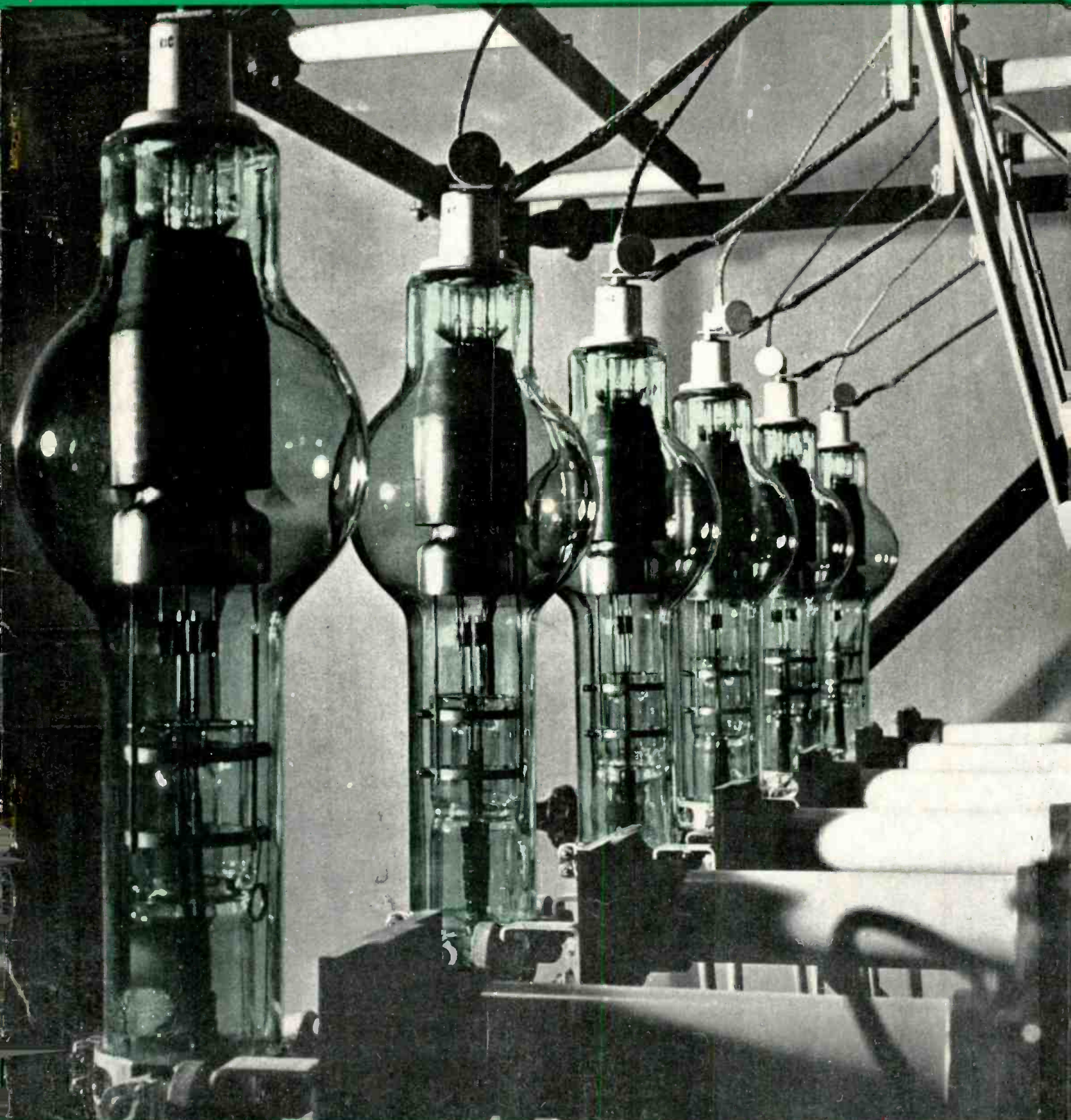
# RADIO

JANUARY, 1945

**Design • Production • Operation**



**The Journal for Radio & Electronic Engineers**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In their design considerations leading Tube Manufacturers are now specifying MYKROY because it provides the ideal combination of essential insulation characteristics . . . *low-loss — dimensional stability — high strength and heat resistance.*

Through advanced engineering ideas utilizing improved materials and better techniques, modern radio tubes achieve a high degree of efficiency. Complete vacuums within the tubes provide the perfect low-loss inter-electrode insulation; externally, however, insulation of lower dielectric properties is often used, considerably reducing tube efficiency.

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*Write for full information today. Ask for your copy of the MYKROY Bulletin #104 — containing the scientific facts about this vastly improved Radio Tube Insulator.*


**MECHANICAL PROPERTIES***

| | |
|---|---|
| MODULUS OF RUPTURE | 18000-21000psi |
| HARDNESS | Mohs Scale 3-4 BHN. BHN 500 K9 Load. 63-74 |
| IMPACT STRENGTH | ASTM Charpy .34-.41 ft. lbs. |
| COMPRESSION STRENGTH | 42000 psi |
| SPECIFIC GRAVITY | 2.75-3.8 |
| THERMAL EXPANSION | .000006 per Degree Fahr. |
| APPEARANCE | Brownish Grey to Light Tan |

**ELECTRICAL PROPERTIES***

| | |
|---|---|
| DIELECTRIC CONSTANT | 6 5-7 |
| DIELECTRIC STRENGTH (⅛") | 630 Volts per Mil |
| POWER FACTOR | .001-.002 (Meets AWS L-4) |

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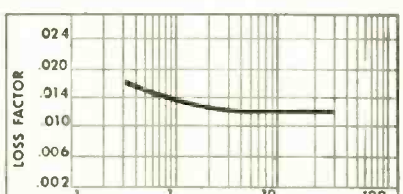
GRADE 8. Best for low loss requirements.
GRADE 38. Best for low loss combined with high mechanical strength.
GRADE 51. Best for molding applications.

Special formulas compounded for special requirements.




Based on Power Factor Measurements made by Boonton Radio Corp. on standard Mykroy stock.

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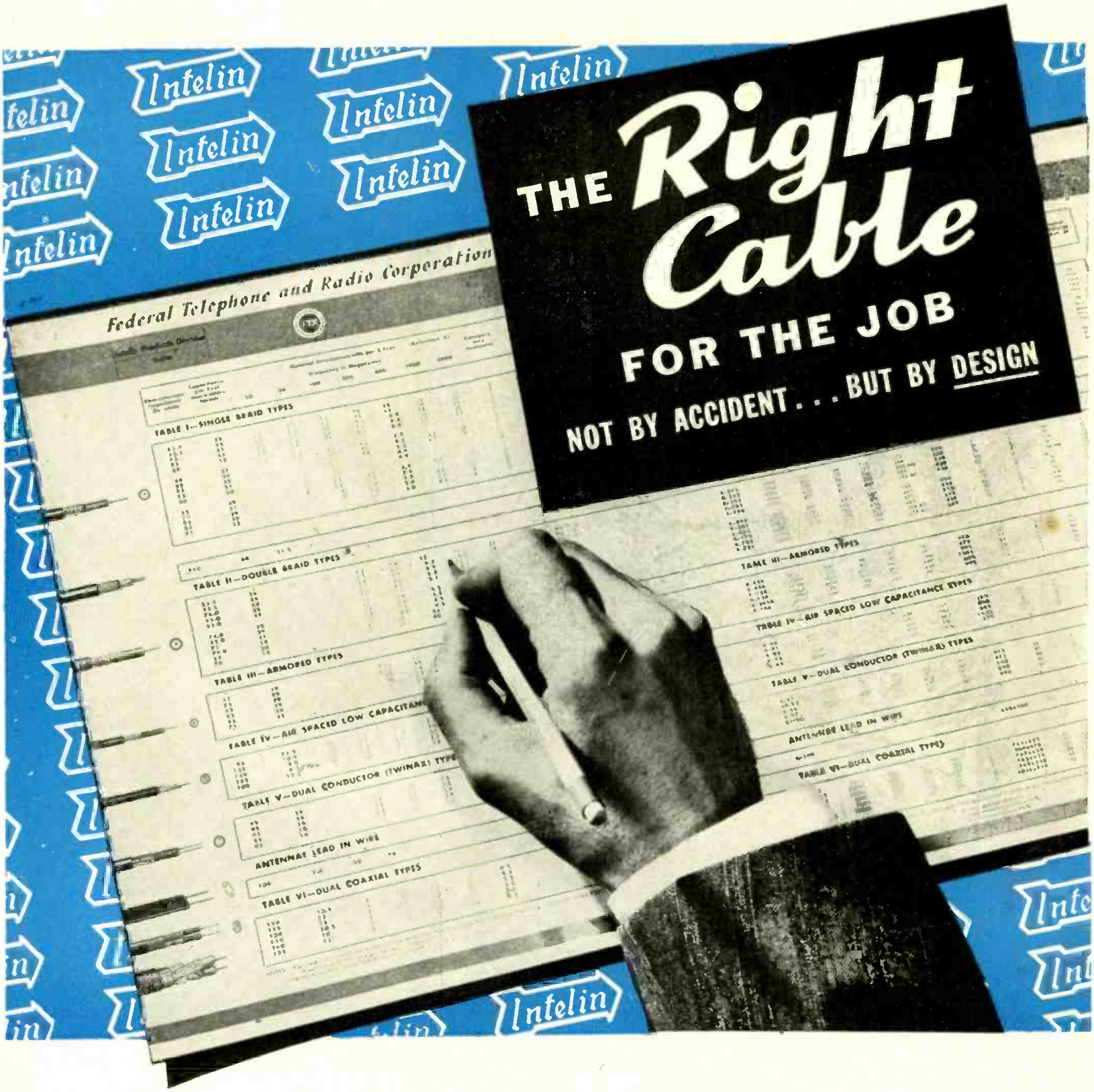


To assist the equipment designer Federal offers comprehensive data on high frequency cables.

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# RADIO

Published by RADIO MAGAZINES, INC.

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Sanford R. Cowan . . . . . . . . . Publisher

JANUARY 1945 Vol. 29, No. 1

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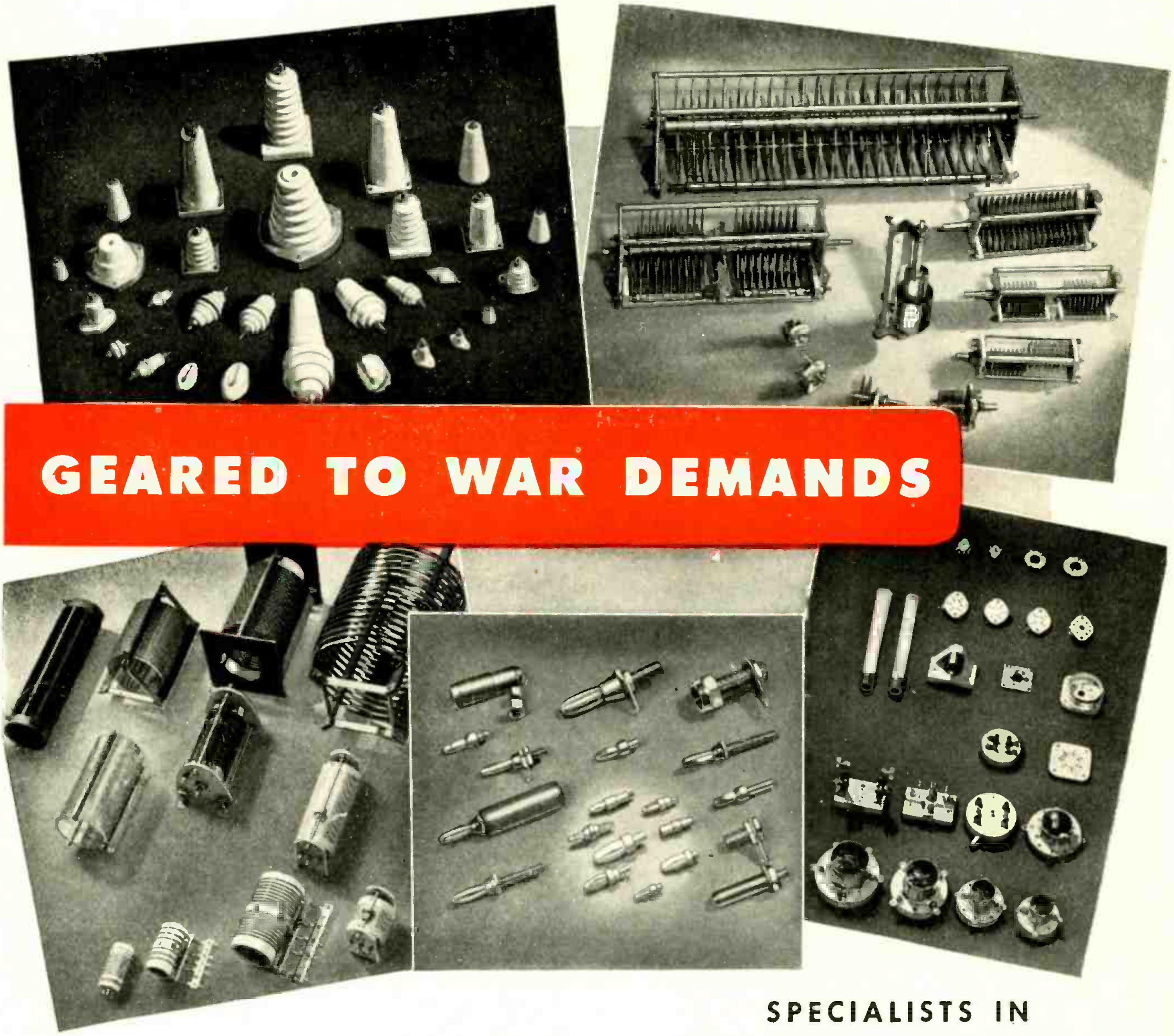


# Transients

## FCC PROPOSED FREQUENCY ALLOCATIONS

★As we go to press, we learn that the FCC has just issued its report on proposed frequency allocations for bands from 25,000 to 30,000 kc as tabulated below:

| | |
|---|---|
| 25-30 mc. | Fixed and mobile operations |
| 30-40 | Fixed and mobile operations, except for aeronautical services. |
| 40-42 | Fixed and mobile operations. |
| 42-44 | Fixed and mobile operations, except aero nautical, and to be used temporarily by FM |
| 44-50 | The No. 1 television channel |
| 50-60 | Amateurs 50-54, and television channel No. 2 from 54 to 60 |
| 60-84 | Television, channels 3, 4, 5 and 6. |
| 84-102 | FM |
| 102-108 | Not allocated. Reserved for future assignment to FM or other services. |
| 108-118 | Air navigation (dropping out former amateur band) |
| 118-132 | Aeronautical mobile service |
| 132-144 | Government |
| 144-148 | Amateur services |
| 148-162 | Police, fire, forestry and railroad services |
| 162-180 | Government services and navigation aids |
| 180-216 | Television, government services, and non-governmental fixed and mobile services. |
| 216-420 | Government and amateurs |
| 420-450 | Amateurs and air navigation |
| 450-460 | Air navigation, temporarily |
| 460-470 | Citizens radiocommunication service ("walk-ie--talkies") |
| 470-480 | Experimental facsimile broadcasting |
| 480-960 | Experimental Broadcast services, including television |
| 960-1125 | Navigation aids |
| 1126-1225 | Amateurs |
| 1225?1325 | Television relay experimentation |
| 1325-1450 | Government |
| 1450-1500 | Air navigation |
| 1500-1550 | Meteorological service |
| 1550-1650 | Experimental aerontautical mobile services |
| 1650-1900 | Government |
| 1900-30,000 | Governmental and non-governmental services |

If approved, these allocations are to take effect after the war. A short period has been allotted so that those who wish to file objections to the report may do so, and undoubtedly some will. FM receives its usual kicking around, being deprived of its present band and moved upstairs to the 84-102 mc region, in defiance of the recommendations of panels 2 and 5 of the RTPB. The reason given is that the new band will eliminate sky-wave effects, and will provide more channels. Anticipating objections that this frequency shift will render obsolete most FM broadcast receivers now in service, it is pointed out that the RTPB recommendations for a wider band in the present segment would necessitate changes, too. The FCC standpoint seems to be that half a loaf is worse than none. And it would seem that the sky-wave effects present on lower frequency f-m bands should be certainly less objectionable than similar effects on equivalent television bands which are retained.

As for television, 12 channels below 225 mc have been proposed as at present, and an additional band between 480 and 920 mc is allotted for color and high-definition systems. This gives advocates of both schools of thought on the subject an opportunity to show what they can do. For television relay experimentation, the band from 1225 to 1325 mc has been chosen.

Amateurs are assigned the 144-148 mc band, part of the 420-450 band, and frequencies from 1125 to 1225 mc. These offer interesting possibilities for development.

Unquestionably the most interesting of all proposals is that assigning a band from 460 to 470 kc for "citizens radiocommunication service". It is intended that this band be used for such applications as two-way "walkie-talkie" service, for the doctor who wants to keep in touch with his office, for farmers and others who want to contact individuals at work in fields, and for the host of other applications of similar nature which immediately are bound to occur to any imaginative person.

For the hiker, camper, and others on the go, self-propelled or otherwise, the "walkie-talkie" should soon become a necessity, with but little encouragement from advertising copy-writers. For manufacturers of this type of apparatus, and for the hundreds of thousands of people employed by them, reconversion may become something to be longed for, not a specter of despair. And this applies likewise to the manufacturers of crystals, who have been wondering what may become of them in the postwar period, and to the host of makers of component parts who have viewed glumly the constant emphasis on high-unit-cost apparatus proposed for postwar marketing, with its inevitable low sales volume prospects.

Of course, the frequency band provided for "walkie-talkies" is relatively small, but it can be enlarged. The vital point is that, for the first time, unlicensed individuals may use radio apparatus to communicate with each other. Here, indeed, is an FCC action which transcends a purely routine function and becomes an act of statesmanship. For many it will appear almost as an act of Providence!

—*J. H. P.*

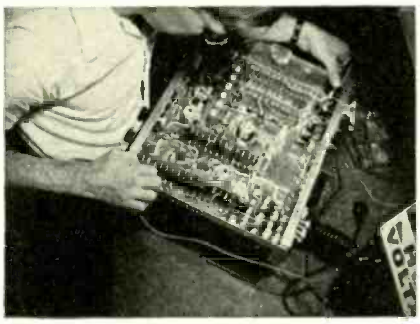
# SYLVANIA NEWS

## ELECTRONIC EQUIPMENT EDITION

JANUARY — *Published in the Interests of Better Sight and Sound* — 1945

## *Electronic Devices Broaden Sylvania's Service to Industry*

The manufacture of electronic equipment for certain specialized communications and industrial applications is an important phase of Sylvania service. Manufacture of this type of equipment is carried on in a separate Industrial Apparatus Plant located at Williamsport, Pa.



*An electronic device undergoes test in the laboratories of Sylvania's Industrial Apparatus Plant.*

This aspect of Sylvania's activities is a natural outgrowth of the company's intensive experience in the design and application of electron tubes.

### DID YOU KNOW...

That Sylvania Tungsten Lamps are standard equipment for signaling purposes on many telephone switchboards? They are made in a range of electrical characteristics for use in any type of switchboard.

* * *

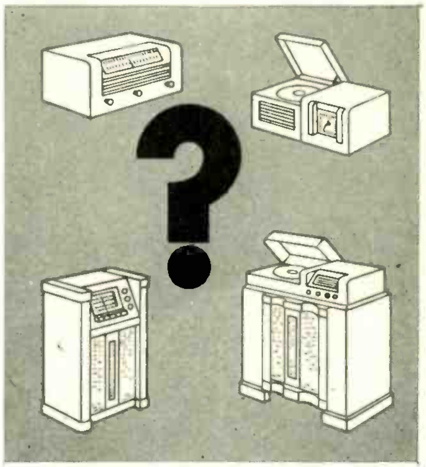
That Sylvania Near Ultra-Violet Lamps activate the fluorescent dials on airplane instrument panels? Lamps are small, compact, designed to operate from a 24-28 volt direct current source.

## Sylvania Begins Survey of Public Interest in Television Receivers

### *Findings Will Assist Manufacturers in Gaging Markets, Determining Price Range*

Thousands of personal interviews and an intensive advertising campaign in the pages of leading consumer publications form the twin phases of a comprehensive survey which Sylvania is launching to gage the interest of consumers in the purchase of television sets, and to learn the extent of the potential market for receivers in various selling price ranges. The results of this survey are expected to be of great value in guiding the planning of the manufacturers of television sets.

Television, moreover, is but one of the aspects which will be covered in this nation-wide poll. Consumers will also be queried on such points as their interest in FM; the desirability of short-wave bands; reaction to push button tuning. The reasons why people decide on new set purchases will also come in for scrutiny.



*The type of set people prefer—floor or table model, radio only or radio-phonograph combination – will also be studied in the Sylvania survey.*

As the survey progresses, findings will be reported from time to time in future issues of SYLVANIA NEWS.

### *LOCK-IN TUBES IDEAL FOR UHF*

The trend toward the use of ultra-high frequencies brings to the fore the outstanding advantages of Sylvania's Lock-In Tubes. While the name of this line of tubes has tended to emphasize the physical details of mounting, one of the chief motivating forces in their design was the desire of Sylvania engineers to improve the electrical characteristics of tubes, particularly at the higher frequencies.

The Lock-In feature itself has been responsible for the extensive use of these tubes, particularly in automobile radios; electrical features point to wide utilization in television and FM.

**SYLVESTER SURVEY**

*"I wonder if I could have your views on what the postwar radio will be like."*

# SYLVANIA ELECTRIC

SYLVANIA ELECTRIC PRODUCTS INC., *Radio Division,* Emporium, Pa.

MAKERS OF RADIO TUBES, CATHODE RAY TUBES, ELECTRONIC DEVICES, FLUORESCENT LAMPS, FIXTURES, ACCESSORIES, INCANDESCENT LAMPS

# TECHNICANA

## NEGATIVE FEEDBACK

★ It is customary to employ inverse feedback in audio amplifier design to improve frequency response. This is particularly necessary when the output tube is a pentode or beam power tetrode having high plate resistance and the load is a loudspeaker having an impedance which varies with frequency.

Negative feedback, if excessive, may result in extreme cutback of high frequency reponse so that an unnatural quality is obtained from the speaker.

Some of the factors to be considered in amplifier design are discussed by S. W. Amos in the December 1944 issue of *Wireless World*. The article is entitled "Feedback and the Loudspeaker."

The equivalent electrical circuit of a dynamic loudspeaker speech coil is shown in *Fig. 1*, in which $R$ and $L$

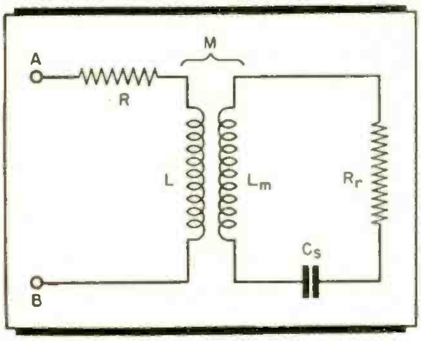



Figure 1

represent the resistance and inductance of the speech coil, $L_m$ denotes the mass, $C_s$ the compliance of the diaphragm and air load, and $R_r$ is the radiation resistance representing the resistive component of the actual power radiated from the speaker.

The impedance characteristic of a typical loudspeaker is shown in *Fig. 2*.

The usual matching rule for triodes

[*Continued on page 9*]

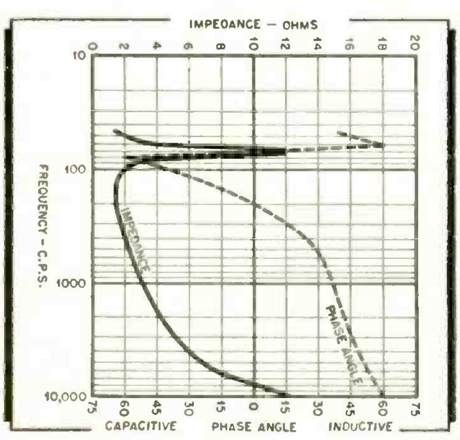
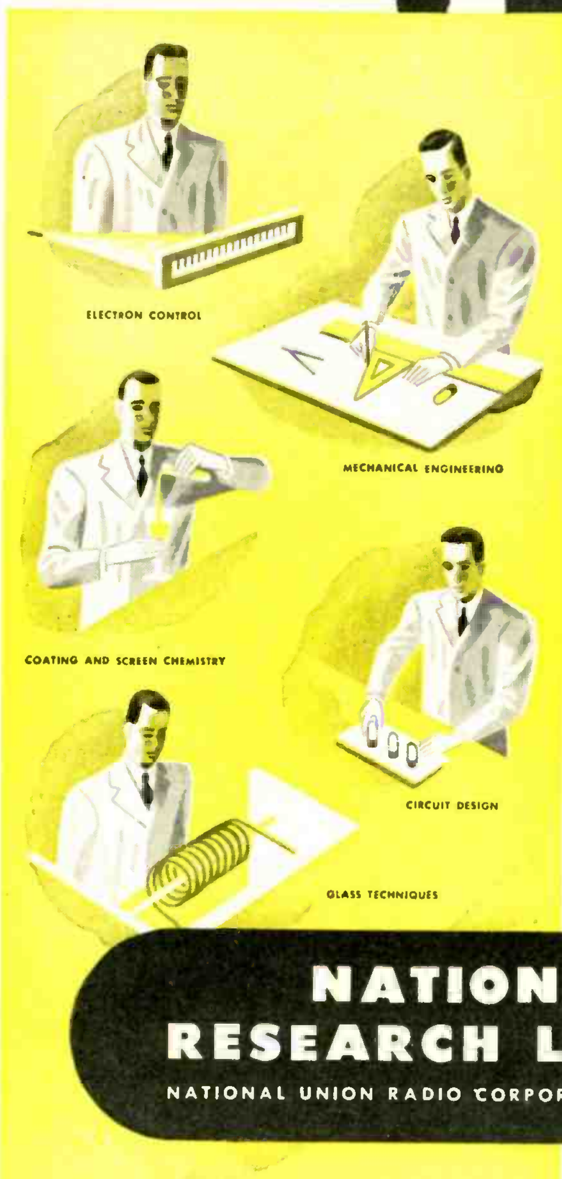



Figure 2

# Bring Your Electronic Projects to NATIONAL UNION


## LET'S GET YOUR POST-WAR PRODUCT READY NOW

Now you don't have to postpone that important electronic research job your company may have shelved for lack of engineering manpower or equipment. National Union Laboratories offer you something you couldn't buy for "love nor money" these days . . . completely equipped modern electronic research laboratories, staffed by an outstanding group of experienced engineers.

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Electronic Laboratories are pioneers in the field of vibrator conversion of current, and have developed many exclusive advantages in the heavy and light-duty power supply field. For radio telephone, aircraft radio, fluorescent lighting and electrical appliance operation and other specialized applications, Vibrator Power Supplies are the superior type of current conversion unit. . . . Consult with E-L engineers concerning your power supply problem.

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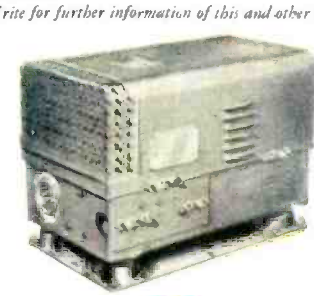
Model S-1050 is a typical military model Vibrator Power Supply which may easily be adapted for peacetime mobile radio transmitters. Input voltage: 12 or 24 volts DC. Output voltage: 475 volts DC at 200 MA, 8 volts DC at 4.5 MA. Dimensions: 9½ x 8¾ x 13 13/16 inches. Weight: 52 pounds.

*Write for further information of this and other models.*



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# *Here all similarity ends...*

## from this point on, it's craftsmanship!

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*Etched crystals are an outstanding discovery and development of Bliley research engineers. This technique, by means of which crystals are finished to frequency by acid action rather than abrasive action, was an established part of Bliley production long before Pearl Harbor. It has since proven to be an essential element in the manufacture of crystals that have the dependable characteristics necessary for military communication in global warfare.*

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Do more than before...

buy **extra** War Bonds


*A new star has been added*

**Bliley CRYSTALS**

BLILEY ELECTRIC COMPANY UNION STATION BUILDING · ERIE, PENN.

## TECHNICANA

[*Continued from page 7*]

is that the load should be twice the tube plate impedance at 400 cycles. For pentodes the plate resistance, at the transformer secondary, will be approximately five times the loudspeaker impedance.

The output circuit will be similar to *Fig. 3*.

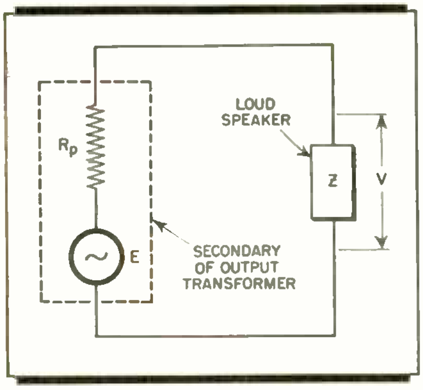



**Figure 3**

The author calculates circuit conditions for different frequencies as in *Table I*, in which *V* is the voltage across the voice coil which is the measure of loudspeaker output, *I* is the current through the voice coil, and *W* is the radiated power.

**TABLE 1**

| | 400 cycles | 10,000 cycles | 70 cycles |
|---|---|---|---|
| **TRIODES** | | | |
| V | 2E/3 | E | 12E/13 |
| I | E/3 | E/12 | E/13 |
| Z | 2 | 12 | 12 |
| W | $2E^2/9$ | $E^2/12$ | $E^2/13$ |
| **PENTODES** | | | |
| V | E/6 | 3E/4 | E/2 |
| I | E/12 | E/16 | E/22 |
| Z | 2 | 12 | 12 |
| W | $E^2/72$ | $3E^2/64$ | $E^2/44$ |

*Table I* shows that at 10,000 cycles the coil voltage is 3/2 times that at 400 cycles, for a triode, but 4½ times the 400-cycle value for a pentode. The increase at bass resonant frequency is similarly greater for a pentode than for a triode.

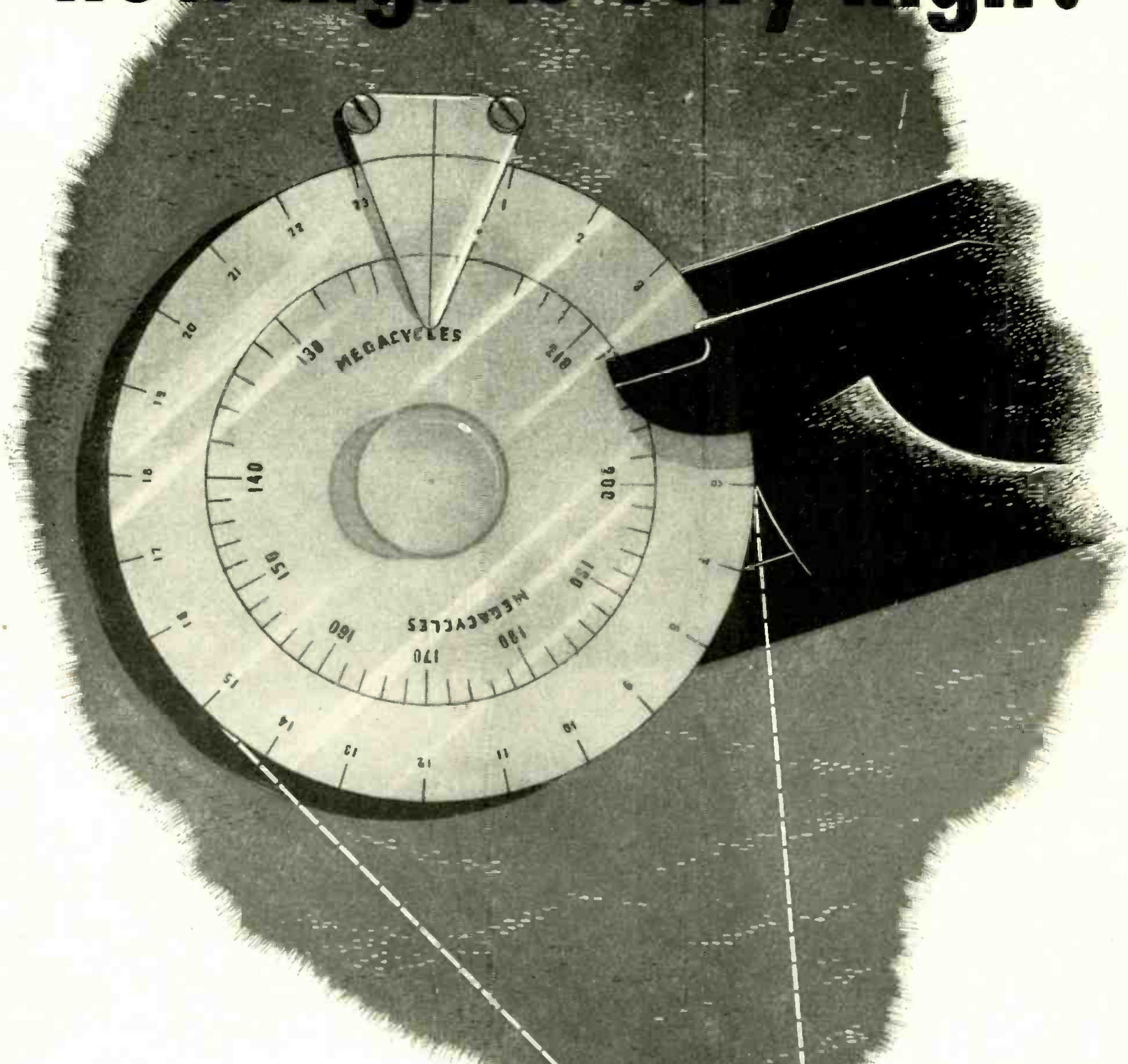
The output at the high frequencies is accentuated by the fact that $L_m$ tends to decrease, since only the center part of the diaphragm remains an effective radiator, and the sound is concentrated along the axis of the speaker.

In the case of pentodes at high frequencies, $L_m$ is too small compared with the tube resistance to reduce the current to the right proportion.

With negative feedback there is an optimum value, placed by the author

[*Continued on page 12*]

# how high is very high?





★ Engineers at Hallicrafters are continually striving for new heights of perfection in high frequency development work. The Model S-37 is one example of the progress they have made. This is the first and only set of its kind—covering both AM and FM and operating in the range of 130 to 210 Mc. Two r.f. stages are used and in conjunction with an intermediate frequency of 18 Mc., assure an amazingly high ratio of image rejection. It is becoming a valuable instrument in the hands of all exploring the upper reaches of the high frequency ranges.

**hallicrafters RADIO**

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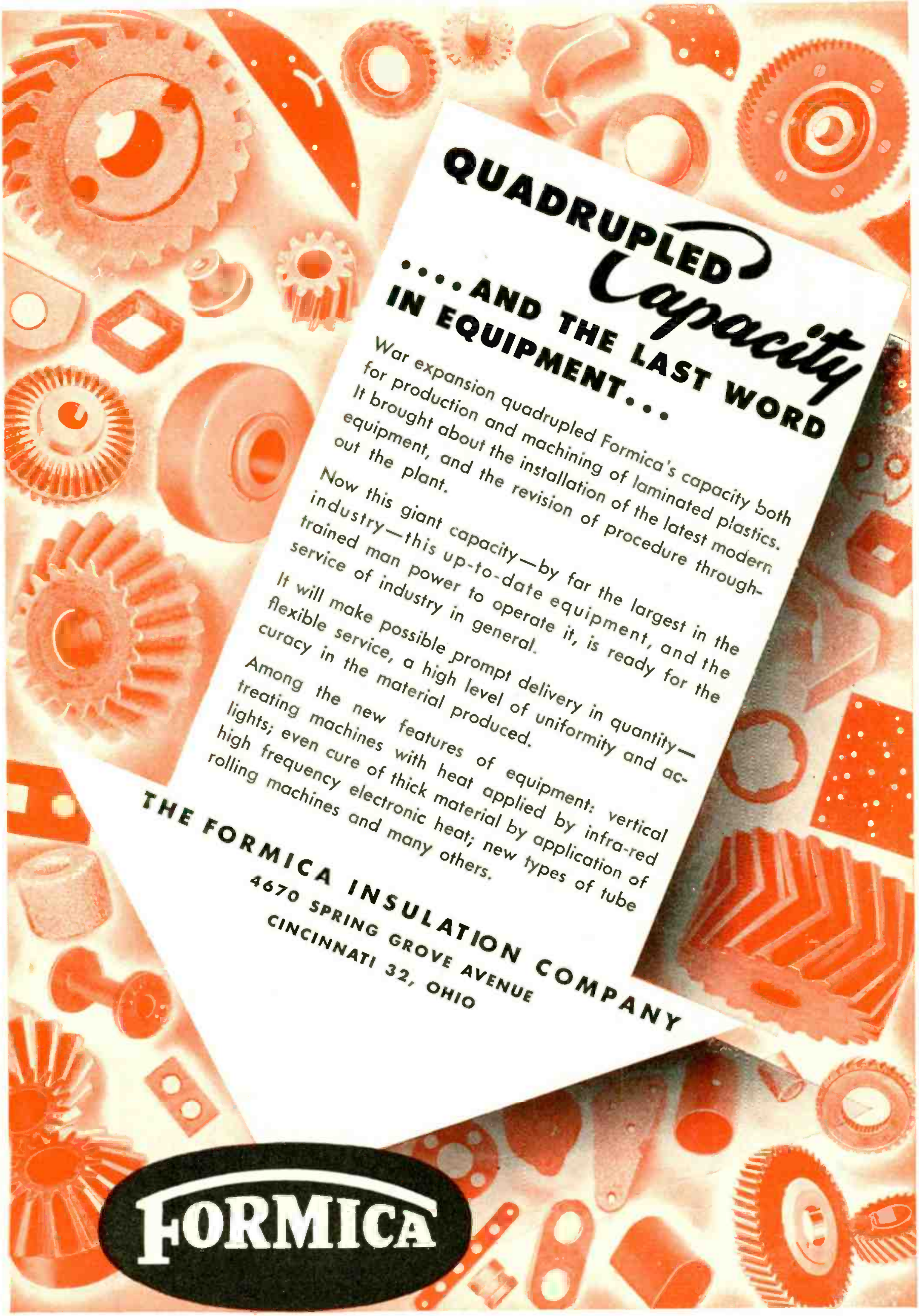

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....AND THE LAST WORD IN EQUIPMENT...
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Now this giant capacity—by far the largest in the industry—this up-to-date equipment, and the trained man power to operate it, is ready for the service of industry in general.
It will make possible prompt delivery in quantity—flexible service, a high level of uniformity and accuracy in the material produced.
Among the new features of equipment: vertical treating machines with heat applied by infra-red lights; even cure of thick material by application of high frequency electronic heat; new types of tube rolling machines and many others.
THE FORMICA INSULATION COMPANY
4670 SPRING GROVE AVENUE
CINCINNATI 32, OHIO
FORMICA

## TECHNICANA

[*Continued from page 9*]

at that value which reduces the plate resistance of the pentode to that of a typical triode. If the feedback exceeds this value "top cut" will occur. There is no limit on the feedback so far as the bass response is concerned, since the bass response is very large for pentodes.

The plate resistance of a tube is reduced by feedback so that $R_p/R_p^1 = 1 + \mu\beta$ where $R_p$ is the plate resistance without feedback and the $R_p^1$ the plate resistance with feedback, $M$ is the amplification without feedback, and $\beta$ is the feedback fraction. For a pentode $R_p$ = 50,000 ohms, and the desired value with feedback is 2,000 ohms, typical plate resistance of a triode. For the circuit of *Fig. 4*, used by the author, M = 4,000 and $\beta$, calculated from above formula = .006. This permits the calculation of feedback resistor value for $R_1$ and $R_2$.

Voltage feedback cán be accomplished from the secondary of the output transformer. In this case the optimum feedback ratio is 1/5, for above values, and a calculated gain of 113.

Excessive feedback can also be controlled by the application of top boost by tone control, or by the introduction of frequency discrimination in the feedback circuit. The author illustrates with sample circuits.

[*Continued on page 14*]

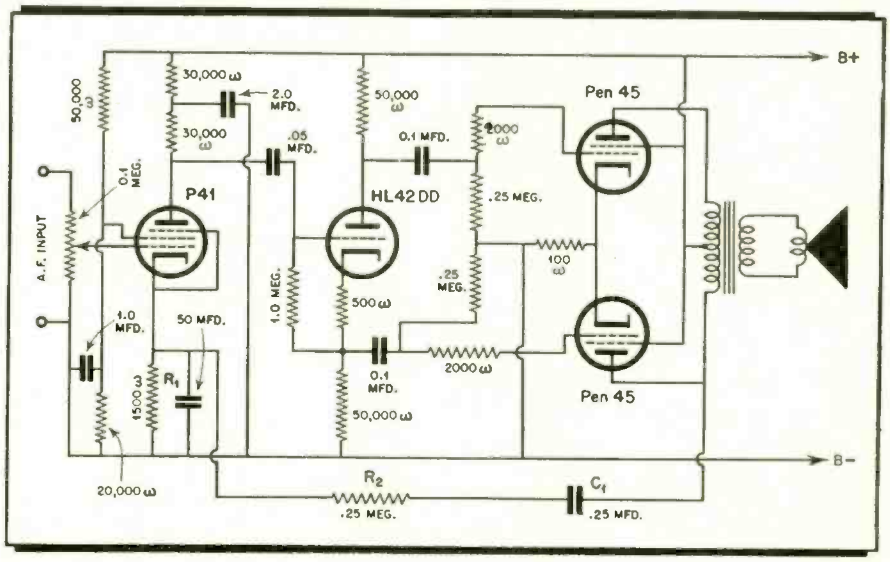



**Fig. 4 Negative feedback amplifier**

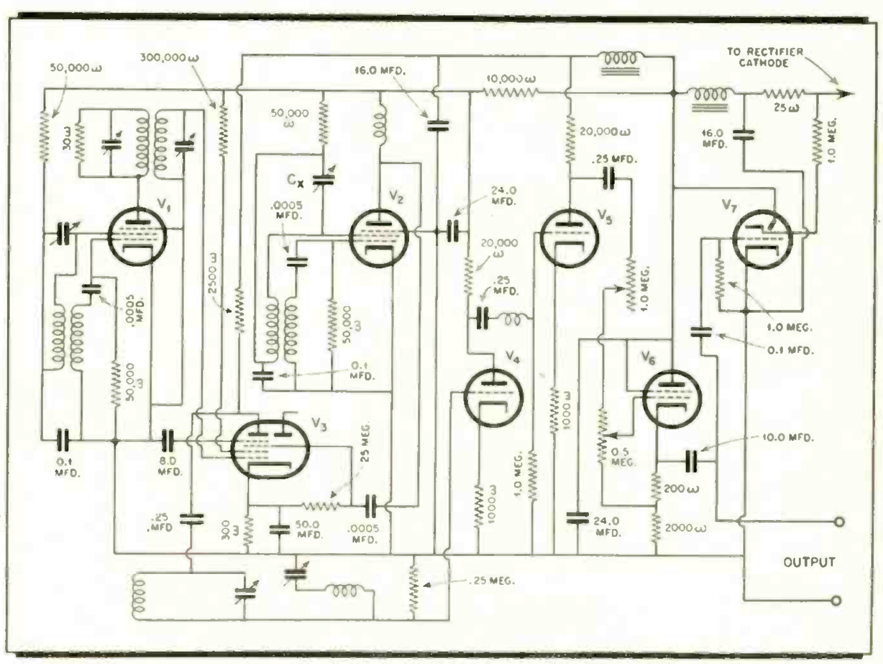
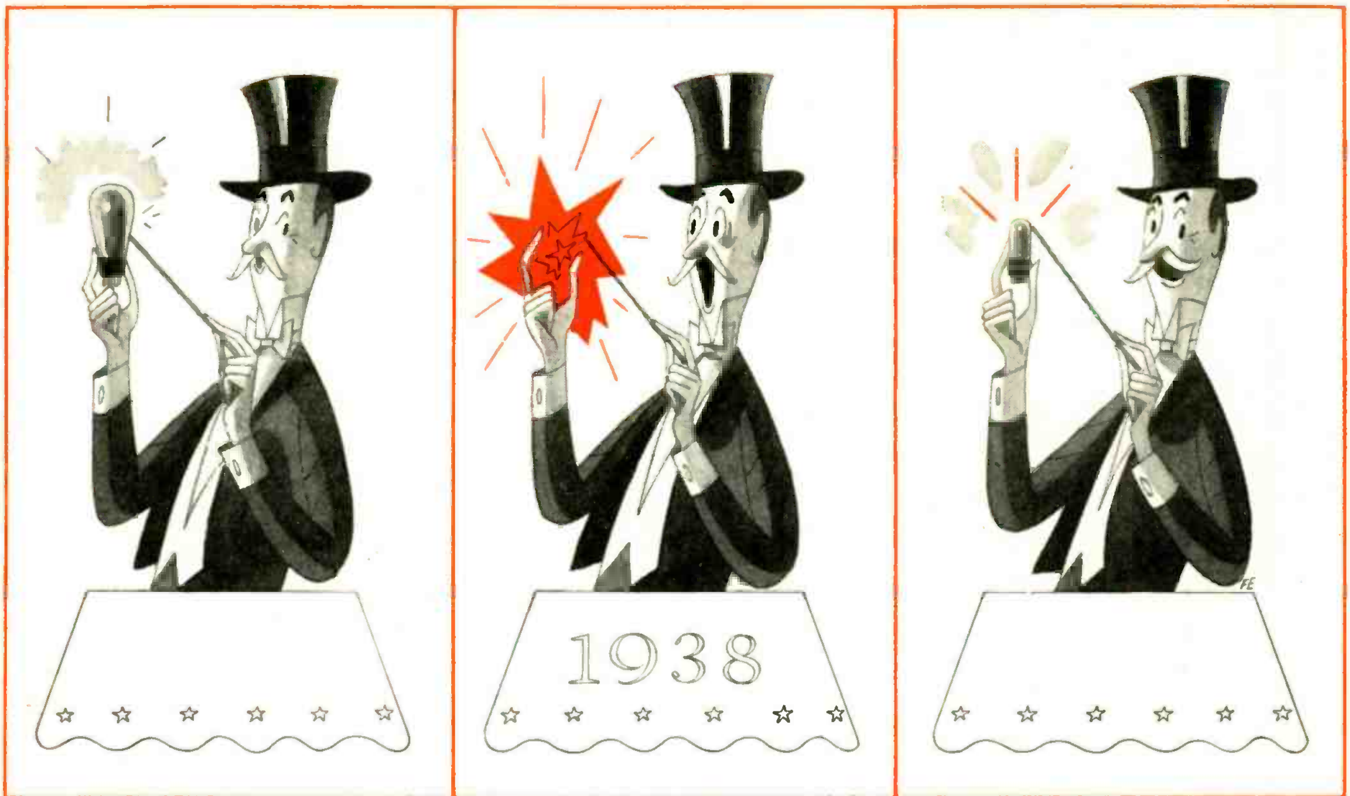



**Fig. 5 Audio frequency oscillator**




## *THEY SAID IT COULDN'T BE DONE!*

Back in 1938, Hytron began designing new dies and converting production machinery for the first BANTAM GT tubes. The industry said in effect: "You're crazy; it won't work. You can't telescope standard glass tubes to BANTAM size and get the same results." Beam tetrodes, such as the 50L6GT, particularly were considered impossibilities. The intense heat developed during normal operation would warp the elements and crack the small glass bulb.

But Bruce A. Coffin, originator of the BANTAM GT, stuck to his guns. In a few short years, Hytron developed over fifty GT types. The GT became the most popular receiving tube.* Short leads, low capacitances, advantages of shorter bombardment at lower temperatures, ruggedness of compact construction plus both top and bottom mica supports, smaller size, standardized envelopes and bases — all contributed to that popularity.

The BANTAM GT permitted new space economies in pre-war receivers. Only its universal acceptance as standard by all manufacturers makes possible fulfillment of the Services' demands for receiving tubes. In increasing numbers, as this war draws to its ultimate conclusion, Hytron will continue to supply you with the popular BANTAM GT tubes which everyone said just couldn't be made.

**1941 industry production figures: GT—52,000,000; metal—27,000,000; standard glass, G, and loctal—56,000,000.*

OLDEST EXCLUSIVE MANUFACTURER OF RADIO RECEIVING TUBES

**HYTRON CORPORATION**

ELECTRONIC AND RADIO TUBES

SALEM AND NEWBURYPORT, MASS.

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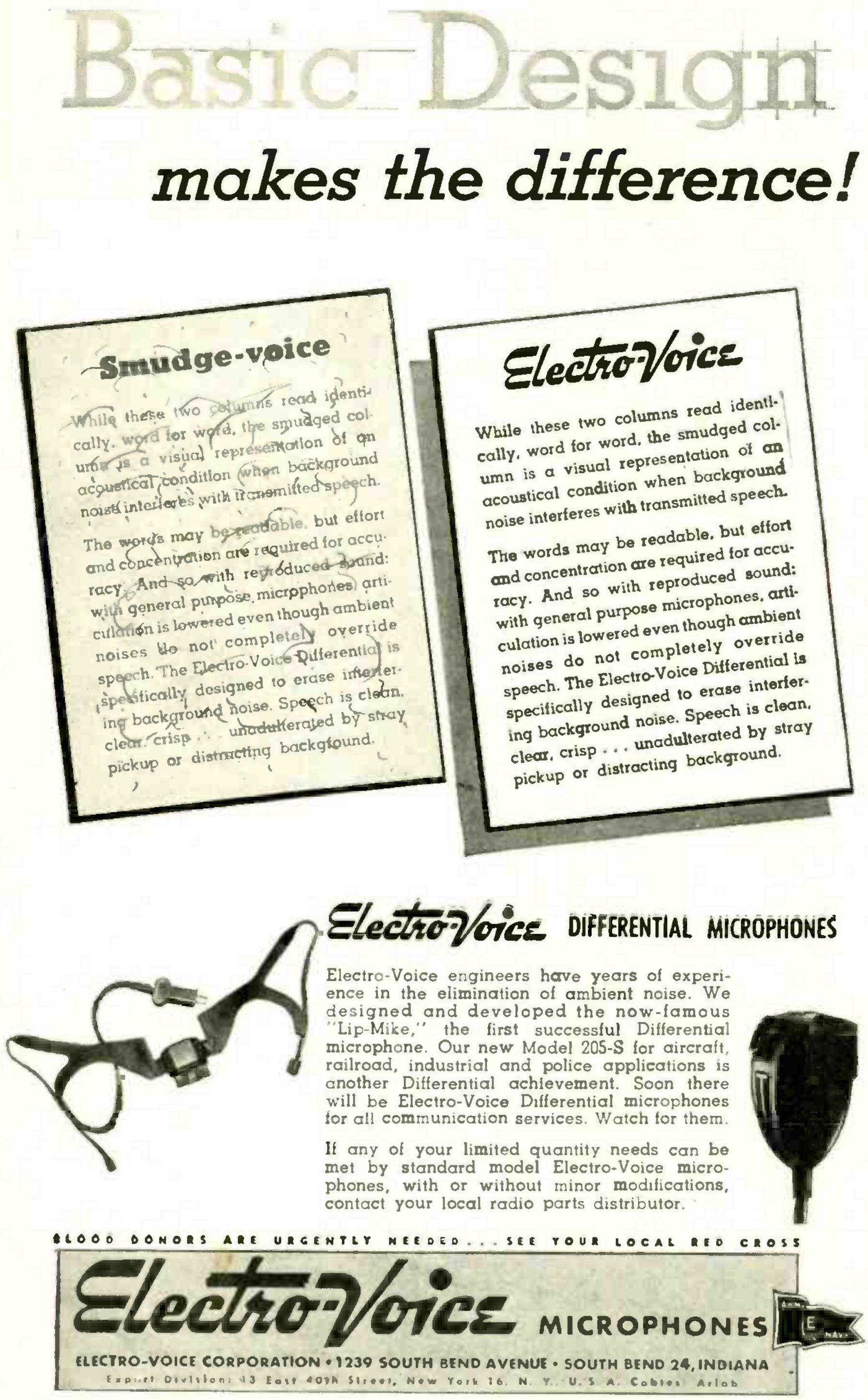


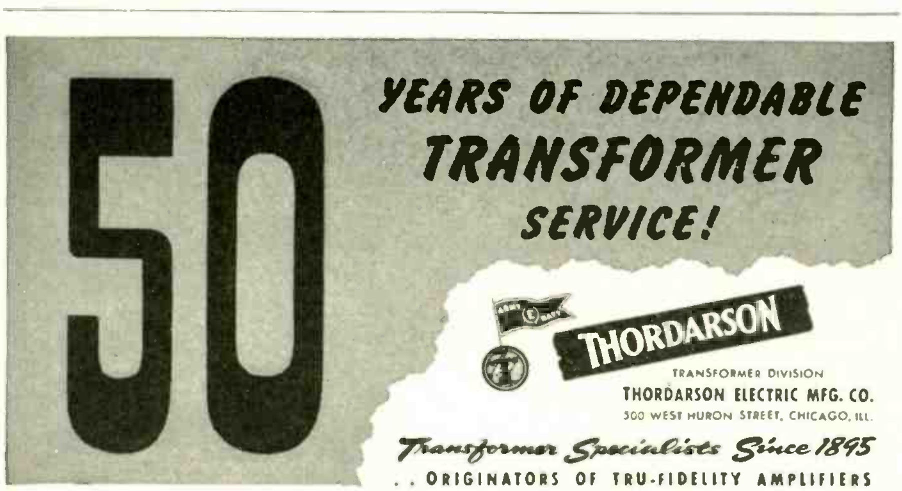


## TECHNICANA

[*Continued from page 12*]

### AUDIO FREQUENCY OSCILLATOR

★ A wide band beat frequency oscillator employing electron coupling and making use of a suitable capacity network to cover the entire range from 0 to 15,000 cycles is described in the November 1944 issue of *Electronic Engineering* by C. E. Cooper.

The author points out that there are several considerations in the design of a good beat frequency oscillator:

1. Good output waveform is desired. This means that one of the beating oscillators must be harmonic-free.

2. Frequency drift due to temperature variations must be avoided. If the two oscillators are identical in design, including physical construction, drift can be minimized.

3. Detector distortion must be avoided. When the signal amplitudes are in the ratio of approximately 10-to-1 distortion is less likely.

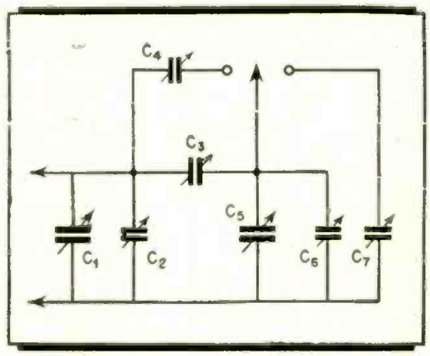


Figure 6

4. Oscillator frequencies must be properly selected. The author recommends a fixed oscillator frequency of 10 times the highest audio frequency desired as the best compromise. With higher frequencies filtering from the audio beat frequency will be simplified, but temperature drift will be greater. It is also recommended that the variable oscillator operate above the fixed oscillator in frequency.

5. The audio frequency output from the detector should be held constant, by operating at constant variable frequency oscillator output amplitude.

In the circuit shown in *Fig. 5* tube $V_1$ is the fixed frequency oscillator and $V_2$ the variable frequency oscillator. Oscillations in each are generated by the cathode, grid, and screen electrodes, and electron coupled by their respective plates to the detector mixer, $V_3$, which is a triode-hexode, the triode section not being used.

[*Continued on page 68*]

# AMPHENOL


• Amphenol offers highly developed ability to design and produce electrical components of the most critically engineered type. This skill is based on many years of experience in radio since its pioneering stages—now deepened and strengthened by the extreme demands of war production.

Fortunately Amphenol's great capacity is available at a time when the whole science of Electronics is coming into its own. Amphenol is ready to play as big a part in its own phase of the Electronic Industry, as Electronics will play in the post-war world.

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# BY MYCALEX CORPORATION OF AMERICA

## Issued in an Effort to Clear up and to Avoid Continued Confusion in the Trade

IT has come to our attention that in some quarters electronic engineers and purchasing executives are under the erroneous impression that the MYCALEX CORPORATION OF AMERICA is connected or affiliated with others manufacturing glass-bonded mica insulation, and that genuine "MYCALEX" and products bearing similar names are all "the same thing" . . . are "put out by the same people" . . . and "come from the same plant."

## THESE ARE THE FACTS:

1 The MYCALEX CORPORATION OF AMERICA is not connected or affiliated with any other firm or corporation manufacturing glass-bonded mica insulating materials. It is 100% American in ownership and operation.

2 The word "MYCALEX" is a registered trade-mark owned by MYCALEX CORPORATION OF AMERICA, and identifies glass-bonded mica insulating materials manufactured by MYCALEX CORPORATION OF AMERICA.

3 The General Electric Company, by virtue of a non-exclusive license it had under a MYCALEX patent through the MYCALEX (PARENT) COMPANY LTD., has been permitted use of the trade-mark "MYCALEX" on its glass-bonded mica insulating materials.

4 The MYCALEX CORPORATION OF AMERICA has behind it over 20 years of research leadership, dating back to work done by the original MYCALEX (PARENT) COMPANY, LTD. of Great Britain, from which it obtained its American patents. MYCALEX CORPORATION OF AMERICA owns U. S. patents and patent applications on improved glass-bonded mica insulation marketed under the trade-mark "MYCALEX."

5 **The products of MYCALEX CORPORATION OF AMERICA are: (a) "MYCALEX 400"—the most highly perfected form of MYCALEX insulation, approved by the Army and Navy as Grade L-4 insulation. MYCALEX 400 is sold in sheets, rods and fabricated form. (b) "MYCALEX K"—an advanced capacitor dielectric with a dielectric constant of 10 to 15, which can be fabricated to specifications. (c) MOLDED MYCALEX available to specifications in irregular shapes and into which metal inserts may be incorporated.**

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# Problems in Locating BROADCAST TRANSMITTERS

**HAROLD E. ENNES**
Station WIRE

**A discussion of the factors involved in choosing the proper location for a broadcast station**

THE selection of a proper site for radio broadcast transmitting plants is one of the most important engineering problems of the radio field. It is far from being an exact science, and can only be carried out properly by experienced radio engineers. A discussion, however, of the problems involved in the choice of a new transmitter location proves to be of considerable interest, and will be presented briefly in this paper with an analysis of the more fundamental points involved.

## Basic Considerations

In contrast to the requirements of the general field of communications, it is the primary objective of a broadcast station to deliver not just an "understandable" signal, but an interference-free and distortionless signal to the receiver. This kind of service is rendered by a station in what is defined as the primary coverage area of the transmitter. Primary service is the result of the ground wave at the surface of the earth, which must have a carrier-to-noise ratio of at least 18 db, and a field strength of at least several times the strength of the sky wave.

The so-called "secondary coverage" area of the transmitter is that area outside the primary service area supplied through the medium of the sky wave, and therefore subject to selective fading and resultant distortion. Since the sky wave (at broadcast frequencies) is almost entirely absorbed during the daytime, the secondary service area of any appreciable importance appears only at night. *Fig. 1* illustrates the attenuation curve of the sky-wave through the sunset period.

The field strength required for satisfactory coverage depends on the interference level which, of course, is dependent upon the orientation and conditions at the receiving point. In general, the interference level is greatest in the business section of large cities, less in the residential areas, still less in small towns and least of all in rural areas.

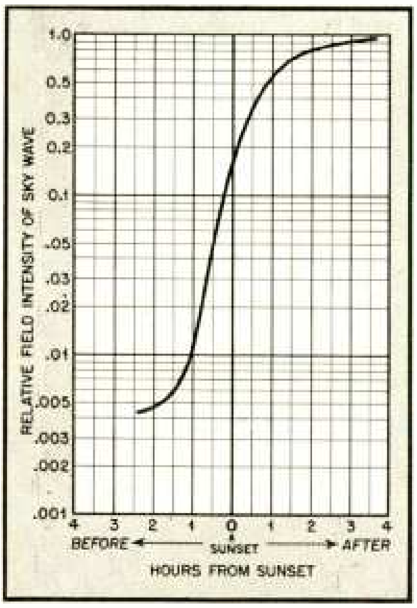



**Fig. 1 Attenuation curve of sky wave through the sunset period**

*Table 1* shows the approximate field strengths necessary for adequate coverage under various conditions. In locations where conditions are more favorable than average, primary coverage will be obtained with weaker field strengths than those indicated in the table, and of course coverage of an intermittent nature prevails at times in localities which experience an hour-to-hour variation of interference intensity.

When it is contemplated to build or move a broadcast station to a new location, an application for approval of the transmitter site must be submitted to the Federal Communications Commission. Included with this report is a map having a scale of not less than one inch to the mile, showing the 250, 25 and 5 mv/m contours and the population residing within the 250 mv/m contour (blanket area). This map must also show by various symbols the proposed location, character of each area (business, manufacturing, residential, etc.), heights of tall buildings or other obstructions, density and distribution of population and location of airports and airways. The desirability of any particular site may be judged primarily by field strength contours which would be produced by a transmitter at that location, considering the population within each contour, and the areas where the signal might be subject to nighttime fading and interference. It is obvious, then, that propagation data that will permit prediction of signal attenuation in all directions from a proposed site is a primary requisite for choosing a transmitter location.

### Ground-Wave Propagation Data

The primary service-area resulting from a transmitter of a given power depends upon earth conductivity, frequency of operation and directivity of the antenna system. The distance at which the ground wave can provide this primary coverage will be affected greatly by the frequency as illustrated in *Fig. 2*.

The effect of the soil conductivity on the signal attenuation is shown in the graph of *Fig. 3*. This type of graph, giving the ground-wave field intensity curve plotted against distance for various conductivity values, is published by the FCC. It is plotted for a block of frequencies as shown, and some 20 graphs are necessary to cover the standard broadcast band.

The approximate and average soil conductivity values in the United States are shown on the map of *Fig. 4*, also published by the FCC. The protected service contours and permissible interference signals on the same channel for various classes of broadcast stations are shown in *Table 2*. *Table 3* shows the permissible interference signals for adjacent channels.

These various curves and tables form the nucleus for coordinating necessary information in selecting the location of a broadcast transmitter.

## TABLE 1
### APPROXIMATE FIELD STRENGTH REQUIREMENTS

| Area | Field Intensity Ground Wave |
|---|---|
| City business or factory areas | 10 to 50 mv/m |
| City residential areas | 2 to 10 mv/m |
| Rural-all areas during winter or northern areas during summer | 0.1 to 0.5 mv/m |
| Rural-southern areas during summer | 0.25 to 1.0 mv/m |

—From *Standards of Good Engineering Practice: FCC.*

## TABLE 2

**Protected Service Contours and Permissible Interference Signals for Broadcast Stations**

| Class of station | Class of channel used | Permissible power | Signal intensity contour of area, protected from objectionable interference[1] | | Permissible interfering signal on same channel[2] | |
|---|---|---|---|---|---|---|
| | | | Day[4] | Night | Day[4] | Night[3] |
| Ia | Clear | 50 kw | SC 100 uv/m AC 500 uv/m | Not duplicated | 5 uv/m | Not duplicated |
| Ib | Clear | 10 kw to 50 kw | SC 100 uv/m AC 500 uv/m | 500 uv/m (50% sky wave) | 5 uv/m | 25 uv/m |
| II | Clear | 0.25 kw to 50 kw. | 500 uv/m | 2500 uv/m[5] (ground wave). | 25 uv/m | 125 uv/m[5] |
| III-A | Regional | 1 kw to 5 kw | 500 uv/m | 250 uv/m (ground wave). | 25 uv/m | 125 uv/m |
| III-B | Regional | 0.5 to 1 kw night and 5 kw day. | 500 uv/m | 4000 uv/m (ground wave). | 25 uv/m | 200 uv/m |
| IV | Local[6] | 0.1 kw to 0.25 kw | 500 uv/m | 4000 uvm/m (ground wave). | 25 uv/m | 200 uv/m |

SC = Same channel.
AC = Adjacent channel.

[1] When it is shown that primary service is rendered by any of the above classes of stations, beyond the normally protected contour, and when primary service to approximately 90% of the population (population served with adequate signal) of the area between the normally protected contour and the contour to which such station actually serves, is not supplied by any other station or stations, the contour to which protection may be afforded in such cases will be determined from the individual merits of the case under consideration. When a station is already limited by interference from other stations to a contour of higher value than that normally protected for its class, this contour shall be the established standard for such station with respect to interference from all other stations.

[2] For adjacent channels, see Table V.

[3] Sky wave field intensity for 10% or more of the time.

[4] Ground wave.

[5] These values are with respect to interference from all stations except Class Ib, which stations may cause interference to a field intensity contour of higher value. However, it is recommended that Class II stations be so located that the interference received from Class Ib stations will not exceed these values. If the Class II stations are limited by Class Ib stations to higher values, then such values shall be the established standard with respect to protection from all other stations.

[6] Class IV stations may also be assigned to regional channels according to Section 3.29.

—From *Standards of Good Engineering Practice: FCC.*

## TABLE 3
### ALLOWABLE ADJACENT CHANNEL INTERFERENCE

| Channel Separation Between Desired and Undesired Station | Maximum Ground Wave Field Intensity of Undesired Station |
|---|---|
| 10 kc | 0.25 mv/m |
| 20 kc | 5.0 mv/m |
| 30 kc | 25 mv/m |

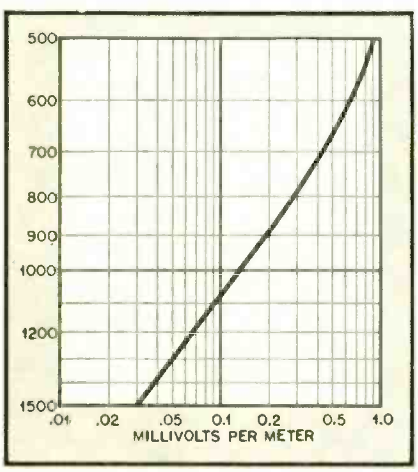



Fig. 2 Ground wave primary coverage

### Use of Propagation Data

As an example of the use of the above propagation data, assume that it is desired to find the approximate interference that a 5 kw class 2 station on 980 kc may cause to a 1 kw class 2 station on 990 kc. Also assume that the stations are separated by a distance of 175 miles, and use non-directional antennas of such height as to produce an effective field (for 1kw) of 175 mv/m. From *Fig. 4* it is determined that the terrain around each station falls within an estimated conductivity of 6 X $10^{-14}$ e.m.u. From *Table 2* it is seen that the protection to class 2 during daytime is to the 500 $\mu$w/m contour. Since the curves as shown in *Fig. 3* are plotted for 100 mv/m at a mile, to find the distance to the 500 $\mu$v/m contour of the 1 kw station we determine the distance on the appropriate curve to the

$$\frac{100 \times 500}{175} = 285$$

285 $\mu$v/m contour. Thus we may observe from the graph of *Fig. 3* and the curve marked 6 (for 6 X $10^{-14}$ e.m.u.), that the estimated radius of the service area of the 1 kw station is about 40 miles. Since 175 — 40 = 135, we have 135 miles for the interfering signal to travel. Again from the appropriate

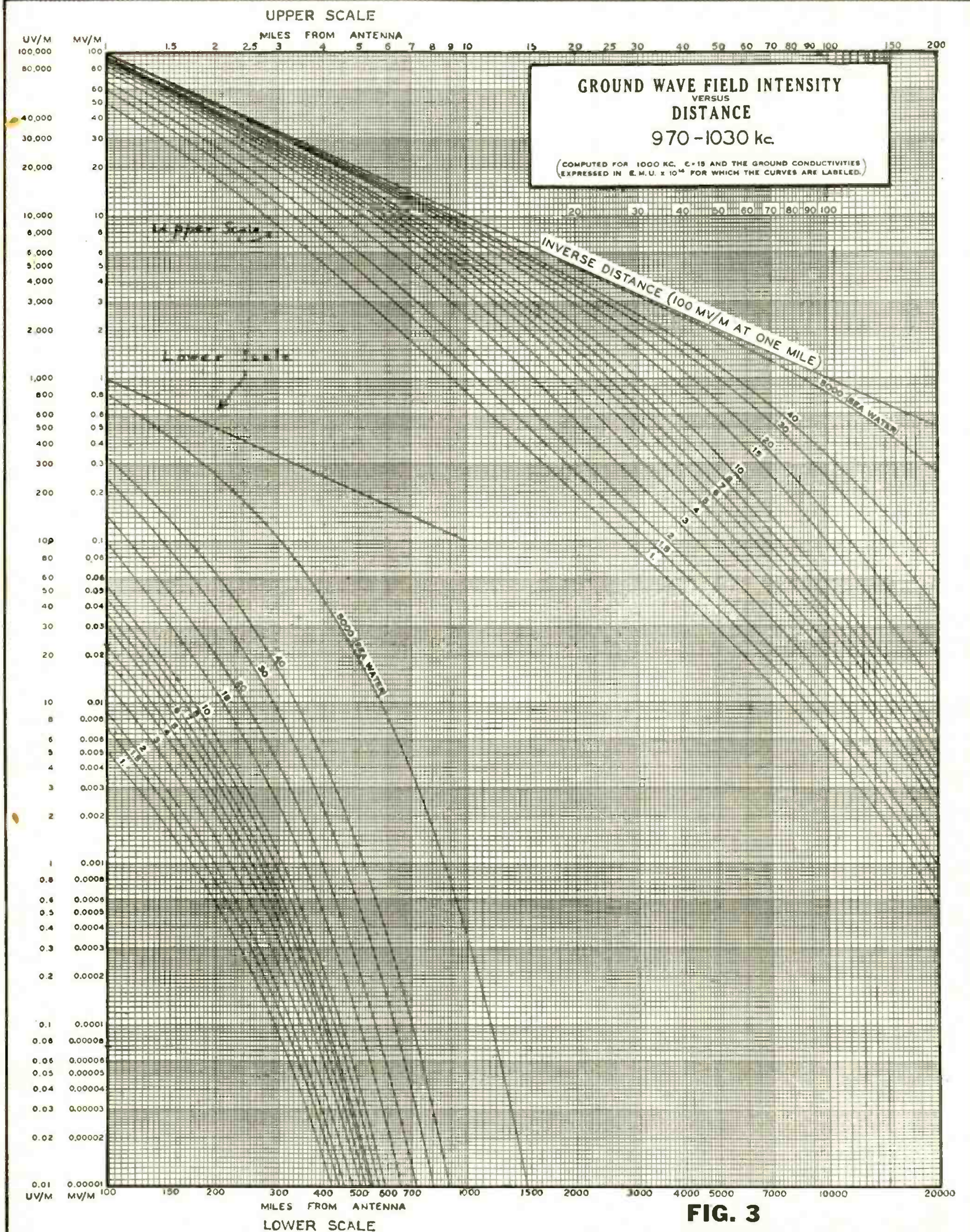

UPPER SCALE
MILES FROM ANTENNA
GROUND WAVE FIELD INTENSITY
VERSUS
DISTANCE
970 - 1030 kc.
(COMPUTED FOR 1000 KC. ε=15 AND THE GROUND CONDUCTIVITIES EXPRESSED IN E.M.U. x 10¹⁴ FOR WHICH THE CURVES ARE LABELED.)
INVERSE DISTANCE (100 MV/M AT ONE MILE)
5000 (SEA WATER)
UV/M
MV/M
MILES FROM ANTENNA
LOWER SCALE

FIG. 3

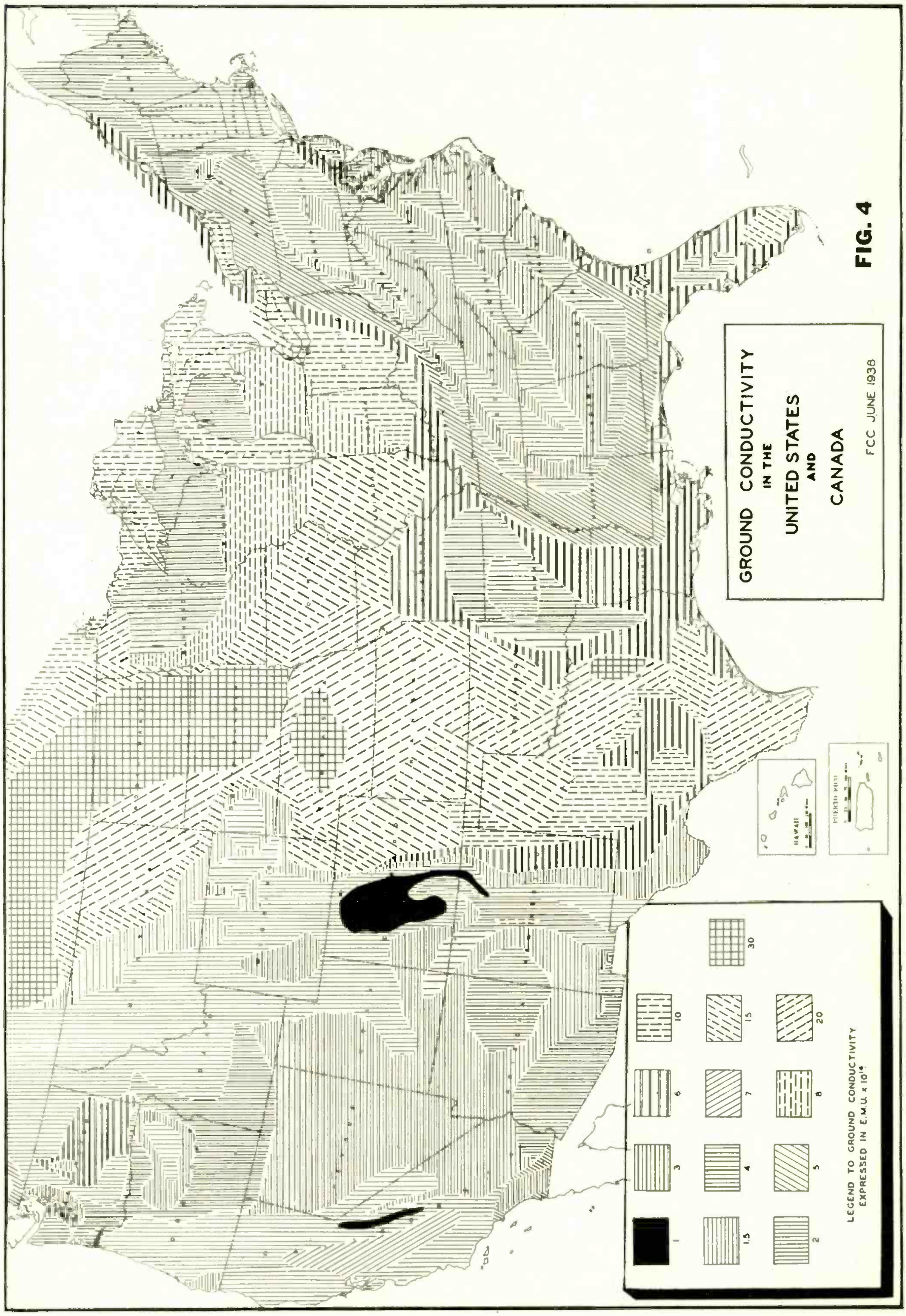

GROUND CONDUCTIVITY
IN THE
UNITED STATES
AND
CANADA
FCC JUNE 1938
HAWAII
PUERTO RICO
1
1.5
2
3
4
5
6
7
8
10
15
20
30
LEGEND TO GROUND CONDUCTIVITY
EXPRESSED IN E.M.U. x 10^14

FIG. 4

curve of *Fig. 3* we find that the signal from the 5 kw station at 135 miles would be 62.5 µv/m. The stations are separated by 10 kc and from *Table 3* it is observed that the undesired signal may have a value up to 250 µv/m without a declaration of interference by the FCC.

The above principles do not apply when a sky-wave signal for the undesired station is in excess of 5 times the desired signal for 10% or more of the time when the frequency separation is 10 kc. If this condition prevails, then the interference must be estimated on the basis of the sky wave also, and the propagation curve of *Fig. 5* must be used rather than the ground-wave curves of *Fig. 3*.

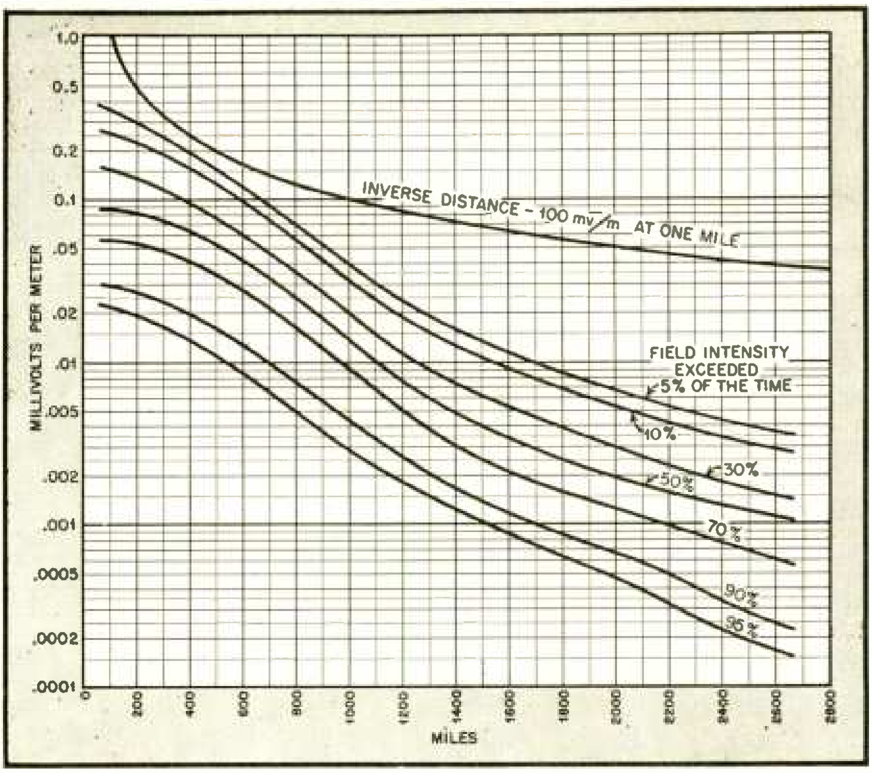



**Fig. 5 Propagation curves of sky wave**

## Other Considerations

In actual practice, in cities and populated areas, the effective conductivity that must be used in determining ground-wave propagation is less than the actual conductivity of the earth due to energy losses in buildings framework such as exist in business, industrial and apartment-house districts. The setting up of a test transmitter and plotting the contours of the resultant field strengths is the most reliable means of determining the effective conductivity, although in most instances today this may be computed effectively by means of broadcast stations already existing in the area and converting the results to the frequency of the proposed new transmitter.

Although it is well known that high antenna efficiency and low signal attenuation result from a site where high ground conductivity prevails, other factors may determine that a less desirable site from the standpoint of ground conductivity might actually be far more desirable to achieve good coverage in certain localities. If, for example, a directional antenna system must be used to cut down on the signal west of the city to be served, then the transmitter should obviously not be located east of the city regardless of a much higher ground conductivity that might prevail there. It is also inadvisable to locate the transmitter in old sections where a great amount of overhead power and telephone lines exist and where house wiring and plumbing is apt to be old and outmoded. This is so because high signal intensities in these localities cause cross modulation in the receiver due to the non-linear conductivity between contacts of wiring and other conductors such as plumbing systems. The FCC will not allow installation of a transmitter in this type of locality unless the station assumes full responsibility of adjusting all complaints. Since this type of interference is independent of receiver selectivity, it can usually be eliminated only by correction of the poor conditions causing the trouble. Consequently, it is apparent that an expense of several thousand dollars might be incurred by a licensee locating a transmitter in this type of locality. Other considerations in the choice of a site are:

1. Location of airports and airways.
2. Availability of power sources.
3. Availability of telephone and program circuits.
4. Flood levels.
5. Accessibility of building.
6. Acreage of land available and cost of same.

*Table 4* has been offered by the FCC as a general guide to be used in determining the approximate site of a broadcast transmitter. It is seen that at low powers in larger cities it is advisable to locate the transmitter as near the center of the area to be served as possible. When this is necessary, the building selected should be large enough to accommodate an adequate ground or counterpoise system. It is also well to keep in mind that the height of the building should not be near a quarter-wavelength of the op-

[*Continued on page 70*]

### TABLE 4
**BROADCAST TRANSMITTER DATA**

| Power of Station | Population of City or Metropolitan Area | Approximate Radius of Blanket Area 250 mv/m** (Miles) | Site-Distance From Center of City. (Business or Geographical) (Miles) | Maximum Percentage of Total Population in Blanket Area (Percent) |
|---|---|---|---|---|
| 100 watts | 5,000 - 50,000 | 0.15 | 1 | 1 |
| 100 watts | 50,000 or more | .15 | * | — |
| 250-500 watts | 5,000 - 150,000 | 0.3 - .5 | 1-3 | 1 |
| 250-500 watts | 150,000 or more | .3 - .5 | * | — |
| 1 kilowatt | 5,000 - 200,000 | .6 - .9 | 2-5 | 1 |
| 1 kilowatt | 200,000 or more | .6 - .9 | * | — |
| 5-10 kilowatts | All | 1.5 - 2.5 | 5-10 | 1 |
| 25-50 kilowatts | All | 3.0 - 4.5 | 10-15 | 1 |

*In these instances it is usually necessary to locate the station within the city in order to render satisfactory service.

**These radii are only approximate and the actual blanket area (area within the 250 mv/m contour) may be materially different.

# Factors Involved in Choosing

**P. H. ALBERT**

**An analysis of the properties of dielectric materials, how their characteristics are affected by various operating conditions, and suggestions regarding their selection to meet specific requirements**

SUITABILITY of an insulating material is not determined by any one isolated factor, but by a series of factors intimately related.

Since it is impossible to select an insulation correct for any possible set of conditions, certain guideposts must be established to aid the radio designer in the proper selection of material.

Among the qualities which can determine a material's usefulness are three broad qualities: dielectric, physical, and mechanical. Each of these headings is exceptionally and purposely broad, so that further elaboration is necessary.

## Properties

The dielectric properties of a material are those responses to an electrical stimulus of either alternating or direct current. They include, among others, the dielectric strength, the insulation resistance, the dielectric constant, the dissipation or power factor, and the arc resistance.

The physical properties are defined in terms of the mechanical stresses the material will accept, the mechanical or structural response to certain ambient conditions, and its reaction to heat and burning. The mechanical properties are limited to the ability to be formed by molding, machining, or other manufacturing operations.

Basically, the mechanical and physical properties of a material would appear to be sidelights on the more important properties of the material's dielectric behavior, since it is ultimately intended as a dielectric. However, other limitations of the material in terms of the mechanical and physical shortcomings often limit its final utility.

The multiplicity of electrical conditions which an insulating material can be expected to meet causes an almost immediate grouping of such materials into low-loss materials and medium-loss materials. Further considerations can compel a distinction between a solid, gas, or liquid dielectric.

The important dielectric properties are the following:

*Dielectric Strength*
*Insulation Resistance*

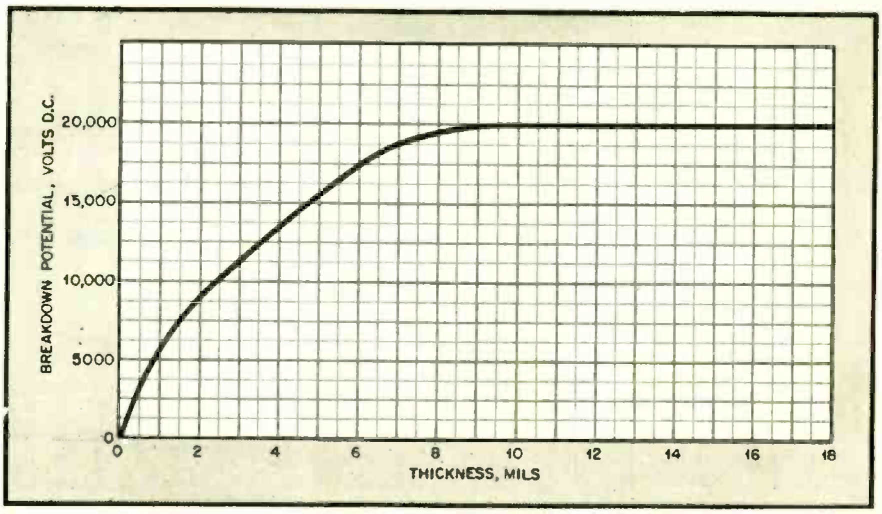



Fig. 1 Breakdown potential is a function of thickness

# INSULATING MATERIALS

*Dielectric Constant*
*Dissipation or Power Factor*
*Arc Resistance*

## Dielectric Strength

The dielectric strength is defined as the maximum permissible voltage gradient without the electrical failure of the material. From a testing source, arbitrary data is developed which represents the average of a number of puncture tests, with the results expressed in volts per mil. Such data is arbitrary in the sense that it is a laboratory approach to actual operating conditions.

Several factors influence the dielectric strength as a mathematical and real quality: size and shape of electrode, thickness of material, frequency applied, method of application (short vs. step-by-step), relative ambient conditions of humidity, temperature, and pressure, and the time of application, among others.

The size of the electrode is a factor for several reasons. As the size becomes smaller, i.e., pin point in nature, the voltage stress becomes focused on a smaller area, causing in many cases a more rapid deterioration of the dielectric medium. The second factor is the inclusion of conducting particles in most dielectric media. As the space occupied by the electrodes increases, there is more possibility that a conducting particle will appear in the voltage path. If such particles recur infrequently and can be eliminated in quality control testing, the test cannot be considered indicative of the material's behavior under true operating conditions.

The shape of the electrode imposes other restrictions on the usefulness of such data obtained. It has already been pointed out that the shape will tend to focus the voltage stress if the electrode is pin-pointed. At the same time, a rectangular electrode will present certain edge effect problems. This problem can be defined in terms of the necessity for maintaining a uniform field during the stress testing.

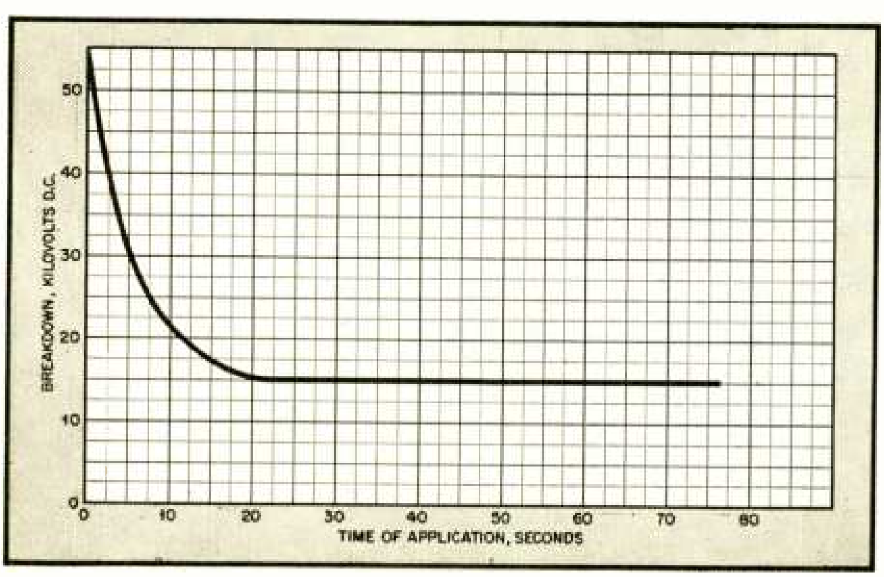
Two equally different influences obtain in the response of a material of different thicknesses to dielectric stress. When a material becomes increasingly thin, the conducting particles discussed previously have more effect than in a thicker section. After the thickness of the material is sufficiently greater than the thickness of any combination of conducting particles, the separate condition obtains that the dielectric strength (expressed in volts per mil) decreases with thickness.

*Fig. 1* shows an idealized approach to the problem of predicting dielectric strength as a function of thickness. Certain formulae have been developed in the literature to explain mathematically this variation, but no formula has been found to be applicable to any given number of materials, even assuming certain arbitrary constants.

The state of the art of dielectrics is perhaps the clue to the inability to put into mathematical expression dielectric strength as a function of thickness. The additional unknowns which enter into such measurements also prohibit such an idealized formula.

As a whole, the electrical industry has learned to analyze the insulation problem with clarity. The capacitor and transformer industry, as a whole, discard one insulation thickness in considering the proper dielectric stress which can be safely applied to an insulation. At first glance this appears to be a safety factor added because of the instability of certain insulations: actually, it is part of the awareness of foreign materials in even the best dielectrics.

**Fig. 2. Breakdown as a function of time**




## Test Factors

Important also are the method and time of testing. These are important

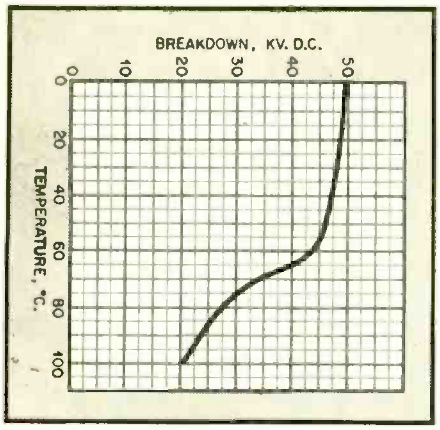



**Fig. 3 Breakdown as a function of temperature. (Organic-base material)**

because they are analogous to mechanical tests such as when shear testing is compared to loaded shear testing or to some other material properties. It has been found electrically, as well as mechanically, that a continuously loaded specimen will fail at a much sooner point than a specimen placed under shock conditions. Table One shows the step-by-step (loaded ratings of certain insulating materials compared with the short time (shock) ratings of the same materials.

Perhaps, it could be pointed out that the loaded condition is more indicative of the material's eventual behavior than any shock condition of testing—although the latter is useful in predicting the material's behavior under dielectric surge stress conditions.

Any such curve as will show the time-breakdown relationship of an insulation will tend to level off at the steady state voltage stress. Such a curve, as produced in *Fig. 2,* shows that there is the expected exponential relationship between time of application and voltage breakdown.

Several other influences should be noted in analyzing the dielectric

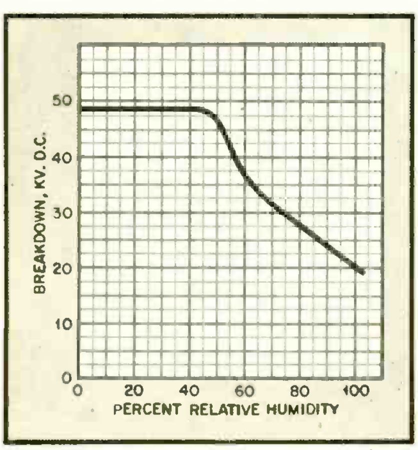



**Fig. 4 Breakdown as a function of humidity**

strength of a material: ambient conditions of temperature, humidity, and pressure. Curves illustrating the effect of temperature and humidity are presented in *Figs 3* and *4,* respectively. No data is presented on the effect of altitude, since the data in connection with typical insulating materials is limited.

Temperature, as an influence in dielectric behavior, is perhaps the most serious single deteriorating effect. Whatever the source of the temperature increase, be it internal or external, the end results are the weakening of the material's chemical structure to some degree, carbonization or complete deterioration if the temperature rise is sufficient.

Moisture as a damaging influence on electrical insulation arises from two sources: absorption and formation of a water coating. Since the former is part of the phenomena of dielectric strength and acts as a series of conducting particles through the electrical medium, it is the form of moisture most important in this discussion.

That moisture and pressure decrease the effective surface creepage conditions is another dielectric phenomena, unrelated to dielectric strength, per se. It is known that the failure of electrical insulation can manifest itself into two ways: puncture or flashover. Decrease of the effective surface path will result in the latter type of dielectric failure.

Variation of the insulation resistance under a number of ambient conditions is also a governing influence on insulation. Insulation resistance, as the term is commonly employed, consists of the volume resistivity and the effective surface resistance. Since the two are inseparably related, it is virtually impossible to reduce the effect of the other.

The conditions of temperature and of humidtiy effect the true insulation resistance of a material. It is understood that the voltage strength also has an effect, but this quantity has not been reported subjectively as yet. The temperature resistance characteristics of typical polyvinyl chloride wire insulation and typical capacitor mineral oil behavior are presented in *Fig. 5;* humidity effects on the insulation resistance of the former is presented in *Fig. 6.*

Since these conditions exist, radio design must include a "fudge factor" for the worst possible set of conditions of temperature, humidity, and pressure. To predict such a fudge factor will involve a complete knowledge of the circuit's application and of the material to be employed.

The former properties can be considered indicative of the insulating properties of a material; the proper-

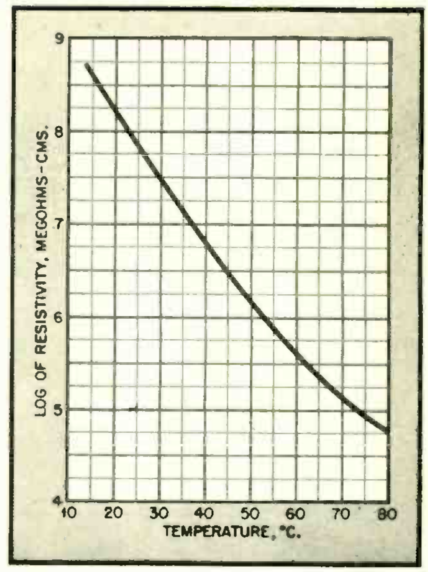



**Fig. 5 Temperature insulation resistance characteristics of polyvinyl chloride**

ties to be discussed can be considered indicative of the dielectric properties of a material. These properties include the dielectric constant, the dissipation or power factor, and the dielectric loss factor.

## Dielectric Constant

Dielectric constant is commonly defined as the quality which determines the maximum change a dielectric will accept per unit volume. This constant is expressed as a ratio using air's dielectric constant as 1. Completely related to the dielectric constant is the dissipation or power factor. *Fig. 7* shows the mathematical relationship of these factors.

It is interesting to note that these two factors, i.e., the dissipation factor and the power factor differ less than .0005 when the dissipation factor is less than 0.1. This results mathematically from the fact that the cotangent of the phase angle and the cosine of the same angle are approximately the same.

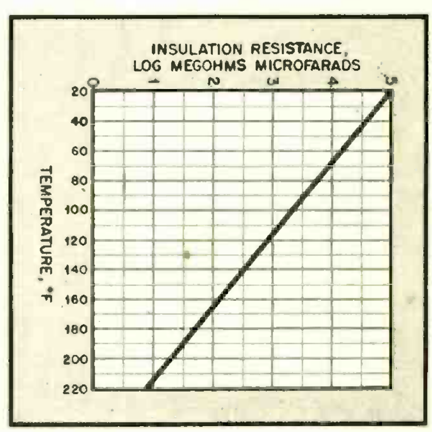



**Fig. 6 Insulation resistance-temperature characteristics of mineral oil capacitors from American War Standard C75.16)**

The product of the dielectric constant and of the dissipation factor is called the dielectric loss factor. It is the direct measure of the watts loss in a material, as related by the following formula:

$$P = cG^2ctf$$

where $P$ = power loss in watts
$c$ = constant of measurement
$G$ = voltage gradient
$e$ = dielectric constant
$t$ = dissipation factor
$f$ = frequency

It is generally and correctly assured that heat is the end point of all insulation. The AIEE has set up certain codes which define the ability of an insulation to withstand high temperatures. These high temperatures are damaging whether the heat is internally produced or externally reproduced. Here the difference between a low loss material and a high loss material enters our considerations. For low frequency, usage such as power or audio frequencies, the electrical loss factor, as expressed by the dielectric loss factor, can be relatively high. For high and ultra high frequencies, the loss must be consistently low. Certain ceramic and plastic forms with loss factors less than .016 measured at 1 megacycle have been deemed suitable.

Again, certain ambient conditions will affect the life of an insulation by deleteriously affecting the dielectric loss factor. Some of these conditions include, as before, temperature, moisture content, frequency, and magnitude of the applied voltage. Since it becomes impossible to reproduce curves showing dielectric behavior under any combination of conditions, *Fig. 8* selects a typical liquid impregnant and shows its dielectric behavior with temperature.

It should be noted that conventional insulation materials have a wide variation in dielectric response. This accounts for restricted uses of many of these materials.

### Arc Resistance

One remaining dielectric property remains: arc resistance. This quality is defined as the ability of a surface of an insulating material to withstand surges of high current density.

Several materials can be accepted as having high arc resistance. Ceramics and melamines in general are quite useful in these applications.

It has been suggested that certain physical or mechanical properties of a material can make the insulation unuseable, although it has desirable electrical properties.

Analogous to the dielectric strength of a material are certain other physical qualities which define the pressure gradient a material will accept. Several strengths are variously related, but differ to the extent that each load is differently applied.

Consider tensile, shear, compression, and impact strength as qualities of a typical material. These and such other factors as hardness, resiliency, and abrasion resistance are indicative of a material's response to mechanical loading. Not all materials, obviously, can be expected to possess the ability to respond exceptionally well in all types of mechanical loading.

The tensile strength of a material represents the "stretch" a material will accept. The compression strength is the converse. Rubber used for electrical wire insulation must be "stretchable," i.e., must have a high tensile strength; rubber used for standoff insulation, vibration insulation, or for gasketing must be compressible.

Impact strength, as defined, represents the shock condition of a force applied against a material. It differs from shear strength in that it is not a calibrated opposing force applied tangent but a force of a dropped body.

Other physical considerations include the heat range of an individual material, the moisture absorption, and resistance to selected solvents. These should be weighed in the selection of a material, although no extended consideration is to be given to these properties in this article.

Finally, the mechanical properties of forming must be considered: What types of molds can be used? What types of molding processes can be employed? Will the end product be machinable? Can the material be held to close tolerances consistent with its size and shape? What types of shapes can be produced? These questions present themselves every time a material must be selected. Further consideration of these problems in relation to individual materials will be given at a later date.

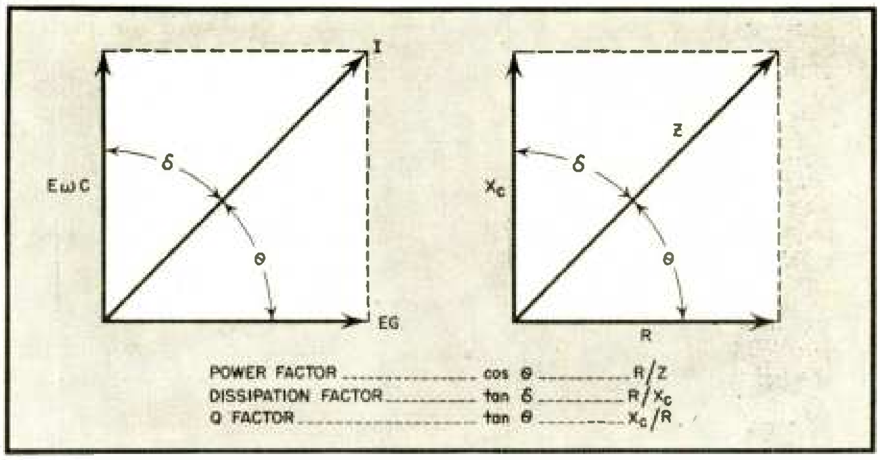



**Fig. 7. Vector relationships of a parallel circuit of a capacitor and its impedance relationships**

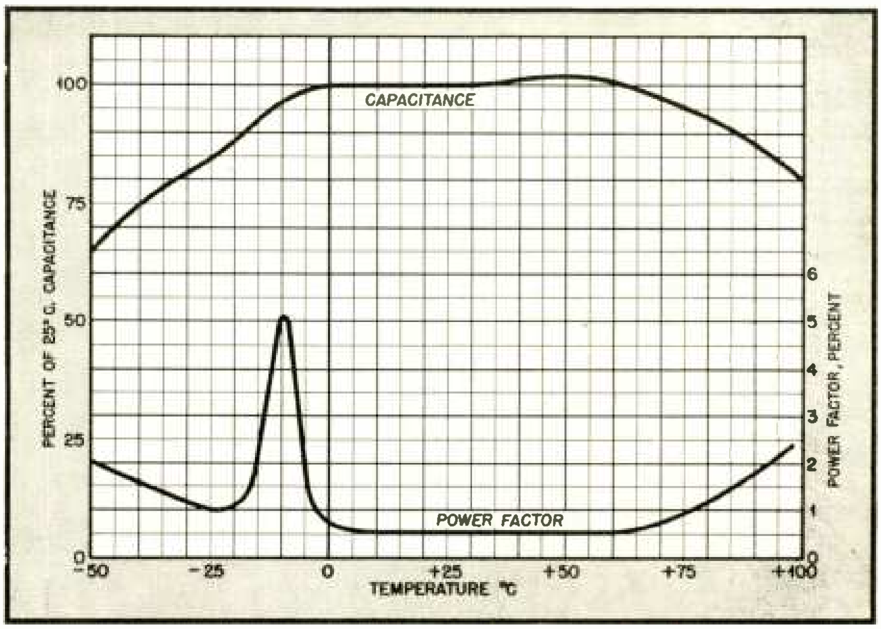
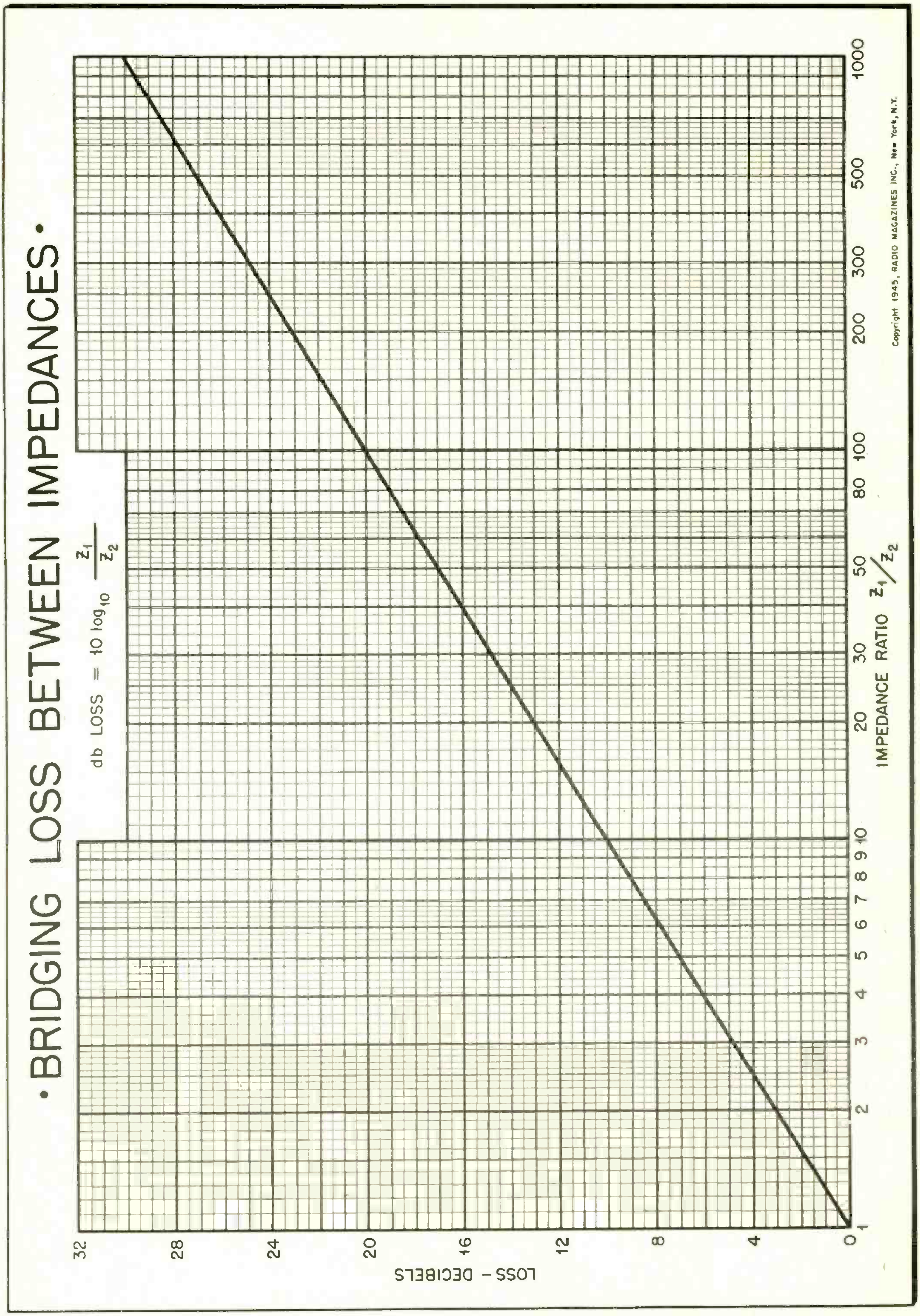



**Fig. 8. Variation of dielectric constant (capacitance) and power factor at various temperatures, using a typical capacitor impregnant**



• BRIDGING LOSS BETWEEN IMPEDANCES •
db LOSS = 10 log10 Z1/Z2
LOSS – DECIBELS
0
4
8
12
16
20
24
28
32
IMPEDANCE RATIO Z1/Z2
1
2
3
4
5
6
7
8
9
10
20
30
50
80
100
200
300
500
1000
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# An Unbalanced Bridge
# RC OSCILLATOR

**E. M. McCORMICK**
Fort Lauderdale, Fla

**A new type of resistance-capacity oscillator covering frequencies from 0.8 to 860,000 cycles**

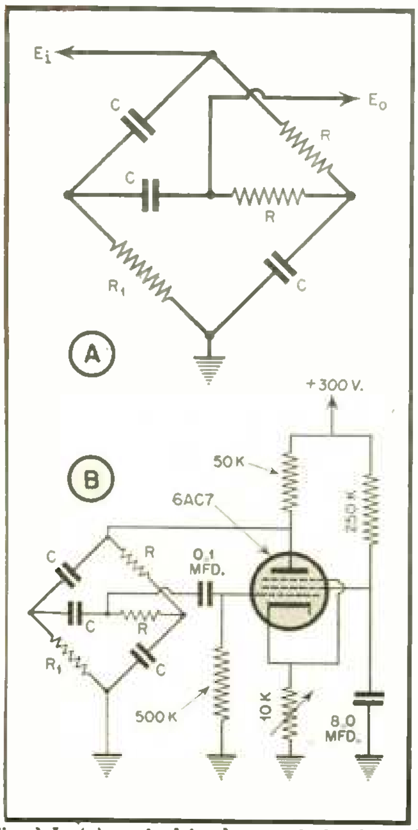



**Fig. 1 In (a), typical fundamental circuit, and (b) application to unbalanced bridge oscillator**

If the output of a single stage amplifier is shifted 180° and fed back to the input, oscillations will be maintained provided the overall gain is greater than one.

There are several types of selective networks using condensers and resistors for obtaining this phase shift. One of these has the elements arranged in an unbalanced bridge, as shown in *Fig. 1a*. $E_i$ is the input voltage to the network and is taken directly from the plate of the tube. $E_o$ is the output voltage which is fed to the grid of the stage through the usual RC circuit. In the case to be considered here, the condensers are all of the same value *C*, two resistors have the same value *C*,

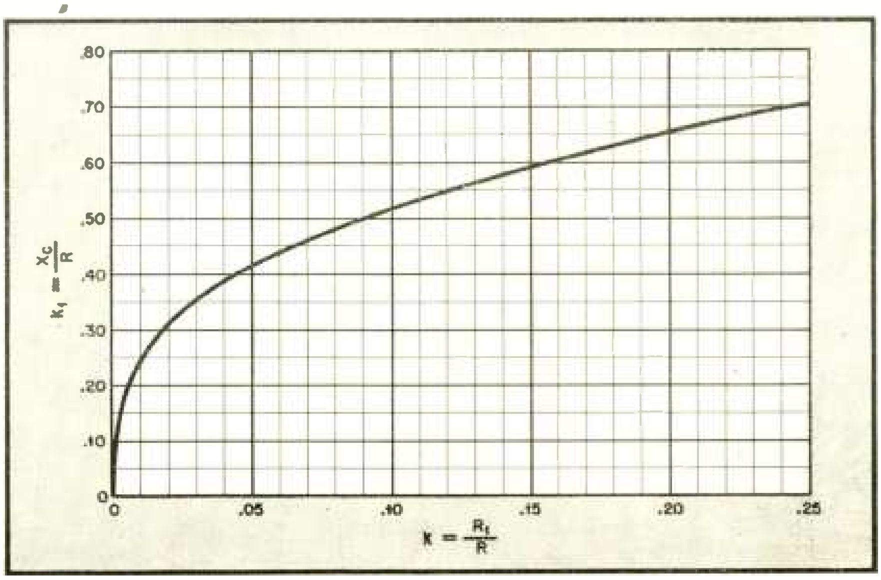



**Fig. 2. The value kl is plotted for different values of k**

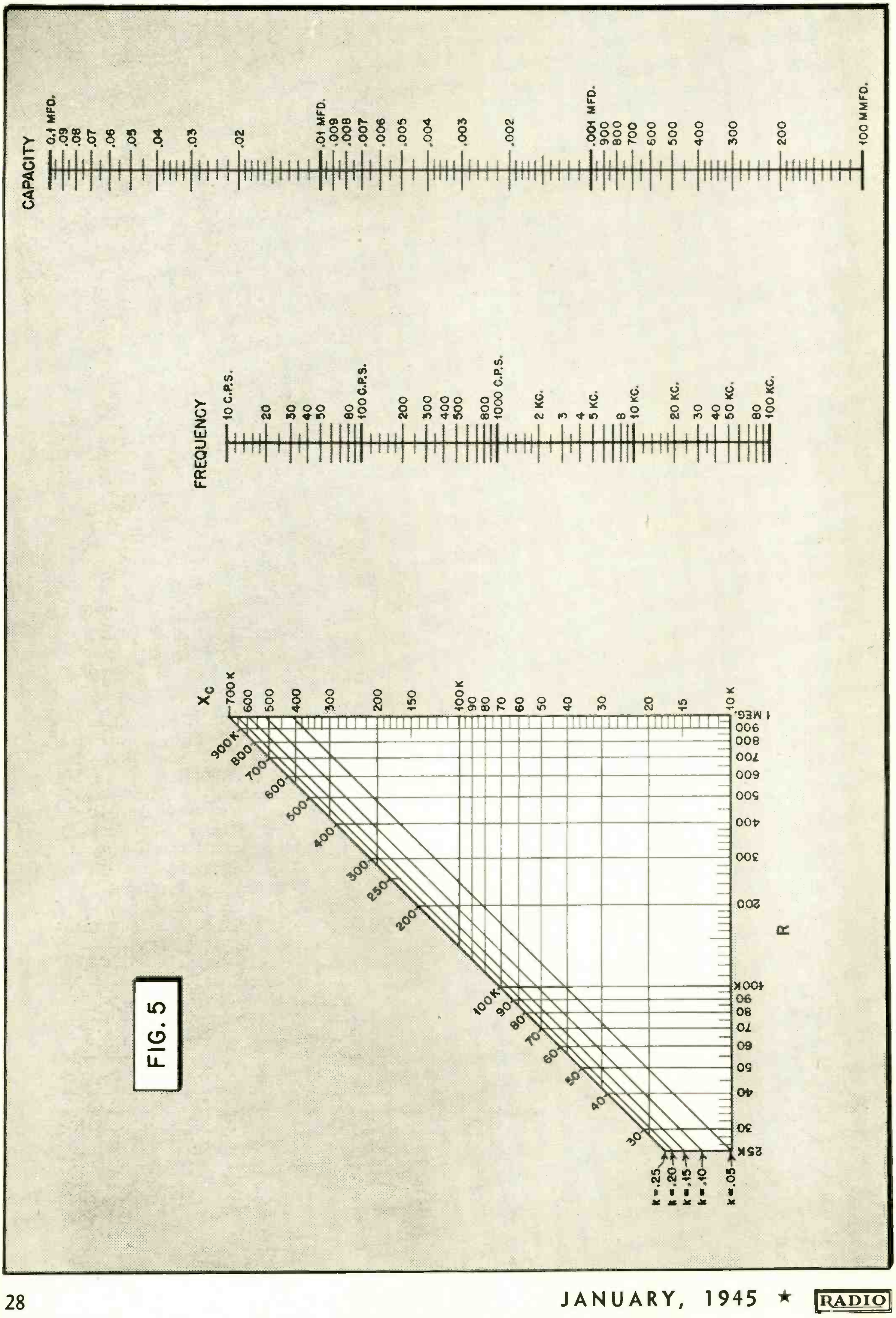

CAPACITY
0.1 MFD.
.09
.08
.07
.06
.05
.04
.03
.02
.01 MFD.
.009
.008
.007
.006
.005
.004
.003
.002
.001 MFD.
900
800
700
600
500
400
300
200
100 MMFD.
FREQUENCY
10 C.P.S.
20
30
40
50
80
100 C.P.S.
200
300
400
500
800
1000 C.P.S.
2 KC.
3
4
5 KC.
8
10 KC.
20 KC.
30
40
50 KC.
80
100 KC.
$X_C$
700 K
600
500
400
300
200
150
100 K
90
80
70
60
50
40
30
20
15
10 K
R
1 MEG.
900
800
700
600
500
400
300
200
100K
90
80
70
60
50
40
30
25K
900K
800
700
600
500
400
300
250
200
100 K
90
80
70
60
50
40
30
k = .25
k = .20
k = .15
k = .10
k = .05

FIG. 5

while the third resistor $R_1$ is the variable element.

## Characteristics

An oscillator using such a network to control its frequency is quite stable and produces a good sine wave. The attenuation is reasonable. When $R_1 = .05R$ the ratio of $E_o$ to $E_i$ is 6.43%. This means that a gain of 15.6 is necessary to overcome this loss.

When the three condensers are all the same size the value of $X_c$ for 180° phase shift is independent of the value of the condensers. Thus the best way to control the frequency of oscillations is to change $C$ as with a three section ganged condenser. The frequency will be inversely proportional to capacitance. Thus frequency variations of 10 to 1 can be obtained. It will be noted when using this method that one section of the condenser must have no common connection with the others. The size of $R_1$ also controls the frequency, however, variations of about 2 to 1 can be obtained. Furthermore the attenuation of the network varies with $R_1$ necessitating constant readjustment of the gain. $R_1$ can be used as a fine frequency control. As such it could be used to set the minimum frequency of an oscillator to any specific value within reason without impairing the ratio of frequencies available. $R_1$ is usually a rheostat that is not altered after the initial adjustments.

The following are defined for convenience in working with the network:

$$k = \frac{R_1}{R} \qquad (1)$$

$$k_1 = \frac{X_c}{R}, \text{ where } X_c = \frac{1}{2\pi fC} \qquad (2)$$

$$\rho = \frac{E_o}{E_i} \qquad (3)$$

$$\rho = \frac{M(M+P)+N(N+Q)-j(MQ-NP)}{(M+P)^2+(N+Q)^2} \qquad (4)$$

$$M = (2k_1^2-1)k \qquad (5)$$

$$N = (2k-k_1^2)k_1 \qquad (6)$$

$$P = 3k_1^2 \qquad (7)$$

$$Q = (2k+1)k_1 \qquad (8)$$

For 180° phase shift two conditions must be met. First, the real part of (4) must be negative and, second, the imaginary part must be zero. From the first condition we find that $M < 0$ and $N < 0$. Therefore there can be no 180° phase shift unless the following is true.

$$k < .25 \qquad (9)$$

$$MQ-NP = 0 \qquad (10)$$

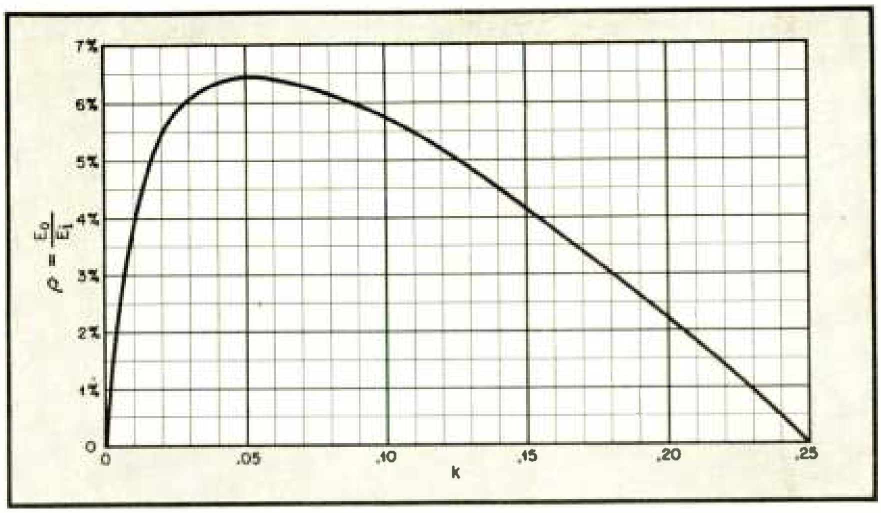



Fig. 4 Plot of the ratio Zt/R for various values of k

$$k_1^4 - \frac{4}{3}k(1-k)k_1^2 - \frac{1}{3}k(2k+1) = 0 \qquad (11)$$

$$k_1^2 = \frac{2}{3}k(1-k) + \frac{1}{3}\sqrt{3k+10k^2-4k^4} \qquad (12)$$

In *Fig. 2*, $k_1$ is plotted for different values of $k$.

To facilitate the calculation of $\rho$, $P$ is assumed to be $>>M$ and $Q>>N$. Therefore, the real part of 4) reduces to

$$\rho \cong \frac{N}{Q} = \frac{2k-k_1^2}{2k+1} \qquad (13)$$

This equation has been plotted in *Fig. 3*. From that graph it is seen that there is no feedback when $k = .00$ and when $k = .25$ The maximum feedback is obtained when $k = .05$. It is best to operate with $k$ between .05 and .25 for two reasons. First, greater stability is obtained when $k$ is large. This can be seen in *Fig. 2*. The slope of the curve indicates the change in $k_1$ and subsequently in frequency for a given change in $k$. This slope is reasonably flat in the region mentioned. Thus drift due to temperature variations are minimized. The second reason is apparent from *Fig. 4*. In this figure the ratio of $Z_t$ to $R$ is plotted as $k_2$. $Z_t$ is the impedance of the network as seen by the plate of the stage. When $k$ is less than .05 the value of $k_2$ falls off rapidly. This means that the oscillator would be loaded down reducing the effective gain of the stage.

## Nomograph

A nomograph, *Fig. 5*, is provided for solving oscillator networks of this type. Two examples will explain its use. First, assume that it is desired to build an oscillator to operate at 1000 cps using .001 μfd condensers. With a ruler connect the .01 μfd point on the *Capacity* line with the 1000 cps point on the *Frequency* line. The intersection of the ruler with the $X_c$ line determines the latter to be 157 K where $K$ is 1,000 ohms. From this point follow left horizontally to the slanting lines representing different values of $k$. Choose some reasonable value of $R$ that will also necessitate the use of a larger value of $k$ as pointed out above. Tak-

[*Continued on page 70*]

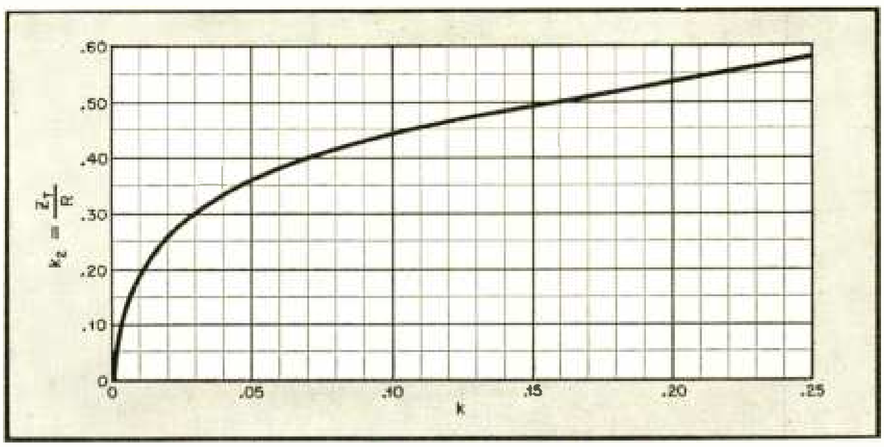



Fig. 3. Plot of the function ρ for various values of k

# Preparing Component

A. C. MATTHEWS

THE design of electronic equipment is not confined to electrical and mechanical development work. After the first sample has been completed electrically and mechanically it is then necessary to write specifications for the component parts.

It has been said, "If one unit can be built, a million can be built". This is true provided the specifications of the components making up the unit are so well written that production parts will all fit and work together as well or nearly as well as the engineering sample. It is one thing to write rigid specifications without regard to cost, wherein every conceivable condition of operation is taken into account, and another to write specifications where only the necessary characteristics and tolerances are specified. The latter requires considerable experience and a sound knowledge of electrical and mechanical engineering, as well as considerable production experience. The importance of this phase of engineering is not fully realized by many engineers. Specifications that are too exacting, as mentioned previously, unnecessarily increase the cost of the product but, on the other hand, specifications which are not sufficiently complete often result in inferior material being received. Obviously, incorrect components can cause considerable production difficulties and result in high labor costs as well as wasting materials.

In this article some general recommendations will be made for the specification of component parts and examples given of typical errors. After specifications have been completed and sample components are received for approval, it is usually the duty of the engineering department to inspect or measure these samples to ascertain whether they will fulfill the requirements for the job. It is extremely important that all of the information given on the drawing or specification of the sample component be carefully checked before approval. Not only should the

**TABLE 1**

**SPECIFICATION CHECK LIST**

**INDUCTORS — TRANSFORMERS**

| SPECIFY | SPEAKERS | LOOP ANTENNA | CHOKES R-F | CHOKES AUDIO | TRANSFORMERS R-F | TRANSFORMERS I-F | TRANSFORMERS A-I | TRANSFORMERS POWER |
|---|---|---|---|---|---|---|---|---|
| Inductance and Tolerance—Each winding and tap. | | X | X | X | X | X | X | X |
| Coupling Factor or Mutual-Spacing between coils | | | | | X | X | X | |
| Q or Figure of Merit @—KC. Shielded, unshielded | | X | X | | X | X | | |
| Inductance with —ma d-c, and volts a-c @—cycles | X | | | X | | | X | |
| Distributed or Capacity between windings | | X | X | | X | | X | |
| Wire Size and Insulation | X | X | X | X | X | X | X | X |
| Rated Volts &/or Current | X | | | X | | | | X |
| Voltage Breakdown—Corona | | | | X | | | | X |
| Leakage Resistance—Humidity Between windings or to case | X | | | X | X | X | X | X |
| R-F Two Frequency Spec. | | | | | X | | | |
| Type Winding—Universal, bank, layer, random | X | X | X | X | X | X | X | X |
| Powdered Iron Core Type | | | | | X | X | | |
| Laminated Iron—Type, Size | | | | X | | | X | X |
| Core Loss & Excitation Current | | | | | | | | X |
| Turns Radio | | | | | | | X | X |
| Temperature Rise | X | | | X | | | | X |
| Mechanical Hum or Buzz | X | | | X | | | | X |
| Electrostatic Shield | | | | | X | | | X |
| Resistance of Windings | X | | | X | | | X | X |
| Voice Coil Z and Phasing | X | | | | | | | |
| Frequency Response | X | | | | | | X | |
| Flux in Gap & Magnet Size | X | | | | | | | |
| Hermatic Seal or Impregnation | X | X | X | X | X | X | X | X |
| Mounting Type & Dimensions Lugs, leads, studs, bolts | X | X | X | X | X | X | X | X |
| Shield or Case Type-Material, mounting and dimensions | | X | | X | X | X | X | X |
| Exterior Finish | X | X | | X | X | X | X | X |
| Underwriters' Requirements | X | X | X | X | X | X | X | X |
| Identification Code | X | X | X | X | X | X | X | X |

# Specifications

**An analysis of methods of presenting design and test specifications for radio components to be used in production.**

**TABLE 2**

**CAPACITORS — SPECIFICATION CHECK LIST**

| SPECIFY | VARIABLE Air | VARIABLE Mica (Trimmers) | VARIABLE Ceramic (Trimmers) | FIXED Paper | FIXED Mica | FIXED Ceramic | ELECTROLYTIC Wet / Dry |
|---|---|---|---|---|---|---|---|
| Capacity & Tolerance | X | X | X | X | X | X | X |
| Q or Power Factor (Normal, after humidity) | X | X | X | X | X | X | X |
| Drift Characteristic—(Temp, aging, retrace) | X | X | X |  | X | X |  |
| Leakage Resistance — (Normal, after humidity) |  |  |  | X | X | X | X |
| Reactance at — KC. | X | X | X | X | X | X | X |
| Temperature Range & Max. Operating Temperature |  |  |  | X | X | X | X |
| Working, Surge or Breakdown Voltage—Altitude, corona | X | X | X | X | X | X | X |
| Housing—(Metal, cardboard, molded, ceramic, hermetic seal) |  |  |  | X | X | X | X |
| Exterior Finish—Plating, wax, paint, fungus resisting | X | X | X | X | X | X | X |
| Mounting & Dimensions—Lugs, leads, bushings, clamps, bolts | X | X | X | X | X | X | X |
| Maximum Dimensions | X | X | X | X | X | X | X |
| Dielectric & Treatment | X | X | X | X | X | X |  |
| Rotation & Torque | X | X | X |  |  |  |  |
| Capacity Curve vs. % Rotation | X | X | X |  |  |  |  |
| Section Matching & Tolerance | X |  |  |  |  |  |  |
| Plate Type—Shaped, formed, etched, plain | X |  |  |  |  |  | X |
| Microphonics | X | X |  |  |  |  |  |
| Life Test—Cycles rotation | X |  |  |  |  |  |  |
| Shaft, Bearings, Wipers | X |  |  |  |  |  |  |
| Maximum Current at —kc. | X | X | X | X | X | X | X |
| Ripple Current (Max.) |  |  |  |  |  |  | X |
| Leakage Current |  |  |  |  |  |  | X |
| Identification &/or Color Code | X | X | X | X | X | X | X |

components be measured and inspected in every detail, but they should actually be substituted in a working model of the product in which they will eventually become a part. Such a procedure will often uncover some overlooked difficulty, and necessitate a revision in the specifications which might otherwise be overlooked had the component only been checked against the drawing. A few such cases will certainly impress upon the engineer the importance of detailed specifications and fortunately the trouble can usually be remedied in time to prevent production difficulties.

The measurement and actual use of the samples before approval is therefore nearly as important as the writing of the original specifications.

## Specifications

First, let us consider the drawings or specifications. These are usually made on tracing cloth or paper suitable for reproduction. Several methods of reproduction are currently used and each have their advantages and disadvantages which, however, will not be discussed at this time since we are primarily interested in the information appearing on them.

Some drawings merely show one or more views of the part with a specification consisting of a descriptive name followed by the word "Type #—— as made by XYZ Manufacturing Co." Such a specification leaves much to be desired. In the first place, the purchasing department is limited to one source of supply. Furthermore there is little control over the characteristics of the part either electrically or mechanically, and the supplier would be justified in making small changes in an effort to improve his product which might seriously affect its usefulness in a particular design. Being a standard part with the supplier, undoubtedly the "improved version" could be returned, but in the meantime production would be seriously affected and a loss of both time and money would result.

## Confusing Specifications

In contrast to the over-simplified specification we have the type that is confusing due to its complexity. This type gives information on all details (which incidentally it should) but in being so meticulously complete the information is given more than once. For instance, an i-f coil is specified as having a certain number of turns of a specific size and type of wire, wound commercial service. This along with other factors such as ambient temperature, humidity, altitude, and in certain cases Underwriters requirements must all be reviewed; keeping in mind that on a specified form and mounted in a particular type of shield can. The physical spacing between windings as well as the mutual inductance, individual coil Q, inductance, gain under typical operating conditions, selectivity and coupling factor are also given. This type of drawing not only specifies all of the materials to be used but specifies the completed performance as well. While on the surface such a drawing may seem to be the last word in engineering perfection, it leaves much to be desired from the part manufacturers' standpoint. Very few manufacturers have the same facilities for the fabrication of parts; one may have a particular type of winding machine which will handle an equivalent type of wire, but is not adaptable to the exact size specified. The completed transformer, however, can be made to perform in accordance with the electrical specifications if certain unnecessary parameters are disregarded. In order to supply the transformer according to the print it is necessary that new equipment be purchased which, unless the order is quite large, will result in an increased cost.

Such a situation could have been prevented if the designer had only required that the overall performance and the physical dimensions be within specified limits. The information as to raw materials could have been included for reference purposes or they might have been specified along with the note "or equivalent". It is definitely a waste of time, for example, to specify the exact number of turns of wire on a coil and then give the required inductance. One or the other should be sufficient. Likewise, spacing between coils should not be given in inches if the mutual inductance between the same coils is specified. In other words, give only pertinent information or data, together with all allowable tolerances. If it is desired to include extra information or data to aid in the fabrication of the part, state plainly that the information is for reference only or the values are "approximate". This is good engineering practice as its serves as a guide not only to the part manufacturer but to other engineers who might be considering the use of the same component in another design.

### Tolerances

Another important item in preparing specifications is the assignment of tolerances. These have a very definite relation to the cost of the part and should be specified with forethought. The fact that a certain type of coil, for example, has previously been used with a tolerance of plus or minus one percent

**TABLE 3**

**RESISTORS — SPECIFICATION CHECK LIST**

| SPECIFY | VARIABLE Comp. | VARIABLE Wire | Metalized | FIXED Comp. | FIXED Wire | POWER TYPE |
|---|---|---|---|---|---|---|
| Resistance and Tolerance | X | X | X | X | X | X |
| Resistance curve vs % Rotation | X | X | | | | |
| Power Dissipation (free air) | X | X | X | X | X | X |
| Max. operating volts across unit | X | X | X | X | X | X |
| Maximum Operating Temp. | X | X | X | X | X | X |
| Voltage Coefficient | | | X | X | X | X |
| Temperature Coefficient | | | X | X | X | X |
| Reactance at —kc. | | | X | X | X | |
| Life vs. Resistance (overload) | | | X | X | X | X |
| Life vs. Cycles Rotation | X | X | | | | |
| Noise | X | X | X | X | X | |
| Maximum Physical Dimensions | X | X | X | X | X | X |
| Shaft—length, diameter, type | X | X | | | | |
| Taps and position | X | X | | | X | X |
| Terminals—Leads—Lugs (Ground-insulated) | X | X | X | X | X | X |
| Insulated Covering | | | X | X | X | |
| Degrees Rotation (with or without switch) | X | X | | | | |
| Salt-water Immersion | X | X | X | X | X | X |
| Leakage to Case—Humidity | X | X | X | X | X | X |
| Torque—Operating | X | X | | | | |
| Mounting—(Self leads, ferrule, rod, bushing, locating pins) | X | X | X | X | X | X |
| Exterior Finish—(Wax, cement, vitreous, fungus resisting) | | | X | X | X | X |
| Identification or color code | X | X | X | X | X | X |

**TABLE 4**

**SPECIFICATION CHECK LIST**

MISC. COMPONENTS — chiefly insulating materials

| SPECIFY | INSULATED WIRE & CABLES | TERMINAL PANELS | SOCKETS Tube | Toggle | SWITCHES Push Button | Wave Band |
|---|---|---|---|---|---|---|
| Dielectric—Grade & Type | X | X | X | | X | X |
| Impregnation—(Wax, fungus resisting) | X | X | X | | X | X |
| Capacity/Q Ratio at —kc. | X | X | X | | X | X |
| Insulation Resistance—(Internal, surface—humidity) | X | X | X | X | X | X |
| Voltage Breakdown—(Normal, altitude, humidity) | X | X | X | X | X | X |
| Salt water Immersion | X | X | X | X | X | X |
| Maximum Mechanical Dimensions | X | X | X | X | X | X |
| Mounting—Dimensions (Angles, clip, bushing) | | X | X | X | X | X |
| Degrees Rotation and/or Throw (Snap, momentary, index) | | | | X | X | X |
| Sections & Positions | | | | X | X | X |
| Shaft—(Length, diam., thickness) | | | | | X | X |
| Wire Size—(Solid, stranded) | X | | | | | |

**TABLE 5**

**SPECIFICATION CHECK LIST**

**METAL PARTS**

**SPECIFY**

MATERIAL—Steel, brass, copper, zinc, bronze, aluminum, alloys.

TYPE—Sheet, rod, tubing, strip, special.

GRADE—Hard, soft, cold or hot rolled, annealed, permeability, special heat treated.

PROTECTIVE COATING—Plating, paint, chemical, fungus resisting.

PROCESS—Electroplate, dip, spray, brush.

DIMENSIONS & TOLERANCES—Fractions, decimals, radii, degrees.

FABRICATION — Cast, machined, stamping, drawing, formed.

DETAILS—Punch formed, extruded, embossed, knurled, finish marks, grain direction, etc.

TEST REQUIREMENTS — Underwriters, salt spray, strength, hardness, etc.

of its inductance does not give the designer the liberty of using the same value. Other factors such as Q, operating frequency, circuit, etc. should be considered. Obviously the greater the tolerance the lower the cost of manufacture, which in turn permits the selling price to be more competitive. Tolerance is certainly not confined to electrical specifications alone. Physical dimensions in fractions or decimals should be carefully considered. Decimal tolerances are more often justified when production of large quantities are involved, where die cost and original set-up charges will be spread over a large number of units. Another reason which might make it profitable to specify a dimension as a decimal quantity is where the saving in labor due to "perfect" fit in an assembly operation would be obtained. In general, labor costs more than raw materials, particularly when skilled or semi-skilled personnel are required to perform the operation.

The intended service, that is, whether intermittent or continuous, has a definite bearing on the writing of specifications. An example of this is the two ratings given to transmitter tubes, viz: *(1)* ICAS, intermittent commercial and amateur service. *(2)* CCS, continuous commercial service. This along with other factors such as ambient temperature, humidity, altitude, and in certain cases Underwriters requirements must all be reviewed; keeping in mind that unnecessarily rigid specifications are to be avoided whenever possible.

Measurement methods may vary greatly between manufacturers and this being the case, it is advisable with certain parts to either specify the method preferred, or actually include instructions in the form of a diagram on the part drawing. Such a procedure need only be used when there is a chance of considerable error should an alternative method be used. As an example of this, where the specification of a small mutual inductance is desired it might be well to note "Mutual inductance to be measured on Carey Foster bridge". This should be sufficient since the Carey Foster bridge is well known.

Where it is important, due to the special nature of the design, a complete schematic showing all circuit constants should be included. For example, suppose we have a complex i-f transformer in which we are interested mainly in the shape of the selectivity curve and gain. To specify all of the critical parameters together with allowable tolerances would require a great amount of unnecessary engineering. *Fig. 1* shows a typical simplified transformer drawing wherein only the desired characteristics have been specified with tolerances. Obviously such a specification is much more easily understood and followed, since only the overall result is specified without regard to such factors as coil spacings, Q etc. Of course, there may be instances where certain parts used in the construction might vary in such a way that the overall performance was not impaired, yet some undesirable effect might be experienced. An example of such a case is where the effectiveness of a shield can be so poor that magnetic coupling occurs between the coils and other parts of the unit, but the transformer performance as a unit is not affected. Such inconsistencies are rare although they must be considered before writing specifications.

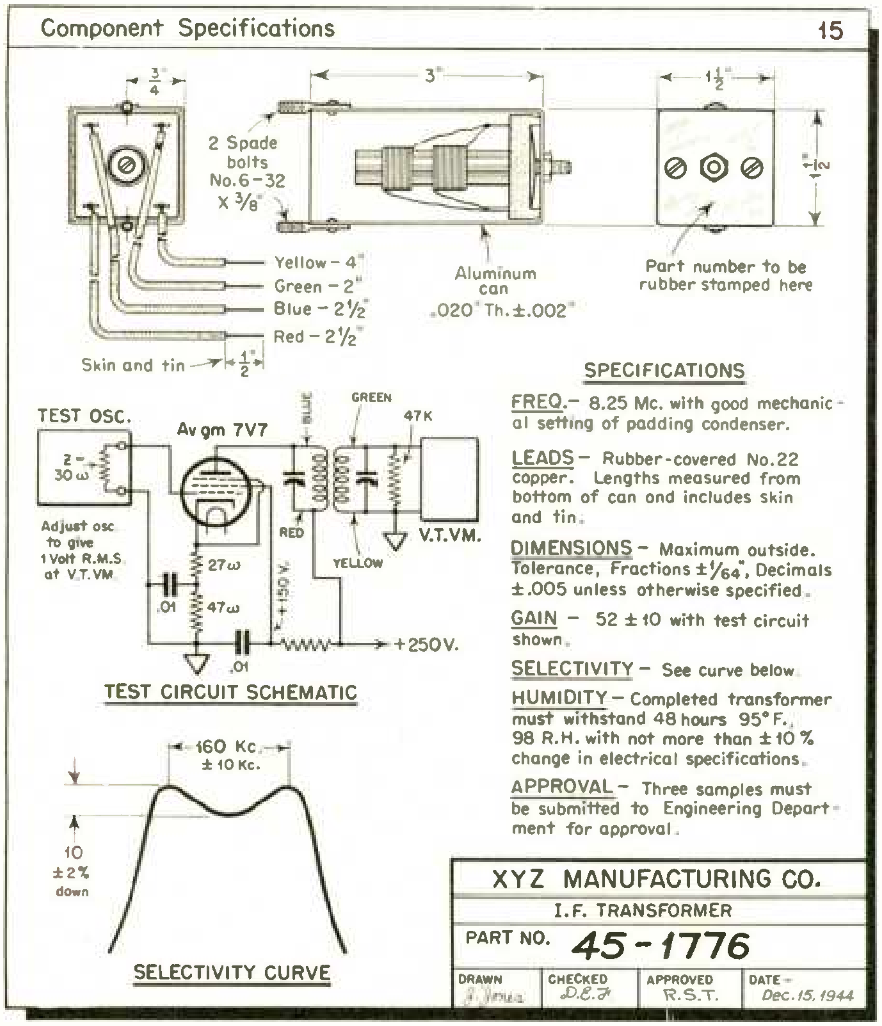



**Fig. 1 Representative specification sheet**

## Approved Samples

Some engineering departments make a practice of supplying the part manufacturer with an approved sample as a guide, and cover this with a note on the drawing stating, "In all respects not covered by the specification the purchased part must conform with the en-

*(Continued on page 70)*

# RADIO BIBLIOGRAPHY

**F. X. RETTENMEYER**

RCA Victor Division, Radio Corporation of America

## 17—AIRCRAFT RADIO, PART 5

Phase Synchronization in Directive Antenna Arrays with Particular Application to Radio Range Beacon—F. G. Kear—*Bureau of Standards Jrnl. of Research*—Vol. 11, 1933, Page 123.

The Cathode Ray Oscillograph in Radio Research—R. A. Watson Watt, J. F. Herd and L. H. Bainbridge-Bell—*H. M. Stationery Office*—1933.

Note on Theory of Night Errors Adcock Direction Finder System—J. F. Coales—*Jrnl. I.E.E.*—Vol. 71, No. 429, June 1932, Page 497.

Variation of Bearings Observed in Short-Wave Direction Finder (on a small rotating frame)—Asukai, M., and Hayasi, T.—*Wireless Engr.*—Vol. 9, March 1933, Page 169.

Piel-Registrierungen des Nachteffekts—M. Dieckmann—*E.N.T.*—Vol. 9, Feb. 1932, Pages 46-48.

Polarization of H.F. Waves and Their Direction Finding—S. Namba, E. Iso and S. Ueno—*Sci. Abs.*—Sec. B., Vol. 35, Jan. 1932, Page 41.

Wireless and Night Flying. The Marconi-Adcock Direction Finder—*Flight*—Vol. 24, Feb. 19, 1932, Pages 154-155.

An Experimental Direction Finding Station—R. Keen—*Wireless World*—Vol. 14, April 2, 1924, Pages 66-71.

Some Radio Direction Finding Observations on Ship and Shore Transmitting Stations—R. L. Smith-Rose—*Jrnl. Institution Elec. Engrs.* (London)—Aug. 1924, Page 701.

British Patent 220,029—1924—Robinson et al.

The Effect of Local Conditions on Radio Direction-Finding Installations — R. L. Smith-Rose—*I.E.E. Jrnl.*—Vol. 61, Pages 179-191; discussion, Pages 191-196, Jan. 1923.

The Effect of Underground Metal Work on Radio Direction Finders—R. L. Smith-Rose and R. H. Barfield—*Wireless World and Radio Rev.*—Vol. 11, Nov. 4, 1922, Pages 165-171.

Improvements in Means for Determining the Direction of a Distant Source of Electromagnetic Radiation—F. Adcock—British Patent No. 130,490—1919.

Wireless Directional Finder the Secret of Adcock's Success—*Wireless Age*—August 1919, Page 18.

Instruments and Radio Flying—K. S. Day (Text)—Distributed by Air Associates—Page 81.

Air Traffic Rules—Civil Air Regulations as Amended to May 31, 1938—Part 60, Page 252. Published by U. S. Department of Commerce—Bureau of Air Commerce.

Through the Overcast—A. Jordanoff (Text)—Funk & Wagnalls, 1938, Page 278.

Instrument and Radio Flying—K. S. Day (Text)—Air Associates, 1938, Page 105.

Flightray—*Communications*—Vol. 18, No. 10, Oct. 1938, Page 22.

Practical Use of Radio as a Direct Aid to the Landing Approach in Conditions of Low Visibility—R. S. Blucke—*Royal Aeronautical Society Jrnl.*—Vol. 42, June 1938, Page 483.

A Method of Exciting the Aerial System of a Rotating Radio Beacon—H. A. Thomas—*Jrnl. I.E.E.*—Vol. 77, 1935, Page 285.

The Night Performance of Marconi-Adcock Direction Finder—S. B. Smith—*Marconi Review*—No. 50, September-October 1934, Page 1.

Marconi Direction Finder, Type DFG 90 —*Marconi Review*—No. 48, May-June 1934, Page 1.

Elimination of Phase Shifts Between the Currents in Two Antennas—H. Roder—*I.R.E. Proc.*—1934, Vol. 22, Page 374.

A Radio Compass Development in His Majesty's Signal School—C. E. Horton and C. Crampton—*Jrnl. I.E.E.* (London) —Vol. 73, No. 441, Sept. 1933, Page 284.

Cause and Elimination of Night Effects—H. Diamond—*Bur. of Standards Jrnl. of Research*—Vol. 10, No. 1, January 1933, Page 7.

The Lorenz Blind Landing System—R. Denman—*Wireless World*—April 5, 1935, Page 332.

Present State in the Arc of Blind Landing of Airplanes Using Ultra-Short Waves in Europe (Lorenz Company's glide-path system)—E. Kramar—*IRE Proceedings*—Vol. 23, #10, Oct. 1935, Page 1171.

A New Field of Application for Ultra Short Waves—E. Kramar—*IRE Proceedings*—Nov. 1933, Page 1519.

Lorenz Blind Landing System—*Wireless World*—April 5, 1933, Page 332.

Automatically Controlled Blind Landing—G. V. Holloman—*SAE Jrn.*—Vol. 42, #6, June 1938, Page 13.

Air Corps Automatic Landing System—*The Reserve Officer*—October 1937, Page 16.

Automatic Hookup Lands Plane Blind—*Aviation*—October 1937, Page 57.

Army Air Corps Radio Blind Landing System Adapted as Standard by Bureau of Air Commerce—*Air Commerce Bulletin*—Vol. 5, No. 6, Page 107.

Progress Reported on New Blind Landing System—Metcalf (MIT)—*Aviation*—Vol. 37, July 1938, Page 40.

Three Spots and a Horn—D. G. Fink—*Aviation*—Vol. 37, #9, Sept. 1938, Page 28.

Instrument and Radio Flying—K. S. Day (Text)—Air Associates, Inc.—1938, Page 237.

Metal Horn Focuses Ultra Short Waves—*Radio and Television*—Vol. 9, No. 6, October 1938, Page 332.

Le Guidage par cable et le guidage sans cable des navires et des avions—C. Sourgonnier—*Rev. Gen. De l'Électricité*—Vol. 28, July 5, 1930, Page 19.

Le guidage par Cable Sous-marin, Procède William Loth, est Definitivement au Point—Jean Labadie—*Science et La Vie*—Vol. 37, April 1930, Page 306.

Remarques sur le Guidage Magnetique des Navires—E. Fournier—*Comptes Rendus*—Vol. 189, Oct. 21, 1929, Page 598.

The Field Radiated from Two Horizontal Coils—G. Breit—*Bureau of Standards, Scientific Papers*—#431, March 10, 1922.

Field Locator Makes Travel by Air Safe—*Aerial Age Weekly*—Vol. 15, June 26, 1922, Page 379.

Sur la Solution du Problème de Guidage des Mobiles aeriens par Brume où de Nuit sans Aucune Visibilité—W. Loth—*Comptes Rendus*—Vol. 173, Dec. 1921, Page 1152.

Finding Aircraft Landing Stations by Means of Audio Frequency Receivers—E. C. Hanson—*Aerial Age Weekly*—Vol. 9, May 19, 1919, Page 489.

Landing Aircraft by Sound—*Wireless World*—June 26, 1936, Page 627.

Ear Specialist (Editorial)—*The Sportsman Pilot*—Vol. 15, No. 4, April 1936, Page 16.

An Instrument Landing System—E. N. Dingley—*Communications*—Vol. 18, No. 6, June 1938, Page 7.

Status of Instrument Landing Systems—W. E. Jackson—*IRE Proceedings*—Vol. 26, June 1938, Page 681.

Instrument Landing, Today and Tomorrow—H. W. Roberts—*Aero Digest*—Vol. 32, June 1938, Page 79.

Proposed Blind Landing System (Microwave receivers, distributed over landing field, each starting its own relay-controlled audio-oscillator when excited by highly directional beam from areoplane)—Sorenson—*Aero Digest*—Vol. 30, #5, May 1937, Page 64.

Instrument Landing Systems for Aircraft—H. W. Roberts—*Aero Digest*—October 1936, Page 32.

Coming in to Land—T. Lee—*Western Flying*—July 1936.

A New System for Blind Landing of Airplanes—K. Baumann & A. Ettinger—*IRE Proceedings*—Vol. 24, #5, May 1936, Page 751.

Radio Blind Landing System to Be Installed on Midcontinental Airway—*Air Commerce Bulletin*—Vol. 15, #8, Feb. 15, 1935, Page 179.

Blind Landing Method for Aircraft—Societe Francaise Radio-Electrique—*Hochfrequenztechnik und Elektroakustik*—Vol. 48, #3, 1936, Page 109. French Patent 799180, Sept. 3, 1935.

Instrument and Radio Flying—E. A. Cutrell—*Aviation*—Vol. 34, June 1935, Page 11.

Blind Approach Prospects—*The Airplane*—Aug. 31, 1935.

Radio Approach System Assists Airmen to Land under Low Ceilings—*Air Commerce Bulletin*—January 15, 1934, Page 165.

Energized Cables Lower Hazards of Fog—*Electric World*—Vol. 99, April 9, 1932, Page 642.

Über ein Elektrisches Verfahren für Flugplatzbergrenzungen zur Erleichterung von Blindlandungen—*Hochfrequenztechnik und Elektroakustik*—Vol. 40, August 1932, Page 41.

Atterrissage Radio-Éléctrique des Avions en Temps de Brune—L. de la Forge—*QST Francais*—Vol. 12, April 1931, Page 25.

Photocell Beacon to Aid Fog Flying—Electronics—Vol. 2, June 1931, Page 695.

Flying an Airplane in Fog—Doolittle—*SAE Jrnl.*—March 1930, Page 318.

Pamphlets by the Guggenheim Foundation for Aeronautics; Solving the Problem of Fog Flying, October 1929—Equipment Used in Experiments to Solve the Problem of Fog Flying, March 1930.

Localized Radio Landing Signals for Airplanes—*Radio Service Bulletin #60*—April 1, 1922, Page 14.

Radio Tells Aircraft Altitude—*Aerial Age Weekly*—15, May 22, 1922, Page 258.

The Field Radiated from Two Horizontal Coils—Gregory Breit—*Bureau of Standards* Scientific Paper No. 431, 1922.

U. S. Patent #1,898,474—Loop Antenna—filed June 26, 1919.

U. S. Patent #1,555,345—Aircraft Landing System—Filed January 19, 1929.

Blind Landing Aids, Electrical Engineers' Handbook—Pender and McIlwain (*Communication* and *Electronics*) Page 16.

The New Radio Controlled Automatic Pilot—*The Aeroplane*—Feb. 23, 1938, Page 230.

Automatic Homing—*Flight*—Feb. 24, 1938, Page 181.

Instrument and Radio Flying—K. S. Day—(Text)—Dist. by Air Associates, Page 50.

A Directional-Reading Radio—Wave Reflection—Type Absolute Altimeter for Aeronautics—Sadahir Matsuo—*IRE Proceedings*—July 1938, Page 848.

The Acoustic Altimeter—Delsasso—*Science*—Vol. 85, May 28, 1937, Page 10.

A Research of Direct-Reading Altimeter for Aeronautical Use by Radio Wave Reflection—S. Matsuo—*I.E.E. Japan Jrnl.*—Vol. 56, (2) No. 571, Feb. 1936, Page 89.

The Application of Radio Technique to the Acoustical Aircraft Altimeter (Dubois-Laboureur System)—Van Steenbergen—*The Radio Centrum*—Vol. 2, Jan. 24 and 31, 1936, Page 45 (Dutch).

A Study of The Direct-Reading Absolute Altimeter for Aeronautics by the Radio Wave Reflection Method—S. Matsuo—*Report of Radio Research in Japan*—Vol. 6, #1, May 1936, Page 10 (Abstracts).

Messgenauigkeit des Behmlotes für Flugzeuge bei geringen Flughohen—E. Schreiber—D.V.L. Report #205, Z.F.M.—Vol. 22, No. 3, 1931, Page 77—*D.V.L. Yearbook*—1931, Page 591.

The Behm Acoustic Sound for Airplanes with Reference to its Accuracy—E. Schreiber—*T.M.* No. 588, *N.A.C.A.* 1930.

Landing Indicator for Airplanes—*Radio Engineering*—Vol. 10, April 1930, Page 47.

Height of Airplanes Above the Ground by Radio Echo—E. F. Alexanderson—*Radio Engineering*—Vol. 9, 1929, Page 34.

True Altitude Meters—L. A. Hyland—*Aviation*—Vol. 25, No. 18, 1928, Page 1322.

Means for Ascertaining Elevations of Aircrafts—E. N. Todd—U. S. Patent No. 1,557,380 issued Oct. 13, 1925.

Bodendistanzmessung vom Luftschiff mittels Kapazitätsmethode — H. Lowy — *Physik Z.*—Vol 26, No. 18, 1925, Page 646.

Capacity Compensating Device — J. H. Hammond, Jr., U. S. Patent No. 1,561,228, Issued November 10, 1925.

Ballonversuche über die Abhangigkeit der Antennenkapazitat von der Bodendistanz—E. Alberti, W. Klemperer, and H. Lowy—*Physik Z.*—Vol. 26, No. 18, 1923, Page 644.

Radio Tells Aircraft Altitude—*Aerial Age Weekly*— May 22, 1922, Page 258.

Experiments with Underground Ultra High Frequency Antenna for Airplane and

[*Continued on page 66*]

# This Month

## W-E TELEVISION

Western Electric Company plans to manufacture television transmitting equipment in the postwar period, according to an announcement by F. R. Lack, vice president in charge of the company's radio division.

Mr. Lack pointed out that during peacetime Western Electric is the manufacturing and supply unit of the Bell System and a leading manufacturer of radio broadcasting equipment. Since Pearl Harbor, he said, the Company has become the Nation's largest producer of communications and electronic devices for the Armed Forces, including amplitude modulated and frequency modulated radio transmitting equipment.

Supplementing the plans for manufacture of television transmitters. Mr. Lack indicated that an active program of television development will be undertaken as soon as war conditions permit. The postwar transmitting equipment will be distributed through Graybar Electric Company.


The yachtsman's telephone has gone to war. The midget Western Electric 8 watt radio transmitter and receiver which formerly enabled the small boat owner to keep in communication with the Coast Guard, land telephone system and with other radio-equipped vessels, is shown above installed aboard a Merchant Marine training ship.

## WPB ACTIONS

The Industrial Sound Equipment Industry Advisory Committee believes that electronic equipment controls should not be revoked until all military requirements can be met, but that controls should be modified as war demands decrease and materials become more readily available, officials of the War Production Board's Radio and Radar Division said today.

Revocation or modification of Limitation Order L-265 was considered by the committee, which met recently in Washington. Equipment used in public address systems, inter-communication systems and other industrial sound amplifying equipment falls within the category of electronic equipment involving the use of vacuum or gaseous tubes, under L-265. Since the war, considerable apparatus of this sort has been used in industrial plants to increase production, maintain morale, and save time and labor. The military demand for this type of equipment and many of its components also contributes to the present civilian shortages, it was pointed out.

Means of acquiring equipment for civilian uses were outlined to the committee by John Creutz, Government presiding officer, who said that a user may file WPB Form 541 with an equipment manufacturer through any WPB field office, provided no construction is required. If construction is required, Form 617 must be filed.

WPB field offices will screen all applications on their merits. The burden of proof in establishing essentiality will rest with the applicant.

WPB Radio and Radar Division officials announced it is possible that some commercial equipment not suitable for military, marine and foreign uses, which require special sealing and weather proofing, might become available for industrial use. Industry members pointed out that they probably could use rejected Army and Navy equipment if it could be made available. Supplies of sound equipment for industrial purposes and installations have been inadequate during the past year, members said, adding that they now had not stocks on hand.

Means of aiding jobbers in securing sound equipment for service and repair of their customer's systems were discussed and it was recommended that permission to acquire essential sound equipment be extended to a number of jobbers. Such jobbers that require units of equipment should file Form 547, but it was explained that this would not apply to, nor cover parts. Applications for equipment will be considered and the worthy ones processed, officials said. However, such stocking as allowed would be for emergency repairs, and not for general resale.

The issuance of a pamphlet entitled "Guide of Industrial Sound", designed to explain the uses and value of sound equipment, was announced. This document will soon be put on sale by the Superintendent of Documents.

## BROWDER J. THOMPSON KILLED IN ACTION

Browder Julian Thompson, Associate Research Director of RCA Laboratories, Princeton, N. J., who had been on leave from RCA since December, 1943, serving as expert consultant in the Office of the Secretary of War, was killed in action during a flight in an Army plane in the

[*Continued on page* 44]

# RADIO DESIGN WORKSHEET

## NO. 32—PUSH-PULL CIRCUIT FUNDAMENTALS; SIMPLE SOLUTION OF HALF-WAVE AND FULL-WAVE LINEAR RECTIFIERS

### PUSH-PULL CIRCUIT FUNDAMENTALS

In *Fig. 1(a)* is shown a line *AA'* representing a magnitude and a direction. The length of *AA'* might represent a force, a voltage, or a current. Moreover, the direction in which this force, or voltage, is applied is defined by the position of *AA'*. However, the voltage may be applied in a direction *AA' or A'A*. This is further defined in *Fig 1(b)* in which the sense is expressed by the arrow showing that the direction of the voltage in *AA'*. The line *AA'* is a vector.

Vectors may be added or subtracted by several means. For example, in *Fig. 1(c)* we have two vectors *AA'* and *AB* having a common origin *A*. As long as the magnitude, direction and sense of the vectors are unchanged they may be set up with a common origin or end to end. Thus, to add the two vectors they may be placed as shown in *1(c)* and the parellelogram completed. The diagonal of the parallelogram is then the vector sum (i.e., *AO*).

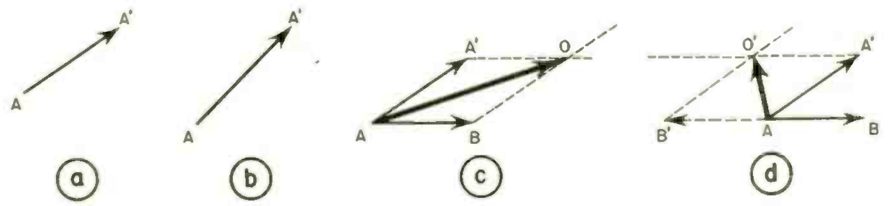



Figure 1

Vectors may be subtracted in like manner. That is, by reversing the sign (i.e., sense) of one of them and adding vectorially as at *1(d)*. Here is represented *AA'—AB*. Thus *AB'* = —*AB* adding *AB'* and *AA'* yields *AO'*, again by completing the parallelogram. The difference *AB* — *AA'* would be equal in magnitude to *AO'* but opposite in sense; in other words — *AO'*. *Fig. 2* shows another method of adding and subtracting vectors by placing them end to end and joining the origin and the point of the last vector for the result.

Sense and relative direction are often described as phase. Thus the phase of *B* lags *A* and *C* leads *A* in phase. This is in accordance with the accepted pattern of considering that the vectors rotate in an anti-clockwise direction for alternating or pulsating electric current or voltage.

An alternating current or voltage may also be represented by a sine wave or simple harmonic motion as shown in *Fig. 3(a)* either as a sine wave or a line with sense.

The position of the vector relative to any other vector may be shown by the angular rotation of the vector in radians (or degrees) or as indicated by the two sine waves of *Fig. 3(b)*. Here vector *C* is shown leading *B* by $\pi/2$ radians (i.e., 90 degrees). Obviously *B* and *C* may be added or subtracted in either form with similar results. Procedures are identical but adding and subtracting sine waves is somewhat laborious since the waves must be added or subtracted point by point.

*Fig. 4* shows a generalized push-pull circuit with power supply circuits

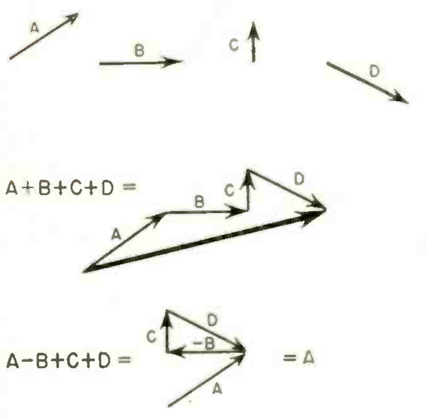



Figure 2

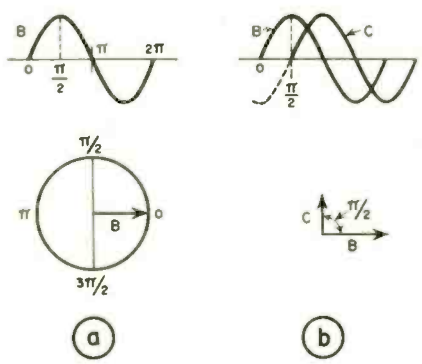



Figure 3

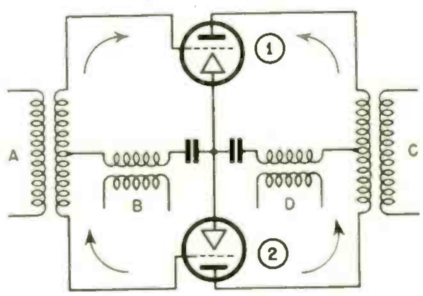



Figure 4

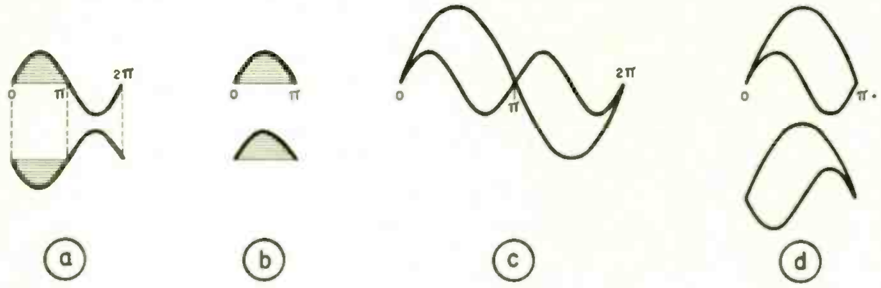



Figure 5

omitted. If a voltage $E = C \sin \alpha$ is introduced at *A* the grids of tubes *(1)* and *(2)* will be energized in phase opposition. That is the grid of tube *(1)* will be negative while the grid of tube *2* is positive and vice versa. This will result in similar currents or voltages being developed in the plate circuits of tubes *(1)* and *(2)*. The wind-

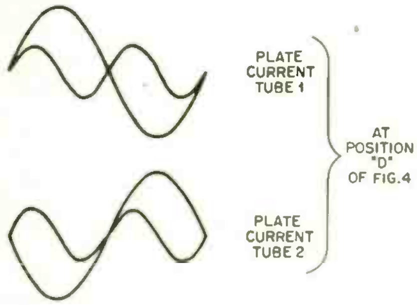



Figure 6

ings of transformer *C* are so connected that these currents are additive in the secondary. Since these currents are out of phase direct addition would result in cancellation if the two did not differ in phase by other than $\pi$. However, if two identical waves differing in phase by $\pi$ radians are to be combined so that their fundamentals are additive, the situation shown in *Fig. 5* results. As a result second and other even order harmonics introduced by the push pull circuit will be balanced out or at least materially reduced. This is obvious if it is recalled that the effect of the push-pull balance is to invert the half of the wave from $\pi$ to $2\pi$, shift it in phase by $\pi$ radians, and add directly to the positive half-cycle from 0 to $\pi$. The cancellation of even harmonics is evident from an inspection of *Fig.* (d).

However, transformer *D* in *Fig. 4* is not connected differentially so the plate currents of the two tubes add directly. Since they differ in phase by $\pi$ radians the situation pictured in *Fig. 6* results. In this case the even harmonics are in phase and additive, whereas the fundamental and odd harmonics cancel out as indicated in *Fig. 6*. It should be remembered that odd harmonics are symmetrical about $\pi$ insofar as their relation to the fundamental is concerned, whereas even harmonics are not.

Next, consider the effect of the introduction of the signal at *B* in *Fig. 4* instead of at *A*. In this case both grids are essentially in parallel and are each positive at the same instant. As a result the plate currents are in phase and due to the differential correction of transformer *C*, the fundamental balances out as do the even and odd harmonics, but all of them appear at *D*. This can be visualized by inverting a wave and its harmonics as shown in *Fig. 7*. This is legitimate because the currents in the two halves of the primary of *C* are theoretically equal and opposite. It therefore follows that complete cancellation will take place provided the currents are identical and the transformer *C* is perfectly balanced. At transformer *D*, however, both plate currents are in phase, and since they are identical theoretically even to harmonic content, they are additive as are all harmonics. This can be visualized by comparing the push-pull circuit obtained by folding one half of the push-pull circuit over the other so that tube *2* coincides with tube *1* and the two halves of transformer *A* and coincide. Consequently, transformers *B* and *D* may be viewed as would the normal input and output transformers of a single tube circuit.

The above analysis applies chiefly to amplifier circuits since only one signal wave has been considered. In a future article the results of the introduction of two signals will be analyzed, including the introduction of one signal wave at *A* and another at *B*. At that time we will consider, in addition to even and odd harmonics, even and odd order modulation products.

## SIMPLE SOLUTION OF HALF-WAVE AND FULL-WAVE LINEAR RECTIFIERS

*Fig. 8* represents the current voltage characteristic of a linear half-wave rectifier. If it is assumed that the volt-

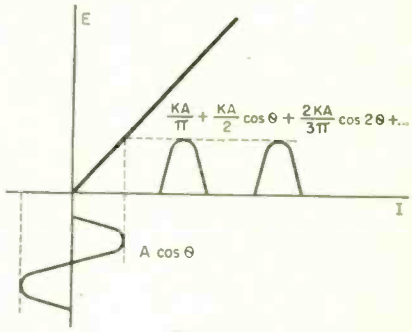



Figure 8

age to be rectified is sinusoidal, it may be represented by:

$$E = A \cos \theta$$

A solution of this simple case may be obtained by multiplying the voltage to be rectified by an appropriate square wave, having the same periodicity. Such a wave can be represented by:

$$\frac{K}{2} = \frac{2K}{\pi} \cos \theta - \frac{2K}{3\pi} \cos 3\theta + \ldots\ldots$$

The result of multiplying this equation yields:

$$\frac{KA}{\pi} + \frac{KA}{2} \cos \theta + \frac{2KA}{3\pi} \cos 2\theta + \ldots\ldots$$

Following the same reasoning a full-wave rectifies functions as two half-wave rectifiers in which the rectified voltages differ in phase by $\pi$ radians.

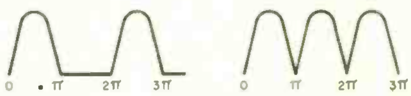



Figure 9

The direct current positions will add directly but the odd harmonics, including the fundamental, will subtract. If the two rectifiers are identical the odd harmonics and fundamentals will vanish. See *Fig. 9*.

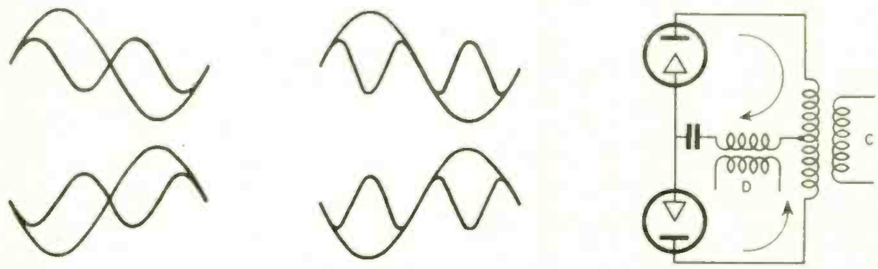


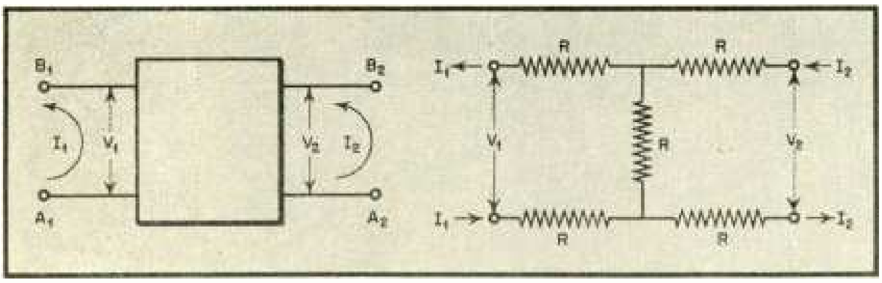

Figure 7

PART 7

# The Terminology of ELECTROMAGNETIC THEORY

**Because recent developments in the field of microwave radiation and generation have greatly widened the engineer's interest in electromagnetic theory, the following alphabetical list of terms, ideas, and theorems is presented. It is not so much intended that the discussions be rigorous definitions as that they shall give interesting ideas and serve as an introduction to the concepts.**

**Transducer**—*Any combination of conductors and dielectrics having two pairs of accessible terminals is called a transducer.* Thus a transducer may be any




such thing as a telephone transmission line, a transformer, or even a pair of radio antennas located some distance apart. If the input terminals which are called $A_1$ and $B_1$ have a current $I_1$ flowing in $A_1$ and out $B_1$, and if the output terminals, $A_2$ and $B_2$ have a current $I_2$ flowing in $B_2$ and out $A_2$ (see figure) then the transducer is said to be a linear transducer if

$$V_1 = Z_{11} I_1 + Z_{12} I_2$$
$$V_2 = Z_{21} I_1 + Z_{22} I_2$$

where the $Z$'s are impedances and the $V$'s are the input and output voltages.

In general, linear transducers are obtained whenever non-linear devices, such as vacuum tubes and iron-core transformers, are avoided.

It is of course possible to solve the above equations for the currents. When this is done they are often written in the form

$$I_1 = Y_{11} V_1 + Y_{12} V_2$$
$$I_2 = Y_{21} V_1 + Y_{22} V_2$$

In either of these sets of equations the quantities $Z_{11}$, $Y_{11}$, $Z_{22}$, and $Y_{22}$ are the impedance or admittance of an appropriate pair of terminals when the other set is open-circuited. The other $Y$'s and $Z$'s which are often referred to as transfer admittances or impedances are also found with one set of terminals open-circuited, but this time the voltage at the open-circuited set is combined with the current in the other set to obtain admittance or impedance. The $Z$'s and the $Y$'s are all a function of the electrical properties of the transducer and may also depend on frequency but they are independent of the $V$'s and $I$'s.

For example, if the transducer is five equal resistors, each of $R$ ohms connected in the form of an H with the lower and upper ends of the H considered respectively as accessible pairs of terminals, the $Z$'s and $Y$'s will have the following values:

$$Z_{11} = Z_{22} = 3R$$
$$Z_{12} = Z_{21} = R$$
$$Y_{11} = Y_{22} = 1/3R$$
$$Y_{12} = Y_{21} = 1/R$$

**Tubes of Force**—A vector field is a space which has a vector of a given direction and magnitude defined at each and every point. Such a field may be described by an equation or a pair of equations which give vector magnitude and direction as a function of some coördinate system or it may be represented graphically by the use of lines of force. Even when the mathematical method of specification is used it is often desirable to supplement that description by graphical methods so as to allow a more ready physical picture of the situation.

To represent a vector field with lines of force, imaginary lines are drawn throughout the space so that the vector for any point has a direction tangent to the lines of force in that neighborhood and a magnitude equal to the density with which the lines have been drawn. *If a bundle of lines of force which pass through a certain neighborhood are considered together and if the outer lines of that bundle are spanned by a tubular surface, that surface is called a tube of force.*

Tubes of force are particularly useful in some calculations because of several properties which they have. For one thing, no two lines of force can ever cross since such a crossing would make the specification of the vector at the crossing point ambiguous. This means that a tube of force contains the same flux (same number of lines of force) throughout its length and by any change in its cross-sectional area a strengthening or weakening of the field is indicated.

Tubes of force may be considered as carrying lines of force much as pipes carry a liquid. Indeed, if the vector field is one giving the flow velocities in a liquid system, the tubes of force may actually correspond to physical pipes carrying the fluid.

**Vector Potential-A**—In the steady state the electric potential of a point in space is the energy necessary to bring a unit charge to that point from some place which we call zero potential. This method of describing the electrical properties of a space has several advantages. It is intrinsically simpler than the statement of the three field components; it allows certain mathematical calculations to be carried out in a simple fashion; and it makes use of the volt which has considerable physical significance.

*[Continued on next page]*

[*Continued from page 39*]

In the magnetic case, however, it is not generally possible to talk about such a scalar potential. The energy involved with a unit magnetic pole is not uniquely determined by the position of that pole in space and since that is what we mean by scalar potential, we can not assign unique potential values to such points.

An example of this is apparent in the case of a magnetic pole located in the neighborhood of a wire carrying a current. The work involved in getting the pole to such a position may be anything depending upon the number of trips around the wire that were made enroute.

The magnetic vector potential is a means of overcoming this difficulty and allowing a potential function to be set up that will salvage at least some of the advantages of scalar potential theory. For example, in the case of a wire carrying a steady current, the magnetic vector potential is a vector pointing along the wire in a direction opposite to the current flow. In Gaussian units the magnitude of the vector potential falls off with distance from the wire in accordance with

$$A = -(2i/c) \ln r$$

This is in contradistinction to the way the scalar potential falls off with distance from a charge, which is given by

$$\phi = \rho/r$$

To find $H$ from $A$ it is necessary to take the curl of $A$ while, in the scalar potential case the negative gradient of $\phi$ will give $E$.

*The vector potential of a vector H is given by curl A = H plus some specification on div A which in the steady state case is taken as div A = 0.*

In the general case where the electromagnetic fields may change with time neither $E$ nor $H$ have zero curls, which is the criterion for setting up scalar potentials. We may nevertheless use $\phi$ and $A$ by setting $E = -\text{grad}\ \phi - (1/c)(\delta A/\delta t)$ instead of simply $-\text{grad}\ \phi$, and by defining $A$ with div $A = -(1/c)(\delta\phi/\delta t)$.

**Wave Guide Cutoff Wavelength—$\lambda_c$**—Hollow pipe wave guides have characteristics that are in many ways similar to those of high-pass filter networks. If a wave of a given frequency and strength is incident into the input end of a wave guide, equal or lesser amounts of power will be caused to emerge from the far end. The decrease in energy during transmission is called attenuation and may be due not only to actual losses into heat but also to the reflection of energy back along the path from which it came.

Even if we assume that the guide is made of a perfectly conducting material, attenuation which is usually measured in db per foot is possible because of reflection and, in general, is found to depend upon frequency in such a way that at some frequency it increases very rapidly with a further decrease in frequency.

*The wave length $\lambda_c$ corresponding to the cutoff frequency $f_c$ beyond which the attenuation of a wave guide rises very rapidly is called the cutoff wave length.*

In an actual wave guide where dissipative attenuation is also taken into account, a plot of attenuation versus frequency usually shows a minimum at a point just above the cutoff and gradually increases again at higher frequencies. This high-frequency attenuation is due to the finite conductivity of the material and is so much smaller that it is not easily confused with the large attenuation experienced with wave lengths that are longer than the cutoff wave length.

A slightly more mathematical but also more accurate way to describe cutoff in a wave guide has to do with the propagation constant and the characteristic impedance. When the wave length is small the propagation constant is a pure imaginary quantity indicating a traveling sinusoidal wave and the impedance is real, showing that no energy is to be reflected from points along the interior of the guide. On the other hand for long wave lengths, the propagation constant becomes real and thus designates an exponential falling off of the energy transmitted while the impedance becomes imaginary to show the presence of a reflected component. The frequency or wave length at which these quantities change from real to imaginary is called the cutoff frequency or wavelength.

**Wave Guide Modes**—*A given piece of hollow pipe wave guide is capable of transmitting electrical energy in one or more of an infinite number of ways or modes which are distinguishable from each other because of characteristic patterns of the electromagnetic field which are formed within the guide.*

In a particular case only one or a limited number of modes may be excited, depending upon the frequency that is employed and how the energy is introduced into the wave guide. For example, with a rectangular wave guide all the possible modes may be included under two main groups which are commonly referred to as respectively transverse electric and transverse magnetic modes.

These names are usually abbreviated as *TE* and *TM*. They indicate in the one case that the electric field is directed only crosswise of the wave guide and not at all along its length while in the other case the same is true of the magnetic field. The various modes existing in each class are given by subscripts as $Te_{mn}$ or $TM_{mn}$. The subscript $m$ tells the number of half-wave variations in field intensity that are to be found in traveling one way across the rectangle while $n$ gives the same information for the other transverse dimension.

The mode of a wave guide which can be utilized with the lowest possible frequency for a given set of dimensions is called the dominant mode. It is generally the most useful one because it can be used under conditions that deny competition from any higher modes which are then well beyond cutoff so that practically no energy can be accepted by them. In the case of a rectangular wave guide, the $TE_{10}$ mode is dominant and is the only mode that will propagate if the narrow dimension of the guide is sensibly less than a wave length. With a circular wave guide, only the dominant mode is transmitted without severe attenuation if the radius of the pipe is appreciably less than 0.38 times as great as the wave length but greater than 0.29λ.

**Wave Length in Wave Guide—$\lambda_g$**—In coaxial lines using an air dielectric the wave length is always the same as in free space and is given by $\lambda f = c$ where $c$ is the velocity of light. In all types of hollow pipe wave guide the wave length is longer than it is in free space so the phase velocity given by $V = \lambda_g f$ is greater than the velocity of light and the group velocity which is the speed with which a modulation signal is carried along the wave guide is less than the velocity of light. *The wave length $\lambda_g$ is related to the cutoff wave length and the free space wave length by the relation*

$$\lambda_g = \frac{\lambda}{\sqrt{1 - \left(\frac{\lambda}{\lambda_c}\right)^2}}$$

From this expression it is clear that if a wave guide is operated very near its cutoff frequency $\lambda_g$ becomes very large and the group velocity may become relatively small. In a practical wave guide, however, the attenuation due to current losses in the walls of the guide also becomes large as cutoff is approached so that a lower limit to the group velocity is encountered rather soon.

**Weber**—The unit of magnetic flux in the Giorgi or mks system of units is the weber. *If an open circuited loop of wire is initially in a field free space and if a magnetic field is allowed to build up through the loop at a rate such that one volt appears across the terminals of the loop, then at the end of one second the magnetic flux through the loop is one weber.*

Thus the weber is not a unit of $B$ directly as is the gauss in the Gaussian system of units but rather is analogous to the more infrequently used flux unit called the Maxwell.

Magnetic field strength, $B$, is measured in terms of webers per square meter. This is in accord with the usual graphical device in which lines of flux are defined as a family of imaginary curves drawn in a space in such a way that at any point a tangent shows the direction of the field and the density of the lines gives its strength.

A weber is, in this picture, the name of one of these imaginary curves and by the convention, the number of webers per unit of area is the strength of the field.

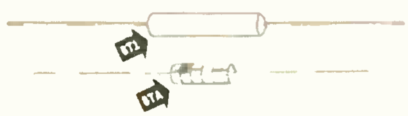
# New Products

### NEW IRC 1-WATTERS

International Resistance Company announces a new addition to their well known BT line . . . the BTA insulated 1-watt resistor, available for prompt delivery on priority orders.

Designed particularly for applications requiring American War Standards' RC30 Specifications, the BTA also will fill a real need in a wide variety of limited space, low-power applications.

Characteristics of the new, small BTA compare favorably with those of the widely used Type BT-1, although the new unit is only 60% of the size of the BT-1.



Tests indicate that the 56°C. temperature rise of the BTA is lower than that of any other 1-watt insulated composition resistor of comparable size.

The type BTA is 0.718" long by 0.250" in diameter. It has a wattage rating of 1-watt at 40°C. ambient and a voltage rating of 500-volts. Minimum range is 330 ohms. Standard maximum range is 20 megohms. Higher ranges are available on special order.

Requests for technical bulletin on the BTA insulated resistor should be addressed to Department N7, International Resistance Company, 401 N. Broad Street, Philadelphia 8, Pa.

### PUNCH-LOK CATALOG

A new catalog on the Punch-Lok clamps and fittings for many purposes is now available upon request to the B. F. Goodrich Company, Akron, Ohio, national distributors of the product. Feature of the catalog is the pictorial descriptions, accompanied by text of the many clamps and fittings, together with tables giving information on all sizes. Tools used in applying Punch-Lok clamps and fittings are also described.

### THEATRE TELEVISION HANDBOOK

A comprehensive handbook on the what, how and why of theatre television has been prepared by the RCA Service Company for theatre managers and projectionists, it was announced by W. L. Jones, Vice President of the Company. The book, which will be ready for distribution before the end of December, is profusely illustrated throughout.

Rapidly growing interest in this great new potential entertainment medium had resulted in many requests from theatre managers and projectionists for lectures on the subject. Due to the difficulties existing today in carrying out such a program, it was felt that a book, containing much of the lecture material which had been prepared, would best meet present day requirements and provide much valuable information to industry members generally the announcement stated.

Although the contents are primarily devoted to technical discussions of the reception and large-screen projection of television programs, several chapters deal with such non-technical subjects as television commercial possibilities, the handling of programs, and audience response.

In step-by-step fashion, the technical discussions provide projectionists with an abundance of data ranging from a review of electrical fundamentals to video circuits, sweep and synchronizing circuits, and the operation of a television system. The theory and operation of diodes and rectifiers, voltage amplifiers, and limiters are thoroughly explained.

Entitled "Theatre Television Handbook for Projectionists," the book will be mailed without charge to theatre owners, managers, and projectionists upon request to the RCA Service Company, Inc., Camden, N. J.

### ELECTRONICALLY CONTROLLED PROCESS INCREASES TRANSPARENCY OF LENSES

Small squares of glass, each having a circular center area treated to make is appreciably more transparent than the rest of the square, were handed to guests at a meeting of the Kiwanis Club of Philadelphia as evidence of the improvement in everyday products which is being effected by industrial applications of electronics.

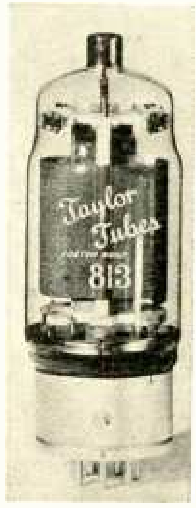
The treatment, which promises more efficient cameras, microscopes, field glasses, and eyeglasses after the war, according to Fred W. Wentker, of the Radio Corporation of America, consists of applying to both sides of the glass a film of a specific transparent material about 5 millionths of an inch thick. This film, the thickness and hardness of which is controlled by electron tubes, increases transparency by minimizing the tendency of the glass to reflect light.

### NEW TAYLOR 813 TUBE

Continuing the manufacture of beam power transmitting tubes under the RCA license, Rex L. Munger, Sales Manager of Taylor Tubes, Inc., 2312 Wabansia Avenue, Chicago, has announced that production has been started on the 813 tube.

The Taylor 813 is a beam power tube of extremely high sensitivity with a maximum plate dissipation of 100-watts. It requires less than 1-watt of driving power to produce about 260 watts when used on CW; and it need not be neutralized in circuits which provide adequate shielding. The tube utilizes low screen current and, when used as a frequency multiplier, is able to generate a high harmonic output at high efficiency. It can be operated at maximum ratings up to frequencies of 30 MC and with reduced ratings up to 60 mc. Maximum CW output is 360 watts, and plate modulated output is 240 watts, when operated in class C. Mounting is either vertical or horizontal, but in the latter case the filament must be kept in a vertical plane.

The tube is 7½ inches maximum overall length, and has a maximum diameter of 2 9/16 inches. It has a medium metal plate cap and is fitted with a giant 7-pin base of ceramic construction surrounded by an aluminum shell.




Electrical characteristics: Filament (thoriated tungsten) voltage—10 volts a-c or d-c at 5 amperes; transconductance for plate current of 50 ma is approximately 3750 umhos; interelectrode capacitances—grid to plate (with external shield)—0.2 (max.) mmf, input—16.3 mmf, output—14 mmf.

Typical operating conditions (Class C telephony)—d-c plate voltage—100 volts; d-c screen voltage—400 volts; d-c grid voltage—minus 130 volts; peak r-f grid voltage—210 volts; beamforming voltage—0 volts; d-c plate current—150 ma; d-c screen current—20 ma; d-c grid current (approximately)—6 ma; driving power (approximately)—1.2 watts; power output—175 watts with a carrier condition with a maximum modulation factor of 1.0.

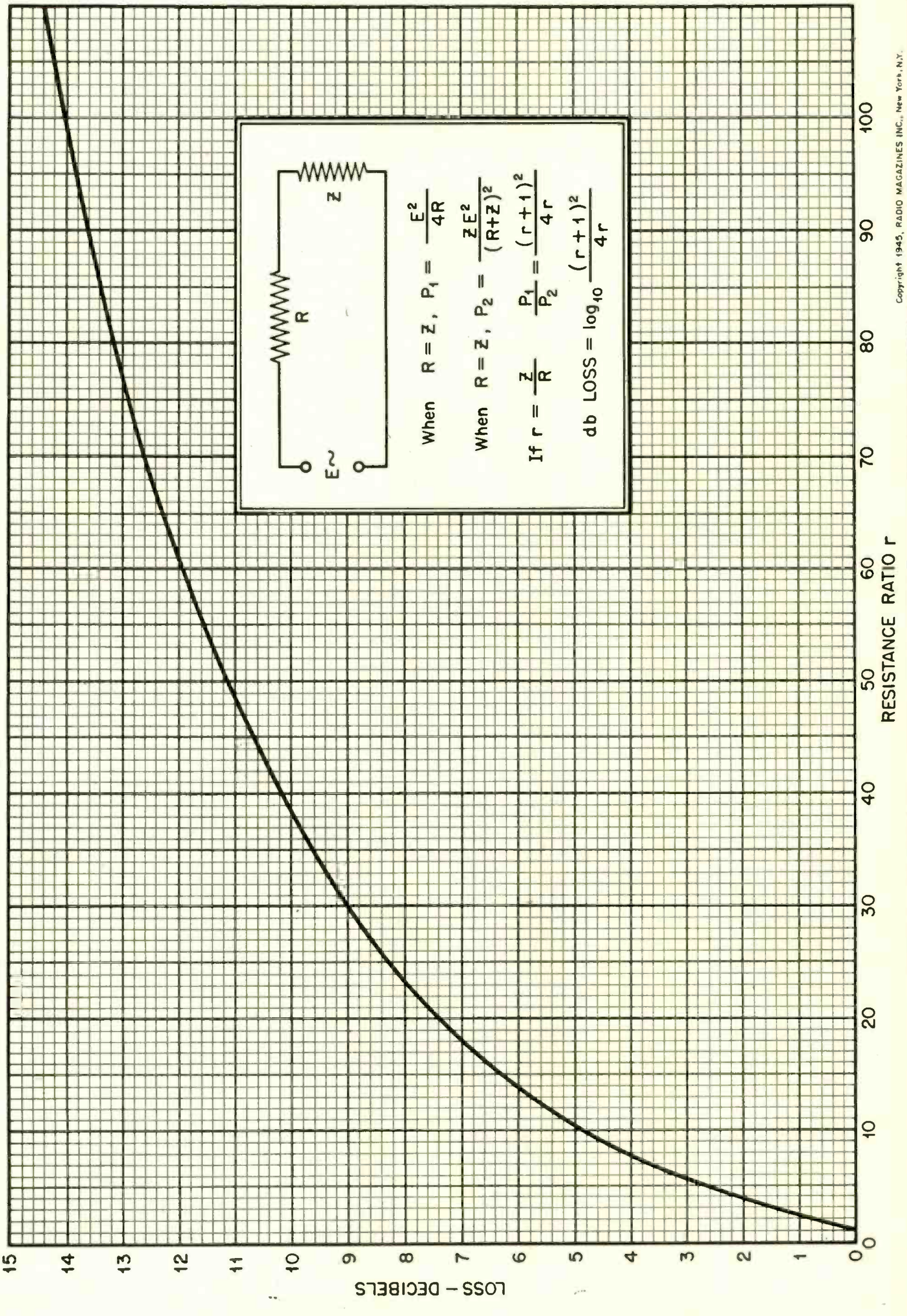
The tube is presently available solely ority basis for war contracts, it was stated.

### CARBON PILE RHEOSTATS

Under impetus of war requirements demanding resistance adjustments more critical, more precise, smoother, and more dependable resistance variation than is possible with conventional variable resistance units, the Stackpole Carbon Company, St. Marys, Pa., has developed many new types and sizes of continuously adjustable carbon

[*Continued on page* 56]

# • LOSS DUE TO IMPEDANCE MISMATCH •



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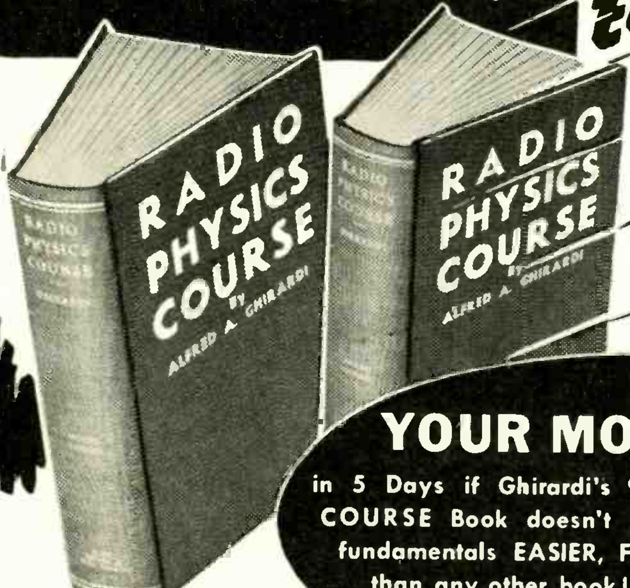


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## THIS MONTH

[*Continued from page* 41]

Mediterranean Theater while on a special mission for the Secretary of War, it has been announced by the War Department. Mr. Thompson was forty years old.

The announcement said that Mr. Thompson, who previously had been reported missing, lost his life on the night of July 4-5, 1944. It described his mission as "of direct and vital importance to the war."

Mr. Thompson was recognized as one of America's foremost radio research engineers, having completed many outstanding developments, including perfection of the famous "acorn" tube used in ultra-high frequencies. He headed important research work on television tubes and tubes for generating power, and was credited with advances in screen-grid tubes and power pentodes that became mainstays in broadcast reception.

Mr. Thompson was awarded the Morris Liebmann Memorial Prize by the Institute of Radio Engineers in 1936 for his contributions to the ultra-high frequency field of radio. He was a Fellow of the Institute of Radio Engineers and the American Physical Society; a member of Tau Beta Pi; and Sigma Xi. He had been a Director of the Institute of Radio Engineers since 1937.

### W. R. JONES PROMOTED

The appointment of Mr. Walter R. Jones to the newly created post of General Engineering Manager for Radio Receiving Tubes by Sylvania Electric Products Inc., has been announced by Mr. Roger M. Wise, Vice-President in charge of Engineering. Mr. Jones formerly manager of commercial engineering at Sylvania joined the company in 1929 to set up a sales engineering laboratory.

W. R. Jones

In his new capacity, Mr. Jones will have the direction of the engineering program for radio receiving tubes including the design and development, commercial engineering, chemical, mechanical and standardizing sections.

A senior member of the Institute of Radio Engineers, and a Fellow of the Radio Club of America, he is chairman of the Applications Sub-Committee for Miniature Tubes for the War Production Board. He supervised creation of a series of charts on radio now used to train men in various electronic branches of the Armed Forces. A native of Ossining, New York, Mr. Jones is a graduate of Cornell University, and has headquarters in Emporium, Pennsylvania.

### MICROWAVE RELAYS FOR TELEVISION

Nation-wide television hook-ups through microwave radio stations 20 to 100 miles apart all over the country were predicted as an immediate possibility as soon as the war is over by Dr. George B. Hoadley, in charge of the instructional microwave laboratory at the Polytechnic Institute of Brooklyn, at the 597th meeting of the New York Electrical Society in New York City.

George F. Bateman, Dean of the School of Engineering, Cooper Union, and president of the Society, presided at the meeting.

Dr. Hoadley gave the first talk authorized to date by the Publication Referee of the National Defense Research Committee covering an anlysis of a complete postwar microwave system for communication purposes. Recently Dr. Hoadley completed his


## *Another modern electrical development pioneered and perfected by Sprague*

Pioneered many months ago by Sprague, glass-to-metal seals for Sprague Capacitors and hermetically-sealed *Koolohm Resistors have progressed far beyond any "laboratory curiosity" stage. Not only are they being produced commercially at better than 10,000 seals per day, but they have proved highly efficient both electrically and mechanically. Seal sizes range from very small up to 3" diameter. They work equally well with practically any metal including steel, brass, and monel metal, and do not require the use of glass bushings and adjacent metal rings with "matched" temperature coefficients of expansion.

There are, of course, plenty of "scientific" reasons why glass-to-metal seals of this type are not feasible. Here again, however, the allegedly impossible has simply provided the incentive for another outstanding Sprague engineering achievement. Actually, the only disadvantage to the seals so far uncovered is the fact that corona voltages are a little lower than we'd like them to be—yet this limitation only becomes a factor at voltages upwards of 25 KV. In all respects, the Sprague glass-to-metal seal answers the old problem of guarding Capacitors and Resistors adequately against leaks and moisture—and without organic bushings or other materials which might be attacked by fungus.

Today, glass-to-metal sealed Sprague Capacitors and *Koolohm Resistors are available in 8,000 electrical characteristic combinations—which is another way of saying that there is a sealed unit for every application that needs one. Details gladly sent on request.

**SPRAGUE ELECTRIC COMPANY, NORTH ADAMS, MASS.**
**(Formerly Sprague Specialties Co.)**

ARMY E NAVY

# SPRAGUE

* T. M. REG. U. S. PAT. OFFICE

**PIONEERS OF ELECTRICAL-ELECTRONIC PROGRESS**

part in a government sponsored research program.

With the great impetus the war has given electronics and the tremendous still secret advances which have been made, the succession of booster stations long envisioned by scientists is now actually practical, Dr. Hoadley said.

To illustrate the component parts of a microwave communication system, Dr. Hoadley demonstrated newly developed devices in action. One of these was a wave guide used as a microwave transmission link. It was a plain section, ten feet long, of galvanized iron drainpipe 3½ inches in diameter. Dr. Hoadley showed that waves actually occur inside this pipe which is used to go from the generator to the transmitting antennae to get the power there in concentrated form without spilling over into space. Anyone familiar with electricity would think it necessary to have two wires within these microwave tubes; but this is not the case. At the beginning of the war transmission through such a pipe had just become known and had never been used in any practical system. It had been in laboratory use in the training of radio technicians for the Navy, but to date it has not been permitted to be shown outside of these laboratories.

While the principles on which national television could be achieved were recognized by scientists, Dr. Hoadley explained, it took the war to bring about the developments which will hold down the microwaves to the defined and limited beam necessary to operate station links. These links will be placed across the country at 20 to 100 mile intervals and in parallel bands 150 to 200 miles apart, much as the several transcontinental railroads now span the country, making it possible for any event of national interest to be transmitted into homes throughout the country.

The advantage of microwave links is the fact that communication can be achieved at microwave frequencies with relatively less transmitter power than would be required for broadcast service. Dr. Hoadley illustrated this point by saying that where a satisfactory short link can be achieved with a small metallic reflector not more than three feet in diameter and at the outside for a longer distance not more than eight feet, the same directional beam obtained with ordinary radio would require a reflector at least a mile in diameter.

The reason microwave boosters are necessary to link television stations located in cities is the fact that the short wave they utilize is bounded by the horizon and cannot travel over the curve of the earth's surface. The microwave links have the same horizon limitation so direct beams must be provided at intervals to take the television broadcast from its source to another broadcast point.

Continuing the discussion of horizon limitation, Dr. Hoadley said that the searchlight provides the closest analogy to microwave transmission. Just as no searchlight can bend over a mountain, for instance, no microwave can jump it. If hills are to be crossed a relay station must be as the top point to pick up stations on either side.

Release by the military of information and the imagination of American industrial designers will be the two determining factors in the use microwaves will be put to in the postwar era, Dr. Hoadley pointed out. Possible uses, he said, may be to increase the availability of radio-telephone communication since this means of communication because of interference between stations already has reached its peak of use. It will be necessary to go to higher and higher frequencies and to evolve new schemes to get around this interference. Another use will be the spanning of water gaps by telephone companies to eliminate costly and delicate sunken cables. In fact, Dr. Hoadley added, a microwave relay station can be set up at any point where it will eliminate costly construction and maintenance in carrying through telephone poles and wires.

A use not entirely confined to the communications field but one which will turn the amazing war employment of radar into a similar civilian use will be the protective equipping of ships and planes so that fog never again will hamper the movement of either. The same technique which made it possible for the American fleet in its first great Pacific battle to pass midway between the Japanese fleet at night and demolish it, will make it possible for ships to enter a port regardless of the extent of the pea soup enveloping it. Never again will such a disaster as that which occurred when the Titanic hit an iceberg be a concern to express ships crossing the Atlantic. Just

# RCA's New 170-A Audio Chanalyst

**Tests Everything from Microphones to Multiple Speakers**

THE new 170-A Audio Chanalyst is a combination testing unit which includes the famous Voltohmyst circuit, a new diode flat through the audio range, a B.F.O. signal source, a gain calibrated amplifier, and speaker and line output connections.

The various channels of the RCA Type 170-A can be used independently or in unison to check all common defects in audio amplifiers and sound systems. Polarity indication and a.c. can be determined instantly with the new electronic indicator, without danger of overload!

A pamphlet containing full description and specifications of the 170-A Audio Chanalyst will be sent gladly, on request.

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as our convoys today covered with their radar screen know the location of every ship in their area of the ocean, so peacetime ships will know the existence of everything afloat in their vicinity without, for instance, the intensive effort which the iceberg patrol has had to carry out in years past to spot the presence of these hazards to shipping.

To illustrate his points Dr. Hoadley recently demonstrated a horn type radiator which is analogous to the horn on a loudspeaker; a parabolic reflector analogous to the searchlight, and a klystron oscillator which incorporates the rhumbatron to produce high frequency oscillation. With the klystron oscillator Dr. Hoadley transmitted music from a transmitter to a receiver and also showed how the microwave radio beam is reflected from an object such as the Palisades. He gave this demonstration with a metallic sheet and again drew the analogy to light which bounces off an object in its path.

## WCEMA OFFICERS

Howard D. Thomas, Jr. General Manager of the Packard-Bell Company, Los Angeles, has been elected to the Presidency of the West Coast Electronic Manufacturer's Association, Los Angeles Council, for 1945. The retiring President, H. L. Hoffman, Hoffman Radio Corporation, was elected to the Board of Directors.

Other officers elected were Lew Howard, Peerless Electrical Products Company, Vice President; James L. Fouch, Universal Microphone Company, Ltd., Treasurer.

Howard D. Thomas, Jr.

Elected to the Board of Directors in addition to Mr. Hoffman were D. A. Marcus of Electronic Specialty Company, Ashford M. Wood, Littelfuse, Inc., and Clay F. Fisher of Radiation Products, Inc.

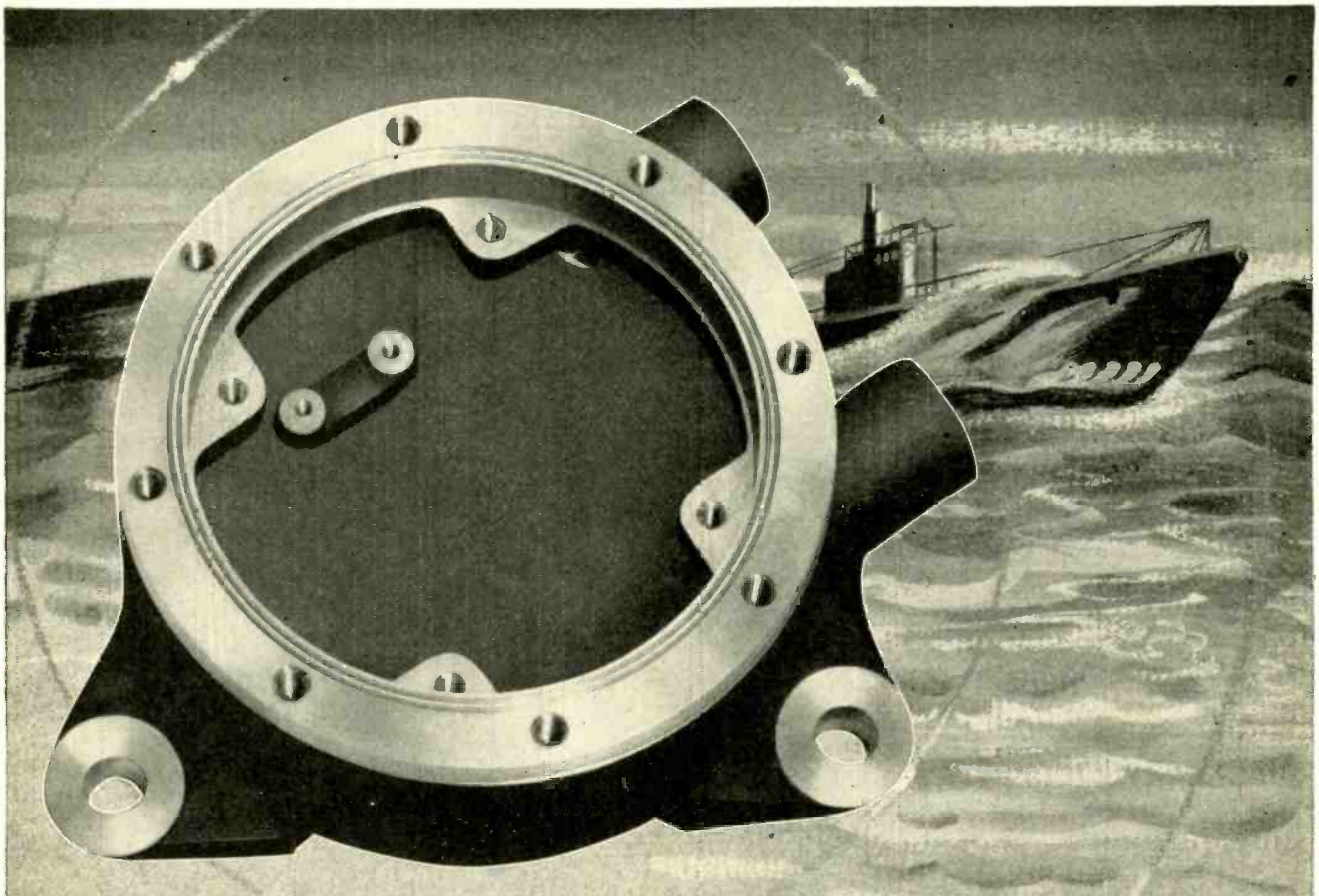
## NEW APPOINTMENTS

**A. M. Wiggins**

Mr. A. M. Wiggins has been appointed Chief Research Engineer at the Electro-Voice Corporation in South Bend, Indiana.

After having received his BS in Electrical Engineering at the Texas Technological College in 1933 and his MS in E. E. at the University of Texas in 1936, Mr. Wiggins was employed by the Seismic Explorations, Inc., Houston, Texas from 1937 to 1941. In 1942, he served in the Research Dept. of the RCA Manufacturing Co., in Camden, and later went to the RCA Lab-

A. M. Wiggins



# A POSTWAR LOUD SPEAKER?

YES, if you are going to use it on a submarine. But don't expect all Jensen postwar loud speakers to look like this. This one was designed especially to be used on submarines and to withstand the terrific pressure of fathoms of deep sea water and the explosive concussion of depth charges.

Just the same, Jensen Engineers and factory have learned plenty in the process of designing this and many other specialized speakers for front line operations. Jensen postwar speakers will reflect this experience in the most extensive and improved line of loud speakers ever known. More than ever before, every buyer and user of a loud speaker will find positive assurance of the most advanced art in Jensen products. Intensive specialization for more than 15 years is one good reason for that . . . Jensen alone can claim that distinction.

**Jensen**

RADIO MANUFACTURING COMPANY
6601 S. Laramie Ave., Chicago 38, U.S.A.

*Manufacturers and Designers of Fine Acoustic Equipment* oratories in Princeton, New Jersey, where he remained until the present time.

Mr. Wiggins' invaluable background in the design of microphones and accoustic devices will be utilized in the research laboratories of the Electro-Voice Corporation, where rapid strides are being made in the design and development of all types of microphones.

**Thomas A. White**

Jensen Radio Manufacturing Company, well-known manufacturers of loud speakers and acoustic equipment of this city, announced today over the signature of Mr. A. Leslie Oliver, chairman of the board, the appointment of Thomas A. White as president and general manager to succeed W. E. Maxon, retired.

Mr. White who is well known throughout radio and electronic circles, acquired an interest in the company he now heads in 1928, shortly after its organization, becoming sales manager. On January 1, 1940 he was elected to the position of vice-president. Under his sales direction the Jensen company has pioneered many loud speaker innovations and has forged ahead to a position of undisputed leadership in the acoustic field.

Mr. Maxson's resignation was accepted in compliance with his request for retirement after completing fifteen years of service with the Jensen company. He became manager in 1930 and was elected to the office of president and general manages on January 1, 1940. Mr. Maxson will remain on the board of directors and announces he will retain his Chicago residence and his home at West Mystic, Connecticut.

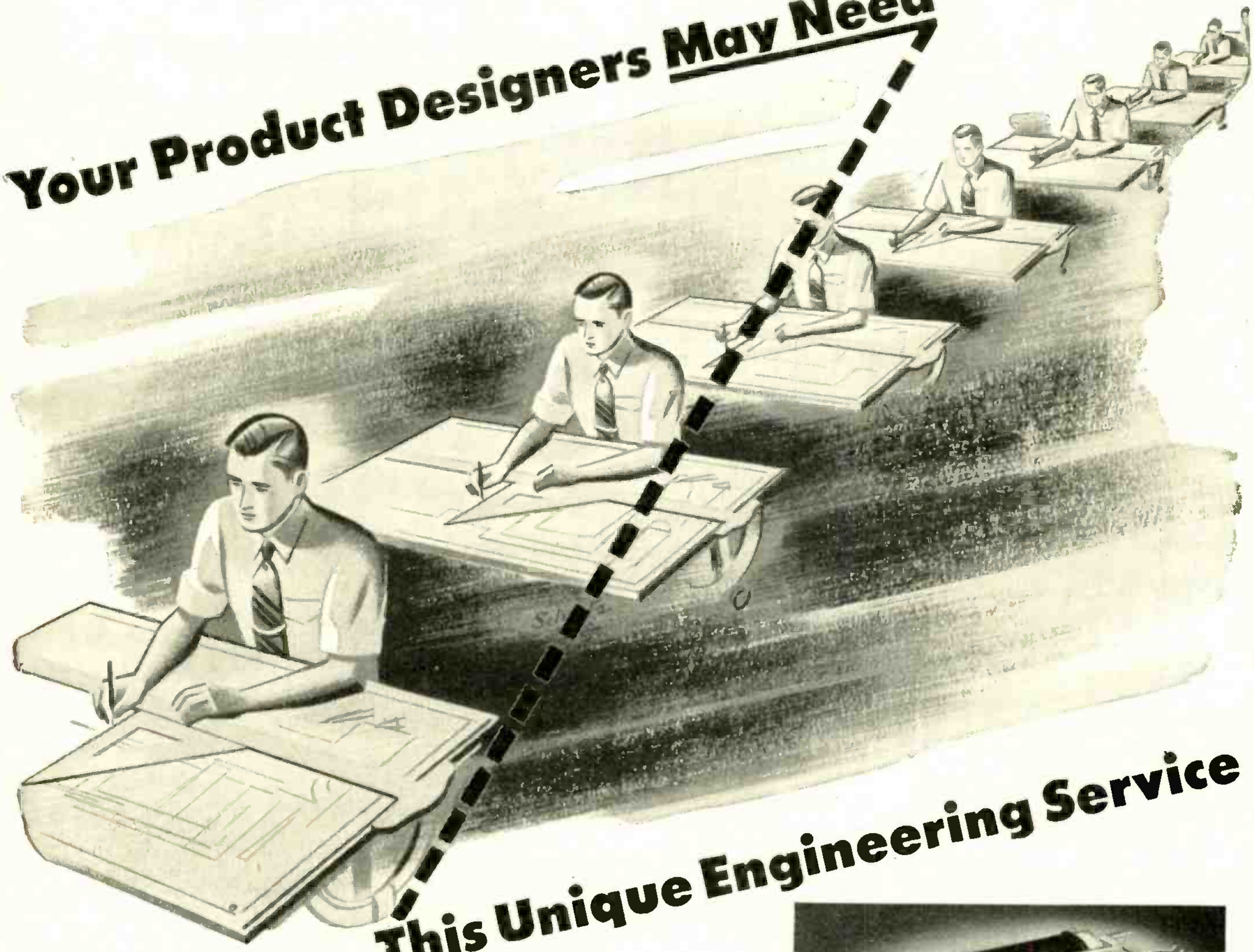
**Dr. Bennett S. Ellefson**

Dr. Bennett S. Ellefson has been appointed Assistant to the Vice President in charge of Engineering, Sylvania Electric Products Incorporated. His office is located

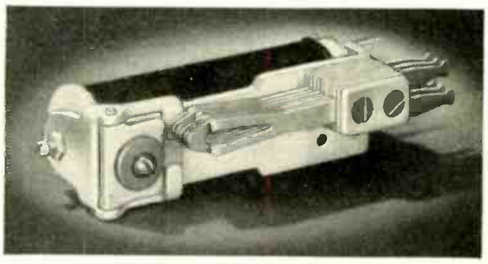
Dr. Bennett S. Ellefson

at Sylvania Center, Bayside, Long Island. Associated with the company since 1937, Dr. Ellefson has specialized in research on fluorescent screens, special uses of glass, fluorescent powder for cathode ray tubes and specialized war products. He

# Your Product Designers May Need



# This Unique Engineering Service



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holds a number of United States and foreign patents on fluorescent materials and glass, including certain special war products.

Prior to joining Sylvania, Dr. Ellefson conducted important research on industrial chemical processes. He is a member of the Institute of Radio Engineers, the American Society for the Advancement of Science, the American Chemical Society, the American Ceramic Society, Phi Kappa Phi and Sigma XI. A native of Canby, Minnesota, he holds a B. A. from St. Olaf College, M. S. from the University of Minnesota and Ph. D. from Pennsylvania State College.

### K. C. Burcaw

K. C. Burcaw

K. C. Burcaw has been appointed sales manager of the Cornell-Dubilier Electric Corporation, Jobber Division. Mr. Burcaw brings to his new position a wealth of sales experience.

In 1924, Mr. Burcaw together with Mr. Wildberg, incorporated the Radiart Company. After that he represented them in the Michigan, Indiana, Kentucky, Chicago territory. In 1934, he returned to Cleveland to create a Radio Jobber Division for the Radiart Corporation. And as Sales Manager he not only sent sales volume to new highs, but was also instrumental in making the Radiart line an important factor in the jobber field.

Mr. Burcaw is now rounding out plans which will bring to his work at C-D the same intensive selling and aggressive merchandising that marked his successful years at Radiart. Between jobber calls he intends to continue his aviation and "ham" hobbies. He holds the rank of flight officer in the Civil Air Patrol and is the communications officer of his squadron. He has taken part in numerous plane-to-ground two way radio experiments.

### Max E. Markell

Max E. Markell, for the past four years chief of the vacuum tube section of the

"COIL? ALBION CAN SHIP YOU ALL
THE COILS YOU NEED."

U. S. Signal Corps at Camp Evans, has joined RCA's Tube and Equipment organization as a specialist on industrial tube applications, according to an announcement by L. W. Teegarden, General Manager of the RCA Tube and Equipment

Mr. Markell will work under the direction of L. S. Thees, Manager of RCA's Equipment Tube Section at the Company's Harrison, New Jersey plant. He will specialize on tube applications for industrial dielectric and induction heating equipment.

Mr. Markell, well known in the industry as technical advisor to the Officer In Charge of Production at Camp Evans, was graduated from the University of Michigan with an engineering degree. He has served as engineer for stations WHN, WNEW and WHOM in New York, and later as an engineer on radio receiver design for the Interstate Broadcasting Company.

**Dr. Donald B. Sinclair**

The General Radio Company announces the appointment of Dr. Donald B. Sinclair as Assistant Chief Engineer in charge of circuit development.

Dr. Sinclair was born in Winnipeg, Manitoba, in 1910. He attended the University of Manitoba from 1926 to 1929. He received the degree of S. B. from the Massachusetts Institute or Technology in 1931, S. M. in 1932, and Sc. D. in 1935. Prior to joining the General Radio engineering staff in 1936, he was a Research Assistant at M. I. T. from 1932 to 1935, and a Research Associate in 1935 and 1936. Dr. Sinclair is a member of Sigma Xi and a Fellow of the Institute of Radio Engineers.

Dr. Donald B. Sinclair

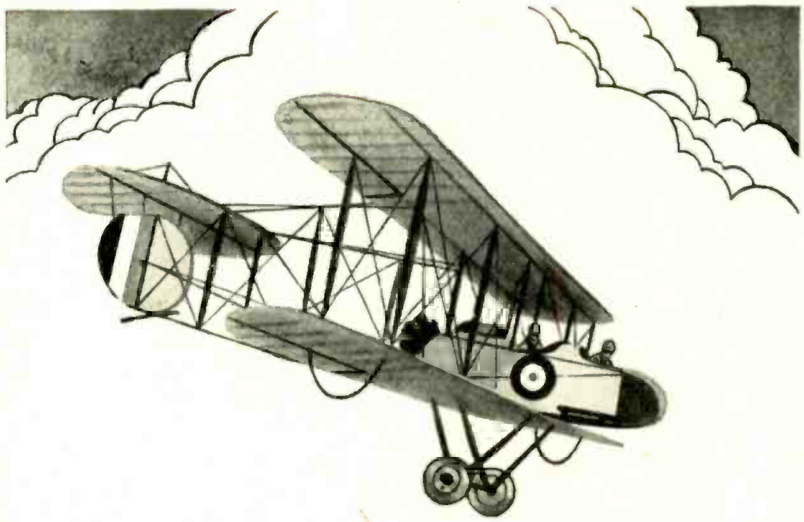
**Charles Knoblauch**

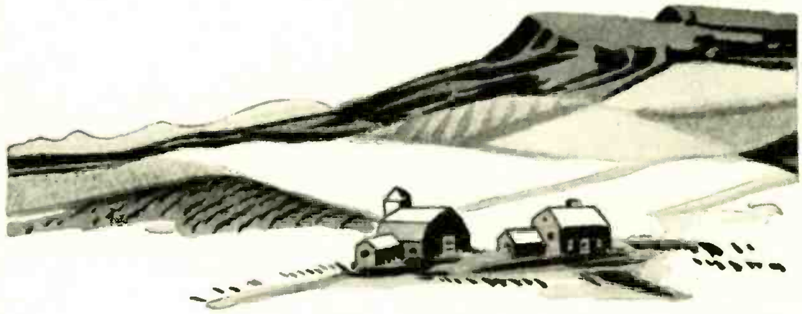
The Hallicrafters Company, Chicago, producer of high frequency radio war equipment, recently appointed Charles Knoblauch superintendent of the firm's Clearing plant.

Knoblauch, formerly assistatnt superintendent of Hallicrafters' 26th street plant, has been with the company for more than six years. He has been engaged in radio production work for the past seventeen years.

**...Hardly had man learned to fly than he began to feel the urgency of the need to communicate between ground and plane.**

Radio headsets are one of C. T. & E. Division's contributions to aviation communications in World War II.





One of the first successful attempts in such two-way contact was accomplished with equipment designed and manufactured by *Connecticut Telephone & Electric.*

Since the early days of the telephone, our people have been identified with progress in communications. Today the principles of communications have applications of the greatest importance to industry, in connection with product development and production control.

Our developmental engineers also have much to offer to industrial executives seeking to produce a better product at lower cost. If our engineering and production facilities might tie in with your plans, we shall be happy indeed to talk with you.

## CONNECTICUT TELEPHONE & ELECTRIC DIVISION

**GREAT AMERICAN INDUSTRIES, INC.**

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## NEW PRODUCTS

[*Continued from page 41*]

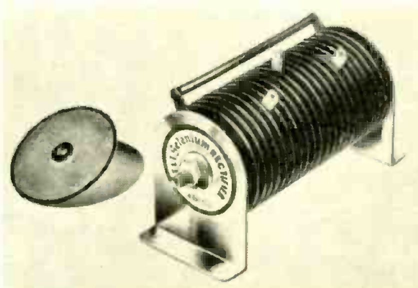
rheostats formed of carbon disc piles. Simply by changing the pressure applied to these piles, every possible resistance value within their range is made available without opening the electrical circuits in which they are connected. The pressure to vary the resistance to the most critical adjustment may be applied electrically, mechanically, centrifugally or hydraulically. Uses range from both generator and line voltage regulator applications to remarkable speed control through governed field current on motors. Many other projects incorporating the Carbon Pile Resistor are now in the development stage.

Stackpole regularly supplies Carbon Piles in practically any length pile and diameter required. Available resistance ranges have been materially expanded, and a greater degree of resistance variation may now be obtained in a pile of given size. Careful engineering control of manufacture assures a high degree of uniformity on a quantity production basis. Typically, a Carbon Disc Pile 1½" long composed of discs .432" in diameter permits a resistance range of from 60 ohms with 1 oz. pressure to .3 ohms at 32 lbs. pressure. Bulletin giving complete engineering data will be sent on request to the manufacturer.

### CENTER CONTACT RECTIFIER

Center Contact, a patented plate construction in metal-plate rectifiers which allows complete coating protection against destructive atmospheres, is available in units now being manufactured by Selenium Rectifier Products, Federal Telephone and Radio Corporation, Newark, New Jersey.

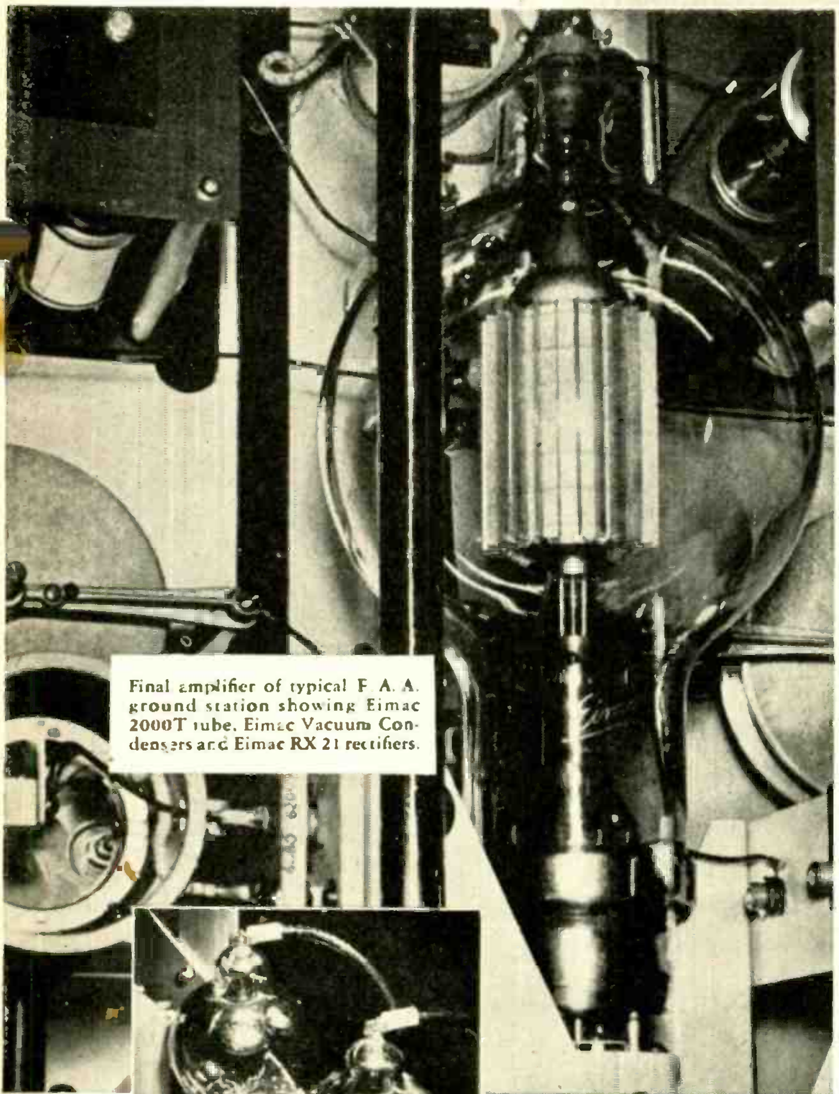
Developed especially for use in equipment being manufactured for the Army



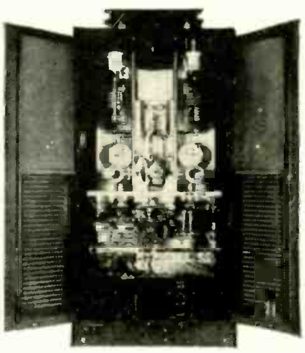
and Navy, this type of construction permits a new method of applying protective coatings to metal-plate rectifiers. Where the standard petal contact is sprayed with a protective coating, Center Contact is especially adapted to the application of a heavier and better coating to protect the rectifier from fungus-bearing, salt spray laden or corrosive atmospheres. In such applications, the metal plate rectifiers are necessary as other types of rectifiers cannot be completely protected against such destructive conditions.

The Center Contact construction is available in the same range of sizes and capacities as the standard petal-type contact.

# PAA PAN AMERICAN USES EIMAC TUBES



Final amplifier of typical P. A. A. ground station showing Eimac 2000T tube, Eimac Vacuum Condensers and Eimac RX 21 rectifiers.



Pan American World Airways, which has done so much to advance the war-time goals of the nation, has just announced a plan for a new service to South America. Employing a fleet of stratosphere planes, carrying 108 passengers, flying at more than three hundred miles an hour, Pan American proposes to take travelers from New York to Rio de Janiero in less than twenty hours instead of the present sixty-six hours, charging $175 for the trip, as against the current rate of $491.

Pan American Airways and all its associated and affiliated companies, which comprise the P. A. A. World System, have been using Eimac tubes in the key sockets of all ground stations for a number of years.

Because of the extensive operations of Pan American World Airways, these tubes have been subjected to about every test possible—altitudes; ground level; extremely cold climates and high temperatures found at the equator; conditions of high and low humidity; and in some instances, when new bases are being built, perhaps somewhat trying power conditions. The high regard which P. A. A. engineers have for Eimac tubes is clearly evidenced by their continued and more extensive use, as the years roll by.

The fact that Eimac tubes are the number one favorite of the commercial airlines is important evidence to substantiate the oft repeated statement that "Eimac tubes are first choice of leading electronic engineers throughout the world."

*Follow the leaders to*

**Eimac TUBES** REG. U. S. PAT. OFF.

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PLANTS LOCATED AT: SAN BRUNO, CALIFORNIA AND SALT LAKE CITY, UTAH

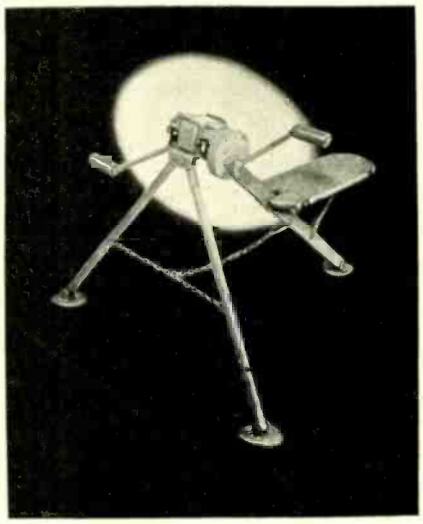
*Export Agents: FRAZAR & HANSEN, 301 Clay Street, San Francisco, California, U. S. A.*

It retains the features of high voltage per plate, ability to withstand heavy temporary overloads and operates at high efficiency over a wide range of capacities with no maintenance expense.

### CARTER HAND GENERATOR

A one-man hand generator delivering about 40 watts has been released by Carter Motor Company, 1608 Milwaukee Avenue, Chicago, it was announced by Robert W. Carter, Managing Director of the firm.

It is developed around the original Carter magmotor, and is a unit with permanent magnet fields which save about 10-watts of primary power usually associated with the hand generator type of rotary equipment. The generator provides 8 volts DC at 5 amperes for charging batteries, where other charging apparatus is not available.



One man, seated on the seat which folds up when not in use, turns two cranks (of special construction to prohibit their being detached through anti-axial strains) which are immediately demountable with no tools required. Drive is by means of a gear train, one of which is bakelite to create a smoother and quieter operating unit.

The hand generator is moisture-proof and the shafts of the crank handles are sealed and the unit is completely enclosed. Output is to two terminals to which the charging line is connected. A chain suspended between the legs prevents collapse when the unit is set up. Because of the use to which the generator is intended, no filters are included. Neither is a meter provided since the batteries are not capable of being over-charged by turning the cranks.

While the units are now being manufactured only for the Military and allied services, a wide range of peace-time consumers are expected, among which are field expeditions, yachtsmen (to charge their ship's batteries), remote radio stations, farmers and ranchers, it was stated.

### CAPACITOR CATALOG

To provide designers, experimental engineers, and production executives with a practical, working selection of ceramic


## HERE'S MORE DOPE ON BRIDGEPORT:

After V-Day, the same personnel that meet the most exacting military specifications and the same capacity that enables Bridgeport to produce search coils and variometers in the quantities necessary for our Armed Forces will be your assurance of quality and service.

Bridgeport's central location, right near the center of population, gives you fast, trunk line service to any point in America. Write to us TODAY to insure early postwar delivery of R. F. coils and chokes, I. F. transformers and transmitting coils and chokes.

# BRIDGEPORT

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Bridgeport, Illinois

R. F. Coils • R. F. Chokes • I. F. Transformers
Transmitting Coils • Transmitting Chokes

capacitors, the Electrical Reactance Corp. of Franklinville, N. Y., have prepared a handbook that contains 81 standard rating ceramic capacitor samples.

In addition to actual working samples, this catalog includes plant illustrations which show the manufacturing processes and testing methods including the application of solid silver for condenser plates, which the manufacturer claims is non-ageing, non-corrosive and maintains excellent conductivity. An A. S. A. Color Code included in this handbook makes its reference value complete.

### MICARTA 444

A new Westinghouse plastic, known as Micarta 444, combines the desirable molding properties of thermoplastic materials and the good physical characteristics of thermosetting materials. A modification of the resin in standard Micarta causes the substance to soften when hot, as do thermoplastic materials, but at a much higher temperature, about 300 degrees F, which is far above the service range. Thus the new Micarta can be heated and pressed into deep-drawn and complicated shapes. The pressures are lower—about 50 to 100 pounds—and the times much shorter than required for curing of thermosetting resins. Dies can be made of hard wood or of thermosetting laminates. This makes the manufacture of a relatively small number of parts from a single die economical as the cost of these parts is not loaded with the distributed cost of an expensive die.

When cool the product has the good strength and freedom from embrittlement characteristic of many thermosetting materials. Used in aircraft for nonstructural and semistructural members, a weight saving of some 50 percent over a comparable volume of metal has been achieved. In addition, a considerable saving in man hours of labor has been made. In one particular operation, a single sheet of formed Micatra replaced an airplane part formed of four separate pieces of aluminum. The aluminum sections were welded together. Forty inches of weld were saved which contributed to the one and one-fourth man hours required for the aluminum part. The formed Micarta part requires 19 minutes to produce and weight but half as much. These savings indicate the possibilities afforded by the material in applications where good insulating qualities, high impact strength, and good thermal stability are required.

### CORRECTION

We regret that the three cuts used to illustrate the item regarding inverted triode applications, appearing in the Technicana section of the December, 1944 issue, were not the proper ones for this article. They were intended to illustrate the item on the effect of high temperature solders on copper wire, appearing on page 68 of this issue.

We extend our apologies to our readers and to the authors involved.

## TRANSMITTERS

[*Continued from page 21*]

erating frequency, as radiation efficiency may be greatly reduced by this condition. Although it has been found generally advisable to select a building as tall as possible relative to other buildings, certain factors sometimes arise, especially in buildings of several hundred feet in height, that cause troublesome conditions. It has been shown that on some high roof-top installations, extremely good antenna efficiency prevails, but in other cases the reverse condition results. It is always advisable to set up a test transmitter at the proposed roof-top location in order to predict the antenna performance.

### References

For the convenience of readers interested in detailed studies of all phases of the choice of transmitter sites, the following references are listed:


1. Standards of Good Engineering practice. FCC.
2. William B. Lodge, "Selection of Radio-Broadcast Transmitter Location"; *IRE Proceedings,* October 1939.
3. Glenn D. Gillett & Marcy Eager; "Some Engineering and Economic Aspects of Radio-Broadcast Coverage", *IRE Proceedings,* February 1936.
4. P. E. Patrick, "Service Area of Medium Power Broadcast Stations", *IRE Proceedings,* Sept. 1942.
5. William A. Fitch and William S. Duttera, "Measurement of Broadcast Coverage and Antenna Performance", *RCA Review,* April 1938.
6. Edgar H. Felix, "The Use of Field-Intensity Measurements for Commercial Coverage Evaluation", *IRE Proceedings,* July 1944.
7. R. F. Guy, "Engineering Factors Involved in Relocating WEAF", *RCA Review,* April 1941.
8. R. Brown and G. D. Gillett, "distribution of Radio Waves from Broadcasting Stations over City Areas", *IRE Proceedings,* August, 1924.
9. Allocation Survey, FCC Report 18108, Sept. 1, 1936.
10. R. Brown, De L. K. Martin and R. K. Potter, "Some Studies in Radio-Broadcast Transmission", *IRE Proceedings,* February, 1926.
11. F. E. Terman, "Radio Engineers' Handbook", McGraw-Hill Book Co. 1943.


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## OSCILLATOR

[*Continued from page 29*]

ing $R = 250$ K, $k$ is about .18, thus R1 is approximately 45 K. Referring back to *Fig. 3*, we find that $\rho = 3.1\%$ so that a gain of 32.2 is necessary to overcome network loss. If it is desired to set the oscillator to exactly 1000 cps

*History of Communications. Number Thirteen of a Series*

# MILITARY RADIO COMMUNICATIONS


Today the allied military radio equipments represent the "tops" in engineering design. Progress from the spark transmitter of World War 1 to present-day equipment is, indeed, a far cry. Taking up where they left off December 7, 1941, Universal Engineers, with their added experience with precision military equipment, shall produce for the public, electronic devices not of fantastic design — but of proven utility and quality.

After Victory is ours, radio amateurs, affectionately known as "hams," will be back after their experience with military radio equipment with an even greater desire to operate their own "rigs." It will be then that Universal will again have Microphones and recording components available on dealers' shelves.

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FOREIGN DIVISION: 301 CLAY STREET, SAN FRANCISCO 11, CALIFORNIA ·· CANADIAN DIVISION: 560 KING STREET WEST, TORONTO 1, ONTARIO, CANADA then $R_1$ would be a rheostat set to the correct value.

For a second example, suppose we have a three gang insulated shaft condenser, 350 mmf maximum and 35 mmf minimum per section. It is desired to build a 5 kc to 50 kc oscillator. Referring to the nomograph we find $X_c$ to be 93 $K$. Using $R = 200\ K$ and $R_1$ a 25 K rheostat our network would be complete. With $C$ set for maximum capacitance $R_1$ would be about 15 K. The frequency range of the oscillator could be changed to 4 kc to 40 kc by merely changing $R_1$.

In order to get a good sine wave from this type oscillator, the overall gain should be slightly over unity. Thus when the attenuation of the network varies the gain must be controlled. This can be done with a manual control, degeneration from an unbypassed cathode resistor, or by a suitable automatic gain control. The attenuation of the network does not vary when the three condensers are changed together in a gang. The gain needs readjustment only when $k$ is changed.

All the calculations in this paper are based on the assumption that the 180° phase shift is in the network. Considering that the phase shift in the plate and grid circuits are negligible is permissible in this case.

A typical circuit is given in *Fig. 1b*. The 10K rheostat in the cathode of the tube is the degeneration control. Frequencies from 0.8 cps to 860 kcs were observed.

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## SPECIFICATIONS

[*Continued from page 33*]

gineering approved sample." This has advantages in that an actual sample may be used for calibration of the suppliers test equipment, however, through constant handling the approved sample is often damaged and could result in the supplier unknowingly building inferior parts.

In order to distinguish parts made by different manufacturers it is standard practice to assign a code letter or number to each supplier. All drawings, where applicable, should include a note to the effect that this identification is to be plainly marked on each component. Such a system is an aid in checking the source of supply of a defective part. The main thought to keep in mind is that the supplier must produce his parts from the information given on the drawing or associated specifications. The designer should therefore consider the drawings from the manufacturers point of view. He should mentally go through the process of building the part from start to finish, not forgetting such problems as inspection or testing. If after doing this no points need clarification it is safe to assume the drawings to be complete.

To cover thoroughly the specification of component parts would require a small-sized book on the subject. In order to simplify the problem, a series of five tables which indicate the desired specifications for a particular type of electronic equipment have been prepared. Such tables, of course, can only serve as a guide since it is obviously unnecessary to specify each item mentioned. However, unless each item shown is considered carefully the chances of inadvertently omitting one is very great.

### Tests

The measurement of component parts has been thoroughly covered in the literature as to methods,[1] so no detailed discussion will be given at this time. But it is important as mentioned previously, that every detail shown on the drawing or specification be checked and a record made of the results. All test conditions, particularly electrical, should be noted, such as temperature, humidity, voltage, frequency, circuit parameters, etc. Without complete records as to the conditions of test the results are of little value so *do not trust to memory.*

### Conclusion

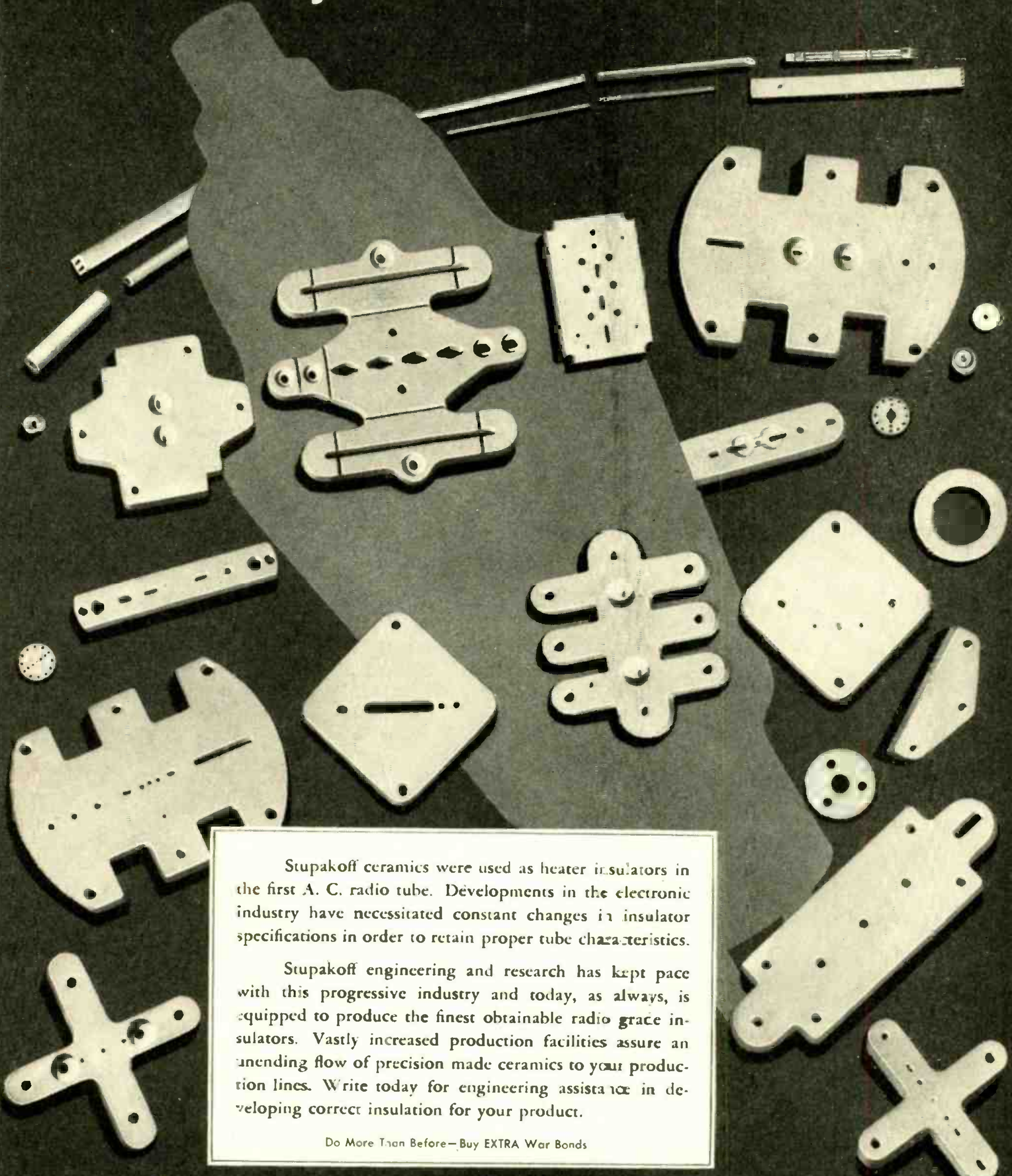
In conclusion let us summarize briefly the technique of component specification.

1. Give only pertinent data on construction.
2. Specify as wide tolerances as permissible.
3. Specify electrical performance in as simple a manner as possible.
4. Indicate methods of testing where required.
5. Mentally fabricate the part from the information on the drawing or specification.

---

[1] Measurements in Radio Engineering—*Terman*—McGraw-Hill Book Co.

# *Ceramics* for ELECTRONIC TUBES by STUPAKOFF



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## BIBLIOGRAPHY

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Landing Beam — H. Diamond and F. W. Dunmore — Research Paper RP-1006, (*Jrnl. of Research of the National Bureau of Standards*—Vol. 19, July 1937)—Published by Department of Commerce—Bureau of Standards.

Marconi Aerodrome Approach Beacon Equipment, Type WBD. 4—*The Marconi Review*—May-August 1937, #66, Page 15.

Radio Approach System Assists Airmen to Land Under Low Ceilings—*Air Commerce Bulletin*—Vol. 5, #7, Jan. 15, 1934, Page 165.

Performance Data on Systems of Radio Aids for Blind Landing of Aircraft—*Air Commerce Bulletin*—Vol. 4, #21, May 1, 1933, Page 525.

Performance Tests of Radio System of Landing Aids — H. Diamond — Research Paper RP-602 (Reprint of *Jrnl. of Research of the National Bureau of Standards* — Vol. 11, October 1933) Published by Dept. of Commerce, Bureau of Standards.

Flying in Fog—Aeroplane—Vol. 38, Feb. 5, 1930, Page 234.

Blind Flying—A Race Against Death with Only Dials to Guide You—Assen Jordanoff—*Popular Science*—Vol. 117, Nov. 1930, Page 38.

A Radio Beacon and Receiving System for Blind Landing of Aircraft—H. Diamond and F. W. Dunmore—Research Paper RP-238 (*Jrnl. of Research of the National Bureau of Standards* — Vol. 5, 1930) — Published by Dept. of Commerce, Bureau of Standards.

Landing Blind: System in Use at Pittsburgh Airport—C. S. Van Dresser—*Radio News*—Vol. 20, July 1938, Page 16.

Air Track has New Position Finder on the Marker—*Aviation*—Vol. 37, July 1938, Page 41.

Statue of Instrument Landing Systems—W. E. Jackson — *IRE Proceedings* — June 1938, Page 681.

Experiments with Underground Ultra High Frequency Antenna for Airplane Landing Beam (Pit aerial and transmitter, for centre of landing field to give steeper approach path and other advantages: with mathematical analysis and investigation of polarization of received wave)—H. Diamond and F. W. Dunmore—*National Bureau of Stds. Jrnl. of Research*—Vol. 19, #1, July 1937, Page 1.

Air Track—C. E. Planck—*Southern Flight Magazine*, March 1937.

Air Track — *Aviation Magazine* — March 1937.

Modern Aircraft Radio—W. E. Jackson—*National Safety News*—October 1935: also published in Shell Aviation News—Feb. 1936, and *Revista de Aeronautica*—April 1936.

Zero-Zero; two systems for blind landing of aircraft by radio — E. A. Cutrell — *Aviation*—Vol. 34, August 1935, Page 22.

Radio Blind Landing System to be Installed on Mid-Continental Airway — *Air Commerce Bulletin* — Vol. 6, Feb. 1935, Page 179.

Radio System for Landing Aircraft During Fog—H. Diamond—*Electronics*—June 1933, Page 158.

Radio System for Blind Landing of Aircraft to be Given Service Tests — *Air Commerce Bulletin* — Vol. 4, #18, March 15, 1933, Page 441.

Airplanes Land Blind—Guided by Radio—H. Diamond and F. W. Dunmore — *Sci. Am.*—Vol. 145, July 1931, Page 20.

A Radio Beacon and Receiving System for The Blind Landing of Aircraft—H. Diamond and F. W. Dunmore—*Bureau of Stds., Jrnl. of Research*—Vol. 5, Page 897, 1930—*IRE Proceedings*—Vol. 19, Page 585, 1931.

*Air Commerce Bulletin*—(in Brief) No. 2, August 15, 1930, Page 79.

Performance Tests of a Radio System of Landing Aids — H. Diamond — *Bur. of Stds., Jrnl. of Research* — Vol. 11, 1933, Page 463 — *Air Commerce Bulletin* (in brief), No. 4, March 15, 1933, Page 441 and May 1, 1933, Page 525.

The Present State of Development of Radio Instrument Airplane Landing Systems in this Country and Abroad—E. N. Wendell — *Proceedings Radio Club of America*—Vol. 15, #3, March 1938, Page 22.

Lorenz Instrument Landing System as Demonstrated at Indianapolis—*Communication & Broadcast Engineering* — June 1937, Vol. 4, #6, Page 12.

Ultra-Short-Wave Radio Landing Beam—R. Elsner and E. Kramar: Lorenz Co.—*Communication & Broadcast Engineering*—Vol. 4, #3, March 1937, Page 12.

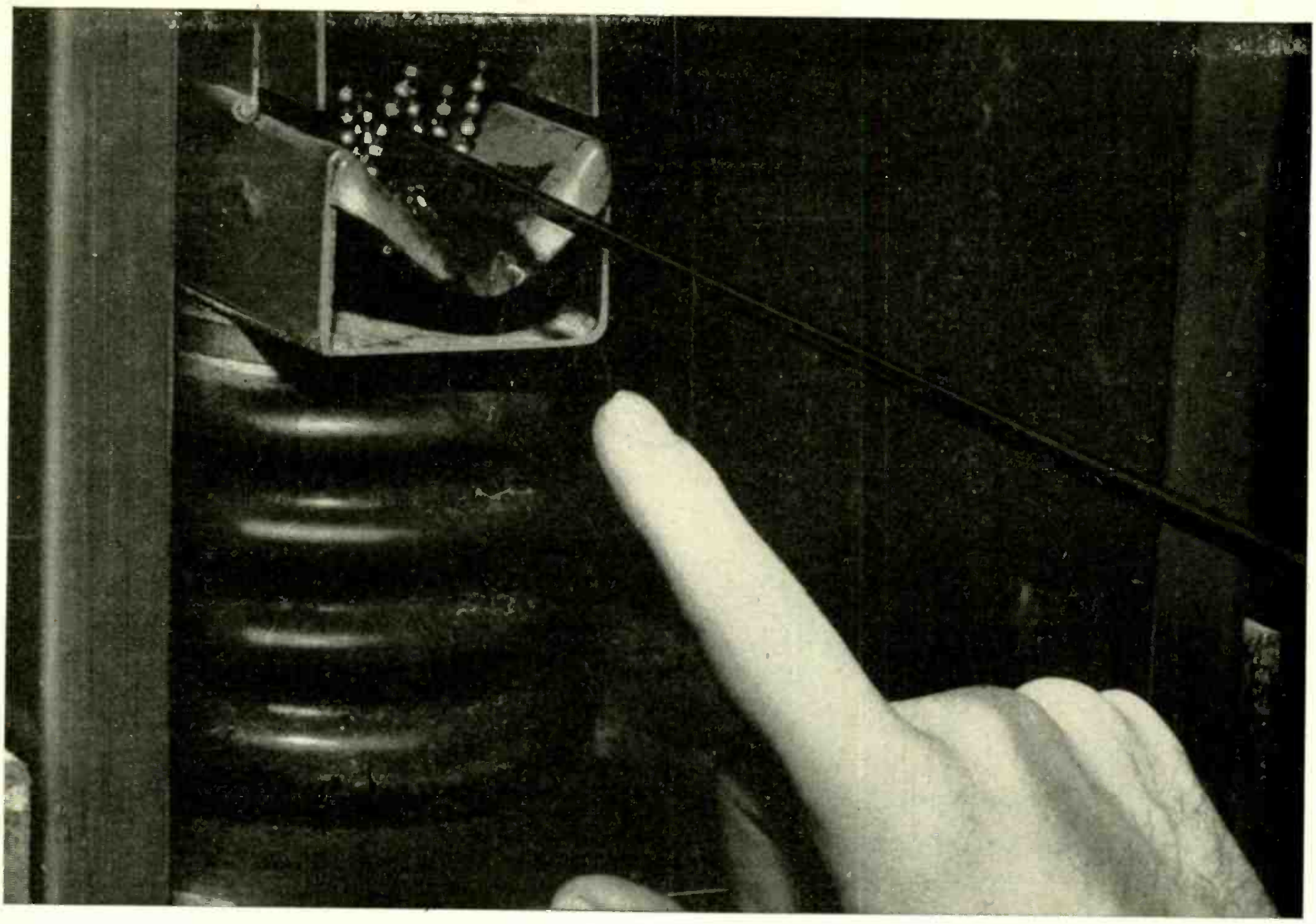
Ultra-Short-Wave Radio Landing Beam: The C. Lorenz-A.G. Radio Beacon Guide Beam System—R. Elsner and K. Kramar—*Electrical Communication*—Vol. 15, #3, January 1937, Page 195.

Pea Soup Parking—*The Airplane*—March 4, 1936.

The Technique of Blind Approach—*Flight*—Sept. 17, 1936.

Bad Weather Landing Apparatus — W. Moser — *Telefunken Zeitung* — Vol. 17, #74, Nov. 1, 1936, Page 5.


[*To Be Continued*]



# High dielectric strength of Geon electrical insulation proved by a string of beads

As GEON insulated wire leaves the extruder and the cooling bath in today's modern wire factories it passes through a group of little metal beads like the ones in the picture. In this test the beads are charged with high voltages well beyond the requirements of the insulation being applied to the wire. Thus high dielectric strength which permits *thin-wall* insulation—and its attendant gains in all phases of wiring efficiency—is assured.

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**Geon**

*Polyvinyl Materials*

# TECHNICANA

[*Continued from page 14*]

From the mixer plate the signal is taken to the first a-f. amplifier $V_4$ through a combination parallel-series low-pass filter. The a-f signal develops across the series circuit and is applied to the grid of $V_4$.

The second amplifier tube is $V_6$. Gain is adjusted by two controls leading to the $V_6$ input. Tube $V_6$ is a triode-connected output pentode, used as a cathode follower to provide an output impedance of approximately 150 ohms.

Tube $V_7$ is an electron-ray tube used to adjust zero setting or to make frequency checks against the supply voltage frequency or its harmonics.

The capacity network is illustrated in *Fig. 6,* in which $C_2$ is the major part of the tuning capacity for the variable oscillator. Capacitor $C_1$ is employed for zero adjustment.

The main tuning capacitor $C_5$, in parallel with $C_6$, is in series with $C_3$ and $C_4$ at the high setting, and in parallel with $C_7$ at the low setting.

Full coverage of the range, without cramping at either end, is made possible by the circuit used.

## RESISTORS

★ The limitations to the use of composition and carbon resistors are strikingly illustrated by use of a chart showing the cumulative effects of permissible deviations from nominal rated value.

This chart, which is duplicated in *Fig. 7,* was prepared by Thomas Roddam in an article entitled "Standardized Components, Part 1" which appears in the December 1944 issue of *Wireless World.*

The author examines some of the implications of the war specifications published by the British Standards Institution in "The Services Radio Components Book".

The resistance deviations of *Fig. 7* are more or less nominal deviations to be expected in "Class 2" composition resistors, but the chart is useful as a guide for circuit designers when selecting components.

The so-called "Class 2" composition resistor is described as one having medium stability and construced either with a film composition or a solid carbon composition moulded into a rod. It may be either insulated or uninsulated.

The "Class 1," or high stability resistor is constructed with a carbon film deposited on a glass or ceramic tube and may be insulated, or not. The "Class 1" resistor is characterized by smaller deviations than are shown in *Fig. 7,* the total deviations amounting to approximately 11% from nominal, instead of 27½%.

The author discusses briefly noise voltages appearing in composition resistors and frequency effects, also wire would and variable resistors.

## EFFECT OF HIGH TEMPERATURE SOLDERS ON COPPER WIRE

★ Proof that commonly used high temperature molten solders have destructive effect on copper wire has been discovered by engineers of the Fairchild Camera & Instrument Corporation, New York.

While conducting tests that resulted in the finding of a new method for clean-stripping Formex type insulation from fine wire (sizes #36-44), Fairchild engineers explored this interesting phenomenon, and have worked out a preventative. Since its existence may not be generally known, this destructive effect and the remedy should be of particular interest to engineers and

[*Continued on page 76*]

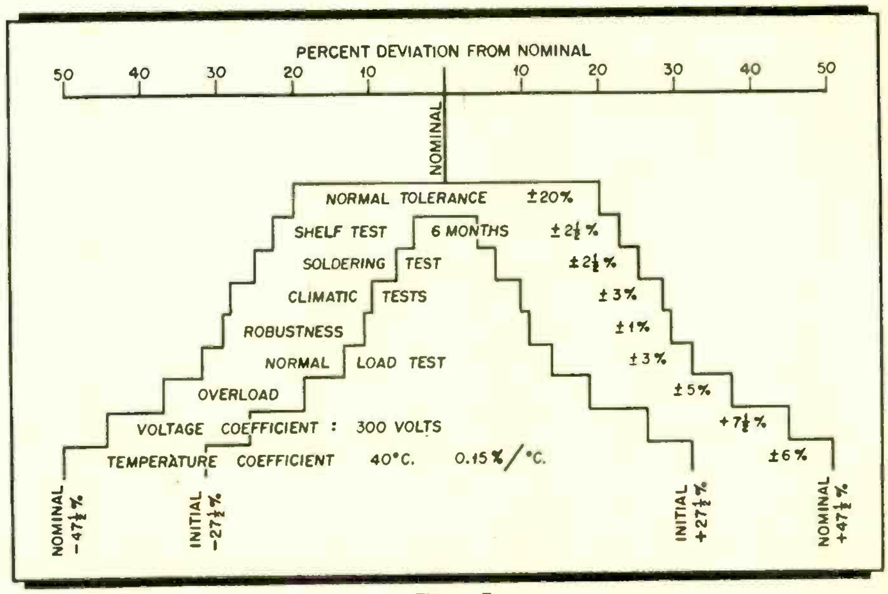
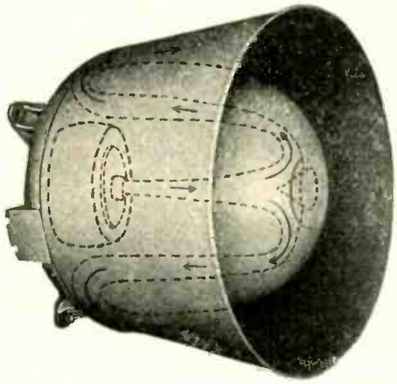
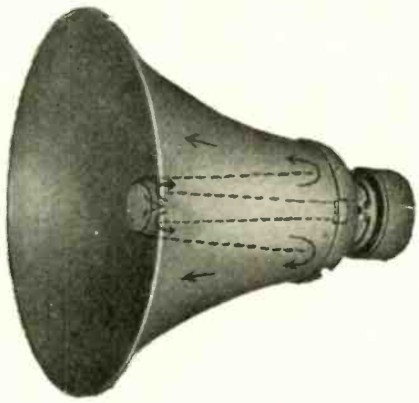



Figure 7

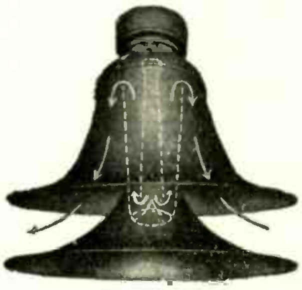
# A Safe Bet for Steady Sales



*Left*—MARINE SPEAKER; approved by the U. S. Coast Guard, for all emergency loudspeaker systems on ships. Re-entrant type horn. Models up to 100 watts. May be used as both speaker and microphone.



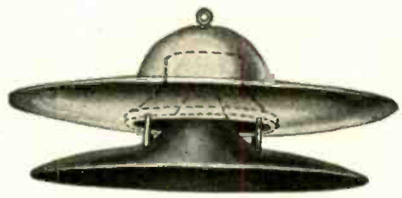
*Right*—RE-ENTRANT TRUMPET; available in 2½-3½-4½-6 ft. sizes. Compact. Delivers highly concentrated sound with great efficiency over long distances.



*Left*—RADIAL HORN SPEAKER; a 3½' re-entrant type horn. Projects sound over 360° area. Storm-proof. Made of RACON Acoustic Material to prevent resonant effects.

*Right*—AEROPLANE HORNS; super-powerful and efficient P.A. horns for extreme range projection. 9-4 and 2 unit Trumpets available.

*Left*—PAGING HORN; extremely efficient 2' trumpet speaker for use where highly concentrated sound is required to override high noise levels. Uses P.M. unit.



*Right*—RADIAL CONE SPEAKER; projects sound over 360° area. Cone speaker driven. Will blend with ceiling architecture. RACON Acoustic Material prevents resonant effects.

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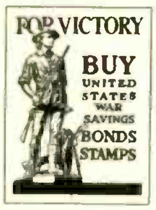


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production men in the electrical, radio and electronic fields.

The Fairchild tests with small diameter coppor wires show the need of rigid temperature control, and, to a lesser degree, close attention to solder composition, in the hot tin dip method of tinning or soldering wires. The life of fine wire, dipped in any solder, is lessened with increasing solder temperature. Low temperature solders, from the melting or liquid point to 600 degrees (Fahrenheit), should be used for tinning and making joints on wire sizes finer than approximately #34 (.0063-inch diameter).

Conclusions reached indicate high solder temperatures are more destructive to wire if the tin content of the solder is too high. This destructive effect also increases as the wire diameter becomes finer. By proper control and by proper clean-stripping—in case of insulated wires, synthetic or otherwise—this danger can be avoided. Tests reveal positively that life of a given wire is greater if lead content of the solder, for any temperature, is higher.

Hitherto, one of the most widely used methods of stripping and tinning Formex-insulated wire has required that the wire be dipped into molten solder held at about 1025-1100° F. This is commonly known as the "hot dip solder method," and is a single-step operation for both stripping and tinning such coated wire. Although an efficient method, it has a major drawback in that high temperatures are required for proper removal of synthetic insulation.

In this method, laboratory tests show two effects: 1) the wire suffers a reduction in diameter in the stripped and tinned section; 2) some embrittlement of the wire occurs due to the high temperatures encountered.

The crux of the investigation of the hot dip solder method shows other factors. Synthetic rosin-coated wire must be dipped, above a critical temperature of 932° F., into molten solder. Polyvinal acetal insulation is transformed by the heat, and insulation in this action apparently serves as a flux to permit tinning of the copper wire in the same dipping operation. More positive and complete stripping and tinning are obtained at slightly higher temperatures, approximately 1025-1100° F. For example, in the small wire sizes of #29 H.F. (Heavy Formex) and #40 H.F., the action is completed in about 10 and three seconds, respectively, both at about 1050° F.

Further, if the wire is kept in the hot solder long enough, the submerged section is completely eaten away. "Long enough" is an inadequate expression here; for #29 H.F. wire it represents about 20 seconds, and for #40 H.F., 5-6 seconds. The leeway for #29 is relatively appreciable, but not for #40 wire. Heavy Formex will not properly strip and tin below the indicated times, and fine wire suffers by this tight control. Although stripping-tinning action may be held through close control to the minimum time required, some copper loss can be expected. Higher temperatures, up to 1175° F., reduce the minimum dipping times, but also shorten the destruction times. Number 40 H.F. is destroyed practically as the stripping and tinning are completed.

A review of this data leads to three major conclusions:

1) The life and diameter of any small to fine size copper wire in any solder is decreased with increasing molten solder temperatures.

2) The higher the tin content of tin/lead solder, the shorter is the life of a given wire in that solder for any given solder temperature. Unfortunately, however, an all-lead solder results in a considerably weaker solder joint than tin/lead solders.

3) For a given solder composition and solder temperature, the finer the wire size (diameter) the shorter is the wire life in the solder.

Further conclusions to the tests are:

The all-around best solder of those tested appears to be the 40/60 combination, commonly referred to as soft solder. Other solders in this vicinity may offer even better properties. For certain other purposes, regardless of these findings, hard, or 60/40 solder may be best.

Some form of wire weakening or loss of tensile strength, broadly classified as embrittlement, may be imparted to copper wire from tin/lead solders in the 1000° F. temperature range.

On the basis of these facts only, it is apparent that a low solder temperature should be used for tinning and/or making joints on wire sizes finer than approximately #30-32. Preferably, these solder temperatures should be kept either within

150° to 200° F. above the melting or liquid point of the solder used, or under 600° F. For Formex or Formvar coated wires, a low tempertaure insulation stripping method other than the hot tin dip method now becomes necessary. Other methods, involving high temperatures, such as the gas flame method, tend to introduce wire embrittlement and copper oxidation, and are no better.

In summary, for the safety of the wire lead being stripped, the production assembly schedule, or the final assembled piece of precision equipment—electric motor or other appliance—it is important that the fine sizes (#34-46) of synthetic coated wire be stripped, tinned and joined or soldered at temperatures at or under 600° F.

This phenomenon in wire destruction is not alone interesting, it is important and serious. Such reduction in diameter in hot tin dipping means weakened leads, perhaps production losses either at the dipping operation, or later in assembly, and an inferior product that fails in the field; this is especially true in the finer wire sizes of #34-40, or even finer.

Based upon these initial observations, detailed tests were conducted by Fairchild engineers. The tests were to determine the time required for complete destruction of copper wire. Three variables had to be considered in these tests:

1) *Wire size*—Three wire sizes, #29, #34 and #40, were selected as representative of the more commonly used small and fine wires which would suffer to some degree under this known destructive action.

2) *Solders*—Three tinning solders, 60 tin/40 lead, 40 tin/60 lead, and 0 tin/100 lead (using pure lead), gave an approximate general working range down to pure lead. This was considered an indicative selection of tinning solders.

(Incidentally, metallurgically, all solders with a melting point below 600-700° F. are defined as "soft" solders. All solders having a melting point of approximately 1100-1200° F. are considered "hard" solders; this includes silver solders. Sometimes, though, silver solder is used; its melting point is about 1200° F. All the tin/lead solders are considered "soft," but 40/60 is often referred to as "soft" solder; 50/50 as "common" solder; 60/40 as "hard" solder. The difference in solder designations, metallurgically, and in the trade, should be borne in mind.)

3) *Solder temperature*—For purposes of these tests at Fairchild's, temperature ranges of 550 to 1175° F. were selected. A 600° range represents the lowest reasonable working temperature practical, just above the melting or liquid points of soft solders. It should be noted that 60/40 solder melts and goes into the liquid state at about 400° F., 40/60 solder becomes mushy at its melting point of about 360° F., and goes into the liquid state at about 475° F., and pure lead melts to a liquid at 621° F.

The 1100° F. group, however, was considered as representing the approximate working range that would be encountered in normal practice for hot tin dip stripping of Formex. In these laboratory tests it was found that Heavy Formex coated wire required minimum temperatures of 1005-1025° F. to be stripped.

All test samples of copper wire were stripped in advance of the synthetic insulation. This was essential because, first, the synthetic insulation would not be affected by temperatures below 1000° F.; second, all wire specimens should be in like condition for the consistency of test results. Formex was stripped from the wire samples by the new Fairchild process of stripping Formex coating by dipping the wire in two chemical solutions, leaving test specimens in thoroughly clean and usable condition.

All wire test specimens were bent into a standard hairpin shape with one side bent outward at right angles near the end opposite the loop. The specimens were handled by this projection. They were plunged, loop down, into the molten solder, only deep enough to permit the free side to remain out of the solder to about one-half its length. When this vertical projection fell over, due to the destructive action of the solder, the test specimen was considered destroyed as the wire was so eaten away as to be incapable of supporting even this small weight.

The wire life or destruction time was measured accurately from the moment of entry into the solder. The solder was kept in a temperature-controlled, electrically-heated castiron pot of two cubic inches capacity. Dross was scraped from the solder surface immediately before each test.

No attempt was made in the Fairchild investigation to determine an optimum tin/lead ratio.

All curves clearly demonstrate that temperature increase has a tremendously non-beneficial effect upon the destruction time. An unfortunate but important outcome of this analysis is that, for a given set of conditions, wire life decreases materially with decrease in wire size (diameter).

This destruction of the copper is believed to be an alloying away, or driving into, solution of the copper largely by the tin in the solder and to a smaller degree by the lead. Melting points of these three metals are: copper 1981° F., tin 450° F., and lead 621° F. In metallurgy, two metals of different melting points will result in a mixture with a lower melting point than either of the constituent metals possesses alone. Although the melting point of the copper is high, it is believed that the presence of the two other molten metals causes the copper to be dissolved into the tin/lead alloy by this action. In effect, the molten solder is the solvent.

The second detrimental condition of wire embrittlement at high temperatures has been observed. Photo-micrographic analysis of longitudinal sections of untinned and tinned wires shows a surface to subsurface coarsening of the copper crystals in 1050° F. solder dipped wire. This zone does not penetrate to a great depth. Also, a new constituent of possibly a copper-tin alloy is to be found between the solder and copper zones in the 1050° F. wire. This new constituent generally is hard and probably is a contributing factor to fatigue failure of wire. This condition has not been extensively at Fairchild Camera & Instrument, and only in a secondary sense.

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| Sperry Gyroscope Co., Inc. | *Radio-Electronic Devices* | Cover 4 |
| Sprague Electric Co. | *Resistors* | 45 |
| Stupakoff Ceramic & Mfg. Co. | *Ceramics* | 65 |
| Surprenant Elec'l Insulation Co. | *Plastic Insulations* | 64 |
| Sylvania Elec. Prod., Inc. | *Tubes* | 6 |
| Tech Laboratories | *Attenuators* | 56 |
| Thordarson Elec. Mfg. Co. | *Transformers* | 14 |
| Triplett Elec. Instru. Co. | *Portable Instruments* | 62 |
| Universal Microphone Co. | *Microphones* | 63 |
| U. S. Treasury Dep't | *War Bonds* | 71 |
| Van Pells, Max | *Distribution* | 70 |
| Western Electric Co. | *Help Wanted* | 68 |
| Wholesale Radio Labs. | *Tube Base Calculators* | 46 |
| Wrigley Jr., Co., Wm. | *Institutional* | 44 |

**HARVEY UHX-25**
A 25-Watt General Purpose Radio-Telephone Transmitter—Available for operation between 1.5 M. C. and 30 M. C.

**HARVEY "AMPLI-STRIP"**
For I-F and AUDIO Amplification.

**HARVEY OF CAMBRIDGE**

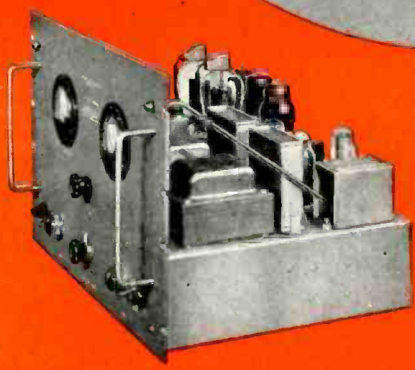
# RADIO AND ELECTRONIC EQUIPMENT

The units illustrated are representative of HARVEY OF CAMBRIDGE design and construction "know-how" as well as precision of manufacture and testing. Each is a precision product designed and developed by HARVEY OF CAMBRIDGE to fill specific needs in the radio-electronic fields.

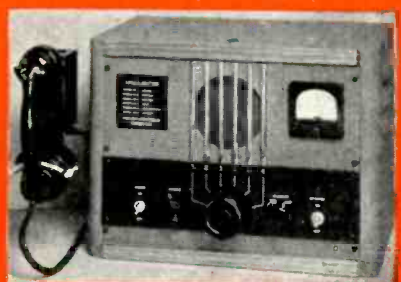
Some, like the 206 PA Power Supply and the "Ampli-Strip" are new developments resulting from HARVEY's one-hundred per cent war work.

Others, like the UHX-25 Transmitter and Marine 25 Radio Telephone are typical of HARVEY OF CAMBRIDGE products which have long been recognized as standards of quality and dependability.

Years of exclusive specialization in the manufacture and development of this type of equipment are your guarantee of complete satisfaction from all HARVEY OF CAMBRIDGE products and of competent, intelligent assistance in bringing to a successful solution any of your present or projected radio-electronic problems.



**HARVEY Regulated Power Supply 206 PA**
For laboratory D.C. Source—Range 500 to 1000 volts.



**HARVEY MARINE 25**
A 6-Channel Marine-Radio Telephone.

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**HARVEY RADIO LABORATORIES, INC.**
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