than one item.

3. This service applies only to literature and new product items in this issue. It does not apply to advertisements. Write directly to the company for information on its advertisements.

PLEASE NOTE: Requests for unnumbered items must be made direct to the manufacturer.

In the event this copy of ELECTRONICS is passed along to other members of your company, please leave this sheet in for their convenience. This assures everyone in your plant the opportunity to fill in their requests. When the round is completed, cards can then be detached along perforated lines and dropped in the mail. Each individual request will be mailed by us to the company offering the information and for that reason must be completely filled out.

Write in circle number of item describing one item wanted → ○

Your Company Name.....

Address.....

Your Name.....

Your Title.....

ELECTRONICS, 330 W. 42nd St., New York 18, N. Y.

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Write in circle number of item describing one item wanted → ○

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Your Name.....

Your Title.....

ELECTRONICS, 330 W. 42nd St., New York 18, N. Y.

An electronics service designed for READERS and MANUFACTURERS

FOR THE READER ... ELECTRONICS fundamental policy has always been to supply its readers with all the pertinent and timely industry news. The ELECTRONICS Reader Service supplements this policy by offering the reader an easy and effective means of obtaining complete, up to the minute data on new products and of maintaining at his fingertips comprehensive, practicable information on "who's doing what" in the industry.

In every issue of ELECTRONICS there's complete coverage of the month by month development by manufacturers of new materials, components and equipment, as well as brief mention of all the important, new, manufacturers' technical pamphlets and catalogs. Some of these items will be of particular interest to specific design and plant engineers, buyers, executives and others of our readers. They will want to make further inquiry concerning the new products described or they will want to read and make a permanent part of their industrial library some of the manufacturers' literature and catalogs.

ELECTRONICS Reader Service makes it easy for them to obtain in readily accessible and usable form the information they desire.

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3-1-48

FOR THE MANUFACTURER ...

ELECTRONICS Reader Service will also be welcomed by manufacturers who are desirous of placing the complete news of their product developments as well as their technical bulletins and catalogs in the hands of those members of the electronic industry . . . including design, electrical and production engineers, researchers, physicists, executives, and buyers—who have a particular interest in, or represent a potential buying power for, their products.

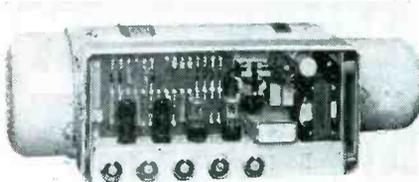
SUGGESTIONS FOR THE IMPROVEMENT OF OUR READERS' SERVICE ARE INVITED

ELECTRONICS is constantly seeking new and improved ways of providing its readers with the news and information they want and need, and of assisting the manufacturer in effectively delivering his message to electronic markets. If you have any ideas for us, send them along. They will receive prompt consideration.

antenna furnishes coupling to the transmitter. Operation is from 117 volts either a-c or d-c.

Electronic Amplidyne (45)

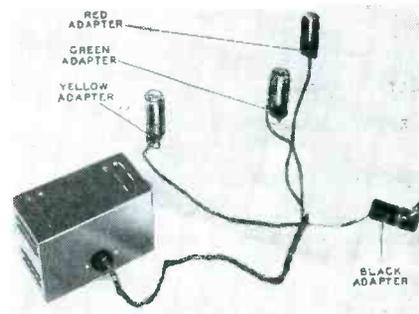
GENERAL ELECTRIC Co., Schenectady 5, N. Y., announces an electronic amplidyne which is useful for precise regulation of current,



voltage speed of motors. The unit consists of a high-gain balanced d-c electronic amplifier and a motor amplidyne. It has an output of $1\frac{1}{2}$ kw, 250 volts and can be used on either a 220- or 440-volt, 3-phase, 60-cycle power supply.

Linearity Check (46)

PHILCO CORP., Philadelphia, Pa. Model 5072 Crosshatch generator enables a television service man



to check and adjust the linearity of a receiver's vertical and horizontal sweeps without depending on test charts from a television station. By means of an adapter harness the unit obtains required plate power, filament power and synchronizing voltages from the receiver itself.

Direct-Coupled Amplifier (47)

AMPLIFIER CORP. OF AMERICA, 398 Broadway, New York, 13, N. Y. Developed to accommodate the G-E



ADD THIS NEW NOTE --
THE QUALITY NOTE --
to your combinations

with the GENERAL ELECTRIC VARIABLE RELUCTANCE PICKUP

BROADCAST STATIONS must have the finest reproduction possible for transcribed programs. Their chief engineers, the most critical customers in the world, are really tough to convince because they have the technical facilities to test every claim made for the equipment they use.

Hundreds of broadcast stations have changed over to the General Electric Variable Reluctance Pickup for studio use

Design engineers on radio-phonograph combinations are sceptics of the first order when it comes to specifying a new unit for their sets. They have to be shown.

A number of leading manufacturers are now specifying the General Electric Variable Reluctance Pickup

Letters from music lovers in increasing numbers tell us how much the General Electric Variable Reluctance Pickup has increased their listening pleasure—how it has brought out new beauty in their old recordings.

The opinions voiced by the general public should mean much to you because—they can be your customers

Write today—learn how the General Electric Variable Reluctance Pickup can help keep your production lines humming. *General Electric Co., Electronics Department, Electronics Park, Syracuse, N. Y.*

188-G1

GENERAL  ELECTRIC



PIPE COUPLINGS



ELECTRICALLY HEATED PRESSURE HEADS



CONTINUOUS FILM RECORDING CAMERAS

AND EQUIPMENT FOR CATHODE RAY

OSCILLOGRAPHY, ETC.



We undertake the Design, Development and Manufacture of any type of Optical—Mechanical—Electrical Instrument. Including Cameras for special purposes.

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More than 14 years of know-how and experience in every

PYROFERRIC IRON CORE

Pyroferric Iron Cores were first made in 1933 and the experience and know-how gained in each succeeding year are inherent in every powdered iron product today produced by the Pyroferric Company, including: a full line of standard sized Powdered Iron Screw-Type Cores of varying lengths, with standard threads, as well as a complete line of powdered iron cores, with and without inserts.

For Powdered Iron Cores to meet your specifications, address your inquiry to

PYROFERRIC Co.

621 East 216 Street, New York City 67

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Circuit Tester
20,000 Ohms per Volt



THE NEW SERIES "85"

Compact, laboratory styled, *high sensitivity* test set "Application Engineered" for production, test, laboratory, school and service-maintenance phases of modern *radio-electronics-communications*.

- 20,000 Ohms per Volt D.C.
- 1000 Ohms per Volt A.C.
- VOLTAGE RANGES:** 0-3-12-60-300-1200-6000 A.C. & D.C.
- CURRENT RANGES:** 0-120 microamps
0-1.2-12-120 MA.
0-1.2-12 Amps. D.C.
- RESISTANCE RANGES:** 0-6000—600K—6 Meg
—60 Megohms.
- DECIBEL RANGES:** From —26 to +70DB.

Complete with batteries and test leads **\$38.75**

PLUS superior physical features:

- ★ 4 3/8" wide angle meter.
- ★ Heavy duty molded bakelite instrument case size 5 1/2 x 7 1/8 x 3".
- ★ Heavy gauge, anodized aluminum panel.
- ★ Rotary Range and Function Selection.
- ★ Recessed 6000 volt safety jacks.
- ★ Only two pin jacks for all standard ranges.

Ask to see this and other "Precision" Application Engineered instruments, on display at leading radio parts distributors. Write for new, complete 1948 catalog, including details of the Precision Electronic tube testing circuit.

PRECISION

APPARATUS CO., Inc.
92-27 Horace Harding Blvd.
Elmhurst 10, N. Y.

Export Division, 458 Broadway, New York City, U. S. A. Cables, MORHANEX



variable reluctance magnetic pickup without additional pre-amplification or equalized circuits, the model ACA-100GE direct-coupled amplifier develops 23 watts with less than one percent total distortion.

T-V Tubulars (48)

CORNELL-DUBILIER ELECTRIC CORP., South Plainfield, N. J. Type TMC-



187 capacitor developed for television service has a capacitance of 0.005 microfarads at 3,500 working volts, d-c.

Laboratory Furnace (49)

LINDBERG ENGINEERING CO., 2444 West Hubbard St., Chicago 12, Ill. has developed the model G-10 box type electronically controlled laboratory furnace with temperatures up



Audax

TRADE MARK

TUNED-RIBBON

reproducers

TUNED-RIBBON Pick-up model SA-79
(Actual Size—Special STUDIO-arm not shown)

- A model for every purpose



Jewel Stylus EASILY REPLACED BY USER

ADMIRABLY this revolutionary NEW line by Audax bears out the business maxim:—

“LOOK TO THE LEADER FOR LEADERSHIP”

* Because a “permanent-point”—be it diamond, sapphire or metal—will maintain its original shape for only a limited number of plays, after which it progressively erodes the record grooves, the importance of being able to replace it has always been of primary consideration. Heretofore such replaceability entailed severe penalties in range, compliance and point-pressure. Most of the TUNED-RIBBON models provide the all-important replaceability without those penalties.

SPECIFICATIONS TUNED-RIBBON SA-79

- Linear 50 cyc. to over 10 k.c.
- Point Pressure—about 24 grams
- Genuine Sapphire Stylus—EASILY REPLACED BY USER
- Output—about—30 db
- Impedance—200 ohms to 500 ohms
- Vibratory Momentum—very low
- Quick plug-in connectors
- Arm is aluminum, Special Studio Design, Tangent-Tracking, ball-thrust and pivot-point bearings in gimbal mounting—eliminating side thrust and drag.

TUNED-RIBBON delivers not only Wide Range, (which is but one line in the chain)—but also the vital factors so necessary for quality performance and EAR-acceptability . . . proving anew AUDAX right to the slogan:—

“The Standard by Which Others Are Judged and Valued”

Yes, Audax TUNED-RIBBON has put something into reproduced music that was not there before . . . let YOUR ears be the final judge.

* SEND FOR COMPLIMENTARY PAMPHLET ON THIS VITAL SUBJECT

AUDAX COMPANY

500 Fifth Avenue

New York 18

CREATORS OF FINE ELECTRO-ACOUSTICAL APPARATUS SINCE 1915

You are cordially
invited to visit the:

TELEVISION INDUSTRIES CO.

booth No. 335 & No. 336 at the IRE Show in New York

National Wholesale Distributors for . . .

BAUSCH & LOMB
TELEVISION PROJECTION LENS
AND
The DUMONT INPUTUNER

**TELEVISION
INDUSTRIES**

540 BUSHWICK AVE.
BROOKLYN 6, N. Y.

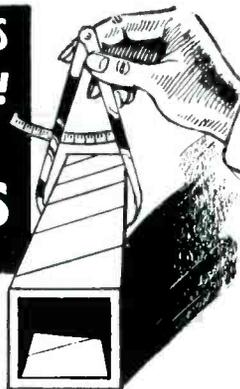
**ELECTRONICS REQUIRE COILS
OF GREATEST ACCURACY!**

--- AND THIS

Begins WITH **BASES**



Precision-built to all factors of coil-base service in electronics. Spirally wound for maximum strength. Sturdy—compact—dependable!



Now standard at regular prices. (Formerly made on special order only, at increased cost). Advantages: automatic stacking—closer core engineering, saving wire—no need of coil-forming after winding.

**PRECISION
DI-FORMED
PAPER TUBES
COIL FORMS**

WRITE FOR SAMPLES

Di-formed, (square or rectangular). Any length, any ID or OD. Ask for New Mandrel list. Many new sizes.

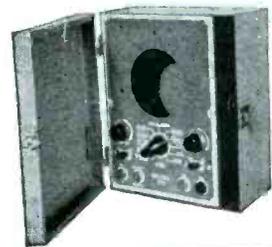
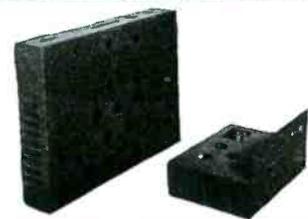
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ALSO MAKES
ROUND AND
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—ANY
SHAPE**



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TO HELP YOU WITH YOUR
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SHEET METAL PRODUCTS —
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INSTRUMENT PANELS, RADIO COMMUNICATION CASES and ENCLOSURES, OSCILLATOR BOXES, CHASSIS and CABINET ASSEMBLIES, RACKS and SPARE PARTS BOXES, WATERPROOF CABINETS and BOXES, METAL STAMPINGS, FORMING and WELDING of FERROUS and NONFERROUS METALS.

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BROOKLYN 16, NEW YORK
TEL. SLOCUM 6-7501

to 3,000 F top heat, and for continuous operation as high as 2,500 F. It is designed for operation on 230 volts, 60 cycle, single phase a-c. For further information request bulletin No. 980.

Signal Calibrator (50)

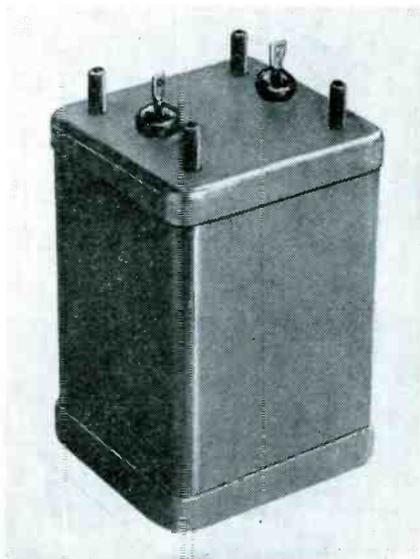
INDUSTRIAL ELECTRONICS, INC., 21 Henry St., Detroit 1, Michigan. The Electro-cal is an instrument pro-



viding precision measured signal voltage for calibration purposes. Output signals in the form of 60-cycle sine waves up to 1,000 millivolts are available in eight ranges. An output signal of 0-5 volts can also be read directly on the meter.

Plastic Capacitors (51)

UNITED CONDENSER CORP., 422 E. 138th St., New York 54, N. Y. Plastic dielectric capacitors with su-



Precision hi-meg resistances in a range of 100 to 10,000,000 megohms

Actual size • all values
Vacuum sealed in a glass envelope

Victoreen HI-MEG resistors were developed for use in electrometer circuits and other applications where stability, accuracy, and high humidity operation are of prime consideration. The resistor element is vacuum sealed in a glass envelope. A special silicon varnished surface makes the hi-meg less susceptible to humidity effects than other circuit components. A carefully controlled accelerated aging process insures stability and reliability. The range of 100 to 10,000,000 megohms assures full coverage in values which were hitherto unobtainable. Production is current.

Radiation instrumentation

Victoreen "know how" of radiation measuring instruments is based on a background of 20 years devoted exclusively to such problems and assures quality performance for your particular needs.

These include laboratory and survey instruments to measure alpha, beta and gamma radiation, for personnel protection, field surveys and such fine components as the VX series subminiature electrometer vacuum tubes and the VG series Geiger counter tubes.

These components and instruments such as the 356 Alpha meter, the 263A beta and gamma meter, the 247A gamma radiation survey meter, and the 287 minometer and pocket ionization chambers have contributed to the history and are pacing the progress of radiation instrumentation.

Write for information and data sheets.

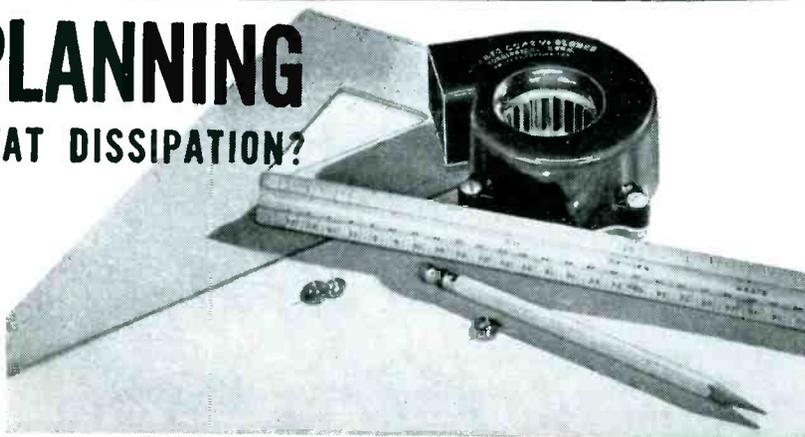


THE VICTOREEN INSTRUMENT CO.
5806 HOUGH AVENUE
CLEVELAND 3, OHIO

DEPT.

A

PLANNING HEAT DISSIPATION?



MOVE AIR, 15 to 60 cubic feet a minute

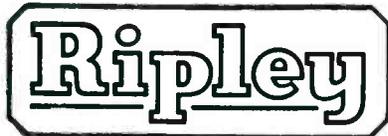
There is a light, compact, highly efficient L-R Blower giving you maximum heat dispersion under all climatic or temperature conditions. Each of these blowers requires minimum space and produces maximum C.F.M. Specifications are listed below so that you may choose the size best suited to your needs.

SPECIFICATIONS

MODEL 1½. Weight (without motor) ... 2½ ounces Output: 15 C.F.M. at 8000 R.P.M. Height 3"	MODEL 2½. (Illustrated) Weight (without motor) ... 5½ ounces Output: 50 C.F.M. at 8000 R.P.M. Height 4½"
MODEL 2. Weight (without motor) ... 5 ounces Output: 25 C.F.M. at 8000 R.P.M. Height 3¾"	MODEL 3. Weight (without motor) ... 12½ ounces Output: 260 C.F.M. at 8000 R.P.M. Height 6½"

All models have light-weight, high-impact plastic housings, turbo type wheels and are made with either clockwise or counter clockwise rotation.

Electronic



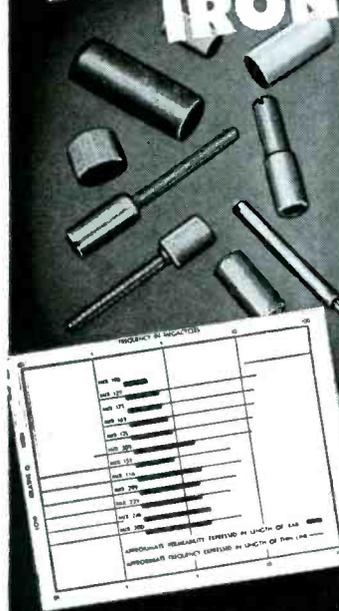
Controls

New York Office:
11 West 42nd Street

RIPLEY CO., INC.

Factory and Engineering Office:
Middletown, Conn.

MOLDITE IRON CORES



PERMEABILITY TUNING CORES

Moldite permeability tuning cores are manufactured to meet the most precise requirements. Modern mass production methods of manufacturing perm cores have resulted in increased quality and economy to our customers.

MOLDED IRON CORES

Moldite magnetic iron cores are manufactured to exact specification with an exclusive powder mix on each specific requirement at audio, broadcast, FM and Television frequencies. New formulae and methods of processing increase Q values, result in greater stability and density. "MOLDITE SAMPLE KIT" equips engineering labs with a complete stock of sample iron cores for all applications. Cores selected and ordered by identifying number will be duplicated exactly in production. Write for latest Moldite catalog and sample kit.

NATIONAL MOLDITE COMPANY

25 MONTGOMERY ST., HILLSIDE 5, N. J.

WESTERN REP.
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942 Maple Avenue
Los Angeles, Calif.

MID-WESTERN REP.
Irving Rose
314 No. Michigan Ave.
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SO. AMERICAN REP.
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Buenos Aires, Argentina

BRADLEY PHOTO ELECTRIC CELLS



Reduce Production Costs

Bradley Luxtron* photocells improve control over manufacturing operations, reducing your costs. They meet the most exacting requirements. Advanced manufacturing techniques make light-actuated Bradley cells the choice all over the world.

Luxtron photocells convert light directly into electrical energy. No external source of voltage is required. Besides the housed model shown with its plug-in contacts, Bradley also offers tube socket, nut-and-bolt types and pigtail contact mountings. In addition, Luxtron unmounted cells are available in many different sizes and shapes.

* U. S. PAT. OFF.

Illustrated literature, available on request, shows more models of Bradley photocells, plus a line of copper oxide and selenium rectifiers. Write for "The Bradley Line."

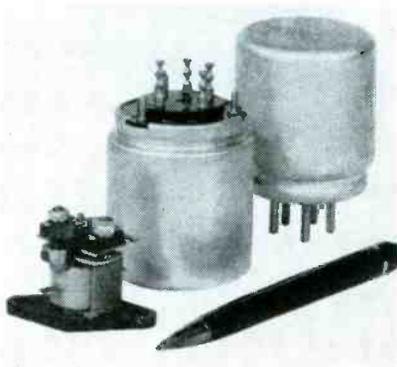
BRADLEY LABORATORIES, INC.

82 Meadow St. New Haven 10, Conn.

perior electrical characteristics are available in a wide range of voltage and capacitance. They can be furnished to close tolerances with housings either hermetically-sealed metal, glass or ceramic, or wax-sealed cardboard tubes.

Current-Sensitive D-C Relays (52)

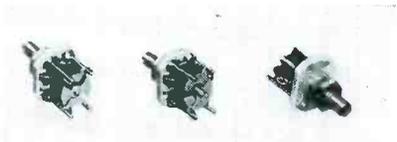
GENERAL ELECTRIC Co., Schenectady, N. Y. Eight types of single-pole, double-throw, current-sensi-



tive, d-c relays are announced. Input ratings range from 10 to 180 milliwatts, 0.47 to 1,470 milliamps, and 0.07 to 67,000 ohms. Additional information is given in GEA-3819D.

Air Variables (53)

E. F. JOHNSON Co., Waseca, Minn. A new line of air variable capacitors is available in single, differen-

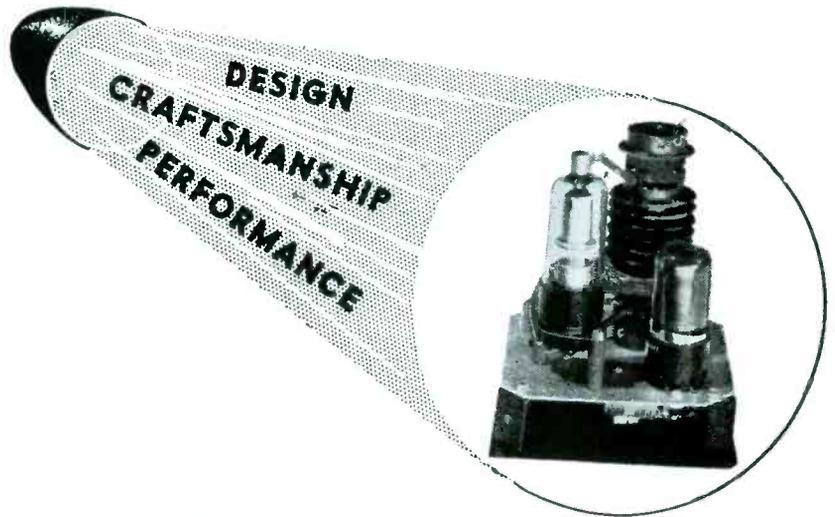


tial, and butterfly types. Each of the three is available in four different capacitances. All have single-hole mounting, steatite end frames, and beryllium copper contact springs. Full details are available from the manufacturer.

Power Triode (54)

RADIO CORP. OF AMERICA, Harrison, N. J. The 5671 is a forced-air-

SPOTLIGHTING Super TELEVISION HI-VOLTAGE POWER SUPPLY



Be sure to visit our booths No. 241 and 242 at the Radio Engineering Show of the 1948 I.R.E. National Convention, March 22-25, Grand Central Palace, New York.

Power supply coil is furnished in aluminum case

Super Electric precision components for the electronic industry give you the very best in design and craftsmanship techniques. Super's sixteen years of precision manufacturing assure you of strength, durability and top-notch performance.

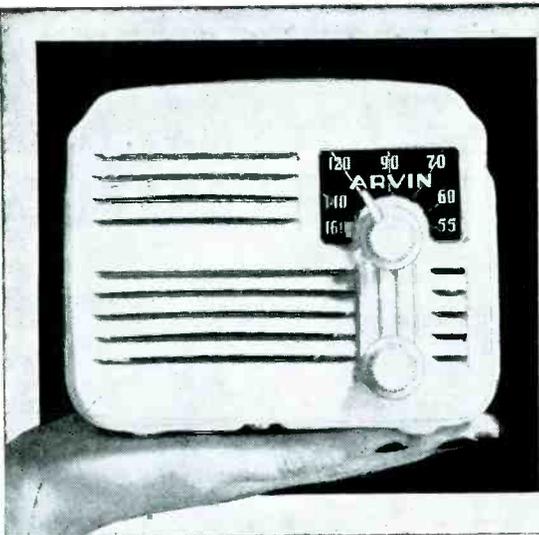
We welcome the opportunity to show you the gains from using Super-engineered components.

1. The illustrated television hi-voltage power supply is intended to provide D. C. voltage up to 10,000 volts at a current drain not to exceed 1 milliampere.
2. Model A supplies up to 7000 volts D. C. at 800 micro-amperes. Power input required: 300 volts D. C. at 50 milliamperes and 6.3 volts at .45 amperes.
3. Model B supplies up to 10,000 volts D. C. at 1 milliampere. Power input required: 360 volts D. C. at 90 milliamperes and 6.3 volts at .9 amperes.
4. These units are of the r. f. type and eliminate the hazards inherent in other types of high voltage power supply.

USE OF THE FOLLOWING SUPER ELECTRIC CO. COMPONENTS <i>Indicated by dots</i>	420 mmfRMA STANDARD GANG			365 mmfRMA STANDARD GANG			35 mmf	TELEVISION
	TUNING RANGE			TUNING RANGE			TUNING RANGE	
	535- 1620 kc	1.6- 5.6 mc	5.6- 19.25 mc	535- 1620 kc	2.0- 6.0 mc	6.0- 18.0 mc	88- 112 mc	
OSCILLATOR COIL	•	•	•	•	•	•	•	•
LOOP ANTENNA	•			•				
ANTENNA COIL	•	•	•	•	•	•		•
R-F INTERSTAGE TRANSFORMER	•	•	•	•	•	•	•	
BAND PASS ANTENNA COIL (Double Tuned)	•			•				
BAND PASS R-F COIL (Double Tuned)	•			•				

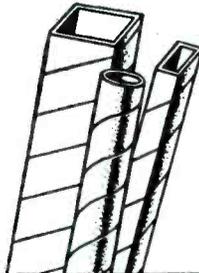
In addition to the components described, SUPER will build to customer specifications.

Super
ELECTRIC PRODUCTS CORPORATION
1057 Summit Avenue Jersey City 7, N. J.
PRECISION COMPONENTS



Paramount
PAPER TUBES
are used in winding coils for
ARVIN
RADIOS

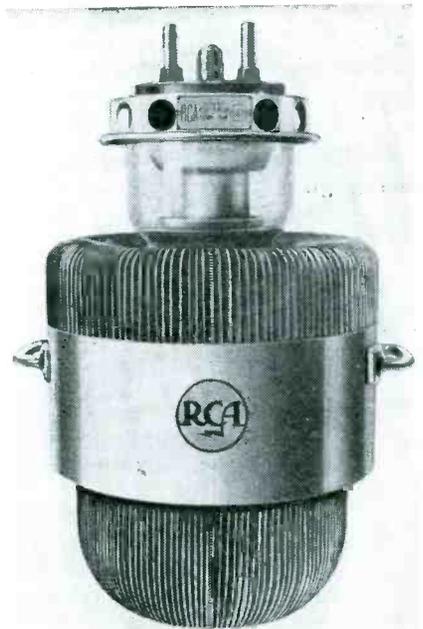
● This is typical of the wide use of PARAMOUNT paper tubes by leading manufacturers of electrical, radio and electronic products. With over 15 years of specialized experience, PARAMOUNT can produce exactly the shape and size tubes you need for coil forms or other uses. Square, rectangular, or round. *Hi-Dielectric, Hi-Strength, Kraft, Fish Paper, Red Rope*, or any combination, wound on automatic machines. Tolerances plus or minus .002". Made to your specifications or engineered for you.



SEND FOR ARBOR LIST OF OVER 1000 SIZES

Lists great variety of stock arbors. Includes many odd sizes. Write for Arbor List today.

Inside Perimeters from .592" to 19.0"



cooled power triode for high-power broadcast stations. It contains a thoriated-tungsten, multistrand filament.

PARAMOUNT PAPER TUBE CORP.

616 LAFAYETTE ST., FORT WAYNE 2, INDIANA

Manufacturers of Paper Tubing for the Electrical Industry

Burner Program (55)

COMBUSTION CONTROL CORP., 77 Broadway, Cambridge 42, Mass. Fireye program control type 24PJ8

BALLANTINE ELECTRONIC VOLTMETER, DECADE AMPLIFIER and MULTIPLIERS



since 1935 the only VOLTMETER featuring a simplified LOGARITHMIC SCALE

MODEL 300 ELECTRONIC VOLTMETER

MODEL 220 DECADE AMPLIFIER

MODEL 402 MULTIPLIER

10 MICROVOLTS to 10,000 VOLTS

ONE BILLION TO ONE—This enormous range of AC voltages—is easily covered by the Model 300 Voltmeter, Model 220 Decade Amplifier and Model 402 Multipliers illustrated above. The accuracy is 2% at any point on the meter scale, over a frequency range of 10 cycles to 150 kilocycles. The Model 300 Voltmeter (AC operated) reads from .001 volt to 100 volts, the Model 220 Amplifier (battery operated) supplies accurately standardized gains of 10x and 100x and the Model 402 Multipliers extend the range of the voltmeter to 1,000 and 10,000 volts full scale.

Descriptive Bulletin No. 10 Available

BALLANTINE LABORATORIES, INC. BOONTON, NEW JERSEY, U.S.A.



provides automatic starting and programming for commercial oil burning equipment. Full details of the equipment are given in Bulletin CD4751.

Mercury Contact Relay (56)

POTTER & BRUMFIELD MFG. Co., 549 West Washington Blvd., Chicago 6, Ill. has developed a mercury contact relay especially for current control in installations where there is danger due to ignition of fumes, dust or gas by arcs from open switches. The unit is sealed and

At last!

Practical data for designing AUTOMATIC CONTROL systems

Systematic design procedures -
Test procedures -
Working formulas, curves and diagrams -



Here, at last, is real, practical aid in designing servomechanisms—a presentation of theory, specific design procedures, and helpful test procedures, that will enable you to fulfill specified operating requirements, get the satisfaction you want from an automatic control system. The book analyzes various servo systems—those with viscous output damping, error-rate damping, integral control, etc. It presents scores of problems like those you actually encounter in servomechanism design, with the working formulas, curves and diagrams necessary for their solution.

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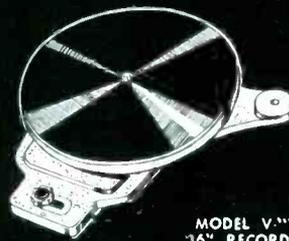
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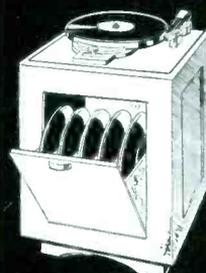
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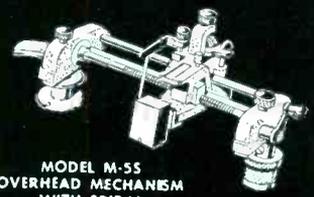
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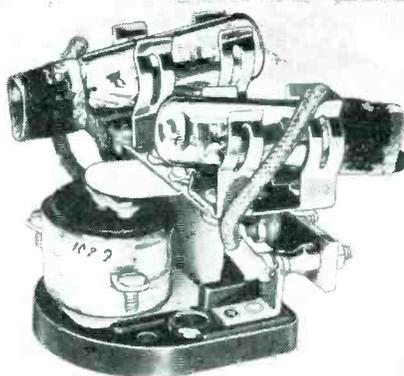
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(continued)



can be supplied for voltages up to 440 volts a-c or 230 volts d-c.

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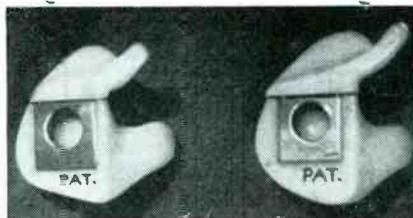
RADAR ENGINEERS, 1319 Second Ave., Seattle 1, Wash. Type RPS-3 regulated power supply furnishes



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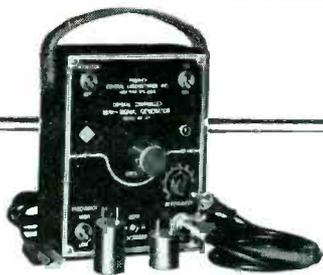
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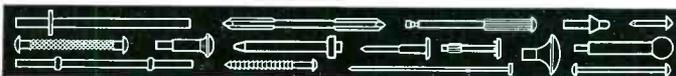
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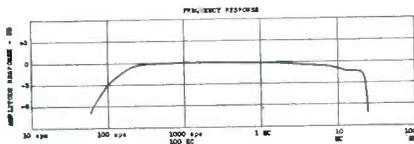


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NEW PRODUCTS

(continued)

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Television Film Pickup (59)

ALLEN B. DUMONT LABORATORIES, INC., 42 Harding Ave., Clifton, N. J. Model TA-512-A dual iconoscope



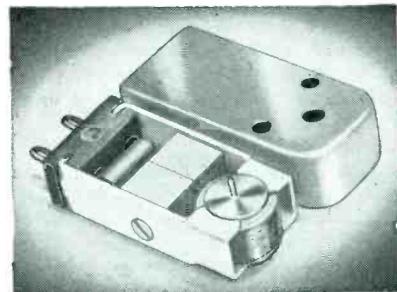
film pickup for which the control console is illustrated has been designed for the use of either positive or negative film on television programs. Electronic fading circuits are provided. The projection equipment is housed in wall cabinets.

Television Recorder (60)

EASTMAN KODAK Co., Rochester 4, N. Y. A 16-mm motion picture camera has been developed for use in television studios for recording movies directly from the face of a monitoring picture tube. Pictures are taken at the rate of 24 frames a second. The device can be used for reprogramming or for record purposes.

Variable Reluctance Pickup (61)

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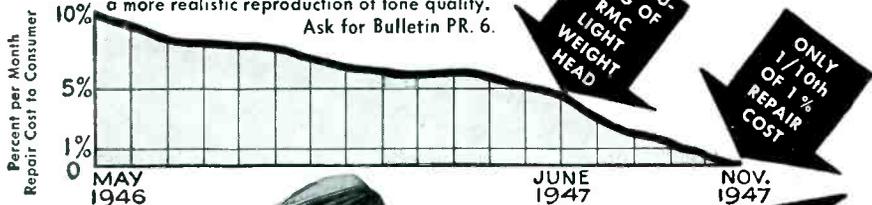
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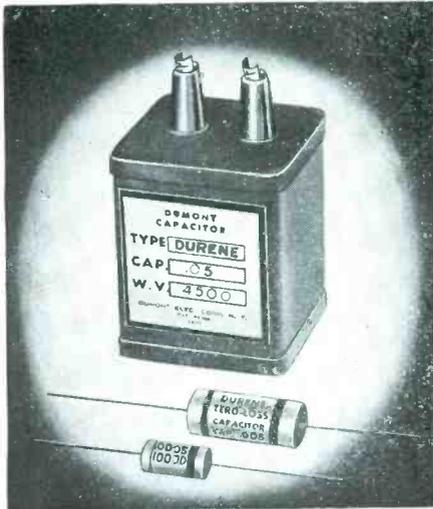
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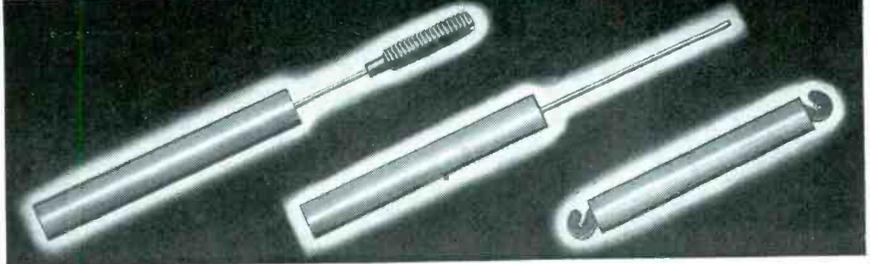
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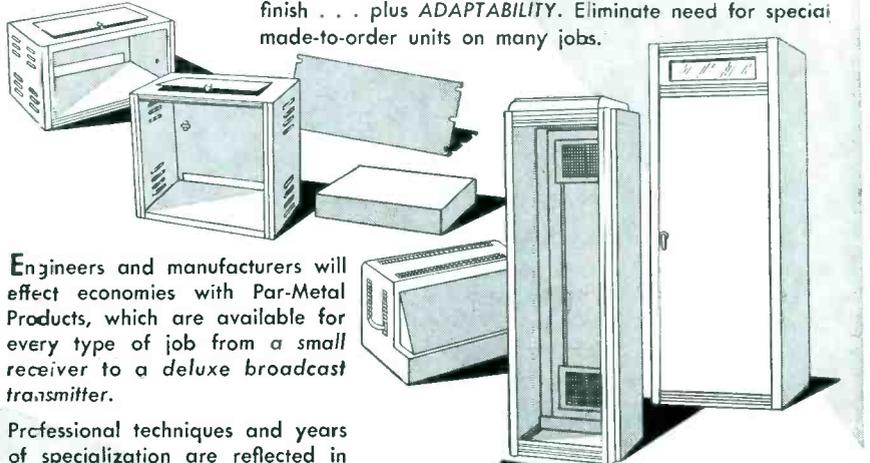
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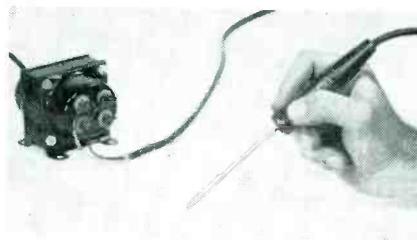
NEW PRODUCTS

(continued)

250, and 500 ohms. Output is 60 millivolts at 1,000 cycles with lateral displacement of 0.001 inch.

Midget Soldering Iron (62)

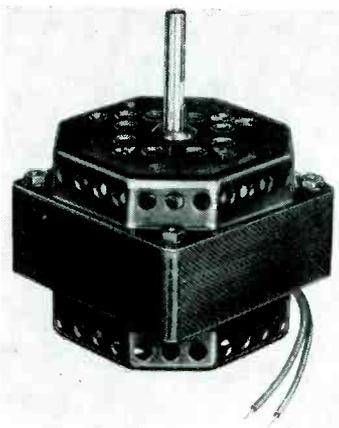
GENERAL ELECTRIC Co., Schenectady, N. Y. A new midget soldering iron is 8 inches long, has tips $\frac{1}{4}$ and



$\frac{1}{8}$ inch in diameter and weighs 1 $\frac{1}{2}$ ounce without the cord. It operates from 6 volts, consuming 25 watts and is illustrated with the step-down transformer used to adapt it to normal socket voltage.

Smooth Power Motor (63)

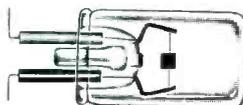
GENERAL INDUSTRIES Co., Elyria, Ohio. An improved model RM-4 small motor for use in wire and tape recorders has recently been an-



nounced. Features are freedom from vibration and magnetic field radiation, and minimum noise.

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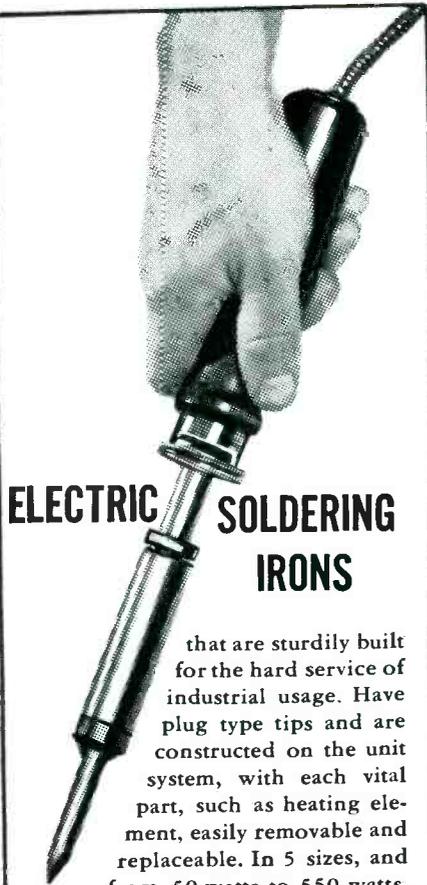
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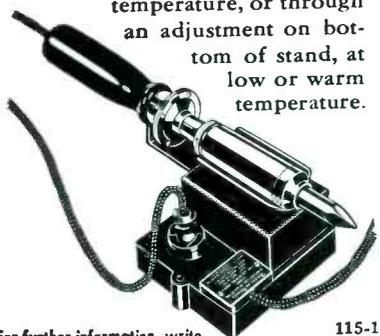
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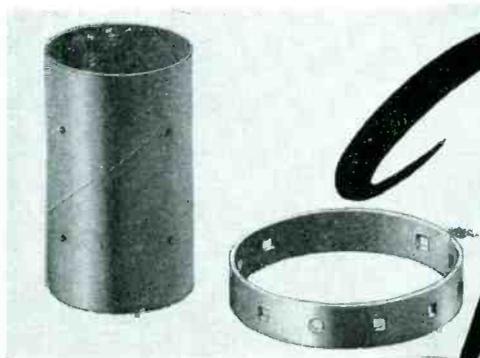
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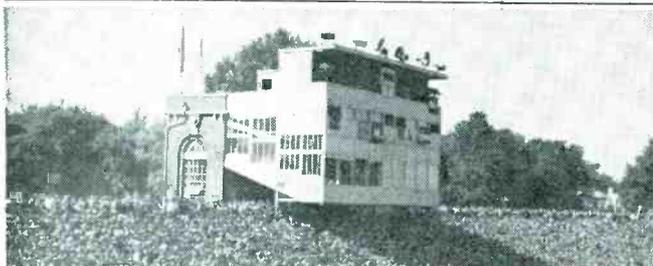


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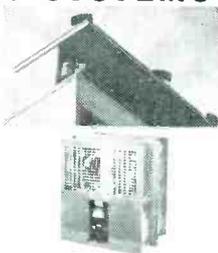
University of Michigan stadium, Ann Arbor, Mich. Altec Lansing large multicell horns driven by Altec Lansing 1/4 KW amplifier, are centralized over press stand, override noise level of 86,000 spectators. Reiss Public Address Systems, Detroit, contractors.

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Above: large multicell Altec Lansing speakers. Below: Altec Lansing 287W 1/4 KW Industrial amplifier.

N. Y. The type R radiation vacuum thermocouple now available generates about 356 microvolts from the heat of a lamp consuming 546 watts at a distance of 1 meter. Details are given in Bulletin V24.

Public Address Mike (65)

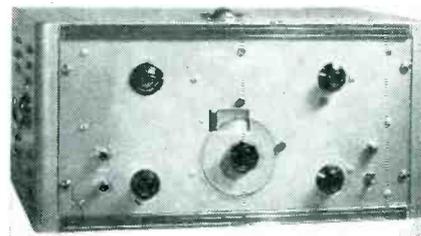
AMPERITE Co., INC., 561 Broadway, New York 12, N. Y. The new velocity microphone model RBHG (high impedance) and RBLG (50 to 200 ohms) has a frequency response



from 50 to 11,000 cycles within plus or minus 2 db. Output is minus 62 db. The ribbon itself has a peak at 10 cycles.

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GENERAL ELECTRIC Co., Syracuse, N. Y. Type YCL-1 r-f capacitometer measures capacitance at 75 kc directly from 0 to 1,000 micromi-



crofarads. Calibration charts allow the measurement of capacitance up to 20,000 micromicrofarads and of inductance up to 10,000 microhenrys.

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Let our engineers help de-
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Booth 202

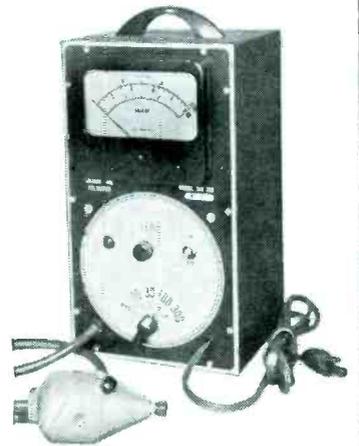
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March 22nd-25th inclusive.

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FLUSHING NEW YORK



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This new Signaling Timer electrically controls time intervals of industrial processes with laboratory exactness. When the interval is started, a red pilot light goes on. During the interval a pointer shows the exact time elapsed.



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At the end, the controlled circuit is automatically opened or closed and a buzzer sounds. Sockets allow additional lights or buzzers in remote locations.

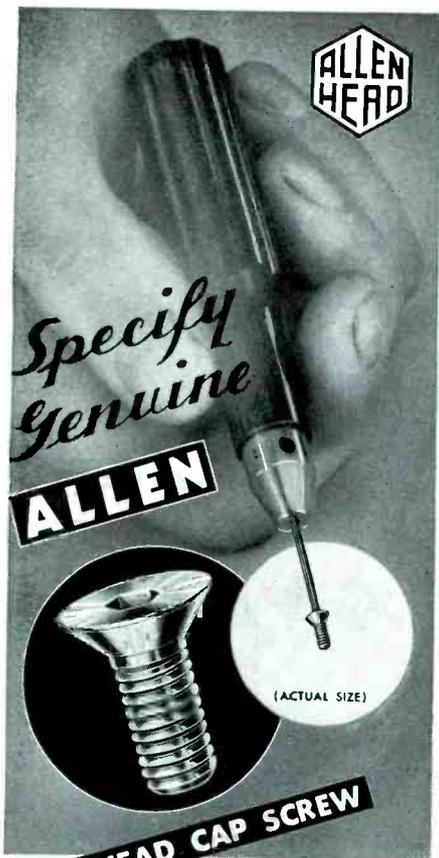
If you need accurate timing—plus visual and audible signal attention, write us today for literature on the versatile new Series S Signaling Timer. There is a model for your particular interval, voltage and frequency requirements.

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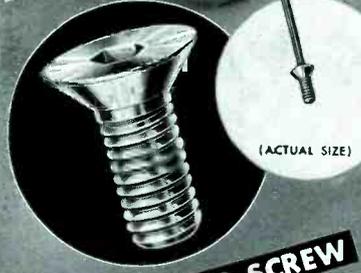
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FLAT HEAD CAP SCREW

Holds to Driver for fast assembling; Stays fast in flush set-ups

These advantages reach all the way down to the smallest "V"-Head Cap Screws made. Illustration shows a No. 4 (stock size "Allen") held on a "Handi-Hex" Allen Driver, — fastest fastening combination for small parts in electronic devices. Positive hex-socket wrenching achieves tight set-ups; threading to high Class 3 fit keeps them tight... Write us for informative

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NEW PRODUCTS (continued)

for measuring, recording and controlling liquid levels. No connectors are necessary from the outside to the inside of the containing vessel. This effect is accomplished by the penetrating effect of gamma rays from a radium source.

Wire Recorder (68)

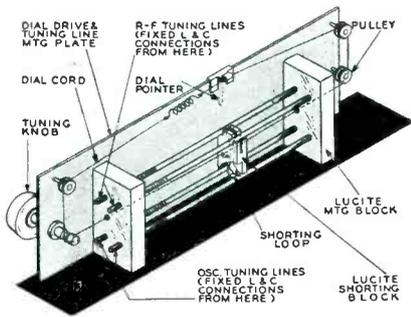
NATIONAL POLYTRONICS, INC., 162 Greenwich St., New York 6, N. Y. Model 5-A wire recorder complete



with self-contained amplifier and microphone is listed at \$79.50. The wire can be reused thousands of times as the machine automatically erases while re-recording.

F-M Tuner (69)

EDWARDS FM RADIO CORP., 168 Washington St., New York 6, N. Y. The Fidelotuner comprising two tunable lines and a movable short-



ing block is now available for experimenters who desire to build f-m tuners.

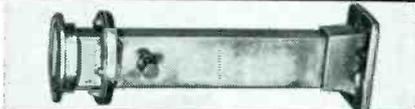
Decade Oscillator (70)

MUIRHEAD & Co., LTD., Elmers End, Beckenham, Kent, England. Decade

FOR LUGS AND TERMINALS



FOR RADAR PLUMBING



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FOR ALL CURRENT-CARRYING CONNECTIONS

YOU CAN'T BEAT -- SIL-FOS and EASY-FLO BRAZING

These two Handy & Harman patented low-temperature silver brazing alloys give you everything you want in making electric current-carrying joints. For joints brazed with SIL-FOS and EASY-FLO . . .

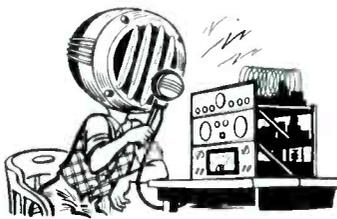
1. are high in electrical conductivity
2. are strong as the joined metals themselves, with the ductility to withstand severe vibration, shock and temperature changes.
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Well liked by amateurs, home recording fans, and special P. A. users. Slightly rising frequency characteristic aids voice clarity. A real all weather performer. Thrifty too! High impedance.



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MOLDED

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The "All-Weather" Resistors

Of particular interest to all who need resistors with inherent low noise level and good stability in all climates



TYPE 65X

Actual Size

STANDARD RANGE

1000 OHMS TO 15 MEGOHMS

Used extensively in commercial equipment including radio, telephone, telegraph, sound pictures, television, etc. Also in a variety of U. S. Navy equipment.

HIGH VALUE RANGE

15 to 1,000,000 MEGOHMS

This unusual range of high value resistors was developed to meet the needs of scientific and industrial control, measuring and laboratory equipment—and of high voltage applications.

SEND FOR BULLETIN 4505

It gives details of both the Standard and High value resistors including construction, characteristics dimensions, etc. Copy, with Price List mailed on request.



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FLEXIBLE SHAFTS • FLEXIBLE SHAFT TOOLS • AIRCRAFT ACCESSORIES
SMALL CUTTING AND GRINDING TOOLS • SPECIAL FORMULA RUBBERS
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MODEL 204A—REGULATED POWER SUPPLY

0-500 Volts D.C. at 300 Ma. with Positive or Negative Ground

The Model 204A Regulated Power Supply will provide from 0-500 volts of well regulated and well filtered D.C. The output voltage is continuously variable without switching and either positive or negative side may be grounded.

Specifications:

OUTPUT VOLTAGE

High Voltage: 0-500 Volts D.C. continuously variable (Without switching). Current: 300 Ma.
Low A.C. Voltage: 6.3 Volts A.C. at 6 amps. center-tapped, unregulated.

REGULATION

Within 1% for voltage between 30-500 volts, from no load to full load.
Within 1% for line voltage variations from 105 to 125 volts at full load current for any voltage between 30-500 volts and within 2% at 10 volts.

HUM VOLTAGE

Within 10 Millivolts at any voltage or load with ratings.

LINE INPUT

105-125 Volts A.C. 50-60 cycles.

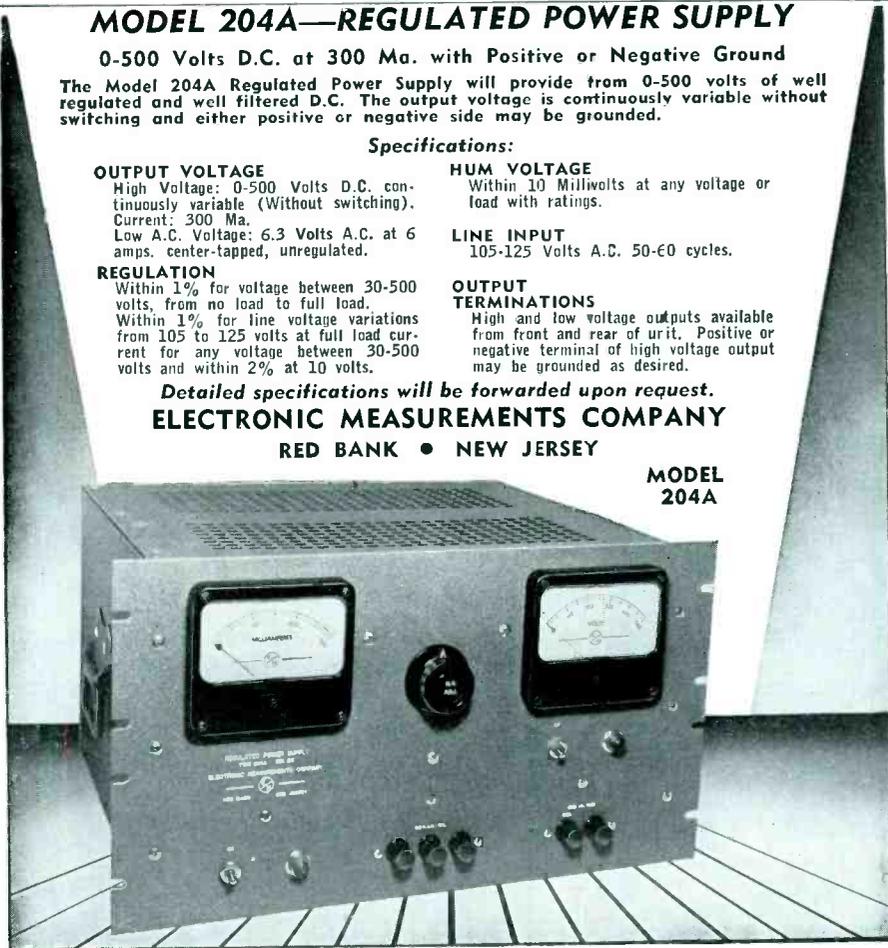
OUTPUT TERMINATIONS

High and low voltage outputs available from front and rear of unit. Positive or negative terminal of high voltage output may be grounded as desired.

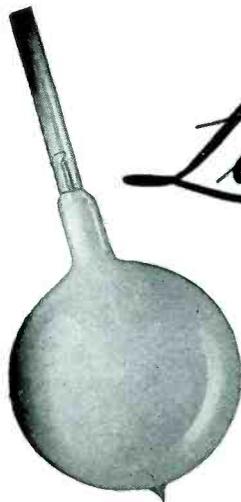
Detailed specifications will be forwarded upon request.
ELECTRONIC MEASUREMENTS COMPANY

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MODEL 204A



Linde



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NEON
XENON

and Standard or Special MIXTURES

LINDE rare gases are spectroscopically pure—argon, helium, neon, and standard mixtures are available in one- and two-liter glass bulbs and in cylinders; xenon and krypton are available in liter and fractional-liter bulbs.

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Unit of Union Carbide and Carbon Corporation
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Model 250

A device for generating a test signal particularly useful for examining the transient and frequency response of audio circuits.



B & W FREQUENCY METER

Model 300

An accurate and convenient means of making direct measurements of unknown audio frequencies up to 30,000 cycles. Integral power supply.



B & W AUDIO OSCILLATOR

Model 200

A source of stable, accurately calibrated frequencies between 30 and 30,000 cycles. Self-contained power supply.



B & W DISTORTION METER

Model 400

Ideal for measuring low level audio voltages and determining their noise and harmonic content. Self-contained power supply.



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These Amrecon multiple purpose relays are designed for either A.C. or D.C. operation. Each is available in a variety of contact combinations and capacities. Most units are available in light and heavy duty contacts nominally rated from 5 to 15 amps, 115 volts A.C., noninductive. Others are rated as high as 50 amps, at 115 volts A.C., noninductive. The relays illustrated are but a few of our many types.

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NEW PRODUCTS

(continued)

oscillator type D-105-A has a frequency range from 1 cycle to over 100 kilocycles. This resistance-capacitance type instrument is described in bulletin B-528-D. It is operated from 200 to 250 volts, 50 cycle through a magnetic-type a-c stabilizer.

Variable A-C Unit (71)

SUPERIOR ELECTRIC Co., Bristol, Conn. The new Voltbox is a portable source of a-c voltage and comprises a variable autotransformer mounted on a special aluminum base equipped with outlets and switches as well as a meter.

Literature

(72)

Capacitors. Cornell-Dubilier Electric Corp., South Plainfield, N. J. More than twenty different classes of capacitors are described in detail and illustrated in the new 24-page catalog No. 200. The handy reference book also includes list and net prices.

(73)

Technical Bulletins. Radio Corp. of America. Single page technical bulletins are available on each of four new additions to the tube line. The new tubes are the 6AV6, 12AV6, 5618, and 5652.

(74)

Magnetic Phonograph Pickups. Lear, Inc., 11916 West Pico Blvd., Los Angeles 34, Calif. The design of new magnetic recorder heads which may be used for stainless steel wire recordings is described in a 4-page reprint. Schematics and response curves are included.

(75)

Transformers. Raytheon Mfg. Co., Waltham 54, Mass. General design data is listed in a four-page brochure on transformers, reactors, and saturable magnetic components.

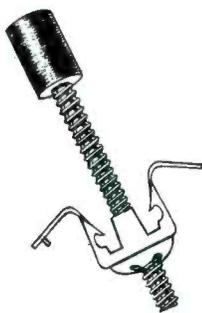
(76)

Wire Recording Heads. Lear, Inc., 11916 West Pico Blvd., Los Angeles 34, Cal. Two sheets give ample

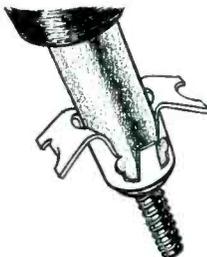
**Big Savings with
PALNUT
Coil Tube Fasteners**



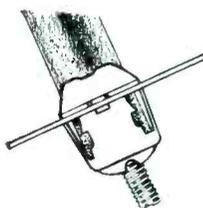
DOES 3 JOBS!



1. Provides required tension on iron core adjusting screw to maintain accurate setting, thru use of specially designed "Palnut" thread form.



2. Provides support for the RF or IF coil tube. All coil tube length above chassis is usable electrically, as fastener does not extend above chassis.



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SAMPLES of this speedy, efficient "Palnut" Coil Tube Fastener, plus engineering data, sent upon request on your business stationery.

The PALNUT Co.

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NEW PRODUCTS

(continued)

coverage of performance data and installation specifications for the magnetic wire recording head WH-200 and reproducing WH-201.

(77)

Commercial Crystals. Bliley Electric Co., Erie, Pa. Bulletin 36 is a well-illustrated, complete listing of all except amateur types of quartz crystals for all types of commercial applications.

(78)

Remote Shaft Rotation. Ford Instrument Co., Inc., 31-10 Thomson Ave., Long Island City 1, N. Y. Telesyn and other motors are described in 16 catalog pages. Bulk of the information concerns apparatus for remote control of shaft rotations.

(79)

Fixed Radiophone. Belmont Radio Corp., 5921 West Dickens Ave., Chicago 39, Ill. Model US 20-1 fixed station radio equipment is a compact 20-watt unit for use in conjunction with a mobile radiophone. Its specifications are listed in a four-page booklet.

(80)

Constant Voltage Transformers. Sola Electric Co., 2525 Clybourn Ave., Chicago 14, Ill. Bulletin CV-102 gives construction and operating theory, as well as a wide variety of data and a complete catalog of standard constant voltage transformers.

(81)

Radioassays. Tracerlab, Inc., 55 Oliver St., Boston 10, Mass. In volume No. 7 of Tracerlog are found a complete description of radioassay procedures. Three pages are devoted to the SC-9A manual sample changer with pre-amplifier, designed to standardize radioactivity analyses.

F-M Servicing. General Electric Co., Syracuse, N. Y. A handy 28-page booklet (ESD-21) on f-m servicing, well-illustrated with schematics, block diagrams, sketches and curves, is available from distributors for twenty-five cents.

Silicone News



DC Silicones Help Maintain High Performance Standards of Portable SoundScriber



DC 33 Silicone Grease permanently lubricates portable SoundScriber gear drive. DC 4 Compound damps vibrations in playback head.

A portable recording machine that can be used in your car is obviously subject to operation in extremes of temperature. Yet turntable speeds are critical. The SoundScriber Corporation, New Haven, Connecticut, has solved this problem with a sealed gear drive mechanism permanently lubricated with DC 33 Silicone Grease.

Here are the benefits reported from the use of DC 33 Silicone Grease in the drive mechanism:

1. It eliminates the need for relubrication; DC 33 does not evaporate or dry out.
2. DC 33 retains its consistency and provides effective lubrication at temperatures ranging from -95° to 300° F. It therefore permits the motor to start easily and operate satisfactorily when cold; it does not thin out and leak through bearing joints at high temperatures as do other greases or oils having a low enough torque at low temperatures.

And here are the advantages of DC 4 Silicone Compound as used in the playback heads of all models of the SoundScriber:

1. It effectively damps the moving coil of this playback uniformly at any temperature—giving an "oil damping" effect without requiring elaborate sealing devices.
2. DC 4 is inert to most organic materials. It can, therefore, be used in direct contact with the rubber supports in the playback heads. Dow Corning Silicone Products are notably indifferent to temperature changes. They possess other unique properties that may be even more useful to you. We've had nearly five years' experience in the commercial production of Silicone Greases, Fluids, Resins, and Silastic*. Telephone the branch office nearest you for engineering assistance, or write for Catalog N1-3.

*TRADEMARK FOR DOW CORNING SILICONE RUBBER

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MIDLAND, MICHIGAN**

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In Canada: Fiberglas Canada, Ltd., Toronto
In England: Albright and Wilson, Ltd., London



ELECTRICAL INSTRUMENTS for Laboratory & Plant



WHEATSTONE & KELVIN BRIDGES

Eighteen models covering laboratory, plant and field applications. Ranges from 0.00001 ohm to 100 megohms. High accuracy. Exceptionally sturdy construction. Bulletin 100.

GALVANOMETERS

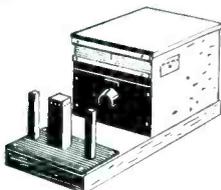
Fifty-one models in a wide range of sensitivities for nearly every application. Spotlight Galvanometers with sensitivities up to 0.0006 μ A per mm. Widely used in laboratory and production line testing, for deflection as well as null measurements. Bulletin 320.

PRECISION POTENTIOMETERS

Twenty-seven laboratory and portable models for precise voltage measurement. Widely used as laboratory standards in meter calibration and for thermocouple measurements. Bulletin 270.

COIL TESTERS

For rapid low-cost production testing of shorts and opens in coil windings of nearly every shape and size. Bulletin 109.



LIMIT BRIDGES

For rapid low-cost production testing of resistors from 1 ohm up to 10 megohms. Bulletin 100.

DECADE RESISTANCE BOXES

Thirty-five models covering the range from 0 to 100,000 ohms. Decade Resistors with increments down to 0.01 ohm available. Exceptionally sturdy construction assures long-term accuracy. Bulletin 100.



STANDARD RESISTORS

Reichsanstalt and National Bureau of Standards types from 0.001 ohm up to 10,000 ohms, limit of error 0.02% and 0.01%. Standard shunts from 0.00002 ohm to one ohm, limit of error 0.04%. Bulletin 100.

SPECIAL INSTRUMENTS

In addition to the partial listing of instruments above, the Rubicon Company produces a wide variety of special equipment involving in one way or another the precise measurement or control of some electrical quantity. Inquiries for equipment to meet special needs are invited.

RUBICON COMPANY

Electrical Instrument Makers
3757 Ridge Avenue • Philadelphia 32, Pa.

NEWS OF THE INDUSTRY

(continued from p 148)

may be obtained from the U. S. Naval Observatory, Washington 25, D. C.

The Canadian Dominion Observatory (Ottawa) broadcasts time signals continuously over station CHU on frequencies of 3,330, 7,335 and 14,670 kc; and at certain hours over other stations located at Ottawa, Halifax, and Churchill. Information may be obtained by writing the Dominion Observatory, Ottawa, Canada.

A comprehensive list of United States and foreign radio time signals is given in chapter 3 of "Radio Navigational Aids", Hydrographic Office publication No. 205, for sale by the Hydrographic Office, Washington 25, D. C., price \$1.25.

IRE Convention Space Increased

HALF of the third floor of Grand Central Palace in New York City will be used for exhibits at the IRE 1948 Engineering Show, March 22-25, in addition to the first two floors. Radio-electronic Frontiers, the theme of the 1948 Show, will focus attention on the new progress and markets of the industry. The technical program this year consists of 130 papers in 26 sessions, plus two special symposia.

Electronic Warfare Training

FORMATION of an extensive electronics warfare program for the Reserves has been planned by the U. S. Marine Corps. The program will stress training in the fields of gea for aircraft, pilotless aircraft, radar, and television. Units will be concentrated geographically in areas where the electronic industry flourishes. Candidates will be chosen on the basis of their technical background, professional skill, and willingness to enroll in study courses in their chosen fields.

Plans are made for 560 units (each composed of an officer and nine enlisted men): 10 special tactical; 250 radar, missile, and pilotless aircraft; 200 radio and communication; 100 telephone communication.

A nationwide Marine Corps Reserve Radio Network will be set



**MICRODIMENSIONAL
WIRE & RIBBON
FOR VACUUM TUBES**

WOLLASTON PROCESS WIRE

drawn as small as .000010";

Made to your specifications for
diameter and resistance . . .

WRITE for list of products.



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COME!



HEAR— over 100 excellent technical papers on research and engineering, covering the new "Radio-Electronic Frontiers."

SEE— 175 exhibits of radio components, parts, instruments, sound systems and transmitters.

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THE INSTITUTE OF RADIO ENGINEERS, Inc.
1 East 79th St., New York 21, N. Y.

IN-RES-CO WIRE WOUND RESISTORS

WL 5/8-5/8" x 3/16" (Radial Lead) .01 Ohms min. 3,000 Ohms max.
WLA 5/8-5/8" x 3/16" (Axial Lead) .01 Ohms min. 3,000 Ohms max.



WL-1" x 3/16" (Radial Lead) { .01 Ohms min.
WLA-1" x 3/16" (Axial Lead) { 10,000 max.

New Economy Line!

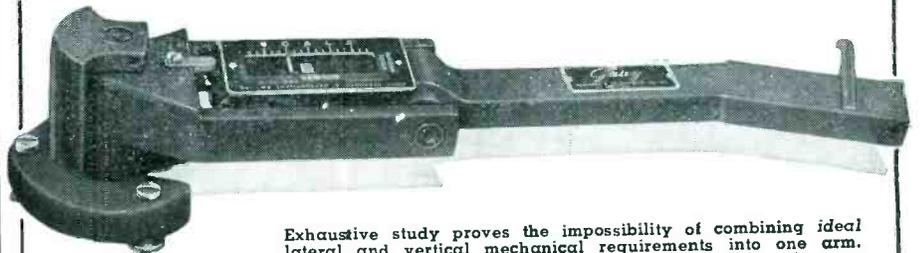
Here's a new line of resistors priced for real economy. Wire wound to a tolerance of 1% — higher accuracy on special order at slightly higher cost. Write today.

INSTRUMENT RESISTORS CO.

1036 COMMERCE AVE.
UNION, NEW JERSEY

APPLICATION-DESIGNED RESISTORS!

For the finest lateral reproduction the GRAY TRANSCRIPTION ARM



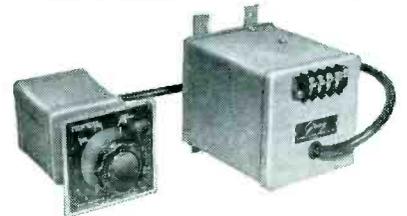
Featherweight magnesium, frictionless motion, adjustable stylus pressure, self-leveling base.

Exhaustive study proves the impossibility of combining ideal lateral and vertical mechanical requirements into one arm. The Gray Transcription Arm, designed for finest lateral reproduction accommodates all modern cartridges—General Electric, Pickering, etc.—has been adopted as standard equipment by national radio networks including CBS, ABC and numerous independent radio stations. Arm less cartridge \$35.00.

DIAMOND G.E. CARTRIDGES!

At last a permanent solution to the quality pick-up problem. We can now supply a Selected G.E. Cartridge with finest quality Diamond Stylus for mounting in the Gray Transcription Arm. The practically unlimited life of the Diamond Stylus makes it an exceptionally economical investment at \$29.63 net to radio stations.

Gray Equalizer For G.E. Cartridge



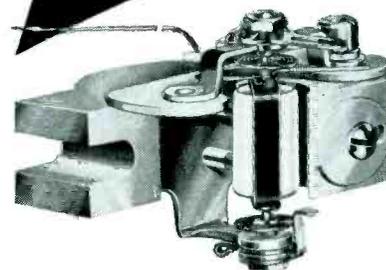
FOR RADIO STATION USE. No. 601, 4-position Equalizer (Flat, N.A.B., etc., etc.) expertly engineered for use with the G.E. Variable Reluctance Cartridge. Matches pick-up to microphone channel. Adopted by radio networks. Complete \$42.50.

GRAY RESEARCH & DEVELOPMENT CO.
ELMSFORD 6 • WESTCHESTER COUNTY • NEW YORK

ONE OF A SERIES

ALNICO MAGNETS

WHY BURLINGTON PANEL INSTRUMENTS PROVIDE UTMOST RELIABILITY . . .



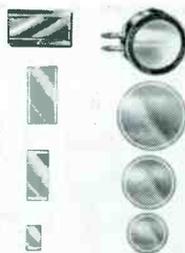
MAGNETS OF ALNICO are standard for all DC instruments because it is the most stable magnetic material available, having greatest resistance to effects of stray magnetic fields, vibration, shock and heat. All ranges AC and DC available in 2 1/2", 3 1/2", 4 1/2", rectangular or round case styles and are fully guaranteed for one year against defects in workmanship or material. Refer inquiries to Dept. F-38.



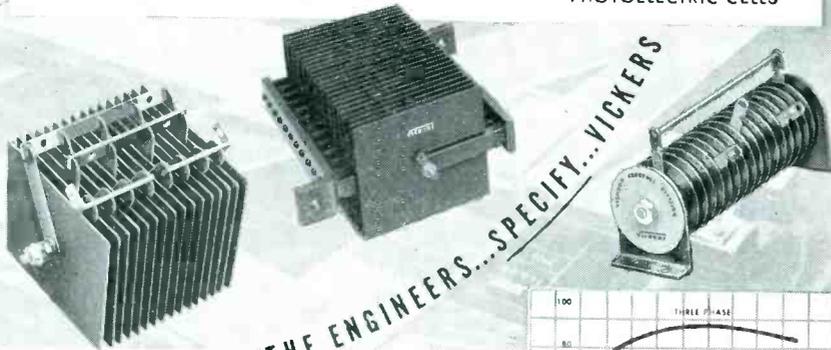
INSTRUMENT COMPANY
BURLINGTON, IOWA

LINKING FUNCTION TO DESIGN

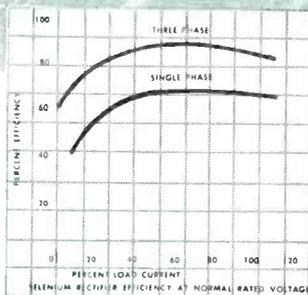
Engineers and Designers who insist on dependable components have adapted Vickers Selenium Rectifiers into their circuits. They are specifying Vickers products, and are submitting their rectifier problems to us. Our greatly expanded plant facilities, plus the recognized dependability of Vickers products, make it possible for us to offer the most complete line of Selenium Rectifiers and self-generating Photoelectric Cells.



PHOTOELECTRIC CELLS



FOLLOW THE ENGINEERS... SPECIFY... VICKERS



3-1

VICKERS ELECTRIC DIVISION



2160 EAST IMPERIAL HIGHWAY • EL SEGUNDO, CALIF.

EXPORT: Frazer & Hansen, Ltd., 301 Clay St., San Francisco 11, Calif.

CANADA: Powertronic Equipment Ltd., 494 King St., E. Toronto 2, Canada

FREQUENCY MODULATED SIGNAL GENERATOR



MODEL 78FM

86-108 MC

Also Available For Other Frequency Ranges



1 to 100,000 MICROVOLTS

Variable Output

With Negligible Carrier Leakage

MODULATION: 400 cycle internal audio oscillator. Deviation directly calibrated: 0 to 30 kc. and 0 to 300 kc. Can be modulated from external audio source.

Audio fidelity is flat within 2 db from dc to 15,000 cycles. Distortion less than 1% at 75 kc. deviation.

The Model 78FM when used with Measurements Model M-275 Converter provides output in the IF ranges of 4.5, 10.7 and 21.7 mc.

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- Standard Signal Generators
 - Pulse Generators
 - FM Signal Generators
 - Square Wave Generators
 - Vacuum Tube Voltmeters
 - UHF Radio Noise & Field Strength Meters
 - Capacity Bridges
 - Megohm Meters
 - Phase Sequence Indicators
 - Television and FM Test Equipment

MEASUREMENTS CORPORATION

BOONTON NEW JERSEY

up to function in conjunction with the Naval Reserve Communication net.

Reservists will receive instruction in all phases of electronics through correspondence courses, lectures, training films and recordings. Units will be provided with the latest equipment necessary for thoroughly training personnel in operation, maintenance, and tactical application. Training will also include field trips to both civilian and military electronic laboratories, manufacturing plants, radio communication facilities, and telephone companies.

Individuals interested in participation in this program may obtain complete information from the nearest Marine Corps Reserve activity, or by writing to the Electronic Warfare Section, Division of Reserve, Headquarters, U. S. Marine Corps, Washington 25, D. C.

Research Corporation Awards

AS THE RESULT of a National Research Council survey of the undergraduate origins of those receiving a Ph.D. in physics over a 10-year period, two men were given special awards by Research Corp. (holder of Cottrell electrical precipitation patents and other donated patents). A. A. Knowlton, professor of physics at Reed College, Portland, Oregon, received a special award for his record of stimulation and inspiration of undergraduates for three decades. Clifford N. Wall, who left North Central College at Naperville, Illinois in 1944 for a permanent physics staff appointment at the University of Minnesota, was likewise specially awarded with a plaque and honorarium of \$1,000.

Lee DuBridge, now president of the California Institute of Technology, was voted an annual award in recognition of his scientific contributions in the field of radar and his outstanding administration of the wartime microwave laboratory. The other annual award was presented to Merle A. Tuve of the Carnegie Institution of Washington, for scientific contributions in

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For use in computing and analyzing devices; generation of low frequency saw tooth and sine waves; controls for radio and radar equipment; position indicators; servo-mechanisms; electro medical instruments, measuring devices—telemetering; gun fire control where 360° rotation, high precision and low noise levels are essential.

The type RL14MS sinusoidal potentiometer is illustrated. It is wound to a total resistance of 35,400 ohms and provides two voltages proportional to the sine and cosine of the shaft angle. It will generate a sine wave true within ±.6%. Overall dimensions are 4 3/8" diameter x 4 11/32 long plus shaft extension 1/4" diameter x 1 1/4" long.



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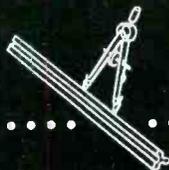
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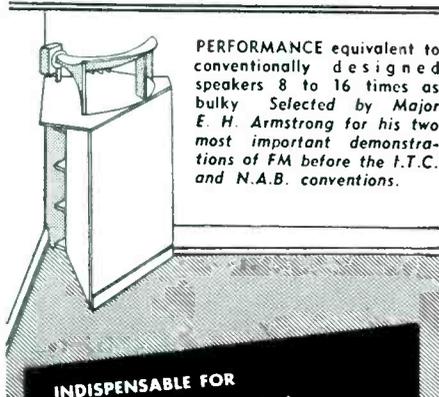
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30 to 15,000 cycles



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making possible the proximity fuze and outstanding administration of the groups which equipped the armed forces with this device.

Navy Aids to Research

UNDER its electronics program during the fiscal year 1947 the Office of Naval Research helped the following laboratories to convert to peacetime basic research: Cruft Laboratory at Harvard, using the Radio Research Laboratory; Research Laboratory of Electronics at MIT, using facilities of the Radiation Laboratory; Insulation Research Laboratory at MIT, to initiate research on insulation material with special emphasis on dielectrics.

Research under ONR contracts has been started on direction finding, nonlinear devices with special attention to magnetic amplifiers, and observation of electromagnetic radiation in the radio frequency spectrum from the Milky Way, the sun, and other celestial bodies.

New research tools have come into use for studying superconductivity and ferromagnetism at microwave frequencies. Ultrasonic power can now be generated at frequencies as high as 1,000 mc, with possible applications to moving target indicator problems and storage requirements in digital computers. Microwave techniques have proven useful in the construction of linear accelerators for nuclear research.

The Naval Research Laboratory reported production of a c-r tube for storing signals indefinitely, a simulator tube, a new type of microwave oscillator, and a sealed model of a high-power magnetron. It also engaged in much research in communications in general, radio techniques, search radar countermeasures, and systems utilization.

The NRL Radio Division originated, and demonstrated for the first time during the past year, two basically new radar tracking systems. Also developed were two subminiature ten-channel pulse-time airborne telemetering systems, and multichannel communication equipment for the 225-400 mc range.

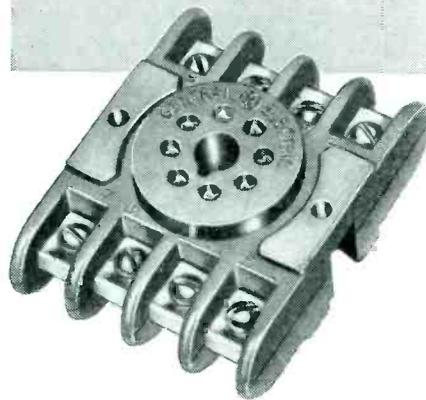
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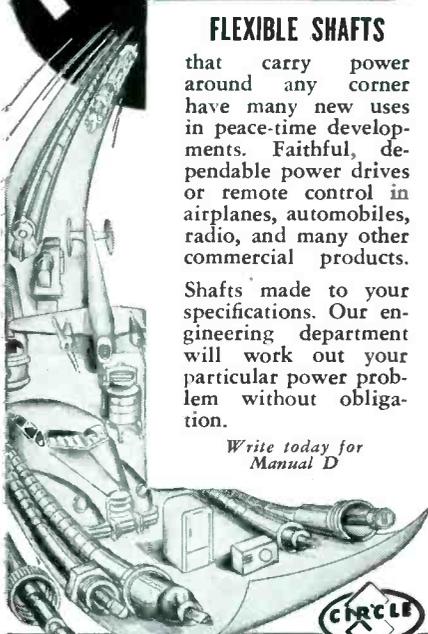
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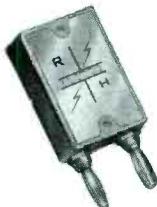
CRYSTALS



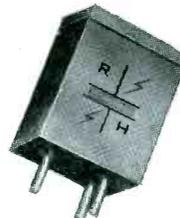
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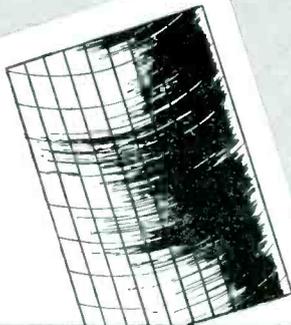
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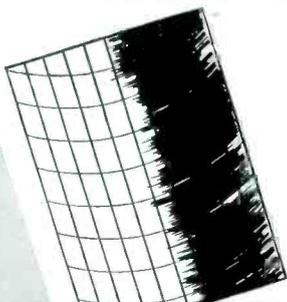
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NEWS OF THE INDUSTRY (continued)

tion led to the development of new types of crystals and a special technique for growing quartz crystals.

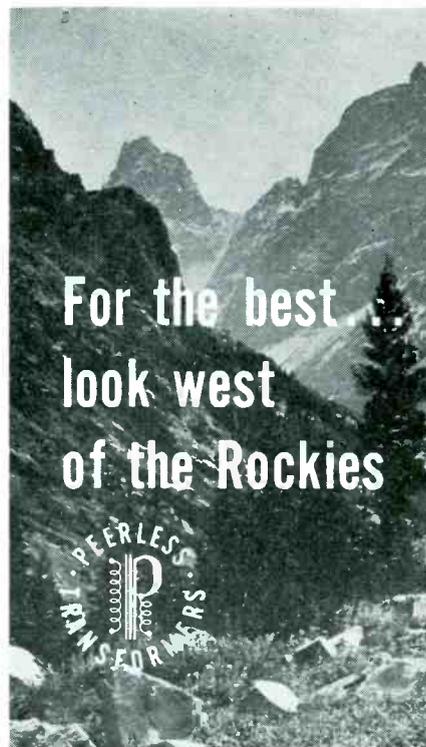
SAE Report on Automotive Radio Installations

THE SOCIETY OF AUTOMOTIVE ENGINEERS has published a 45-page report dealing with applications of two-way radio communication to the operation of automotive fleets. A subcommittee of the society, composed of truck fleet operators and 23 engineers from the communications and automotive industries and headed by W. C. Baylis, communications engineer of the New York Power and Light Corp., collaborated in the preparation of the report.

Subjects studied and reported on include selection of automotive generators and batteries to accommodate the increased load due to the radio equipment; physical description of radio equipment and the space requirements for its installation; antenna space and mounting requirements; selective calling systems; safety features to be included in the design and installation of equipment; licensing of operating personnel. Charts and sample calculations to aid in determining generator and battery requirements are incorporated in the report along with tables of weights and dimensions of typical two-way radio equipments.

Range of Reliable Communication

General conclusions were reached by the subcommittee as to the range of reliable communication that can be had in the three frequency bands available for mobile communication. In the 30-44-mc band, with 250 watts of transmitter power at the fixed station, ranges of 10 to 15 miles can be obtained. In open country, with favorable conditions, this range will increase to 40 to 50 miles. The 152-162 mc band will provide ranges of 8 to 10 miles in cities and 25 to 35 miles in open country. This high-frequency band appears to be less influenced by obstructions in urban areas than does the 30-44-mc band. The more recently available frequency band of 72-76-mc was given only limited tests, but appears to have a range comparable to that of the 30-44-mc



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band and noise level typical of the 152-162-mc band.

Cost of the 30-44-mc equipment was about \$500 at the time the report was prepared, while that of the 152-162-mc gear was \$600. The cost of 72-76-mc equipment is between these two figures. These estimates do not include the cost of selective calling equipment, installation expenses, nor the cost of changes to existing automotive electrical equipment that may be necessary in making a radio installation.

Copies of the report may be had from the Society of Automotive Engineers, Inc., 29 West 39th St., New York, N. Y. Price is \$2.00 to nonmembers of the SAE and \$1.00 to members.

BUSINESS NEWS

TELEX, INC., Minneapolis, Minn., has added to its hearing aid laboratory an annex 10,000 sq ft in area and two stories high, to house the tool and die and precision plastic divisions.



New annex of Telex, Inc.

MICROWAVE EQUIPMENT Co. recently opened a new showroom and general offices at 397 Bloomfield Ave., Verona, N. J. Manufacturing facilities are being expanded to include test components for the microwave frequencies.

THE NATIONAL ASSOCIATION OF RELAY MANUFACTURERS held its first annual meeting on January 16 and 17, in Chicago. A complete report of its progress in standardization of specifications and nomenclature for electrical relays was given.

WIRE RECORDING CORP. OF AMERICA has taken over the assets and manufacturing facilities of St. George Recording Equipment Co. of New York City. The new plant is at 1331 Halsey St., Brooklyn, N. Y.

MANUFACTURERS of precision instruments converted to the new absolute ohm, as adopted by the International Committee of Weights

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115 Volts
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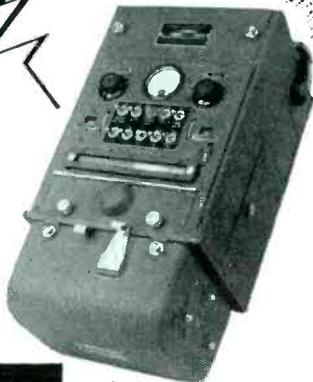
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Specially developed for recording in flight, the TYPE S12-A OSCILLOGRAPH is ideal for operation under acceleration or vibration. The S12-A is a complete instrument with internal governor motor, gear-driven record, timing device, record numbering, automatic record-length control, and record footage indicator. Case is rigid cast aluminum only ten inches wide by 18 inches long. Complete instrument weighs only 35 pounds.



Hathaway
Type S12-A twelve-element
Recording Oscillograph

WRITE FOR
BULLETIN SP-167A



and Measures, in January 1948. The new unit is about 0.05 percent smaller than the International Ohm formerly used; resistors having 0.1 percent accuracy or better will therefore be made to the new standard, identified by abs stamped on the label.

SYLVANIA ELECTRIC PRODUCTS, INC., has begun construction of Sylvania Center, a campus-type electronic research development at Bayside, N. Y. The research project, under the direction of Bennett S. Ellefson, is designed for the long-term peacetime development of electronic and lighting equipment, television, f-m, and radar.

UNITED ELECTRIC CONTROLS Co., Boston, Mass., manufacturers of electric temperature, pressure, and vacuum controls, moved to larger quarters in Watertown, Mass.

RADIO CORP. OF AMERICA has announced a million-dollar expansion program providing an additional 40,000 sq ft of floor space for television tube production at its Lancaster, Pa., plant.

ACHESON COLLOIDS CORP., Port Huron, Michigan, now occupies its new plant with increased manufacturing and laboratory facilities, supplemented by those of its newly purchased London subsidiary, E. G. Acheson, Ltd.



New Acheson Colloids plant

OHMEGA LABORATORIES, INC., Pine Brook, N. J., recently formed outgrowth of Kay Electric Co., will carry out special development work for the parent company and manufacture instruments for electronic measurements.

PERSONNEL

WAYNE COY, radio director of the Washington Post, was appointed chairman of the FCC by President Truman, with confirmation of his nomination by the U. S. Senate to fill out the term of former chair-

ANOTHER TECH LAB FIRST!

NOW ON ALL ATTENUATORS AND POTENTIOMETERS

Silver Alloy Contacts

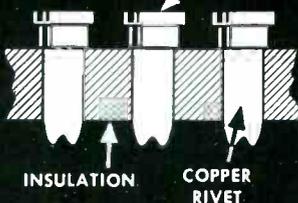
New Silver Alloy contacts make possible improved Attenuators and Switches in smaller sizes.

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TYPE 800 UNIT
with new contacts



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New SUPERHET TUNER

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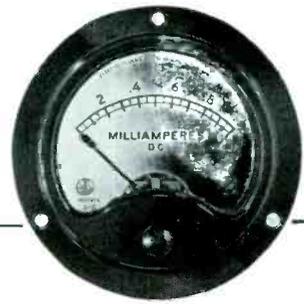
JK STABILIZED HEAT JKO-7

Designed to accommodate crystals from 80 to 3,000 kc and recommended for broadcast and frequency standard applications. Operating temperature 50° C plus or minus 1°, others also on special order. Available as double oven on special order. Crystals electrostatically shielded. Better thermal insulation results in lower heater current consumption and shorter warm-up time. Also available with oven control.

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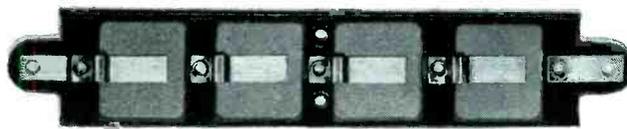
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130 Volts, a-c rms maximum input. Maximum inverse peak voltage 380. Instantaneous peak current 1000 ma. Continuous operating current 100 ma.

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man Charles R. Denny. He previously served as director of NAB and of FM Broadcasters, Inc., predecessor of the present FM Association.



W. Coy



G. E. Sterling

GEORGE E. STERLING, formerly chief engineer of the FCC, was named by President Truman to succeed E. K. Jett (resigned) as a member of the FCC. He has been associated with radio since 1913 when he took out the first amateur license in the state of Maine. His recent appointment became effective with Senate approval.

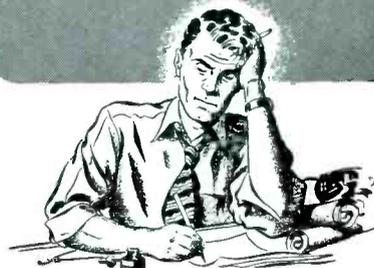
R. L. SMITH-ROSE, new IRE vice-president, was promoted to director of radio research in the Department of Scientific and Industrial Research, London. He had been superintendent of the radio division of the National Physical Laboratory since 1939 and was responsible for extensive investigations in radio direction finding and propagation of radio waves over the ground and through the lower atmosphere.

JOHN A. WILLOUGHBY has been designated acting chief engineer of the Federal Communications Commission.

CARLTON WASMANSDORFF, for six years superintendent of communications for the Glendale, Calif. police department, is now in charge of development engineering for Hoffman Radio Corp., Los Angeles. He was at one time chief engineer for Maguire Industries in New York, and served two years in San Francisco as chief engineer for Globe Wireless.

NEAL MCNAUGHTEN, former chief of the allocation section of the FCC engineering department's broadcast division, recently became assistant director of the engineering depart-

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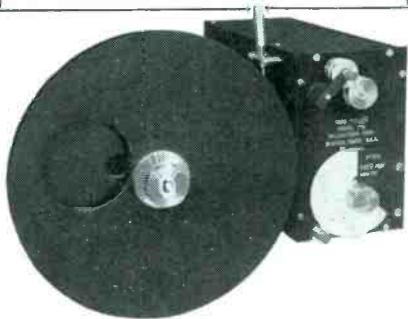


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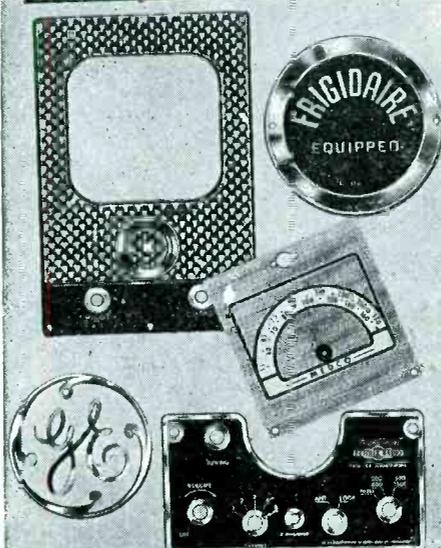
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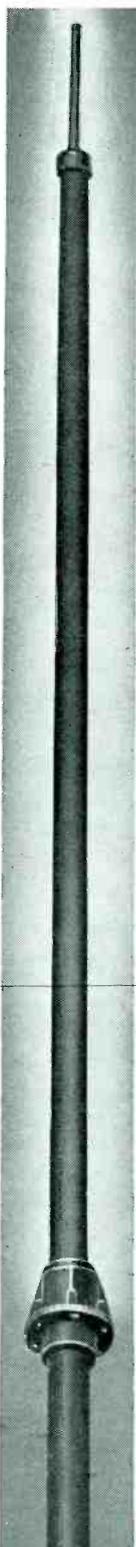
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(continued)

ment of the National Association of Broadcasters.

FRANK G. BACK received the Television Broadcasters Association award for the development of the Zoomar Lens, which makes possible instantaneous following of action by the camera.

JAMES A. MCGREGOR, formerly an engineer with the American District Telegraph Co. and associated with MIT Radiation Laboratory from 1940 to 1945, is now president of Microwave Equipment Co., Verona, N. J.

NEWELL A. ATWOOD, Commander, USN, engaged in electronics duty with the Navy since 1941, is now Electronics Officer at the New York Naval Shipyard, Brooklyn, N. Y.

VIRGIL M. GRAHAM, director of technical relations for Sylvania Electric Products, Inc., Flushing, N. Y., has been elected chairman of the Joint Electron Tube Engineering Council sponsored by RMA and NEMA.



V. M. Graham



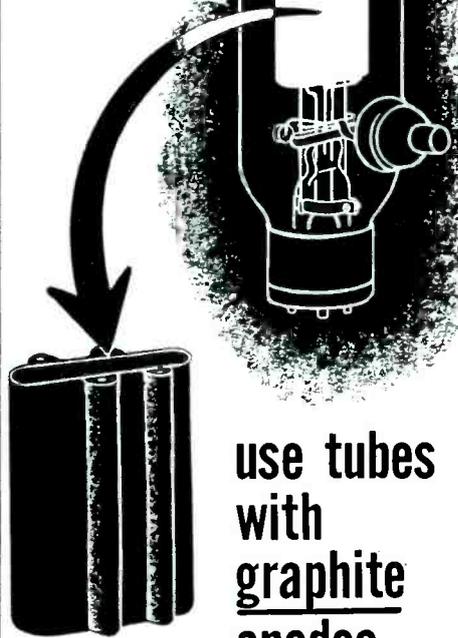
E. D. A. Geoghegan

EAMONN D. A. GEOGHEGAN has been appointed factory manager of the Chicago plant of Solar Mfg. Corp. He was formerly chief engineer at Tobe Deutschmann Corp. in Canton, Mass.

WILLIAM C. EDDY, director of television at WBKB in Chicago, was presented with an award by the Television Broadcasters Association for application of existing microwave equipment to a relay between South Bend, Ind., and Chicago.

EDWIN T. KAISER, previously associated with Western Electric Co. as design engineer and with Essex Electronics Co. as plant manager, has been appointed production manager of U. S. Fiber & Plastics Corp., Stirling, N. J.

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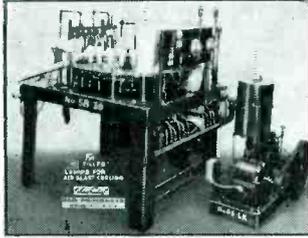
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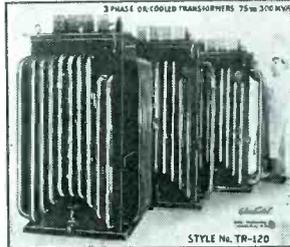
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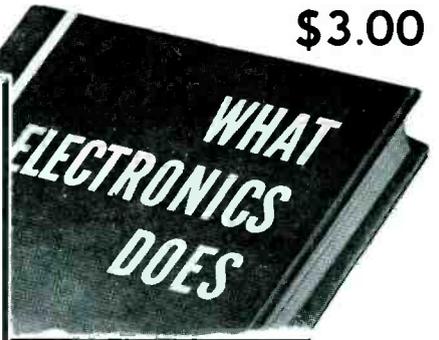
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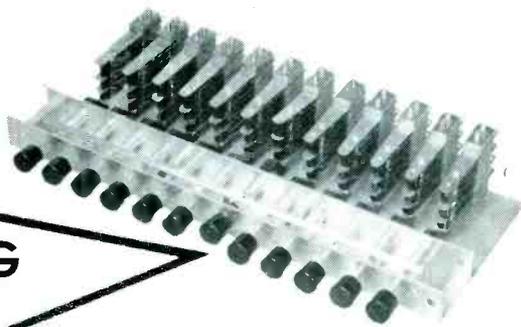
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13

NEW BOOKS

Very High-Frequency Techniques

BY THE STAFF OF THE RADIO RESEARCH LABORATORY, *Harvard University*. McGraw-Hill Book Company, Inc., New York, N. Y., 1947, 1,057 pages, \$14.00 per set of two volumes.

THESE VOLUMES are concerned primarily with the problems incident on the design of transmitters, receivers, transmission lines, and antennas of considerable bandwidth in the frequency region from 100 to approximately 10,000 mc. The greater proportion of the discussion is confined to the region from perhaps 300 mc, where conventional lumped-constant circuits become impractical, to about 6,000 mc, which marks roughly the upper limit of the more successful designs. Of course, the discussion of designs at higher frequencies may have been limited by security considerations. In addition to the unusual bandwidth requirements, the discussion differs from other presentations of wartime radar research in the emphasis on c-w rather than pulse techniques.

There is a great deal of interesting material contained in these volumes. The presentation suffers somewhat from the difficulties which inevitably accompany multiple authorship; the differences in terminology and points of view of approximately 50 authors have not been completely eliminated. Thus, in one chapter on antennas, gain otherwise unspecified means gain relative to an omnidirectional radiator, while in another the same term denotes gain relative to a dipole.

A fairly successful attempt to eliminate repetition in various chapters where fields of interest overlap has been made by extensive cross-referencing. However, this has the rather unfortunate result that many of the figures illustrating one chapter are likely to be found in another and, indeed, frequently in the other volume.

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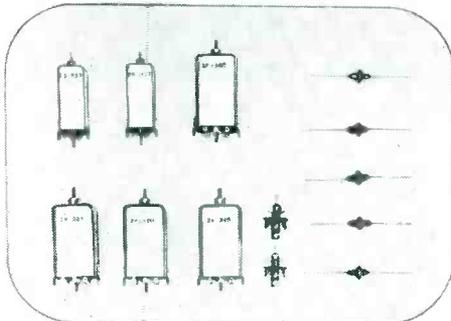


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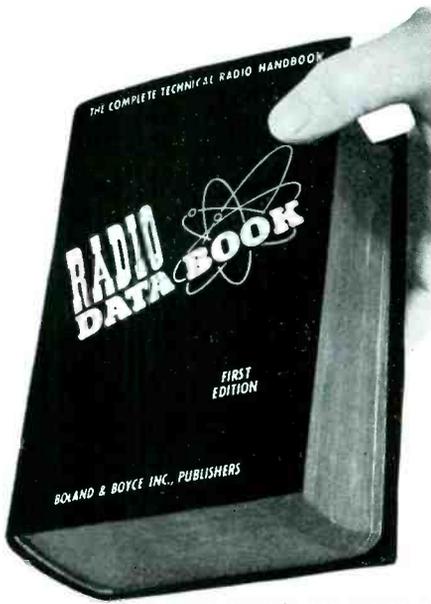
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frequency range from 100 mc to 1,400 mc seems a rather remarkable accomplishment. The discussion of high-frequency oscillators, both power oscillators and local oscillators for receivers, seems quite complete. An interesting discussion of the resonator is a valuable feature of the book.

An adequate index is included, together with a bibliography; the latter is probably most valuable for its inclusion of a list of recently declassified internal reports available through the Department of Commerce.—B. J. MILLER, *Chief, Guided Missile Electronics Section, Ordnance Development Division, National Bureau of Standards.*

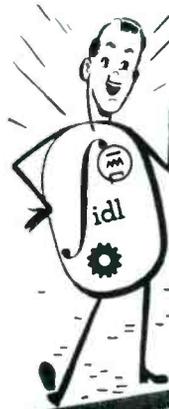
Frequenz Modulation

BY PAUL GUTTINGER. Verlag AG Gebr. Leemann & Co., Zurich 39, Switzerland, 1947, 183 pages, Fr. 25.

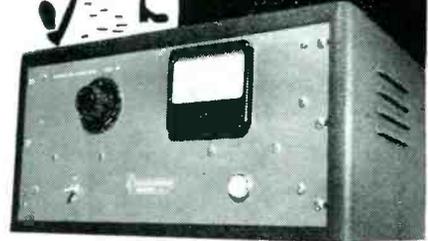
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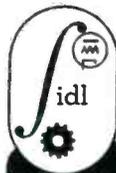
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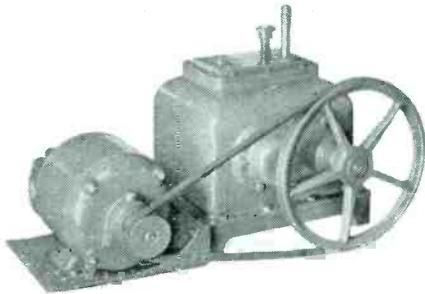
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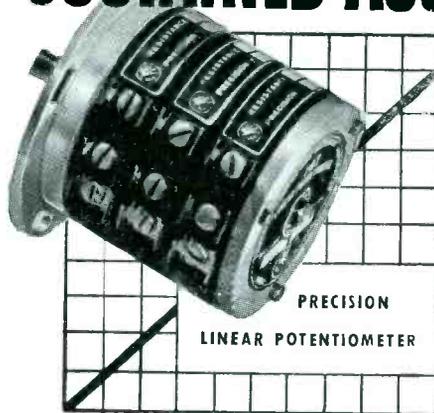
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tubes which take transit time into account, show the importance of this factor in the choice of reactance tube connection.

The final chapter on f-m receivers contains material of interest to the designer. In the discussion of the r-f stage, formulas are developed for input resistance and capacitance which include the influence of grid-plate capacitance, plate circuit tuning, transit time, and cathode inductance. For the i-f amplifier a criterion is given to limit circuit distortion to 1 percent. Formulas for gain per stage and amplitude characteristic in db for single and double-tuned stages are also given. The discussion on the limiter is excellent but is concerned with principles rather than actual circuits. The chapter closes with a discussion of discriminators and a mathematical analysis of the commonly used phase discriminator.

This volume also contains a mathematical appendix on Bessel functions and complex integration and an extensive chronologically arranged f-m bibliography of nearly 300 items running from 1922 to 1947.

To anyone interested in f-m and having a reasonable working knowledge of German, this book will prove a useful tool.—JOHN H. BOSE, *Columbia University, New York, N. Y.*

Automatic Record Changer Service Manual

PUBLISHED BY HOWARD W. SAMS & Co., Indianapolis, Indiana, October 1947, approx. 400 pages, \$4.95.

THIS book provides complete and standardized service data on 41 different postwar automatic record changers and recorders, including the Brush Soundmirror magnetized paper tape recorder, Brush Mail-a-Voice magnetized paper disc recorder, Silvertone model 771 wire recorder, St. George series 1100 wire recorder, and Webster models 79 and 80 wire recorders. Each of the 41 sections contains entirely original data based on first-hand examination, test, and analysis of the actual instrument, just as is done for radio receiver models during preparation of Photofact Folders published by the same company.

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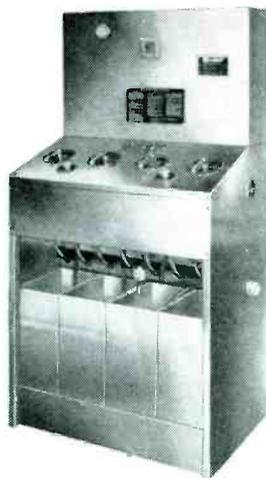
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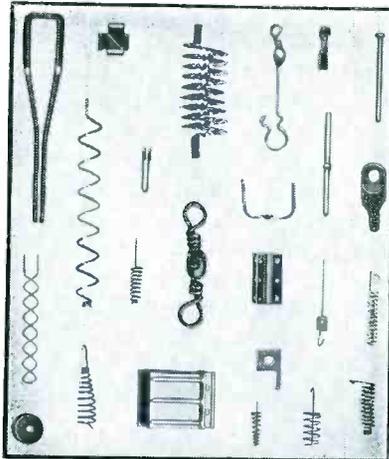
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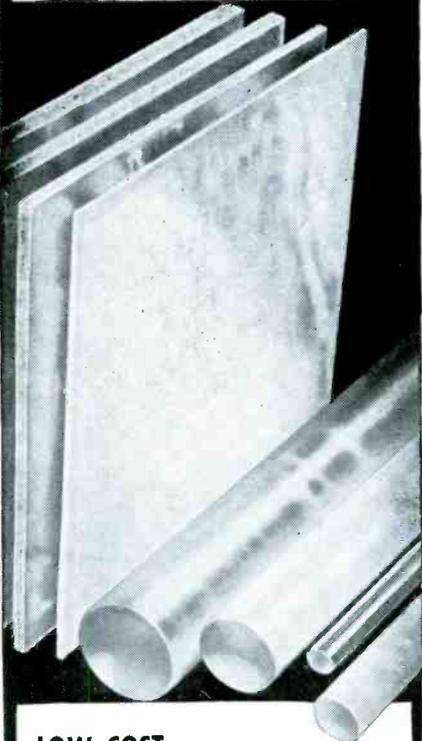
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to general types of automatic record changers and types of motor drive systems associated with them, are gems of technical organization and writing on a complicated subject. The various methods used for record support, record selection, pickup arm handling, determining set-down point, and tripping are described clearly, concisely, and logically so that one gets a satisfying complete picture of how these mechanisms are supposed to work.

Going far beyond the usual manufacturer's service manual, this book with its clear-cut instructions and illustrations truly offers an education in the latest styles of mechanical gadgetry for converting recordings to sound automatically.—J.M.

Mathematics for Radio Engineers

By LEONARD MAUTNER, *Research Engineer, Allen B. DuMont Labs. Pitman Publishing Corp., New York, 1947, 327 pages, \$5.00.*

WRITTEN for engineers who have lost facility in handling mathematics and those who, although proficient in radio techniques, have never acquired a command of mathematics, this book briefly reviews the elements of enumeration, then describes trigonometric relations, complex algebra, differential and integral calculus, solution of differential equations, and Fourier series. In scope the book penetrates further into the subject than books intended for technicians, but is less extensive than engineering texts used in colleges. As such it bridges a gap in math-book literature.

Although this is a mathematics book, material is presented in its relation to typical basic problems of radio rather than as abstract mathematical methods. The presentation thus makes the subject more tangible than usual works of this calibre. Because of the choice of only those phases of mathematics frequently encountered in solving radio circuit problems, and the close correlation of the mathematics with radio, engineers will find this book a ready key to mathematics in their work. Answers are included for the problems at the ends of the chapters so that the book is useful

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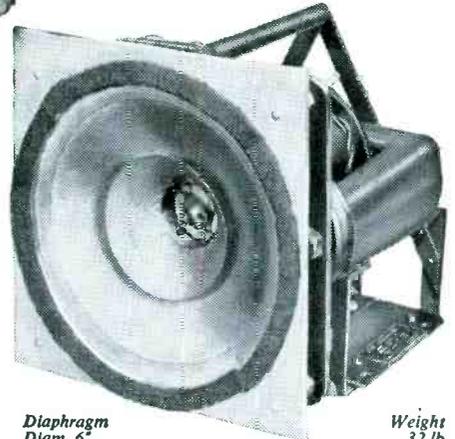
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for home study. The work is also suited for trade schools which believe that radio technicians, to advance in their work, should be well grounded in mathematics.—F. R.

• • •

Books Received for Review

ELECTRETS. By Thomas A. Dickinson. Plastics Research Co., Alhambra, Calif., 1948, 32 pages, \$2.50. Pocket-size monograph dealing with properties, applications, and manufacturing techniques of electrets, defined as dielectric bodies that retain an electric field after the applied voltage is removed. Purpose of book is to show that expensive permanent magnets for electronic equipment can be replaced with polarized dielectrics such as plastic or ceramic units.

UNDERSTANDING VECTORS AND PHASE. By John F. Rider and Seymour D. Usian. John F. Rider Publisher, Inc., New York, N. Y., 1947, 153 pages, 99 cents. Pocket-size paper-cover book for men lacking an engineering background, to help them understand radio-electronic articles and books written at the engineering level. Eight chapters explain vectors and give examples of their use in radio circuits.

SPI HANDBOOK. Society of the Plastics Industry, 295 Madison, New York, N. Y., 1947, 451 pages, \$7.50. Though prepared by a committee of some 300 authorities in the field as a handbook for molders and fabricators of plastics parts, much of the contents is of importance also to the ultimate user. Chapter coverage includes design of molded articles, use of inserts, cementing and assembly of plastics, machining and finishing and recommended practices for fabricating laminated plastics.

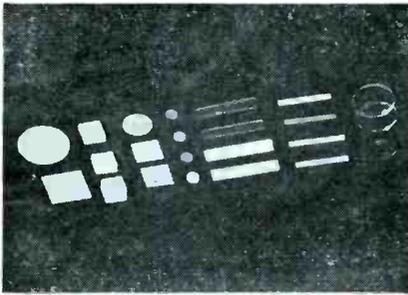
INDUSTRIAL APPLICATIONS OF INFRARED. By James D. Hall, Advisory Engineer, Lamp Division, Westinghouse Electric Corp. McGraw-Hill Book Co., New York, 1947, 201 pages, \$3.50. What would have been one chapter of a book on heating several years ago has now justified expansion by inclusion of numerous specific examples of use. Chapters discuss infrared heat, equipment, installation, and applications of infrared lamps for a variety of processes requiring surface application of low-level heat.

PERPETUAL TROUBLE SHOOTER'S MANUAL, VOL. XV. John F. Rider, Publ., Inc., New York, N. Y., 1947, over 1,200 pages, plus 181-page HOW IT WORKS supplement, \$18.00. This series constitutes a tool for radio servicemen and a guide to current radio practice for set designers. Where original manufacturers' diagrams are not clear, supplementary diagrams have been added. The paper-bound supplement covers new electrical and mechanical features of receivers and has an index to the manual. Among subjects included are the double superhet, superhet oscillators, r-f coupling, feedback, phase inversion, gimmicks, and f-m circuits.

THE ABC OF ELECTRONICS. By E. B. Watton. Percival Marshall & Co. Ltd., 23, Great Queen St., London, W. C. 2, 1947, 133 pages, 7/6. Bird's-eye view of modern industrial electronics, with one chapter on communications, combining technical explanations of operating principles with popular descriptions of such applications as the Radarange, snooper-scope, speaking clock, and tube train counter. Well illustrated.

TABLE OF THE BESSEL FUNCTIONS $J_0(z)$ AND $J_1(z)$ FOR COMPLEX ARGUMENTS. 2nd ed. Mathematical Tables Project, National Bureau of Standards, Columbia University Press, New York, 1947, 403 pages, \$7.50. A clarification in labeling graphs has been made in this edition. No errors in the tables having been reported, they have been reproduced from the original plates.

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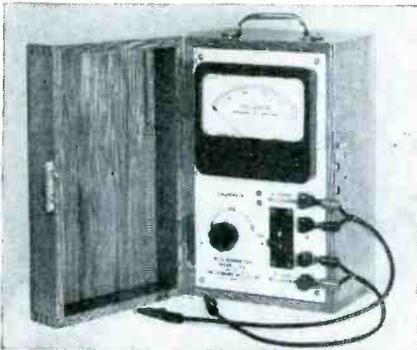
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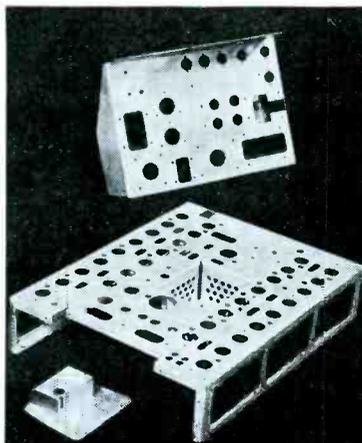
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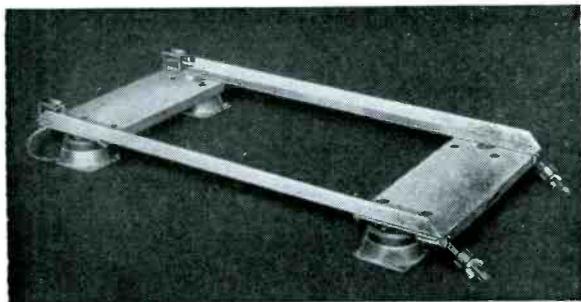
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Backtalk

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Reference Sheet Data

DEAR SIRS:

METICULOUS readers who wish to use the graph in the Reference Sheet, Efficiency of Inductive Coupling, page 138, December ELECTRONICS, may make the following additions.

In the formula, subscripts can be added to Q in both places where it appears. In the lefthand graph, all values of Q , are identical with the values given in the righthand graph. The primary resistor in the diagram can be indicated as R_p . The ordinates of both parts of the graph are, of course, $k_2 Q_p$.

A. C. HUDSON

National Research Laboratories
Ottawa, Ontario

Hartley Law

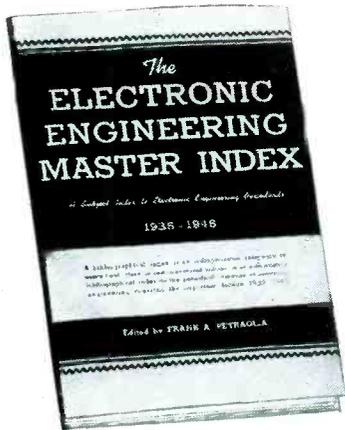
DEAR SIRS:

ELECTRONICS is to be complimented upon the fast and clear reporting of the IRE symposium regarding the revision of Hartley's Law which was held in New York on November 12, 1947.

Since so little has appeared on this subject treating it in a general way, I feel that one correction is necessary for the historians. The first statement of the new law to appear in print was, to my knowledge, in the Quarterly Progress Report of the Research Laboratory for Electronics of the Massachusetts Institute of Technology, dated 15 April 1947, which receives an extensive circulation among the military services. ELECTRONICS can probably lay claim to first publica-

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tion in a magazine of general interest and circulation.

Another historical step in this field should be credited to Dr. D. Gabor of the British Thomson-Houston Company Research Laboratory in his article entitled "Theory of Communication" in the *Journal of the Institution of (British) Electrical Engineers* in November 1946.

Mr. Wheeler made a very important point in his discussion which appears to have been lost or overshadowed by the proceedings of the evening. He pointed out that uncertainty of signal location due to noise should not be dismissed in that simple statement wherein one considers only the rms power in the noise or signal plus noise. It is becoming increasingly important that the engineer have available in engineering form (as opposed to the mathematical), means of dealing with these uncertainty relationships.

In many systems it may be possible to take a calculated risk in operating at low signal-noise ratios where this uncertainty sphere is more diffuse. In such systems, the engineer must have available the probabilities that noise may be mistaken for signals or that signals be missed completely. Mr. Wheeler also pointed out that in many simple receiving systems the noise power N was related to the bandwidth of the system W by well-known relations.

Dr. Shannon also discussed briefly the significance of distortion as a warping of the space which might in theory be rewarped by another operation to achieve its original form. This is also a significant point as it relates Hartley's discussion of intersymbol interference caused by circuit decay or distortion to Dr. Shannon's remarks.

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MR. MAISEL of Portland, Ore. (Backtalk, Jan. 1948) says "One problem . . . here in the remote

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BACKTALK

(continued)

west is the lack of the latest available components . . . a challenge to us local fellows . . .”.

The implication is that anyone who lives east of Chicago has only to walk to the corner radio store to find shelves crammed with electronic rarities — subminiature tubes, varistors, butterfly circuits, and of course button capacitors.

I have been doing circuit development in a large Government laboratory in Washington, D. C. for several years, and some time before that lived in Los Angeles. Radio parts are definitely less available here than they were in Los Angeles. Washington has several good parts jobbers, but their size and stocks are modest and their locations inconvenient. For that matter, I have seen plenty of similar places in New York and Chicago that weren't so hot either.

Personally, I buy parts by mail order. The Laboratory gets components from sources all over the country. Unusual items are often ordered directly from the manufacturer.

Any material that is not regularly bought by lots of radio servicemen and amateurs is likely to be pretty scarce at parts dealers in any city, no matter where it is. A year ago the mail order houses seemed to be habitually out of stock on half or more of the things I ordered (even as were the local dealers), but recently I have had much better luck. The greater distances in the west make for higher parcel post charges, of course; but gasoline, bus fare, and shoe leather don't come for free either.

On another subject, Mr. Meredith's letter (Backtalk, Jan. 1948) shows that he is a most unusual patent attorney. In my four years as a patent examiner I encountered few attorneys who didn't use "electron discharge device" when they meant *tube*. One reason for patent lingo being what it is, is the necessity for broad language to avoid its being interpreted later in a restrictive sense. The other reason is that it is harder to write up a case thoughtfully than it is to just let the words roll out.

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DELCO DUAL BLOWER



SPECIAL \$15.95

Immediate Delivery

Blows 200 CFM; 110 Volt AC, 60 Cycles; overall length 10 3/4"; overall width 6 3/4"; each blower opening 2" in diameter; intake opening 2 1/2" in diameter. Unit has DELCO sealed in motor requiring no lubrication—built-in mounting brackets; ideal unit for cooling large tubes or exhaust for laboratory use—also perfect for Photo Dark-room application.



MINIATURE TUBE PULLER

Niagara solves your miniature tube breakage problem with this new sensational invention. Tubes may now be easily extracted or placed into those hard-to-reach places, without the fear of breakage or burning of hands. This new invention incorporates a heat resistant rubber cap with aluminum body and handy thumb-operated plunger release. Be sure to get yours today. Money back guarantee. **Only 88¢**

FULL WAVE SELENIUM RECTIFIER



Perfect for bias application—Use your DC relays from an AC source. Only requires 3" x 1 1/2" mounting space Rectifier for input up to 300 V at 40 ma output. **\$.89 or 5 for \$4.00**

NEW BANTAM BLOWER

Blower 6 v. AC or DC hi speed blower made by John Oster. Rated at 5000 RPM—1.8 AMP—made for continuous duty—1 1/2" overall diameter—1" blower output—1 1/4" blower intake **\$5.95**

SELENIUM RECTIFIERS FOR ALL APPLICATIONS

Full Wave Bridge Types				Full Wave Center Top			
Input From	Output From	Current	Price	Input	Output	Current	Price
0-18 V.A.C.	0-14 V.D.C.	1 AMP	\$1.95	0-400 V.A.C.	0-350 V.D.C.	600 Mills	\$5.95
0-18 V.A.C.	0-14 V.D.C.	5 AMP	4.45				
0-18 V.A.C.	0-14 V.D.C.	10 AMP	7.45				
0-18 V.A.C.	0-14 V.D.C.	15 AMP	9.95				
0-18 V.A.C.	0-14 V.D.C.	20 AMP	13.95				
0-18 V.A.C.	0-14 V.D.C.	25 AMP	16.95				
0-18 V.A.C.	0-14 V.D.C.	30 AMP	14.95				

Half Wave Types			
Input From	Output From	Current	Price
0-18 V.A.C.	0-7 V.D.C.	3 AMP	\$2.25
0-18 V.A.C.	0-7 V.D.C.	5 AMP	2.95
0-18 V.A.C.	0-7 V.D.C.	10 AMP	4.95
0-18 V.A.C.	0-7 V.D.C.	15 AMP	6.95
0-18 V.A.C.	0-7 V.D.C.	20 AMP	8.95
0-18 V.A.C.	0-7 V.D.C.	25 AMP	10.95

Input From	Output From	Current	Price
0-36 V.A.C.	0-28 V.D.C.	3 AMP	\$5.95
0-36 V.A.C.	0-28 V.D.C.	5 AMP	7.45
0-36 V.A.C.	0-28 V.D.C.	10 AMP	12.45
0-36 V.A.C.	0-28 V.D.C.	15 AMP	18.95
0-36 V.A.C.	0-28 V.D.C.	20 AMP	25.95
0-120 V.A.C.	0-100 V.D.C.	2 AMP	14.95
0-120 V.A.C.	0-100 V.D.C.	5 AMP	19.95

XTALS

We can supply power xtals of any frequency ground to .02 tolerance in any type of holder for any surplus or standard transmitters or test equipment as well as any receiver IF frequency. Prices on request—write to our engineering department.

METERS

MM 4-0-100MA Model 301 Weston 3 1/2" \$3.95
 MM 10-0-1 amp DC-Model 301 Weston 3 1/2" 3.95
 MM 14-0-150 MA NX 35 Westinghouse 3 1/2" 3.95
 MM 19-0-800MA Weston Model 301MA 3.35
 MM 33-0-1MA-MD-300 I K-McClintock 3 1/2" 3.95
 MR 13-0-8 R.F. amp—425AM-Weston 3 1/2" 4.95
 MV 8-0-4 K.V. DC—Roller Smith 3 1/2" 2.95

G. E. INTERLOCK SWITCH

Hi-voltage is lethal—protect yourself and family—this switch automatically shuts off Hi-volt. circuits while adjustments are being made—low pressure—hi current capacity positive action. Silver plated contacts. Pr. **\$1.00**

5TP4 PROJECTION TUBE

Perfectly operating condition but with very slight imperfection. Ideal for engineers, experimenters, inventors, or school instructors. Regular price of these tubes is \$65.00—**\$20.00**
 Special Bargain

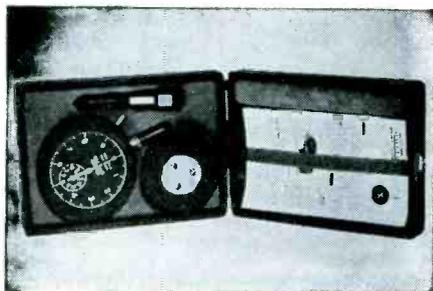
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All Prices f.o.b. N. Y. C. NIAGARA RADIO SUPPLY CORP. CREDIT EXTENDED TO RATED ACCT'S.
 160 GREENWICH STREET, NEW YORK 6, N. Y.

**PORTABLE CHRONOMETRIC
TACHOMETER**

\$2450



JAEGER WATCH CO. MODEL #43-A-6

CAN BE USED FOR SPEEDS UP TO 20,000 R.P.M.
CAN BE USED FOR LINEAL SPEED MEASUREMENTS
TO 10,000 F.P.M.

IDEALLY SUITED FOR TESTING THE SPEEDS OF
MOTORS, PARTICULARLY OR FRACTIONAL HORSE
POWER, GENERATORS, TURBINES, CENTRIFU-
GALS, FANS, ETC.

VERY SMALL TORQUE—Requires Practically no Power
to Drive.

UNEQUALLED READABILITY 2" OPEN FACE DIAL—
EACH DIVISION ON LARGE DIAL EQUALS 10 R.P.M.;
EACH DIVISION ON SMALL DIAL EQUALS 1,000
R.P.M.

GREATEST ACCURACY — Meets Navy Specifications —
Guaranteed to be within 1/2 of 1%.

RESULTS OF TEST READING REMAIN ON DIAL
UNTIL NEXT TEST IS TAKEN.

PUSH BUTTON FOR AUTOMATIC RESETING.

COMPLETE WITH THE FOLLOWING ACCESSORIES:

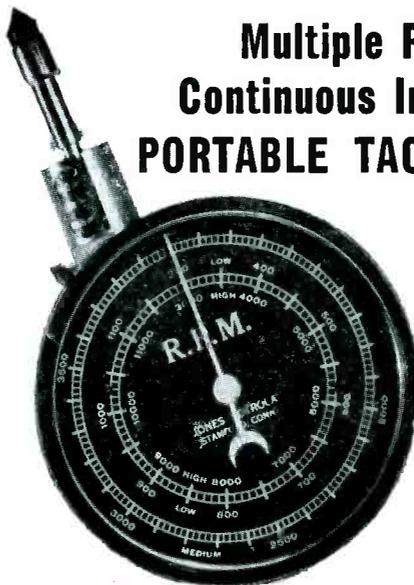
- 1—LARGE POINTED RUBBER TIP
- 1—LARGE HOLLOW RUBBER TIP
- 1—6" CIRCUMFERENCE WHEEL TIP
- 1—OPERATING INSTRUCTIONS
- 1—TEMPERATURE CORRECTION CHART.

The combination of the above features will give accurately,
within a few seconds, by direct reading, the R.P.M. of
shafts or the lineal speeds of surfaces without any acces-
sories or timing of any kind. Each unit comes complete
in a red velvet lined carrying case 5" x 3 1/2" x 1 1/2". NET
LIST PRICE \$75.00—SURPLUS—NEW—GUARANTEED.

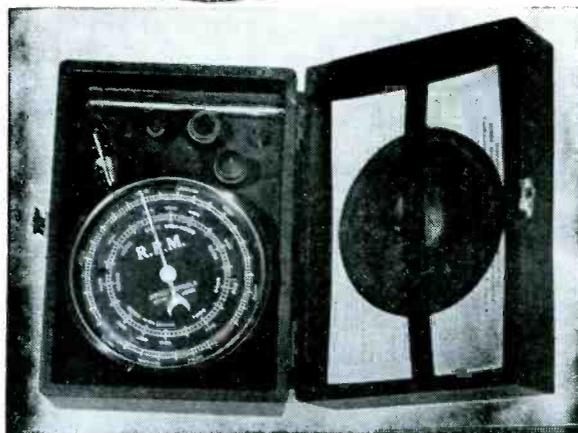
YOUR COST \$24.50 FOB, NEW YORK

**Multiple Range
Continuous Indicating
PORTABLE TACHOMETER**

\$2450



2/3 Actual Size



This unit is of the centrifugal mechanical type and is designed to
show instantaneously and continuously the speed or change in
speed of any revolving shaft or surface. No stop watch or other
mechanism required.

- Three Ranges in R.P.M. and Three Ranges in F.P.M.
- LOW RANGE 300- 1,200
(Each Division Equals 10 R.P.M.)
 - MEDIUM RANGE 1,000- 4,000
(Each Division Equals 20 R.P.M.)
 - HIGH RANGE 3,000-12,000
(Each Division Equals 100 R.P.M.)

LARGE OPEN DIAL 4" DIAMETER.

RUGGEDLY CONSTRUCTED For Heavy Duty Service.

BALL BEARING AND OILLESS BEARINGS — Require No
Lubrication Whatsoever.

READILY PORTABLE — Fits Neatly Into Palm of Hand.

GEAR SHIFT FOR SELECTING LOW, Medium and High Ranges.

GREATEST ACCURACY — Meets Navy Specifications 18-T-22,
Type B, Class A.

COMPLETE WITH THE FOLLOWING ACCESSORIES:

- 1—STEEL TIP
- 1—CONICAL RUBBER TIP Metal Mounted
- 1—RUBBER LINED Metal Cone Tip
- 1—PERIPHERAL RUBBER WHEEL 1 Ft. in Circumference
- 1—EXTENSION ROD
- 1—SMALL SIZE CONVEX RUBBER TIP, Metal Mounted
- 1—OPERATING INSTRUCTIONS.

MADE BY JONES MOTROLA, STAMFORD, CONNECTICUT.
Comes Complete in Blue Velvet Lined Carrying Case: 7 1/2" L x
4" H x 5" W. LIST PRICE \$75.00—SURPLUS—NEW—GUARAN-
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YOUR COST \$24.50 FOB, NEW YORK

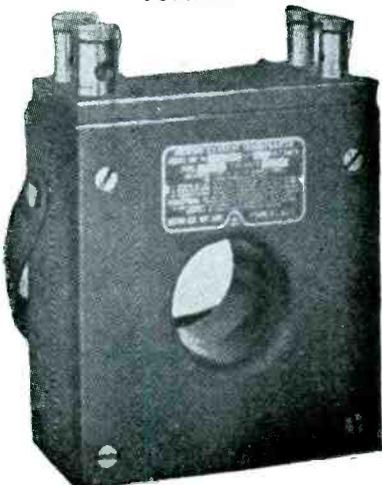
All items are Surplus-New-Guaranteed. C.O.D.'s not sent unless accompanied by 25% Deposit. Orders accepted from rated concerns,
public institutions, etc., on open account. We carry a complete line of surplus new meters suitable for every requirement, such as
portable, panel, switchboard, recording instruments, laboratory standards, etc. Over 50,000 Meters in Stock. We also stock
various surplus components, tubes, parts, and accessories and can supply large quantities for manufacturers, exporters, etc. Send
for free circular Manufacturers, Exporters, Dealers—We invite your inquiries.

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PORTABLE CURRENT TRANSFORMER



Weston Model 461 Type 4 (see illustration). This unit can be used with any precision 5 Amperes A.C. Meter to extend the ranges of the meter to 50, 100, 200, 250, 500 or 1000 Amperes A.C. Accuracy within 1/2% of 1%; Normal Secondary Capacity = 15 Va; Binding Posts for 50 Amperes tap; Inserted primary for 100, 200, 250, 500 and 1000 Amperes; insulated for use up to 2500 volts. List Price \$88.00. **NET fob, NY \$35.00**

MULTI-RANGE PORTABLE A C VOLTMETER

Weston Model 433, 150/300/600 volts A.C. Accuracy within 1/2% of 1% from 25 to 125 cycles. Hand calibrated Mirror scale 4.04" long with 150 scale divisions; Knife edge pointer. Moving Iron Band type. Magnetically shielded. Dimensions 5 1/2" x 3 1/2" **Net \$47.50**

PORTABLE A. C. AMMETER 0-200 AMPERES SELF CONTAINED

Weston Model 155, accuracy within 1/2% of 1%; Hand calibrated mirror scale 5.18" long. Knife edge pointer; unshielded movement, 25-500 cycles. Hardwood case. Dimensions 7" x 7 1/2" x 3 1/4" @ **\$32.00**

SPECIAL METERS

Frequency Meter—Dual Range—covers frequency ranges from 48 to 52 cycles and 58-62 cycles J.E.T. 30-F—Dual element, Vibrating Reed type—115 V—3 1/2", rd fl metal case. \$5.95
Voltage Polarity Phase Rotation Tester—Triplet 337 AYP—Checks 115, 220 and 440 line voltage—locates open circuits, blown fuses, damaged wiring, etc. Indicates whether A.C. or D.C. and polarity of D.C.—Checks phase rotation to determine direction of rotation of motors, operation of controls, etc.—Consists of a 3" square meter and a small polarized vane movement in a small handy sized case—Complete with 36" leads with test prods **\$8.50**

D. C. MICROAMMETERS

100-0-100 microampere—zero center—approximately 950 ohms resistance—W.E.—3 1/2", rd fl bake case—concentric style **\$6.50**

A. C. VOLTMETERS

15 V. (100 MA)—W.H., NA-35—3 1/2", rd fl bake case **\$3.95**
150 V (10 MA)—W.H., NA-35—3 1/2", rd fl bake case **\$5.50**
150 V—Triplet 331-J.P.—with external resist for series connection to increase range to 300 V. (multiply reading by 2) to make a dual range 150-300 Voltmeter—3 1/2", rd fl bake case. **\$5.50**

D. C. MILLIAMMETERS

20 MA—GE DO-53—3" sq fl bake case. **\$3.25**
80 MA—GE DO-41 3 1/2" rd fl bake case. **\$3.25**
1 MA—Triplet 0321—3 1/2", rd fl bake case—with circuit diagram **\$3.95**

PORTABLE D.C. AMMETER MULTI-RANGE 0-3, 0-30, 0-300 AMPERES

General Electric DP-9 (50 MV movement) Accuracy within 1/2% of 1%; Hand calibrated mirror scale; Knife edge pointer, magnetically shielded. Complete with leads and external shunts for 3, 30 and 300 Amps. Plastic case with hinged cover. Dimensions 2 7/16" x 6 9/16" x 4 13/16". @ **\$37.50**

PORTABLE D. C. AMMETER MULTI-RANGE 0-3, 0-30, 0-300 AMPERES

Roller Smith Type NPD (50 MV movement) Accuracy within 1/2% of 1%; Hand calibrated mirror scale 5.25" long; magnetically shielded. Complete with leads and external shunt for 3, 30, and 300 Amps. Hardwood carrying case 8"x8"x5 1/2" with hinged cover. @ **\$45.00**

PORTABLE D. C. VOLTMETER DUAL RANGE 0-3, 0-150 VOLTS

Westinghouse Type PX-4, accuracy within 1/2% of 1%; 3 1/2" long mirror scale; Knife edge pointer, 200 ohms per volt movement. Dimensions 4 1/2" x 4 1/2" x 2". @ **\$17.50**

PORTABLE D. C. VOLTMETER 0-10 VOLTS

Weston Model 280, accuracy within 1%; Hand calibrated mirror scale 2.76" long. Knife edge pointer, magnetically shielded, 100 ohms per volt movement. @ **\$7.50**

PORTABLE A. C. AMMETER WESTON MODEL 528

DUAL RANGE 0-3 Amp. and 0-15 Amp. full scale for use on any frequency from 25 to 500 cycles. The ideal instrument for all commercial, industrial, experimental, home, radio, motor and general repair shop testing. Comes complete with a genuine leather, plushlined carrying case and a pair of test leads. A very convenient pocket sized test meter priced at less than 50% of manufacturers list. Your cost **ONLY \$12.50**

PORTABLE A. C. VOLTMETER WESTON MODEL 528

DUAL RANGE 0-15 and 0-150 Volts for use on any frequency from 25 to 125 cycles. Complete with plushlined leather carrying case and a pair of test leads. This Voltmeter, with the matching model Ammeter above, makes an ideal pair of test meters for any mechanic to carry around in his tool box. **ONLY \$9.50**
COMBINATION OFFER: 528 Voltmeter—528 Ammeter—BOTH FOR **\$21.00**

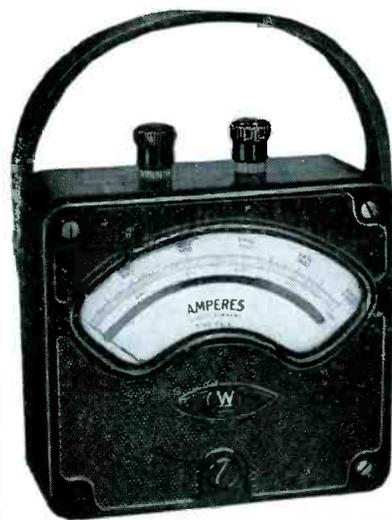
RADIO FREQUENCY AMMETERS

1 A R.F.—Weston 425—3 1/2", rd fl bake case @ **\$7.50**
2.5 A—Weston 507—2 1/2", rd fl bake case @ **\$3.95**
2.5 A—Simpson 36—3 1/2", rd fl bake case @ **\$4.95**
2.5 A—W.H. NT-35—3 1/2", rd fl bake case @ **\$5.50**
2.5 A—McClintock—3 1/2", rd fl bake case @ **\$4.50**
3A—W.H. NT-35—3 1/2", rd fl bake case @ **\$5.50**

D. C. VOLTMETERS

15 Volt—G.E., DW-41—black sc, no Captlon—sc cal 0-15—2 1/2", rd fl bake case @ **\$2.50**
30 Volt—G.E., DW-41—2 1/2", rd fl bake case @ **\$2.95**
1.5 KV—W.H. NX-35—with 1000 ohms per volt—external prec wire wound resistor & mtg clips—3 1/2", rd fl bake case @ **\$7.25**

PORTABLE D. C. AMMETER 0-1 AMPERES D. C.



Westinghouse Type PX-4, accuracy within 1/2% of 1%; 3 1/2" long mirror scale with 100 scale divisions; Knife edge pointer; Moving coil D'Arsonval movement. Dimensions 4 1/2" x 4 1/2" x 2" @ **\$17.50**

PORTABLE D. C. AMMETER 0-25 AMPERES—SELF CONTAINED

General Electric DP-9, accuracy within 1/2% of 1%; Hand calibrated Mirror scale; Knife edge pointer, magnetically shielded. In plastic case with hinged cover. Dimensions 2 7/16" x 6 9/16" x 14 13/16". @ **\$19.00**

PORTABLE D. C. AMMETER 0-50 MILLIVOLT MOVEMENT

Weston Model 45 for use with external shunts. Accuracy within 1/2% of 1%; Hand calibrated mirror scale 5.18" long with 100 scale divisions (Scale calibrated 0-25 Amps.) Knife edge pointer; magnetically shielded; Complete with external 25 Amp 50 MV shunt and leads. (We also have other external shunts for use with this meter). In Hardwood carrying case 8" x 8" x 4 1/4" with hinged cover. Complete @ **\$32.50**

- 1000 Amp 50 MV shunt @ **\$12.00**
- 2000 Amp 50 MV shunt @ **\$20.00**
- 4000 Amp 50 MV shunt @ **\$40.00**

CODE TRAINING SET AN/GSC-T1

Made by T. R. McElroy, Boston. Operates off 6, 12, 24 or 110 V D.C. or 110 V or 230 Volt, 60 cycle.

An excellent unit for schools or clubs for code training. This unit is designed for group training of telegraph code to students whereby each student sends a message from any prepared text to the instructor. It provides a visual signal through a blinker or an audible signal through a monitoring speaker. Has volume control, variable frequency oscillator, a phone jack for a monitoring headset, pitch and tone control, rotary switch for selecting the operating voltage and power supply.

Complete with spare fuses, power cord and battery adapter; 10 Telegraph Keys with 10' line each, 1 #6 x 5 tube and 2 #6A3 tubes.

Complete in chest 10 1/2" x 17" L x 13 1/2" H—Net wt. 49 lbs.

Can be used anywhere—batteries A.C. or D.C. Durable—Good for a lifetime of Service! **NET fob, NY \$24.50**

All items are Surplus-New-Guaranteed. C. O. D.'s not sent unless accompanied by 25% Deposit. Orders accepted from rated concerns, public institutions, etc., on open account. We carry a complete line of surplus new meters suitable for every requirement, such as portable, panel, switchboard, recording instruments, laboratory standards, etc. Over 50,000 Meters in Stock. We also stock various surplus components, tubes, parts, and accessories and can supply large quantities for manufacturers, exporters, etc. Send for free circular—Manufacturers, Exporters, Dealers—we invite your inquiries.

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"Communications"

THE BEST BUYS IN SURPLUS

AS 125/APR Cone type receiving antenna, 1000 to 3200 megacycles. (as shown) New \$4.50

SO-13 ANTENNA 24" dish with feedback dipole. 360 deg. rotation, complete with drive motor and selsyn. New 75.00
Used 45.00

APS-4 3 cm. antenna. Complete. 14 1/2" dish. Cutler feed dipole, directional coupler, all standard 1" x 1/2" waveguide. Drive motor and gear mechanism for horizontal and vertical scan. New 65.00

AN/TPS-3 Parabolic dish reflector approx. 10' diam. Extremely lightweight construction. New, in 3 carrying cases 49.00

Relay system parabolic reflector; approx. range: 2000 to 6000 mc. Dimensions: 4 1/2" x 3". New 85.00

TDY "Jam" radar rotating antenna, 10 cm. 30 deg. beam, 115 v.a.c. drive. New 100.00

140-600 mc. cone type antenna, complete with 25' sectional steel mast, guys, cables, carrying case, etc. New 49.50

RADAR SETS

S09-10CM. SURFACE SEARCH 4, 20 and 80 mile ranges; Raytheon, 250 KW peak power input to 2J27 magnetron. Complete set including: spare parts, tubes, wave guides and fittings. Send for information.

S013-IDENTICAL TO S09. Complete set, used. Consists of transmitter and receiver, PPI scope modulator, motor alternator, rectifier, power unit and new rotating antenna. \$375.00

SN RADAR-GE, low power, 5 and 25 mile ranges. Uses GL464 as pulsed oscillator, 5" "A" scope, "S" band. Extremely compact; ideal for demonstration and laboratory work. 115V 60C operation. Used, excel. Cond. \$600.00

MICROWAVE TUBES (Magnetrons)

Tube	Freq. Range	Pk. Pwr. Out.	Price
2J31	2820-2860 mc.	285 Kw.	\$10 00
2J21A (725-A)	9345-9405 mc.	50 Kw.	25 00
2J22	3267-3333 mc.	265 Kw.	15 00
2J26	2992-3019 mc.	275 Kw.	15 00
2J27	2995-2992 mc.	275 Kw.	15 00
2J32	2780-2820 mc.	285 Kw.	15 00
2J38	Pkg. 3245-3263 mc.	5 Kw.	25 00
2J55	Pkg. 9345-9405 mc.	50 Kw.	25 00
2J31	24,000 mc.	35 Kw.	17 50
W.E. 700A	680-710 mc.	100 Kw.	35 00
W.E. 720BY	2800 mc.	1000 Kw.	25 00

MAGNETS

For 2J21 (725-A), 2J22, 2J26, 2J27, 2J31, 2J32, and 3J31

4800 Gauss, 1/2" bet. pole faces, 3/4" pole diam.	Each	Price
1500 Gauss, 1-1/2" bet. pole faces, 1-1/2" pole diam.		8.00
1000 Gauss, electromagnet, adjustable 2-1/2" to 3" bet. pole faces, 2-1/2" pole diam.		12.00
2100 Gauss, 1-1/2" bet. pole faces, 3/4" pole face diam.		4.00

12 and 24 Volt Filament Transformers



(All primaries 110 v., 60 cycles). No. 517: Output: 12 v @ 10 amps or 24 volts @ 5 amps. \$2.75
No. 2217: Output: 24 volts @ 3 amp. size: 3" x 3 1/2" x 3" (as shown) \$1.50

INVERTERS

PE 206-A. Input: 28 VDC @ 38 amp. Output: 80 volts @ 500 volt-amps. 800 cycles. Leland. New, complete with enclosed relay, filter, instruction book \$12.50
PE 218: Input: 25-28 VDC @ 82 amps. Output: 115 volts @ 1500 volt-amps, 380-500 cycles. \$15.00

30 MEGACYCLE RECEIVER STRIP

2 Mc. I.F. Bandwidth, 20 db Gain per Stage, 120 db. Overall Gain. \$25.00

MICROWAVE PLUMBING 10 Centimeter



Sand Load (Dummy Antenna) wave guide section with cooling fins. app. 2 1/2" high \$28.00

10 cm. dipole and reflector, with type "N" fitting. 2.75

10 cm. McNally cavity type SG Ea. 3.00

Crystal mixer, "S" band. Complete with type "N" fitting and LN22 crystal. 3.85

10 cm. waveguide, 5/8" choke to cover. Per section 12.00

Per set of 4 sections 45.00

Pick-up loop with adjustable tuning section, used in duplexer cavity. 1.50

Waveguide to flexible coax coupler (RG 18/U), with flange Gold plated. App. 10" high (as shown) 17.50

10 cm. Horn, rectangular-to-square-to-circular RF assembly ending in horn, radiating circularly polarized beam. Waveguide input. Complete with flange 35.00

Rigid coax directional coupler CU90/UP, 20 db. drop. Has short right angle, about 8" 5.50

Flexible coax connector, 3/8" rigid coax to 3/8" rigid coax. Rigid coax slotted section. CU-60/AP 5.00

Stub-supported rigid coax, gold plated, 5' lengths. Per length 5.00

3/4" coax, rotary joint. 6.00

Magnetron coupling to 3/8" rigid coax 4.00

3/8" coax, rt. angle bend, 15" L. OA. 2.00

3 CENTIMETER

Thermistor mount in waveguide with tunable terminations \$8.00

Tuner/attenuator, W.E. guide, gold plated. 3.75

TR-ATR section with waveneter iris flange. 4.00

CG/APS-3, straight waveguide section, 10" choke to cover 1.75

Right angle elbow, 5/2" choke to cover, 2 1/2" radius, E plane 4.50

H plane 5.50

Twist, 90 deg., 6" choke to cover 5.00

Waveguide sections 2 1/2" long, silver plated, with choke flange 4.50

Waveguide, 90 deg. bend, E plane, 18" long. 4.00

Waveguide, 90 deg. bend, E plane with 20 db. directional coupler 4.75

Rotary joint, choke to choke. 6.00

Rotary joint, choke to choke, with deck mounting 6.00

S-curve waveguide, 8" long choke to choke. 2.50

Duplexer section using LB24 10.90

3 cm. waveneter; transmission type with square flanges. (Also available in absorption type with square and circular flanges) 15.00

3 cm. stabilizer circuit, tunable transmission type. Model 1551 (TRX 11GA) 20.00

3 cm. waveguide, 1-1/2" x 1/2" ID 1/16" wall Per ft. 1.25

Choke flanges, circular, solid brass.55

"T" square flanges (TR-ATR) 7-1/2" choke to choke, square flanges 3.50

Bend, 180 deg., 2 1/2" radius ea curve, 12" cover to cover, with pressurizing nipple. 3.00

Directional coupler CG 124 APS-15A on 16" section cover to cover, 15 deg. bend. 5.00

Feedback dipole with 90 deg. twist, 7 1/2" long OA 3.50

TR cavity for 721-A tube. 2.50

1.25 CENTIMETER

"K" band mixer section. \$10.00

Waveguide directional coupler. 25.00

Wave Guide Section 1" cover to cover. 2.00

T Section choke to cover. 4.50

Mitred Elbow cover to cover. 3.00

Mitred Elbow and "S" sections choke to cover. 3.50

Flexible Section 1" long choke to choke. 3.00

CONNECTORS

UG 21/U. Type "N". Male. \$.75

UG 86/U. Gold Plated.95

SPECIALS

10 CM. RF Package. Consists of: SO Xmtr.-receiver using 2J27 magnetron oscillator, 250 KW peak input, 707-B receiver-mixer. \$150.00

Modulator-motor-alternator unit for above. 75.00

Receiver rectifier power unit for above. 25.00

Rotating antenna using dipole feed and parabolic reflector. New less hood 75.00

Used. 45.00

RT39APG15 Transmitter-receiver. Lighthouse tube oscillator. 5 KW. App. 2700 Mc. operation. With Lighthouse and TR tubes. 100.00

All merchandise guaranteed. Mail orders promptly filled, prices F.O.B. N. Y. C. Send Money Order or Check. Rated Concerns send P.O. Shipping charges only send C.O.D. Send for Flyers.

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PULSE EQUIPMENT

All Standard name items

APQ-13 Pulse modulator. Contains multivibrator, amplifier, rectifier, air and oil sections. Designed for 400 cycle operation. W.E. # D 151756. Contains following tubes: 1-3E29, 1-6AG7, 1-8018, 1-705-A \$49.95

G.E. PULSE NETWORK. #25E5-1-350-50P2T, 25 KV, 5 sections, "E" circuit, 1 microsecond pulse length, 350 PPS, 50 ohms impedance. \$45.00

G.E. PULSE NETWORK. #GE3-5-2000-50P2T, 5 KVA, "E" circuit, 3 sections, .5 microsecond, 2000 PPS, 50 ohms impedance. \$6.50

705-A Rectifier Tube, with Ceramic Socket. \$1.25

PULSE TRANSFORMERS

HI-Volt input transformer, W.E. # D166173. Impedance ratio 50 ohms to 900 ohms. Freq. range: 10 kc to 2mc. 2 sections parallel connected, potted in oil. \$12.00

W.E. KS 9800 Input transformer. Winding ratio between terminals 3-5 and 1-2 is 1:11, and between terminals 6-7 and 1-2 is 2:1. Frequency range: 380-520 c.p.s. Permalloy core. \$2.00

GE # K 2731
Repetition Rate: 635 PPS, Pri. Imp: 50 Ohms, Sec. Imp: 450 Ohms, Pulse Width: 1 Microsec. Pri. Input: 9.5 KV PK. Sec. Output: 28 KV PK. PWK Out: 800 KW. Bifilar: 2.75 Amp. \$19.50

Type G.E. K2450A Will receive 13KV, 4 micro-second pulse on pri., secondary delivers 14KV Peak power out 100KW GE \$15.00

Hi Volt input pulse Transformer W.E. # D169271 \$9.95

Pulse Input line to magnetron, G.E. K2748A, \$12.00

Utah Pulse or Blocking Oscillator Transformer Freq limits 780-810 cy/3 windings turns ratio 1:1:1 Dimensions 1 13/16 x 1 1/2 x 1 9/32 \$1.50

MICROWAVE TEST EQUIPMENT

"S" band lab. bench set-up. Consists of one direct-reading waveneter; app 2600-3400 mc. (cavity type); one dummy load with crystal probe, one line stretcher full wave; two waveguide to RG 18/U coax couplers, two 1" sections w/flanges. All standard 3" x 1 1/2" waveguide \$250.00

10 CM ECHO BOX, complete with micrometer adjust cavity & resonance indicator. Type TS 238/GP. With calibration chart. \$105.00

10 CM WAVE METER, Model "SL". Micrometer adjust cavity with micrometer resonance indicator. Includes 115 VAC operation converter section. In grey metal carrying case, complete with cables & spares. Made by Western Electric. \$135.00

W.E. I 136-A Signal generator, 2700-2900 Mc. range. Lighthouse tube oscillator with attenuator & output meter. 115 VAC input, reg. Pwr. supply. With circuit diagram. \$50.00

DYNAMOTORS

PE 73CM. Power supply for BC 375. Input: 28 VDC. Output: 1000 VDC @ 350 Ma. Starting relay, filter, etc. \$1.95

BD 77KM Power supply for BC 191. Input: 14 VDC. Output: 1000 VDC @ 350 Ma. with spare fuse links, etc. \$5.95

PE 101C. Input: 13/26 VDC @ 12.6/6.3A. Output: 400 VDC @ 135 Ma., 800 VDC @ 20 Ma. 9 VAC @ 1.21 A. \$3.49

Input: 28 VDC. Output: 250 VD @ C @ 60 Ma. Westinghouse. \$1.95

PC77. Input: 12 VDC. Output 275 VDC 110 Ma. 500 VDC @ 50 Ma. \$3.25

DAG 33A: Input: 18 VDC @ 3.2 A. Output: 450 VDC @ 60 Ma. \$2.45

DM 33 A. Input: 28 VDC @ 7 A. Output: 540 VDC @ 250 Ma. Power supply for modulator for SCR 274 N. \$3.95

Dyn. Model 23350. Input: 27 VDC @ 1.75 A. Output: 245 VDC @ 75 Ma. \$1.75

DM-21: In 14 VDC 3.3 A Out 235 VDC 90 Ma. with filter \$2.59

PE 55. Input: 12 VDC @ 25 amp. Output: 500 VDC @ 400 ma. (slightly used, but in excellent condition) \$4.95

MP 10-G. Power supply using 2 dynamotors. Input: 24-28 VDC. Output: 1000 VDC @ 40 ma. 320 volts dc @ 100 ma. New, complete with enclosed relays, filters, etc. \$40.00

MK II dynamotor power supply. Input: 12 VDC @ 9.4 amp. Output: 275 VDC @ 110 ma. 500 VDC @ 50 ma. New, with connecting cable and plugs \$4.75

Varistors \$.95 Ea. (Western Electric)

D-167176
D-170225
D-162356

Thermistors \$.95 Each (Western Electric)

D-167332 Bead
D-170396 Bead
D-163392 Button



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Fixed Winding 230/130
Commutator range 0-260 Volts, .65 KVA.
Max. amp. 2½

Price \$19.95

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Fixed Winding 115 Volts—60 cycles
Commutators range 103-126 Volts
Maximum output .25 KVA
Housed in shielded case 5" x 6" x 6"

Price \$8.95

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Fixed Winding 115 Volts—400 cycles
Commutator range 75-120 Volts
Load — .72 KVA
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Price \$3.95

PIONEER GEN-E-MOTOR

Dynamotor #SS2669 input volts 18 output
volts 450
Overall dimensions 6" x 3½" x 4"

\$1.75

TRANSFORMERS

Plate

Primary 115 volts 60 cycles
Secondary 1350 volts C.T. at 450 ma.
Housed in shielded case 5" x 5½" x 5½"

Price \$3.95

Filament

Primary 115 volts 50-60 cycles
Secondary 6.3 volts at 6.6 amps.
Shielded case 2½" x 3½" x 4½"

Price \$1.25

Filament

Primary 115 volts 60 cycles
Secondary 2.6 volts 10 amps.
6.4 volts 5.5 amps. C.T.
6.4 volts 1 amp. C.T.

Price \$1.95

Driver Transformer

Thordarson #T-67D78
Suitable for use in driving Class AB or
Class B audio modulator.
Stepdown ratio primary to ½ secondary
2.1/1
Primary resistance 500 ohms
Secondary resistance 250 ohms C.T.
Housed in fully shielded case 3½" x 3¼"
x 2¾"

Price \$1.25

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(Similar to Thordarson)
Match Class AB 6L6 Tubes (6600 ohms)
to 500 ohm line
Fully shielded in case 4" x 3½" x 4¼"

Price \$1.25

TUBES

(New surplus priced for quick sale)

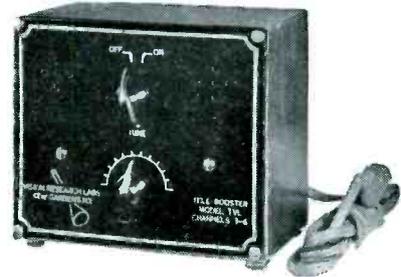
Type	Price
1B24	\$2.95
2C46	4.95
2J34	9.75
2J55	9.75
3B24	.55
3C23	2.45
4B27	2.95
5D21	9.95
4C33	2.95
5U44	.45
6E5	.60
6F8	.95
6H6	.45
6SJ7	.45
6Y6	.65
23D4	.35
45	.55
RK60	2.95
VR78	.45
HY114B	.45
350B	4.95
388A	4.95
394A	2.95
705A	1.95
801A	.45
954	.45
957	.45
1629	.20
9002	.35
9003	.18
9006	.35
50	1.25
VR90	.75
VR105	.75
VR65	.45
1626	.65
1629	.25
1R4	.65
1631	.65
1632	.25
1633	.65
1644	1.25
7193	.45
RCA 836	.75
866 A	.95
Sylvania 3 D6/1299	.75
28D7	.45
724B	1.95
3FP7	.95
5FP7	.95
GE VU111/10E146	.45
Raytheon CK1005	.85
Raytheon 2J37	
Magnetrons	6.50
RK72	.75
RK73	.45

Electrons, Inc.

ELC5B

Characteristics

Grid controlled rectifier, Rates continu-
ous current 5.0 amps. Peak forward
volts 1250 1.95



TELEVISION BOOSTER!

(Model TVL)

Increases signal strength to the television
receiver 16-18Db. Rejects unwanted off-
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connecting in series with antenna termin-
als of receiver, self contained power
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Three models available

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Model FM—88-108 Mc (FM Band)
Available in Walnut or Mahogany finish
Size 3" x 5" x 6"

Price \$26.95

FREQUENCY SWEEP GENERATOR

Vision Model TSW-50 for visual
alignment of FM and television
receivers

Features

Tubes: 6C4—Osc #1, 6C4—Osc #2, 6AG5—
Mixer, 6AG5—Cathode Follower, 5Y3—
Rectifier

Mean Frequency Range, 4 bands: A—5 to
30 mc B—20 to 50 mc C—50 to 100 mc
D—170 to 216 mc. (covers television and
FM IF and Broadcast Frequencies)

Sweep Width: Variable from 500 kc to
10 mc.

Maximum Output: 1 Volt

Output Impedance: 100, 10 ohms

RF Probe for Point to Point check
Electro-mechanical sweep mechanism.

Terminated coaxial output cable Fur-
nished complete with tubes, probe and
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4000-6000 VOLT LOW CURRENT DC SUPPLY

These units have been designed for use
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115 volt power line. D.C. output is filtered.

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2000-3000 Volt D.C. Supply, similar to
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Another of the famous Weston fan shaped line. Very large scale 5.8" long. These meters were made by Weston to General Radio specifications, with special mirrored scale and knifeedge pointer. Accuracy 1%.

0-600 Microamps
170 M.V.
Coil Res: 250 Ohms

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10 for \$100.00

PORTABLE A.C. AMMETER WESTON #528



Double range ammeter. 0-3 Amps and 0-15 Amps. Two of the very useful ranges for your Lab. or shop. Complete in genuine leather case with test leads.

Your Price \$12.25

TRANSTATS—3 K. V. A.



Type RH Input: 115 V 10%. Output: 115 V. Max. Amps: 26 A. Made as a line voltage corrector 10% of input voltage, or can be connected to give plus 20% or minus 20% of input. Can

also be reconnected to be used as an isolated type stepdown with variable secondary. Input: 115 V. Output: 0-30 Volts at 30 Amps. No Knob.

A Real Buy at \$18.00

(same type, but 25 KVA. Input: 103-126 V. Output: 115 V.-2.17 A.)

Price \$6.50

STEPDOWN TRANSFORMER



Made by General Electric. Heavy duty stepdown transformer, with considerable overdesign. Ideal for rectifier applications, low voltage heating, general laboratory use, etc. Open frame type.

Input: 115 Volts—60 Cycles
Output: 15 Volts (at full load)
Capacity: 180 V.A.
Size: 3 1/2" x 3 1/2" x 4"

Your Cost \$3.75

Quantity prices available

HEAVY DUTY STEPDOWN TRANSFORMERS

Input: 115 V. (with 8 taps in primary).
Output: from 16 to 10.5 V. (in 8 steps).
Capacity: 1.25 KVA—Sec. Amps: 100.
Size: 13"x10"x5". Approx. Weight: 30 Lbs.
Open Frame Construction.

Your Cost \$12.50
10 for \$100.00

H. V. Plate & Fil. TRANSFORMER

Westhse Encased Oil Filled

Plate: Pri-108-122V, 60 Cy. Sec—15 KV @ .020 A. 18 KV @ .015 A. Fil: Pri—105/115/125 Sec—2.5 V @ 5 A Overall Dimen: 13 1/2"W x 14 1/2"L x 7"D. Weight: Approx 50 lbs.

Price \$22.50

All meters are white scale flush bakelite case unless otherwise specified.



VOLT—OHM—MILLIAMMETER

Made by Triumph Mfg. Co. to Signal Corps Specs—Test Set 1-77-H.

Ranges:
Volts DC—0-30/300/1500
Volts AC—0-15/150
Ohms—0-1000

M.A., DC—0-300,000
0-300,000
Equipped with snap-on carrying handle—size 5 1/4"x 3 1/2"x2 3/8". Your Price \$8.50

D. C. MICROAMPS

0-100 Microamps, res. 100 Ohms
3" Rd. Westinghouse NX/35

\$7.95

0-150 Microamps—2" rd. G.E.—DW51 or Whse NX33. Res: 500 Ohms.

Your Cost \$3.75

D.C. AMPS & MILLS

0-1 Ma 2" G.E. DW41 (special scale)	\$2.95
0-1 Ma 2" Weston 506	3.75
0-2 Ma 2" Sun 1AP525-5	2.25
0-2 Ma 3" Weston 301	4.95
0-3 Ma 2" Weston 506 with metal case	1.85
0-5 Ma 2" Dejur S-210	1.95
0-25 Ma 2" G.E. DW41	2.95
0-30 Ma 2" G.E. DW41	2.95
0-100 Ma 2" sq. Simpson 127	2.95
0-100 Ma 3" Weston 301	4.95
0-500 Ma 2" G.E. DB41	3.25
0-1 Ma 3" sq. Westhe RX-35 (Scale: 1.5 KV)	4.25
0-1 Ma G.E. DO-41-Black Scale 3" (Scale: 3 KV)	3.85
0-15 Ma 3" Westhse NX-35 (scale: 15/150/300)	2.95
0-30 Ma 3" Weston 301 (Metal)	3.75
0-1 A. 3" sq. Weston 301	5.50
0-10 A. 3" sq. Triplett	2.50
0-10 A. 3" Simpson #25	4.50
30-0-30 A. 3" Simpson 25	4.50
0-30/120/600 Ma Weston Portable-Model 280—Precision Type	5.95
0-300 A. 3" Roller-Smith (fl. bake. Type TD-50 MV) (with ext. shunt)	4.95
0-300 A same as above (without shunt)	2.25
0-300 A. 4" Weston #643 (fl. metal—black scale—ext. Shunt)	8.50
0-300 A. 4" same as above (without shunt)	5.50

D. C. VOLTS

0-15 V. 2" Westhse BX-33 (Black scale)	2.75
0-15 V. 2" Simpson #125	2.95
0-20 V. 2" Weston 506 (1000 Ohms per Volt)	2.95
0-15 V. 3" Westhse CX-35	3.95
0-40 V. 2" Weston 506	2.95
0-150 V. 2" Weston 301 (Black scale—metal case)	4.50
0-150 V. 3" G.E. DO-41	4.75
0-150 V. 4" Weston 643 (Black scale—flush—metal)	6.75

A. C. VOLTS

0-10 V. 2" G.E. AW-42	\$2.95
0-10 V. 3" G.E. AO-41	3.75
0-150 V. 2" Simpson 155 (metal case)	2.95
0-150 3" G.E. AO-41	4.50
0-150 V. 3" Simpson 55	5.95
0-75 V. 4" Weston 642 (Surface Metal Case)	6.75
0-300 V. 4" sq. Triplett (431A 300/600 V. scale)	3.25

A. C. AMPS

0-1.5 A. 2" Weston 507 (RF)	\$3.50
0-2 A. 3" Westhse RT-35 (RF)	3.95
0-3 A. 3" Westhse NA-35 (scale: 120 A.)	3.95
0-30 A. 3" Triplett (metal)	2.95
0-5 A. 4" Weston 642 (surf.)	7.95
0-5 A. 4" sq. Triplett 431A (scale: 150/300)	2.95

WESTON MODEL 269 FAN SHAPED METER



One of the Weston popular fan shaped line. Exceptionally long scale for size of instrument. Accuracy — with 1%. Scale length—4". Spade pointer. Here is a good movement for special purpose instruments. Comes with blank scale with arc drawn in. Ready for plotting calibration points. Can be used to make up any range of volts, amps, M.A., etc. Full scale deflection—5 M.A.—40 M.V.

List \$29.83

Your Cost \$8.95 10 for \$75.00

A.C. VOLT-AMMETER SET



Westinghouse RA-37—4" Sq. 0-300 Volts A.C. Scale: 300/600 Volts A.C. With Potential Transformer for 600 Volt Range \$10.00
Westinghouse RA-37—4" Sq. 0-5 Amps A.C. Scale: 75/150 Amps A.C. With Donut Current Transformer for Double Range 75/150 to 5 \$10.00
Price: for ALL 4 PIECES \$17.50

HEAVY DUTY RHEOSTAT

WARD LEONARD

10 ohms—9.2 Ampe —9.2 Amps (Not tapered). 14" Dia. Complete with handle and legs for rear of panel mounting.

Your Cost \$5.95

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6 Amp. (Tungar type) for battery chargers, rectifiers, etc.

Your Cost \$1.50
(minimum order of 10 tubes)

SELENIUM RECTIFIERS

Full Wave Bridge
Approximate Rating

Federal Type #	Input Max.	Output Max.	Amps.	Price
10B1CV1	18 V.	14 V.	.5	\$.98
10B2CV1	36 V.	28 V.	.5	1.50
4B3CV2	48 V.	36 V.	.5	2.75
5B2AV1	36 V.	28 V.	1.6	4.25
5B2AV5	36 V.	28 V.	8	11.75
11BA6AM1	120 V.	100 V.	1.6	11.95
9D0812R	150 V.	115 V.	1.6	14.50

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Cap. Mfd.	V.C.	Height	Weight	Length	Price
10	1000	5-7/8 x 1-5/4	x 3-7/8"		\$1.85
4	1000	5-7/8 x 2-3/4	x 1-1/4"		.85
1	1000	3-5/7 x 2	x 1-1/16"		.50
1	500	x 1-1/4"	x 1-1/16"		.25
.25	1000	1-1/2 x 1"	x 3/4"		.25

G. E. H. V. PYRANOL CAPACITORS

.001 Mfd.—50 K.V. DC.—5 1/2"x7 3/4"x4" \$12.50
Insulators 4" Dia. x 7" High.
1 Mfd.—25 K.V. DC.—13"x7"x4" \$9.85

POWER TRANSFORMER

Pri—440/220 V 60 Cy Sec—125/115/105 V Rating .8 KVA RCA Open construction. Bracket mounted, pri & sec terminal boards. Overall dimensions: 5 1/2"H x 7 1/2"W x 8"D. Mounting dimensions: 6 3/4"x5 3/4". Price \$12.50

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AY-20, AY-30, AY-54, etc.
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G. E. 2J5HA1, 2J5FB1, 2J6F3,
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60 CYCLE AC MOTORS

G.E. Reversible. 1/150 H.P. Shunt wound. 40 volts 5000 rpm. Split field. Stock #SA-18 Price \$4.75 ea. net.
Stock #SA-19. Similar to above but not split field. Price \$2.75 ea. net.
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Pioneer Magnetic Amplifier Assembly. Saturable core type output transformer. 400 cycle. Operates from plates of 6SN7 to supply 1 phase of servo motor. Stock #SA-44. Price \$8.75 ea. net.

Sinusoidal Potentiometer—Navy Type CFW-631539. 32000 ohms. 2 output voltages. Sine and Cosine function of shaft position. D.C. input. Stock #SA-124. Price \$7.50 ea. net.

Constant Speed D.C. Motor—G.E. 5BA25MJ24. 24 V. D.C. 7100 rpm. RC noise filter. Stock #SA-100. Price \$8.50 ea. net.

Timing Motor—Haydon 1 rpm. 115 V. A.C. Stock #SA-133. Price \$2.85 ea. net.

DC Selsyn System—24 V. DC transmitter and indicator. Indicator calibrated for flap position. 360° dial easily added. Stock #SA-129 Price \$9.50 per system.

PIONEER SERVO AMPLIFIERS

12073 and 12077

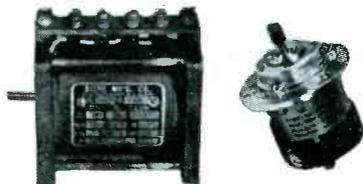
Delco 5069466 DC Motor.

27 V. 10,000 rpm. 1" x 1" x 2" Stock #SA-65.



Price \$1.95 ea.

SERVO MOTORS



Pioneer CK-2, CK-5, 10047-2-A and **Kollman** 776-01 for 400 cycles. **Diehl** FP-25-3, FPE-25-11 (CDA-211052) and ZP-106-8 (CDA-211377) for 60 cycles.

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2 V D.C. per 100 rpm.
Suitable to 5000 rpm.

Stock #SA-130. Price \$8.75 ea. net.
Elinco PM-2. Similar to S-130. Use to 2000 rpm. Stock #SA-53. Price \$6.25 ea. net.
Elinco FB-55. 4.7 V. per 100 rpm. Use to 10,000 rpm. Stock #SA-3. Price \$12.50 ea. net.

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E.A.D. J-33. 115 V. 3 phase. Synchronous. 8000 rpm, 2" x 3". Stock #SA-59. Price \$6.75 ea. net.

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Westinghouse Blower. Type FL. 6700 rpm. Capacitor type motor. 2 inch Sirrocco blower. Outlet 3/4" x 1 1/8". Includes capacitor. Stock #SA-144. Price \$6.75 ea. net. Quantity prices on request.

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12 Cm. dipole and 13 in. parabola housed in weather proof Radome. 24 V. DC spinner motor for conic scan. Shipping weight 70 lbs. Stock #SA-95. Price \$9.50 ea. net.



INVERTERS



Pioneer 12116, 12117, 12121, 12123, etc.
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General Electric 5D21N3A, etc.

DC MOTORS

Diehl FDE-14-2. 27.5 V. Shuntwound. Reversible. 1 1/2" diam. x 2 1/2" lg. Stock #SA-10. Price \$4.75 ea. net.

Delco 5066665. 27.5 V. 4000 rpm reversible. 1 oz/in torque. 2 1/2" lg. x 1 3/4" diam. Stock #SA-14. Price \$4.75 ea. net.

Diehl 5068571. 27.5 V. Alnico field. 10,000 rpm. Similar to S-65 but has straight shaft extension. Stock #SA-151. Price \$2.75 ea. net.

John Oster. Series wound. 27 V. 7000 rpm. 1/100 H.P. Stock #SA-30. Price \$2.75 ea. net.

Radio Compass Loop LP-21-LM. Stock #SA-99 Price \$9.50 ea. net.

Phase Shift Capacitor—4 stator single rotor. 0-360° phase shift. Stock #SA-114. Price \$4.75 ea. net.

Magnesyn—Pioneer CL-3. 6 power. Transmitter or receiver. Stock #SA-6. Price \$3.75 ea. net.

Null Type Synchro Indicator. Consists of Bendix size 5 synchro, magic-eye tube, illuminated 360° dial, rectifier tube, transformer, etc. Use with S-43. Stock #SA-119. Price \$6.95 ea. net.

SINE COSINE GENERATORS

Diehl Types FJE-43-9 and FPE-43-1



Remote Position Indicating System



6-12 V. 60 cycles. 5 inch indicator with 0-360° dial. Heavy duty transmitter. Stock #SA-115. Price \$9.95 per system.

All Items
New & Guaranteed

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247 CROOKS AVE.

ANTENNA RELAY UNIT

0-10 Meter Weston Thermo-couple unit with 50 MMF, 5000v Vacuum condenser, and heavy duty relay

\$1.98



RELAYS

Sigma No. 4RJ 2000 ohms SPDT. Can adjust to less than 1 ma

69c

GENERAL RADIO 566A WAVEMETER

.5 mc to 150 mc

5 PLUG IN COILS, Reg. Price \$69.50, BRAND NEW **\$39.50**

SELENIUM RECTIFIERS Full Wave Bridge Type

INPUT		OUTPUT		
up to 18v A.C.	up to 12v D.C.	1 Amp.	\$1.95	
up to 18v A.C.	up to 12v D.C.	5 Amp.	4.45	
up to 18v A.C.	up to 12v D.C.	10 Amp.	7.45	
up to 18v A.C.	up to 12v D.C.	15 Amp.	9.95	
up to 18v A.C.	up to 12v D.C.	30 Amp.	14.95	
up to 36v A.C.	up to 28v D.C.	1 Amp.	3.45	
up to 36v A.C.	up to 28v D.C.	5 Amp.	7.45	
up to 36v A.C.	up to 28v D.C.	10 Amp.	12.45	
up to 36v A.C.	up to 28v D.C.	15 Amp.	18.95	
up to 54v A.C.	up to 36v D.C.	25 Amp.	98	
up to 115v A.C.	up to 100v D.C.	25 Amp.	2.95	
up to 115v A.C.	up to 100v D.C.	6 Amp.	6.95	
up to 115v A.C.	up to 100v D.C.	5 Amp.	19.95	

SOLA

Constant Voltage Transformer

Pri.: 190 to 260v 60 cyc. Sec.: 115 volts @ 1.74 amps. Rated 250 V. A.

Brand New **\$29.95**

GLIDE PATH RECEIVER R-89/ARN-5

Glide Path Receiver used in the Instrument Landing System covering the frequency range 332 to 335 mc; complete with the following tubes: 7-6AJ5, 1-12SR7, 2-12SN7, 1-28D7, and including three crystals 6497KC, 6522K.

Brand New **\$12.95**

PERMALLOY SHIELDS for CATHODE RAY TUBES

3" Shield **\$1.49**
5" Shield **1.98**

TUBES (Brand New) Army-Navy Inspected

1N21	\$0.39	371B	\$5.95
2AP1	2.25	450TH	39.95
2C40	1.19	703A	7.95
2D21	.89	715B	7.95
2V3G	1.25	721A	4.35
2X2	.84	726/AC	7.50
3AP1	3.00	801	1.49
3BP1	2.95	802	1.98
3E29	2.95	803	8.95
3GP1	3.95	804	9.95
5BP4	4.95	805	4.95
5CP1	3.95	806	14.95
5JP1	11.95	807	.95
5Y3	8.95	808	2.95
5R4GY	.98	809	1.50
5Y3	.41	810	5.95
6AB7	.99	811	1.95
6AC7	.99	812	3.15
6AG5	.99	813	8.95
6AG7	.99	814	4.45
6AJ5	.99	815	3.95
6AK5	.90	829-A-B	3.00
6AL5	.99	832	2.25
6AC6	1.09	833A	39.50
6AR6	1.29	836	1.75
6B4G	1.29	837	2.50
6C4	.69	838	3.95
6C5	.49	861	69.50
6D4	.99	866	7.50
6FG	.89	872A	2.50
6F6G	.59	884	.98
6J4	1.50	885	.98
6J5	.55	902	3.00
6J6	.89	954	.75
6L6	1.23	955	.75
6L7	.98	956	.75
6N7	1.02	957	.75
6SH7	.59	958	.75
6SL7	.89	959	.75
6SN7	.69	1005	.69
6SR7	.89	1616	2.95
7A4	.81	1619	.75
7F7	1.25	1620	1.98
7L7	1.59	1622	1.98
10E	.98	1624	.98
15Y	1.50	1625	.75
HK24G	1.75	1626	.75
28D7	.98	8001	6.49
30	.75	8003	9.95
35T/TG	3.50	8005	4.95
VR90	.75	8011	3.75
VR105	.75	8016	1.65
VR150	.75	8025A	4.95
100TH	7.95	1654	1.98
100TS	3.00	9001	1.15
211	1.25	9002	.98
75T	2.95	9003	.98
250TH	14.95	9004	.98
257B	6.49	9005	.98
304TH	9.95	9006	.98
F-127A	22.50	F-128A	75.00

TRANSFORMERS—115 V 60 CYC. HI-VOLTAGE INSULATION

3710v @ 10 ma.	2x2 1/2 v @ 3A	\$9.95	
2500v @ 15 ma.		6.50	
2500v @ 4 ma.	2 1/2 v @ 2A, 6.3v @ 1 amp.	9.95	
2150v @ 15 ma.		6.50	
1750v @ 4 ma.	6.3v @ 3A	7.50	
1700v @ 4 ma.	6.3v @ 6A; 2 1/2 v @ 1.75A	8.50	
1600v @ 4 ma.	700v CT @ 150 ma.; 6.3v @ 9A	8.50	
1600v @ 2 ma.	6.3v @ 6A; 2 1/2 v @ 1.75A	8.50	
1500v @ 7 ma.	2 1/2 v @ 1.75 A	7.50	
1200v CT @ 400 ma.	10v CT @ 10A	9.95	
550-0-550v @ 150 ma.	5v @ 3A; 2x6.3v @ 5A CT	7.95	
526-0-526v @ 60 ma.	925v @ 10 ma.; 2x5v @ 3A; 6.3v @ 3A; 2x6.3v @ 6.3v @ 1A	8.95	
525v @ 35 ma.	5v @ 35 ma; 2 1/2 v @ 1.75A	1.98	
520-0-520v @ 120 ma.	5v @ 2A; 6.3v CT @ 5A	5.95	
500-0-500v @ 25 ma.	262-0-262v @ 55 ma.; 6.3v @ 1A; 2x5v @ 2A	4.40	
500-0-500v @ 100 ma.	5v CT @ 3A	4.95	
400-230-0-230-400v @ 250 ma.	3x5v @ 3A; 6.3v @ 5A; 6.3v @ 3A; 6.3v @ 1A	7.95	
400-0-400v @ 200 ma.	5v @ 3A	4.95	
375-0-375v @ 400 ma.		4.95	
350-0-350v @ 150 ma.	5v @ 3A; 6.3v @ 6A; 75v @ 1A	4.95	
350-0-350v @ 45 ma.	675v @ 5 ma.; 2 1/2 v @ 2A; 2x6.3v @ 1A; 6.3v @ 2 1/2 A	4.95	
350-0-350v @ 80 ma.	6.3v @ 6A; 6.3v @ 3.75A; 2x5v @ 3A	3.98	
350-0-350v @ 120 ma.	5v CT @ 3A; 6.3v CT @ 4.7A	3.95	
350-0-350v @ 70 ma.	400v @ 10 ma.; 65v @ 6.3v @ 6A; 6.3v @ 4A; 5v @ 2A	2.49	
350-0-350v @ 150 ma.	5v @ 3A; 6.3v @ 7.5A; 6.3v @ 3A	5.95	
350-0-350v @ 35 ma.		1.49	
340-0-340v @ 300 ma.	1540v @ 5 ma.	7.50	
325-0-325v @ 120 ma.	10v @ 5A; 5v @ 7A	3.49	
300-0-300v @ 65 ma.	2x5v @ 2A; 6.3v @ 2 1/2 A; 6.3v @ 1A	3.49	
260-0-260v @ 100 ma.	2x6.3v @ 4A; 6.3v @ 5A; 6.3v @ 1A	4.95	
200-0-200v @ 140 ma.	6.3v @ 4A; 5v @ 2A	1.98	
120-0-120v @ 50 ma.		.98	
24v @ 6A		3.50	
6.3v @ 10A; 6.3v @ 1A		3.50	
6.3v @ 1A; 2 1/2 v @ 2A		3.95	
6.3v @ 2 1/2 A; 6.3v @ 2A; 2 1/2 v @ 2A		6.95	
6.3v @ .25A; 6.3v @ 3A; 5v @ 12A; 6.3v CT @ 9A		4.95	
5v CT @ 16A	\$3.49	5v—115A	14.95
5v—190A	17.50	6.3v @ 6.6A	2.95
6.3v CT @ 1A	.98	8v CT 1A	.98
220v to 110v @ .75 kv.			2.98
6.3v CT @ 3A; 5v CT @ 4A			4.25

OIL CONDENSERS G. E., AEROVOX, CD., ETC. All Ratings, D.C.

1mfd. 600v	\$0.35	2mfd. 2000v	\$1.75
2mfd. 600v	.35	3mfd. 2000v	2.75
4mfd. 600v	.60	4mfd. 2000v	3.75
8mfd. 600v	1.10	15mfd. 2000v	4.95
10mfd. 600v	1.15	1mfd. 2500v	1.24
1mfd. 1000v	.70	25mfd. 2500v	1.45
2mfd. 1000v	.60	3mfd. 2500v	1.75
4mfd. 1000v	.95	5mfd. 3000v	1.95
8mfd. 1000v	1.95	1mfd. 3000v	2.25
10mfd. 1000v	2.10	25mfd. 3000v	2.65
15mfd. 1000v	2.25	3mfd. 3000v	2.85
20mfd. 1000v	2.95	1mfd. 3000v	3.50
24mfd. 1500v	6.95	12mfd. 3000v	6.95
25mfd. 2000v	1.05	2mfd. 4000v	5.95
5mfd. 2000v	1.15	1mfd. 5000v	4.95
1mfd. 2000v	.95	1mfd. 7000v	2.95
SPECIAL 2 mfd. 3000v. \$4.45			

HIGH CAPACITY CONDENSERS

2x3500 mfd.—25WVDC	\$3.45
4000 mfd.—30WVDC	2.95
1000 mfd.—15WVDC	.99
3000 mfd.—50WVDC	1.95

BC-314 RECEIVER

Used but in perfect condition. Two stages RF, separate local and beat oscillators. For 12-volt DC operation but easily converted to 110-volt AC. Frequency range 150-1500 KC, continuous in 6 bands. This unit is ideal as an airport or marine low frequency receiver, also a very excellent BC receiver. Complete with tubes, specially priced **\$29.50** at

BC-375-E TRANSMITTER

Operates from 200 kc—12.5 mc complete with all tubes, dynamotor, six tuning units and one antenna tuning unit. Like New **\$29.50**

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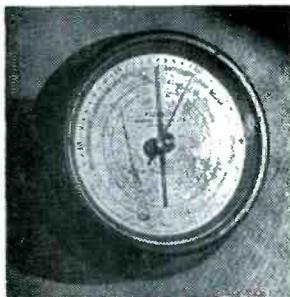
Versatile MOTOR of 1000 uses. Actual size 1" x 1" x 2 1/4". ALNICO Field. Operates 6 to 30 volts DC. Speeds up to 10,000 RPM. REVERSIBLE. Tiny removable gear on shaft. Ideal for models, etc. \$2.50 Check or M.O.

MOTORS

- Delco #5069600 Alnico Field, 250 RPM. 27 V DC 1/4" spline shaft 1/2" long, 1 3/8" x 3 3/4" overall size. \$ 3.95
- Delco Mini Motor, Alnico Field, 10,000 RPM operates 6, 12 or 24 V DC 1" x 1" x 2" overall. 2.50
- Redmond 24 V DC, 6,000 RPM .96 amp 3" dia x 4" long 1/4" x 1" shaft. 2.00
- Redmond 6 V DC 2,000 RPM reversible shunt wound 5/16" x 1" long spline shaft. 3" x 5 1/2" overall size. 5.00
- Bodine 6 V DC 17 RPM geared slo speed powerful. 1/2" x 1 1/2" long right angle shaft. 4" x 8" overall size. 15.00
- F. A. Smith 27 V 10,000 RPM 3/16" x 1" long shaft with worm gear on front end. 1/2" x 3/4" long knurled shaft on back end. 2.50
- G.E. 24 V shunt 145 RPM geared 14" oz torque 1 1/2" x 4" overall size. 2.50

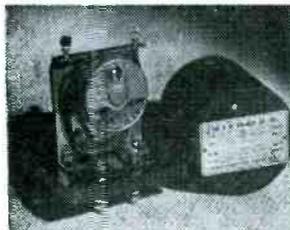
MINI BULBS

Miniature Bulbs # 318 or #323 (3 volt) .19 amp for instruments, hobbyists etc.
Per. Dozen 1.50

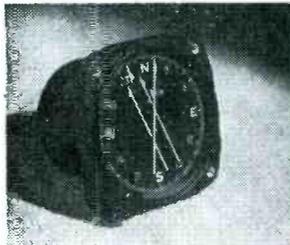


BENDIX BAROMETER

Bendix Friez precision aneroid type, wall mounting 6" dia x 3" wide. 15.00



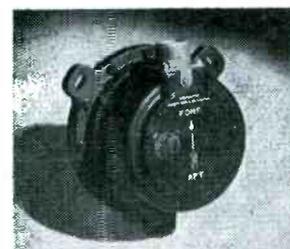
D- 2 MIN. ADJUSTABLE TIMER



A- COMPASS INDICATOR



B- INVERTER



C- COMPASS TRANSMITTER

PUMPS

- A—Pesco pump, vacuum or pressure. Vane type. 3/8" spline shaft. 1/2" threaded prts. 4" dia. x 5" long overall size. 7.00
- B—Delco 24 V DC 1/4 H.P. Vacuum or Pressure. Diaphragm type. 6" x 12" overall size. 15.00

Micro switches normally open or normally closed. 3 for 1.00

A- KOLLSMAN COMPASS C- TRANSMITTER

and remote indicator with power supply for operation on 24 V DC Government cost \$250.00. Special Price 25.00

R.W. CRAMER TIMER

Adjustable time delay. 0 to 120 seconds. 110 V AC. Capacity 10 amps. 4.50

INVERTERS

- 400 cycle Inverters PU/16 AP 24 V DC—60 Amp. Output 6.5 Amps 115 V. 15.00
- PE 218 24 V DC—80 Amp. Output 15 KVA 13 Amps, 115 V. 25.00

TANKS

- A—Tanks 400 lbs. pressure. 5 1/2" dia x 14" long. 1/8" pipe fitting one end. 2.00
- B—Oxygen hi pressure 1800 lbs. with valve, shatterproof. 5 1/4" dia x 21" long, weight 14 lbs. 6.00

BATTERY

6 Volt Willard battery 15 amp capacity 5" x 5" x 6" over-all size. 3.50

AXIAL BLOWER

100 C.F.M. 24 V AC or DC 4 1/2" diameter 5" long 4.50

SIREN

Powerful 12 V DC—6" high 6" long. 5.00

STANDARD 110 V. AC MOTORS

- A—Redmond 1/30 H.P.—Cont. duty, 4" dia.—6" long. 1550 RPM 10.00
- B—Jack & Heintz 1/4 H.P. Resilient mounted 3/8" dia. shaft. Capacitor type. 1725 RPM 22.50
- C—Jack & Heintz 1/2 H.P. Capacitor type 1725 RPM, 3/8" dia. shaft. Resilient mount. 25.00

LANTERNS

- A—Powerful Signal or Spotlite, 6" dia. sealed beam in plastic case. Complete with colored filters and carrying case. 6, 12, or 24 volt. Price \$5.50
- B—Spotlite 12 V with trigger switch and 10 ft. wire. 2.50
- C—Spotlite or Lamp 6 or 12 Volt has combination trigger and on, off switch. Pistol grip handle, all metal and protecting grill for bulb. 6.50

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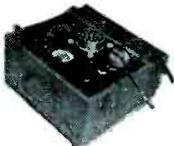
DAVEN AUDIO FREQUENCY METER Model 837E



Direct reading from 0-30 KC in 4 separate ranges on 6" Weston Model 271 Fan Meter. Built-in voltage regulated power supply operates from 115 volts 60 cycles, has high input impedance. With pick-up can be used to determine frequency in vibration tester. With suitable mixer can check deviation of R.F. carrier from standard. Mounts on 8 3/4" x 19" rack panel. Complete with tubes. Slightly used but perfect. Only.....\$59.50

S.C. TEST SET—1-114

In portable wood case 6" x 6" x 10" (including cover not shown). Has Weston 0-150 volt A.C. meter 60 cycle, 2 switching circuits. Complete with line and test cables. A bargain at only \$3.95.



CHOKO BARGAINS

WE 4.3 hy 620 ma. 42 ohms.....\$4.95
N.Y.T. 8 henry 160 ma. 140 ohms D.C.....1.39
C.T.C. 1.5 henry 250 ma. 72 ohms......69
R.C.A. 50 henry 680 amps. high voltage.....19.50
Fed. Tel 6 henry 1.8 amps. high volt.....29.80

R.C.A. POWER TRANSFORMER

770 V.C.T. 100 ma., 6.3 volts—2.5 amp.
5 volts—2 amps.—3 1/2" x 4" x 4 1/2".....\$2.75

AMERTRAN STEPDOWN TRANSFORMER

220-110 100 watts, shielded.....\$2.49

MIDGET VARIABLE BARGAINS

Hammarlund MC 250S 250 mmf.....\$.89
Hammarlund MC 320S 320 mmf......78
Hammarlund APC 100 100 mmf......38
Hammarlund APC 50 50 mmf......29
Hammarlund HFD 30X Dual 30 mmf. D.S....1.18
Bud MC 913 Dual 35 mmf. D.S.....1.26

LINK BC 438 FREQUENCY METER

195-215 mcs. Built in 110 volt 60 cycle power supply. Complete with tubes and crystal. Slightly used. Limited quantity.....\$8.95

TRANSMITTING VARIABLES

Cardwell XD160 X.D. Split stator. 160 mmf./section. 125 spacing.....\$7.95
Hammarlund MTC 150—150 mmf., .07 spacing (easy to split).....1.49

HANDY LAB KITS

25 Popular silver micas.....\$1.95
50 Popular pigtail micas.....2.38
25 Popular ceramics.....1.50
25 Wirewound resistors. 5 to 30 watt.....2.50
15 Bathtub condensers.....1.85

HIGH VOLTAGE MICAS

C.D. .002 2500 W.V. 5000 V.T. type 9.....\$.19
C.D. .002 3500 W.V. 7500 V.T. type 9......69
Micamold .005 2500 W.V. type 4......69
Solar .005 10 K.V. D.C. 11 amp. 3000 K.C. 7.95
C.D. .004 3KV. D.C. 20 amp. 18000 K.C. 2.50
R.C.A. .02 2000V. D.C. 10 amp. 300 K.C.....1.75
Sangamo (F2L) .015 2000V. D.C.....1.80
C.D. (6H) .0013 5000V. D.C.....1.00
C.D. (6H) .005 5000V. D.C. 11 amp. 1000 K.C. 2.50
R.C.A. .006 2500 W.V. 5000 V.T......39
Sangamo (G3) .0005 20KV.....12.95
Sangamo (G4) .001 30 KV.....27.75

FEDERAL TELEGRAPH TRANSMITTER

B.C. 325-B—Phone-CW. 110V 60V cycle input—400 watts output CW. Crystal and Variable Frequency Control—Has Blower Motor, Crystal Oven, Transtat, Modulation Oscilloscope, 11 Panel Meters, etc. Perfect condition....\$575.00

500 foot Drums RG8/U Coaxial Cable
\$24.50 per Drum

U.H.F. COAX. CONNECTORS

UG12U—831R—831J—UG21U—831AP—8318P .39 ea.
Large stocks of Coax. and A/N connectors.

AMERTRAN TRANSTAT or Stepdown Transformer

110/220 volts 60 cycle input. Output variable plus or minus 10% of 115 volts at 8.5 amps. Also can be connected to give different voltage combinations. Brand newonly \$17.50



AMERTRAN VOLTAGE REGULATOR

130/230 volts 50/60 cycles input. Output variable from 0—260 volts. 1.3 KVA, single phase. Like new\$29.50

SPERTI RF

VACUUM SWITCH

9200 volts peak. 8 amps. Used as antenna switch in Collins ART 13. BRAND new\$1.75



VOLTAGE REGULATED Power Supply

Input 110 volts 60 cy. output 150 volts regulated. Used VR 150/30 ad x 5. Well filtered (3 chokes) and has extra 6.3 volt winding. 18" x 3 1/2" x 5". Complete with tubes. Used, but good. \$6.95

OIL CONDENSERS

CD, GE, Aerovox, etc.

2mfd 600 vdc.....\$.36	3 mfd 3000 vdc.....\$3.95
4mfd 600 vdc......80	1 mfd 4000 vdc.....3.75
3/3 mfd 600 vdc......70	1 mfd 5000 vdc.....4.50
4/4/4 mfd 600 vdc......95	1 mfd 7500 vdc.....1.95
14 mfd 600 vdc.....1.35	1/1 mfd 7500 vdc 2.45
2 mfd 1000 vdc......78	.01/.01 12 KV do 5.75
4 mfd 1000 vdc......95	.005/.01 12 KV do 5.50
2 mfd 1500 vdc.....1.25	.65 mfd 12500 vdc 12.95
1 mfd 2000 vdc.....1.15	.75/.35 mfd (dual)
	8/16 KV do.....14.95

WHERE SPACE IS LIMITED

This tiny GE motor only 1 1/4 inches square. Basic movement 0—1 ma. Ideal as "S" meter for BC348, etc. Only.....\$3.95 ea.



METERS (brand new)

2" GE 0—5 ma (amp scale).....\$1.95	
2" GE 0—1.2 (0-100 scale).....2.49	
2" GE 0—1 amp R.F. (internal thermo).....3.49	
2" Weston 150-0-150 microamps. Model 506 (Sperry scale).....3.49	
2" McIntoch 0-50 microamps. (square).....7.50	
2" Weston type 507 0-120 Ma RF.....4.95	
2" Gruen 0-1 MA Basic (0-3V Scale).....2.95	
3" W. E. 500-0-500 microamps. (Blank scale).....3.95	
3" Westinghouse 0-50 amps. A.C.....4.95	
3" Westinghouse 0-2 ma D.C.....3.95	
3" Westinghouse 0-20 ma D.C.....3.95	
3" G.E. 0-15 ma D.C. (square).....3.95	
3" Westinghouse 0-150 volts A.C.....3.95	
3" G.E. 0-200 microamps (volt-scale) 6.95	
3" G.E. Running Time Meter.....7.95	
4" G.E. 1-0-1 ma D.C. (Blank scale) 3.95	

FEDERAL SELENIUM RECTIFIER

Full wave. 36 volts input. 28 volts output at 6.1 amps. Brand new.....\$7.95

ELECTROLYTIC CONDENSER BARGAINS

(Cornell Dubilier, Aerovox, W. E. only)

25 mfd 25 w.v. tubular C.D.....\$.25	
50 mfd 50 w.v. tubular C.D......29	
4 mfd 150 w.v. tubular C.D......18	
8 mfd 450 w.v. tubular C.D......37	
12 mfd 450 w.v. tubular C.D......44	
500 mfd 15 w.v. tubular C.D......49	
10 mfd 450 w.v. can C.D......45	
15 mfd 450 w.v. can C.D......69	
20x20 mfd 450 w.v. can Aerovox.....1.05	
80 mfd 200 w.v. can W.E......69	
200 mfd 200 w.v. can W.E......98	
1000 mfd 25 w.v. can Aerovox......95	

Tremendous stocks on hand.
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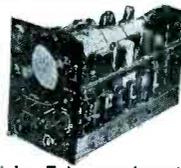
G.E. 2" SCOPE

This compact unit only 4 1/4" x 4" x 6 3/4". Ideal for modulation indicator, etc. Has focus, intensity and reticle brilliance controls. Uses 2AP1 C.R.T. and 9006 rectifier. We supply instructions with each scope. Rectifier built in. Need only 500-600 volts A.C. plus 6.3 volts. Changes very simple with cable and 9006 but less 2AP1.....\$4.95
2AP1 C.R.T.....2.50



APN 4, 5" SCOPE INDICATOR (25 tubes)

Makes an ideal basis for 5" scope. Also can be converted into Panadapter with marker pins at 100 KC - 20KC - 2 KC., for measuring drift and width of F.M. Has electron switch for observing 2 frequencies simultaneously. Unit contains an accurate 100KC crystal. Tube complement: (1) 5CP1 (3) 6SL7 (14) 6SN7 (6) 6H6 (1) 6SJ7. Complete with tubes and 100KC crystal. Marvellous buy at.....\$24.95



POWER PLANT (PE 197)

4 cylinder Hercules Gas driven engine. Output 110 volts 60 cycles, voltage regulated, 5KW-6.3KVA at 80% Pwr. Ftr. Single phase, complete with running spare parts, meter panel, battery, tools, remote cable, etc. Weight 1200 lbs. Export Packed. Excellent for emergency power. Brand new.....\$575.00

MISCELLANEOUS SPECIALS

2-11 mmf. Butterfly with ball bearings.....\$.59	
G.E. S.P.D.T. Relay 10000 ohm coil......59	
Heineman Circuit Breaker 5 amp. 110V. A.C......89	
G.E. Solenoid W/Microswitches 24 V. D.C......69	
Ohmite 25 ohm 25 watt Rheostat......39	
Microswitch 10 amp. (Interlock)......59	
C.H. Bat Handle Switch—D.P.S.T. 1/2 H.P......95	
Veeder Root Counter......95	
Single Plate to P.P. input 3:1 ratio trans....49	

MEGOHM METER

Industrial Instruments Model L2AU 110/220 volts 60 cycle input. Direct reading from 0-100000 megohms on 4" meter. Can be extended to 500000 megohms with external supply. Stopping hardware cabinet 15" x 8" x 10". Brand new with tubes plus running spare parts including extra tubes. Great value only.....\$69.95



WIRE WOUND RESISTORS

Standard Make

5 watt type AA. 20-25-50-200-470-2500-4000 ohms......09 ea.	
10 watt type AB. 25-40-84-400-470-1325-1900-2000-4000 ohms......15 ea.	
20 watt type DG. 50-70-100-150-300-750-1000-1500-2500-2700-5000-7500-10000-16000-20000-30000 ohms......20 ea.	
30 watt type DI. 100-150-2500-3000-4500-5300-7500-18000-40000 ohms......24 ea.	

1% PRECISION RESISTORS—

Standard Make

2000-2500-5000-8500-10000 ohms......39 ea.	
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Kit contains one synchro differential gen. type 6DG—80/90 volt 60 cycle A.C. Dne 220 V. A.C. 5MFD Motor Can. Two silverstans—ideal for use as voltage regulator. This regulator is the leaf type (similar in function to a carbon pile). It provides a continuously variable resistance from 10 to 1200 ohms. When used in bridge circuit, ideal to control servo motor. All brand new in original boxes—ship wt. 40 lbs.....\$4.95

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| 3x.1mfd 400vdc | INVERTED MOUNTING 20c |
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| .0068 | .003 mfd | |
| .013 | .004 | 65¢ |
| .01 | .005 | |

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|----------|-------|----------|-------|-----------|-------|
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| 1L6 | 1.29 | 6B8 G | .78 | 35L6 GT | .70 |
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| 1S5 | .75 | 6J6 | .58 | 2050 | .82 |
| 1T4 | .50 | 6K6 GT | .65 | 9001 | .69 |
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| 500-2500 feet | 3¢ per foot |
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No charge for REELS
500 foot REELS and OVER

BC 1072a IFF transmitter 150-200mcs, 115v, 60cy

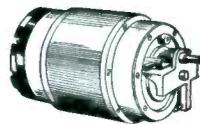
POWER SUPPLY: 0-5000vdc (variac control), 312vdc, 700vdc, 6.3vac. Also contains: 11 tubes, 5KV meter, blower, and many other parts too numerous to mention. Of course, at this price it is used. Shipping weight, 245 lbs. All this for ONLY \$22.50



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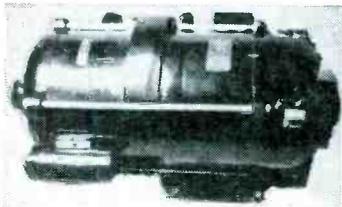
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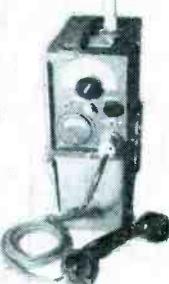
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5-Meter Walkie-Talkie



Model BC-322 Transceiver: simple, popular communications unit. Freq. range 52-65 mc. Uses only two tubes, types 33 and 30. Includes a 5 KC crystal in a crystal calibrator circuit. Range 5 to 150 miles, depending upon location and altitude. Operates from single battery block (not supplied) available from mfr., or other sources. Supplied with telescoping antenna and handset, almost new condition.

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Brand new, RCA, complete, 35 watts peak, 12-15 watts average. Amplifier and close-talking Pressure type (moving coil) microphone. Operates from 12-14 volts DC. Self-contained vibrator power supply. Tubes supplied: 6X4, 6SN7, and 2-6L6. Flat response to 5,000 cps. Output impedance to 15 ohms (2-8 ohm voice coils). Shock mounting employed throughout. Designed for airplane installation, to withstand shock and vibration. Ideal for sound trucks, boats, portable P.A., etc. Conversion to 110V. AC operation easily accomplished. Drain 2 amps standby, 6 amps operate.

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Designed for 25 watt mobile transmitters, by Galvin-Motorola. 2-packs-In-1, with two transformers, two vibrators, and two 0Z4-A gaseous rectifier tubes. Output 540 volts DC, at 160 mls. Simple conversion to 300 volts at 300 ma. Instant output, no heating time required.



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Tests performance, leakage and shorts in ALL receiving tubes, even sub-miniature and acorn. PLUS provision for tubes that may be invented. Durable construction is fully shielded; dust-proof case, high-visibility meter, illuminated chart, no books or charts to be misplaced. Simple, fast operation with positive contact slide-switches; tests EVERY tube element. 110 volt AC. 16 1/2" x 14 1/2". MA-2193. **\$2950**

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Same construction and operating features as counter model. Enclosed in sturdy case with durable black leatherette covering. 12 3/4" x 12 3/4". MA-2194. **\$3250**

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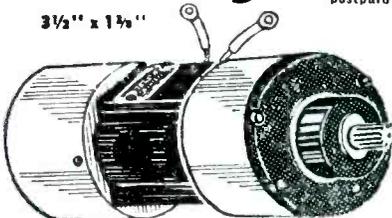


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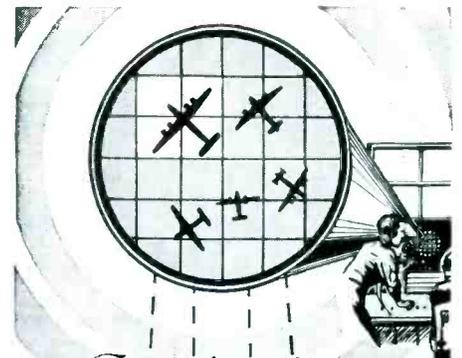
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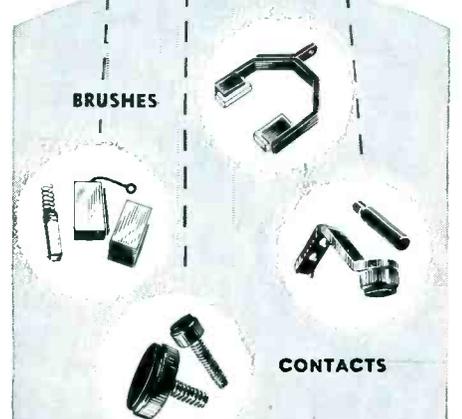


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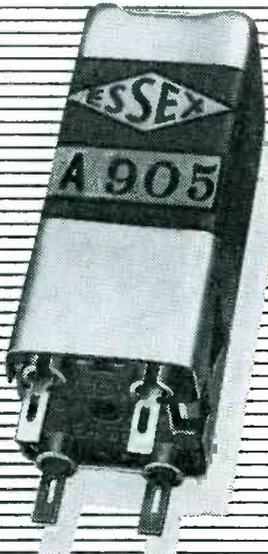
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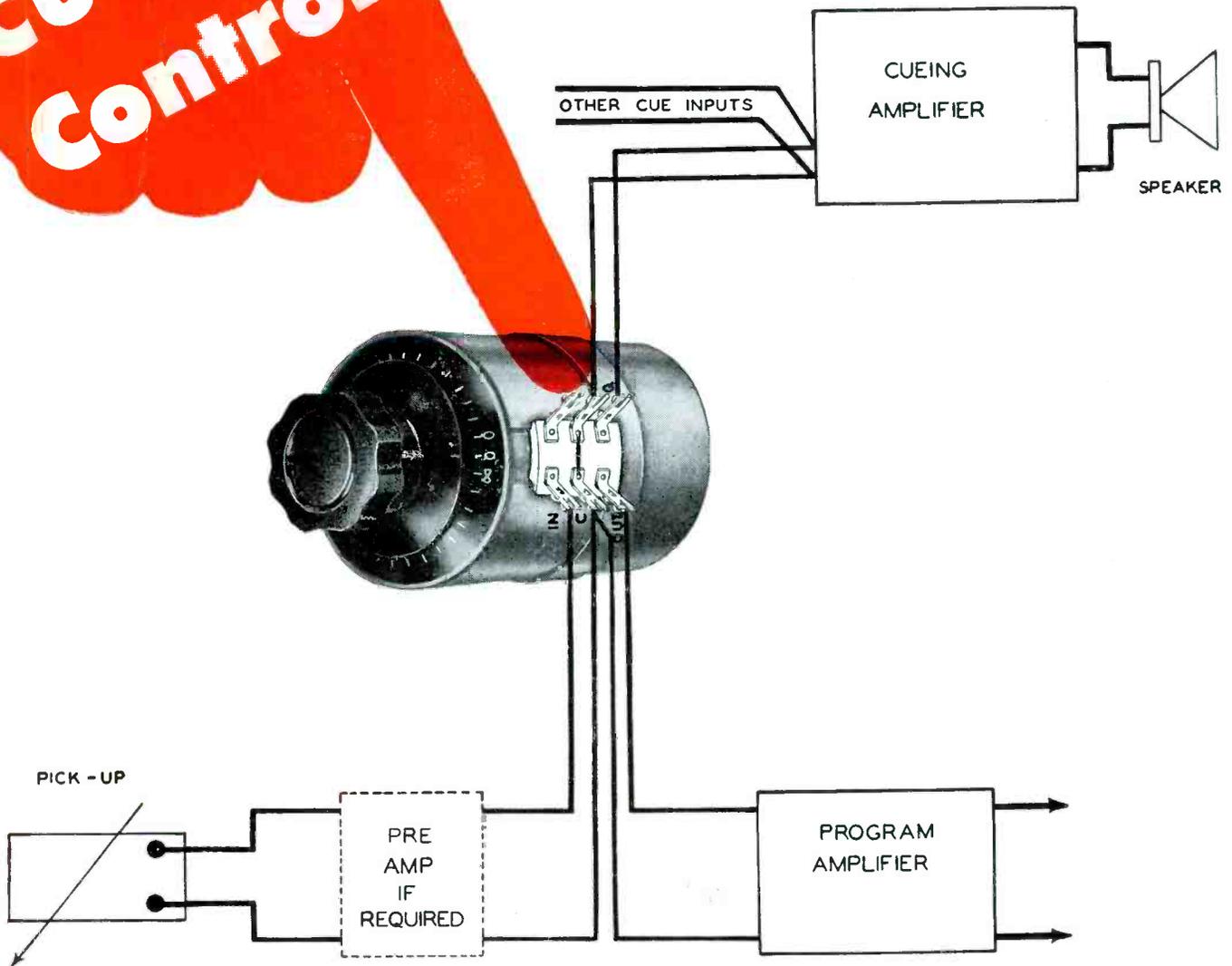
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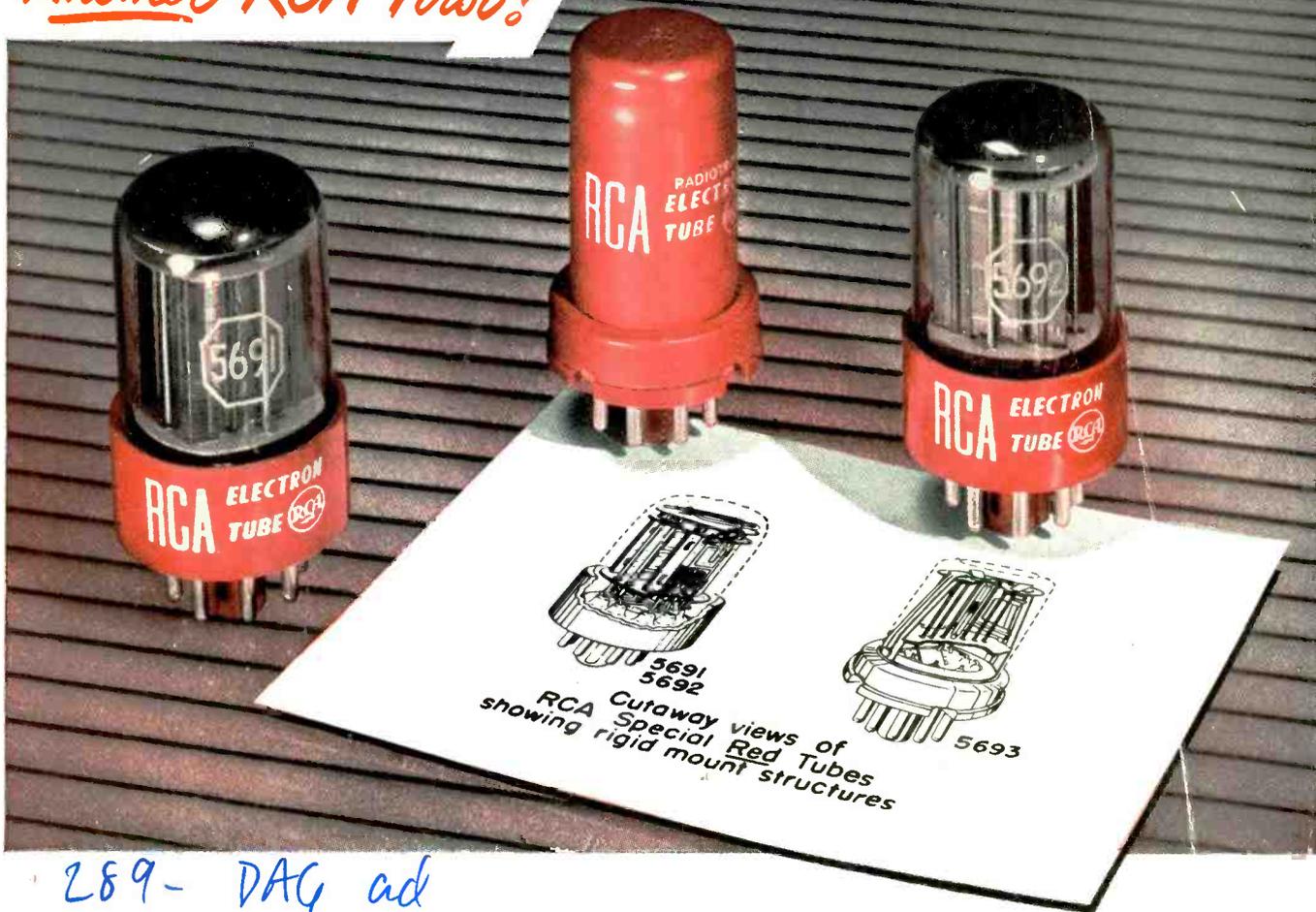
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