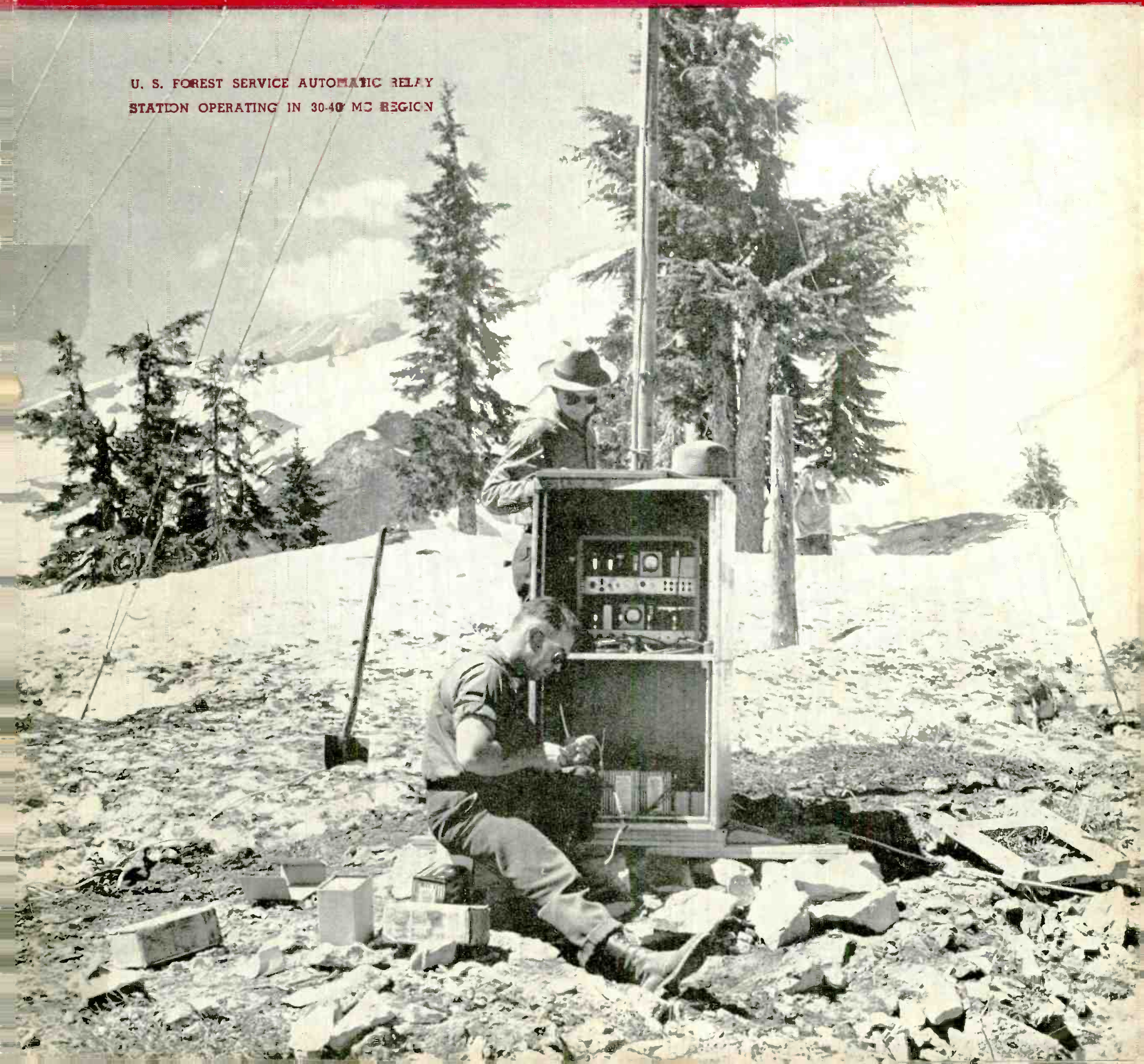
JANUARY • 1942

electronics

radio, communication, industrial applications of electron tubes . . . engineering and manufacture



U. S. FOREST SERVICE AUTOMATIC RELAY STATION OPERATING IN 30-40 MC REGION

electronics

A McGRAW-HILL PUBLICATION

CONTENTS—JANUARY, 1942

DEPARTMENTS

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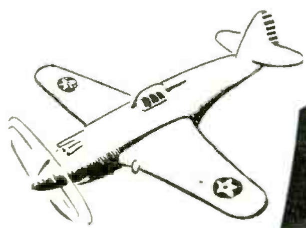
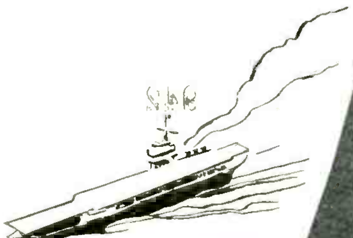
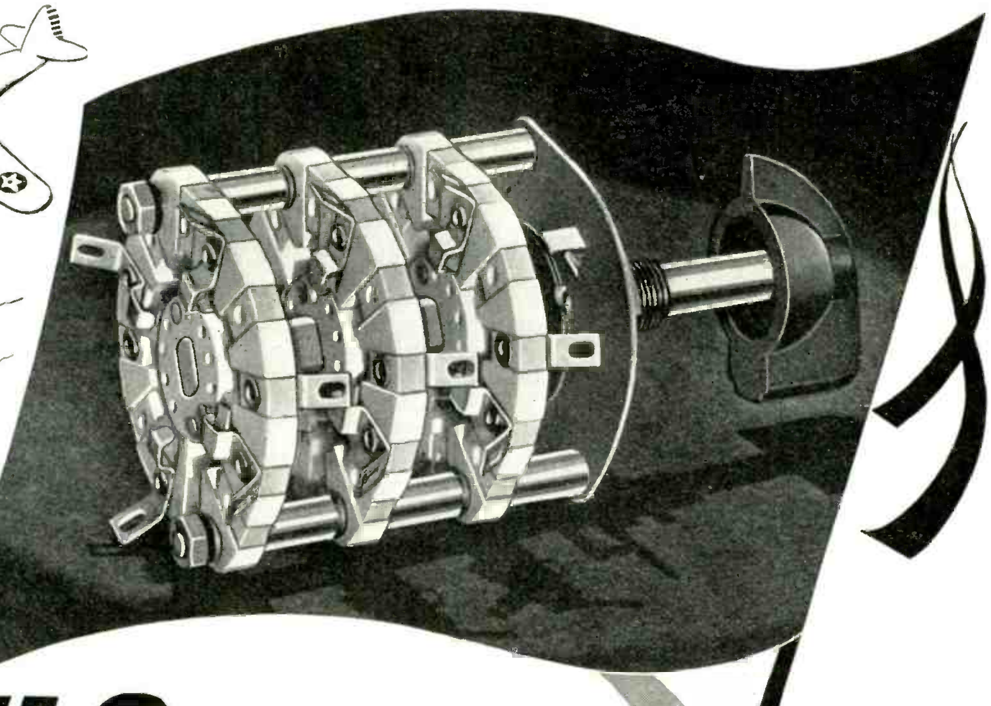
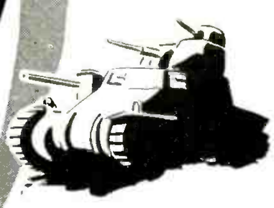






Rigid U.S. Tests Demand CENTRALAB Switches in Your Cummunication Systems



Don't hold up defense development! Centralab NOW offers a kit of parts of high grade Steatite Ceramic Switch Sections and necessary metal parts which will withstand the 200 hour Salt Spray Test, for the immediate construction in your own laboratory of efficient highest quality SELECTOR SWITCHES (over 200,000 electrical combinations available).

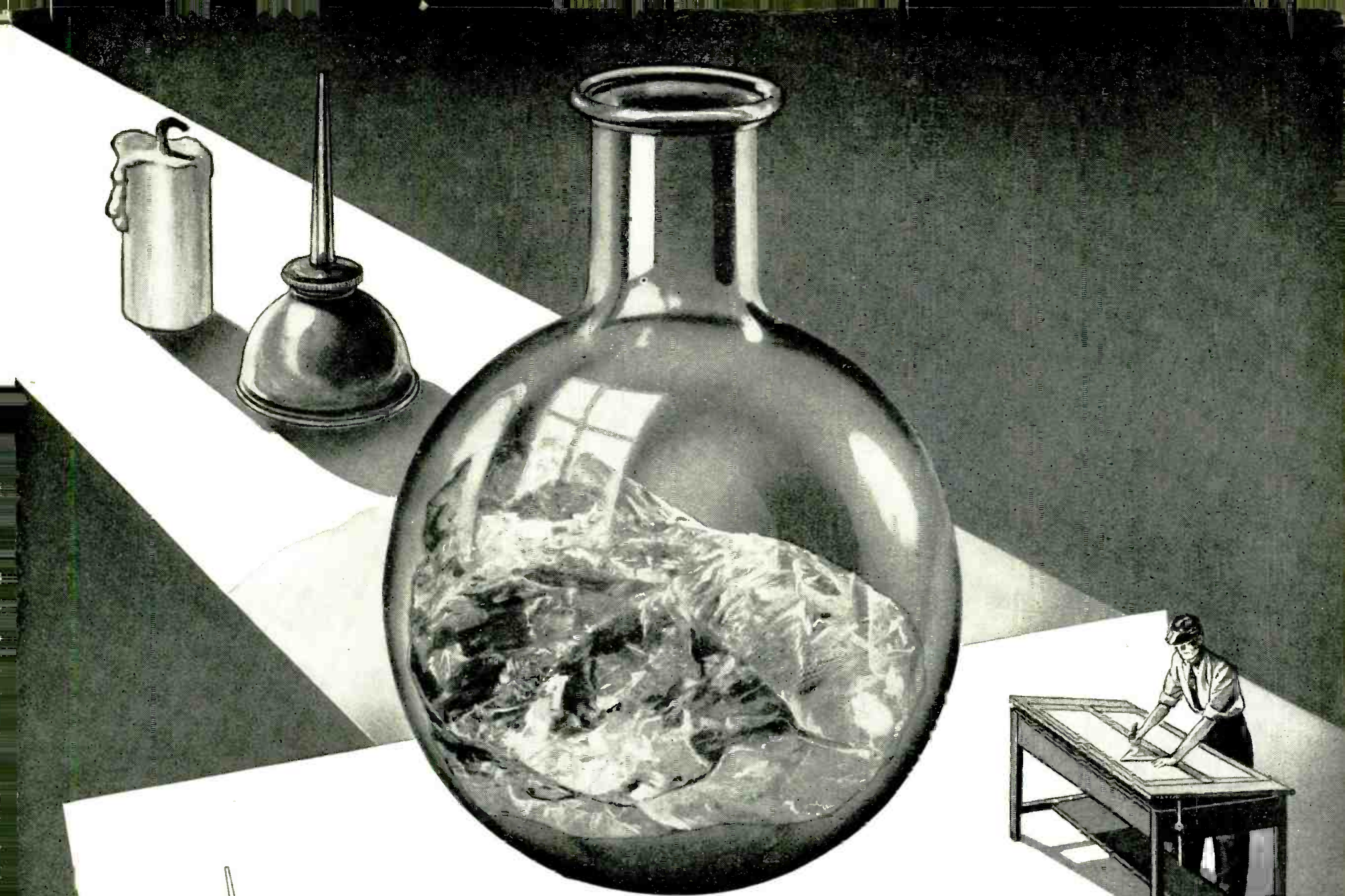
Whether it is the first "hand made" transmitter or receiver, or whether they are rolling off your production line; if you equip them with these CENTRALAB Selector Switches they will pass every test for they are "BUILT FOR ABUSE". For the first or thousandth unit . . . specify CENTRALAB SELECTOR SWITCHES.

Send for special bulletin on Selector Switches for Defense.

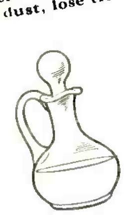
CENTRALAB · **Division of Globe-Union Inc., Milwaukee, Wis.**

Important Features of Centralab Selector Switches

1. High grade Steatite sections, vacuum wax impregnated.
2. Contacts, clips, eyelets and rivets heavily silver plated.
3. Complete index mechanism and operating shafts of stainless steel. All brass parts heavily nickel plated to withstand 200 hour salt spray test.
4. Standard indexing 30° and 90° between positions. Also available in 60° on special request.
5. Sections 3/16" thick. Mounting center of sections 1-9/16". Overall widest dimension 1-7/8".
6. Choice of 2 to 11 positions per section.
7. Kit consists of 61 Steatite Sections of various switching combinations, 36 indexes complete with hardware for assembling 1 to 6 sections per index.



MINERAL OIL. Most tracing papers are treated with some kind of oil. Mineral oil is physically unstable, tends to "drift", never dries completely. Papers treated with mineral oil pick up dust, lose transparency with age.



VEGETABLE OIL, chemically unstable, oxidizes easily. Papers treated with vegetable oil become rancid and brittle, turn yellow and opaque with age.

ALBANITE is a crystal-clear synthetic solid, free from oil and wax, physically and chemically inert. Because of this new stabilized transparentizing agent Albanene is unaffected by harsh climates—will not oxidize with age, become brittle or lose transparency.

A crystal-clear synthetic solid age-proofs this tracing paper

No oil, no wax—but a remarkable new transparentizing agent developed in the K&E laboratories—produces this truly permanent tracing paper! ALBANENE is made of 100% long fiber pure white rags—treated with *ALBANITE*—a new crystal-clear synthetic solid, physically and chemically inert. ALBANENE will not oxidize, become brittle or lose transparency with age.

Equally important, ALBANENE has a fine hard "tooth" that takes ink or pencil beautifully and erases with ease . . . a high degree of transparency that makes tracing simple, produces strong sharp blueprints . . . extra strength to stand up under constant corrections, filing and rough handling. ALBANENE has *all* the working qualities you've always wanted—and *it will retain all these characteristics indefinitely.*

Try ALBANENE yourself on your own drawing board. Ask your K&E dealer, or write us for an illustrated brochure and a generous working sample.

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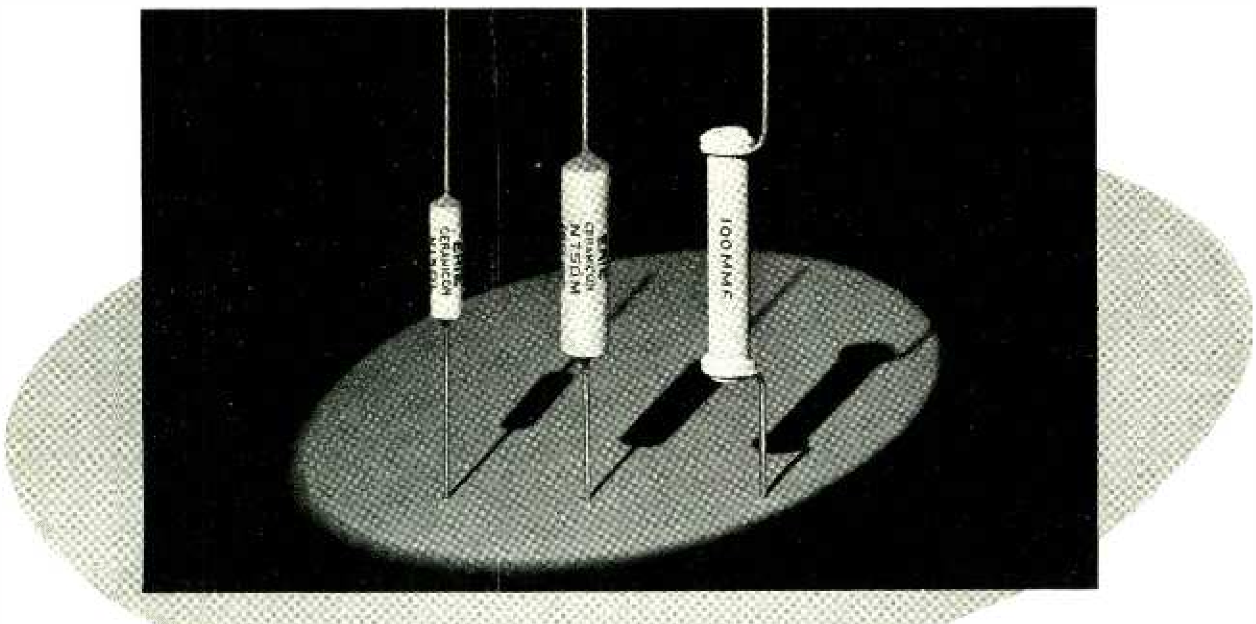
K&E *Albanene* REG. U. S. PAT. OFF.

THE STABILIZED TRACING PAPER

Simple and Sure

COMPENSATION FOR FREQUENCY DRIFT— IN HIGH FREQUENCY COMMUNICATIONS



ERIE CERAMICONS

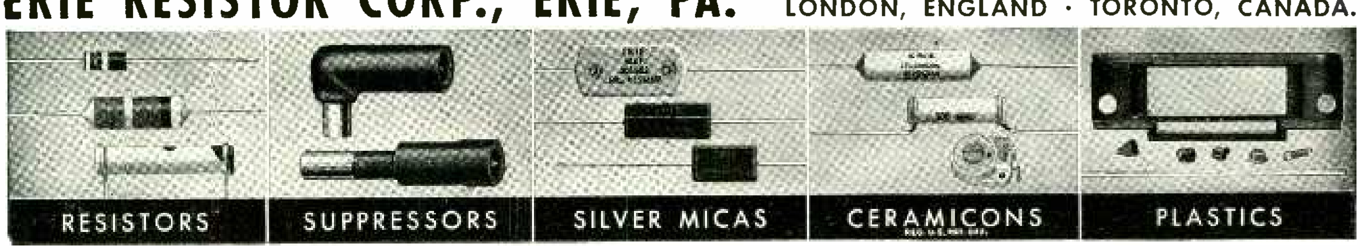
REG. U.S. PAT. OFF.

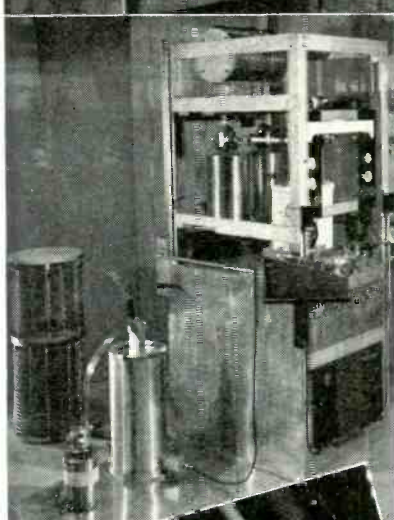
FREQUENCY drift in communications oscillators is caused by physical and electrical changes that occur in various components. While it is possible to eliminate the drift in each component, such a procedure involves considerable re-design and probable increased cost of each component affected. It is far easier to compensate for the total drift by introducing an Erie Ceramicon in the resonant circuit having a temperature coefficient of the opposite sign and of such a value as to offset the undesired drift.

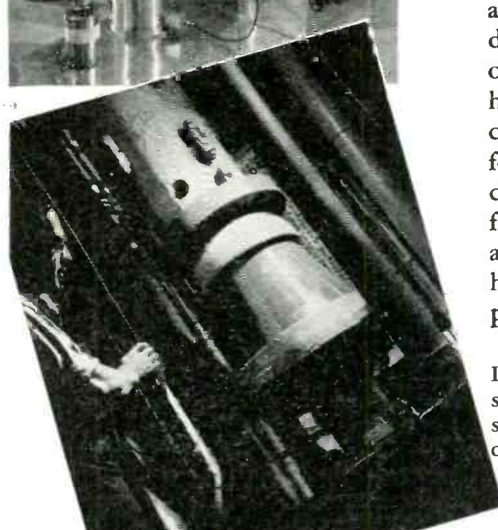
Erie Ceramicons are small ceramic-dielectric condensers with definite, linear, and reproducable temperature coefficients. They are made in 9 standard coefficients ranging from +.00012/°C. to —.00075/°C. Insulated Ceramicons are available in capacities from 1 mmf. to 375 mmf.; non-insulated units from 68 mmf. to 1100 mmf.

Erie Resistor has developed special electronic equipment used in producing and testing Ceramicons that insures a high degree of uniformity of characteristics in these units. This uniformity is essential for dependable compensation in high frequency communications equipment for Military and Naval uses. A revised data sheet giving the characteristics of Erie Ceramicons has just been published. Copies will be sent to interested engineers on request.

ERIE RESISTOR CORP., ERIE, PA. LONDON, ENGLAND · TORONTO, CANADA.







PERFORMANCE CHARACTERISTICS OF LAPP RADIO INSULATORS ARE DEPENDABLE FACTORS

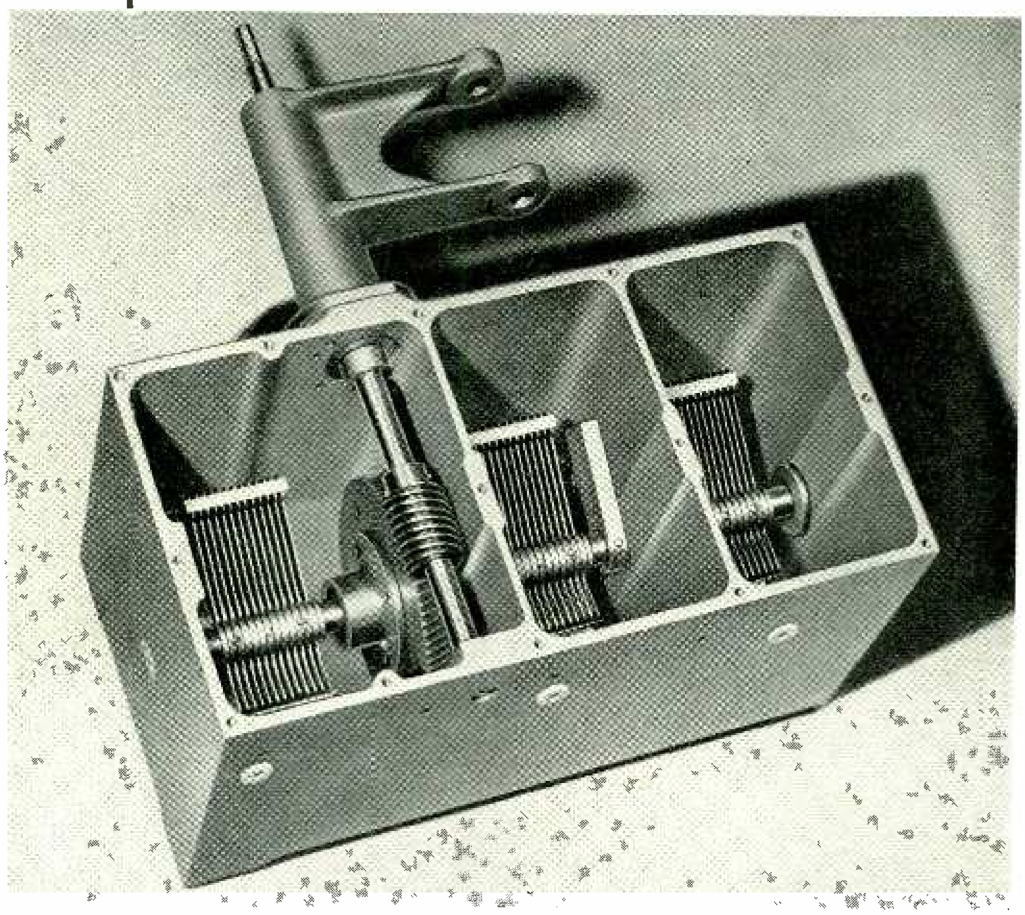
Lapp's contributions to radio broadcast engineering are recognized as highly significant in the advance of the science. Practically every development of antenna structure design, for example, has been worked out with the co-operation of Lapp engineers. Since Lapp developments have been wholly pioneering in nature, it has been necessary to maintain complete testing facilities. In the Lapp laboratory is the usual equipment for 60-cycle electrical, mechanical and ceramic testing. In addition is complete equipment for determining characteristics of units at radio frequency—heat run, radio frequency flashover, corona determination and capacitance. For mechanical testing (lower picture), a 1,500,000 lb. hydraulic testing machine is used—for test of new designs, and for proof-test of every insulator before shipment.

In the construction of new broadcast equipment—or the modernizing of old—the safe bet is to specify "insulators by Lapp." Descriptive literature on Lapp antenna structure insulators, porcelain water coils and gas-filled condensers is available on request. Lapp Insulator Co., Inc., LeRoy, N. Y.

Specify **LAPP**

FOR SECURITY IN ANTENNA STRUCTURE INSULATORS

STABILITY—PLUS



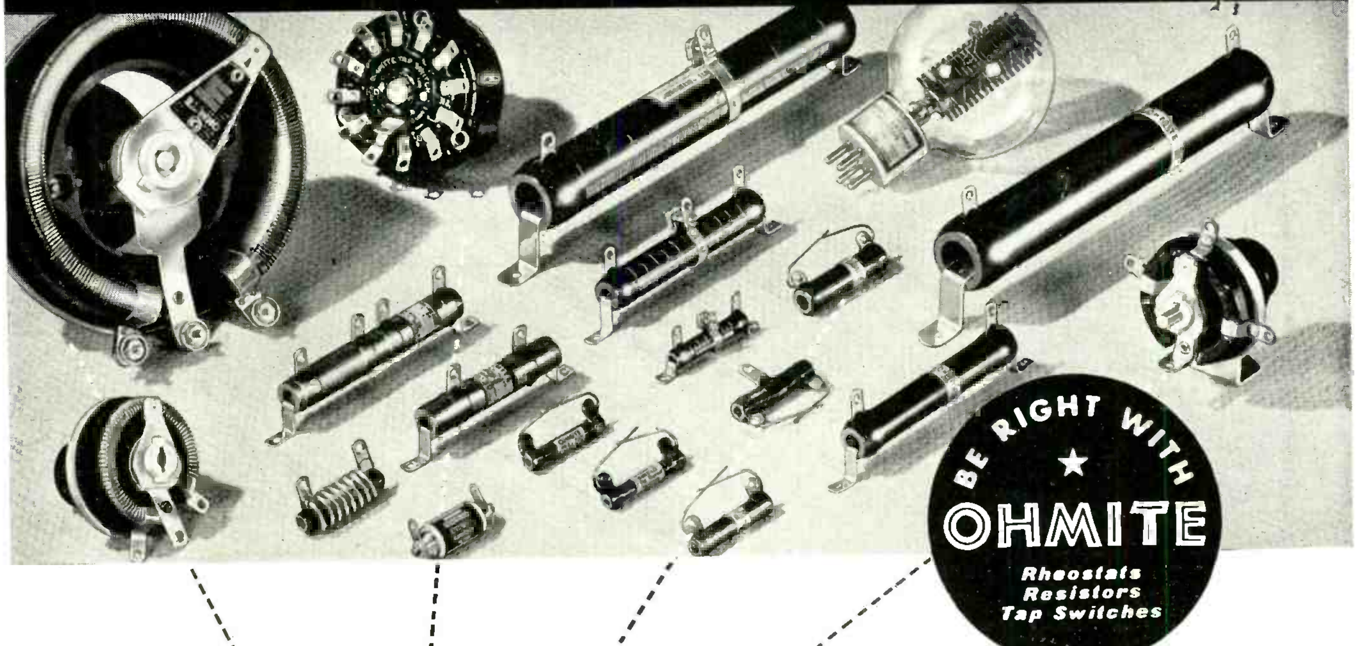
Marine condenser built to withstand severe vibration.

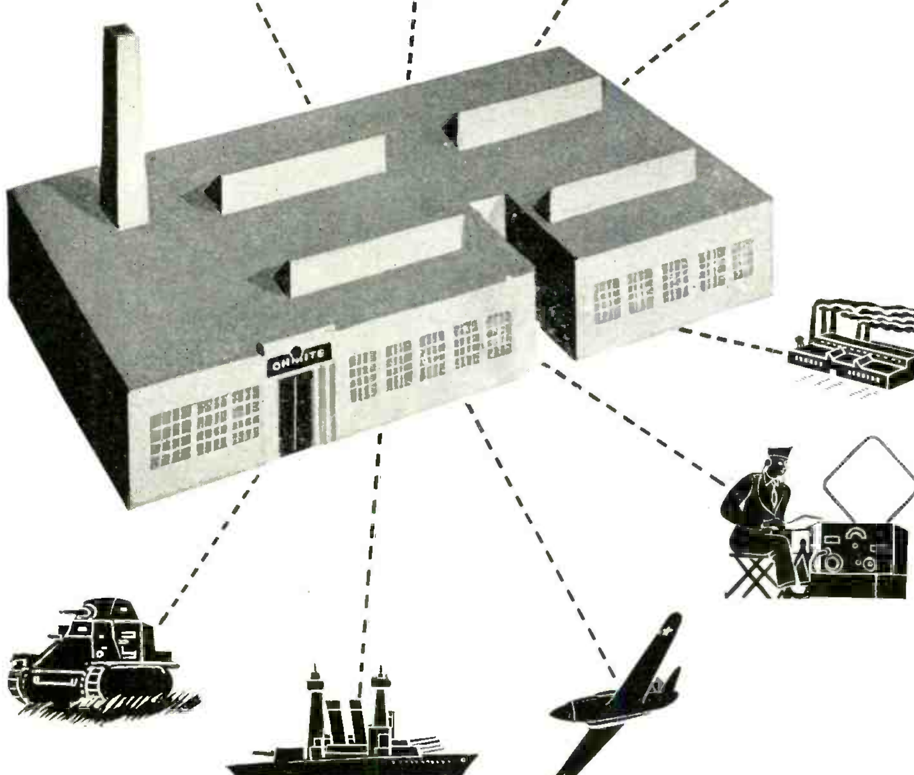
OPERATING on an "All Out For Victory" basis Hammarlund is producing precision variable condensers for every Defense Communications Service. Many of these condensers are comparable to laboratory standards, though produced in great numbers on a mass production basis.

THE HAMMARLUND MANUFACTURING CO., INC.

424-438 West 33rd Street, New York, N. Y.

OHMITE STEPS UP PRODUCTION OF
Rheostats · Resistors · Tap Switches · Chokes



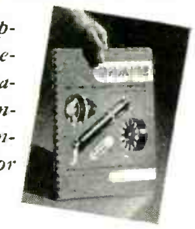


Ohmite is ready for the job ahead. Expanded factory facilities are operating day and night with increased momentum to produce more units, more quickly for Industry and the Armed Forces, for the planes, tanks, ships and other equipment needed for Victory.

The design and construction of Ohmite Rheostats, Resistors, Chokes and Tap Switches insure utmost dependability. The wide variety and extensive range of types and sizes in stock or special units make it easier to answer your exact needs. Ohmite engineers are glad to help you.

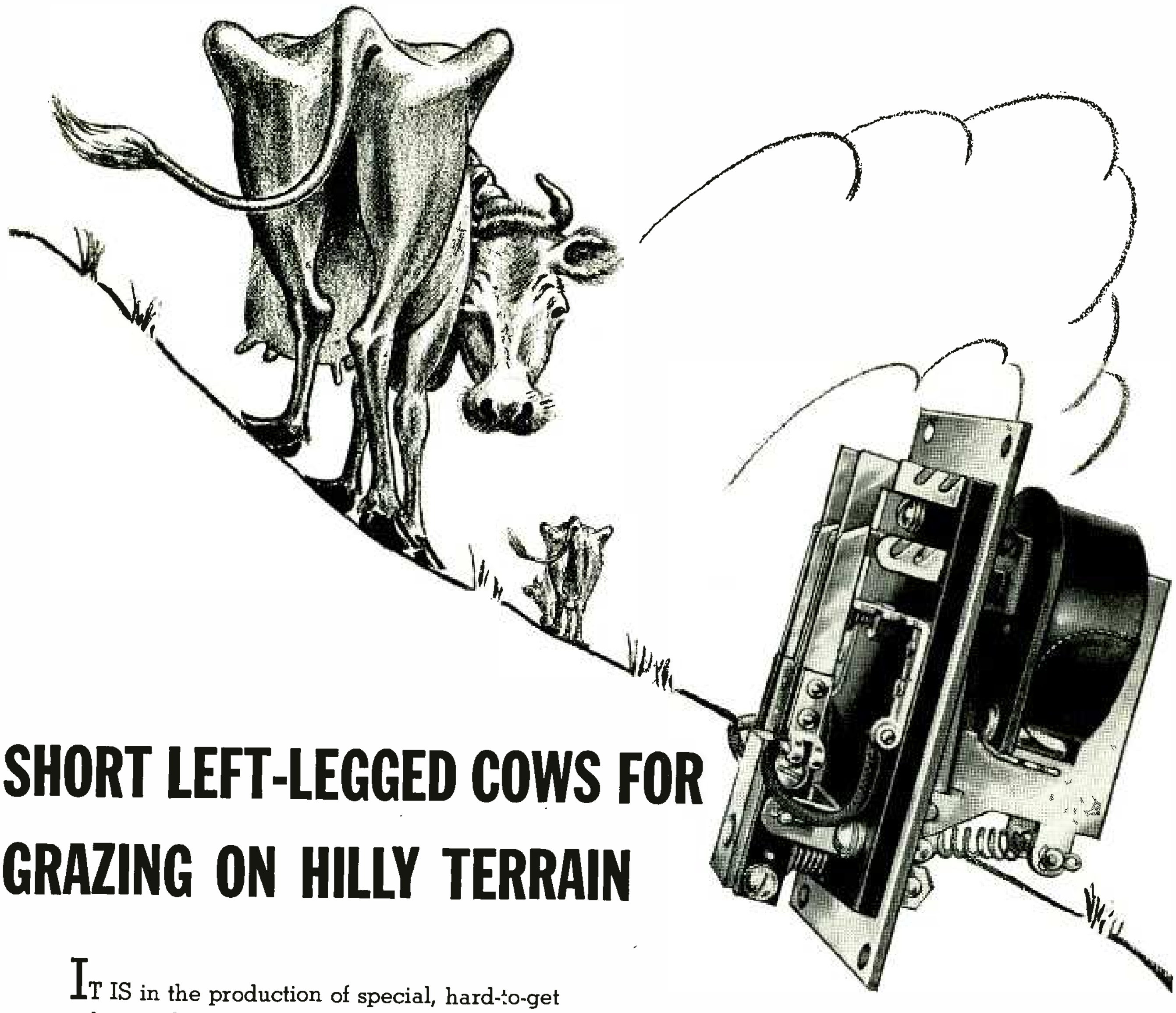
Send for 96-page Catalog and Engineering Manual No. 40.

Most complete, helpful guide in the selection and application of resistance units. Write on company letterhead for your copy.



OHMITE MANUFACTURING COMPANY, 4816 Flournoy Street, Chicago, U.S.A.

OHMITE MARCHES WITH THE NATION!



SHORT LEFT-LEGGED COWS FOR GRAZING ON HILLY TERRAIN

IT IS in the production of special, hard-to-get relays and timers that have never been made before, for exacting jobs that have never been done before, that Dunco engineering excels. Hence the simile.

While cows to the above specifications are probably a biological impossibility, relays designed to meet almost equally unusual specifications are pretty much an everyday occurrence at Dunco. We're producing these regularly for everything from newly developed aviation jobs, to tank jobs and a host of other military uses, as well as for countless industrial applications.

Whatever your Relay or Timer need—whether standard, special, or "extra special," it pays to come to Dunco—*first.* Whatever the type, *Dunco means dependability!*

DUNCO RELAYS AND TIMING DEVICES

STRUTHERS DUNN, INC., 1326 CHERRY ST., PHILADELPHIA, PA.

DUNCO TYPES

30 AMPERE • 6 AMPERE (midget) • SENSITIVE • LOW VOLTAGE, HEAVY CURRENT, D.C. • INSTRUMENT CONTROLLED
MECHANICAL LATCH-IN (Electrical Reset) • MERCURY CONTACT • TELEPHONE AUXILIARY • LAMP CONTROLLING
POLARIZED • OVERLOAD • MOTOR REVERSING • SEQUENCE, RATCHET TYPE • CLOSE DIFFERENTIAL • TIMING

. . . and countless "Customer Specials" designed or adapted to meet your *exact* specifications.

Difficult Measurements Are Easy
With These G-E Instruments

Photoelectric Recorders

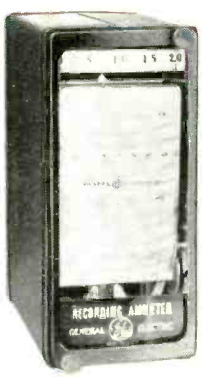
Typical Characteristics (Recording Galvanometer)
Range—0 to 1 microampere
Resistance—approx. 2280 ohms
Response Time—approx. 4 sec.
Dimensions—5½ by 16 by 9¼ in.
Scale Length—3¾ in.

TO RECORD ONE MICROAMPERE

These sensitive instruments can be used to record any quantity indicated by the movement of a tiny mirror. They are the most sensitive recorders known which do not employ electrical amplification of the quantity being measured.

They are very useful for recording values such as grid currents of vacuum tubes, small photo-tube currents, and small thermocouple voltages for low-temperature records. Measurements can also be telemetered.

Both portable and switchboard types are available.



Direct-acting Recorders — Type CD

Typical Characteristics (Milliammeter)
Range—0 to 2 milliampere
Resistance—approx. 1800 ohms
Response Time—approx. 2 sec.
Dimensions—5½ by 12 by $9\frac{7}{16}$ in.
Scale Length—4 in.

TO RECORD ONE MILLIAMPERE

A new direct-current instrument in the Type CD line offers a convenient means for recording plate current and other small current values in lower ranges than were previously possible.

The chart is driven by a Telechron motor, thus assuring dependable operation. The instrument is lightweight, easy to use, and can be obtained in both portable and switchboard types.

This Type CD instrument is one of a complete line for recording current, voltage, watts, power-factor, and frequency.

TO RECORD MICROAMPERES

Here is a new line of direct-current INKLESS recorders—available in high-resistance voltmeters and low-resistance ammeters, milliammeters, and microammeters*. A-c voltmeters and ammeters are also available.

These low-cost instruments are well suited for electronics work because of their low power consumption. Exceptionally small and lightweight, they are readily portable. Provision is also made for wall mounting.

*The microammeters are available down to 125 microamperes, full scale.

New Inkless Recorder—Type CF

Typical Characteristics (Milliammeter)
Range—0 to 1 milliampere
Resistance—approx. 16 ohms
Response Time—approx. 3 sec.
Dimensions—$8\frac{9}{16}$ by $10\frac{9}{16}$ by $5\frac{31}{32}$ in.
Scale Length—3½ in.

For further information about these or other instruments in the complete G-E line, call the nearest G-E office, or write General Electric Company, Schenectady, New York.

HEADQUARTERS FOR ELECTRICAL MEASUREMENT

GENERAL ELECTRIC

602-17

What it takes to *keep 'em flying*

Back of the safety record of America's leading airlines is the world's most dependable radio equipment. Significantly, Cornell-Dubilier capacitors are used by all these major airlines both in ground station and aircraft communications. Here is convincing proof that C-Ds have what it takes — *extra* dependability not only to "keep 'em flying", but to meet your most exacting capacitor requirements.

CAPACITORS MAY LOOK ALIKE BUT...

There is extra long life, extra uniformity and dependability built into C-Ds. Next time you specify capacitors, look for the Cornell-Dubilier seal of experienced engineering. And get the *hidden* extras at no extra cost. Send for catalog. Cornell-Dubilier Electric Corporation, 1006 Hamilton Blvd., South Plainfield, New Jersey. New England Div., New Bedford, Mass.

Cornell Dubilier

. . . MORE IN USE TODAY THAN ANY OTHER MAKE . . .

Communication in War

Not only for the Army and Navy; not only for the 130,000,000 People; but for the COMMANDER IN CHIEF as well, RADIO is the accepted vehicle for local, national and world-wide dissemination of thought.

SUPERIOR

THE BIG NAME IN
SMALL TUBING

SUPERIOR TUBE COMPANY, NORRISTOWN, PENNSYLVANIA

To the RMA, and specifically the Radio Tube Manufacturers—To the Electronics Industry as a whole, Superior Tube Company says:

WE believe it to be our duty to use to the utmost the greatly extended facilities in our Cathode Sleeve Department, where we produce Seamless and Lockseam types to the full extent of raw materials that may be available to us.

Not a thing has been left undone to save *ounces* of scrap, wherever possible.

To us, 16 ounces of Nickel means 5,000 Sleeves, and a million of them above the usual output means someone's plant can run longer.

Tubing from ⅝" OD down... SUPERIOR Seamless in various analyses. WELDRAWN Welded and drawn Stainless. BRAWN Welded and drawn "Monel" and "Inconel". SEAMLESS and Patented LOCKSEAM Cathode Sleeves.

AS THE DOCTOR PRESCRIBES . . .

AmerTran modulation transformers and reactors, oil-immersed type, for large broadcast transmitters.

AmerTran RS plate transformers and reactors, oil-immersed type, for all large installations.

AmerTran W plate transformers and reactors for all small and medium installations.

● Just as the skilled pharmacist compounds the drugs called for by the doctor's prescription . . . so AmerTran's skill, experience and facilities combine to produce Transformers that exactly meet *your prescription* (specification). AmerTran Transformers are engineered mechanically and electrically to render dependable service . . . they can also be designed specifically to meet your particular requirements and conditions. For more than 40 years AmerTran has supplied to all branches of the radio and communications industry all types of transformer equipment regularly required. This equipment is manufactured for all sizes of installations and in large or small quantities. Let us quote on transformers for your needs.

AMERICAN TRANSFORMER CO., 178 Emmet St., Newark, N. J.

Manufactured Since 1901 at Newark, N. J.

AMERTRAN

Built to your Specifications

Radio...all out for Victory

Research and invention have placed radio in the first line of battle

COMMUNICATION—rapid communication—is a vital necessity, on land, at sea and in the air. RCA research and engineering developments in both radio and electronics are strengthening—and will further fortify—the bulwarks of our communications system. At Princeton, New Jersey, the new RCA Laboratories—the foremost center of radio research in the world—are under construction.

★ ★ ★

International circuits, operating on short and long waves, have made the United States the communication center of the world. Today, R.C.A. Communications, Inc., conducts direct radiotelegraph service with 49 countries.

★ ★ ★

Production of radio equipment is essential for news and timely information, for military and naval communications, for dissemination of news among foreign countries. The "arsenal of democracy" has a radio voice unsurpassed in range and efficiency. In the RCA Manufacturing Company's plants, workers have pledged themselves to "beat the promise," in production and delivery dates of radio equipment needed for war and civilian defense.

★ ★ ★

American life and property at sea are being safeguarded by ship-and-shore stations. The Radiomarine Corporation of America has equipped more than 1500 American vessels with radio apparatus and is completely engaged in an all-out war effort.

★ ★ ★

Radio broadcasting is keeping the American people informed accurately and up-to-the-minute. It is a life-line of communication reaching 55,000,000 radio sets in homes and automobiles. It stands as the very symbol of democracy and is one of the essential freedoms for which America fights. The National Broadcasting Company—a service of RCA—and its associated stations, are fully organized for the coordination of wartime broadcasting.

★ ★ ★

New radio operators and technicians must be trained for wartime posts. RCA Institutes, the pioneer radio school of its kind in the United States, has more than 1,200 students enrolled and studying in its New York and Chicago classrooms.

★ ★ ★

When war came and America took its place on the widespread fighting front, radio was At the Ready . . . with radio men and radio facilities prepared to answer the call to duty "in the most tremendous undertaking of our national history."

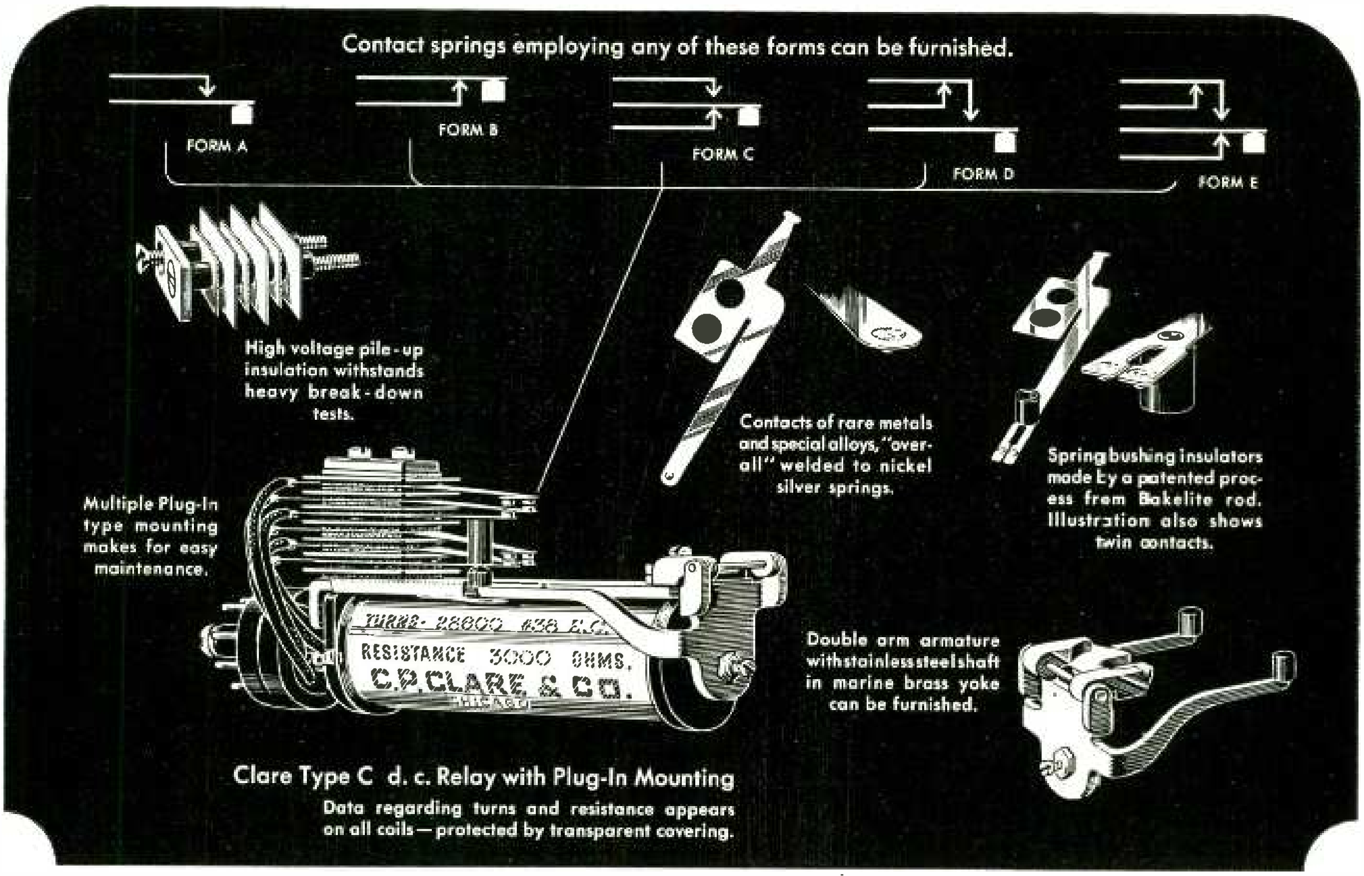
David Sarnoff

PRESIDENT

RCA **Radio Corporation of America**

RADIO CITY, NEW YORK

The Services of RCA: RCA Manufacturing Co., Inc. • RCA Laboratories • R.C.A. Communications, Inc. National Broadcasting Company, Inc. • Radiomarine Corporation of America • RCA Institutes, Inc.



Clare Type C d. c. Relay with Plug-In Mounting

Data regarding turns and resistance appears on all coils—protected by transparent covering.

THIS Clare Relay CAN Take the Place of Many

■ For engineers who want a rugged multiple contact relay that permits innumerable contact arrangements which will enable them to design their product to a smaller size, reduce the number of relays employed, and facilitate relay maintenance, we suggest the use of the Clare Type C d.c. Relay with Plug-In Mounting illustrated and described here.

This relay is ideal for heavy duty service in machine tools, welding timers, automatic weighing equipment, and similar products. It is particularly adapted for use in electronic control devices. It renders excellent service in sequence control and interlocking operations. Wherever unusual arrangements of relay control, ordinarily impossible with ordinary relays, are desired, it can be used advantageously. . . . The reasons for this versatility are as follows:

1 Its standard spring assemblies may embody any combination of the five combinations illustrated. It may be equipped with as many as 20 springs per pile-up with two pile-ups per relay—a total of 40 springs. Think what this means!

2 It can be provided with twelve different standard—or special—types and sizes of contacts which are welded to the nickel silver springs by a special process. The contacts are made from precious metals and alloys, such as silver, palladium, palladium-iridium, tungsten and elkonium. They can be furnished in sizes from .062" silver, rated at 1 ampere, 50 watts, to .1875" tungsten, rated at 4 amperes, 500 watts. Various types may be incorporated in one relay. Also furnished with Micro or other snap action switches which carry a higher rating.

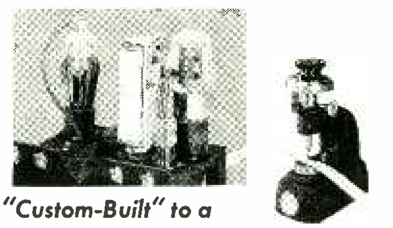
3 The relay shown has high voltage spring pile-up insulators of special heat-treated Bakelite which permits punching without cracks or checks, has minimum cold flow properties and low moisture absorption content. The pile-up assembly is locked together under hydraulic pressure. Projecting wafer insulators which provide creepage path of ¼" between contact springs can be furnished. The entire assembly withstands very heavy break-down tests.

4 The spring bushing insulators are made of Bakelite rod under a patented process. These strong, hard, long wearing bushings are essential where heavy contact pressures are employed, where vibration exists, or heavy duty service is desired.

5 The armature assembly of this relay is standard for light duty and will stand up under ordinary industrial usage. For heavy duty service a double arm armature assembly, utilizing a stainless steel shaft operating in a marine brass yoke, as illustrated above, can be supplied. The heel piece, coil core, and armature assembly of this relay is magnetic metal, carefully annealed. Where sensitivity and timing are important factors, a *special magnetic* metal is recommended to provide permeability.

6 Coils are carefully wound to exact turns on precision machines. Lead-out wires are securely soldered. Coils impregnated with a special varnish are available. Data regarding resistance, number of turns, type of wire appear on the coil as illustrated. The coil is protected with a transparent acetate covering.

7 The relay illustrated is arranged for octal base plug mounting which makes for easy service and replacement. Other types of mounting such as individual angle bracket, strip or panel can be furnished. Easy to handle slip-on Bakelite covers for individual mounting or metal covers for group mounting can be supplied.



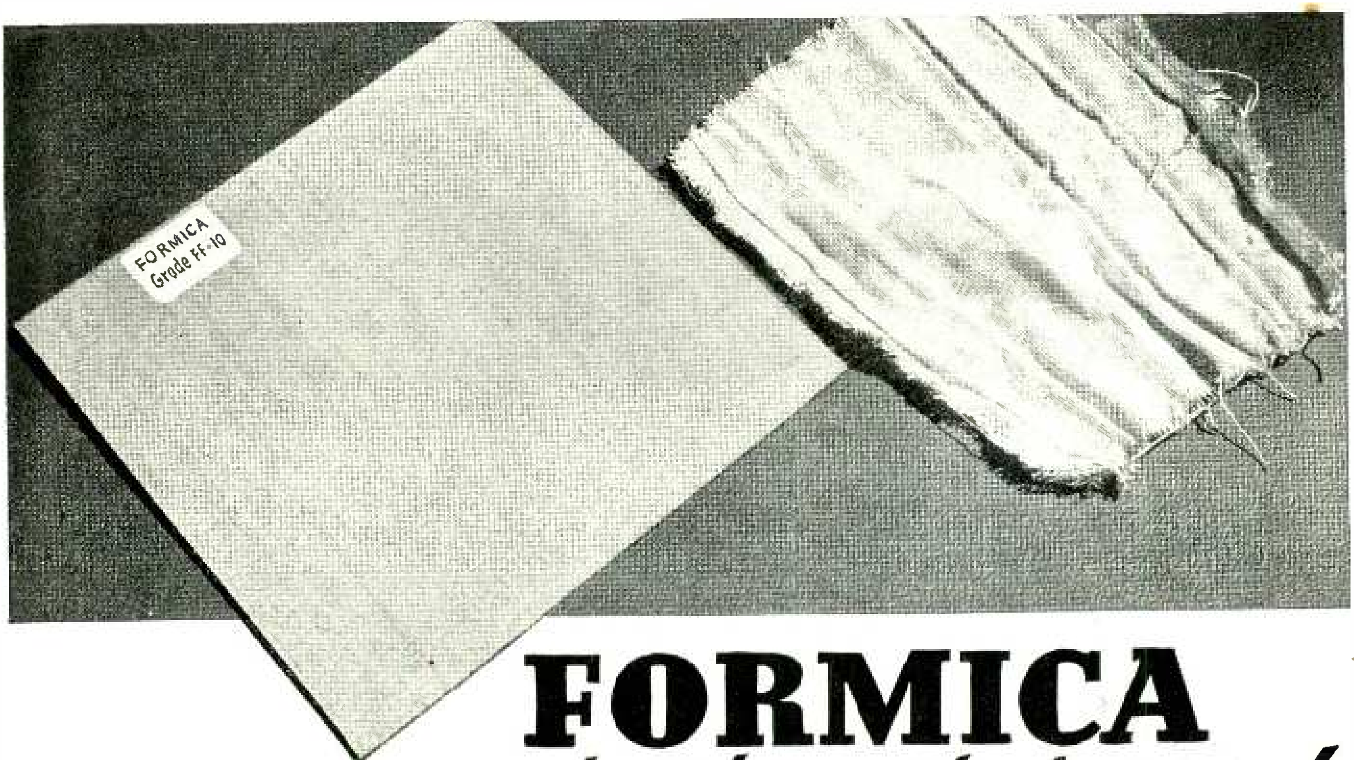
"Custom-Built" to a Prize-Winning Design

The Carson Electronic Micrometer which measures to .000025" without pressure, won the recent Electrical Manufacturing Design Award. This unusual instrument is fitted with a Clare Relay. Its manufacturer, Instruments Specialty Company, Inc. Little Falls, New Jersey, says: "Clare engineers deserve credit for having developed this special relay... We have had to re-order this relay several times... have been well satisfied with its ability to duplicate its initial performance."

These features, plus the fact that all Clare Relays are carefully designed, well-manufactured from the best available materials, and precisely adjusted, assure you that this Clare Type d.c. Relay will reduce your over-all relay cost, simplify your designing problem and insure you better and more dependable performance. . . . Clare engineers are ready at all times to assist you in developing a relay specifically "custom-built" to meet your requirements. A "blueprint" of your problem will bring our suggestions. In the meantime, send for the Clare catalog and data book. C. P. Clare & Company, 4719 W. Sunnyside Avenue, Chicago, Illinois.

CLARE RELAYS

"Custom-built" Multiple Contact Relays for Electrical, Electronic and Industrial Use



FORMICA

- with Glass Cloth Base!

(FIBER GLASS)

High Heat-Resistance

Low Power Factor

FABRICS of glass impregnated with phenolic resins are used to produce several recently developed grades of Formica to meet special conditions. They provide a material better in heat resistance than other types of Formica—a material especially adaptable for instance for motor slot wedges where heat may reach 350 degrees. The material has low moisture absorption and very little cold flow.

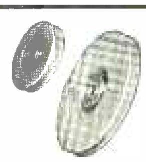
Another grade with Fiberglass base has been developed for flexibility and "tracking" or arc resistance. And a third provides an efficient low loss electrical material at radio and high frequencies.

This type of Formica is available in the form of sheets, tubing and rod from which a wide variety of parts may be machined.

If you have a problem that requires a material with these properties ask for samples:

The Formica Insulation Co., 4661 Spring Grove Ave., Cin., O.

FORMICA



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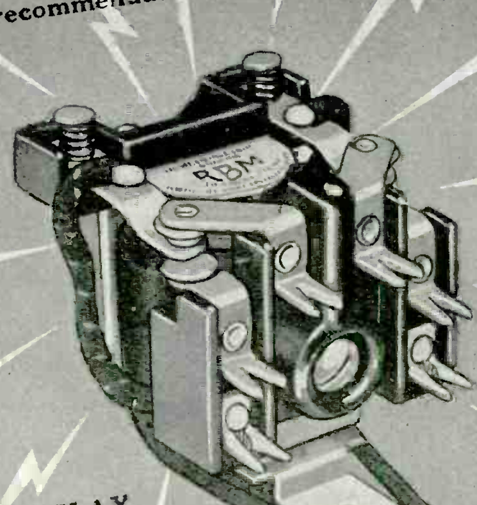

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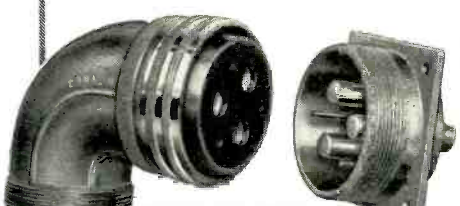
No basic departures from approved CANNON designs... but another forward-looking CANNON IMPROVEMENT in Cable Connectors to speed aircraft output.



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Tooling now in progress. Preliminary information available on request. Production planned within 90 to 120 days.

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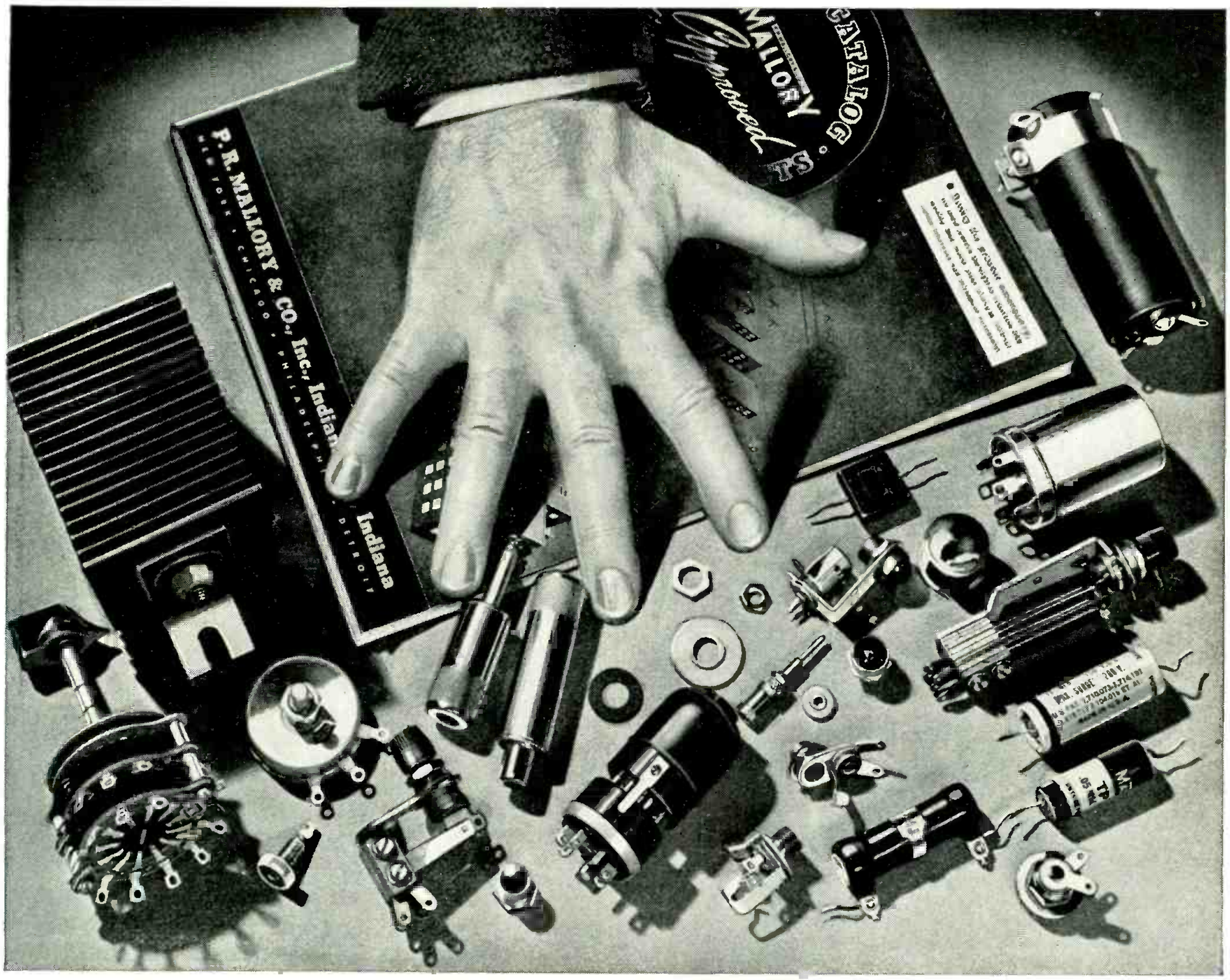

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What Can I Do?

EVER SINCE that Sunday morning when havoc swooped from the skies upon Honolulu, a new question has been churning about in millions of American minds. It is this: What can I do to help my country win this war?

This insistent question has pushed aside all matters of personal interest. From now on, individual wants and wishes must give way to the paramount needs of the nation. We all accept that. We have undertaken a huge job. Or, I should say, we have had a huge job thrust upon us. And unless we see that job through successfully it won't much matter what any of us may want.

That job is to win this war.

No longer are we trying to prepare for a war that we may get into. Today we are trying to win a war we're already in—and in up to our eyes. Nothing that any one of us now can do to help himself can get him very much if it does not also help our country to win this war.

I am sure that those who read these words will find many things to do. Some will enlist in the armed services. Some will become active in civilian defense. Some will labor to relieve distress in their home towns. Some will work with organizations set up to serve the men at the front. Each can and will find something he can do.

But this insistent question "What can I do?" goes beyond the individual and his personal service. It re-echoes through the offices and the shops of every American business concern. And what I have to say here is not directed toward individual effort. Rather is it intended for the men and women of American industry who make that industry a living part of American life. Today they are asking themselves: What can industry do? Or better still, what *must* industry do if our country is to finish the job it has started?

Those of us who work in and with American industry have one supreme obligation. We may feel very patriotic; we may be willing to serve "in any capacity;" we may be willing to sacrifice . . . if necessary. But if we fail to meet that one obligation, we shall fail our country in its time of need.

THAT SUPREME OBLIGATION IS AN HONEST DAY'S WORK, EVERY DAY, FROM EVERY MAN, EVERY WOMAN, EVERY MACHINE. . . . IT IS AS SIMPLE AS THAT!

And that goes for all of us, whether we are engaged in civilian production or working directly on the weapons of war. American victory can be won only through the productivity of American industry.

Efficiency in production is not the responsibility of a few. It can be achieved only as we all put to useful purpose every minute of our time, every ounce of our energy, and every pound of our materials.

This responsibility of industry is the more vital because of what has happened to the business of making war. There was a time when success in war was chiefly a matter of well-trained, well-disciplined armies and competent leaders—when men were everything. In those days, military strength was a matter of strong battalions and able generals. Both still are vital. But today military might is essentially mechanical might. Modern war is an industry just as much as a factory or a railroad. In the first World War, mechanical equipment was relatively simple and limited. But today the special equipment of war and the expert skill needed to use it spell the difference between victory and defeat.

We Americans are not expert war-makers. That is why we must expect to suffer grievous losses before we can win substantial gains. We do not have military training and experience ready to hand when we need them. Neither do we have, ready for action, enough of the machines that are so essential to modern warfare.

So, when it becomes necessary to fight for our lives, we must start from scratch. And today, after a year's effort, we still are not ready to trade blow for blow with enemies who for years have schooled their leaders, trained and disciplined their people, and organized their industries to make war. We shall need more time to develop our strength. And while we are doing that, we must expect reverses.

But there is a brighter side to all this. For it follows that if we are granted this all-important time, the change in the method of warfare is right down our alley. The greater importance of mechanized equipment plays straight into the hand of the world's greatest industrial nation . . . if there is one thing America does know, it is industrial production! Our industries know how to produce. They have the skilled manpower. They have the organized facilities. Beyond any doubt, we can produce all that we need to win the victory that we must win—if only we are given the time.

THE FIRST RESPONSIBILITY OF THE ARMED FORCES IS TO GAIN THAT TIME FOR US.

THE FIRST RESPONSIBILITY OF INDUSTRY IS TO USE TO THE FULL EVERY SECOND OF THAT TIME IN PRODUCING THE WEAPONS

THE ARMED FORCES NEED TO WIN THE ULTIMATE VICTORY. INDUSTRIAL PRODUCTION IS THE KEY TO VICTORY. BUT IT MUST BE BIGGER PRODUCTION AND FASTER PRODUCTION THAN WE EVER HAVE KNOWN.

Heretofore American industry has worked to produce more of those things which make our lives more enjoyable. Today it must divert much of its energy from the products of peace to the weapons of war.

This change sets up a new yardstick of industrial performance. In time of peace we measure production efficiency in terms of money saved. From now on, we must measure efficiency chiefly in terms of time saved. For the plane, the tank, the gun, or the ship that is ready when it is needed to win a victory, is worth a million times more than the one that is delivered too late to avert a defeat.

Everyone knows how short we are of some materials and machines. But our most tragic shortage is the shortage of time. So whatever we may waste in the days ahead—and unhappily we are bound to waste plenty—let us never forget that the most deadly waste of all is the waste of time.

Time wasted never can be replaced. No one ever has discovered a substitute for time. If we would avoid the waste of this irreplaceable ingredient of victory, we must use every minute of it effectively—*while we still have it.*

That goes for us all. It goes for the man or the woman at the bench, at the desk, at the counter, in the field, or in the executive office. It goes for the politician as well as for the business man. It goes for the humblest and the most powerful. A nation at war cannot carry deadheads. It cannot spare a square foot for any one who will not pull his weight.

In this war, nothing short of complete victory can save the liberties of us all, rich and poor, employer and employee, haves and have-nots alike. The price of that victory is the labor, the loyalty, and the devotion of every last one of us. Winston Churchill said it well for the British people. You know how he said it. I need not repeat it.

All this imposes upon American industry, its owners, its managers, and its workers, the gravest responsibility they ever have assumed. If our country is to survive as a free nation, American industry must rise to that responsibility. If our country should fall, it would fall because American industry fell short of the need. It would be another case of "too little and too late".

This grave responsibility calls for the keenest management industry ever has known. It calls for unremitting research to make the most of our resources. It calls for the reduction of waste to a record minimum: that goes for waste of time, labor, and material. It calls for keeping our machinery working as near to full capacity as we can contrive. It calls for the highest rates of unit production we ever have known. That will mean skillful coordination by management and the most intelligent cooperation that the men in the shops can give. It calls for inventive ingenuity to match that of a nation which has produced some of the world's outstanding technical genius. For this is a war of technical proficiency.

But above all, it calls for a new devotion to the day's work. For so long as we are at war, the day's work will determine our country's security.

Whatever may be our material resources and our technical skill, however resourceful our management, however broad the scale of our effort, industry cannot measure up to its prodigious responsibility if any of us shirk the day's work. Right there is where we find the one thing we *all* can do—the one thing that is within the power of each of us.

THAT ONE THING IS SIMPLY TO DELIVER AN HONEST DAY'S WORK WHEREVER WE ARE CALLED TO SERVE. HONEST WORK WILL WIN THIS WAR. LOAFING WILL LOSE IT. THE SHOWDOWN WILL BE WHETHER HITLER CAN DRIVE HIS PEOPLE TO WORK HARDER THAN WE ARE WILLING TO WORK. THERE IS NO ONE TO DRIVE US. WE MUST DRIVE OURSELVES!

Is that so much to ask? It is all our country asks of us, the men of industry. It is all that the men who must work the guns and tanks in the field ask of us. It is all that the men who work our ships and our planes ask of us. "Give us the planes, the guns, the ships, the tanks, and all the rest of our tools," they tell us, "and we'll give you the victory that means so much to us all. But, in the name of that victory, give them to us quickly—QUICKLY—QUICKLY!"

Is that, I repeat, too much to ask of us?

* * * *

To help American industry achieve ever-higher standards of efficiency has been the traditional mission of McGraw-Hill for three-quarters of a century. Normally that effort has been directed toward higher efficiency in the business of peace. But, as in the first World War, twenty-five years ago, it now is directed toward efficiency in the business of war and in every department of American effort that can contribute, directly or indirectly, to the achievement of victory.

And to that mission, I here pledge every resource of this company, its publications, its books, its staff, and every service it is qualified by experience and training to render to American industry, now enlisted in our common cause.

That is what we of McGraw-Hill can do. And that is what we *shall* do to our utmost.

James H. McGraw, Jr.

President, McGraw-Hill Publishing Company, Inc.

This message is appearing in all McGraw-Hill industrial and business publications, reaching over a million readers.

CROSS TALK

► **ABOUT OURSELVES** . . . Now that we are at war, it is vitally necessary that every operation in which we editors and readers engage be aimed at the business of prosecuting this conflict to our advantage. This means, immediately, that waste effort must be completely eliminated. To us this means that ELECTRONICS must be aimed at you, the reader. Material which the reader does not read represents wasted effort, paper, printing time and expense, etc. To you, the reader, this means that you must help us not only by reading the paper but you must help us select the editorial contents, help us edit and publish it.

ELECTRONICS was founded to be a "campfire of council" to all those who are vitally concerned with designing, manufacturing and using electron tube apparatus. For nearly 12 years ELECTRONICS has been written by its readers and its editors for their mutual benefit. This must continue; and without beating around the bush any more the editors hope that every reader will consider ELECTRONICS as a medium by which he, individually, may contribute his bit of information to all others similarly engaged. No matter how small a contribution to saving material or labor or time, or to making existing equipment last longer or operate better—that information may be worth a gold mine to other electronics people.

To find out what our readers want in the way of editorial contents, we make continual surveys of reading habits and reading preferences, by mail and by actual contact with readers through our editorial research and circulation field men. The results of these questionnaires are of inestimable value to the editors; and our only wish is that more subscribers would take advantage of these questionnaires to tell the editors what they want. Editors can (and do!) guess at what readers want to read but much better results can be had if the readers help by contributing their own desires.

In a recent survey of reading habits, one answer indicated that the subscriber felt the quantity of the editorial contents had been reduced recently. This is not the case. Since 1937 the editorial contents have increased steadily. At the same time the number of advertising pages has increased too, and apparently it is this increase which has given the reader the impression that the number of editorial pages has gone down.

It is as important to the reader as to the publisher that manufacturers of equipment tell their messages in the advertising pages of any publication. For if there were no advertising the reader or the publisher would have to bear the entire cost of publication. The publisher has no interest in maintaining a paper just for the hell of it, nor has he any philanthropic motives in publishing. If there were no advertising in ELECTRONICS, the average issue would cost considerably more than the reader pays now, especially since many readers take advantage of reduced subscription rates by buying more than one year at a time. Under these conditions there would be no publication.

Each of the 17,300 paid readers to ELECTRONICS (September issue) bears a certain portion of the total cost of publication. The revenue from advertisers is the only other source of income. We have no membership dues, no angels! If there is a difference between the total cost and the total income, the publisher either makes a profit or he takes a loss.

Other readers have trick ideas about how they wish the contents to be arranged—no articles "turned over" into the back of the book; all articles on a given subject placed in one part of the issue so they can be filed together, all advertising in one section and the text in another, and all sorts of ideas which would be swell for some and terrible for others. All of these ideas have been considered; and many of them have been tried out. It is a fact, however, that present-day magazine arrangements suit most of the readers most of the time, and that must be the aim.

Your editors want all sorts of suggestions for improving this service. Contributed articles, criticisms, even an occasional kind word (!) are always greatly appreciated. Many plans are in the making for 1942, and as these plans unfold we hope to get closer and closer to you 17,300 readers.

► **UHFI** . . . In a recent conference of college professors called together to provide plans for courses on uhf, question of terminology came up now that the ultra-ultra high frequencies are being used. It was decided to use the terms UHFI ("ultrahigh frequency indeed") for these super-short waves.

Speaking of initials—what do you suppose WRGB stands for? You're wrong—they're the call letters of G-E's commercial television station.

► **FREE** . . . Copies of Mr. McGraw's statement, "What Can I Do?", appearing in this issue are available in reprint form for those who want them. No charge will be made for small numbers of reprints, larger numbers will be supplied at cost.

Mobile 30-40 Mc Receiver

A receiver, for mobile use, and receiving amplitude-modulated signals, designed to compete with frequency modulated systems from standpoint of immunity to pulse-type noises. May be manually tuned, or spot-frequency tuned

INABILITY to obtain adequate coverage with mobile equipment employing amplitude modulation, as opposed to frequency modulation, is in practically all cases the result of inferior receiver performance in the presence of heavy ignition interference. The U. S. Forest Service Type KU-R receiver herein described relieves this condition to such an extent that many amplitude modulation communications systems now being discarded with heavy investment loss can be made to serve adequately. This receiver will not provide completely noise-free reception nor is it directly comparable to fm in this respect. Its performance is, however, so outstanding as compared to mobile a-m receivers with conventional noise limiter circuits that it will undoubtedly assist in solving many of the problems arising from limitations imposed by ignition and other sharp pulse type noise. The Type KU-R receiver permits actual use of absolute signal values below 1 μv when used on cars without spark plug suppressors or other forms of ignition noise treatment. An occasional noisy generator requires correction by electrical filtering and cleaning, but beyond this no special preparation is required to make a workable installation. A convenient and simple measure of useful sensitivity is the signal input value required to produce a 4 to 1 change in the audio power output when modulation is increased from 0 to 30 percent. Measured by this method the average sensitivity of a group of 25 receivers was 1.4 μv. (See editor's note at end of article.)

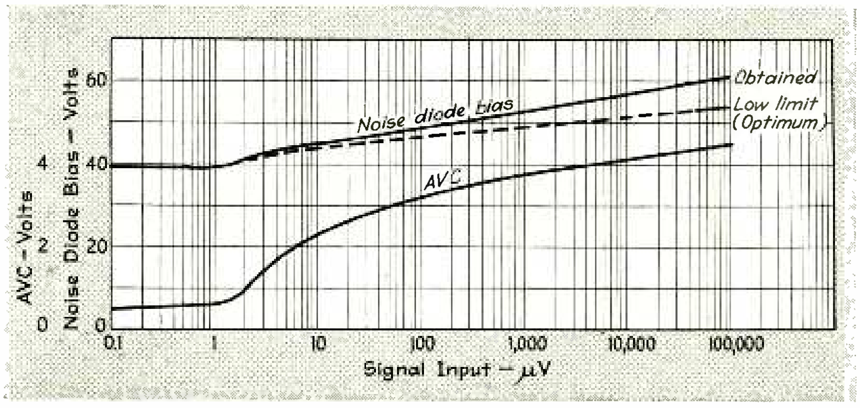
Before entering upon a discussion of this receiver it is of interest to review briefly the general trend of forestry radio equipment to provide a background for the requirements of this unit. Of the 4000 radio telephone units in use by the U. S. Forest Service over 90 percent are of the strictly portable type falling in a weight class of from 6 to 21 pounds complete with all accessories and power. During the past five years the trend of forestry radio has been toward a more intensive use of those frequencies lying between 30,000 and 40,000 kc. Of the 2,000 u-h-f radiophone transmitters in use, only 1 percent have a power output in excess of two watts. The maximum power of this group is 20 watts. Quite naturally there is an urgent need for communication with mobile units, such as fire tank trucks, forest highway patrolmen, and supervisory personnel on large project fires. The limiting factor in the successful application of mobile ultrahigh frequency equipment to this job has, up until this time, been the lack of a satisfactory receiver.

With the normally low signal fields provided by the portable units, it is essential that the mobile receiver provide usable sensitivity in the vicinity of 1 μv absolute. Usable sensitivity in this case is not considered as being realized under ideal laboratory conditions, but rather under actual road test conditions and through electrical noise encountered in heavy traffic.

Primary Design Considerations

The requirements of such a receiver are:

1. Provision for manual tuning over the range of 30 to 40 Mc as well as crystal controlled spot frequency operation.
2. Compact structure to permit installation in space restricted by special fire fighting tools and devices in all types of motor vehicles.
3. Low primary power consumption to permit prolonged use without constant battery charging while the car may be temporarily immobile in fire service.
4. High sensitivity to fit into the general scheme of low power transmitter operation.
5. Broad acceptance band to minimize criticalness of manual tuning and loss of signals due to all sources of drifting.



Ideal and realized characteristics of the noise silencer circuit

for the U. S. Forest Service

By H. K. LAWSON and L. M. BELLEVILLE
U. S. Forest Service Radio Laboratory
Portland, Oregon

6. Freedom from pulse type interference, particularly ignition noise, originating in both the forest car and in other traffic.

These requirements appear generally conventional and relatively universal with the possible exception of the combination of tunable and spot frequency operation.

The two requisites for maximum sensitivity in a receiver are; the highest possible signal-to-noise ratio and adequate gain to deliver full audio output with no input other than the first circuit noise. A triode first detector is used in this receiver to keep the conversion noise at the lowest possible value. One stage of r-f amplification adds further gain in signal-to-noise ratio and assists in suppressing image interference.

It should be noted that the r-f and first and second i-f tubes are of the sharp cutoff type. Among several considerations dictating this choice, the g_m/I_k* noise factor of merit was of major importance, a higher ratio of g_m/I_k being available in tubes of the sharp cutoff type. Further, where power consumption is a consideration the variable-mu tube is at a disadvantage. The saving in plate current by the use of sharp cut-off tubes in this receiver amounts to approximately two watts. Better a-v-c characteristics are also realized with tubes which do not require a high bias for cutoff.

Careful investigation of the field of commercially available receivers failed to disclose a unit with all essential features combined. The most generally available types were of fixed tuned design intended for police service. In this field there appeared to be a lack of high usable sensitivity and good pulse noise suppression. Some of the better receivers indicated high sensitivity as measured in the laboratory and at the same time developed acceptable noise suppression at relatively high signal levels, but all failed to permit use of their maximum sensitivity in the presence of heavy ignition interference.

U. S. Forest Service type KU-R Mobile Receiver. Top to bottom, speaker, r-f tuning head, amplifier unit. Note universal mounting clamp which permits steering-column or under-dash mounting of r-f tuning head. Bottom cover of amplifier unit serves as mounting plate and entire unit may be removed for service by releasing trunk hasps

Although fm may be considered to be the ultimate answer to this problem there are two outstanding reasons that immediately rule out this system for U. S. Forest Service application. First; the Forest Service now has on hand some 2,000 u-h-f radiophones, all amplitude modulated and all serving a useful purpose in forestry communication. Any one of these may be called upon to communicate with a mobile unit, yet such communication is relatively incidental to their entire field of usefulness. Consequently it would not be economically sound to attempt a replacement of all equipment merely to provide a more ideal mobile system. Second; frequency modulation technique has not advanced sufficiently far to date to permit design of a reliable portable unit that can compete in size, weight, cost and over-all low power consumption with the portable units now in service.

A thorough investigation of available mounting space in various types of cars and trucks, resulted in a decision to break down the receiver into two small units, plus an externally mounted speaker. To avoid mechanical complications arising

* Ratio of transconductance to cathode current. See *RCA Review*, April 1941, page 518.

from an attempt to eliminate rubbery backlash from remote mechanical tuning, a complete r-f tuning head was designed to be mounted in the same manner as the conventional remote tuning mechanism. The common flexible shaft method of mechanical tuning becomes satisfactory over the relatively wide range of 30 to 40 Mc only when extremely high gear ratios are employed. Such an arrangement results in slow and tiresome manipulation to tune over the entire band.

Radio-Frequency Tuning Head

The r-f tuning head of this receiver contains the signal r-f amplifier, detector, tunable heterodyne oscillator, crystal oscillator, and frequency multiplier.

An eight-conductor cable and separate i-f transmission line connect the tuning head with the larger unit. The eight-wire cable carries primary power from a switch on the head unit to tube heaters and plate supply, plate voltage for tubes in the tuning head, squelch control and audio level control. The intermediate frequency of 1600 kc is fed to the i-f unit through a length of 64-ohm flexible concentric transmission line. Careful design of the 1600-kc inter-unit line coupling transformers eliminates line resonances and permits the use of any length of high quality line found necessary.

Transfer from manual tuning to crystal controlled spot frequency operation is accomplished by a relatively rough setting of the tuning dial to a pre-marked point and throwing the "manual tune — spot frequency" toggle switch on the tuning head to the spot frequency position. The panel switch serves merely to transfer plate voltage from the tunable oscillator to the crystal controlled oscillator and tripler. It is evident that the tunable oscillator and the fixed frequency tripler are in a measure interlocked through their common coupling to the detector grid. Special attention to mechanical layout and simple but adequate shielding have minimized the interlocking between the tripler and tunable oscillator to a point where it is not apparent at any position of the manual tune dial. The use of an entirely independent spot frequency heterodyne source eliminates the necessity of switching in high frequency circuits where it is usually desired to avoid using such devices.

The i-f amplifier is substantially flat over a band of 50 kc centered at 1600 kc. This choice of bandwidth was influenced by the necessity of receiving some of the older type modulated oscillator transceivers which are still in service. A relatively wide acceptance band also serves to minimize the effect of normal drift of various crystal controlled transmitters. Although all current transmitting equipment of the U. S. Forest Service employs crystals having a temperature coefficient of four parts per Mc per degree C or better, none of these units are temperature controlled, and when operated on a mountain peak, may encounter temperatures varying from near freezing in the morning to over 100 degrees by mid-afternoon.

The Cover Picture

A battery-operated automatic relay or repeater station is shown in operation. It utilizes the 30 to 40 Mc region and ties 5 forests into a central fire and weather forecasting office in the State of California. It also serves as a repeater for mobile equipment in the forest in which it is located. The longest circuit covered is 200 miles. For reasons which our readers will understand, the location of these installations cannot be published now

The requirement of a 50-kc band necessitates three i-f stages for adequate gain. It can be shown that for a given bandwidth and stage gain the intermediate frequency can be varied between fairly wide limits. With available i-f transformer Q's a 50-kc bandwidth can easily be had at an intermediate frequency of 5,000 kc. Such an amplifier would have excellent skirt selectivity. The same gain and bandwidth can also be obtained at a much lower frequency by proper adjustment of circuit Q. This shift will produce several results. First, the image response will be closer to the signal frequency; and second, skirt selectivity will be reduced. This latter factor may be either an advantage or a disadvantage depending upon the application of the receiver; third, stability with drift of trimmer condensers due to temperature change or vibration, will be improved at the low frequency. With consideration given to all of the above factors, the frequency of 1600 kc was selected primarily for the advantage of stability so necessary in mobile equipment.

By far the greater part of the work on this receiver went into the design of the noise silencer. A silencer of practically the same design as appears in the present model was incorporated in one of the test receivers at the beginning of this work. Due to what appeared to be excessive space requirements and circuit complications, the much simpler and more compact series diode limiter was employed in the next test receiver. Analysis of the series diode limiter indicated that this type of circuit could be expected to accomplish everything that might be expected from any form of limiter. A receiver employing this circuit gave excellent results under restricted conditions but the design would not stand the test of use in heavy traffic.

It was finally realized that the diode limiter could do an acceptable job of silencing only up to the point where interference became strong enough to actuate the avc. When this condition is reached, which is usual in the presence of heavy ignition noise, the signal will be reduced by action of the automatic volume control until it is lost in the residual noise. Resulting aural effects range from an increase in the staccato noise to a complete blanketing of the signals, depending upon intensity and rate of ignition. The noise silencer herein presented is based on variations in the type of silencer first proposed by J. J. Lamb (see *QST* Febuary 19, '36). To the best of our knowledge the most important of these variations first appeared in a receiver manufactured by the Pearson-Delane Company.

This form of limiter not only serves as a noise silencer but also protects the avc from the overloading produced by strong impulse interference. This silencer incorporates two major variations in the fundamental circuit proposed by Lamb. First, the output of the noise rectifier is impressed on the injector grid of the third i-f stage through a coupling condenser. This prevents the d-c component in the output of the noise rectifier from appearing on the controlled stage and thus eliminates the blocking normally encountered with this type of silencer.

The second circuit variation is made possible by the first, and consists of an automatic threshold control circuit which maintains the bias on the noise rectifier at the proper value for optimum silencing with variations in signal level.

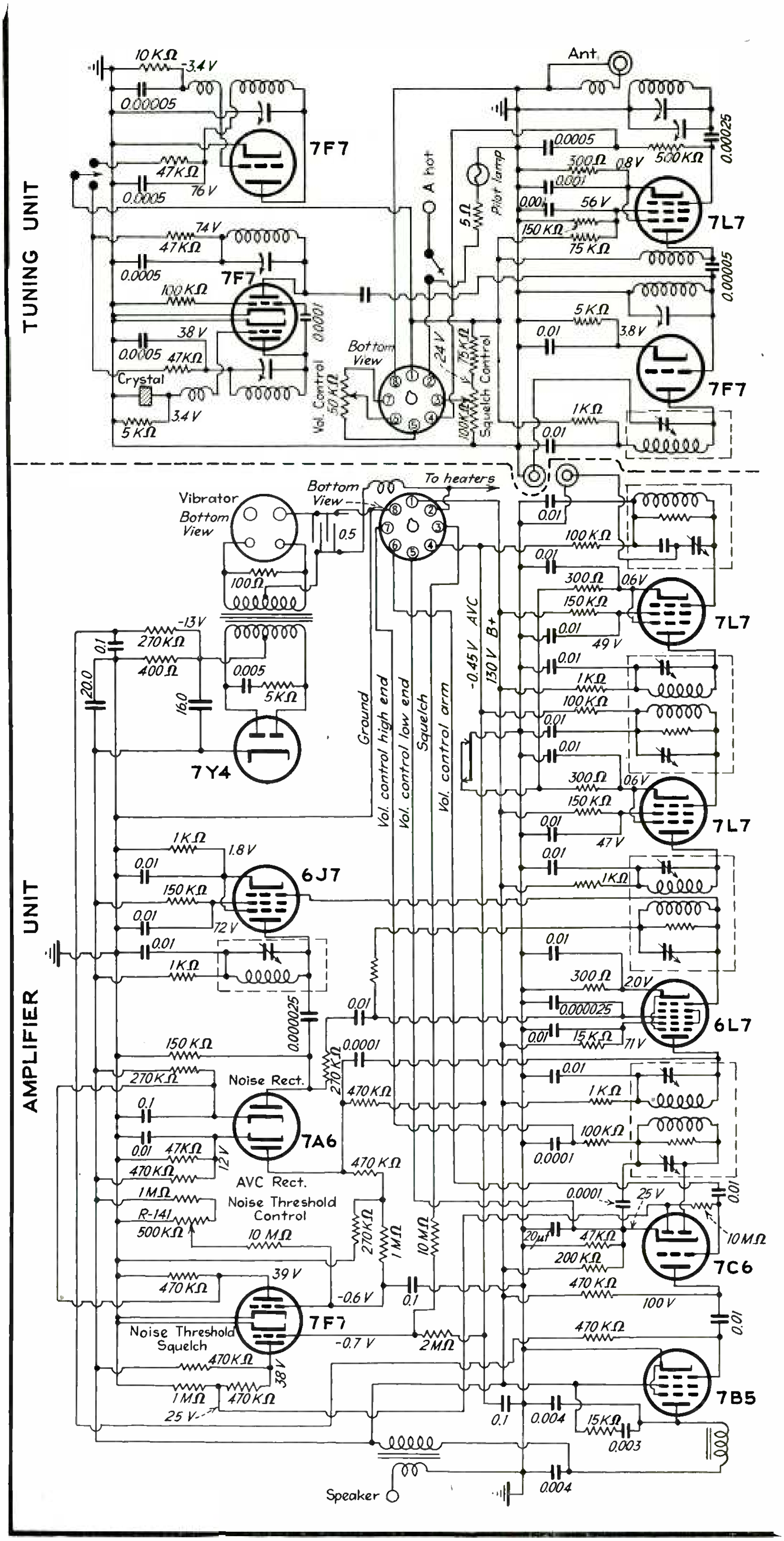
The fundamental operation of the silencer may be briefly described as follows: The output of the second i-f amplifier feeds both the noise controlled third i-f amplifier, and independent noise amplifier in parallel. The output of the 6J7 noise amplifier is rectified by one of the 7A6 diodes, and any pulses or irregularities in this rectified output are fed through the coupling condenser to the injector grid of the 6L7 third i-f stage. These pulses serve to block this tube for the duration of the rectified noise voltage and thus prevent the rise of the original noise impulse to full amplitude in its output circuit. The foregoing constitutes the fundamental actions of this circuit, but without additional devices and elaborations the system remains unworkable.

To produce a workable circuit, it is necessary to adjust automatically the threshold of rectification so that modulation peaks are not rectified and thus cause to clip and distort, and to maintain this threshold of rectification as closely as possible to these peaks to prevent the rise of unwanted noise. An ideal curve for this condition was plotted by applying manual control to the rectifier for various signal levels from 1 μv to 1 volt. The nearest possible duplication of this curve was then obtained with one section of the dual triode 7F7. The slope of the plotted curve produced by this tube can be controlled largely by selection of the proper proportion of a-v-c voltage. The starting point or height of the curve can be further controlled by means of the variable positive potential available at R_{141}. By careful selection of the values of the components in these circuits, it is possible to obtain almost ideal control of the noise rectifier, and accordingly to realize optimum silencing at all signal levels.

Squelch Circuit

The audio output of the receiver is effectively silenced by the operation of a d-c amplifier between the a-v-c bus and the grid return of the

(*Continued on page* 98)



Complete circuit diagram of the Forest Service receiver

Ballast Tubes as Automatic Voltage Regulators

FOR many years resistors capable of automatically varying their value with variations in the current flowing through them have been employed as self-adjusting current and voltage regulators. In spite of this, their numerous advantages are not as widely recognized as they should be. It is therefore the purpose of this article to present pertinent information on their characteristics and applications.

To avoid possible confusion it is well to mention here that this type of resistor is properly termed a "ballast" or "ballast tube". In recent years these terms have sometimes been carelessly (and always erroneously) applied to the fixed dropping resistors incorporated in many ac-dc receivers. According to RMA terminology such usage of the terms is incorrect and misleading.

Because of the widely prevailing belief that effective automatic regulation is necessarily expensive, there are many electrical and electronic designs whose functions, under abnormal or subnormal supply voltages, are impaired by failure to include such regulation. Actually the ballast tube will completely satisfy the requirements of many of these designs and yet add little to their cost.

Ballast regulators offer many advantages aside from their extremely low cost. In many applications they will maintain supply voltage constant within one or two percent under conditions of relatively wide line voltage variation. They function with equal effectiveness in both a-c and d-c circuits and, having no moving parts, are free from mechanical troubles. They are compact in size and light in weight, yet are capable of controlling loads up to 1000 watts or more in certain types of applications. They are suitable for use with both inductive and resistive loads, can be incorporated as built-in components of the equipment to bè controlled or can be used externally to control existing equipment.

Their chief limitations for certain applications lie in (1) a lag of a few seconds in responding to any appreciable variation in load or supply and (2) reduced effectiveness as supply regulators where the load is other than a substantially constant value. In many cases these limitations are readily overcome, in other cases they even prove advantageous, as will be demonstrated in applications discussed later.

Figure 1 shows the nominal control characteristics of a typical ballast tube. It will be noted that with a 200 percent increase in applied voltage (above the rated threshold value) the current change is limited to 10 percent. Even more important, over a greater part of this voltage range the characteristic is substantially flat with the result that the current change is negligible.

Fundamentally, this type of regulator is approximately a constant-current device, increasing and decreasing its resistance automatically to compensate any tendency to change in the current flowing through it. It is immaterial whether this tendency is developed as a result of changes in the supply voltage or in load resistance. In the former case the regulator varies its own voltage drop to offset supply-voltage changes, thus keeping constant the voltage applied to the load. If the load resistance varies, the regulator will vary the voltage applied to the load to the extent necessary to maintain the current constant.

Not infrequently one sees references to the self-regulating characteristics of tungsten and carbon lamps which have regulatory characteristics when employed in series with a load. Curves of Fig. 2 show the vastly greater effectiveness of a ballast tube. For reference purposes the linear voltage-versus-current curve of a perfect fixed resistor is also included. The nominal ballast curve is that of the minimum regulatory characteristics likely to be found in a wide variety of ballast types. The curve of the 3AS shows the greater effectiveness more nearly representative of ballasts designed for use with loads of 1.0 ampere or less.

Comparison to Tungsten and Carbon Lamps

In Fig. 2 all characteristics are plotted on a percentage basis to more directly show their relative effectiveness. In Fig. 3 are shown actual voltage-current measurements for a number of different lamps and ballasts. The ballast curves are extended somewhat beyond their normal rated operating ranges to show overload characteristics available for use over short periods of excessive dissipation.

The Ballast Tube per se

The ballast tube consists of a resistance element of iron wire sealed in a glass envelope containing hydrogen or helium. Its regulatory action is based on (1) the high temperature coefficient of resistance of the iron wire, which causes large variations in resistance for relatively small changes in the current flowing through it, and (2) the cooling effect of the gas used which stabilizes this action and provides a means for shaping and extending the regulatory characteristic.

When currents of lower value than

Well known among radio receiver engineers for their current regulating characteristics, ballast tubes may be employed as inexpensive regulators for many other useful applications

By S. GORDON TAYLOR

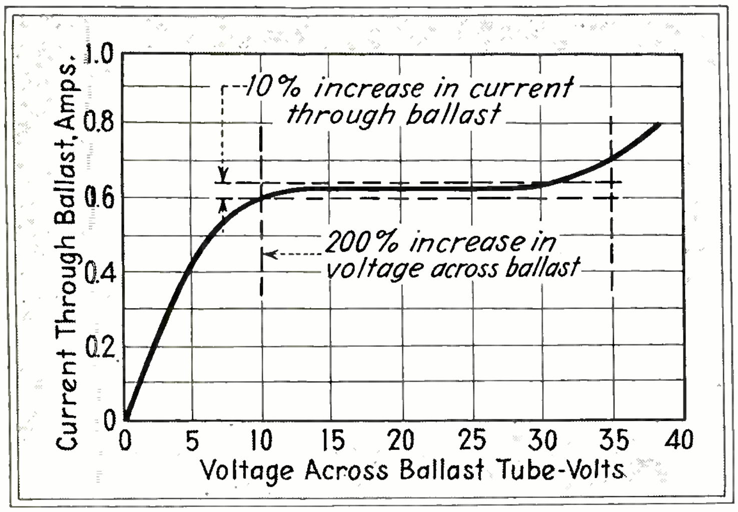


Fig. 1—Nominal characteristics of ballast tube. For a 10 percent change in current through the ballast, a voltage change of 200 percent occurs

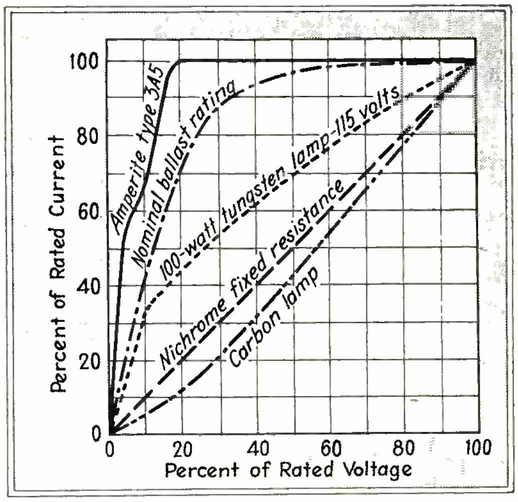
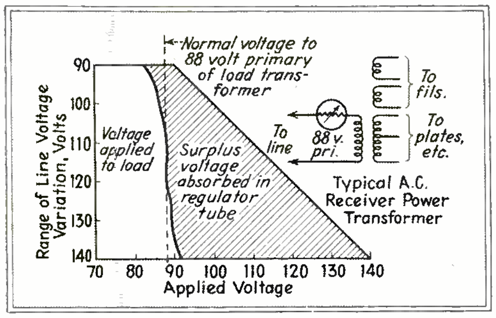
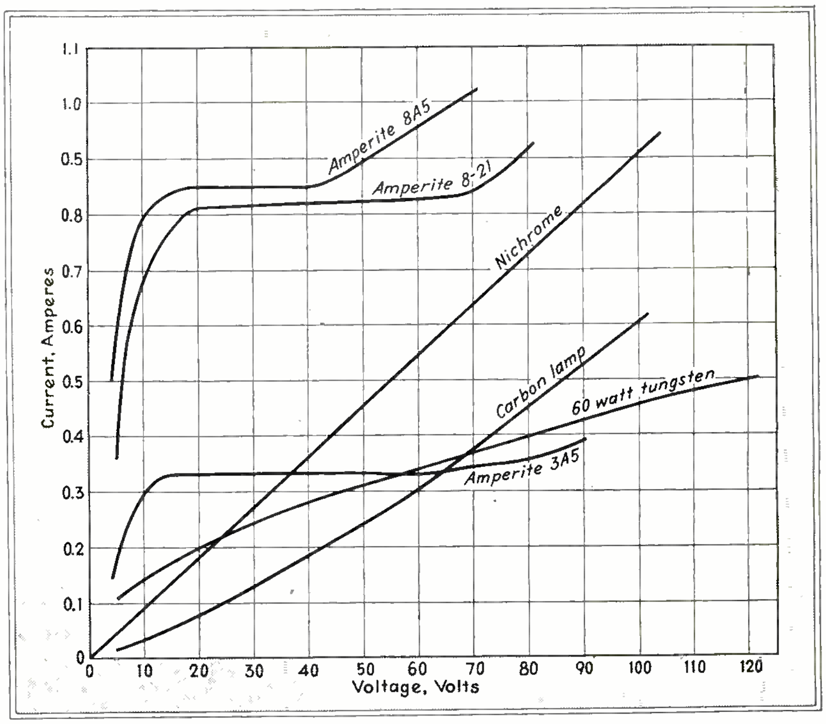


Fig. 2—Voltage-current characteristics of carbon and tungsten lamps compared with those of resistance regulators. Neither type of lamp offers much advantage over a straight dropping resistance whereas the regulator tubes provide regulation over a wide voltage range

Fig. 3—Constant-current characteristics of three typical resistive regulators compared with other types of resistors often recommended for voltage dropping purposes

Fig. 4—Voltage distribution in a typical a-c radio receiver utilizing a resistive regulator to insure reasonably constant supply voltage despite wide variations in the line





the range for which the ballast is designed are passed through it there will be some heating of the wire but the resistance change will be gradual, as indicated by the steep slopes at the beginning of the three regulator curves of Fig. 3. At some particular value of current, determined by the design of the ballast, a critical point is reached beyond which any further increase in current will cause a very rapid change in the resistance of the wire. At another higher and less critical value the resistance change once more becomes more gradual. It is between these two values, known as the "threshold" and "end" values, that the operating range of the ballast is placed. Within this range is another range over which the resistance increase is so rapid as to completely offset any tendency toward current increase. It is over this portion of its operating range that the ballast provides maximum effectiveness.

By varying the form, size and length of the iron wire employed, and its distribution on the spacer-forms, ballasts can be made to widely different specifications. The current threshold, for instance, may be any specified value from 30 ma to 10 amp. The range of control voltage is usually considered to constitute a ratio of 1 to 3; that is, an increase in the controlled current flow, from the threshold value to another value, for example, 10 percent higher, will result in a 200 percent increase in the voltage drop across the regulator. Voltage threshold values can be supplied as low as 0.3 volt or as high as 80 volts. In many types, including the three shown in Fig. 3, the range of voltage change is actually wider than the 1 to 3 ratio mentioned.

Ballast tubes are made in different physical sizes, depending largely on the amount of energy to be dissipated. Inclosed in a tube envelope equivalent in size to a 6L6G tube (diameter 1$\frac{3}{4}$ inch, height 4 inch), the regulator will dissipate up to 20 watts in constant service and up to 30 watts over shorter periods. Life is rated at 3000 hours where dissipation does not exceed 20 watts.

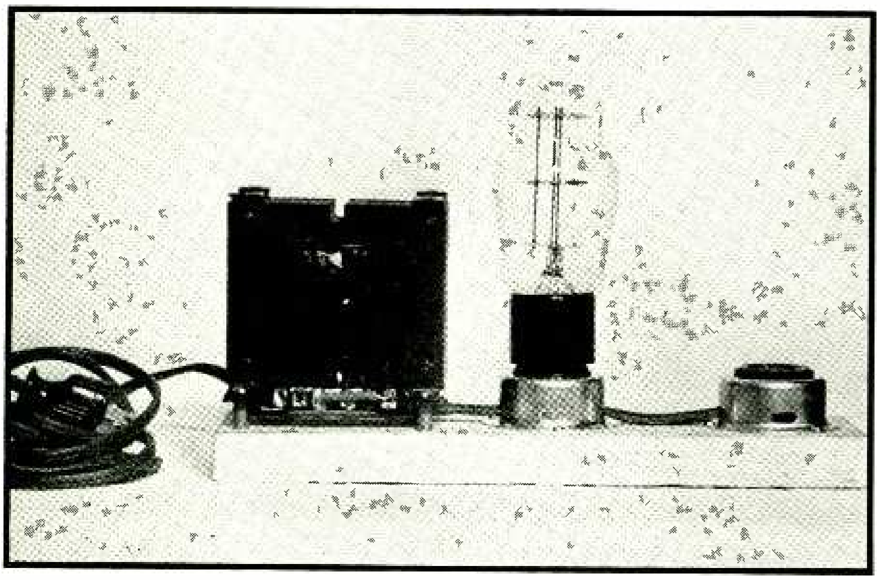


Fig. 5—Resistive regulation can be applied to existing equipment if provision is made for stepping up the supply voltage to compensate the average drop across the regulator tube. Here a stock replacement ballast tube and a filament transformer capable of providing a 22.5-volt boost combine to form a hurriedly assembled plug-in unit which maintained the supply to a communications receiver constant within two volts with the line varying between the limits of approximately 105 to 130 volts

Where constant dissipation up to 40 watts is necessary, a tube envelope of about 2 inches diameter and 5 inches long is employed. This will provide for short-period dissipation up to 50 watts and a 3000-hour rated life where dissipation does not exceed the normal 40-watt rating.

Bases may be of the vacuum-tube, lamp or miniature-bayonet types, those of the vacuum-tube type ranging from two-prong to octal.

While these units are made in a variety of stock ratings for retail distribution, these are intended primarily for replacement purposes in a-c or ac-dc receivers. Substituted for the original fixed dropping resistors in such receivers, these provide the added feature of controlled drop. They are available in sufficient variety to meet the requirements of normal load values from 0.2 to 1.5 amperes.

How to Specify Ballast Characteristics

Where a ballast tube is to be incorporated in a production design or where even a single unit may be required for some individual application, it is the practice to list the actual requirements of the design and submit these specifications to the regulator manufacturer. Included in the data should be maximum and minimum values of:

(A) Voltage variation of supply
(B) Maximum permissible voltage variation at load
(C) Required drop across ballast tube (A minus B)
(D) Load current with voltages shown at (B)

Manufacturing processes are such that samples can be made up speedily and at negligible cost.

Examples of Ballast Application

To illustrate how this works out, the case of a manufacturer of airplane instruments is cited. One of his instruments employs a bridge circuit and it is necessary that the voltage across this bridge be kept constant despite a 27 percent variation in the only available voltage supply source. His requirements, are as follows:

Supply—airplane battery, varying from 22.5 to 28.5 volts.
Permissible range of voltages applied to load 1.95 to 2.0 volts.
Required drop across ballast tube 20.55 to 26.5 volts.
Maximum permissible variation of current through load 0.49 to 0.50 amps.

This problem was a simple one, involving a ballast that would provide a minimum drop of 20.5 volts and automatic variation of about 30 percent to compensate variation of approximately this same ratio in the supply source. Although a range of variation not exceeding 2 percent was specified—a value less than the maximum error in the meter movement employed in the instrument, and less than the error which may be introduced by the eye in reading this meter—the sample ballast made up and submitted to the instrument manufacturer proved fully capable of maintaining the load within the specified values.

It is not always possible to provide this perfection in the form of a resistive regulator nor is such accuracy always essential. In one case a manufacturer desired a ballast tube capable of maintaining a relatively uniform voltage across the filaments of a group of 2-volt tubes when using a 3-volt dry-cell source. Moreover, it was desired to obtain maximum battery life, which meant that the minimum resistance introduced by the ballast would have to be very low if the battery were to prove usable to a reasonably low end-voltage. The ballast supplied in this instance provided the following range of operating variations:

Dry-cell battery supply variation 2.2 to 3.0 volts.

Variation in voltage applied to tube filaments 1.85 to 2.0 volts.

Range of drop across ballast 0.35 to 1.0 volts.

Current variation through load 0.49 to 0.51 amperes.

To achieve this degree of regulation the ballast had to be capable of automatically varying the voltage drop across it in the ratio of 1 to 3. In spite of this wide variation it proved capable of maintaining the filament voltage at the controlled tubes within a total variation of 7.5 percent and the filament current within 4 percent.

Had the nature of this tube equipment been such that a higher degree of regulation was necessary, it could have been obtained by using a 4.5-volt battery. The ballast then would have been called upon to provide a drop varying only between 1.3 and 2.5 volts or a ratio of 2 to 1. Its operation could have been confined entirely to the flat portion of its characteristic and the voltage applied to the filaments held to a maximum variation of 1 to 2 percent.

Because this type of regulator is a resistive device its incorporation in any supply circuit necessarily introduces some drop in the applied voltage. It therefore does not find application in all circuits. Where 6.3-volt tubes are operated from a 6-volt storage battery, for instance, the minimum voltage supplied by the battery when partly discharged may be only 5.7. Any resistance introduced by a regulator in this case would mean subnormal voltage applied to the tube filaments. This would likewise be true in the case of 1.4-volt filaments working from dry cells. But it is seldom, in either of these applications, that any form of regulation is needed.

Operation on A-C Circuits

In a-c circuits it is almost always possible, if a discrepancy does not already exist between supply and required load voltages, to redesign the equipment to provide for the voltage drop called for in using a ballast. Thus where the equipment includes a line transformer this can be wound for a primary rating of 90 volts instead of the conventional 115 volts, if the ballast is one which results in a 25-volt drop at normal line voltage. Line variations above or below normal value will then be absorbed in the regulator with the result that the voltage applied to the transformer primary will remain substantially constant.

Figure 4 illustrates the regulatory action obtained in the case of one a-c radio set employing a ballast which at normal line voltage introduced a drop of 27 volts. The power transformer primary was designed for a supply of 88 volts. For line voltage variations between 105 and 130 the voltage applied to this primary remained within plus or minus 1 volt of its rated value, the regulator drop varying automatically between 17 and 41 volts to maintain this substantially constant value. Even for the wider and highly unlikely variation range of 90 to 140 volts the voltage applied to the transformer suffered a maximum variation of 6 volts, equivalent to about 7 percent.

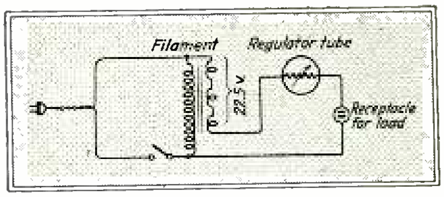


Fig. 6—Circuit of the set-up shown in Fig. 5 in which a filament transformer supplies the additional voltage required by the drop in the ballast resistance

In manufactured equipment a transformer such as this costs no more than one having a conventional 115-volt primary, nor is its design any more complicated. The ballast manufacturer should be consulted when the transformer specifications are drawn, as the required primary-voltage rating will depend on the characteristics of the ballast tube to be used and these in turn are dependent on the anticipated variation in supply voltage, the load current, the degree of regulation required and to a certain extent on the nature of the load supplied by the transformer.

When the necessary regulator drop cannot be taken care of in the design of the equipment itself, it is sometimes practical to increase the supply voltage if the source is either an a-c line or battery. In the former case a transformer of suitable step-up ratio can be added between line and load. In battery-operated equipment the battery voltage can be increased.

Where a regulator is to be employed with an individual piece of a-c equipment, as in the case of existing laboratory apparatus, in application of communications receivers in which constant voltage supply may be important, in the substitution of automatic for manual regulation of filament voltages in transmitters, etc., it is quite possible to provide this form of regulation, either externally or internally, without resorting to any change in existing transformers or other components. This is accomplished by supplying the equipment through a small step-up transformer and a ballast tube. The transformer serves to step up the existing line voltage to provide for the drop introduced by the regulator, thus allowing the normal rated voltage to be applied to the apparatus to be controlled. Such a simple unit, consisting of a transformer, ballast tube and outlet receptacle is shown in Fig. 5 and its circuit in Fig. 6.

The discussion so far has been concerned primarily with the use of the ballast tube in series with a load. Another type of application is illustrated in the circuit and curves of Fig. 7. Here the output voltage of a compound-wound d-c generator, driven by a low-head water wheel, suffered as a result of the wide variation in the lighting load which it supplied. With a suitable ballast tube shunted across the series field the regulation was improved to such an extent that the generated voltage

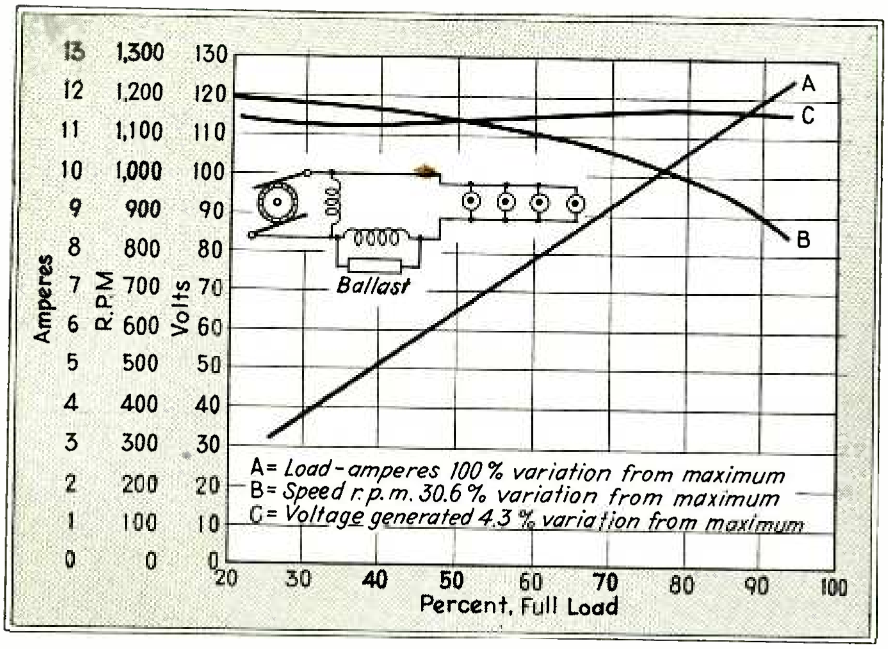


Fig. 7—Load characteristics of compound wound d-c generator driven by water wheel with constant head. Ballast placed in parallel with the series field

was maintained constant between 112.5 and 116 from zero to full load and with generator speed variations of 30 percent.

In this application the ballast operates over the steep, initial portion of its curve as well as into the flat portion. At low load current its resistance is relatively low with the result that a good portion of the load current is by-passed around the series field. As the load current increases, however, the regulator resistance increases, forcing more and more of the load current to flow through the series field winding. The result is that unusually good regulation is obtained at all values of loading.

The Time Lag Characteristic

Reference was made earlier to a lag in the control action of regulators of the resistive type. This lag varies anywhere from a fraction of a second to as much as two minutes, depending on the power being dissipated in the regulator and the range of regulation. This is quite understandable when it is realized that a change in resistance is dependent on changing temperature of the wire. When dissipating energy near the limits of its rating this may involve stabilization of the surrounding temperature at the new level. Even when operating under these conditions the change to the approximate vicinity of the new value will be relatively rapid, the greater part of the time lag lying in the gradual approach within immediate proximity of the final value. Thus from a cold start, regulators designed for controlling currents up to about 1 amp will reach approximately 5 percent of their proper control value within 3 sec.

In some applications this lag may be an advantage. It is possible, for instance, to introduce time delay in the operation of a relay by shunting a suitable ballast resistor across its coil. When the actuating current is applied the ballast serves momentarily as a low-value by-pass. The current flowing through it causes its resistance to rise until the voltage required to operate the relay is reached. Delay periods of from a fraction of a second to 10 sec can be economically obtained in this way.

The other limitation mentioned is presented in cases where load variations assume wide proportions. A typical example is found in vacuum-tube equipment which has provision for cutting off the plate current during stand-by periods, or during the few seconds after such equipment is turned on, while the tubes are warming up and no plate current is being drawn. Under such conditions the load current drawn may be less than half the normal value and the drop across the regulator therefore negligible. This places practically the full line voltage across the load. In the case of a radio set with a 90-volt transformer primary this would be distinctly undesirable.

To avoid this latter condition, ballast tubes can be supplied with an additional fixed resistance shunted by an automatic time-delay switch. This switch is normally open so that when the power is turned on the fixed resistance is in series with the load and limits the current to a desired low value. After a predetermined time interval the switch automatically shorts out this resistor and the ballast resistor takes its normal control. Such an arrangement provides completely automatic protection in starting. Because the resistor and switch are inside the ballast tube, with connections brought out to the tube prongs, they introduce no mounting or wiring complications.

Fixed resistors to serve other purposes can also be included within the ballast tube. It is common practice to include pilot-light shunts in ballasts designed for use in ac-dc receivers, for instance. Automatic switches of either the thermostatic or hot wire types can also be included and these are available in wide variety, from s.p.s.t. to d.p.d.t., for opening or closing circuits and for instant or delayed action.

Where the controlled equipment includes a stand-by switch to cut off plate current this does not by any means preclude the possibility of utilizing a regulator. It is only necessary to incorporate a fixed resistance in series with the supply line, and so arranged that it is inserted in the circuit by the action of a section of the stand-by switch to serve as an auxiliary dropping resistor during periods when no plate current is being drawn.

There is no practical type of regulator device capable of universal service in all types of applications. Some are limited in their applications by the type of current delivered by the source, others by their mechanical complications, size, weight, cost, etc. Regulators of the resistive type are perhaps the most universal of all and certainly the least expensive. Their possibilities are well worth investigating whenever a problem involving regulation arises.

Super-Cardioid DIRECTIONAL MICROPHONE

By B. B. BAUER
Shure Brothers, Chicago

Desirable directional properties have been obtained in a single unit microphone employing the principle of acoustic phase shift. Ruggedness, low noise, good frequency response, axial symmetry of directional pattern and high degree of directivity characterize the Uniphase microphone

UNIDIRECTIONAL microphones have been accorded an ever-increasing acceptance in recent years in the broadcasting, recording and public address fields. The advantages which a cardioid (or heart-shape) pattern presents over a non-directional pattern, found in pressure microphones, are a two-thirds decrease in reverberation energy pickup, separation of the desired from the undesired sounds, and simplification of microphone placement problems. The cardioid is obtained through the addition in equal proportions of a bi-directional (cosine law) characteristic and a non-directional circular characteristic, resulting in the expression $\rho = (0.5 + 0.5 \cos \theta)$ shown in Fig. 1A[1]. Later studies indicated that for maximum unidirectional action it is necessary to mix the circular and cosine law characteristics in a different proportion.

The cardioid fulfilled the formerly accepted definition of a unidirectional microphone as "one which has a high front-to-back response ratio" i.e. is sensitive at the front and relatively insensitive at the rear, along the line passing through the 0 to 180 deg. axis. It is apparent, however, that sounds originating precisely at the front or at the rear of a microphone occur relatively infrequently. The function of a unidirectional microphone appears to be more properly defined as that of accepting the sounds arriving from an imaginary hemisphere at the front of the microphone, and rejecting those arriving from a hemisphere at the rear of the microphone. Calculations based upon the probability of arrival of sounds from random directions indicate that the optimum pattern in accordance with this definition occurs when the proportions of circular and cosine components are in a ratio of 37 percent to 63 percent (see Appendix). This pattern has been termed the super-cardioid, and is shown in Fig. 1B.

Another commonly accepted index of directivity, although not necessarily of unidirectional properties, is the random efficiency of a microphone[2], i.e. its ability to receive sounds arriving from all directions, as compared with that of a non-directional microphone having equal normal incidence efficiency. Decrease in reverberation energy pickup is given, in percent, by $E = 100\ (1-\eta)$ where η is the random efficiency expressed as a fraction. Again, probability calculations indicate that minimum random efficiency occurs when the proportions of circular and cosine components are in a ratio of 25 percent to 75 percent. This pattern has been termed a hyper-cardioid.[3]

The polar patterns obtained with various proportions of circular and cosine components, is shown in Fig. 2 which also lists (a) front-to-back response ratio; (b) front-to-back hemispherical random ratio; and (c) random efficiency. The super-cardioid is roughly twice as unidirectional as the cardioid or the hyper-cardioid from the standpoint of front-to-back random ratio. On the basis of random efficiency, it permits a 73 percent decrease in reverberation energy pickup, as compared with 66 percent for the cardioid and 75 percent for the hyper-cardioid. The hyper-cardioid has a front-to-back discrimination of only 2 to 1 and is,

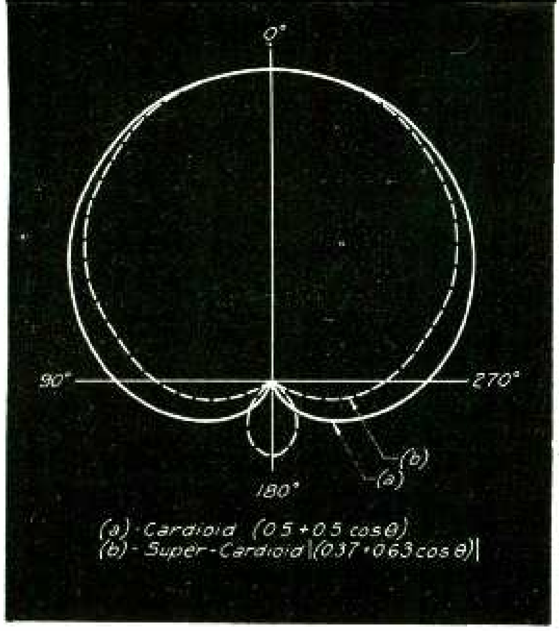
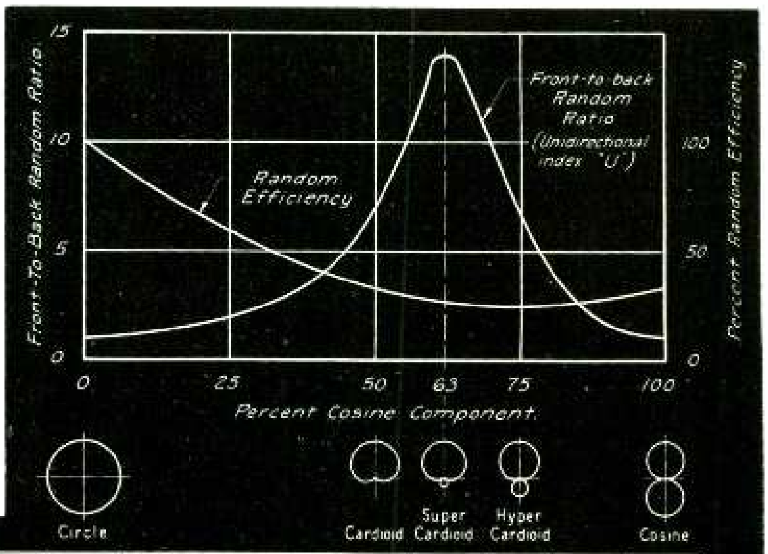


Fig. 1—(Above) Cardioid and super-cardioid directional patterns. Probability calculations indicate that few sounds originate directly in front of the microphone



	Circle		Cardioid	Super Cardioid	Hyper Cardioid		Cosine
Front-to-back Response	1.0		∞	4.2	2		1.0
Front-to-back Random Ratio	1.0		7	14	7		1.0
% Random Efficiency	100		33	27	25		33

Fig. 2—(Right) Random efficiency and front-to-back random ratio curves for various proportions of circular and cosine components and a comparison of several types of directivity patterns

therefore, somewhat unsatisfactory as a unilateral microphone. These considerations definitely point toward the super-cardioid as providing a more satisfactory unidirectional pattern. These conclusions have been checked by extensive field tests in which microphones employing different patterns were used.

The Single Unit Unilateral Microphone

Early cardioid microphones were constructed using a velocity-type ribbon microphone, connected in series with a pressure ribbon microphone.[1] In later years various cardioid microphones have been developed following the same principle, but employing other types of pressure units in combination with a velocity element.[4] Considerable manufacturing experience with such microphones indicates that the two-unit cardioid process entails many technical difficulties and high basic costs, because (a) the frequency response of the two component microphones must be held to close limits to produce a good directional pattern at all frequencies; and (b) electrical networks have to be provided between the two units to compensate for the effect of phase shift, due to the difference in operating principle of the velocity and pressure units, and due to the physical separation between the units which becomes significant at higher frequencies. There is considerable evidence that other investigators found similar problems in connection with two-unit uni-directional microphones.

Realization of these difficulties led to the development of single-unit uniphase cardioid microphones operating on the principle of acoustical phase shift. A uniphase piezoelectric cardioid microphone was first made available in 1937,[5] and a uniphase moving-coil cardioid microphone appeared shortly afterward. Recent studies of the general acoustical problem involved resulted in the development of a new single-unit microphone with a super-cardioid pattern and with a greatly improved performance. The new microphone has the following features: (a) a super-cardioid pattern for optimum unidirectional properties, and low random noise pickup, (b) an excellent frequency response, sensitivity, and high signal-to-noise ratio, (c) ruggedness and low wind-noise pickup common to moving-coil microphones, (d) simplicity and economy which result from the use of only one translating unit, and (e) axial symmetry at all frequencies. The point (e) has not been generally recognized in connection with two-unit unidirectional microphones. However, it is obvious that since such units are not symmetrical about the normal axis, they are not capable of having polar patterns symmetrical in all directions. The distortion of the polar pattern increases with frequency and with separation of the two units. This is indicated in Fig. 3, which shows polar patterns in the horizontal and the vertical plane of a commercial two-unit cardioid microphone, in which the separation between the pressure and the velocity units is two inches. These polar patterns were obtained by using three bands of random frequency noise, of 100 to 400, 400 to 1600, and 1600 to 6400 cps. Horizontal plane patterns closely approximate a cardioid; however, the patterns in the vertical plane are distorted at high frequencies, where the separation is comparable to the wavelength of sound. There is no evidence of such a considerable pattern distortion with the single unit microphone. It is evident, therefore, that the single unit microphone may be more effective, in eliminating sounds reflected from above or below, than a conventional two unit microphone.

Structure and Theory of Operation

A cut-away photograph of the dynamic uniphase structure is shown in Fig. 4, and a cross-sectional view is shown in Fig. 5. The moving coil is wound on a tubular bobbin and suspended from two elastic spiders. It has been found advisable to use the clearance between the moving coil and the inner pole piece as one

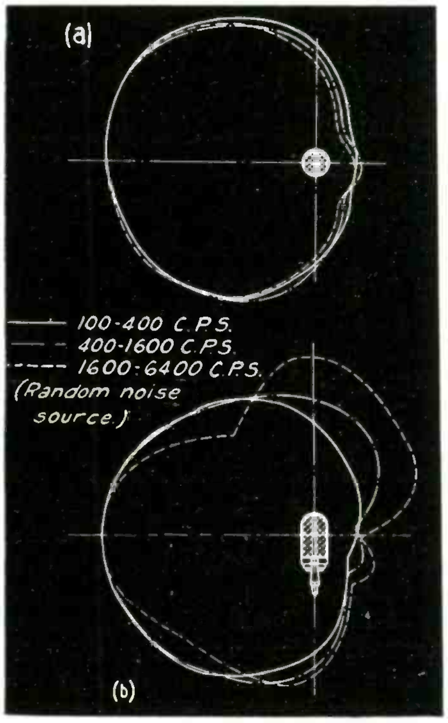


Fig. 3—(Left) Horizontal (a) and vertical (b) plane polar response patterns of a two unit cardioid microphone

Fig. 4—(Right) Cutaway photograph of the dynamic uniphase structure of the new microphone

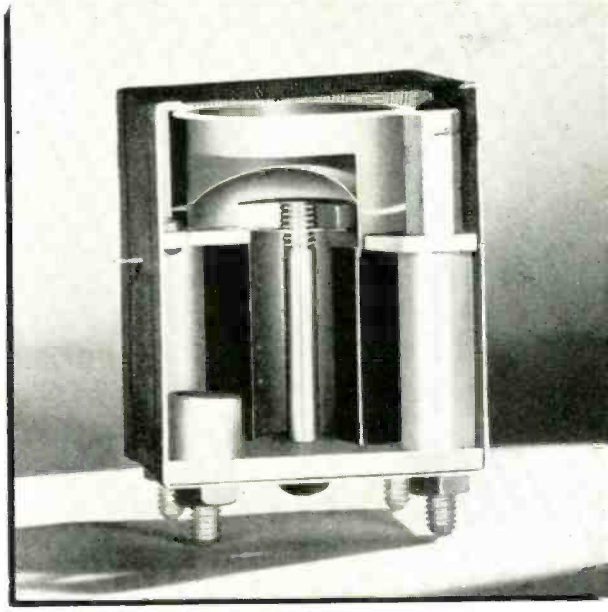
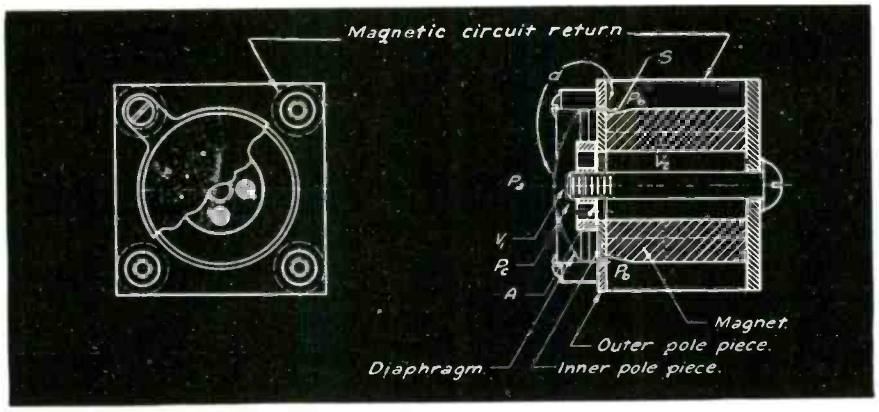


Fig. 5—(Below) Cross section of the unit shown in Fig. 4. An acoustical phase-shifting network produces the effect of combining a velocity microphone with a pressure microphone



of the phase shifting network elements. The action of this network is described in detail below. The volumes enclosed between the diaphragm and the inner pole piece, and inside of the magnet, are also used as part of the phase shifting network. These volumes are subdivided by an acoustical screen A. The magnetic circuit return consists of the outer pole piece and four iron bars, which are designed to provide an adequate magnetic path, and at the same time permit a free access of sound waves to the slit S between the inner pole piece and the coil. The complete unit is covered with a wind screen and suspended in a cradle, the object of which is the elimination of stray vibration pickup.

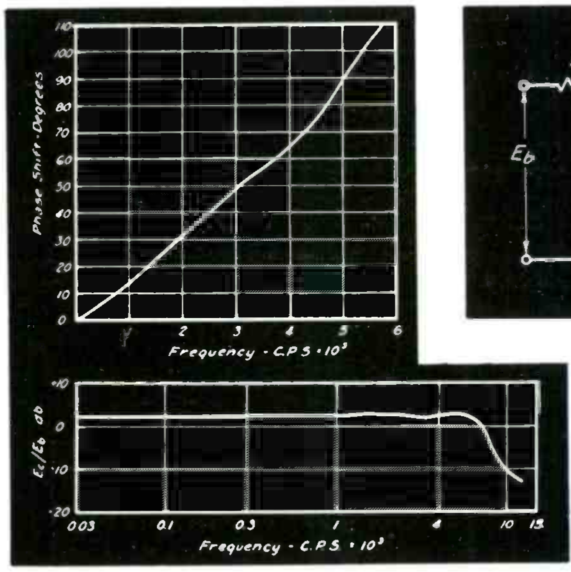


Fig. 7—(Left) Phase shift and pressure curves of the super-cardioid microphone

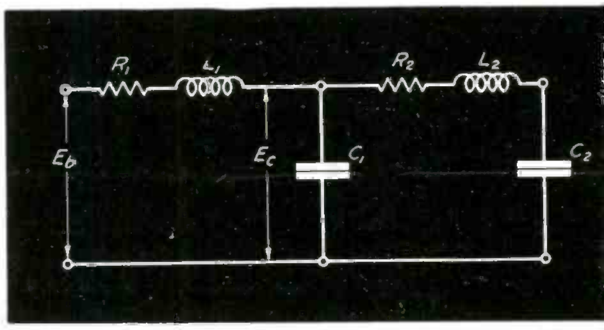


Fig. 6—(Above) Equivalent electrical circuit of the acoustical network

Referring to Fig. 5, a plane sound wave, approaching the unit from the front, first acts upon the front of the diaphragm with a pressure P_a, then flows around the outer pole piece, past the slit S, acting upon it with a pressure P_b. The time required in traveling from the diaphragm to the slit is d/C_v second, where d is the effective air distance from the diaphragm front to the slit, and C_v is the velocity of sound (34,400 cm per sec). This time interval corresponds to a phase shift of $\omega d/C_v$ radians. If the wave is approaching parallel to the diaphragm (90 percent incidence), the time of arrival at the diaphragm, and the median time of arrival at the slit are identical, and P_a and P_b are in phase. Likewise, it is apparent that for waves arriving from any other angle, θ, the effective distance d is decreased by the factor $\cos\theta$, and hence the phase shift between the pressures at the diaphragm and the slit is $\phi_1 = (\omega d/C_v)\cos\theta$ radians. Therefore, ϕ_1 may be compared in function with the velocity (cosine) component of a two-unit unidirectional microphone.[6]

The pressure P_b at the slit acts upon the acoustical network and produces a pressure P_c within the volume under the diaphragm. The magnitude of P_c is the same as that of P_b but it is shifted in phase by an angle ϕ_2 which, in the super-cardioid case, is 37/63 of ϕ_1 at any given frequency. The phase angle, ϕ_2 depends solely upon the network constants, and is, therefore, entirely independent of the direction of sound incidence. Hence, ϕ_2 may be

(Continued on page 91)

Photoflash

By P. A. MARSAL

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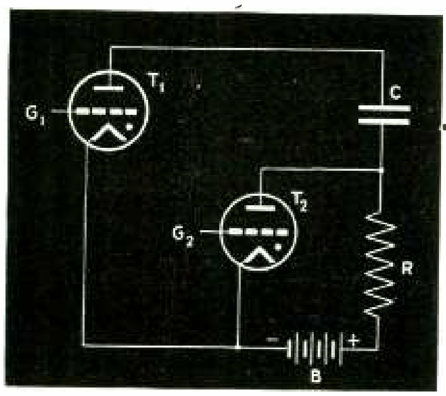


Fig. 1—Basic circuit of interval timer using two gas tubes and a condenser

THE device to be described was designed to quickly indicate variations in the timing of photoflash synchronizers, i.e., the interval between closure of the synchronizer switch (with consequent rapid attainment of peak flashlamp brilliancy) and opening of the camera shutter.

Flashlamps in synchronizers under test appeared to require the shutter to open in 20 milliseconds. The range covered by the photoflash synchronizer tester is therefore from 10 to 45 milliseconds.

Operation is accomplished by two gaseous tetrodes which control the charging of a condenser in accordance with the time interval to be measured. The basic circuit[1, 2] is shown in Fig. 1. Tube T_1, condenser C and resistor R are connected in series across a source of d-c potential. Bridging the resistor R and source of potential is a second tube T_2. In operation, event No. 1, marking the start of the time interval to be measured, exercises control in grid circuit G_1 and causes T_1 to ionize. Condenser C starts to charge through T_1, but before it is fully charged event No. 2 occurs, marking the end of the time interval to be measured. A pulse of voltage exercises control in grid circuit G_2, ionizing T_2. With T_2 ionized, the plate potential on T_1 is reduced to a value below the extinction potential and T_1 is de-ionized, leaving condenser C with a definite charge, the magnitude of which is a measure of the time interval between events number one and two.

Practical Circuit

A practical circuit is shown in Fig. 2. The photoflash synchronizer under test is connected across R_1 in such fashion that the voltage of the battery within the synchronizer appears across this resistor as soon as the synchronizer operating switch is closed, ionizing the 2051 at the left of the diagram and starting the condenser charge cycle. (This connection is facilitated by the fact that most commercial synchronizers have extra sockets for attachment of additional photoflash lamps. One of these may be conveniently connected across R_1.)

A light source, such as the 6-8 volt, 21 candlepower automobile headlight lamp contained within the case at the left of Fig. 3, is mounted so that illumination from it impinges upon the 917 phototube through a magnifier. The camera shutter, with synchronizer shutter actuator attached, is interposed between light source and phototube. When the shutter opens, permitting light to fall on the phototube, current flows through R_2 and the voltage developed across this resistor trips the second 2051, extinguishing the first 2051 by virtue of the virtual short circuit across R_3 and stopping the condenser charge cycle.

The voltage across C_1 is immediately read by rotating switch *SW* one step clockwise, which connects it to the input of a degenerative vacuum-tube voltmeter, calibrated directly in milliseconds as shown by typical curves in Fig. 5. After reading the time interval, switch *SW* is moved one more step clockwise to discharge C_1, is then returned to the original or "charge" position after pausing for an instant in the central or "read" position to note whether the meter returns fully to the index mark denoting a completely discharged condenser. The pushbutton is then depressed, opening the anode circuit of the second gas tetrode and permitting its grid to regain control. The device is now ready for another time interval measurement.

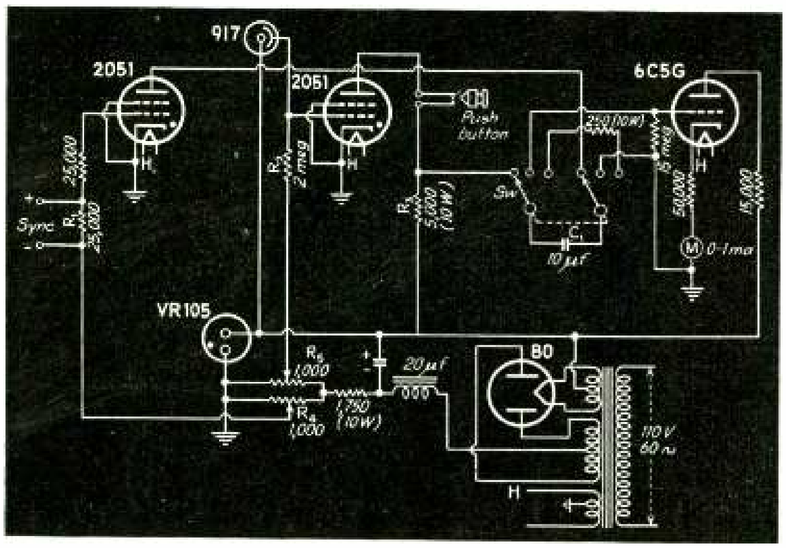


Fig. 2—Wiring diagram of instrument, including voltage-regulated power supply

Initial Adjustments

Two initial adjustments are required. The first of these affects the grid bias on the first tetrode, actuated by battery voltage from the synchronizer. At the plate voltage employed, this tube will trip when its grid voltage drops below −1.35 volts. A normal grid bias of −1.8 volts gives reliable operation. With such

Synchronizer Tester

A phototube, two gaseous tetrodes and a receiving triode used as a degenerative v-t voltmeter combine in one compact instrument to permit rapid measurement of time intervals between 10 and 45 milliseconds on a 0-1 milliameter

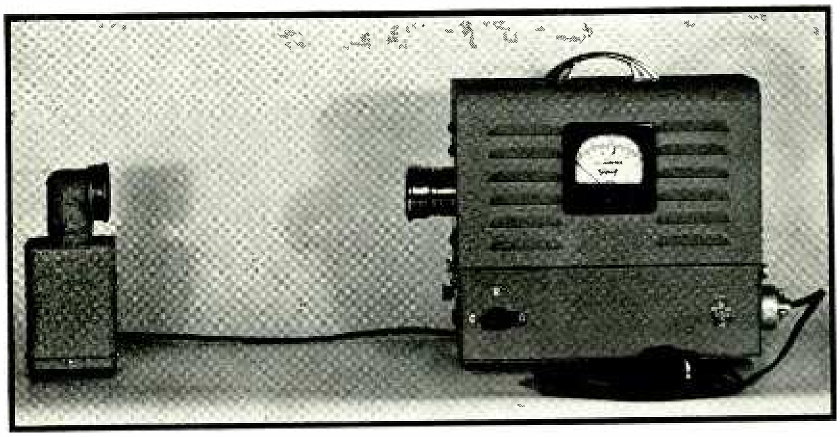


Fig. 3—Completed photoflash synchronizer tester, with light source at left

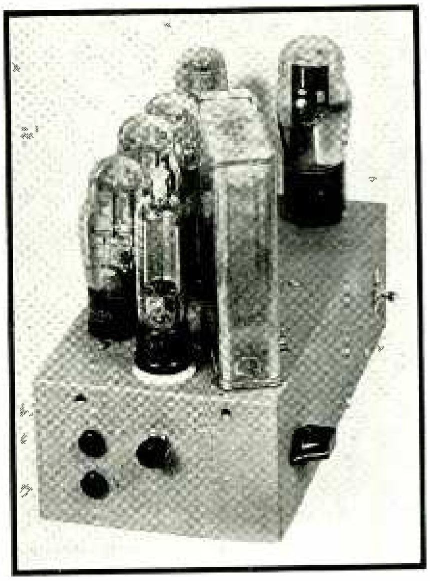


Fig. 4—Chassis layout, showing components

bias 0.5 volt is required from the synchronizer battery and any value greater than this will, of course, serve equally well. Bias is readily adjusted by connecting a 1,000 ohm/volt meter between a "Sync" terminal and ground, adjusting potentiometer R_4 on the back of the chassis illustrated in Fig. 4 but not visible in the photograph.

The second adjustment pertains to the bias on the gas tube controlled by the phototube and a satisfactory setting is one which causes the tube to trip when the camera shutter is three-quarters open. To effect this adjustment, the testing device, light source and shutter are arranged in the respective positions which they are to occupy during subsequent tests. The shutter is placed on "time" and opened. The iris diaphragm is then stopped down 1½ stops from the fully open position, i.e., an *f*/4.5 lens is adjusted midway between *f*/5.6 and *f*/8. Pushbutton is momentarily depressed and then, viewing the gas tetrode controlled by the phototube through the case grille, turning R_5 (also out of sight in Fig. 4) slowly until ionization occurs. The device is then ready for use.

The degenerative type vacuum tube voltmeter is unaffected by normal variations between 6C5G tubes. There is little danger of damaging the instrument in its cathode circuit through improper manipulation for the maximum current which can flow through it is limited to 1.2 ma.

Design Details

The operating range of the voltage regulator tube incorporated within the power supply of the device is from 5 to 30 ma. If good regulation is to be obtained the instantaneous current required from the powerpack should never exceed a value which will reduce the VR105 current below 5 ma. The various loads have been worked out accordingly. It is desirable to have the capacity of C_1 large so that the effects of leakage do not reduce its voltage rapidly (the condenser selected should, of course, embody lowest possible leakage in its design.) On the other hand, if the capacity is excessive it will be necessary to use a lower value of resistance at R_3 to arrive at the same charging voltage in the same time interval. There is then danger, due to the increased current required from the powerpack, of the voltage regulator tube dropping out. The maximum voltage to which the condenser is charged is kept low with respect to the applied voltage in order to operate on the steep portion of the charging curve.

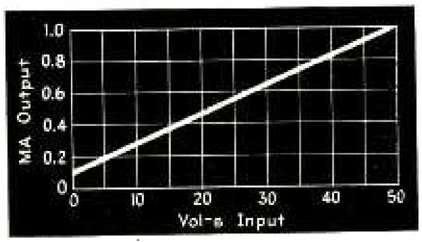
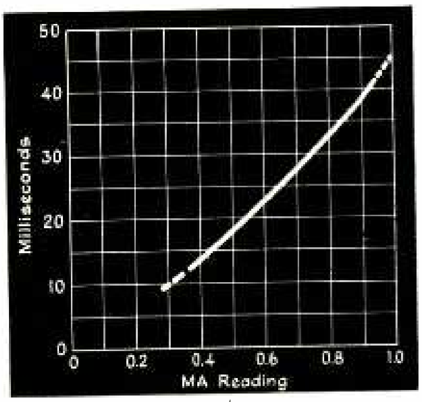


Fig. 5—VTVM calibration curves. Above—current output versus input volts. Below—calibration of current output in terms of time



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2 Bradford, C. I., "The Chronoscope", ELECTRONICS, 1940.

STANDARDIZED MARINE RADIO UNIT

UP to the present time the installation of radio equipment on shipboard has followed no fixed plan. The principal demand for ship radio facilities has been for replacement of obsolete equipment on old vessels, or the installation of selected units of equipment in the case of new ships. In either case, the equipment was placed where space and convenience dictated, and tables or benches were constructed to support the apparatus. As regulations with respect to equipment details and installation methods became more stringent the time required to perform the installation of a complete shipboard equipment has increased to a matter of weeks.

With the plans for building a large number of new cargo vessels came the incentive to standardize radio room installations, and to unify the equipment to the point where the majority of the labor could be accomplished prior to placement of the apparatus on board a vessel. To this end, and in keeping with the trend toward speedier production of quality equipment, the Federal Telegraph Division of International Telephone and Radio Mfg. Corp., of Newark, N. J., I.T.&T. associate, has developed a single unit of equipment in which is housed all of the apparatus required for a modern, efficient and completely reliable radio room installation for cargo vessels.

This marine radio unit is furnished completely cabled, adjusted and ready for installation. The assembly includes an operating shelf, message racks and all necessary appurtenances for complete and efficient operation. The marine radio unit, possesses all of the features required by the Federal Communications Commission, the Bureau of Marine Inspection and the U.S. Maritime Commission, plus many additional features which are included to improve operation, increase operating efficiency and permit ready maintenance.

The equipment includes a main and emergency radio transmitter, providing a power output of 300 watts MCW (A-2) emission, or 240 watts CW (A-1) emission when powered from the ship's d-c lines. In addition the transmitter will deliver 50 watts MCW (A-2) emission, or 40 watts CW (A-1) emission when operated from a 24 volt storage battery. Two motor generators are provided, one operating from the ship's power, and the other from the battery power. Selection of one or the other sources of power is provided by panel switches. This transmitter, which is on the left hand side of the unit, provides operation on any five predetermined frequencies in the range 350 to 500 kc (835 to 600 meters). The transmitter circuit combines simplicity with ruggedness. The frequency determining oscillator, which utilizes a 210 tube, employs ceramic coil forms and low temperature coefficient, aged condensers to insure a minimum frequency deviation from any cause. A buffer amplifier consisting of a F-123-A tube in a band pass circuit, is used to drive a pair of similar tubes in parallel in the final amplifier. This stage is coupled to the antenna circuit by means of a radio frequency transformer, adjusted at installation to the antenna resistance. The antenna circuit comprises a high Q loading inductance and variometer. Only two controls are necessary to change frequencies. The oscillator is employed to obtain MCW. Protective devices such as fuses and a resetting circuit breaker associated with the power amplifier plate circuit reduce the possibility of failure to a minimum. In addition, the circuits employed are those in which the amplifier power is reduced to a low value if the frequency is changed, or the antenna detuned, opened or grounded.

The production of a transmitter of dimensions and characteristics adaptable for use in a compact unit of this type has been a matter of progressive development. Outstanding in this connection is the use of a high frequency power source. The generators, which are powered from the ship's d-c line, develop power at 720 cps for operating the full wave mercury vapor rectifier and filter system in the transmitter. The use of a-c supply provides safety to operating personnel, inasmuch as no high voltage exists outside of the transmitter panel. The physical dimensions of the power units for operating at this

FEATURES OF MARINE RADIO UNIT

1. Installation, Servicing, and Repair Features
   - All equipment completely wired at factory
   - Only power supply and antenna need be connected on board ship
   - All equipment completely standardized and interchangeable
   - All equipment readily accessible for inspection, cleaning, or repair
   - Installation can be made in small fraction of time usually required
2. Features of the Transmitter
   - Main transmitter delivers 300 watts, operating from ship's power line
   - Emergency unit, operating from batteries, delivers 50 watts
   - Two generators are provided; one for ship's power and one for batteries
   - Transmitter operates on five predetermined frequencies
   - Frequency is changed by adjusting only two controls
   - Power supply to rectifiers is at 720 cps.
3. Features of the Receiver
   - Receiver covers 15 to 650 kc in four bands
   - Receiver is battery operated to minimize noise
   - Emergency receiver uses no power
4. Alarm and Direction Finding Features
   - Warning bells automatically rung upon reception of distress signals
   - Manual and automatic means for transmitting distress signals is provided
   - Direction finding facilities are provided

Production for defense is the keynote of standardized marine radio equipment, completed in factory and ready to plug in to ship's power line and antenna. Ease of accessibility of all parts which are standard simplifies and expedites training of personnel using these packaged units. Alarm, distress, and direction finding facilities are provided

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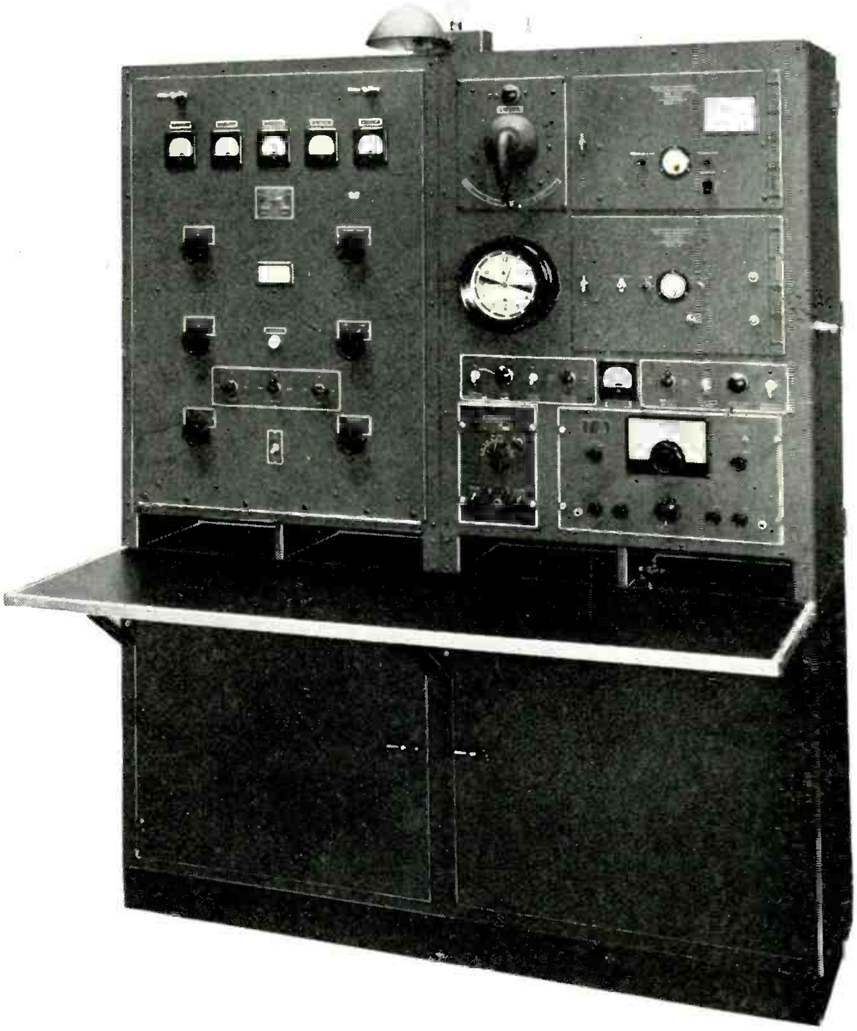
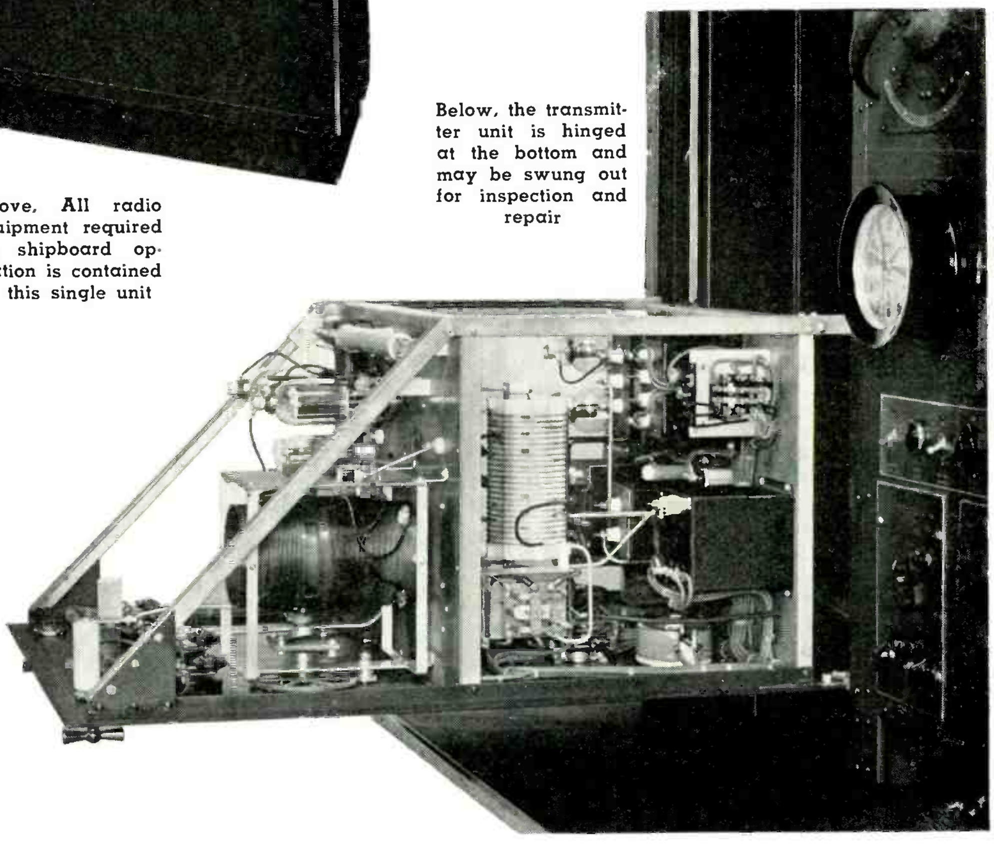


Above, All radio equipment required for shipboard operation is contained in this single unit

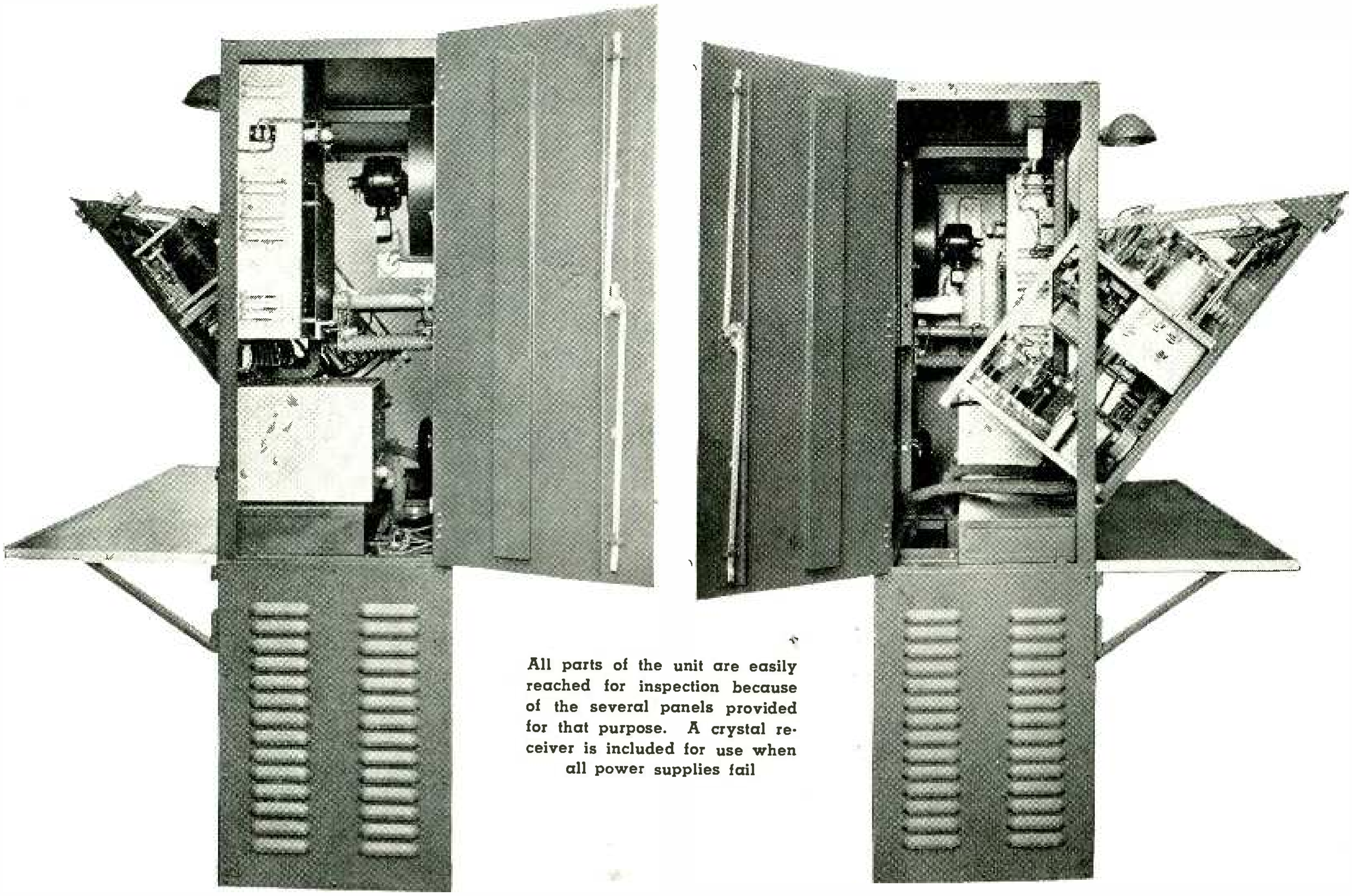
45 or 90 degree angle for service or replacement of parts.

Two receivers are also incorporated in the unit. The regular receiver, 128AX, covers the frequency range of 15 to 650 kc in four bands. It is battery operated, providing as a result, reliability in case of failure of the ship's power. The receiver uses a tuned radio frequency circuit, into which has been built all of the desirable features required in a marine receiver, such as absence of images, smooth regeneration, sharpness of tuning and freedom from vibrational or microphonic noises. The dial is directly calibrated in frequency, and illuminated. The receiver chassis is completely removable from the front, cable length permitting servicing of the receiver on the operating table. The chassis may be completely detached for replacement by removing two plugs attached to the power cables. The second receiver, 123-BX, is a simple affair using a crystal detector. This

frequency are so reduced over that necessary at lower frequencies, that they fit conveniently into the transmitter frame. The motor generators, mounted in the lower section of the unit, although rated at 750 watts, are small enough to be carried by one man. Both machines are mounted on rubber cushions, and arranged on separate bed plates which permit the machines to be slid outward for servicing without disconnecting any wiring. The transmitter fuses and power components are accessible from the left side door, or the transmitter can be swung outward to a



Below, the transmitter unit is hinged at the bottom and may be swung out for inspection and repair



All parts of the unit are easily reached for inspection because of the several panels provided for that purpose. A crystal receiver is included for use when all power supplies fail

receiver, use of which is mandatory on all ocean going vessels, provides means for reception should all other devices fail. Though outmoded, and only dimly recalled by many in connection with the infancy of radio, the crystal receiver in its modern form with etched panel and double circuit tuning, is quite an effective and reliable device when used with a ship's main antenna.

A complete auto alarm equipment is provided in the marine radio unit. The auto alarm, which is composed of two separately mounted chassis hinged to the front panel, is used to monitor the calling and distress band (500 kc) whenever the operator is not on watch, or when he is engaged in reception on other than this band. The upper section of the auto alarm houses a sensitive receiver, receptive to modulated signals in a band approximately 12 kc above and below the 500 kc band. The output of this receiver is rectified, and employed to operate a selector device, which is mounted in the lower chassis. This selector, which is motor driven, segregates the incoming signals, discriminating between distress signals and those of other origin, such as atmospherics and routine ship business. When the international distress call, which consists of 12 four-second dashes spaced one second apart, is received, bells in the radio room, the operator's quarters and on the ship's bridge are operated. and can only be silenced from the operating position. The device is foolproof. It possesses such features as automatic transfer to battery power upon failure of the ship's power, and operation of an alarm bell should a tube fail, the motor speed vary, or the voltage of the battery supply drop abnormally. Signal lights on the bridge and on the operating panel also indicate misadjustment or the requirement for adjustment due to increasing atmospherics or noise level. Both units are hinged to the front panel of the unit, and all of the apparatus which comprises the circuits is immediately accessible from the front of the unit.

An antenna transfer switch is mounted near the top of the unit to effect the transfer of antennas and circuits associated with the auto alarm and receivers for any desired functions. When in normal operating position, the main transmitting equipment is connected to the main antenna, and the receivers arranged to operate through a break-in relay from the main antenna. When placed in the auto alarm position, the main antenna is connected to the auto alarm receiver, and an auxiliary receiving antenna is connected to the receivers to permit reception of press and weather reports on other bands without leaving the distress band unmonitored. By simply placing the switch in this position, the power circuits which place the auto alarm in operation are closed. The auto alarm is thus placed in service by this single simple operation. Another switch position, labelled Direction Finder, closes through the circuits to the radio direction finder on the bridge, permitting its operation. Antenna grounding facilities are also provided. The design of this switch is such that only the grounded handle is exposed to the operator, all high voltage connections being backpanel.

A radio clock is placed directly in front of the operator, in line with his eyes. The clock has special indications for silent periods, and the four second intervals are marked in red on the second hand scale to aid the operator in transmitting the international distress signal, should this be necessary. An automatic keying device, associated with the auto alarm, may be placed in operation by throwing a single switch on the auto alarm panel, whereupon the international distress signal is transmitted automatically, using either the main or emergency power supplies.

Battery charging and control circuits are located on a panel directly above the receivers. Two sets of batteries are provided for both the auto alarm and the main receiver, and the switching facilities permit charging of one set of batteries while the other is in use. The charging switches associated with the transmitter emergency battery are mounted on the front of the transmitter panel. All charging resistors are placed within the cabinet, a ventilating fan serving to exhaust the heat generated. This fan, which also serves to cool the transmitter components, is automatically placed in operation when any of the charging or transmitter switches are thrown, its speed being proportioned to the heat generated. When the batteries are being trickle charged, the fan rotates slowly. When one or more chargers are placed in full operation, the fan operates at high speed, exhausting quite completely the heat generated. Although the placement of charger components and the discreet use of baffle plates provides natural ventilation, absolute safety in case of failure of the fan is insured by a thermostat which functions should the generated heat become excessive, turning off the supply power. The resistors are mounted in clip holders, to enable their ready replacement.

Emergency illumination of the equipment controls and motor generator units is provided, to permit efficient operation in case of failure of the ship's power.

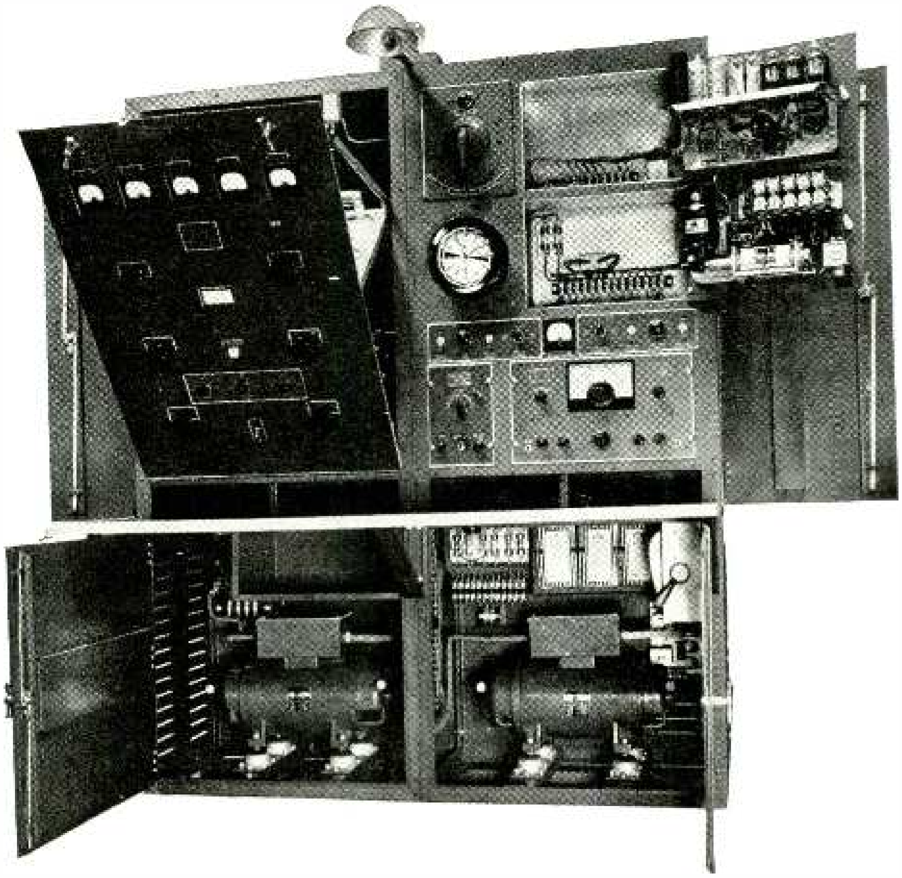
Accessibility of the internal parts has been extended to a point not previously approached in marine equipment. All panels with the exception of the antenna switch are removable from the front. Two side doors permit additional access to the interior for routine inspection.

This marine radio unit has been constructed mechanically for severe use under conditions of unusual vibration which might possibly occur in marine service. All panels are heavily copper plated before painting to prevent rust should the paint become chipped. Equipment labels and designation plates are finished in a soft grey tone, adding considerably to the finished appearance of the unit. All doors are reinforced to avoid annoying rattling, and three point door latches are employed. To facilitate handling, and to enable the equipment to be transported through narrow passage ways and doors, the equipment may be divided into two equal sections, which are bolted together after being mounted in place. Special terminal facilities are provided to simplify this procedure. A compartment is provided in the base section for spare parts.

The apparatus has been carefully treated for electrical noise by use of filters and adequate shielding of conductors.

This marine radio unit is being placed on all of the 312 "Liberty" (EC-2) vessels now under construction by the U.S. Maritime Commission. It is estimated that the time required to install the marine radio unit is but one fifth that required to install the twelve equivalent pieces of apparatus which this unit replaces. The standardization of parts and placement is also being hailed by those responsible for operator instruction, as it is now possible to place an operator familiar with this equipment on any vessel in the "Liberty" fleet, with the assurance that he will be enabled to operate efficiently without additional instruction, inasmuch as each knob and control is in exactly the same place on every vessel. This represents a decided step forward in marine design.

Motor-generator sets operate either from the ship's main power line or from storage batteries. The rectifier unit for the radio equipment is supplied with a-c power at 720 cps



Rectilinear Rectification Applied to Voltage Integration

The average value of small alternating potentials may be determined by rectifying the voltage, summing it up over a known time interval, and measuring the voltage after it has reached a relatively large value. An integrator for this purpose, which overcomes the difficulties and limitations of imperfect rectification, is described

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FREQUENTLY desirable in physiological experimentation is a knowledge of the average voltage produced by a nerve or muscle over a period of time. Outside of biology arise many other situations where a time-average of a fluctuating or alternating voltage must be obtained. The problem is to determine the area under the curve which would represent the fluctuating voltage graphically recorded. If the voltage changes sign it is the area between the curve and the zero axis that must be measured.

Electrical integration of alternating voltages requires (1) rectilinear rectification (an ideal rectifier) and (2) a means of accumulating and storing electric charge. Given proper precautions, charge may be stored in a condenser, but rectilinear rectification is ordinarily considered impossible because rectifying elements such as copper-oxide units and diodes have resistances which vary with the current passing through them. The problem, then, is to combine non-linear rectifying elements in such a way as to produce rectilinear rectification.

The principle employed to straighten out the characteristic of a rectifier can be illustrated by the half-wave rectifier in Fig. 1A and the full-wave rectifier in Fig. 1B. In Fig. 1A, if the two rectifying elements have comparable characteristics, if $R_1 = R_2$, and if R_3 is large compared to the combined resistance of the rectifier and R_2, current will

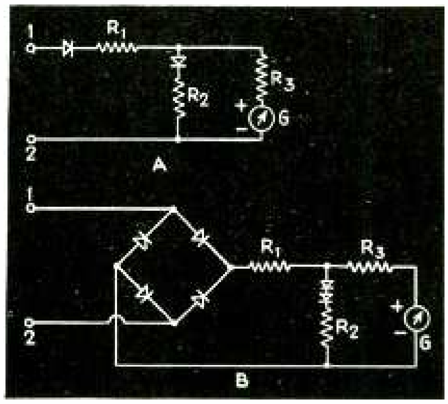


Fig. 1—Fundamental half-wave circuit (A) and full wave bridge rectifier circuit (B) for straightening out the characteristic of the rectifier

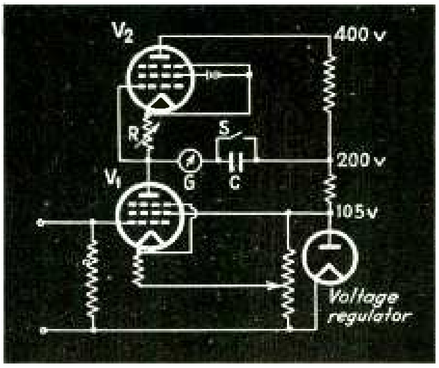


Fig. 2—The basic circuit of the voltage integrator using two pentodes and a voltage regulator tube

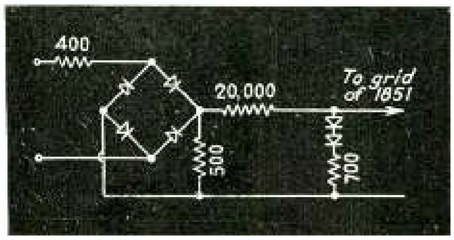


Fig. 3—Practical network for obtaining linear output from a commercial bridge type copper oxide rectifier. Resistance values are given in ohms

flow through the galvanometer G when the input terminal 1 is positive. Furthermore, since the galvanometer circuit taps the midpoint of the voltage drop between terminals 1 and 2, equal changes in the resistance of the two rectifying elements will not affect the voltage impressed upon the galvanometer circuit. Analogous considerations apply to the full-wave circuit of Fig. 1B.

Since we are here using a variable shunt resistance to compensate for the variations in a series resistance, it is possible, by a proper selection of the rectifying elements and the resistances, to obtain almost any desired relation between input voltage and output current. In particular, it is possible to adjust the rectifiers and resistances so as to compensate for the fact that the galvanometer draws a finite current and for the fact that the inverse resistance of the rectifiers is not infinite. Using only resistances, copper-oxide rectifiers and microammeters, the author has constructed several a-c voltmeters with linear scales. By means of a resistance in series with the input, the response of these meters has been rendered independent of frequency over the range 5 to 20,000 cps.

These principles of rectification have been utilized in the construction of voltage integrators capable of a rectilinear response. The basic circuit of the integrator will now be described.

As shown in Fig. 2 a pentode V_1 is used to control the flow of current to a condenser C. In order to reduce the current to zero without recourse to a large negative bias on V_1 a

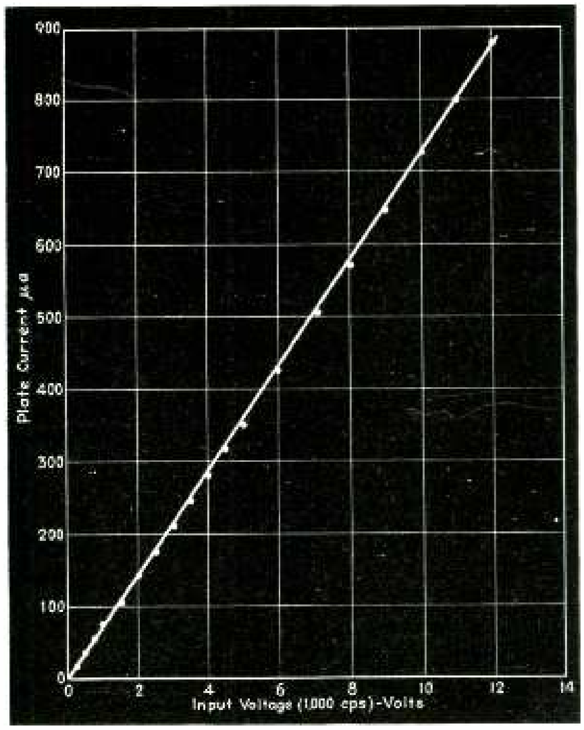


Fig. 4—Input-output characteristics of the combined circuits of Fig. 2 and Fig. 3, illustrating that a linear relationship is accurately attained

second pentode V_2 provides a path for a bucking current to flow through the condenser circuit. When the circuit is balanced by the proper adjustment of the bias resistor *R*, no current flows to the condenser. But then, when a positive voltage is impressed on the grid of V_1 the circuit is unbalanced and if switch *S* is open, charge accumulates on the condenser. The voltage on the condenser may be read directly by means of a vacuum tube d-c voltmeter or the voltage may be used to activate a relay through a thyratron circuit. Both methods of recording the accumulated charge are at present being used in different experiments.

As the voltage across the condenser rises, the plate voltage on V_1 decreases and that on V_2 increases by the same amount. For this reason, the choice of tubes is important. The situation calls for a tube whose plate current is as nearly invariant with plate voltage as possible. When type 1851 tubes are used the current to the condenser can be made to change by less than 3 microamperes as the condenser is charged from 0 to 100 volts. Under these conditions the plate voltage of V_1 falls from 250 to 150 volts and that of V_2 rises from 150 to 250 volts.

The current to the condenser in the circuit of Fig. 2 is not directly proportional to the voltage applied to the grid of V_1, and when this voltage is fed through a conventional arrangement of copper-oxide rectifiers the non-linearity is made even greater. Therefore, in order to obtain direct proportionality between the applied alternating voltage and the plate current of V_1 it is necessary to arrange a network of rectifiers which will exactly compensate for the curved grid-voltage plate-current characteristic of the tube. Such a network is shown in Fig. 3.

The rectifiers in Fig. 3 are commercial instrument-rectifiers. Those in the bridge are rated at 50 ma and those in the shunt arm at 15 ma. The latter have a higher resistance and a lower capacitance. The 400-ohm series resistor in front of the bridge serves to make this particular network flat to within 1 db from 5 to 20,000 cps. The effectiveness of this network, combined with an 1851 tube, in producing rectilinear rectification is shown in Fig. 4. To a close approximation the rectifier has corrected the characteristic of the tube.

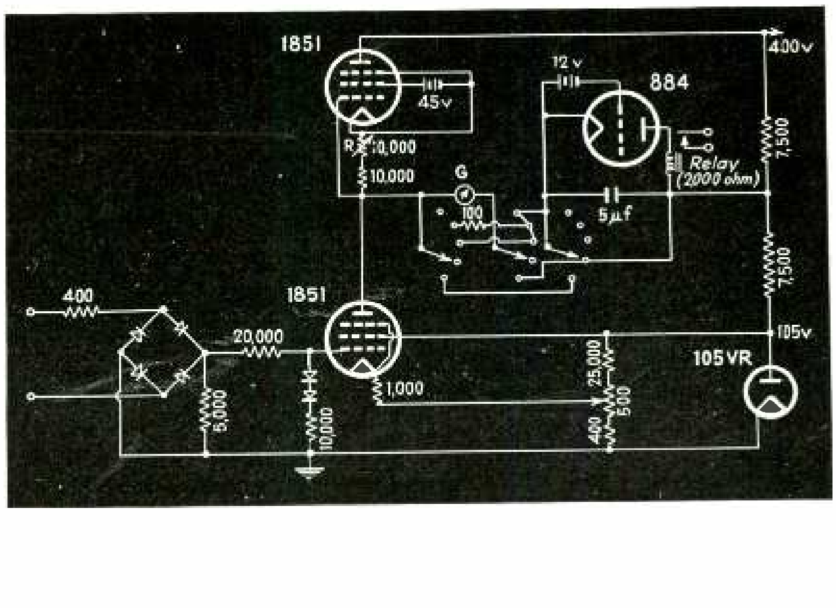
A voltage integrator is now being used in a medical research laboratory to measure the total amount of action potentials produced by the muscles of various patients. The action potentials are amplified and fed to the instrument diagrammed in Fig. 5. In this integrator the $5\mu f$ condenser is discharged through the 884 tube whenever the voltage on the condenser reaches 110 volts. The discharge activates a micro-switch relay which in turn activates a marker on a moving tape. The total number of marks within a given period provides a measure of the muscular activity.

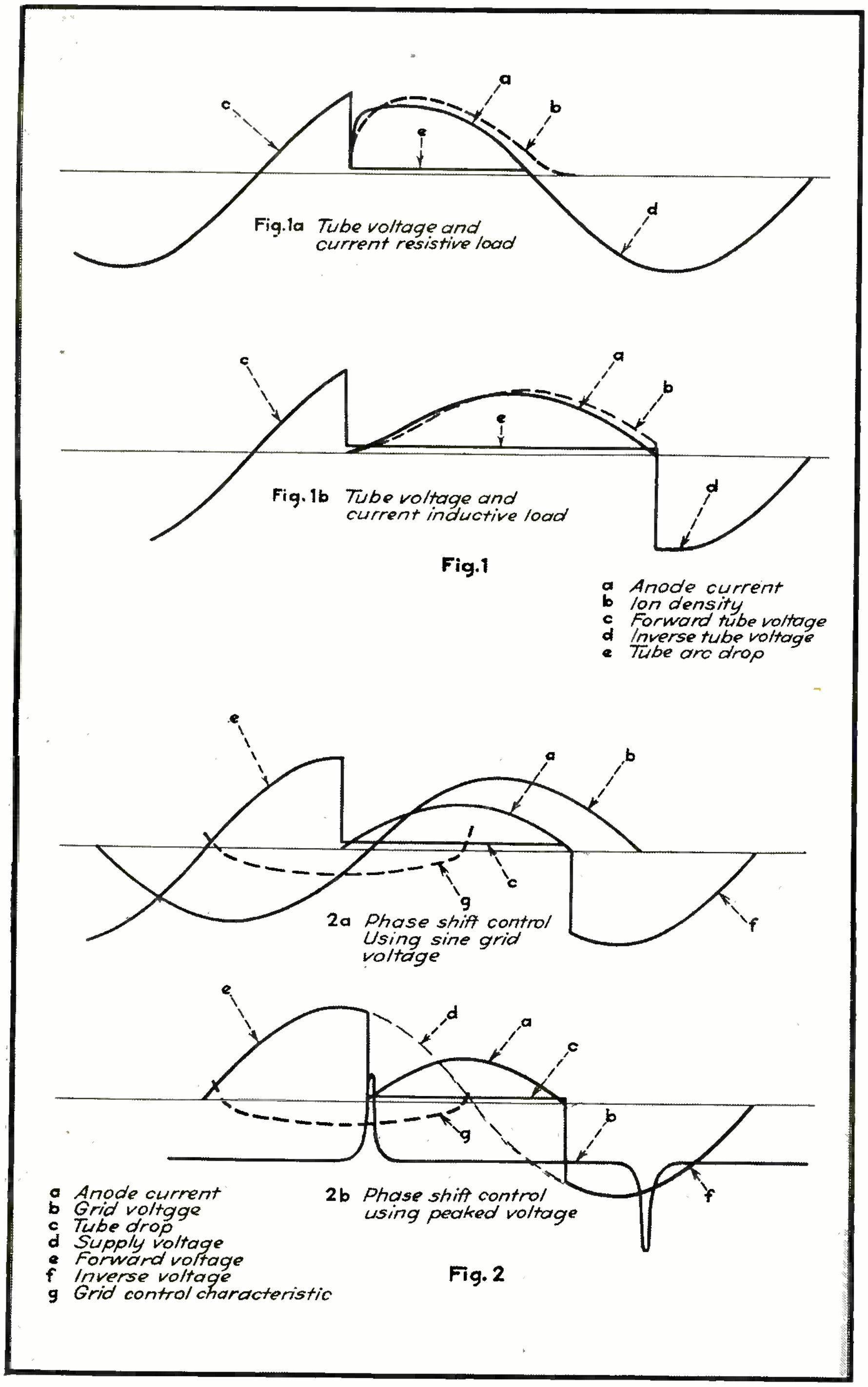
In order more perfectly to balance to zero the current to the condenser, a 3-gang selector switch is provided which on position 4 (as indicated in Fig. 5 below) shorts the condenser and on position 5 connects the microammeter across the condenser. In this position the circuit is balanced by adjusting the variable bias resistor *R*. At positions 1 and 2 of the selector switch the meter is in series with the condenser and at position 3 the meter is shorted out.

The rectifier network of this instrument was adjusted until the frequency with which the condenser discharged was directly proportional to the applied alternating voltage. Linearity was achieved over a range of from 0.5 to 20 volts. The condenser discharges once per second for an input of 5.6 volts rms. At voltages lower than 0.5 the time between discharges is so long that sufficient charge leaks from the condensers to cause a significant amount of non-linearity. But over a range of approximately 40 to 1 the integrator gives a measure which is closely proportional to the area under the curve representing a fluctuating voltage.

The integrator in Fig. 5 has a frequency response which is flat to within 0.5 db from 0 to 15,000 cps. Its input impedance is 3800 ohms at 100 cps, 2700 ohms at 1000 cps and 900 ohms at 10,000 cps. It is fed through a 250-ohm transformer.

Fig. 5—Schematic wiring diagram of the voltage integrator used in biological research





Gaseous

By W. W. WATROUS
and
D. E. MARSHALL

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Bloomfield, N. J.*

A GASEOUS conduction tube is inherently a trouble-free and comparatively rugged device. However, like any other piece of equipment, a certain amount of care must be exercised in its application if satisfactory service and maximum life are anticipated.

This article is written with the knowledge that much of the material may be a repetition of information which has appeared in technical data sheets and engineering texts. It has been concluded, nevertheless, from a large number of cases with which the authors have been concerned, that there is still considerable misunderstanding regarding gaseous tube application. This lack of comprehension, or perhaps the disregard of known facts, has in a number of cases produced unfavorable reaction toward the use of electronic tubes. Furthermore, equipment designers are often as guilty as equipment users in certain instances. It is the purpose of this paper to point out the most important considerations to be observed in the application of gaseous tubes, in the hope that a better understanding may be had of the factors involved in securing long and trouble-free life. Certain examples of short tube life and their most probable causes will be discussed.

Misinterpretation of Rating Information

All tube manufacturers publish data intended to define and limit the various quantities which have importance in determining the amount of power which a given industrial tube will control, and the probable length of trouble-free life which the user can expect.

In general, these ratings are carefully observed. However, the authors have observed cases where the ratings were exceeded with consequent short tube life. This is probably due to lack of suitable measuring instruments for determining the actual duty required of a tube in a given application, or a lack of appreciation of the role which each rating quantity plays in the satisfactory operation of the tube. Several of the most important and some of least well understood ratings will be discussed in the following paragraphs.

Hot Cathode Ratings

By far the largest number of failures found at "end of life" are chargeable directly or indirectly to cathode phenomena. For the most part, these failures are the result of loss of electronic emission. Loss of emission usually occurs after the loss of emissive coating due either to normal evaporation of the active material, or to the more rapid action known as stripping. Emission loss may also occur without loss of coat-

Tubes—and how to treat them

Neglect of the rules for properly operating gaseous conduction tubes is certain to result in unsatisfactory operation, and often to short life. Proper attention to the problems discussed here will prevent unfortunate and disappointing events

ing and such a condition is frequently found after a tube has been overloaded either in current or inverse potential.

The rate at which evaporation (which is usually a normal effect) and stripping (which is abnormal) occur, varies widely with conditions. A cathode which has a life expectancy of several thousand hours may have a life of only a few hundred hours due to improper operating conditions which accelerate the rate at which active cathode material is lost.

While the remainder of the discussion on cathode life is concerned with loss of emission, it should be realized that such emission loss is a very fundamental cause of other types of tube failure. Even in cases where the degree of evaporation or stripping is not sufficient to deplete emission, the secondary effects, due to the deposition of active material on the other tube elements, may be enough to cause a defective tube. Tube failures due to such reasons as arc-back, loss of grid control, and cathode burnouts are at times directly attributable to the primary reason that caused the loss of emissive material.

The underlying causes of rapid stripping, as determined by the examination of field returns over the course of several years, indicate the abuse of certain fundamentals in gaseous conduction tube application. More thorough consideration of these principles on the part of the equipment designer, and user, will result in much more satisfactory tube life.

The question of cathode potential is one of utmost importance. Filament transformers are, almost without exception, designed for the rated cathode potential. However, nominal line voltage varies considerably in various sections of the country, resulting in cathode potential variations which may exceed ± 10 percent.

In certain installations, change from no load to full load conditions may reduce the cathode potential considerably.

Probably, one of the worst sources of trouble is faulty sockets. Either the sockets are not designed for the high currents required, or long use has resulted in loss of spring tension, or corrosion of the contact surfaces. It is surprising to measure the loss of cathode voltage sometimes found either in the socket, or in the associated wiring when relatively high cathode currents are employed.

The purpose of the foregoing discussion is to emphasize the need of insuring that the cathode potential is correct under all conditions of operation. The cathode potential, (which means actual potential on the pins of the tube), should be held to within ± 5 percent of the rated potential to insure maximum life expectancy.

The importance of this close control is understood when it is realized that a reduction of 10 percent in cathode potential may in some instances increase the arc-drop and starting potential 40 percent, and reduce the value at which the cathode sparks* by perhaps 50 percent. Loss of emissive material, either by cathode bombardment resulting from high arc-drop or by sparking is very rapid, and, in extreme cases of under-voltage, may result in tube failure within a very few hours.

Over-voltage, in general, results in enhanced electron emission and might be considered beneficial. However, the increased cathode temperature resulting from the higher voltage, accelerates the rate of evaporation of active cathode material. The result of this is not only reduction in cathode life, but arc-back or loss of grid control caused by the deposition of emissive coating on the anode and grid.

The present form of cathode, used in the majority of hot-cathode gaseous tubes, is designed to operate over a narrow temperature range, and variation of temperature in either direction will materially affect life.

Another cause of reduced cathode life is the application of anode potential before the cathode temperature has reached equilibrium. The effect of such operation is exactly the same as operating the cathode at under-voltage. The only difference is that this condition obtains, perhaps, only a few times per day, whereas under-voltage is continuous. A value for cathode heating time is usually a part of the tube ratings and should be rigidly observed.

Pool Type (Ignitron) Ratings

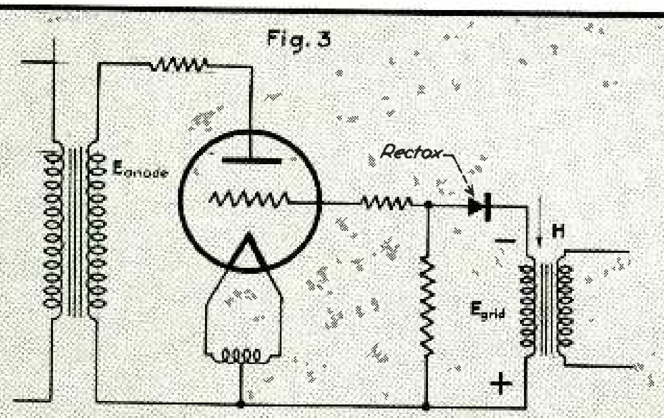
The ignitron is probably the most rugged of all ionic tubes. It has no filament and there are few ways in which the user can misuse the tubes when also using a standard ignitron circuit. These circuits are designed to apply the correct current to the ignitor at the proper time if the equipment is used within the ratings. Departure from the ratings most often occurs in the following ways:

* Sparking is a phenomena obtained in an oxide coating when the emission demand exceeds the capability of the cathode. Electronically, it is the change from distributed thermal emission to an extremely localized arc spot. Physically, it results in the actual mechanical removal of oxide coating from the base metal.

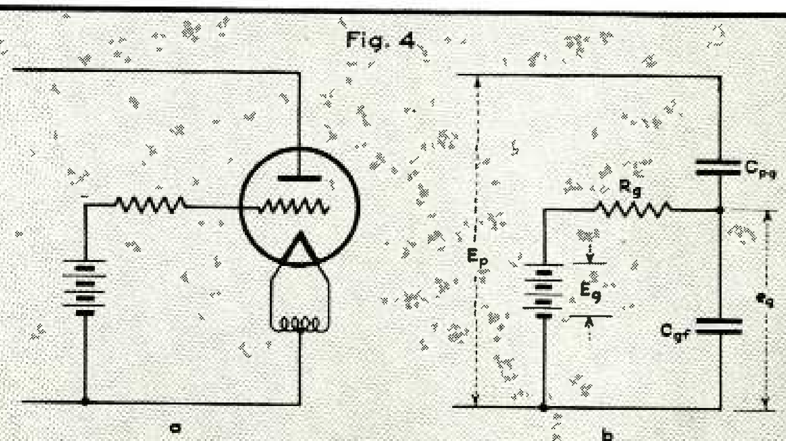
In welding control service, the demand currents drawn by the welder and controlled by the tubes may exceed the rated value. This occurs because often no accurate determination is made of the actual demand current. In many cases a measurement of the demand current can be made by closing the jaws of the welding machine on a copper bar and quickly reading the current with an ammeter, allowing the current to flow only long enough to make the measurement.

The percent duty rating is sometimes exceeded because the original setting of welding time was later found to be inadequate and since the rate of making welds easily increased, the duty required of the tube is increased.

If the demand current of the welding machine is too low, the ignitors may not fire reliably. In nearly all welding control circuits, the ignitors are fired by the load current passing initially through the ignitors. It is possible that if the jaws of the welding machine open before the ignitor circuit is opened, a small exciting current will flow of too low a magnitude to fire the ignitors, but high enough to cause them to overheat with consequent deterioration. Present practice is to connect an auxiliary resistance in parallel with the welder which draws about 25 amps when the welder operates and furnishes enough current to fire the ignitors. On any welder application where the current can fall below 40 amps rms., the auxiliary load must be used.



Thyratron circuit showing the use of a rectox to eliminate positive grid swing



Equivalent grid circuits to explain action of line transients on grid potentials

Peak Inverse Voltage Rating

Inverse voltages which exceed the tube rating, even momentarily, while perhaps not causing destructive arc-backs, may permit inverse current to flow. This inverse current, although low in magnitude, may be accompanied by a high voltage drop. This high drop results in the production of an electron velocity which may be sufficiently high to knock off active cathode material.

Peak Current Rating

Normally, a new tube will stand a certain amount of peak current in excess of the tube rating. The result of such operation, however, if continued, is (1) shortened life and (2) rapid cathode failure. The first effect is caused by an abnormal rate of loss of emissive material due to positive ion bombardment, as the result of the high arc-drop occurring at the high current values. The second effect occurs when the current overload is enough in excess of the rating to cause sparking. The result of the sparking is the mechanical destruction of the emissive material. Continued sparking results in tube failure within a very short time.

Average Current Rating

Exceeding the average current rating of a tube providing the peak current is kept within limits, has little direct effect on cathode life, other than an increase in the rate of emissive material evaporation due to the cathode temperature rise. However, tube heating is directly dependent upon the average current, so that an overload increases dissipation from the anode. The result is an increase in anode temperature which may release gas and ruin the tube. A secondary effect is the resulting increase in grid temperature which promotes loss of grid control.

Operating a tube well within its average rating pays large dividends in life.

Frequency Rating

There is a definite upper limit in supply frequency which can be applied to a tube. The reason for this limitation is that a finite time is required for the products of ionization to disappear, or in other words for the tube to deionize. The higher the frequency, the more the ion density lags behind the current. The result is a reduction in the amount of inverse potential that the tube can withstand. In many cases, the ion density remains high enough due to inverse current to prevent control (in the case of a thyratron or ignitron) in the forward direction. A clearer understanding of this effect may be had by examining (Fig. 1-a).

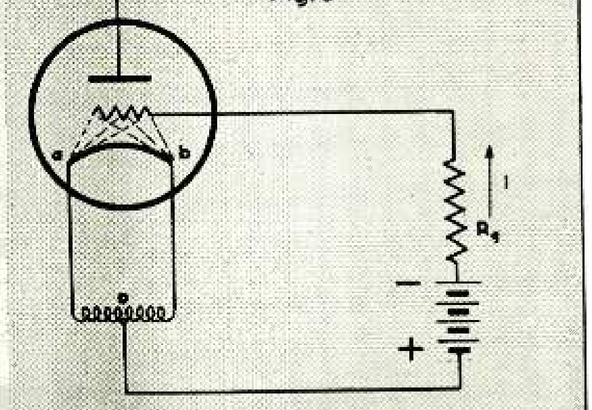
Surge Current Rating

The surge current rating is thought by some to define a sort of super peak current rating. Actually, this rating is intended to be used by the circuit designer as indicated below:

The effective impedance of the power source which supplies the load current should be made high enough to limit the tube current to the surge current rating, in case the load portion of the circuit is short circuited accidentally. The time duration of the short circuit should be limited by protective means, such as fuses or circuit breakers, to a time less than the maximum time specified in the definition of surge current rating given in the tube data sheet. If the short circuiting action is a part of the normal regularly reoccuring action of the circuit, then the tube current should be limited by the maximum peak current rating.

The tube designer considers the surge current rating to define a value of current which will not immediately destroy the tube, but which will materially decrease the safety factor in the tube rating at each occurance.

Fig. 5



Rectifier action of cathode potential

Maximum Averaging Time

The maximum averaging time is a part of the average current rating as it defines the method of calculating the average current. Since the arc-drop of a gas-filled tube is practically independent of the anode current, the loss in the tube becomes a function of the average current flow in the tube. When a tube is used continuously, the average current can be obtained by calculation from the waveform of the current. However, when the tube is used intermittently with very short pulses of current, the average current drawn would be very small if averaged over the entire time between pulses. However, the current of any one pulse could be high enough and last long enough to damage the tube. Therefore, some limit must be placed on the averaging calculation. This is done by limiting the time value by which the current is divided to a definite maximum value. As an example, if a tube were rated 10 amps average at a maximum averaging time of 30 sec., the maximum average current the tube could conduct within the ratings during a one minute interval would be 10 amps. If the pulse duration were 15 sec., the maximum averaging current during the 15 sec. could be 20 amps, since the actual conduction time is less than the maximum averaging time. As the actual conduction time decreases, the maximum average current during the pulse increases until the peak anode current rating is reached. The value of the maximum averaging time depends on the heat capacity of the tube parts.

Maximum Temperature Ratings

An effect often overlooked by the tube user is the extremely rapid increase in mercury vapor pressure with temperature. The importance of this physical law results in the necessity of operating mercury tubes within a limited range of temperature.

Operating a tube above the high temperature end of the published range, may cause high inverse currents, loss of control, or arc-backs. Below the lower temperature limit, the vapor pressure is so reduced that there may be an insufficient number of mercury ions to carry the required current. The result is high arc-drop, and, in some instances, surging. These effects are both very injurious to the cathode. The importance of proper temperature control cannot be stressed too highly.

It should be borne in mind that cathode heating time and tube heating time are not the same. Tube heating time depends on transformer regulation, ambient temperature, method of enclosure, the other widely variable factors. In all cases, the tube heating time should be sufficient to allow the condensed mercury temperature to come within the published range before anode potential is impressed on the tube.

Many tubes, such as ignitron tubes, depend on water-cooling to make possible their high rating. It is often found that troubles in the field occuring with these tubes are caused by failure of the water-cooling. The water flow ratings are given in terms of maximum outlet temperature, and minimum flow in gallons per minute. Both of these ratings are important. The temperature provision is usually well observed, but the importance of water velocity is not always appreciated. The function of water-cooling to keep the temperature of the tube wall and thereby the vapor pressure inside the tube below a given value. The tube wall will assume a temperature higher than that of the water in the jacket, since the energy is moving from the wall to the water. This temperature difference is a function of the velocity with which the water sweeps past the cooling surface. Under conditions of low input water temperature or low load on the tube, it is easily possible to reach a condition wherein the outlet temperature is below the rated maximum and yet have the velocity so low that parts of the tube are operating at too high a temperature.

Another difficulty sometimes encountered occurs where several tubes are operating with their water-cooling jackets in parallel. If the water rate is allowed to decrease, there is great danger that the water flow is not dividing in correct proportion and that the flow in one tube may fall dangerously low. In cases where the water temperature is low enough, the tube water jackets should preferably be operated in series, thus insuring equal flow in all tubes.

Many protective water flow relays have been tried in this service. Many of them actually caused tube failure due to stoppage of water flow caused by silt or scale lodging in the orifices in such a manner that the relay contacts remained closed. Annoying interruptions to service were caused by fluctuations in water flow operating the relay due to its lack of time delay features.

The type relay now recommended for this service is a thermal device, a part of which is heated electrically, and which is cooled by the water flow. A bi-metal thermal relay is actuated by the temperature of the heated part of the relay. It is thus responsive to water temperature and water flow. Time delay action occurs because of the heat capacity of the parts. Since hydraulic pressure plays no part in the action of the switch, no constrictions are necessary and therefore clogging of the switch is kept to a minimum.

Deposits forming on the tube walls can cause loss of efficient cooling and consequent loss of tube life. A good practice is to flush water jackets at regular intervals as determined by the amount of solid material in the water. If the water is re-circulated, it may be advisable to include a commercial rust inhibitor.

Measurement of Rated Operating Conditions

The best method of becoming absolutely sure of most tube operating conditions is by the use of an oscilloscope. Economically, such measurements where values of potential and current are in doubt, are more than justifiable.

Measurements of average current should be made only on instruments using the D'Arsonval principle. Many cases have been found where a so called a-c or d-c instrument has been used. The error resulting can be very large especially with waveforms departing from sine waves.

Condensed mercury temperature measurements are difficult to obtain precisely. However, a measurement, accurate enough for practical purposes, can be secured by attaching one or more thermometers to the glass envelope, by the use of putty or similar material. The exact location of the point of measurement is usually specified in the tube data information. In cases where this point is not shown the measurement should be taken on the glass immediately above the cathode base.

Influence of Circuit Constants on Arc Back Probability

Often errors are made in the original selection of a tube by choosing one not designed for the type service the user has in mind. The reason for this lies in the inability of the ratings to completely define the capabilities of the tube.

Industrial tubes are rated in terms of the maximum inverse and forward voltage and the peak and average current. That these quantities are not fundamental can be seen by considering the function the tube performs through a cycle of its operation. A gas-filled controlled rectifier prevents current from flowing as the anode potential increases from a negative value with respect to the cathode to a more positive value until a point is reached where, at the will of the user, the retarding potential of the grid is released, or an ignitor is fired. As the current flows, the anode-cathode space is completely filled with ionized atoms of the gas with which the tube is filled. As the current nears zero in the cycle, a value is reached at which the rate of production of ions becomes less than the rate of loss, and the tube ceases to conduct in the forward direction. However, there are still a great many ions remaining in the space, thus leaving it partially ionized and in a state that may initiate a current through the tube in the reverse direction. These ions diffuse out of the space at a rate determined by a number of factors, among which are the geometrical configuration of the inner parts of the tube, the ion temperature, the vapor or gas density, etc. The effect is, that the ion density lags the current in the tube by an appreciable angle.

If as shown in Fig. 1-a, the circuit is such that the current and line voltage approach zero together, then the presence of the ions is not serious as the inverse voltage is low during the deionization period. However, if the circuit contains sufficient inductance as in Fig. 1-b the current will continue to flow for a time in opposition to the line voltage. When it finally reaches zero, the current conduction is expected to cease for the remainder of the half cycle even though now the inverse voltage is almost at the peak of the line voltage and the tube is well ionized. Thus, there is an increase in the probability that arc-back will occur and that the current will reverse and flow backwards through the load circuit. In the two cases cited, the peak inverse voltage could easily have same values, but the duty imposed on the tubes is by no means equivalent.

Arc-backs do not always occur when the tube is deionizing, but may occur at other times in the reverse voltage cycle. There is no definitely known explanation for arc-back, and probably no one cause. The explanation which seems most plausible for the arc-back at times other than deionization is that all times incipient arc-backs may occur, which have a very short time duration. These current reversals seldom reach sufficient magnitude to be noticeable, except with the most delicate instruments, and they usually cease to exist before a stable reverse arc can be built up. This concept may appear plausible if we postulate a mechanism. This may be one variation of the well known patch theory. According to this theory, particles of material appear on the anode originating in a variety of ways; such as, sputtered anode material, flakes of cathode coating, mercury scum, etc. These particles are charged by the positive ion currents and very strong fields may appear on the anode surface which cause the phenomena mentioned above.

The role of the circuit comes into the picture as follows: When the incipient arc-back occurs, the reverse current increases at a rate determined by the external circuit. The cause or the patch is destroyed by the discharge. If the current builds up to a stable value before the patch is destroyed, a power arc follows and a real arc-back occurs. According to this theory, the probability of a tube arcing back increases as the rate of change of current the connected circuit can supply to an incipient arc-back increases. Another way to prevent an incipient arc-back from developing to a stable arc is to limit the current which the circuit can supply to a value below which most arc-back causes will develop into true arc-backs.

This theory furnishes an explanation for a number of phenomena observed by tube and tube circuit designers, as enumerated below:

1. The stiffness of the circuit has an effect on the arc-back rate. By stiffness is meant the degree of maintenance of voltage when a load current is drawn. The better the regulation of a rectifier, the more difficult the duty imposed on the tubes.

2. A live load has more effect on the arc-back rate than a dead load. A live load is one which has the ability to store energy and feed it back through the tube when an incipient arc-back occurs. Connected electromechanical loads of high inertia, electrical condensers, or chemical cells may serve as examples of live loads, while inductance which tends to keep the load current from reversing, or resistance which has no stored energy are dead loads.

(*Continued on page* 110)

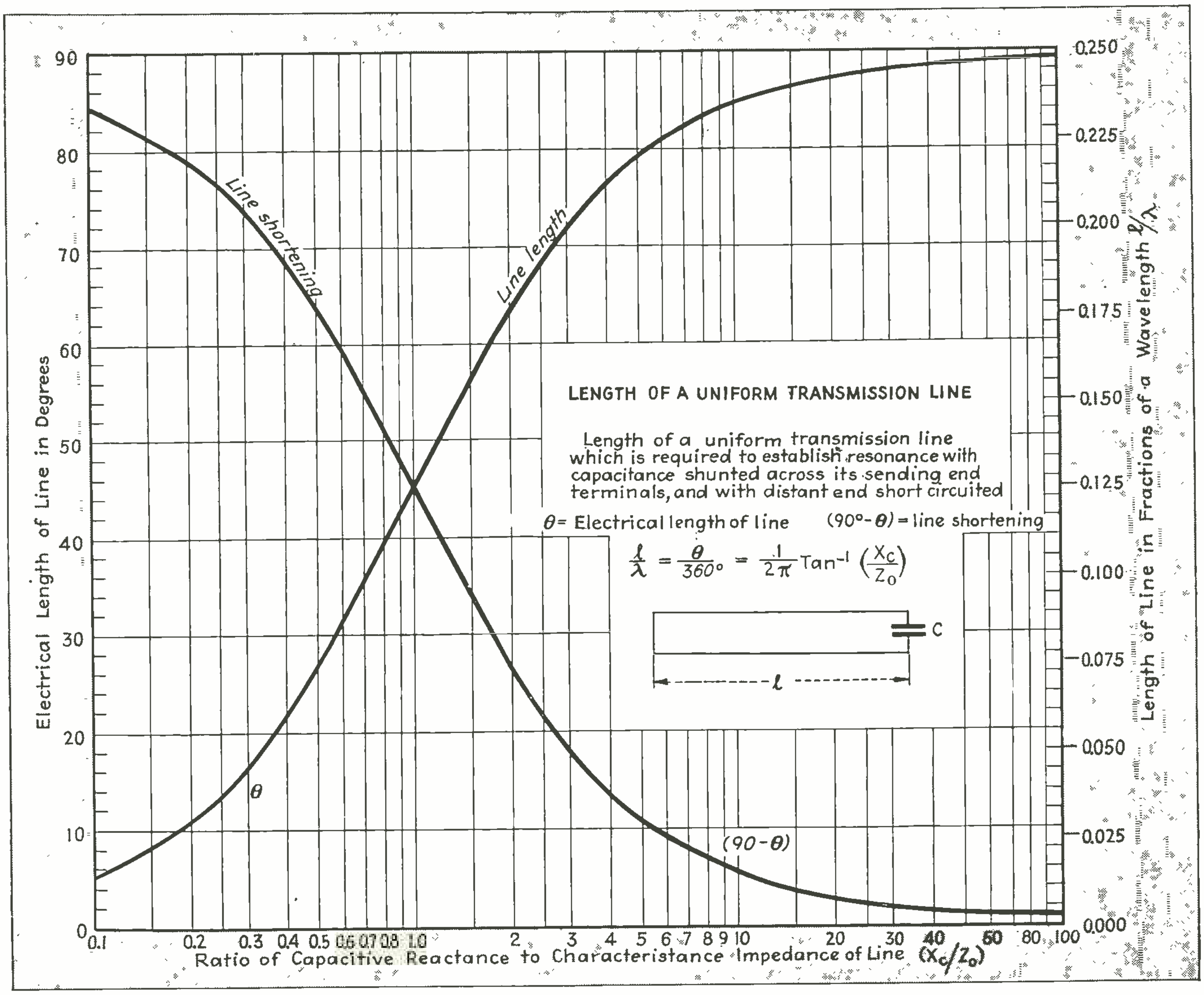
GRAPHS FOR TRANSMISSION LINES

The two graphs making up this Reference Sheet give the characteristic impedance of parallel wire or coaxial cylinder lines, together with the length of the line in electrical degrees or in fractions of a wavelength for capacitance shunted across sending end terminals and distant end short circuited

BY BERNARD SALZBERG
Washington, D. C.

THE two graphs of this Reference Sheet provide a quick and simple means of calculating: (1) the length of a uniform transmission line required to establish resonance with the far end short-circuited and a capacitance connected across the sending end, (2) the amount of shortening of the line as a result of using the condenser, for the same conditions of operation as above, (3) the characteristic impedance of a uniform transmission line of parallel wires, and (4) the characteristic impedance of a uniform transmission line of coaxial cylinders. The charts are easy to use, for it is merely necessary to determine the value of the quantity for the horizontal axis or abscissa and then read off the required value from the vertical scale or ordinate at the

Graph for determining the characteristic impedance of a uniform transmission line of either the parallel wire or coaxial cylinder type



point where the appropriate curve correlates the two coordinate axes.

For the graph giving the length of the transmission line, the horizontal coordinates are given in terms of the ratio of the capacitive reactance of the condenser C to the characteristic impedance of the transmission line. This capacitive reactance in ohms is given by the equation, $X_c = 1/C2\pi fC$, where f is the frequency in cycles per second, and C is the capacitance in farads. The electrical length of the line required to produce resonance may be determined in terms of the electrical length of the line in degrees from the left-hand ordinates, or in terms of fractions of a wavelength from the right-hand ordinates. The degree of line shortening as a result of using the condenser C, is also obtainable in terms of the length in electrical degrees or in terms of fractions of a wavelength.

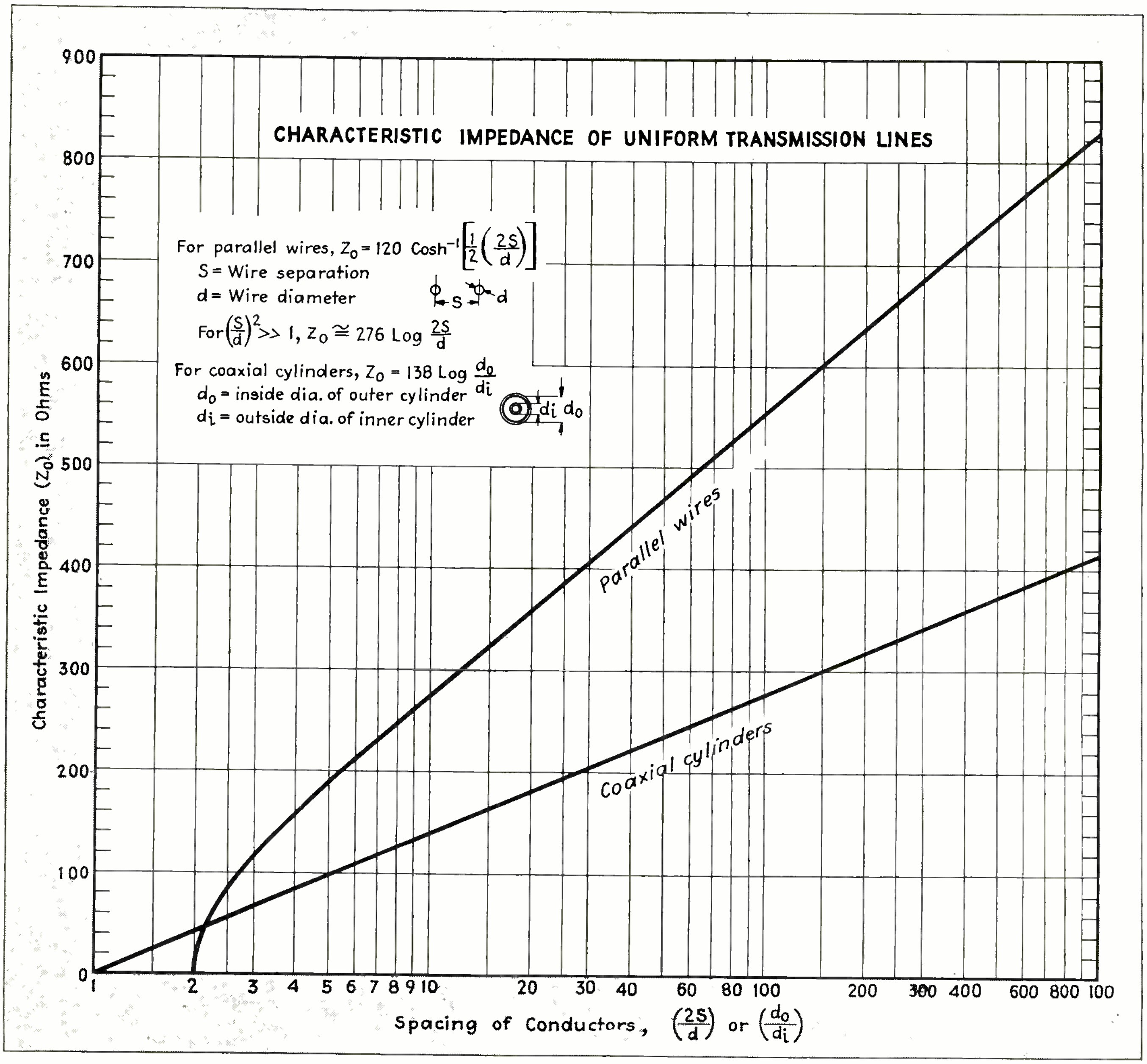
The second graph relates the characteristic impedance of a uniform transmission line with the dimensions of either a coaxial or a parallel wire line. The abscissa is given in terms of the ratio of spacing of the two conductors of the line, whereas the ordinates are given in terms of the characteristic impedance of the line in ohms.

Example

As an example of the use of the graphs, assume we have a coaxial, uniform transmission line whose inner conductor is ¼-in. in outside diameter, while the inner diameter of the outer conductor is 1 inch. The ratio, d_o/d_i is consequently 4, and we find the characteristic impedance to be 83 ohms. If this cable is used at 1,000 kc (10^6 cps) and a capacitance of 1,000 $\mu\mu$f ($10^{-9}f$) is used at the sending end of the line, the capacitive reactance is $X_c = 1/(6.2832 \times 10^6 \times 10^{-9}) = 1{,}000/6.2832 = 159$ ohms, and the ratio of the capacitive reactance to the line impedance is $X_c/Z_o = 159/83 = 1.92$. From the curve showing the length of the transmission line we find the required length of the line to be 62 degrees or 0.172 of a wavelength.

In this particular case the length of the line, in feet, may be obtained very simply. Assuming the rate of propagation along the line at the speed of light, the required length in meters is 300x0.172=51.6 meters or approximately 170 feet. Therefore a coaxial line of the dimensions given, across one end of which is a capacity of 1000 $\mu\mu$f must be 170 feet long to resonant at 1000 kc.

Graph for the determination of the length of a uniform transmission line which is required to establish resonance under the conditions stated on the chart. Line length is plotted as function of ratio of capacitative reactance to characteristic impedance of the line



TUBES AT WORK

A portable field intensity recorder, electronic apparatus on exhibiton at the Chemical Exposition, a phototube width gage, and nail detector are discussed

New Field Intensity Recorder

By H. W. Kline

General Engineering Laboratory
General Electric Co.

Continuous recordings of the intensities of radiated fields from radio transmitting stations operating on frequencies of 26 to 155 Mc are possible with the portable field intensity recorder recently developed in the General Engineering Laboratory of the General Electric Co.

This instrument can be used for recording the tapering of field intensity as a function of radial distance from a transmitter. It can be operated in a motor car or at a fixed point for recording field intensities of the various classes of transmission, such as frequency modulation, television, communication, or special service.

A photograph of the main unit is shown in Fig. 1. The overall dimensions of this unit are: 12¾ inches in height, 31½ inches in width, and 10⅜ inches in depth. It is furnished with an accessory case containing a long and a short adjustable dipole antenna, a fixture common to both antennas for mounting them to a masthead, 30 feet of shielded transmission line of new, low-loss design, a flexible cable for driving the recorder directly from the speedometer of a car, and minor accessories.

The total weight of the accessory case, loaded, is 17 pounds. The total weight of the equipment, ready to operate independently in the field, is 69 pounds.

Novel features incorporated into the design of the main unit include: (1) simple calibration, (2) the use of new, low-drain battery tubes, (3) the internal inclusion of the battery power supply, (4) the internal inclusion of a recorder, and (5) means for driving the recorder chart and marker from the speedometer of a car, thus gearing the chart to the road.

Only two external connections to the unit are necessary. This is especially helpful in mobile installations, where space is limited. The connections are those of the transmission line, which connects to a socket in the front panel, and the flexible shaft which connects to the right hand side of the case. The present converter unit can be interchanged with one extending the frequency range when desired.

Optional accessories can be obtained for driving the chart of the recorder at fixed-point installation. This is explained in greater detail later in this article.

Requirements of the Federal Communications commission specify that broadcasters of f-m and television programs obtain a knowledge of the distribution of field from their stations. This is done in order to register the extent of the service area of a given station, and to govern future allocations for these types of services in a given territory. These findings must be submitted to the FCC within one year after a station goes on the air.

The broadcaster is usually required to determine the pattern of distributed fields at two levels—one millivolt per meter and 50 microvolts per meter for the f-m band. These signal levels are required when receiving on a dipole antenna 50 feet above the ground.

To plot the contours of these levels, it is necessary to make field intensity surveys on eight different radii from the station. It is extremely difficult to obtain the correct position for a level unless this data is recorded.

The problem becomes more involved in that the FCC requires that a point on a contour shall be plotted as representative of the mileage to the end of a segment of length representing 10 percent of the radial distance from a transmitter. The field intensity in this segment must be that of the specified level, or greater, for 50 percent of the distance within the segment.

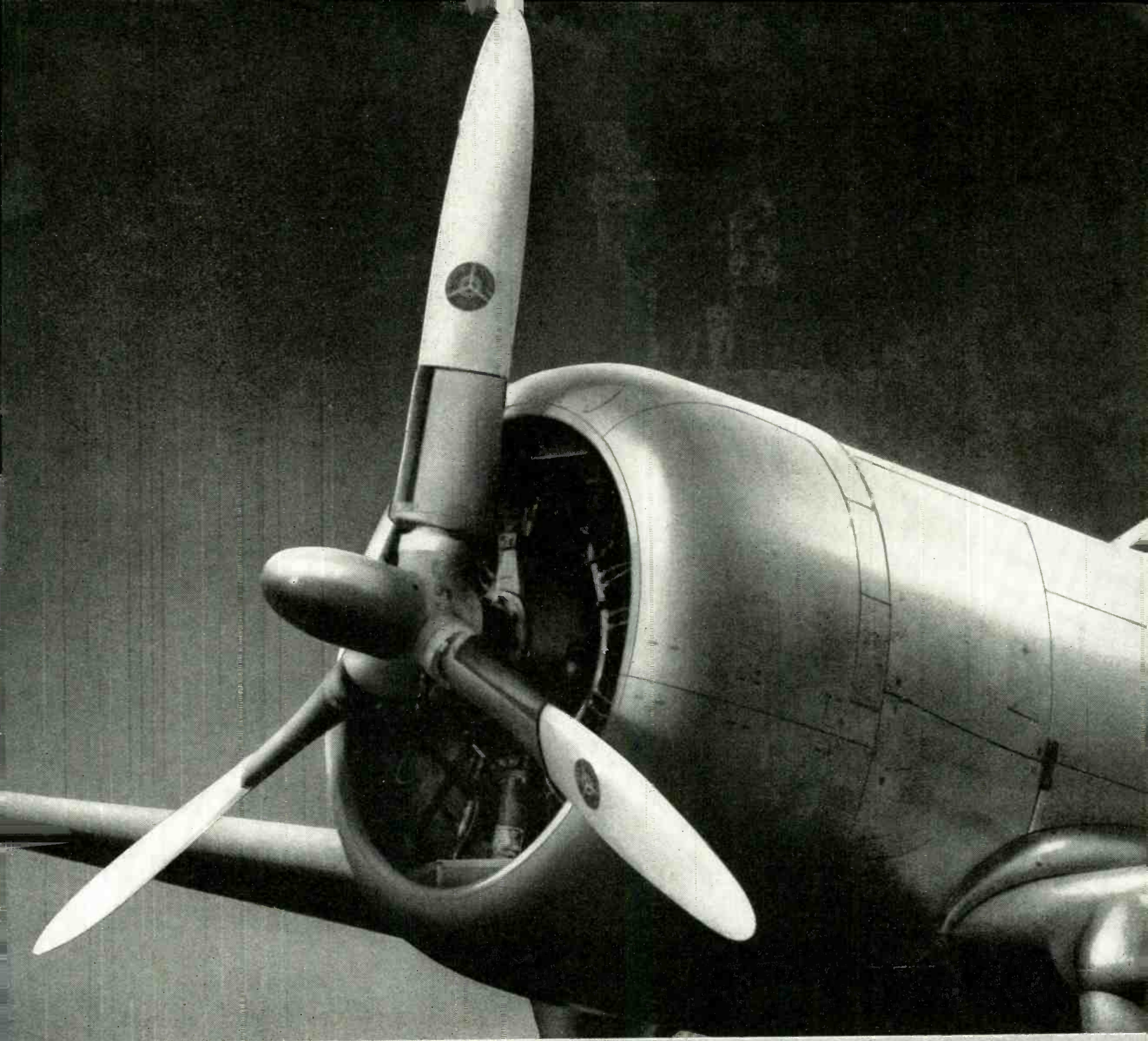
On the record chart the correct value of amplitude is drawn, representing the field intensity level specified. This correct value of amplitude is also drawn at a position on the chart where the recorded amplitudes are at (or exceed) the specified level for 50 percent of the mileage represented by the segment line. The air-line distance from the station to the end of the segment is the distance plotted for a point on a contour of specified field intensity.

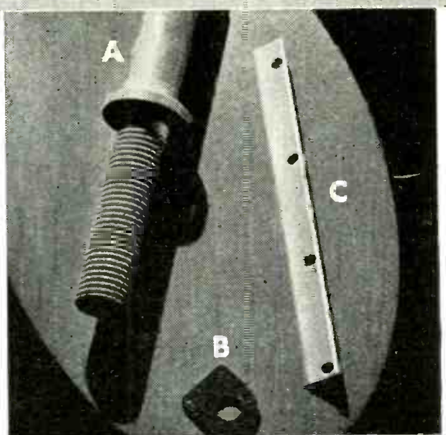
This field intensity recorder is particularly adapted to obtaining this information. The main unit can be installed on a small bench in front of an operator sitting in the rear seat of the average motor car. All controls are facing the operator. Means for supporting the dipole antenna at the rear of the car can be installed at the option of the user. The mast is usually high enough to elevate the dipole 10 feet above ground level.

In recording the intensities of the radiated field from W2XOY, radii were first determined as nearly straight as possible on roads from the transmitting station. One of these radii was traveled to a point sufficiently beyond the level of 50 microvolts per meter to substantiate its location. The equipment was then turned on and allowed to record continually, the intensity fluctuating with distance, due to localized reflections and other effects. Because of such fluctuations it was found desirable to hold the car speed between 20 and 25 miles per hour. This allows the recorder sufficient time to record the rise and fall of these peaks.

Another field in which this instrument is applicable is that of determining the effective radiation from different types of transmitting antennas. Relative data can be obtained under actual operating conditions which will result in improved designs of radiators and higher radiation efficiencies for transmitting antennas. The recorder can also be used to determine the extent of fading and other characteristics on these frequencies, as well as for locating the proper site of a receiving antenna for optimum reception from a given transmitter.

Fig. 1—The field intensity recorder is shown installed in an automobile. The recording mechanism is at the far right





A
B
C

Incorporated into this equipment is a specially designed superheterodyne receiver having features desirable for this class of service. The converter and calibrating oscillator were designed as an interchangeable unit capable of being changed to another converter unit to expand the frequency range if desirable. The various sections of the main units are shown in Fig. 2.

The total frequency range of this equipment, from 26 to 155 Mc is obtained continuously by switching the calibrating oscillator and converter to three separate bands. Band A covers a range of from 25 to 50 Mc, band B a range of from 50 to 85 Mc, and band C a range of from 85 to 155 Mc.

Both the calibrating oscillator and the heterodyne oscillator employ an acorn type 958 triode. Special types of tank circuits, for use with these tubes, were developed for bands B and C, enabling wide band operation. The circuits of the oscillators are similar; the heterodyne oscillator operates five megacycles lower than the signal frequency. This feature requires tracking compensation at one point only—in the grid input circuits of the converter.

The converter tube is a type 1R5. Its function is to pass only the difference frequency of five megacycles by virtue of the beating of the heterodyne frequency with the signal frequency at its input. The converter component of five megacycles in the output circuit of this tube is delivered to the first intermediate frequency transformer. The secondary of this transformer is connected to a fixed capacitor attenuator.

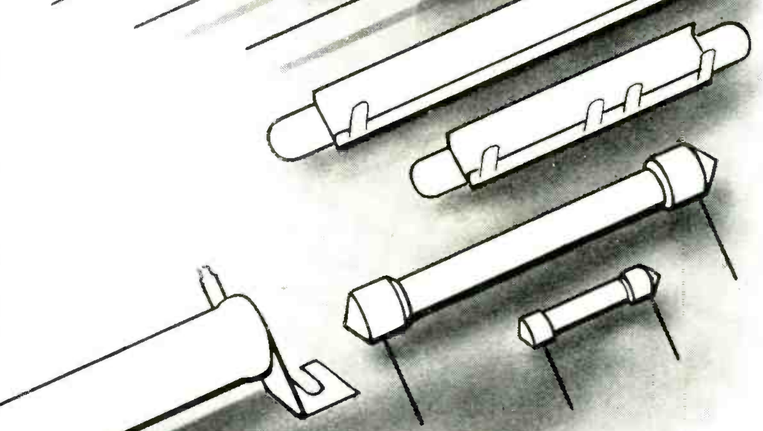
The output of this attenuator can be adjusted to 1, $\frac{1}{5}$, 1/20, 1/100, 1/500, 1/2000, or 1/10,000 of its input voltage. Its accuracy is high for this type of equipment. The maximum error encountered on any tap was plus or minus 3.5 percent.

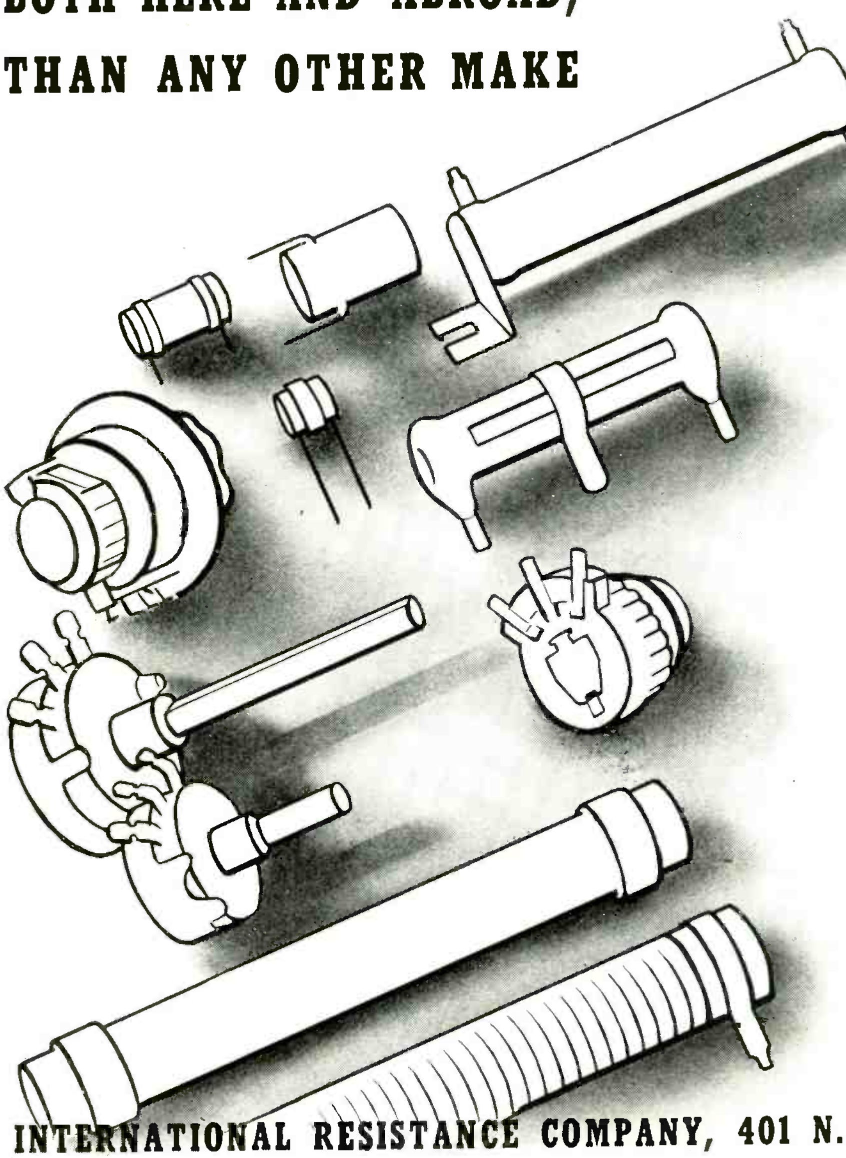
The output of the attenuator is connected to the input of a 4-stage, intermediate frequency amplifier. This amplifier is designed for maximum stability and minimum regeneration. Four type 1T4 tubes are used. The gain is controlled by varying the negative d-c bias on the grids of the first three tubes. The 88-kc band pass of this amplifier allows a deviation from its mean resonant frequency of 5 Mc to a frequency plus or minus 44 kc.

The output of the i-f amplifier is applied to the diode elements of a type 1S5 diode pentode tube. This is the final tube in the line-up. This tube rectifies the intermediate frequency voltage to a direct-current bias which is applied to its pentode grid. If there is audio frequency modulation, this component is also applied to the pentode grid simultaneously with the d-c bias. The pentode half of the tube functions as a d-c and audio frequency amplifier. In measuring the field intensities of f-m stations, it was found that modulation had a negligible effect on the results.

The negative bias voltage from the diode when applied to the grid of the pentode causes a reduction in the plate

MORE IRC RESISTORS ARE USED IN DEFENSE EQUIPMENT, BOTH HERE AND ABROAD, THAN ANY OTHER MAKE





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current of the pentode. A visual meter, recorder, and audio frequency impedance are connected in series and form the plate load of the pentode. The two instruments are operated by the change in plate current. They are first set, under no-signal conditions, to read zero by putting a bucking current through them.

When a reduction in plate current is effected, the compensating current causes an effect equivalent to increasing the current through the instruments, making them read up-scale proportional to the applied grid bias. The deflection of the recorder needle is the same as that of the visual meter. A telephone jack is connected across the audio frequency impedance so that the modulation can be monitored with ordinary headphones.

Before recording, the gain of the intermediate frequency amplifier is preset by applying a known voltage at signal frequency from the calibrating oscillator, with the attenuator on a specified tap, and with the transmission line disconnected in case the signal level is high enough to interfere.

The signal to be measured is intercepted on the horizontal dipole antenna, which is adjusted to a length commensurate with the signal wavelength. The transmission line is connected to the dipole at points of low impedance. The receiver end of the line terminates in the low of the convertor unit's input circuit or at the same point at which the calibrating voltage from the calibrating oscillator is applied.

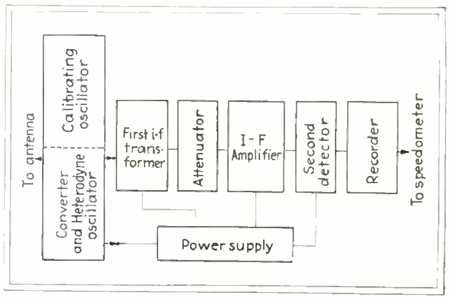


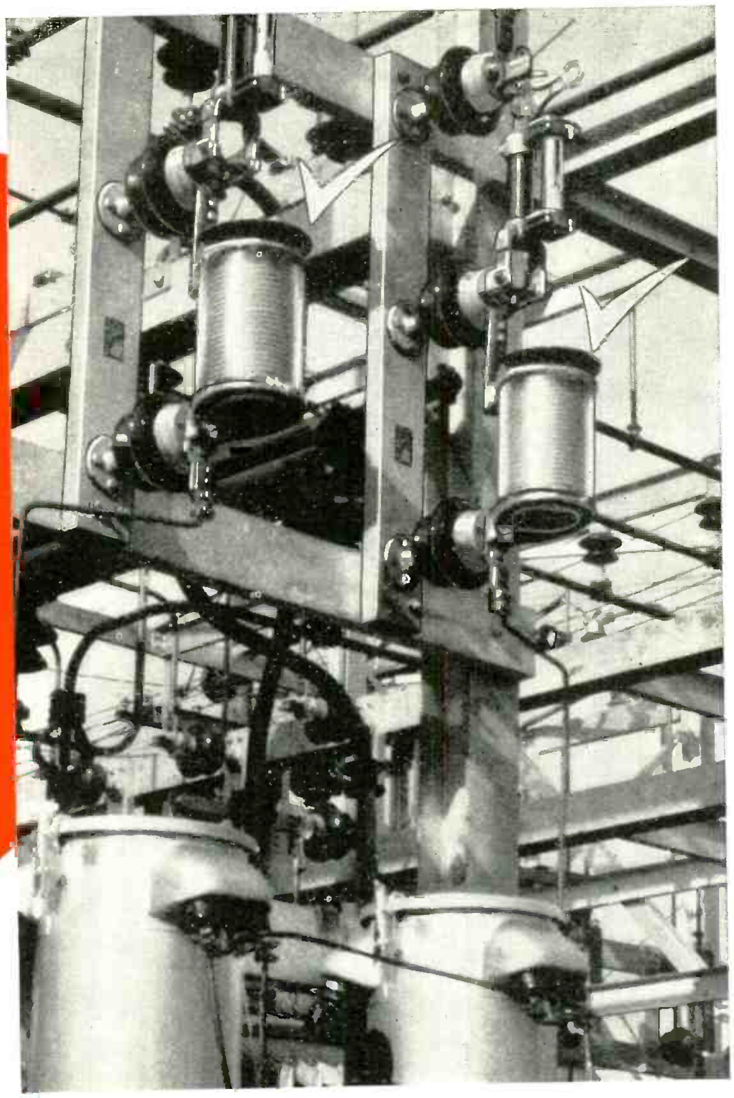
Fig. 2—Block diagram of the portable field intensity recorder

The fundamental calibration of this complete unit was made in the field by coordinating deflections obtained with fields of known intensities over its signal frequency range. The signal amplitude capabilities, given for the extreme frequencies are 15 to 600,000 microvolts per meter at 26 Mc, and 125 to 3,000,000 microvolts per meter at 155 Mc. The minimum amplitudes give instrument deflections of 20 percent of full scale with an attenuator amplitude pass of 1.0.

Frequency-modulated stations are identified, orally, by slight signal detuning so that deviation of the signal is linear over the i-f band pass characteristic. Recordings are made on peak tuning, however, where modulation has negligible effect on the results.

A modified G-E inkless recorder, type CF2, is used for recordings. The

LAVA IN POWER STATION INSTALLATIONS



NOWHERE is dependable service of greater importance than in power station equipment. Failure of a single component may cause interruptions over wide areas.

Certain larger sizes of the well-known current-limiting resistors made by Schweitzer and Conrad, Inc., have cores made of Lava for supporting the resistance wire. This insulating material, which has proved its value for over fifty years, has been chosen in this modern equipment because no other insulating material provides the necessary heat-resisting qualities required in the special units for high-capacity applications.

Lava combines this valuable property with high electrical resistance at room and elevated temperatures.

The manufacturing cost of Lava is reasonable, both in small and production quantities.

Mechanical and electrical properties of Lava are well defined and engineering data will be gladly sent on request.

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modifications consist of the addition of a gear train for driving the chart and marker at rates found by experience to be best for this class of service.

This recorder imprints a record on its chart by action of a cam-driven hammer which strikes the deflecting needle of the movement. By this action, the needle is pressed against the back of the chart. A typewritter ribbon runs across the face of the chart so that each time the needle is struck, a dot is impressed on the chart.

The shaft driving the chart and hammer extends through the right hand side of the case together with a gear shift knob. The end of the shaft is fitted with a universal key allowing drive either by Telechron motor or speedometer.

For mobile measurements, the recorder is mechanically driven by the car speedometer. Fittings are furnished with the flexible coupling shaft to enable connecting it in series with the speedometer without interfering with the normal speedometer action. With this drive, the chart speed is 1 inch per mile and the marking rate is 240 dots per mile.

For fixed point recordings, the chart can be driven by a 1 rps Telechron motor at a rate of 2 dots per second.

Power Supply

The battery complement for this equipment consists of a 1.5-volt dry cell, a 4.5-volt bias battery, and 3 medium-sized, 45-volt plate batteries. Access to the compartment holding the batteries is obtained by removing the back of the main unit.

Initial amplitude calibrations of the field intensity recorder involve errors not exceeding plus or minus 10 percent of true levels.

Repetitive surveys on a given radius showed that the 1 millivolt and 50 microvolt per meter levels could be ascertained with an error of considerably less than plus or minus 5 percent in true distances.

• • •

Electronics at the Chemical Exposition

EVIDENCE THAT ELECTRONIC METHODS are being used to a large degree for industrial purposes was seen at the 18th Exposition of the Chemical Industries held in New York during the week of December 1. Electronic equipment was exhibited by at least 14 different companies and ranged from the familiar rectifier sets to new devices which record the voltage-current curve of a solution under certain conditions by which an analysis of the solution can be made. By little more than casually examining the exhibits and looking for electronic equipment, your editors were impressed with the growth of electronics in chemistry since the last chemical exposition held in New York two years ago.

(*Continued on page 58*)

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Mercury vapor rectifiers were shown by General Electric Co., Westinghouse Electric & Manufacturing Co., and Allis-Chalmers Manufacturing Co. These rectifiers are intended for use in power systems for electric arc welding, manufacture of aluminum, and for all kinds of d-c machinery. It was stated at the GE exhibit that mercury vapor rectifiers having a total capacity of 674,422 kw. had been sold to the chemical industry alone by General Electric. This is an impressive figure by itself and if the totals for the other rectifier manufacturers and for other industries are added to it we have a rough idea of the importance of rectification to American industry.

Selenium rectifiers manufactured by International Telephone & Radio Manufacturing Corp., were exhibited by Fansteel Metallurgical Corp., Chicago. These rectifiers can be arranged in single-phase or multiphase circuits to provide half-wave or full-wave rectification. They find use as the d-c power source in a wide variety of applications including battery chargers, arc welding, burglar alarms, carbon arc lamps, counting and grading machines, electrical precipitation, electroplating, railway signalling, and therapeutic equipment.

Another rapidly growing field is the electrostatic separation of dry powdered materials having different electrical susceptibilities. The electrodes are supplied with very high d-c voltages, of the order of 15,000 volts, either by electronic rectifiers or by motor-generator sets. Exhibitors of electrostatic separators were Sutton, Steele & Steele, Inc. of Dallas, Ritter Products Corp. of Rochester, and Separations Engineering Corp. of New York. A partial list of separations possible by this method are as follows:

1. Sphalerite (zinc blend of the rosin type) and barite from iron and copper pyrites.
2. Graphite from mica.
3. Biotite micas from the muscovites.
4. Garnet from iron pyrites and metal particles.
5. Silica from fluorspar.
6. Purification of barium spar from iron and other minerals.
7. Zircon from rutile.
8. Steel grindings from abrasive grains.

Commercial capacities of the order of 5,000 pounds per hour on materials finer than 60 mesh are being obtained.

A number of different instruments depending upon the change in frequency of an oscillator were shown by the Wheelco Instrument Co., of Chicago. The essential feature of the oscillator is a pair of coils between which a vane passes when it is desired to make some change in the process. A typical illustration is a meter or a gage with a light metal vane attached to the pointer and with the oscillator coils placed at some desired point which may or may not be adjustable. When the value measured by the instrument reaches a critical value, the pointer moves across the scale and the

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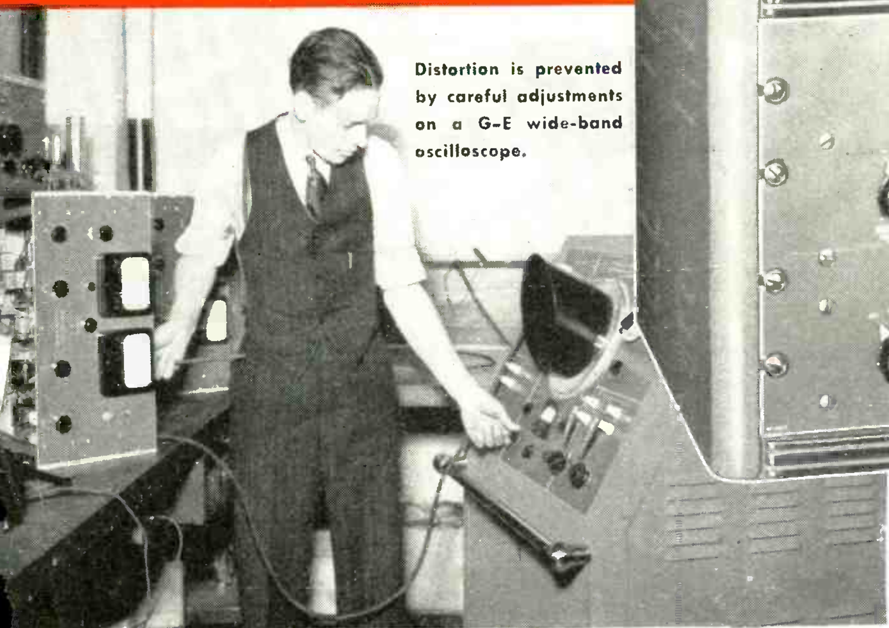
with this G-E *multi-purpose*★ unit



Distortion is prevented by careful adjustments on a G-E wide-band oscilloscope.

Some of the FM Pioneers Who Have Already Bought G-E Monitors

John L. Booth Broadcasting Co., Detroit, Mich.
Capitol Broadcasting Co., Inc., Schenectady, N. Y.
Columbia Broadcasting System, New York, N. Y., and Chicago, Ill. (Five units; three of these for "S-T" service)
Don Lee Broadcasting System, Los Angeles, Cal.
FM Radio Broadcasting Co., Inc., New York, N. Y.
General Electric Co., Schenectady, N. Y. (Three units; one of these for "S-T" service, and one for television sound)
Gordon Gray, Winston-Salem, N. C.
The Journal Co., Milwaukee, Wis.
Johan Lagercrantz, Stockholm, Sweden
Royal Miller, Sacramento, Cal.
Midland Broadcasting Co., Kansas City, Mo.
Moody Bible Institute, Chicago
News Syndicate Co., New York
Radio Engineering Laboratories, Long Island City, N. Y.
San Diego City Schools, San Diego, Cal.
Standard Broadcasting Co., Los Angeles, Cal. (Two units; one of these for "S-T" service)
University of Illinois, Urbana, Ill.
Walker-Downing Radio Corporation, Pittsburgh, Pa.
WFIL Broadcasting Corporation, Philadelphia, Pa.
WGN, Inc., Chicago, Ill.
Yankee Network, Paxton, Mass., and Mt. Washington, N. H.

Approved by the F.C.C.

With this new monitor, General Electric has removed one more hurdle from your path to FM. You will find this self-contained, multi-purpose★ instrument one of the most valuable units in your FM station. It provides:

- ★ **Direct reading of center-frequency deviation (with or without modulation)†**
- ★ **Direct reading of modulation percentage†**
- ★ **Instant calibration against a precision crystal standard**
- ★ **Adjustable modulation-limit flasher†**
- ★ **High fidelity output for audio monitor†**

All tubes and crystal units can be reached easily through the top of the cabinet. Removing chassis assembly from cabinet allows complete access to all panels and wiring.

In FM, more precise measuring techniques are a necessity. This instrument is custom-built for your requirements. Order your monitor now through the nearest G-E office, or direct from General Electric, Radio and Television Dept., Schenectady, New York.

†Provision has been made for remote console operation.

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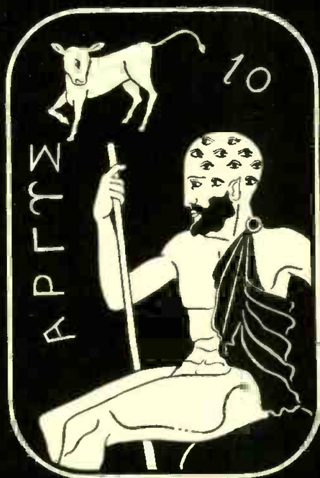
vane passes between the coils thereby changing the frequency of the oscillator. This causes the plate current to change by a sufficient degree to permit the operation of a relay. This principle has been applied to a large number of processes and Wheelco has developed several types of controller heads for various applications. An immersion head, which operates the oscillator circuit when a liquid rises and immerses it, consists of two metallic plates of a condenser. When the liquid passes between them the dielectric constant is changed. This changes the capacitance of the circuit which in turn changes the frequency of the oscillator. A controller head for attachment to the exterior of a glass liquid level guage is also used.

A photoelectrically controlled scale was shown by the Kron Scale Co. of Bridgeport, Conn. A phototube is located behind a window in the pound scale with a lamp directly in front of it. As the load is placed on the platform of the scale the pointer rotates and when it reaches the desired point where the phototube is located, the pointer covers the window, shutting off the light to the phototube.

Two titrimeters using electronic amplification were demonstrated by Eimer and Amend, New York and Fisher Scientific Co., Pittsburgh. End points of chemical reactions are characterized by changes in the conductivity of the solution. Therefore, the end point of a titration can be indicated by a change in the flow of current through the solution upon the application of a known voltage. The Junior titrimeter uses d-c amplification to increase the current to deflect a fairly rugged milliameter. The Senior model also uses d-c amplification, but with a cathode-ray indicator tube of the 6E5, 6G5, etc. series as the indicator for the end of titration. Once these instruments have been standardized and a titration curve set up, routine titrations can be conducted very rapidly. The Junior titrimiter is applicable to oxidation-reduction, acid-base, and precipitation titrations, but not for titrations requiring a glass electrode system. The Senior model can be used, in addition to those titrations mentioned above, for pH work, d-c resistance and voltage measurements, and conductivity titrations. An electrophotometer for use in colorimetric analyses was also demonstrated by these companies. This instrument uses two phototubes to compensate changes in line voltage. It can be standardized very quickly and readings can be made in a few seconds.

An electrophotometer for colorimetric analysis of solutions was also shown by the Fisher Scientific Co. In this instrument a light beam is passed through a standard solution in a standard container to maintain the same distance through the solutions and through a solution of unknown concentration. By the difference of light absorption of the standard and unknown solutions, the degree of concentration can be determined. Where a large num-

(Continued on page 64)



New Books

Theory of Gaseous Conduction and Electronics

By Frederick A. Maxfield, *U. S. Naval Ordnance Laboratory and* R. Ralph Benedict, *Assistant Professor of Electrical Engineering at the University of Wisconsin. 483 pages. Illustrated. Price $4.50. McGraw-Hill Book Co.*

Gaseous Conductors—Theory and Engineering Application

By James Dillon Cobine, *Assistant Professor of Electrical Engineering, Harvard University. 606 pages. Illustrated. Price $5.50. McGraw-Hill Book Co.*

The two books enumerated above, and released by the publisher at approximately the same time are sufficiently closely allied to one another that they will be treated in a single review. Indeed, the scope and general treatment of both books is quite similar and there are chapters in each covering electron emission, arc discharge, kinetic theory of gases, ionization of gas and glow discharges. Both books are intended for the upper class or graduate student in electrical engineering and physics, both bridge the gap between the better known physics text on kinetic theory of gases and the engineering texts on the theory and application of electron tubes, and the point of view and general method of treatment is similar in both cases. Of course, as might be expected from authors working independently, there are certain subjects treated in one of these which are not treated in the other.

In the case of both books, the emphasis has been placed upon the underlying principles involved rather than upon current engineering practice. For this reason both should provide a sound basic training for the physics or electrical engineering student for a number of years to come and should be affected little, if at all, by changes in engineering practice.

The engineering student making his first acquaintance with electronics and the theory of gases may be somewhat disturbed to find a rather considerable section of each of these texts is devoted to the kinetic theory of gases, to the motion of charged particles in a vacuum or gas, to a discussion of the electrostatic field, and to the mechanism of ionization and deionization which subjects are adequately covered in both texts. Nevertheless, such information will be invaluable to him in providing a basic understanding for the conduction of electric current through gases. The chapters on electron emission treat the subject in the usual way common to engineering texts and discuss thermionic, field, and photoelectric emission. The chapter in the book by Maxfield and Benedict is much more complete on this subject and provides a general introduction to some of the more elementary considerations in two, three and other multi-electrode tubes. On the other hand, the text by Cobine is much more complete with regard to material on the rectification of current by vacuum and gaseous discharge tubes. In fact, the chapter on rectifier circuit theory contains about as complete an analysis as has so far appeared in American textbooks.

While it is to be regretted that two books on essentially the same subject have appeared almost simultaneously, either one will provide an excellent text for reference work for those who are fundamentally interested in the conduction of electricity through gases from the point of view of the physical operation involved rather than from the point of view of applying the principles in engineering practice. The rather considerable amount of material on such subjects as the deionizing processes, sparking potential and corona discharge, glow discharge, the arc discharge, space charge, plasma, and gas discharge light sources will be particularly useful as reference material to communication engineers whose previous experience and training has been largely confined to a study of the theory and application of vacuum tubes but who feel the need for becoming more familiar with the whole field of electronics.

This reviewer believes that those instructors having need for a text on gaseous conduction would find either of these recent books well suited to their purpose.—B.D.

Storage Batteries

By George Wood Vinal, *Sc.D., National Bureau of Standards. John Wiley & Sons, Inc., New York. Third Edition. 1940, 450 pages. Price $5.00.*

"A general treatise on the physics and chemistry of secondary batteries and their engineering applications." This is exactly what this book is. Under materials and methods of manufacture the reader will find the history of the lead-acid battery, chemistry and construction of pasted plates, data on separators for lead-acid cells, containers and types of cells. Then follows a description of the Edison cell. A chapter on the electrolyte discusses the properties of sulphuric acid solutions, measuring the solution, the effect of impurities in the electrolyte, and properties of alkaline electrolytes. A chapter deals with the theory of reactions, energy transformations and voltage—which is the theoretical section of the book.

Other chapters deal with methods of rating capacity, methods of operating and charging batteries, testing batteries, present day applications, etc. —K.H.

Photo Relays: Their Theory and Application

By F. H. Shepard, Jr. *Printed by Manville Press, Inc., New York City. 28 pages, illustrated. Price 25 cents.*

Though a comprehensive and detailed treatment of this subject is beyond the scope of this booklet, it covers the field in an interesting manner. The language is non-mathematical and easy to understand. The topics treated are photoelectric phenomena, amplifiers, glow discharge tubes, light sources, and applications. The booklet might well serve as an introduction to the photoelectric field for those engineers who may be a little rusty on their knowledge of this rapidly expanding branch of electronics.—E.E.G.

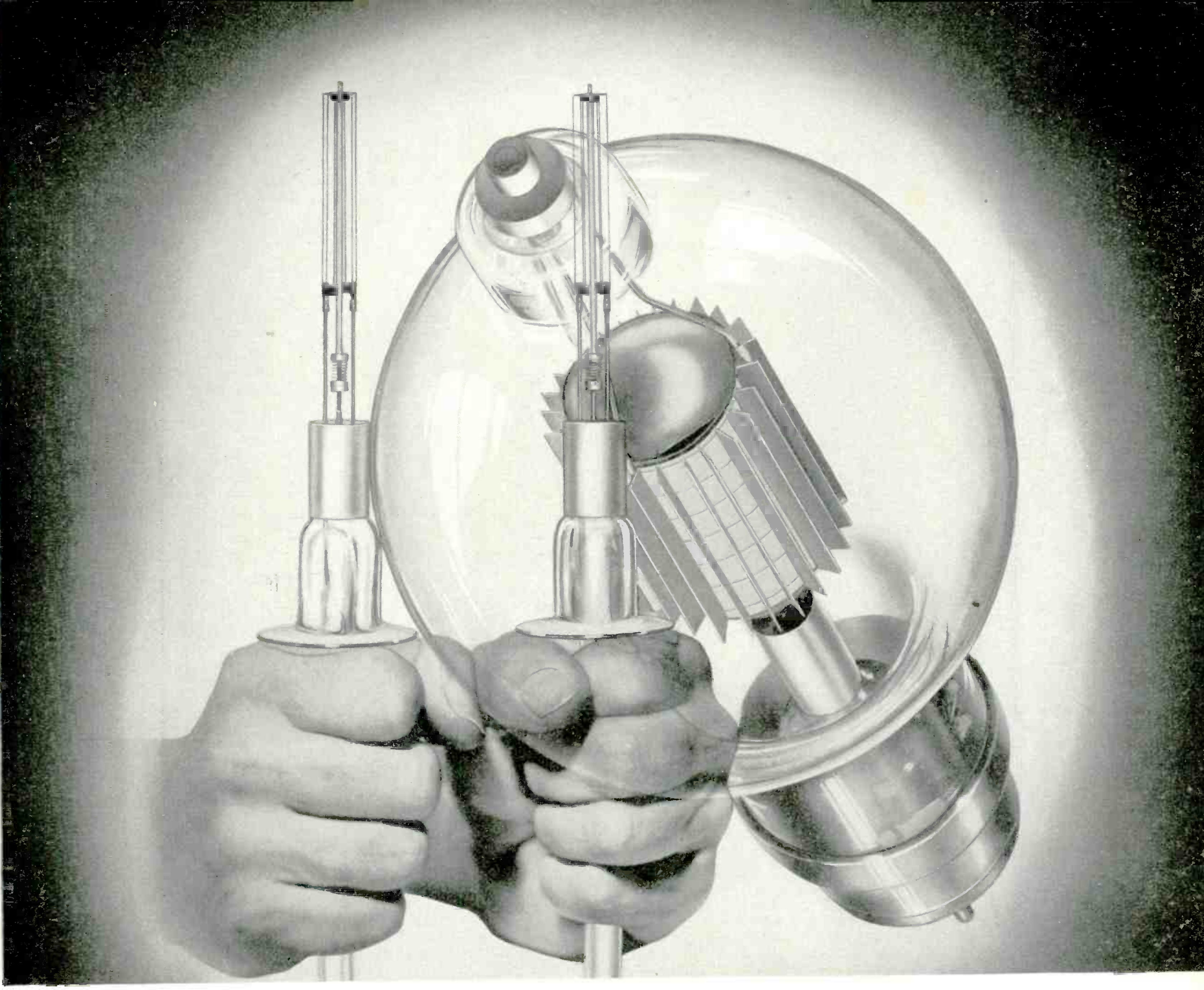
It's About Time

By Paul M. Chamberlain, *Richard R. Smith, New York, 1941, 490 pages. Price $7.50.*

"It's About Time" is all about timepieces, written by a structural engineer with a hobby of collecting old watches. As a book for the expert on watches and other timekeepers, this book is a beauty; and for anyone whose hobby is watches, it is a "must."

The book is divided into three broad sections, the first devoted to escapement mechanisms, the most complex and vital part of any time-telling apparatus. The history of the escapement as it developed into modern practice is written in such a manner than anyone not necessarily interested in time pieces, can find both pleasure and information by the reading thereof. The second part deals with experimental and unusual time pieces —such as those ingenious instruments which strike the hours, or tell the time of sunset or sunrise—the development of watch regulators, etc. Finally a section on famous watchmakers closes the volume.

Throughout, the book is most interestingly written, and most adequately and beautifully illustrated.—K.H.



(*Continued from page* 60)
ber of determinations are to be made a calibration curve made with known concentrations of solution will speed up the operation by an appreciable amount. A voltage regulated power supply is used to assure constant reading in spite of varying line voltages.

The American Instrument Co. of Silver Spring, Md. exhibited a Polarometric Analyzer for the analysis of solutions by the use of a dropping mercury cathode. A pool of mercury lies at the bottom of a glass container and acts as the anode of the system. Immediately above it is the solution to be analyzed in which is immersed the dropping mercury electrode which acts as the cathode. A direct voltage is applied between the anode and cathode as shown in the diagram. As droplets

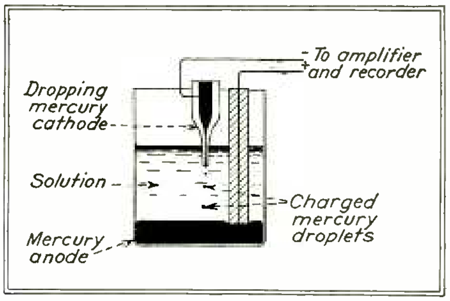


Diagram showing the principle of operation of the dropping mercury cathode

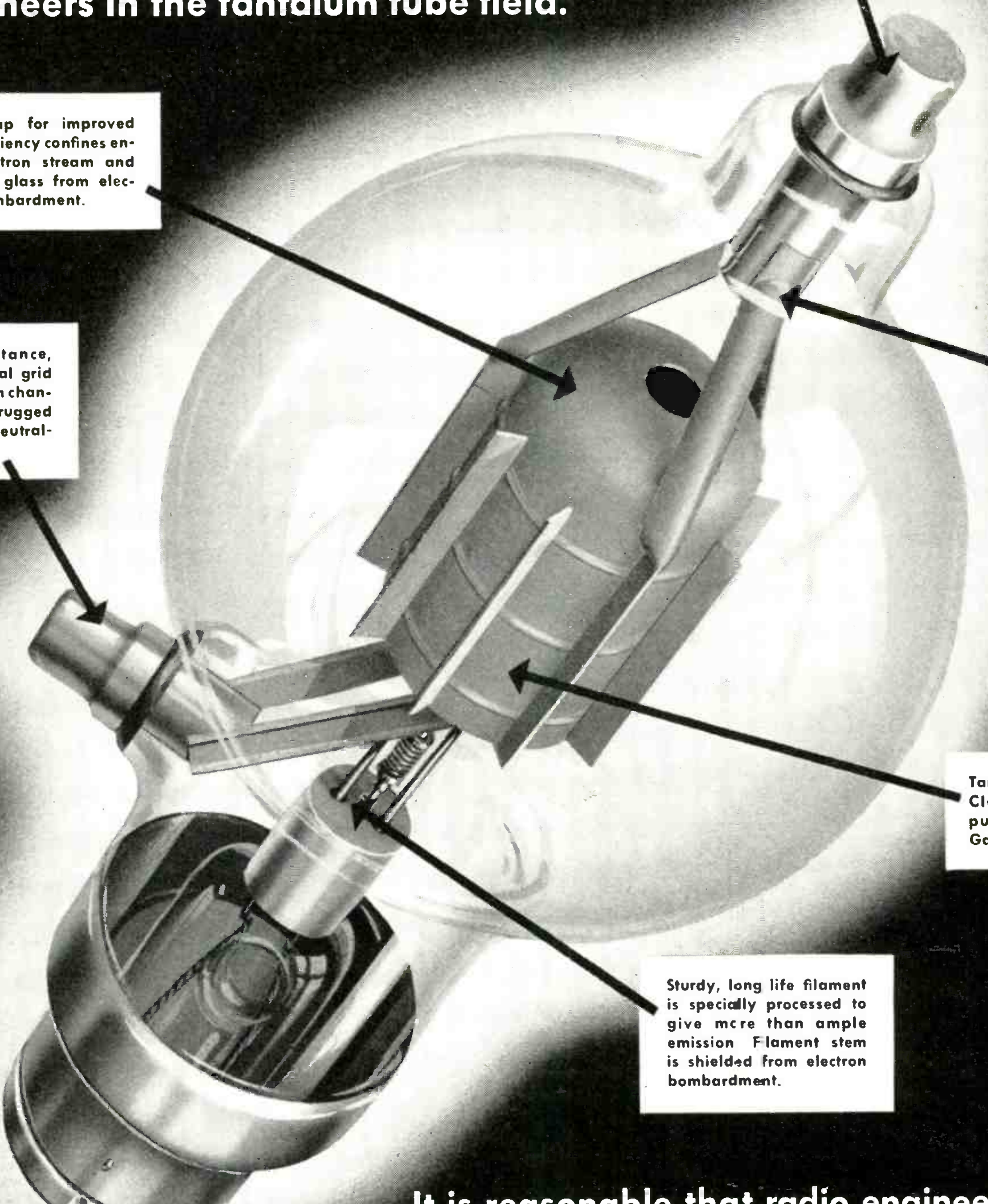
of mercury drop from the cathode they are negatively charged. The degree of charge is a function of the voltage applied to the electrodes. Positive ions of various elements are attracted to the mercury droplets as the applied voltage is increased. This changes the amount of current flowing through the system. By noting the variations of current through the solution as the voltage is increased and by referring to previously prepared data or calibration curves, the elements contained in the solution can be determined. The current is amplified by a vacuum tube amplifier and applied to a mechanical recorder which produces a voltage-current curve. Two magic eye tubes are also used for indication of null points of bridge circuits during calibration of the instrument.

The measurement of hydrogen-ion concentration (pH value), an indication of acidity or alkalinity of solutions, can be made with pH meters shown by Coleman Electric Co. of Maywood, Ill. and National Technical Laboratories of South Pasadena, Calif. Spectrophotometers for determining the light absorption characteristics of solutions were also shown by these companies. A light beam from an incandescent lamp is passed through a prism which can be rotated so that any portion of the resultant spectrum can be made to pass through a narrow slit and then through the solution to a phototube. Thus, the absorption at any portion of the spectrum can be measured.

The Wheatstone bridge has been applied to several instruments shown by Industrial Instruments of Jersey City, N. J., for the measurement of con-

YEAR after YEAR

Gammatron tubes have set the pace. Note the "Firsts"... by the pioneers in the tantalum tube field.



It is reasonable that radio engineers think first of Gammatrons when new designs are considered. Because, they know that selecting Gammatrons assures the maximum UHF efficiency, protection against failure through overload and extra long life. Write for data.

GAMMATRONS of course!

HEINTZ & KAUFMAN LTD., SOUTH SAN FRANCISCO, CALIFORNIA, U. S. A.

ductivity of solutions and the resistance of various types of insulation. The concentration of solutions and impurities in solutions can be determined by the use of the Solu Bridge which uses a cathode-ray tube of the magic eye type as the null point indicator. This instrument measures the conductivity of a solution and by the use of previously obtained data with standard solutions, any impurities can be detected and the concentration of any electrolytic solution can be determined. The Megabridge insulation tester, also using a Wheatstone bridge with a magic eye null point indicator, for the measurement of resistances from 100,000 ohms to 100,000 megohms was exhibited by this company. Also shown was a bridge for laboratory use for the measurement of resistance over the range from 0.2 to 250,000 ohms measured resistance and 0.2 ohms to 2½ megohms specific resistance with an accuracy of one percent.

Equipment for the measurement of vitamin concentration was demonstrated by Photovolt Corp. of New York. Under proper excitation by light from a mercury vapor lamp, vitamin A in solution will fluoresce. Advantage is taken of this phenomenon by using a barrier-layer photocell to measure the intensity of the fluorescence under known conditions for the determination of the concentration of vitamin A. It is also known that vitamin B will absorb light in the 328 millimicron region (ultra-violet) to a greater degree than at other wavelengths. Therefore an argon lamp, rich in ultraviolet light, is used to pass a light beam through the vitamin B solution to a phototube (type 929). By the degree of absorption the concentration can be determined. A photoelectric colorimeter was also shown by this company for the determination of the characteristics of solutions.

• • •

Photoelectric Width Gage

By E. H. Alexander

Industrial Engineering Department, General Electric Co.

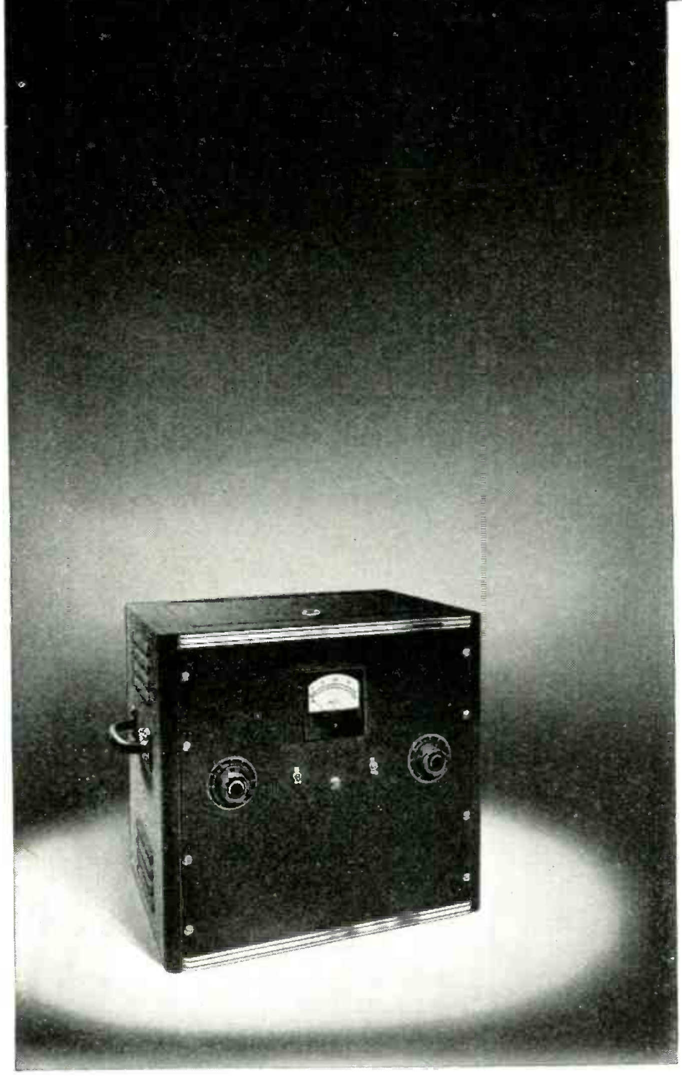
As another example of the increasing use of electron tubes for industrial purposes, mention may be made of a recently developed instrument for measuring the width of flat strips or webbing during production, with the possibility of controlling the manufacturing operations in accordance with the desired strip width.

The half-tone illustration, Fig. 1, shows the general appearance of the photoelectric width gage, which is normally divided into a left-hand and a right-hand phototube unit, and a width indicating instrument. The diagram of Fig. 2 will illustrate the principle of operation, even though only one-half of the gage is indicated.

The strip of material is made to pass between two detector units, one at each edge of the strip. Each of these detector units has a standard light source, lens system, and mirror for

PRESENTING—

the SECO *automatic* VOLTAGE REGULATOR



THE MODERN A-C LINE VOLTAGE CONTROL

This improved type regulator consists of a thyratron tube circuit controlling a motor-driven variable voltage transformer. It maintains a constant output vol-age with variations in input voltage or load current.

- CORRECTS FOR WIDE RANGE OF INPUT VOLTAGES —standard 115 volt units, for example, correct for input voltage variations of plus and minus 17.5% of output voltage.
- HIGH EFFICIENCY—has the high efficiency characteristic of the variable voltage auto-transformer.
- NO INTERNAL MECHANICAL ADJUSTMENTS — does not use a contact-making voltmeter—no critical relay adjustments.
- OUTPUT VOLTAGE AND SENSITIVITY ADJUSTABLE over a wide range by means of knobs on front panel.
- NEGLIGIBLE WAVE-FORM DISTORTION — low exciting current.
- LOW COST PER KVA.
- QUICK RESPONSE—time for full range travel is six seconds.
- OPERATION NOT AFFECTED BY LOAD POWER FACTOR.

APPLICATIONS

Maintains correct constant voltage for—

- Electronic Equipment
- Manufacturing Equipment
- Electrical Testing
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Available for 115, 230, or 440-volt circuits in capacities up to 75 KVA—single or three phase.

SUPERIOR ELECTRIC CO.

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producing a beam of light which is projected from above to the edge of the strip, where it is partially interrupted. The portion of the beam which is not interrupted is focused by a lens system onto a photoelectric tube located below the strip, and this light-sensitive device allows a flow of electric current proportional to the amount of light falling on it. Because the mirror of the optical system is mounted on the movable element of a D'Arsonval type movement, rotation of the instrument element causes the beam of light, which is projected from the source to the mirror, to sweep angularly in a plane vertical to the plane of the material, and at right angles to its direction of travel. Thus, the movement of the galvanometer mirror is capable of projecting a beam of light on the edge of the material, even though its side register should shift within allowable limits.

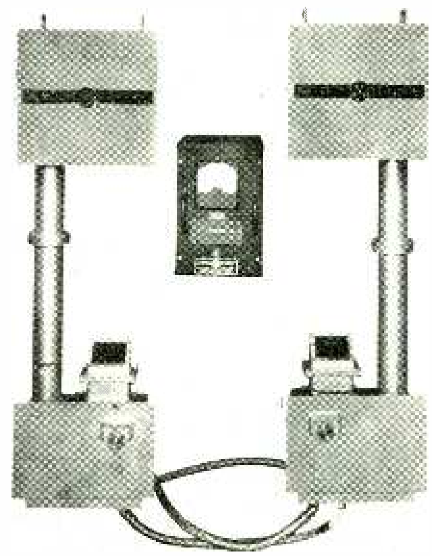


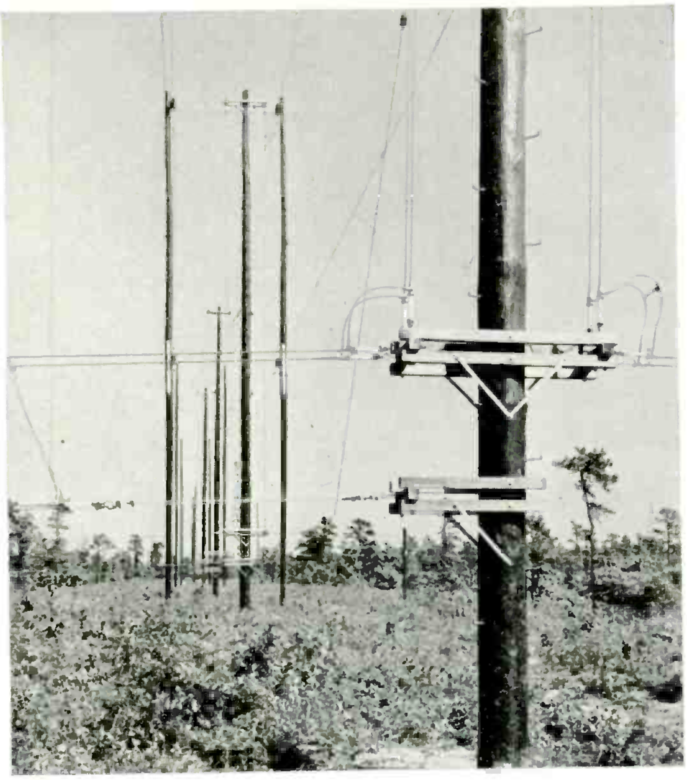
Fig. 1—Right-hand and left-hand units of the photoelectric width gage

The amount of light falling on the phototube determines the amount of current flowing in the instrument carrying the mirror on its rotor. The amplifier is so designed that an increase in light striking the phototube reduces the current in the instrument. Under this condition, the rotor of the instrument turns the mirror toward the edge of the strip (counterclockwise for the left-hand instrument, facing the direction of strip travel, Fig. 2). By adjusting the sensitivity of the amplifier, a condition is obtained where the galvanometer current rotates the mirror to a position which allows just enough light to reach the phototube to cause the amplifier output current to balance the torque imposed by the hair-spring of the galvanometer.

This condition of equilibrium can be produced at any position of the edge within the limits of side register, with different values of instrument current. In fact, stated conversely, different values of instrument current

INSULATION HIGHLIGHTS

PROGRESSIVE ENGINEERING characterizes the design of Columbia Broadcasting System's new 50 KW shortwave stations, WCBX and WCRC, at Brentwood, L. I., soon to be placed in operation. Facilities of the stations are planned for efficient shortwave transmission of programs to Latin America and Europe. Because of present-day conditions, improved reception in these parts of the world of programs from the United States is considered essential.



(*Above*) 13 DIRECTIONAL ANTENNAS are provided at the new stations, and several of them are of the four-section type shown here. Isolantite* strain insulators are extensively used in the construction of these antennas. These insulators find wide application in the radio and communications fields, because of their high mechanical strength and electrical efficiency.

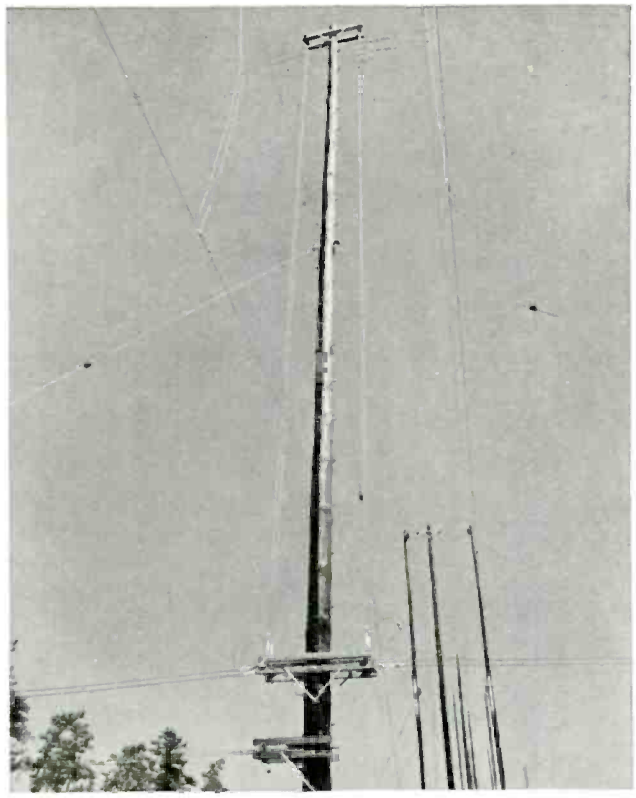
*Registered trade-name for the products of Isolantite Inc.

ISOLANTITE

CERAMIC INSULATORS

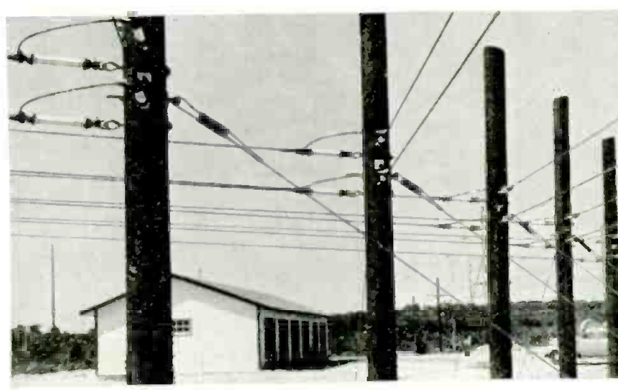
ISOLANTITE INC. FACTORY: BELLEVILLE, NEW JERSEY

SALES OFFICE: 233 BROADWAY, NEW YORK, N. Y.

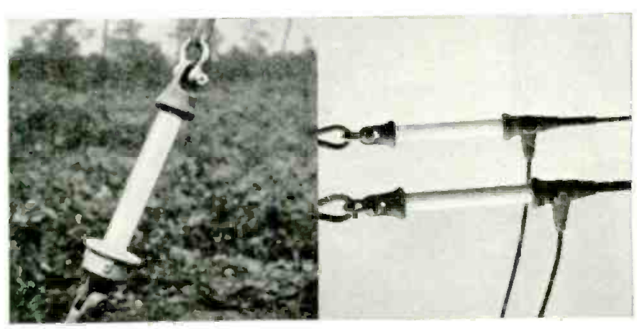


(*Above*) CONSTRUCTION DETAILS of the antennas are shown here. Horizontal wires at left near base of pole provide means for tuning the antennas through the medium of variable line shunts.

(*Below*) ISOLANTITE STRAIN INSULATORS are used also on lead-in wires from antennas to the building which houses the transmitting equipment built by Federal Telegraph Company. Transmitters can be quickly switched from one antenna to another, to maintain most efficient transmission at different times of day.



(*Below*) SPECIAL FITTINGS used on Isolantite strain and other types of Isolantite insulators at the new stations were designed and tested by engineers of Mackay Radio and Telegraph Company and the Columbia Broadcasting System. These fittings were manufactured by Burndy Engineering Company.



represent different positions of the edge in space. As the edge moves transversely, the beam will follow the edge in order to maintain the light balance. Thus, because of an accurate relationship between beam position and instrument current, the amount of current is a measurement of the position of the edge of the material. However, for measuring width, a right-hand detector is also required, to determine the position in space of the right-hand edge.

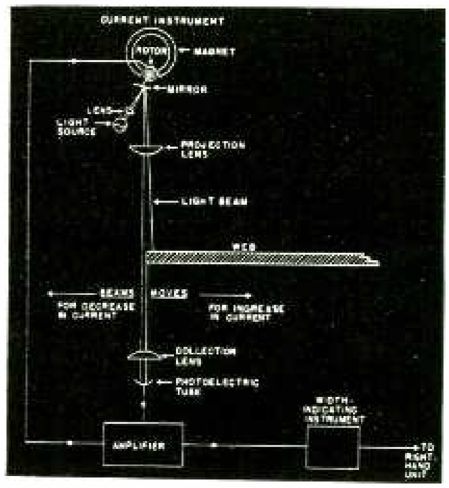
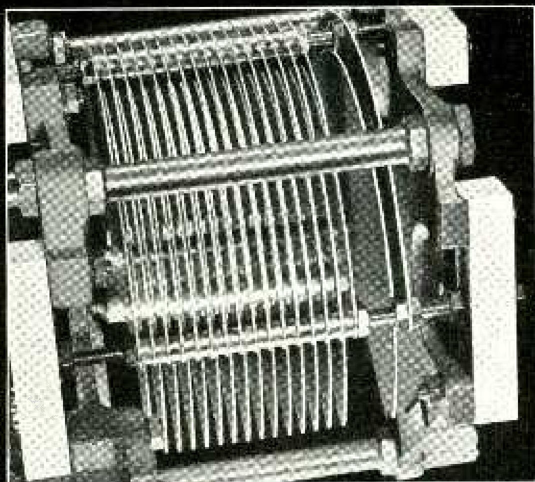


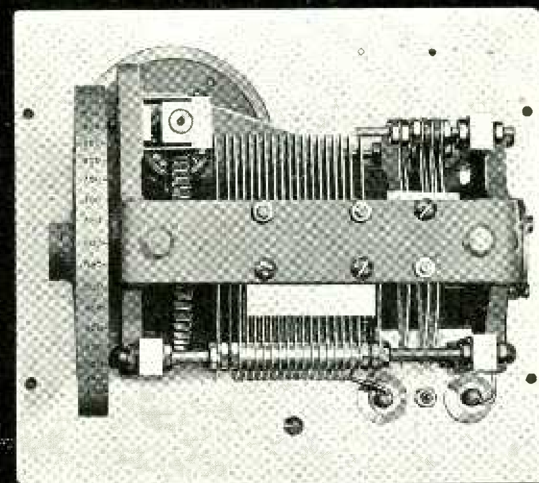
Fig. 2—Diagram illustrating principle of operation of the photoelectric width gage

The currents of both left- and right-hand detectors are totalized on one indicating instrument to measure the width. An increasing current in the totalizing instrument shows an increase in width; and a reduction in current shows a reduction in width. Hence, it can be seen that a shifting in side register with constant width of material simply adds current to the detector on one side and subtracts a like amount of current from the detector on the other side, with the net result of no change on the indicating instrument.

Considering the principal optical axis of the lens system which projects the beam across the edge of the web as the correct side-register position, an accuracy of plus or minus $\frac{1}{32}$ inch can be expected within a zone of $\frac{1}{2}$ inch shift in side register from this point or $\frac{1}{2}$ inch change in total width dimension. For a change in side register up to $\frac{3}{4}$ inch either side of the principal optical axis, an accuracy of plus or minus $\frac{1}{16}$ inch can be expected. This accuracy would also apply to a net change in the width dimension of $\frac{3}{4}$ in. These values are actual and become a decreasing percentage error as the width of the material increases.

Material as narrow as 6 inches in width can be measured and, by staggering the detector heads, it may be possible to reduce this value somewhat. The web should be practically flutter-free at the point of measuring, but a change in elevation of approximately 2 inches can be tolerated at the point where the web intercepts the beam of light. The plane of the web should be perpendicular to the light beams.





MAKING CONDENSERS DIRECT READING

A VARIABLE AIR CONDENSER with semicircular rotor and stator plates can be made to have remarkable linearity over about 80 per cent of a half turn. When used with calibration curves or charts, the accuracy obtained is so high that for many years manufacturers were discouraged from attempting to make condensers direct reading.

This phase of condenser development is now over. Most new condensers have direct-reading scales calibrated to an accuracy as good as was formerly obtained with calibration curves.

The first step in making a condenser direct reading was taken with the now obsolete Type 222 (at left of illustration). The worm was cut with double threads giving 12½ turns for ½ turn of the rotor. The number of plates were adjusted to make the capacitance increment per turn about 100 $\mu\mu$f. Ten turns (or 80 per cent of the available motion) would then correspond to 1,000 $\mu\mu$f.

The scale markings were chosen to indicate capacitance taken out of the circuit. Adjusting plates were provided to make the capacitance per turn exactly 100 $\mu\mu$f. Since the stator plates were supported at three points, the stator adjusting plate could be warped to make up for irregularities in the main stack.

With this construction it was possible to adjust the condenser so that it was direct reading in capacitance difference from the zero mark with an accuracy of 1 $\mu\mu$f or 0.1%, whichever was greater.

The Type 722 Precision Condenser (at right of illustration) was developed as an improvement on the Type 222. Most of the changes . . . ball bearings . . . integral-cut worm . . . cast-aluminum frame . . . worm shaft at right angles to the panel . . . have no immediate bearing on the direct-reading problem.

In the Type 722-D the function of the drum and dial are transposed. Twenty-five turns of the worm produce a half turn of the rotor plates. The dial is divided into 250 divisions; the usable portion of the condenser then has 5,000 divisions; one $\mu\mu$f covers 5 divisions on the 1,000 $\mu\mu$f condenser.

The stator plate at the right of the stack is used to make the capacitance per turn exactly 50 $\mu\mu$f. Since only two stator supports are used, this plate can be tipped to correct for slight irregularities in the main stack. As this plate cannot be warped, a special stator plate, cut out in the middle, is used at the left end of the stack. This plate increases the capacitance per turn at the ends.

Zero capacitance is altered by bending the flat plate which extends from the frame. By means of these various adjustments the large section of this condenser is made direct reading in total capacitance to 1 $\mu\mu$f or 0.1% between 100 $\mu\mu$f and 1,000 $\mu\mu$f. A small section is provided also. This has one-tenth the capacitance of the larger. It is adjusted by similar means to be direct reading in total capacitance to 0.2 $\mu\mu$f or 0.1% between 25 and 100 $\mu\mu$f.

By appropriately shaping the rotor and stator plates, these precision condensers can be adapted to use in a large number of direct-reading instruments. It is now possible to design a condenser which can be made to read directly in almost any one of the many related quantities which the condenser may control in a circuit or an instrument.

GENERAL RADIO COMPANY CAMBRIDGE MASSACHUSETTS

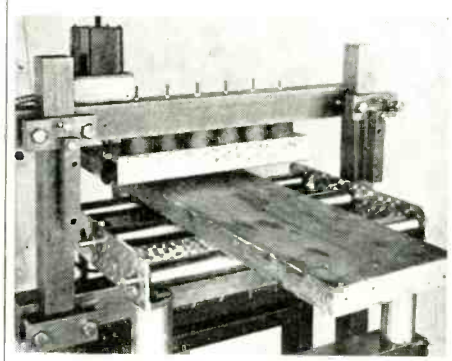
The speed of response of the system is limited only by the damping of the electrical instruments, and is of the order of $\frac{1}{2}$ sec. for a full-scale change of indication. Care must be exercised to prevent excessive amounts of vibration from being transmitted to the equipment. By an excessive amount of vibration is meant a value sufficient to cause an appreciable movement of the galvanometer element on which the mirror is mounted, or to cause mechanical distortion of the optical system.

The ambient conditions under which the equipment must operate deserve careful consideration. Any atmospheric contamination—such as dust, scale, lint, dripping water, smoke, or steam—which is either opaque to light or which will cause dispersion, will affect any system responsive to the quantity of light transmitted through a space in which this contamination exists. This is not to be confused with the normal amount of air-borne substances that accumulate on lens surfaces and can be periodically cleaned off to maintain successful operation. Exposure to radiant heat in such an amount as to elevate the temperature of the equipment above 55 C. total temperature require special consideration for artificial means of cooling.

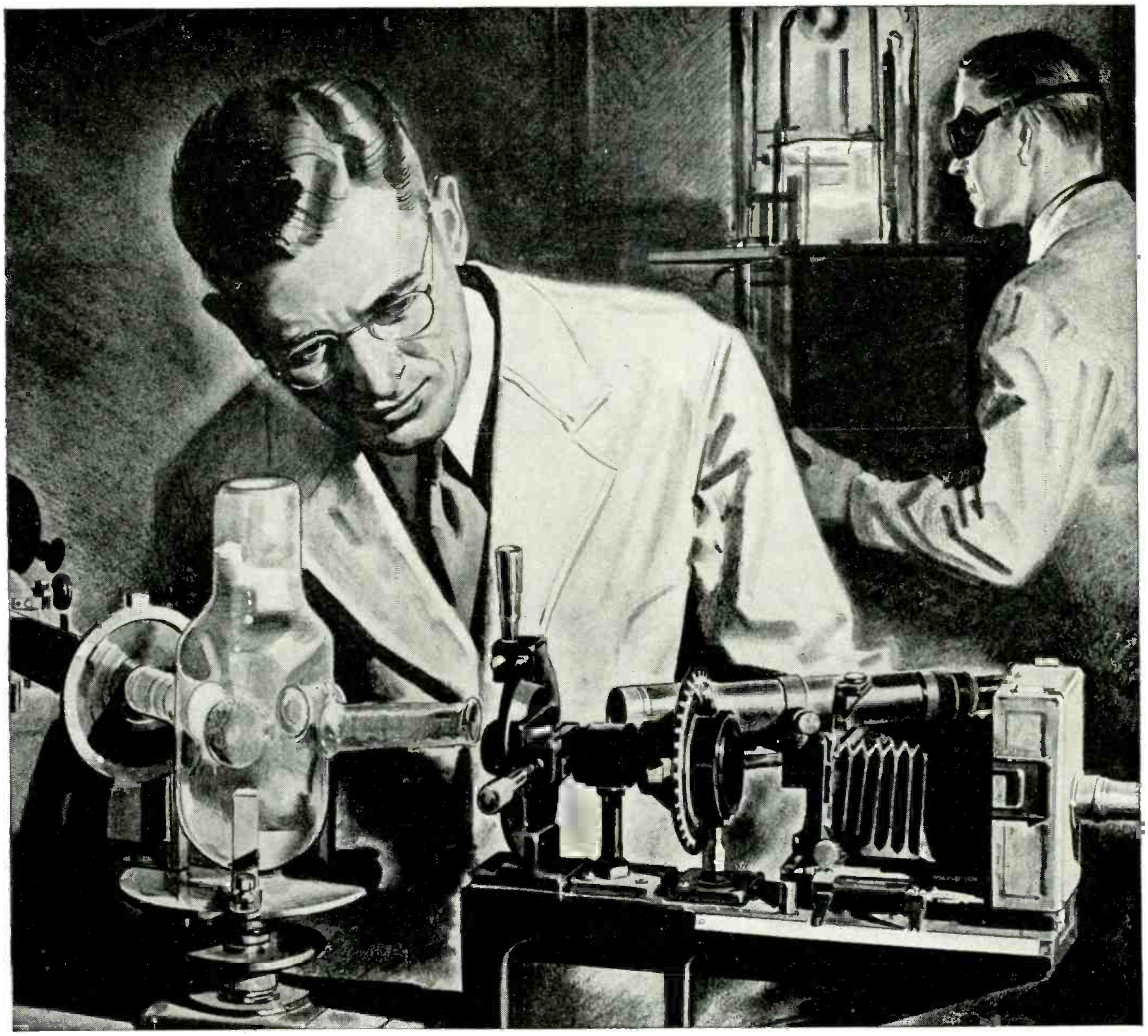
• • •

Nail Detector

AUTOMOBILES ARE SHIPPED to South Africa crated in sturdy boxes built of heavy lumber. The quantities involved, before the start of hostilities, were large enough and the scarcity of lumber in South Africa great enough to justify the reclamation of the automobile crate lumber for other purposes. One of the difficulties involved was that many large nails were used in the construction of these boxes. Naturally these had to be removed before any other use could be made of the lumber. To locate the nails manually was both slow and inefficient. An automatic method making use of the magnetic properties of the iron nails was indicated. Such a device was designed and



The operation of the nail detector depends upon the motion of pieces of iron through a magnetic field



What's ahead for you Engineers?

Many of you who have chosen broadcasting as your life work were pretty young at the time of World War I. Let's look back—to see what's ahead.

Under wartime pressure, radio research went forward by leaps and bounds. Out of new ideas such as those developed by Bell Labs and Western Electric for military use came an entire new post-war industry—*your* industry of broadcasting.

Through peacetime years, Bell Labs and Western Electric kept right on pioneering—helping your industry to grow—with such major improvements as crystal control, stabilized feedback, the Doherty circuit, vertical radiators, directional arrays.

Now the pressure is on again. Resources of Bell Labs and Western Electric are developing many new things in radio to strengthen our land, sea and air forces.

When the present war is over, can you doubt that broadcasting will surge ahead as a result of today's intensified research?

Look forward with confidence! Today's mobilization for war is also a mobilization for the peace to follow. Count on Bell Labs and Western Electric to give you new tools to help you make broadcasting finer than ever in the years ahead!

Western Electric
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constructed by Andrews & Perillo, Inc. of Long Island City, N. Y.

The essential feature of the automatic nail detector is a magnetic circuit with an air gap through which the lumber is passed. If any iron is in the lumber, it will change the reluctance, and consequently the flux, of the magnetic circuit as it passes through the air gap. The changing flux induces a voltage in a pickup coil which is amplified sufficiently to operate an alarm or to mark the lumber at the location of the nail. Note that the operation of this system depends upon the motion of the iron through the airgap and not merely its presence in the gap. If the iron should be stationary, the alarm or marking device will not operate. Therefore this is fundamentally a high speed instrument and the normal speed of operation is about 100 feet of lumber per minute. The normal size of the air gap is 2 by 18 inches, but this can be smaller or larger depending on the size of the material to be tested. It is possible to make this opening as large as 6 by 36 inches to accommodate large pieces.

• • •

35,000-FT. JUMP FOR SCIENCE

Arthur H. Barnes, pilot and parachute jumper, gets a last minute check-up from technical aides at a dress rehearsal in Chicago where he later made a world record parachute jump of 35,000 feet. He is weighted down with various scientific instruments from which he hopes to obtain records as to various conditions encountered by the body in this long jump. Mr. Barnes hoped to prove with the aid of scientists and engineers that properly protected from the elements and supplied with oxygen, there is no limit to the distance a body can fall without ill effects. Among the 113 pounds of instruments worn by Barnes are a moving picture camera, a radio transmitter, an altimeter, and an oxygen tank

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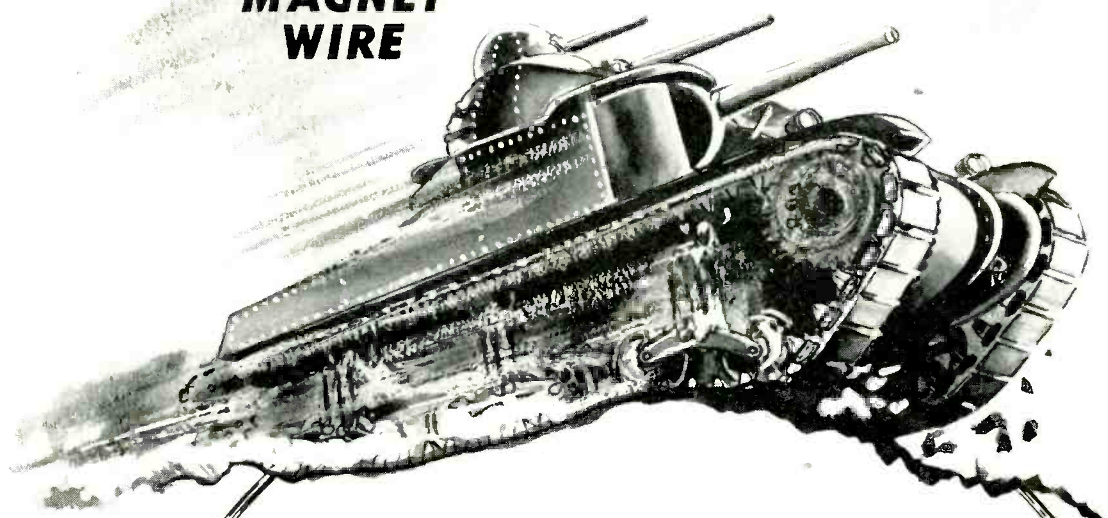

Controlling the brute strength of every tank are the tiny magnet wires in radio-communicating-systems, and other energizing and controlling mechanisms. To insure America's Defense, this wire must be the best that skill and modern methods can produce.

When REA makes the wire for these and other requirements of Army, Navy, and the Air Forces, twenty-five years of experience and the most modern facilities in the industry combine to do the job . . . to produce exactly what is wanted, to deliver it with greatest possible speed. If exacting specifications call for special wire, REA can "tailor-make" it to fit the job.

REA wire . . . with maximum uniformity, longer continuous lengths and superior spooling . . . is helping to speed up Defense production.

If you have a problem relating to wire—procurement, engineering or production—contact REA for quick action!

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Program of the Thirtieth Anniversary Convention Institute of Radio Engineers

January 12, 13, and 14, 1942

Hotel Commodore

New York, N. Y.

MONDAY, JANUARY 12

10:30 A. M.—12:30 P. M. Opening Session

Address of Welcome by the Convention Committee Chairman, I. S. Coggeshall.

Message of the Retiring President, F. E. Terman.

Remarks of the Incoming President, A. F. Van Dyck.

"The Mobilization of Science with Special Reference to Communication", by Dr. F. B. Jewett.

2:30 P. M. —5:30 P. M. Technical Session

"Half a Year in Commercial Television", by Noran E. Kersta, National Broadcasting Company.

"Automatic Radio Relay Systems for Frequencies Above 500 Mc", by J. Ernest Smith, RCA Communications.

"Automatic Frequency and Phase Control of Synchronization in Television Receivers", by K. R. Wendt and G. I. Fredendall, RCA Manufacturing Company (Demonstration).

"Simultaneous Aural and Panoramic Reception", by Marcel Wallace, Panoramic Radio Corporation (Demonstration).

8:30 P. M.—10:00 P. M. Technical Session

"Color Television", by P. C. Goldmark, J. N. Dyer, E. R. Piore, and J. M. Hollywood, Columbia Broadcasting System (Demonstration).

10:30 P. M. Inspection Trip through printing plant of New York Daily News

TUESDAY, JANUARY 13

10:00 A. M.—12:30 P. M. Technical Session

"Preparation of Technical Papers for Publication", by B. Dudley, *Electronics*, McGraw-Hill Publishing Co.

"The Use of Vacuum Tubes as Variable Impedance Elements", by H. J. Reich, University of Illinois.

"A Wide-Range, Linear, Unambiguous, Electronic Phasemeter", by J. E. Shepherd, formerly Harvard University.

"Variable-Frequency Bridge-Stabilized Oscillators", by W. G. Shepherd and R. O. Wise, Bell Telephone Laboratories.

2:30 P. M.—5:00 P. M. Technical Session

"Space-Charge Relations in the Magnetron with Plane Electrodes", by E. V. Condon, Westinghouse Electric Manufacturing Company, East Pittsburgh, Pa.

"Bioelectric Research Apparatus", by Harold Goldberg, Stromberg-Carlson Telephone Manufacturing Company.

"The Dynetric Balancing Machine", by H. P. Vore, Westinghouse Electric and Manufacturing Company.

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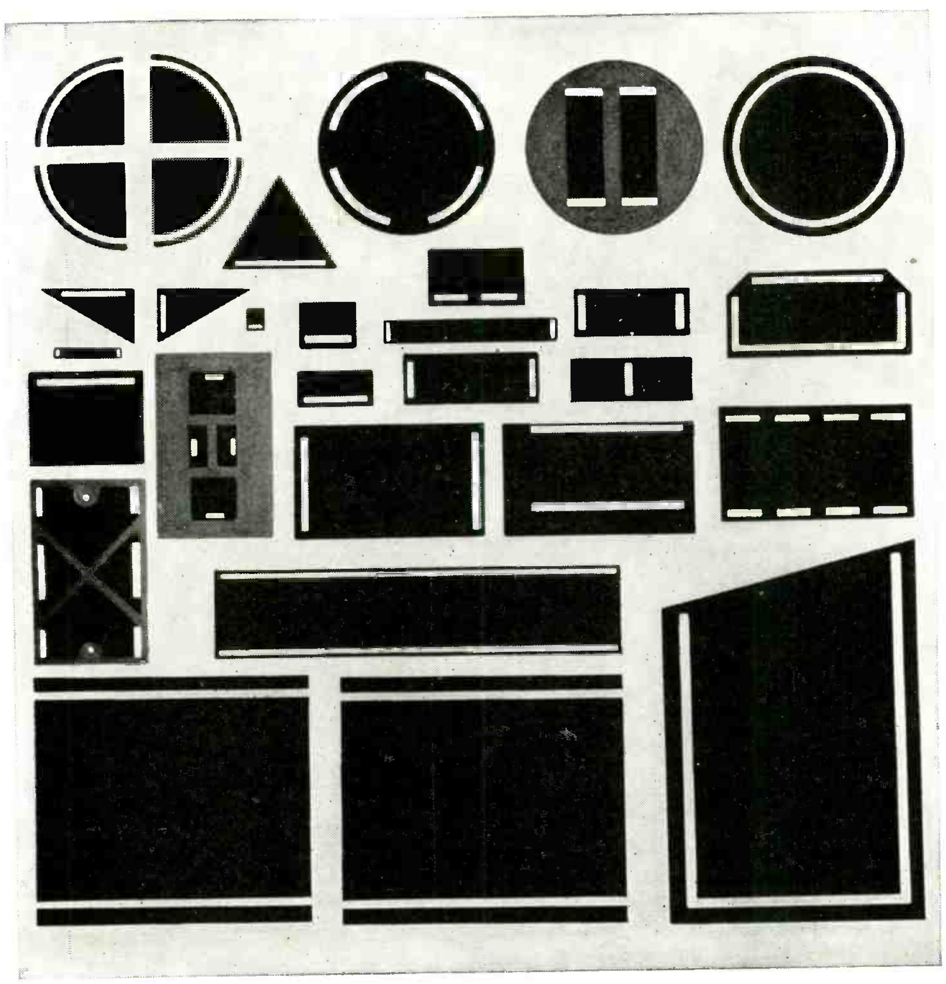
...IN SHAPES, SIZES AND CHARACTERISTICS TO MEET YOUR SPECIFICATIONS *EXACTLY!*



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FOR OVER 53 YEARS LEADERS IN ELECTRICAL MEASURING INSTRUMENTS

"Ionospheric Investigations at Huancays Magnetic Observatory (Peru) with Applications to Wave-Transmission Conditions", by H. W. Wells, Carnegie Institution of Washington.

WEDNESDAY, JANUARY 14

10:00 A. M.—12:30 P. M. College Session

"Modern Techniques in Broadcasting" by J. V. L. Hogan, Interstate Broadcasting Co.

"Modern Developments in Electronics" by B. J. Thompson, RCA Manufacturing Co.

"Demonstration of Facsimile Equipment" by J. Hackenberg, Western Union Telegraph Co.

2:30 P. M.—5:00 P. M. Technical Session

"The Fort Monmouth Laboratory of the Signal Corps", by Major Rex Corput, United States Army.

"Note on the Sources of Spurious Radiations in the Field of Two Strong Signals", by A. J. Ebel, WILL, University of Illinois.

"RCA 10-Kilowatt Frequency-Modulated Transmitter", by E. S. Winlund and C. S. Perry, RCA Manufacturing Company.

"A Stabilized Frequency-Modulation System", by R. C. Pieracci, Collins Radio Company.

7:30 P. M.—10:00 P. M. Technical Session

"The Absolute Sensitivity of Radio Receivers", by D. O. North, RCA Manufacturing Company.

"An Analysis of The Signal-to-Noise Ratio of Ultrahigh Frequency Receivers", by E. W. Herold, RCA Manufacturing Company.

"A New Direct Crystal-Controlled Oscillator for Ultra-Short Wave Frequencies", by W. P. Mason and I. E. Fair, Bell Telephone Laboratories.

"An Ultrahigh Frequency Two-Course Radio Range with Sector Identification", by Andrew Alford and A. G. Kandoian, International Telephone and Radio Laboratories.

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RECRUITS LEARN RADIO OPERATION

At Fort Dix, N. J., new selectees who wish to become radio telephone or telegraph operators for service in field maneuvers or in directing artillery fire, take instruction under Lieut. Phillip Huston, Camden, N. J., and are assimilated on graduation into army units all over the country. Truck mounted equipment is shown in operation in this photograph

THE ELECTRON ART

Forest service radio, analysis of high speed actions, an inductively coupled frequency modulator, wave analysis with the cathode-ray oscilloscope, and the alert receiver are discussed in this month's review of technical literature

U. S. Forest Service Communication Facilities

ABOUT 208,000,000 acres of land are under intensive protection against forest fires by the U. S. Forest Service. This gigantic task is greatly aided by various communications facilities. The November 1941 issue of *Electrical Engineering* carries a report called "The Communication Facilities of the U. S. Forest Service" by A. G. Simson which gives some idea of how the Service uses communications equipment as an effective weapon against forest fires.

The backbone of the national forest communication is wire line, either Forest Service lines or commercial circuits. Radio is used where no other satisfactory means of communication are available. Nearly all of the radio communication is of an emergency nature. It is not considered desirable to have both routine administrative and fire traffic flow over the same radio circuits. In time of emergency the administrative traffic would have to give way to emergency needs which would disrupt the normal forest administration.

The communication system on a forest unit falls into three general classes of use: administrative circuits, such as between the forest supervisor and district ranger officers; fire detection circuits, as between fire lookouts and lookout to central fire dispatcher; and fire suppression circuits, as dispatcher to patrolmen, fire crews and fire trucks, contact with foot and aerial scouts, freighting planes, communication along the fire line, base camp contact, with regional equipment depots, and communication with the mobile fireweather forcast units.

Some idea of the organization of the service for emergencies may be gleaned from Fig. 1. This shows a radio "net" which is used on "conflagration" fires, which are usually from 50,000 to 75,000 acres in extent. The main communication center will be at staff headquarters in the main base camp. From this point communications service will be established with the regional equipment depot, forest supervisor's headquarters, reconnaissance and transport planes, fire weather units, and the sector camps located along the fire line. The sector camps will set up local networks to communicate with the fire line, ground scouts, nearby lookouts, and various fire fighting units within the sector.

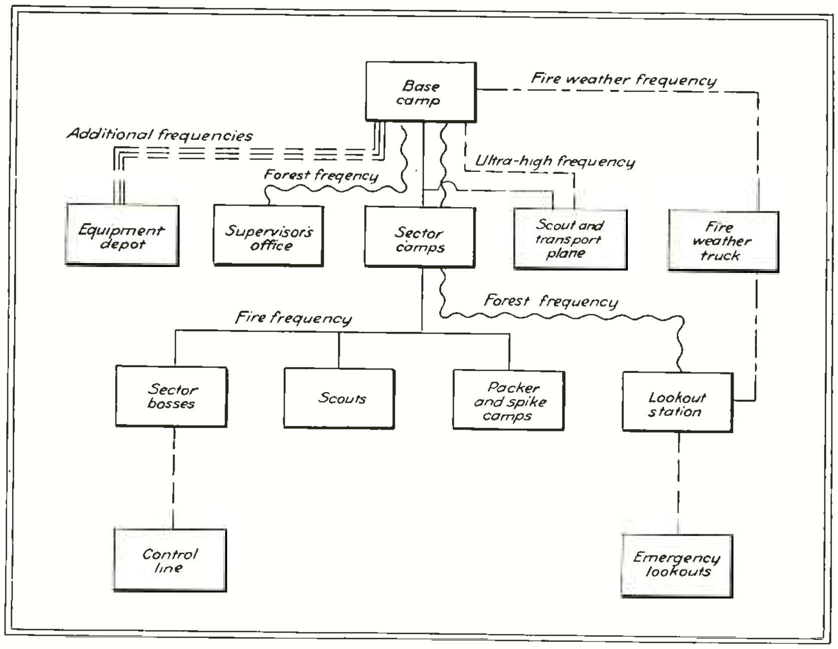


Fig. 1—Block diagram of the radio net used by the U. S. Forest Service in fighting a forest fire of the "conflagration" class—one whose area is 50,000 or 75,000 acres and whose perimeter is about 100 to 150 miles

Originally, the radio frequencies used were entirely in the 2 to 4 Mc band. For the last seven or eight years frequencies in the 30 to 40 Mc band have found increasing favor. This portion of the spectrum represents the best compromise between the desirable characteristics of the ultrahigh frequency such as minimum static, short antennas, circuit efficiencies, and the better coverage below line of sight obtainable with lower frequencies.

Radio equipment requirements development, procurement, and maintenance, are briefly discussed. The high frequency and ultrahigh frequency radiophones used by the Service are also described in some detail.

Analyzing High-Speed Action

THE PRINCIPAL METHODS for studying phenomena too fast for unaided visual observation are described in the October 1941 issue of *General Electric Review*. The article is called "Aids for Analyzing High-Speed Action", by E. M. Watson.

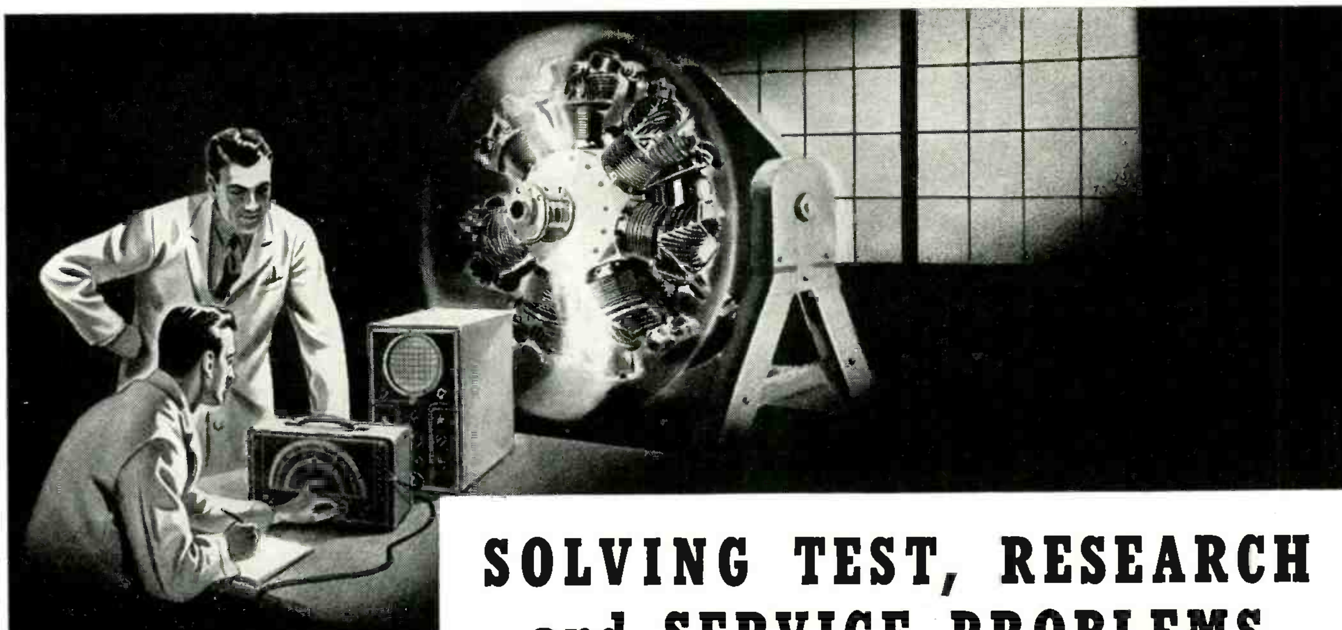
High speed action may be observed by direct visual observation, by means of still cameras, and by motion picture cameras. In each of these methods a shutter or a stroboscope of some sort is used. The shutter method is used where subjects radiate light of themselves, or reflect utility light not used to determine exposure time. Exposure time is determined by the shutter. The stroboscopic method is used where other light does not materially interfere with stroboscopic light. Here the exposure time is determined by the stroboscopic flash.

Each method is treated in detail, and is illustrated with pictures taken by the means described. Though much literature has been published on the various devices used in this field, no attempt seems to have been made to classify or relate the methods employed. Engineers will find this article interesting because it gives a "bird's eye view" of the entire subject.

Inductively Coupled Frequency Modulator

AN INTERESTING FREQUENCY MODULATOR is described in the October 1941 issue of the *Proceedings of the I. R. E.* by Bruce E. Montgomery. This device allows the engineer to design a frequency modulated oscillator that has more power output and one which will operate on a higher fundamental frequency than conventional modulators in use at present.

The fundamental idea of the modulator is very simple. An inductance, capacitance, and resistance in parallel are inductively coupled to the frequency-controlling circuit of the self-excited oscillator. When the resistance is varied, corresponding changes in reactance and resistance are reflected



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ELECTRONIC TEST EQUIPMENT

RCA MANUFACTURING CO., INC., CAMDEN, N. J.
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into the oscillator inductance thereby causing frequency variations. In the circuit used, the parallel resistance is the plate circuit of a 6F6 tube.

The circuit of the frequency modulator coupled to the oscillator is shown in Fig. 1. Variations in the a-c plate resistance of the 6F6 tube are accentuated by the proper placement of a resistor in the plate circuit. The performance of this circuit is shown in Fig. 2. As the grid voltage is varied there is a marked variation in frequency. The circuit constants of the

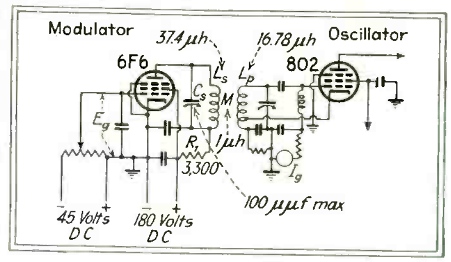

Fig. 1—Circuit diagram of the frequency modulator inductively coupled to a self-excited oscillator operating at 2.5 Mc

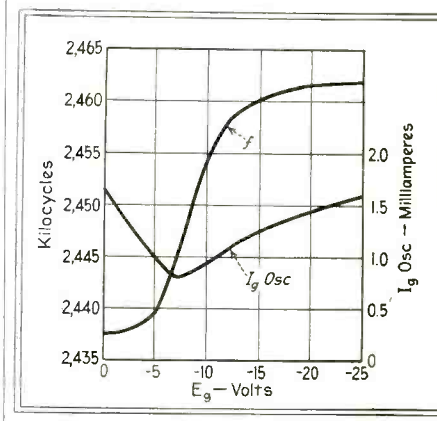

Fig. 2—Variation of oscillator frequency and oscillator grid current of the circuit shown in Fig. 1 as the modulating grid voltage is varied

modulator were chosen for a frequency of 2.5 Mc. However, the total variation in frequency could not be used for modulation because this would bring the highly curved portions of the characteristic into use, and excessive distortion would result. The curve shows that about a 17-kc variation would be available for modulation purposes. This would give a deviation of plus or minus 175 kc at 50 Mc and is considerably more than can be used in practice.

The variation of oscillator grid current with changing grid voltage is also shown. This variation in grid current is caused by the resistance being coupled into the oscillating circuit by the modulator. As this coupled resistance increases, it decreases the amplitude of the oscillations, and thus decreases the rectified oscillator grid current. This effect produces amplitude modulation on the frequency-modulated output. However, the limiting action of the following frequency multiplier stages will remove this am-

Defense Savings Pay-Roll Allotment Plan

How company heads can help their country, their employees, and themselves

voluntary pay-roll allotment plan
- **helps** workers provide for the future
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This is no charity plea. It is a sound business proposition that vitally concerns the present and future welfare of your company, your employees, and yourself.

During the post-war period of readjustment, you may be faced with the unpleasant necessity of turning employees out into a confused and cheerless world. But you, as an employer, can do something *now* to help shape the destinies of your people. Scores of business heads have adopted the Voluntary Pay-roll Allotment Plan as a simple and easy way for every worker in the land to start a *systematic* and *continuous* Defense Bond savings program.

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And don't overlook the immediate benefit . . . money for defense materials, quickly, continuously, *willingly*.

Let's do it the American way! America's talent for working out emergency problems, democratically, is being tested today. As always, we will work it out, without pressure or coercion . . . in that old American way; each businessman strengthening his *own* house; not waiting for his neighbor to do it. That custom has, throughout history, enabled America to get things done *of its own free will.*

In emergencies, America doesn't do things "hit-or-miss." We would get there *eventually* if we just left it to everybody's whim to buy Defense Bonds when they thought of it. But we're a nation of businessmen who understand that the way to get a thing done is to *systematize* the operation. That is why so many employers are getting back of this Voluntary Savings Plan.

Like most efficient systems, it is amazingly simple. All you have to do is offer your employees the convenience of having a fixed sum allotted, from each pay envelope, to the purchase of Defense Bonds. The employer holds these funds in a separate bank account, and delivers a Bond to the employee each time his allotments accumulate to a sufficient amount.

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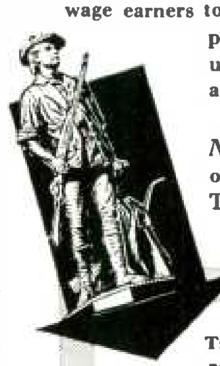
No chore at all. The system is so simple that A. T. & T. uses exactly the same easy card system that is being used by hundreds of companies having fewer than 25 employees! It is simple enough to be handled by a check-mark on a card each pay day.

Plenty of help available. Although this is *your* plan when you put it into effect, the Treasury Department is ready and willing to give you all kinds of help. Local civilian committees in 48 States are set up to have experienced men work with you just as much as you want them to, and no more.

Truly, about all *you* have to do is to indicate your willingness to get your organization started. We will supply most of the necessary material, and no end of help.

The first step is to take a closer look. Sending in the coupon in no way obligates you to install the Plan. It will simply give you a chance to scrutinize the available material and see what other companies are already doing. It will bring you samples of literature explaining the benefits to employees and describing the various denominations of Defense Savings Bonds that can be purchased through the Plan.

Sending the coupon does nothing more than signify that you are anxious to do *something* to help keep your people off relief when defense production sloughs off; *something* to enable *all* wage earners to participate in financing Defense; *something* to provide tomorrow's buying power for your products; *something* to get money *right now* for guns and tanks and planes and ships.



France left it to "hit-or-miss" . . . and *missed.* *Now* is the time for *you* to act! Mail the coupon or write Treasury Department, Section A, 709 Twelfth St. NW., Washington, D. C.

FREE - NO OBLIGATION

Treasury Department, Section A,
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Please send me the free kit of material being used by companies that have installed the Voluntary Defense Savings Pay-Roll Allotment Plan.

Name ______________________

Position ______________________

Company ______________________

Address ______________________

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plitude modulation and leave frequency modulation only at the output frequency.

The author points out that though the frequency modulator he describes was designed for 2.5 Mc only, there appears to be no serious limitations to its use on much higher frequencies. The circuit shown in Fig. 1 is capable of delivering more power than can be secured from a reactance tube frequency modulator which normally uses receiving-type tubes. The use of even larger oscillator and modulator tubes in this inductively-coupled system would allow much more power to be delivered to succeeding frequency-multiplying stages. The combination of higher-frequency operation and increased power output would allow the design of more compact and economical transmitting equipment by eliminating frequency multiplying stages.

• • •

Wave Analysis by Cathode-ray Oscilloscope

COMPLEX PERIODIC FUNCTIONS, when transformed into corresponding voltage waves, may be analyzed with the use of the cathode-ray oscilloscope. How this may be done is explained in an article called "A Cathode-Ray Method of Wave Analysis" by Vincent O. Johnson which appears in the December 1941 issue of *Electrical Engineering*.

If the complex voltage wave is impressed across the horizontal plates of a cathode-ray tube, and a pure sinusoidal voltage across the vertical plates, and if the frequency of the latter voltage bears an integral relation to the fundamental frequency of the complex wave, a Lissajous figure appears on the screen. The area of this figure is directly related to the coefficients of the Fourier series of the wave. The complex wave may be represented by $f(\theta)$ where

$$f(\theta) = A_0 + A_1 \sin\theta + B_1 \cos\theta + A_2 \sin 2\theta + B_2 \cos 2\theta + \ldots A_n \sin n\theta + B_n \cos n\theta + \ldots \quad (1)$$

The sinusoidal wave which is impressed across the vertical plates is represented by $g(\theta)$, where

$$g(\theta) = -K \cos k(\theta + a_k) \quad (2)$$

The function $g(\theta)$ has a frequency k times the frequency of the fundamental of $f(\theta)$. If k is an integer then a Lissajous figure will appear on the screen. The amplitude of $g(\theta)$ is K, and the angle a_k is the phase angle between $g(\theta)$ and the cosine term of the kth harmonic of $f(\theta)$. The area of the Lissajous figure S_k calculated from the two expressions is:

$$S_k = kK\pi\,(A_k \cos ka_k + B_k \sin ka_k) \quad (3)$$

Now if the phase angle a_k were allowed to change to a new value, say β_k, the area of the figure would change to a new value S'_k. This area can be expressed similarly as

$$S'_k = kK\pi\,(A_k \cos k\beta_k + B_k \sin k\beta_k) \quad (4)$$

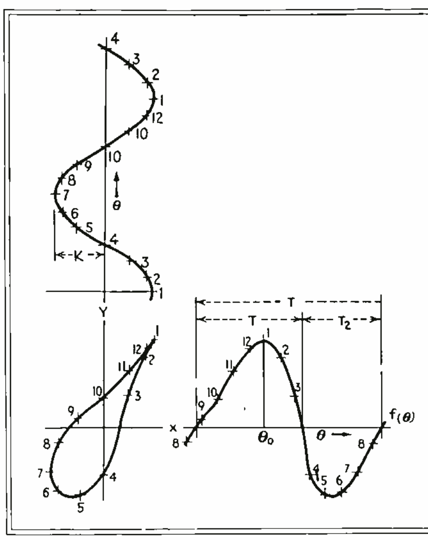
Combining these last two equations together we get:

$$A_k = \frac{S_k \sin k\beta_k - S_k' \sin k\alpha_k}{k K \pi \sin k\,(\beta_k - \alpha_k)} \quad (5)$$

$$B_k = \frac{S_k' \cos k\alpha_k - S_k \cos k\beta_k}{k K \pi \sin k\,(\beta_k - \alpha_k)} \quad (6)$$

The constant term A_o in Eq. (1) is relatively unimportant, and may readily be determined by means of a d-c measuring instrument.

The procedure is relatively simple. The frequency of the oscillator must coincide with the frequency of the complex wave. When the frequencies are synchronized a Lissajous figure will appear on the screen of the cathode-ray oscilloscope. This figure is photographed. Then the phase angle between the two waves is varied and another photograph is taken. A calibration picture is taken also. This figure is produced when two sine waves of a known phase difference are impressed on the horizontal and vertical plates respectively. The distance of the peak from the vertical axis is proportional to the phase difference angle. By referring to this calibration figure $k\alpha_k$ and $k\beta_k$ are determined. The areas of the Lissajous figures are determined by a planimeter.



Plotting the Lissajous figure for the fundamental sine component of $f(\theta)$ with θ_0 at the positive peak

Now if the scales for all the figures are the same A_k and B_k can be calculated from Eqs. (5) and (6) in inches. Each area may be converted by means of its scale constant to a hypothetical unit such as square volts or square amperes. Then K, the assumed constant can be converted to the correct units, and the value of A_k is derived in those units. If K is not constant, Eqs. (5) and (6) must be altered as follows:

$$A_k = \frac{(S_k/K) \sin k\beta_k - (S_k'/K') \sin k\alpha^k}{k\pi \sin k\,(\beta_k - \alpha_k)} \quad (7)$$

$$B_k = \frac{(S_k'/K') \sin k\alpha_k - (S_k/K) \cos k\beta_k}{k\pi \sin k\,(\beta_k - \alpha_k)} \quad (8)$$

The scale constant may be determined by taking a picture of a pure sine wave of known amplitude at the same time the other pictures are being taken.

To vary the phase difference angle the frequency of the sine-wave generator is made slightly higher than that of the harmonic. The figure is stopped by synchronizing the two waves. If the peak of the figure is stopped before it reaches a point midway between the upper right hand corner and the midpoint of the screen the angle will be between 0 and 90 degrees. If it is stopped between the midpoint and the upper left hand corner, the angle will be between 90 and 180 degrees. It is good practice to make $k\alpha_k$ about 45 degrees, and $k\beta_k$ about 135 degrees. Derivations, further discussion of procedure, and experimental results are also covered.

• • •

Receiver Control by Transmitted Signal

A NEW SERVICE IN BROADCASTING is described in the October 1941 issue of the *RCA Review*. The author, Harmon B. Deal, in an article called "Receiver Control by Transmitted Signal—'Alert' Receiver," tells how a broadcasting station may turn on all receivers within range which are equipped with an attachment receiving device, and then, at the end of an announcement, turn them off. The plan is feasible on the sound broadcast band or the ultra-high frequency band.

Use of the facility would be limited to important news flashes because abuse of this privilege would soon result in a loss of listeners who would disconnect the device. The cost of such equipment at the transmitting end is negligible since the equipment required is merely a receiving-tube oscillator. The cost of the receiving attachment is estimated at about ten to twenty dollars, even in small quantities.

A block diagram of the system is shown in Fig. 1. The transmitter sends out a 36-cps modulating frequency to turn on the "alert receiver". This is picked up by the receiver, and causes certain work circuits to turn on the receiver. When the announcement is completed a 24-cps carrier modulat-

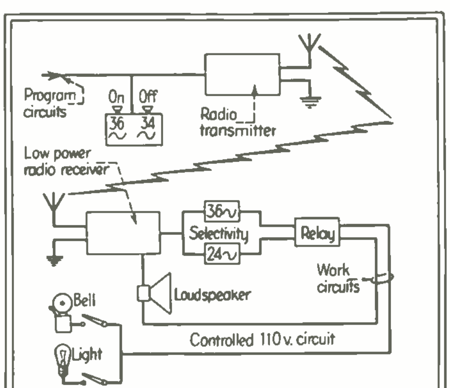


Fig. 1—Block diagram of the transmitter-controlled receiving system

ing frequency is transmitted, and this causes the work circuits to turn off the receiver. The circuit of the control is shown in Fig. 2. The work circuits are tuned-reed relays. The low frequencies are used because they can be used at the same time that ordinary broadcast frequencies are used without interference. To insure absence of interference, a low pass filter is incorporated in the circuit which cuts out all frequencies above 45 cps. As is shown in the block diagram, the control unit can be used to light a warning light or ring a warning bell just before the announcement. The power consumption of the device in Fig. 2 is 28 watts from the 110-volt power supply. It is pointed out that since the original model was built, several smaller multipurpose tubes which are now available can decrease the size and power requirements of the control unit.

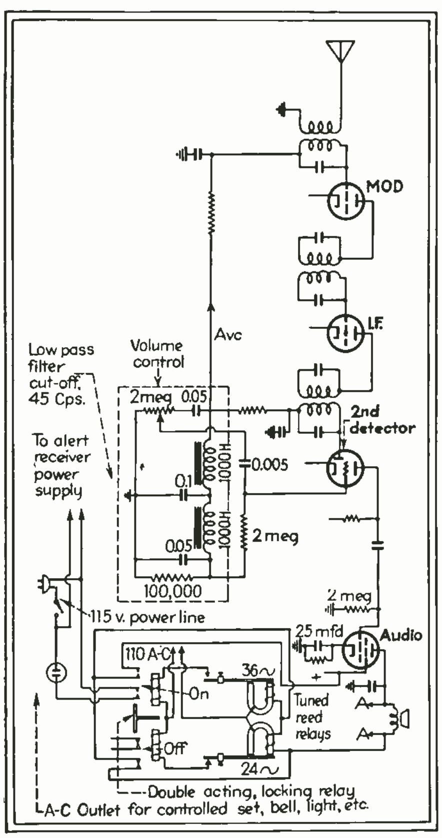


Fig. 2—Simplified circuit diagram of the alert receiver

A model built for operation on broadcast band was given laboratory tests, and then modified for operation in the 50-Mc band. It was tested in the field for several months, with the receiving unit located at various places from 1 to 45 miles from the transmitter. Results were satisfactory in every case.

The author believes that this method provides a useful and appealing possibility for facilitating communication of vital news to Civilian Defense organizations. He also discusses further design considerations of the receiver unit, control-frequency, source, and the selective unit (the tuned-reed system).

Rhodium Contacts

PRECIOUS METALS, which are comparitively inert chemically, have long been used for various types of contacts in electrical switching equipment. A newcomer to the family of contact materials is rhodium whose physical properties are shown in the table. E. H. Laister discusses the use of this metal as a non-corroding contact surface in "Rhodium Contacts", an article appearing in the November 1941 *Electronic Engineering*.

The design of flexible and easily handled equipment usually involves a great deal of switching. Many of these switches carry only small r-f and a-f currents with no d-c potential difference across them to assist in breaking down any oxide or tarnish film that may form during idle periods. Since any changes in the current passing through the closed contacts is usually amplified many thousands of times by the following amplifiers any unstable contact will result in the output being unreliable, noisy, and possibly failing completely. Where r-f currents only are to be carried it is standard practice to use some contact material which is stable in itself. This is usually some form of precious metal, gold-silver and gold-silver-platinum alloys being the most popular.

Physical Properties of Rhodium

Atomic Weight	102.91
Specific Gravity	12.44
Specific Resistance	4.90×10^{-6} ohms per cm cube
Melting Point	1907° C
Coefficient of Linear Expansion	8.5×10^{-6}
Color	Silvery-white

Where absolute reliability under adverse conditions is required, rhodium, one of the platinum group metals, is finding wide and successful application. It is hard, actually file-resistant, and has remarkable wearing properties. It is more chemically inert than platinum, being completely unattacked at ordinary temperatures even by boiling aqua regia. Oxidation in air does not take place below 600 to 800 degrees Centigrade. Though difficult to work, rhodium may be deposited electrolytically with ease. It is quite expensive, 0.001 inch deposit costing about $2.50 per square inch. This thickness is sufficient for r-f contact surfaces even under the most drastic conditions.

It is possible to limit the deposit to quite small areas, and for anything over 0.001-inch thickness, this is usually done. It is common practice to plate an area of less than 1/16 square inch so that this expensive metal appears only where it is needed. For thicknesses less than 0.0002-inch the best and closest grained deposits are obtained on silver which is used as a base metal or as a preliminary electrodeposit on the surface to be plated. Above this thickness the metal is plated directly.

CAA's Part in Instrumentation

THE CIVIL AERONAUTICS ADMINISTRATION has been outstanding in developing new instruments to increase the safety of aircraft. Some of the instrument developments in which the CAA played a large part are reviewed in an article entitled "The CAA and Industry Cooperate to Develop Instrumentation" by C. I. Stanton which appears in the October 1941 issue of *Instruments.*

An interesting development of the CAA engineers was the dual automatic radio direction finder. The instrument is actually two radio direction finders interconnected, with their needles indicating on the same azimuth scale. The needle of each receiver points to the station to which it is tuned. When a station ahead and one to the rear are tuned in, the pilot can fly along a straight line between the stations by moving his plane to the right or left until the needles form a straight line. This device was first installed in the CAA's laboratory plane and is now commercially manufactured, and being installed by the airlines.

The CAA also originated specifications for a new ultrahigh frequency radio receiver which the airlines are now purchasing for use on runs where the CAA has installed u-h-f radio ranges and landing systems. The receiver is equipped with push buttons which can select 33 separate frequencies between 110 and 132 Mc. It can receive u-h-f course signals of the CAA radio range stations and instrument landing localizers, as well as voice instructions from airport traffic control towers.

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SPY HUNT VIA AIR WAVES

William E. Downey, supervisor of the South Pacific Monitor Area, and Robert Powell, operator, at the receiving equipment at Santa Ana, Calif., used for radio monitoring. At the Santa Ana station there are 15 radio engineers and technicians working day and night shifts for monitoring programs originating in the United States or in foreign countries. The Santa Ana station is one of the eleven primary national defense monitoring stations but there are more than 80 secondary stations

Instrument landing systems operating on ultrahigh frequencies are now being installed at a number of airports by the CAA. One simple dial enables the pilot to see at a glance whether he is taking the proper course for landing even though the airport may be enveloped in fog. A brief explanation of the operation of this system is given.

Another interesting development is automatic monitors for low frequency radio ranges and fan markers. This equipment is designed to operate when the range signal deviates from the true course. It gives a warning to the pilot, and sets off a siren and lights a red light in the range station and the airline dispatcher's office. The siren may be turned off, but the red light remains on until the range signal returns to true course. Another monitor acts similarly when the fan marker signal reaches a dangerously low volume.

Instruments developed by the CAA to measure flutter and vibration characteristics of aircraft are now being given ground and flight tests at the Indianapolis experiment station of the CAA. Other devices which are occupying the attention of CAA technical men include a stall warning indicator, an automatic instrument log using infrared film, and equipment for field inspection of aircraft fabric. A broad project aimed at the development of moderately priced dependable instruments for the private pilot is being studied.

• • •

NATIONAL DEFENSE AT DUKE UNIVERSITY

Two members of the staff of Duke University, graduates of technical schools several years ago, who are members of a class which recently completed the first national defense course in communication offered by Duke's College of Engineering in cooperation with the U. S. Office of Education at Durham N. C.

New Directional Microphone

CONTINUED FROM PAGE 33

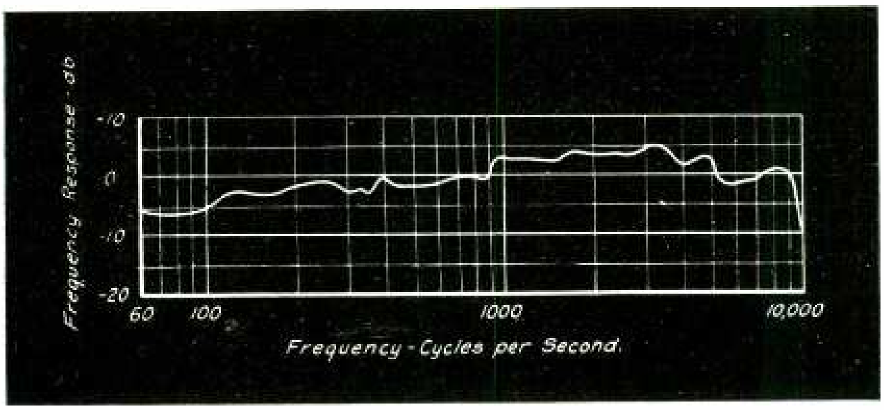

Fig. 8—Frequency response curve of the super-cardioid microphone for an incidence angle of zero degress and with the microphone one foot from the sound source

compared in function with the pressure (circular) component of a two-unit unidirectional microphone. It is apparent, therefore, that by surrounding a moving-coil element with an appropriate phase shifting network, an effect is produced which is equivalent to that obtained by combining a velocity microphone with a pressure microphone. A properly designed phase shifting network is the heart of the uniphase unidirectional microphone.

A discussion of this nature would not be complete without a brief mention of the principles of acoustical network design. Acoustical network analysis is carried out by the use of equivalent electrical circuits. The equivalent circuit theory assumes that sound pressure is equivalent to voltage, and that velocity of the air volume is equivalent to electrical current. The corresponding circuit equivalents are as follows: Acoustical mass (inertance) is equivalent to inductance, acoustical capacitance (compliance) is treated as electrical capacitance, and acoustical resistance is represented by electrical resistance.[7] Referring again to Fig. 5, the slit S is represented by a series resistance R_1 and inductance L_1 in Fig. 6. The volumes under the diaphragm, V_1, and within the magnet, V_2, are represented as condensers C_1 and C_2. The acoustical screen A is also represented as a series resistance R_2 and inductance L_2. The equivalent electrical circuit of the acoustical network is shown in Fig. 6. Voltage E_b represents the pressure P_b, and voltage E_c represents the pressure P_c. The two voltages should be equal in magnitude and displaced in phase through an angle proportional to frequency. This design objective is achieved by determining the values of the electrical circuit components for the desired performance, and then translating these values into the acoustical elements in the microphone structure. The phase shift and relative magnitudes of pressures within the super-cardioid microphone unit illustrated in Fig. 5, are shown in Fig. 7.

The phase shift angle increases directly with the frequency. Therefore, the net pressure difference between the diaphragm sides also increases with the frequency. However, the coil is suspended in such a manner that its mechanical impedance rises directly with the frequency within practically all of the audio frequency spectrum. The velocity of the coil is, therefore, independent of frequency and a flat frequency response results.

Performance

Frequency response of the new super-cardioid microphone is shown in Fig. 8 for 0 deg. incidence at one foot from sound source. Polar patterns are shown in Fig. 9, for random noise frequency bands of 100 to 400, 400 to 1600, and 1600 to 6400 cps, indicating that the directional properties are alike at all frequencies.

The new unit is doubly wind screened, and in common with other moving coil microphones, is notably free from wind noises. This enhances its value in broadcasting from outdoor locations where windage pickup may constitute a problem. The super-cardioid pattern provides an easy means of eliminating undesired noises by proper microphone orientation. Because of the inherent sturdiness of the moving-coil structure, the new microphone is well adapted for remote broadcasting as well as studio work.

Appendix

Random efficiency (sometimes called directional efficiency) of a directional microphone may be defined as the ratio of power delivered into the amplifier (due to a random sound field incident from all directions with equal intensity and random phase distribution) to the power that would have been delivered under the same conditions by a microphone with equal sensitivity in all directions. The random efficiency of a microphone with a response symmetrical about the normal axis is given by:[2]

$$\eta = \frac{1}{2}\int_0^\pi \left\{ f(\theta) \right\}^2 \sin\theta \, d\theta \qquad (1)$$

where $f(\theta)$ expresses the directional sensitivity of the microphone for sounds arriving from angle θ in terms of percentage of 0 deg. incidence response.

What might be called the front random efficiency of a microphone η_f, that is, the random efficiency based on sounds arriving from the front hemisphere, is obtained by integration from 0 to $\pi/2$; likewise the rear random efficiency of a microphone η_r, based on sounds arriving from the rear hemisphere, is obtained by integration from $\pi/2$ to π. In a microphone having a directional pattern in the form of a Limaçon,

$$f(\theta) = (1 - k) + k\cos\theta \qquad (2)$$

where k is a fraction representing the contribution of the cosine unit to the total output. The values for η, η_f, and η_r are given by substitution of Eq. (2) into Eq. (1), and integrating from 0 to π, 0 to $\pi/2$, and $\pi/2$ to π respectively. Performing these integrations, the following relations are obtained:

$$\eta = 1 - 2k + 4/3\,k^2 \qquad (3)$$

$$\eta_f = \frac{1}{2} - k/2 + 1/6\,k^2 \qquad (4)$$

$$\eta_r = \frac{1}{2} - 3/2\,k + 7/6\,k^2 \qquad (5)$$

The unidirectional index of a microphone has been taken as a ratio of η_f to η_r

$$U = \frac{\frac{1}{2} - k/2 + 1/6\,k^2}{\frac{1}{2} - 3/2\,k + 7/6\,k^2}$$

A plot of the function U (Fig. 2) shows that the maximum unidirectional ratio of 14 to 1 is obtained when $k = 0.63$. The pattern corresponding to this maximum, $f(\theta) = 0.37 + 0.63 (\cos\theta)$ has been called a super-cardioid. Substituting $k = 0.63$ into Eq. (3), the super-cardioid pattern is found to have a random efficiency of 27 percent.

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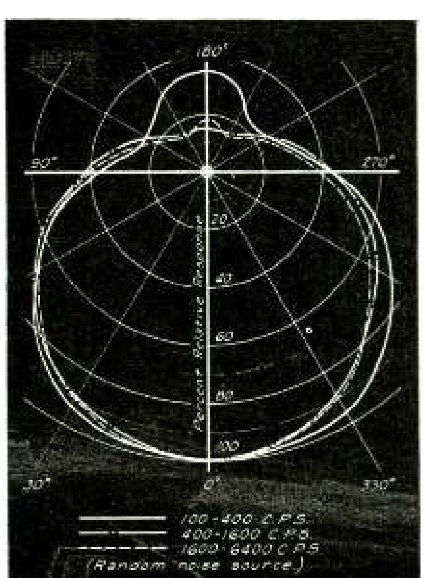
Fig. 9—Horizontal polar patterns for several frequency bands. Note the similarity of the directional patterns at the different frequencies



TUBES

Characteristics of cathode-ray and television picture tubes are presented this month in addition to the new receiving tube types registered by the RMA Data Bureau during November 1941

Tube Registry

New tube types registered by the RMA Data Bureau during November 1941

Type 7W7 (GL)

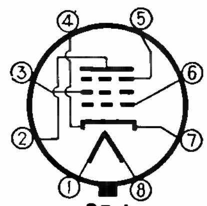
PENTODE voltage amplifier, sharp cut-off, heater type, T-9 integral glass envelope base, seated height 2¼ inches (max), 8-pin lock-in base.

RATINGS

E_f = 7.0 v
I_f = 0.48 amp
E_b = 300 v (max)
E_{c2} = 150 v (max)

TYPICAL OPERATION

E_f = 6.3 v
I_f = 0.45 amp
E_{c1} = −2.2 v (cathode resistor = 160 ohms)
I_b = 10 ma
I_{c2} = 3.9 ma
g_m = 5800 μmhos
r_p = 0.3 megohm
E_{c1} (for cathode current cutoff) = −6 v
C_{in} = 9.5 μμf
C_{out} = 7.0 μμf
C_{gp} = 0.0025 μμf (max)
Basing 8BJ-L-5



8BJ

Type 14W7 (GL)

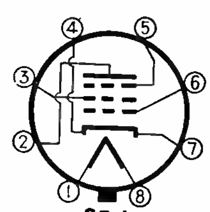
PENTODE voltage amplifier, sharp cut-off, heater type, T-9 integral glass envelope base, seated height 2¼ inches, 8-pin lock-in base.

RATINGS

E_f = 14 v
I_f = 0.24 amp
E_b = 300 v (max)
E_{c2} = 150 v (max)

TYPICAL OPERATION

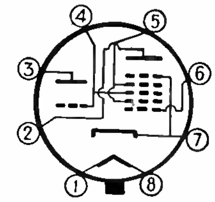
E_f = 12.6 v
I_f = 0.225 amp
E_b = 300 v
E_{c2} = 150 v
E_{c1} = −2.2 v (cathode resistor = 160 ohms)
I_b = 10 ma
I_{c2} = 3.9 ma
g_m = 5800 μmhos
r_p = 0.3 megohm
E_{c1} (for cathode current cutoff) = −6 v
C_{in} = 9.5 μμf
C_{out} = 7.0 μμf
C_{gp} = 0.0025 μμf (max)
Basing 8BJ-L-5



8BJ

Type 14S7 (GL)

TRIODE-HEPTODE converter, remote cut-off, heater type, T-9 integral glass envelope-base, seated height 2¼ inches (max), 8-pin lock-in base.



8BL

TYPICAL OPERATION

E_f = 12.6 v
I_f = 0.150 amp
E_b (heptode) = 250 v
E_b (triode) = 250 v
$E_{c2,4}$ = 100 v
Triode Grid Resistor = 50,000 ohms
r_p (heptode) = 1.25 megohm (approx)
I_c (triode) = 0.4 ma
I_b (heptode) = 1.8 ma
I_b (triode) = 5.0 ma
$I_{c2,4}$ = 3.0 ma
Total Cathode Current = 10.2 ma
g_c (heptode, E_{c1} = −2 v) = 525 μmhos
g_c (heptode, E_{c1} = −21 v) = 2 μmhos

TRIODE SECTION ONLY

E_f = 12.6 v
I_f = 0.150 amp
E_b = 100 v (max)
E_c = 0 v
I_b = 6.5 ma
r_p = 11,000 ohms
g_m = 1650 μmhos
μ = 18

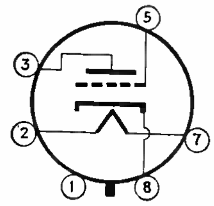
DIRECT INTERELECTRODE CAPACITANCES

Heptode Grid 1 to Heptode Plate = 0.02 μμf (max)
Heptode Grid 1 to Triode Plate = 0.10 μμf (max)
Heptode Grid 1 to Triode Grid 1 and Heptode Grid 3 = 0.35 μμ (max)
Triode Grid to Triode Plate = 1.0 μμf
Signal Input = 5.0 μμf
Oscillator Output = 3.5 μμf
Mixer Output = 8.0 μμf
Basing 8BL-L-7

Type 6C5GT/G

TRIODE, heater type, T-9 glass envelope, seated height 2¾ inches (max), 6-pin small octal base.

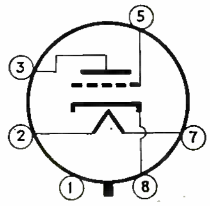
E_f = 6.3 v
I_f = 0.3 amp
E_b = 250 v
E_c = −8 v
I_b = 8 ma
g_m = 2000 μmhos
r_p = 10,000 ohms
μ = 20
C_{gk} = 4.4 μμf
C_{pk} = 12 μμf
C_{gp} = 2.2 μμf
Basing 6Q-1-1



Type 6J5GT/G

TRIODE, heater type, T-9 glass envelope, seated height 2¾ inches, 6-pin small octal base.

E_f = 6.3 v
I_f = 0.3 amp
E_b = 250 v
E_c = −8 v
I_b = 9.0 ma
g_m = 2600 μmhos
K_p = 7700 ohms
μ = 20
C_{in} = 4.2 μμf
C_{out} = 5.0 μμf
C_{gp} = 3.8 μμf
Basing 6Q-1-0



Type 7S7 (GL)

THE basing of the type 7S7 tube as given in the July 1941 issue of ELECTRONICS was 8AR-L-7. This has been modified to include the addition of a fifth grid connected to the cathode and hence to pin No. 7. The new basing is 8BL-L-7. The characteristics and the new basing diagram of the type 7S7 are reproduced below.

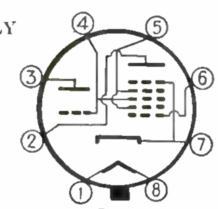
TRIODE-HEXODE converter, remote cutoff, heater type, T-9 integral glass envelope-base, seated height 2¼ inches (max), 8-pin lock-in base.

TYPICAL OPERATION

E_h = 6.3 v
I_h = 0.30 amp
E_b(hexode) = 250 v
E_b(triode) = 250 v
$E_{c2,4}$ = 100 v
Triode Grid Resistor = 50,000 ohms
r_p(hexode) = 2 megohms (approx)
I_c(triode) = 0.4 ma
I_b(hexode) = 1.7 ma
I_b(triode) = 5.0 ma
$I_{c2,4}$ = 2.2 ma
Total Cathode Current = 9.3 ma
g_c(hexode, E_{c3} = − 2v) = 600 μmhos
g_c(hexode, E_{c3} = − 21 v) = 2 μmhos

TRIODE SECTION ONLY

E_h = 6.3 v
E_b = 100 v (max)
E_c = 0 v
I_b = 7.0 ma
r_p = 10500 ohms
g_m = 1700 μmhos



8BL

DIRECT INTERELECTRODE CAPACITANCES

Hexode Grid 1 to Hexode Plate = 0.04 μμf
Hexode Grid 1 to Triode Plate = 0.10 μμf
Hexode Grid 1 to Triode Grid 1 and Hexode Grid 3 = 0.35 μμf
Triode Grid 1 to Triode Plate = 1.0 μμf
Signal Input = 5.5 μμf
Oscillator Output = 3.5 μμf
Oscillator Input = 6.0 μμf
Mixer Output = 9.0 μμf
Basing 8BL-L-7

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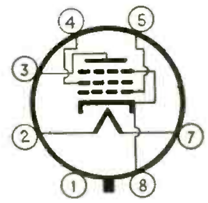
ARMY REPAIRS

It is the job of the Royal Army Ordnance Corps to keep the wheels of the army well oiled and running smoothly. At the central Ordnance Depot of South-east England, and its many sub depots, may be found all types of war materiel ready for issue to the fighting forces. At this depot, stores are refurbished and made like new and nothing is wasted. The burned out equipment on the left will be repaired to match its shining counterpart on the right

Type 6F6GT/G

PENTODE power amplifier, heater type, T-9 glass envelope, seated height 2⅞ inches, 7-pin octal base.

E_f = 6.3 v
I_f = 0.7 amp
E_b = 250 v
E_{c2} = 250 v
E_{c1} = − 16.5 v
I_b (zero signal) = 34 ma
I_{c2} (zero signal) = 6.5 ma
r_p = 80,000 ohms
g_m = 2500 μmhos
R_l = 7000 ohms
P_o = 3.2 watts (8%)
Basing 7S-0-0



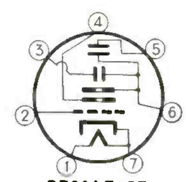
Cathode-Ray Tubes

Type 2501A3

DuMont

CATHODE-RAY tube; medium-persistance, green fluorescent screen; electrostatic focus and deflection; usual application—oscillographic; diameter, 3 inches; 7-pin base.

E_f = 2.5 v
I_f = 2.1 amps
E (anode 1) = 500 v (max)
E (anode 2) = 1500 v (max)
E (grid) for cutoff = − 80 v
Deflection Factor
$D_1 - D_2$ = 100 v (d.c.)/kilo-volt-inch
$D_3 - D_4$ = 100 v (d.c.)/kilo-volt-inch



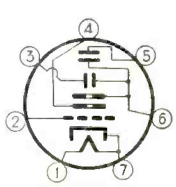
2501A3-C3

Type 2501C3

DuMont

CATHODE-RAY tube; short-persistance, blue fluorescent screen; electrostatic focus and deflection; usual application—oscillographic, diameter 3 inches, 7-pin base.

E_f = 2.5 v
I_f = 2.1 amps
E (anode 1) = 500 v (max)
E (anode 2) = 1500 v (max)
E (grid) for cutoff = − 80 v
Deflection Factor
$D_1 - D_2$ = 100 v (d.c.)/kilo-volt-inch
$D_3 - D_4$ = 100 v (d.c.)/kilo-volt-inch



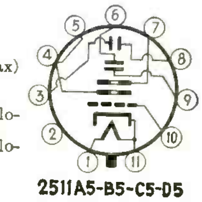
2501A3-C3

Type 2511A5

DuMont

CATHODE-RAY tube; medium-persistance, green fluorescent screen; electrostatic focus and deflection; usual application—oscillographic, balanced deflection and television, diameter 5 inches, 11-pin magnal base.

E_f = 6.3 v
I_f = 0.8 amp
E (anode 1) = 600 v (max)
E (anode 2) = 2000 v Max)
E (intensifier) = 6000 v (max)
E (grid) for cutoff = − 50 v
Deflection Factor
$D_1 - D_2$ = 28 v (d.c.)/kilo-volt-inch
$D_3 - D_4$ = 25 v (d.c.)/kilo-volt-inch



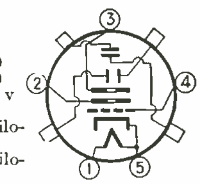
2511A5-B5-C5-D5

Type 2507B5

DuMont

CATHODE-RAY tube; long-persistance, green fluorescent screen; electrostatic focus and deflection; usual application —oscillographic and high voltage; diameter 5 inches, 5-pin base.

E_f = 2.5 v
I_f = 2.1 amps
E (anode 1) = 1000 v (max)
E (anode 2) = 3000 v (max)
E (grid) for cutoff = − 120 v
Deflection Factor
$D_1 - D_2$ = 55 v (d.c.)/kilo-volt-inch
$D_3 - D_4$ = 50 v (d.c.)/kilo-volt-inch



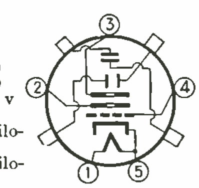
2507A5-B5-C5

Type 2507C5

DuMont

CATHODE-RAY tube; short-persistance, blue fluorescent screen; electrostatic focus and deflection; usual application —oscillographic and high voltage; diameter 5 inches; 5-pin base.

E_f = 2.5 v
I_f = 2.1 amps
E (anode 1) = 1000 v (max)
E (anode 2) = 3000 v (max)
E (grid) for cutoff = − 120 v
Deflection Factor
$D_1 - D_2$ = 55 v (d.c.)/kilo-volt-inch
$D_3 - D_4$ = 50 v (d.c.)/kilo-volt-inch



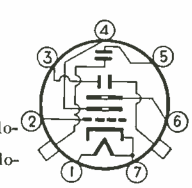
2507A5-B5-C5

Type 2509A5

DuMont

CATHODE-RAY tube; medium-persistance, green fluorescent screen; electrostatic focus and deflection; usual application—oscillographic and balanced deflection; diameter 5 inches, 7-pin base.

E_f = 2.5 v
I_f = 2.1 amps
E (anode 1) = 500 v (max)
E (anode 2) = 1500 v (max)
E (grid) for cutoff = − 80 v
Deflection Factor
$D_1 - D_2$ = 60 v (d.c.)/kilo-volt-inch
$D_3 - D_4$ = 60 v (d.c.)/kilo-volt-inch



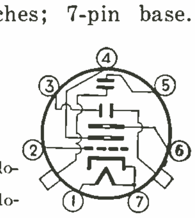
2509A5-C5

Type 2509C5

DuMont

CATHODE-RAY tube; short-persistance, blue fluorescent screen; electrostatic focus and deflection; usual application —oscillographic and balanced deflection; diameter 5 inches; 7-pin base.

E_f = 2.5 v
I_f = 2.1 amps
E (anode 1) = 500 v max)
E (anode 2) = 1500 v max)
E (grid) for cutoff = − 80 v
Deflection Factor
$D_1 - D_2$ = 60 v (d.c.)/kilo-volt-inch
$D_3 - D_4$ = 60 v (d.c.)/kilo-volt-inch



2509A5-C5

30-40 Mc Receiver

(*Continued from page 25*)

first a-f tube. Operating under a no-carrier condition the grid of the first audio tube is biased beyond cut-off, thus effectively silencing the audio output of the receiver. A small negative shift in a-v-c voltage produces approximately a 40 times shift at the plate of the d-c squelch amplifier in the positive direction. A portion of this shift is applied to the grid return of the 7C6 audio tube. The shift is limited by the diode to a value which permits only a very small grid current to flow and the first audio tube operates as if the 10 megohm grid-leak were returned to the cathode. The sensitivity of the squelch circuit is such that the audio channel may be held inoperative with no signal, and be entirely opened by a signal of less than 1 μv, or if set to reject signals below three microvolts the circuit may be entirely opened with an input of 3.5 μv. Due to the protection afforded the a-v-c circuit by the noise silencer, the squelch circuit remains relatively insensitive to ignition noise.

Low-pass Output Filter

The inclusion of a simple low-pass output filter, having a cutoff frequency of 5,000 cps, increased the usable sensitivity of this receiver by a factor of two to one. This result is reasonable when it is considered that the random noise output of a wide band receiver does not cut off at 3 to 5 kc as in the case of the more conventional narrow band unit, but extends to possibly 25 kc before being appreciably attenuated by the selectivity of the i-f amplifier. The importance of this high frequency noise output is greatly increased by the rising impedence characteristics of the usual output transformer-speaker combination. Inclusion of this type of filter serves to minimize one of the principle disadvantages inherent in broad band i-f amplifier receivers.

Power Requirements

It is usually desirable to hold the power consumption of a mobile receiver to a minimum without sacrificing performance. The type KU-R receiver draws 5 amps. from a 6-volt battery, which is moderate when it is considered that twelve tubes are employed. Power savings not common in usual practice were effected by the following points.

1. The power consumed by the B supply will be roughly proportional to the square of the B supply voltage. The item which usually dictates the required B voltage is the required audio output. By mounting the loud speaker separately, at approximately ear level, intelligibility is greatly increased and much less audio output is required. An output of 500 mw used in this manner appears to be adequate and is readily obtained with a plate voltage of 150.

2. The use of sharp cutoff r-f and i-f amplifier tubes as previously discussed accounts for further saving.

3. Tubes having 0.15 amp. heaters in place of 0.3 amp. heaters are used wherever suitable tubes of this type are available.

A slight sacrifice in primary power consumption was made in the selection of a tube type rectifier in place of a self rectifying vibrator. It was felt that this was more than offset by elimination of an occasional complication arising from the variety of battery polarities encountered.

Space for power components was reduced and added simplicity effected by the use of a resistor-capacitor filter in place of the usual iron core choke arrangement. The drop in the filter resistor is used as bias for the audio power-output tube. Since the compact arrangement of all circuits in this receiver necessitates complete isolation filtering these added filters are, where necessary, designed to augment the simple basic power filter.

It should be noted that even though the vibrator power supply is an integral part of the receiver unit, only the most conventional r-f filtering is required for noise-free power supply operation. The noise silencer serves to remove the vibrator interference which, by radiation or otherwise, may escape suppression in the power supply r-f filter. This reliance on the noise silencing circuit to cover an additional function results in a saving in space and greater freedom in mechanical layout.

Editor's note.—Regarding this method of indicating sensitivity, the authors state, "an unmodulated 1 μv signal is fed into the receiver and the noise output measured. Then the input is modulated 30 percent and a second reading taken. This reading will be approximately 3 times the first. Now the input is increased to 1.4 μv and the two readings taken again. These readings will be 4 times the first set."

NEWS OF THE INDUSTRY

Year-end summary by Institute of Radio Engineers shows that 1941 was another banner year with 14 million radio receivers made. Government services need men; allocation of funds to Signal Corps

Military Needs Radio Men

BOTH ARMY AND NAVY are clamoring for experienced radio personnel. For some time the Navy has been enlisting recruits to operate and maintain the important aircraft locater used so successfully in Great Britain. Here it is known as the Radar, and for military reasons, its principle of operation is not divulged. Men trained in its use, however, are assured of an interesting and useful occupation in the defense effort.

At the moment 5000 men are needed for the Radar. These must be high school graduates, and must either be or have been experienced amateur operators or be experienced radio service men. Upon enlistment in the United States Navy Reserve as Class V-6 with rank of Radiomen, Second Class, base pay $72 per month, the men will undergo extensive training before assignment.

In the anual report of the Chief of Naval Operations, Admiral Harold R. Stark this month stated that of the 903 officers in the Naval Reserve, 653 are now on active duty and of approximately 7,000 enlisted men, 5,277 are now in active service.

Signal Corps, too, is looking for qualified radio amateurs between ages of 18 and 35, unmarried and in good physical condition. Other amateurs who are disqualified by age, dependents or minor physical disabilities are needed to serve in a civilian capacity in Army radio stations, thus releasing enlisted personnel for active military duties.

Licensed radio amateurs had another opportunity to serve their country when Federal Security Administrator Paul V. McNutt called upon them to apply at State employment offices for free training in marine radiotelegraphy. Some 1,500 new radio operators will be needed during the next two years to man ships now being built for the merchant marine.

Record Production of Broadcast Receivers

THE YEAR 1941 just closed, set another record for annual receiver production, topping the record-breaking figure of last year by some 2 million units. According to a year-end summary of production made by the Institute of Radio Engineers 14 million receivers for reception of broadcast signals were manufactured. The majority of these were low-priced table-model sets. Although much of the productive capacity which made such manufacturing possible will be shifted to other lines during 1942, the evidence points to the tremendous productive capacity that is available for making any sort of radio equipment which can be produced on a production line. The detailed breakdown of the year's production will be found in the table below.

Comparison of 1941 output with that of other years is given in the following table:

Year	Number of receivers
1941	13,800,000
1940	11,831,000
1939	10,760,000
1938	7,142,000
1937	8,065,000
1936	8,248,000
1935	6,026,000
1934	4,556,000
1933	4,157,000
1932	2,444,000
1931	3,594,000
1930	3,838,000
Prior to 1930	15,000,000

New DCB Set-up for Communications

In a move to coordinate handling of strategic materials and metals for the communications industry, the Defense Communications Board and OPM have outlined their respective responsibilities. OPM establishes a Communications Branch and is to have all responsibility for implementing and processing the policies recommended by the DCB.

Two, at least, of the new key officials involved in the new setup have communications backgrounds. Leighten H. Peebles is slated to be appointed as the head of the new Communications Branch. He is an engineer with experience with General Electric and J. G. White, with whom he supervised the construction of the high-power long-wave radio stations operating at Belmar and New Brunswick, N. J., Hawaii, Chatham and Marion, Mass., and Bolinas and Marshall, Calif. During NRA he was deputy Administrator in charge of the telephone and telegraph codes.

One of the liason officers between OPM and DCR will be George J. Dempsey, with the FCC since 1935 in common carrier division. Mr. Dempsey has had long experience in the Bell System, with the Signal Corps and in telephone regulation in the Interstate Commerce Commission. Two other DCB engineers are yet to be appointed. All three will report to E. K. Jett, Chief Engineer, FCC, and to Mr. Peebles.

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BROADCAST RECEIVER PRODUCTION FOR 1941 ESTIMATED FROM FIRST NINE MONTHS OF YEAR

Type	No. of Units	Retail Dollar Volume	Average List Price	% of Unit Volume	% of Dollar Volume
Radio Receivers, table models	6,100,000	$108,000,000	$17.70	44.3%	24.65%
Radio Receivers, consoles	640,000	46,500,000	72.70	4.64	10.60
Portable Sets	1,660,000	42,800,000	25.70	12.05	9.76
Automobile Sets	3,040,000	111,000,000	36.50	22.10	25.30
Farm Battery Sets	790,000	20,900,000	26.40	5.74	4.77
Radio-Phono Comb.					
table models	548,000	21,600,000	39.40	3.98	4.93
console	416,000	61,800,000	148.00	3.02	14.10
Radio-Phono-recorder	53,000	7,100,000	134.00	.38	1.62
Record players	186,000	4,750,000	25.50	1.35	1.08
Chassis without cabinets	330,000	13,700,000	41.50	2.39	3.13
FM adapters	9,000	360,000	40.00	.06	.08
TOTAL*	13,772,000	$438,510,000	$31.80	100.	100.

DCB Rules on Alien Visitors

Procedures necessary when aliens wish to visit plants in which communications materials are either manufacturered or used have been laid down by the DCB. Permission must be obtained from the War or Navy Departments or from the Office of Scientific Research and Development according as to the nature of the work going on in the plant concerned. Permission is granted after inspection of papers of the aliens desiring entry to plants. Papers required are representations from high diplomatic officials of the alien's country, showing the reason for the visit, what the visitor desires to see and what use is to be put to the information secured. These documents are to be forwarded to DCB together with statements from the company involved.

New Funds for Communications

A FUND OF $239,000,000 for the Signal Corps was approved by the House Appropriations Committee December 3 in the Third Supplemental National Defense Appropriation Bill. This money would be used for the needed equipment for 8 aircraft warning regiments, 8 aircraft warning battalions and other units. This is in addition to appropriations previously secured. One objective of these new funds would be to expand the aircraft warning units by 765 officers and 16,750 enlisted men. About $3,000,000 is needed for new radio manufacturing facilities, according to Brigadier General Albert Brown of the General Staff.

Navy has also presented proposals for additional funds for communication equipment on commercial ships, for direction finding and locating ships by radio beams and for fleet training equipment.

The first meeting of the Civilian Technical Advisory Board of the Chief Signal Officer of the Army occurred on December 1. At that time Major General Dawson Olmstead stated that with the first two supplemental appropriations, the Signal Corps had been granted over one and one-quarter billion dollars for expenditure. At the time of this meeting the Signal Corps had approximately 3,800 officers, 40,275 enlisted men and 10,000 civilian employees with an additional 1,128 officers and 26,205 enlisted men authorized in pending legislation.

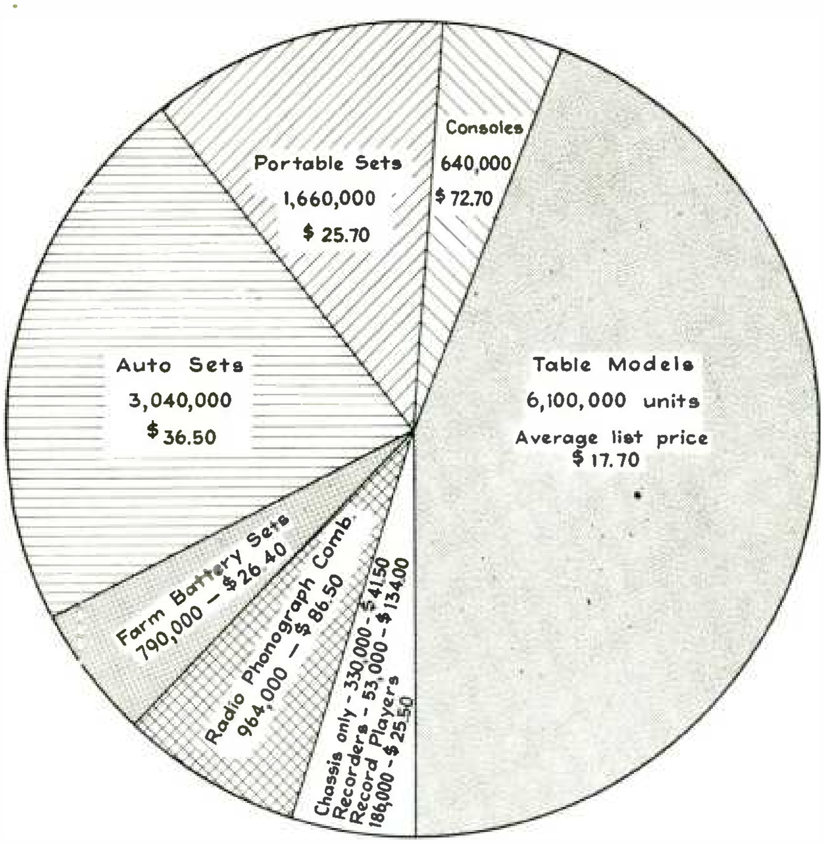
SIGNAL CORPS AWARDS

Contracts awarded ($50,000 and over) for radio apparatus since December 1.

Concern Receiving Award	Item	Amount
RCA Mfg. Co.	Radio equipment	$947,389
Hammarlund Mfg. Co.	Receivers	49,243
Bendix Radio Div.	Radio parts	695,302
Belmont Radio Corp.	Receivers and parts	74,261
Amperex Electronic Pro.	Tubes	553,250
Westinghouse E & M Co.	Tubes	580,000

1941 Broadcast Receiver Production

13,772,000 Units — $438,510,000 Retail Dollar Volume



NEW PRODUCTS

Month after month, manufacturers develop new materials, new components, new measuring equipment; issue new technical bulletins, new catalogs. Each month descriptions of these new items will be found here

High-Gain Antenna

A NEW TYPE OF ANTENNA, known as High-Gain, has been announced by Jefferson-Travis Radio Mfg. Corp., 380 Second Avenue, New York, N. Y. The unit provides improvement in transmitter range and receiver performance

when used in conjunction with radio communication equipment on all types of military and commercial mobile vehicles and on boats. The manufacturer states that its advantages are that it permits a shorter or lower antenna to be used without loss of operating efficiency, and it provides greater efficiency when it is the same height or length as would be a conventional type antenna.

The basic element of the antenna is its tuning coil assembly, which consists of a weatherproof high Q coil enclosed in a metal shield. This is surmounted by a short whip. Flexibility of mounting is provided by a base stud, by means of which the tuning coil assembly can be supported on a tubing or pipe of appropriate length. The assembly may also be supported on a base insulator and wire used in place of the whip as the "radiator" portion of the antenna.

The tuning coil assembly provides an accurate means of matching the transmitter to the antenna at the operating frequency. This resonant antenna tends to eliminate extensive power losses which may occur through application of loading introduced within the transmitter itself to compensate for lack of antenna length.

While greatest operating efficiency with the antenna is experienced when it is tuned to a single frequency, improvement is also evident on adjacent frequencies within a narrow band, as for example 2100 kc to 2800 kc in the marine frequency range. Dead spots and directional effect are reduced and coverage is increased. Receiver operation is also improved, since the antenna is tuned, and signal to noise ratio is increased.

Checker for Industrial Tubes

A SELF-CONTAINED TUBE CHECKER (known as Universal) for industrial type electron tubes has been announced by Weltronic Corporation, East Outer Drive, Detroit, Mich. The instrument is provided with seven sockets and may be used to check many well-known make and type of industrial tubes, except ignitrons. Special tubes may be checked through the use of socket adapters. Vacuum tubes can be checked with a milliammeter, which is provided. The checker provides, through a one-inch cathode-ray tube, a visual analysis of plate current.

Checks which can be made on the Universal include: Thyratrons—wave form, break-down point in cycle, and

grid control; mercury rectifiers—current wave form and plate current; high vacuum rectifiers—current wave form, and plate current; high vacuum control tubes—wave form, plate current, and grid control; full-wave rectifiers (2 plate)—wave form and plate current on each half, individually.

The instrument is provided with adjustments for intensity, horizontal and vertical amplitude, and focus for the oscilloscope. It is housed in a black crackle-finish box and has a sloping control board. The unit which comes with a 6 ft. cord is semi-portable and its construction lends itself to shop and laboratory checking of tubes. It operates on 110 to 120 volts, 60 cps.

Blackout-Panel Oscillograph

ALLEN B. DUMONT LABORATORIES, INC., Passaic, N. J., announce a new black-out-panel Type 208 oscillograph which

can be used under adverse lighting conditions or in total darkness when necessary. The specially processed steel panel is treated with a non-radioactive luminous paint that retains its maximum luminosity for several minutes after exposure to ordinary light, and can be observed for an hour or more after that. The glow is of the same color and intensity as the standard medium persistence screen of the cathode-ray tube used. The black-out panel is an optional feature in Type 208 oscillograph.

Multiplier Transformer

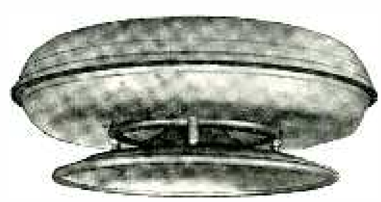
A POWER TRANSFORMER designed for use with the RCA 931 electron multiplier tube by The Kenyon Transformer Co., Inc., of 840 Barry St., Bronx, New York, is known as type T-211. Primary handles 0/105/115/125 volts at 60 cps. High voltage secondary delivers from 100 to 1000 volts r.m.s. in steps of 100 volts at 10 ma. Low voltage secondary supplies 2.5 volts at 1.75 amperes. Case is Kenyon's standard 4A.

Adjustable Resistor Contact

POWER WIRE WOUND RESISTORS of the adjustable variety above 25 watts, made by the International Resistance Co. of 401 N. Broad St., Philadelphia, Pa., are now made with new contact bands designed to prevent breakage of wire by excess tightening and also to resist contact corrosion. Silver contact buttons are mounted on heat-resistant stainless steel springs spot-welded to the bands in such a manner that button pressure on the wire remains constant regardless of clamp tightening. The new bands may, if desired, be obtained separately in $\frac{9}{16}$, $\frac{3}{4}$ and $1\frac{1}{8}$-inch diameters.

Cone Speaker Projectors

A COMPLETELY NEW LINE of radial cone speaker projectors designed for uniform sound projection in all directions has been made available by University Laboratories, 195 Chrystie Street, New York, N. Y. The model RBP radial projectors have pleasing appearance and compact construction of the flat



ceiling type speakers and good tone quality. An "infinite baffle" sealed acoustic chamber gives added bass response. Other features are: a flat top design which is suitable for ceiling or single suspension mounting, the unit is waterproofed for outdoor use, it is of all steel construction with "floating rubber" speaker mounting and "non resonant" rubber rims. The instrument is especially useful for music reproduction in factories. It is available for 12 and 8 inch cone speakers.

Armored Power Rheostat

TO WITHSTAND exceptionally hard usage, particularly where units must be exposed, an armored type power rheostat rated at 25 watts and available in standard resistance values of from 1 to 5000 ohms is made by Clarostat Mfg. Co., Inc., 285-7 N. 6th St., Brooklyn, N. Y. Mounted in a perforated metal housing, the rheostat has flat lug terminals at the rear of its casing, while the front face has an ear or locking pin which engages in a hole or indentation in the panel or mounting surface, preventing the entire unit from turning when single-hole mounted. Winding is imbedded in an inorganic cement over an insulated metal core in such a way that maximum heat dissipation occurs even when just a portion of the winding is in use.

Voltage Regulator

THYRATRON TUBE CIRCUIT CONTROL of a motor-driven variable voltage auto-transformer is the operating principle used in a new line of "Seco" automatic voltage regulators manufactured by Superior Electric Company of 34 Harrison St., Bristol, Conn. Regulators are available for use on 115, 230, or 440 volt circuits in capacities up to 75 kva., are designed to maintain a constant output voltage with variations in input voltage or load. Output voltage and sensitivity are adjustable over a wide range by means of controls on the front panel and regulators have the high efficiency and low exciting current characteristics inherent with the variable voltage auto-transformer. Response is rapid, with a full range travel time of 6 seconds. Operation is not affected by changes in power factor of load, nor does the regulator itself affect the power factor or waveform of the system to which it is attached.

Miniature Terminal Bushings

A NEW LINE OF MINIATURE terminal bushings, suitable for transformers, condensers, and similar applications in the radio and electrical industries, has been placed on the market by Isolantite Inc., 233 Broadway, New York, N. Y.

Bushings are supplied complete with hard copper tinned terminals and nickel-plated copper flanges. Flanges may be spun or eyeleted into $\frac{1}{16}$-inch or thinner metal panels and cases, according to the manufacturer. Terminals are slotted to accommodate leads, or leads may be soldered into center eyelets of terminals if desired. Insulator bodies are of glazed Isolantite. Bushings are supplied in two terminal lengths and two insulator lengths, making a total of four combinations. Full details of construction are given in Bulletin No. 104-A, available from the manufacturer.

U-H-F Transmitting Capacitor

ENGINEERED and designed for use in ultrahigh-frequency radio transmitters, television and FM transmitters, as well as in miscellaneous applications in the u-h-f range, a new Type 1860 transmitting capacitor is available from Aerovox Corporation of New Bedford, Mass. In such applications

this capacitor is adaptable for use as a fixed tuning capacitor, for by-passing, blocking, coupling and neutralizing, and as an antenna series capacitor. Losses are low because of a highly refined sulphur compound utilized as the dielectric, by the elimination of corona and by design and construction. The case is grounded and a single high-tension mica-insulated brass terminal is used. The aluminum case measures approximately 2x2½ inches, and is provided with a mounting base with 2 holes for 10–32 screws. The capacitor is available in .00001 and .000025 μf in 10,000 volts and .00005 μf in 5,000 volts.

Universal Bridge

NEW INSTRUMENT by Shallcross Mfg. Co. of Collingdale, Penna., is a combination Wheatstone and Kelvin bridge, model 638-1. It has an effective measurement range from as low as 0.0001 ohm to as high as 11,000,000 ohms and, by using a source of current of considerable capacity such as the single cell of a storage battery, will detect and measure as low as 0.00001 ohm. The rheostat arm consists of four decades, variable in 1 ohm increments. Ratio arm has two sets of multipliers, one set designated W for use in Wheatstone bridge measurements, the other designated K for use with the Kelvin measurement method. Built-in galvanometer having a deflection of 1 mm microampere is an integral part of the set. Instrument is furnished complete with all binding posts necessary for connection of resistances to be measured and batteries.

Metal Duplicating System

SMALL METAL PARTS may be made in limited quantities without dies with Di-Acro benders, brakes and shears. These precision machines are accurate to 0.001 inches.

The illustration shows three typical steps in this process. First, the man at the right is cutting strips from a stock sheet to the required size with the shear. Second, the operator in the center is forming a channel from the accurately sized strip with the brake.

Third, the man at the left is putting a bend on each end of the channel with the bender.

All three machines are adapted for either right or left hand operation. They are available from O'Neil-Irwin Manufacturing Company, located at 321 8th Avenue South, Minneapolis, Minn.

Molded Magnetic Cores

DESIGNED FOR ELECTRICAL, radio and high frequency use are new molded magnetic cores offered by The Ferrocart Corp. of America, Hastings-On-Hudson, N. Y. Typical cores include small pot types 0.485 inches outside diameter by 0.400 inside diameter and 0.215 high. Center core is 0.158 inch in diameter and 0.125 inch high. When the two are placed together a completely inclosed winding space is provided, 0.250 inch long and 0.120 inch high, may, for example, be used in the construction of high gain 455 kc i-f transformers of small size such as those employed in camera-type portable radios. Closed pots with movable center screw cores are also being produced.

Concentric Disc Resistors

CONCENTRIC DISC RESISTORS, now being supplied by International Resistance Company, 401 North Broad Street, Philadelphia, Pa., are designed for engineers faced with the problem of getting pure resistance loading of low power concentric transmission lines. The resistors are available in a variety of sizes and resistance values. They have a minimum of inductance and capacity and should prove useful in h-f measurement circuits, signal generating equipment and u-h-f devices now under development.

Microphotometer

A RAPID AND CONVENIENT METHOD for analyzing spectrographic plates or films in research and industrial laboratories is provided by a new recording microphotometer announced by Leeds & Northrup Company, 4934 Stenton Ave., Philadelphia, Pa. Plates or films are mechanically scanned by a motor-driven scanning unit and the relative positions and densities of spectrum lines are automatically recorded by an L&N Speedomax recorder. Pen and ink records of standard and test spectrograms are drawn at high speed on one chart. Designed to accommodate plates or films as large as 4 inches high by 10 inches wide, the scanning unit includes on a heavy cast base an optical system, a plate stage, a drive mechanism for the plate stage, an a-c operated amplifier and all necessary controls.

Conductivity Cell

ELECTROLYTE CONDUCTIVITY may be accurately determined through the use of a new fill-type conductivity cell with a constant of approximately 15, made available by Industrial Instruments, Inc., 156 Culver Ave., Jersey City, N. J. Known as type CEL-3, the cell is of resistance glass construction with platinum electrodes. It is used by placing the electrolyte in the body of the cell proper, connecting to the conductivity bridge by means of mercury placed in the connecting bulbs on each end, with connecting wires dipping into mercury pools. A thermometer, supplied, may be inserted in the electrolyte for temperature readings.

Fine Adjustment Rheostats

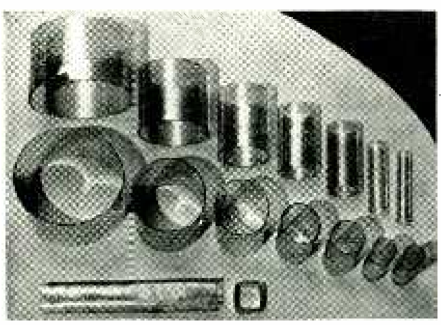
REX RHEOSTAT COMPANY, 37 West 20th Street, New York, N. Y., announce Fine Adjustment rheostats which enable any value of the current or voltage to be set as closely as possible within the controlling range of the rheostat. The smallest possible adjustment is from one turn of the resistance winding to the next, whether performed by hand or through means of a vernier drive or similar device. The degree of resulting variation depends upon the ohmic value of this one turn of the winding in relation to the ohmic value of the whole circuit. As more resistance of the rheostat is placed in the circuit, the finer the adjustment of the current becomes, and vice versa. This effect can be achieved over almost the entire regulating range of the rheostat. Two windings are arranged on the same tube; the wire of one winding for these rheostats has about five times the cross section area of the other winding serving for coarse adjustment. Through this method each turn of the coarse adjustment is divided into approximately five equal steps at the fine adjustment.

Fullwave Variable Transformer

LATEST ADDITION to the line of "Vari-tran" variable voltage transformers made by United Transformer Corp. of 150 Varick St., New York, is a full-wave type designed for use with low voltage rectifiers such as those employed in plating processes, battery charging and other similar applications. The new device obviates the necessity for a separate step-down transformer in such cases, since it has an insulated secondary provided with two contact arms moving in opposite directions each side of the center tap.

Lumarith Protectoid Tubing

A TUBING USEFUL TO THE electrical industry has been developed by Precision Paper Tube Company, 2033 West Charleston Street, Chicago, Ill., it is announced by Celluloid Corporation (180 Madison Avenue, New York, N. Y.) manufacturers of the cellulose acetate (Lumarith Protectoid is the trade name of the product) used in making the tubing. Spiral wound Lumarith Protectoid is available in round, oval



and square shapes, is produced from 1/16 inch to 3 inch (inside diameter) in varying wall thicknesses, and in continuous lengths that can be cut to required sizes as it emerges from the winder. Besides clear transparent, the tubing is also available with a paper or fiber base with an outside layer of Lumarith Protectoid. The electrical properties of this new acetate make it useful for cores for speaker field coils, in bobbins, for random wound ignition coils, spaghetti insulation for wire, protection for especially delicate metal parts such as micrometer handles, etc.

Coaxial Vertical Antenna

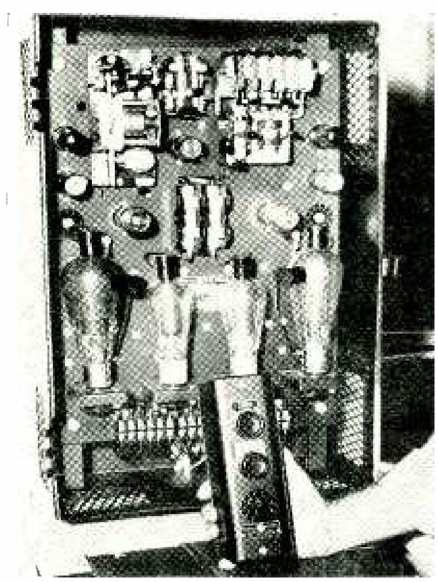
HALF-WAVE VERTICAL ANTENNA cut to specification for ultrahigh frequencies between 30 and 200 Mc., for use with concentric transmission lines and requiring no matching network or tuning are now available from the Wunderlich Radio Company, 1337 Fargo Ave., Chicago. Radiators consist of a 1/4-wave "whip" constituting the upper section, insulated from a 1/4-wave "skirt" constituting the lower section, with a short section of 3/8-inch concentric feeder carried through the skirt to the insulated, gas-sealed and weather-protected junction between the two furnished as part of the setup. Maximum radiated power in the ground plane plus simplicity and neatness of radiator installation are noted features. The antennas are suitable for either transmission or reception.

Flashlight Battery

A FLASHLIGHT BATTERY which can be recharged is available from Ideal Commutator Dresser Company, 1273 Park Avenue, Sycamore, Ill. Its main advantages are 1,000 hours or more of bright light with proper care; occasional charging at convenient periods and the addition of distilled water is all the care required; by extensive research, spillage and creeping corrosion have been eliminated; it is easy to add the distilled water; special light bulbs with lower voltage rating are used to give a more piercing light (both screw base and flanged fixed focus lamps are available); a-c chargers with a variety of voltages and frequencies, d-c chargers and automobile charger clips make recharging convenient.

Electronic Motor Control

DESCRIBED IN BULLETIN No. GED-927A, available from General Electric Company, Schenectady, N. Y., is a new electronic control system known as Thy-mo-trol. The system employs electron tubes to convert alternating cur-



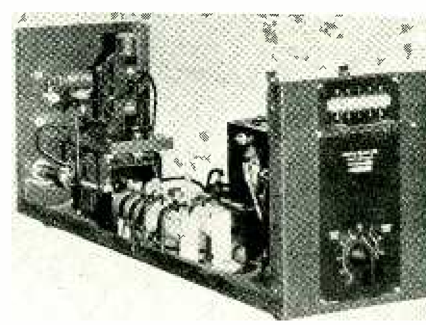
rent to controlled direct current thus providing variable armature and field voltages for operating a d-c motor. The system not only provides stepless, wide-range speed control, but also performs additional functions of starting, accelerating, protecting and stopping. Standard units are designed to cover motor sizes up to 5 hp at 230 volts.

Carbon Resistors

THE KEYSTONE CARBON COMPANY, 1935 State Street, St. Marys, Pa. announce that its line of negative temperature coefficient resistors are now available with metal coatings for making electrical connections, instead of the moulded-in wires previously available.

Magnetic Oscilloscope

A MAGNETIC OSCILLOSCOPE, which is a new peak-reading portable instrument, has been announced by General Electric Company, Schenectady, N. Y. The instrument was developed primarily for use in resistance welding, but it may be applied as a supplement to other instruments used in trouble shooting and in making installation adjustment, and can be used in checking operation of electronic controls, voltage regulation measurements, current measurements made with pointer-stop instruments, etc.



The oscilloscope has a high-speed response to both current and voltage, made possible by the use of a permanent-magnet type of oscillograph galvanometer. Magnitude, symmetry, and uniformity of current wave are revealed quickly by the length, position, and uniformity of a horizontal trace of light on the ground-glass viewing screen. A narrow light beam from an internal lamp impinges upon the tiny galvanometer mirror, the movements of which are reflected to the viewing screen. The instrument requires no reset time. A quick change from potential to current measurement is accomplished by turning a switch on the front of the box. The instrument is almost entirely free from magnetic field interference.

Mass Spectrometer

EXHIBITED RECENTLY at the Exposition of Chemical Industries was a new portable mass spectrometer for gas analysis and continuous process control work. This is a new product of Westinghouse Electric and Mfg. Co., East Pittsburgh, Pa. Essentially a high vacuum tube in which the gas to be studied is admitted under a pressure of 10^{-4} mm of mercury and ionized by an electron beam, the spectrometer is capable of measuring as little as 0.001 per cent oxygen in nitrogen.

Literature

Radio Noise Suppressors. Catalog 12-F describes "Elim-O-Stat "radio noise suppressors manufactured by Solar Mfg. Company, Bayonne, N. J. Three different types of suppressors are described: Types R are for use with receivers and also with appliances; Types A are for use with appliances only; and the others are miscellaneous types.

Selenium Rectifiers. A 16-page booklet available from International Telephone & Radio Mfg. Company (67 Broad Street, New York, N. Y.) is devoted to selenium rectifiers for use where direct current is required from an a-c source, from milliwatts to kilowatts.

Capacitor Analyzers. Six different types of capacitor analyzers are described in Catalog 12-G available from Solar Mfg. Company, Bayonne, N. J. Some replacement parts and optional accessories for analyzers are also listed.

Aircraft Receiver. Available from RCA Manufacturing Company, Camden, N. J. is a bulletin which describes Model AVR-100 beacon and broadcast band receiver, and Model AVR-101 beacon band receiver. Both receivers are for light planes.

Transformer Case Specs. A new folder prepared by Acme Electric of Cuba, N. Y., contains line-drawings showing the physical sizes, shapes and mounting arrangements of transformer cases recommended by this firm to manufacturers ordering special units for radio, television, control, industrial and other applications.

Ceramic Insulation. American Lava Corporation, Chattanooga, Tenn., have available a reprint which contains previously unpublished material on the electrical properties of high frequency ceramics. This material has been reprinted from *Electronic Engineering*, a British publication.

Radio Tube Handbook. National Union Radio Corp., 1181 McCarter Highway, Newark, N. J., have issued a new radio tube handbook which supplements their engineering data book. It costs ten cents, and contains information on over 600 tube types.

Erratum. It was announced in the November issue that a new catalog on precision metal shielded wire was available from Precision Tools Company. This should have read Precision Tube Company, 3824 Terrace Street, Philadelphia, Pa.

Common Misapplications

(*Continued from page 46*)

3. A decrease in arc-back rate is often found after a period of "seasoning" or operation.

The first two affect the building-up of the incipient arc-back to a stable form and the third indicates the removal of the causes or patches.

The above rather sketchily outlined theory again shows how the peak inverse voltage may not be the only factor defining the difficulty of a duty imposed on a given tube. A rating to cover this phenomonon has not as yet been devised. It would have to define and limit the rate of rise and the magnitude of the current which the circuit can deliver to an arc-back.

Since these quantities are not directly connected with any of the functions the tube performs when operating properly, they are difficult to define by a tube rating.

The problem is usually solved by making the rating tests in the type of service in which the tube finds its most popular use. For this reason, it is desirable for the intended user of the tube in an unconventional circuit to confer with the tube manufacturer before making a final choice of a tube.

Influence of Grid Circuit on Thyratron Stability

There have been a number of applications where trouble due to erratic thyratron operation has been reported. In a large percentage of cases, especially where extremely low grid power was not a factor, very reliable operation has been secured simply by alteration of circuits or circuit constants.

Very often, too high a positive potential is applied to the grid of a thyratron. The ratings usually call for maximum grid potentials of about 12 volts. This is intended to prevent the grid assuming the role of an anode and drawing currents from the cathode. In small size tubes, this additional current may be an appreciable percentage of the total cathode current resulting in cathode overloading. Another effect is that of increased grid temperature which may result in loss of control. The most serious effect, however is that it permits ionization within the tube at a time when the anode may be negative with respect to the cathode.

One example of this is shown in Fig. 2-a, where the grid potential is alternating and the firing point is determined by shifting the phase of the grid potential with respect to the anode potential.

It will be noticed that when the tube is caused to fire late, the grid potential may be positive and thus be producing ionization in the tube at the very time when the tube should be deionized, and, in a condition to withstand reverse voltage. This increases the probability of occurance of arc-back, especially on the high voltage circuits. A conventional method of preventing arc-back is to employ a large enough value of grid resistance to limit the amount of ionization on positive grid swings. This is far from a satisfactory method, however, and usually results in the use of much higher grid resistance than would normally be necessary.

Another method is to connect a copper oxide rectifier in the circuit as shown in Fig. 3. This prevents the grid going positive with respect to the cathode, but at the same time permits the use of a grid swing of high magnitude. The result is more precise control.

The best way to prevent arc-backs due to ionization from positive grid current is to use a peaked wave transformer which makes the grid potential positive for only a small fraction of a cycle. This potential should preferably be superimposed on a fixed negative d-c bias. In this case, conditions are as shown in Fig. 2-b. Here the grid potential is positive only when the tube is passing current and no grid produced ionization is present in the tube when the anode is negative.

Certain circuits, especially those employing high values of grid resistance show a lack of stability. An explanation of one of the common causes of instability follows:

In Fig. 4-a a thyratron circuit is shown; Fig. 4-b shows schematically the equivalent grid to anode capacity C_{pg} and the grid to cathode capacity C_{gf}. In parallel with C_{gf} is the biasing voltage E_g. In series with the grid resistor R_g. If the anode cathode voltage E_p should increase with a steep wave front, the voltage e_g of the grid tends also to increase. This tendency is opposed by the battery voltage. If the resistance in the grid circuit is too high the effect of the battery is minimized and the grid voltage may momentarily rise to a high enough value to cause breakdown.

The obvious cure is to reduce the value of grid resistance to a minimum consistent with the published grid current rating. Such a cure is applicable, however, only in the following types of application: (1) where limitations in grid driving power do not dictate the value of grid resistance, and (2) where means are used to prevent high positive grid swings.

In addition to a low value of grid resistance, a condenser should be connected between grid and cathode. This condenser serves to by-pass transient grid currents. The value of capacity employed should be as large as possible, the exact capacity being determined by the particular circuit requirements.

While these suggestions to improve stability are not possible in certain applications, there are a large number of installations where more than sufficient grid power is available, and the operating frequency is low enough to allow the use of a large value of grid by-pass capacity.

Where extremely high values of grid resistance are necessary and no by-pass capacity is permissible, the use of a shield grid thyratron is suggested.

Influence of Cathode Return Circuits (Direct Heated Cathodes)

The grid biasing effect due to the cathode potential is often overlooked in the application of a thyratron. This effect may be demonstrated by the following experiment. Consider first, the effect produced by the cathode potential with the anode and grid returned to one side of the cathode. Assume the anode phase and filament phase of a given polarity. A certain value of critical grid bias is determined. Now, if the cathode phase is reversed, the bias value changes by a value approximately equal to the cathode potential. Connection to the center tap minimizes this effect, and, in addition, is desirable from the standpoint of more complete utilization of the complete cathode surface. This results in increased life, especially with d-c anode supply. For a-c anode supply, an approximate quarter-phase relationship between anode and cathode supplies is the ideal. In practice, this is seldom used, except for comparatively large tubes.

At times, an attempt is made to operate a thyratron at characteristic values of anode potential requiring very low values of grid bias. Study of Fig. 5 will show that with a tube using a directly heated cathode and centertap return, it is never advisable to operate with a negative grid bias which is less than 0.7 E_f. From Fig. 5, it will be seen that as soon as the bias voltage is reduced to a value less than half the peak cathode potential, the grid circuit acts like miniature full-wave rectifier.

When the filament phase is such that the end a is positive with respect to the center tap o current flows through R_g in the direction shown. When the end b is positive, the current flows again through R_g in the same direction. The result is a full wave rectified current flowing in the grid resistance which biases the grid negatively thus requiring the addition of more positive bias. The magnitude of this bias depends on the potentials involved, the value of grid resistance, and the emissivity of the cathode, especially near the end sections. The result of the developed grid potential is a flattening out of the characteristic curve at values of bias less than the critical value of 0.7 E_f described. The nature of the effect is to make this portion of the characteristic curve, (i. e., the flat portion) unstable. Furthermore, individual tubes may vary considerably in bias characteristic and starting potential, at values below this critical value.

Influence of Cathode Return Circuits (Indirect Heated Cathodes)

Tubes employing indirectly heated cathodes should have the anode and grid returns made directly to the cathode. This statement seems almost superfluous, yet it is surprising how many instances have occurred where the effects of improper returns were either not known or disregarded.

The most common practice in indirectly heated cathode design is to connect one side of the heater internally to the cathode. If the cathode returns are made to the opposite heater leg or to the transformer centertap, the following effects may be experienced:

1. Change in bias potential by as much as, ± 1.4 E_f. This change is apparent when the phase of either the anode or cathode is altered. The effect is largest when the return is made to the free heater leg.

2. When the grid bias is reduced to a value less than 1.4 E_f, high grid current may occur as the grid actually assumes a positive potential with respect to the cathode.

3. Possibility of heater burnout, especially in multitube circuits of large capacity. The anode current, especially during surges having a steep wave front, tends to flow through the heater to return to the cathode. This current may add to the normal heater current to such a degree that the additional temperature resulting causes burnout.

The cure for these troubles is to connect the grid and anode returns to the cathode.

Practically all gaseous conduction tubes employ glass in one form or another. The use of glass does not necessarily greatly impair the ability of a device employing such material from withstanding shock. Precautions must be exercised to prevent subjecting the glass parts to undue shock or strain.

Incorrect Mechanical Design of Equipment

Common sense is probably the best guide in installing tubes, yet there have been a number of cases where even that was disregarded.

A list of don'ts will be given as a guide to insure against loss of tubes through mechanical difficulties.

1. Don't mount the tube and socket without cushioning if the tube is subjected to shock or vibration.

2. Don't clamp the base of the tube unless it is clamped at a point near the bottom of the base. Use a minimum of clamping pressure.

3. Don't allow extremely hot or cold substances to come in contact with glass parts.

4. Don't subject the bulb or connection to strain. Use flexible connectors and holders.

5. Don't operate a newly installed hot cathode mercury tube until the mercury has been driven from the upper section by cathode heating.

6. Always operate a mercury-filled tube base down.

7. If the tube temperature is not controlled, permit a free circulation of air around the tube.

The impression, which may be left after reading this paper, is that electronic tubes are unreliable, cranky and difficult to apply. However, the real purpose of the paper is to show that with the proper consideration of the many factors involved in applying an electronic tube, excellent tube life and satisfactory performance can be obtained.

It is felt that a good many equipment designers and users, have not considered all of the factors which make for good tube life and dependability. The hope is expressed, that bringing definite examples of improper application to the fore, may result in a general improvement of tube performance in the field.

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RCA Manufacturing Company, Inc., Camden, New Jersey

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