RADIO

NOVEMBER, 1945

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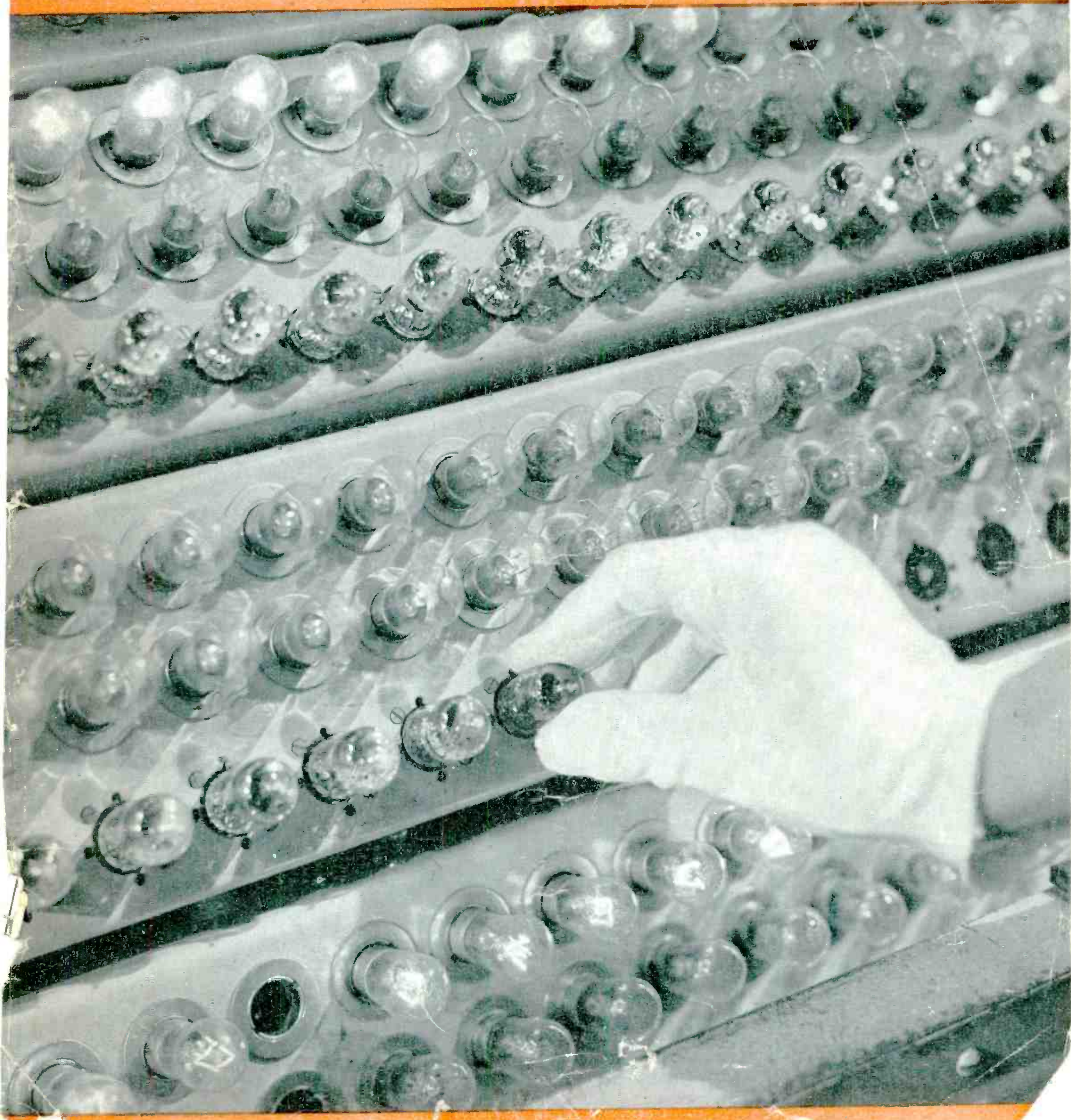

The Journal for Radio & Electronic Engineers

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Should Radio Service Dealers be Licensed?

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Screaming headlines in the New York Times, the World Telegram, the Herald-Tribune, articles in *The Reader's Digest* — *you* know the unfavorable talk they have helped spread, the hardship they have worked on every *honest* radio service dealer.

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What's the answer? *Raytheon will announce it shortly* for Raytheon has been working for years on a new, foolproof way to protect the public—and to help the *ethical radio service man.* A revolutionary new merchandising plan that will raise the public's opinion of the radio servicing profession and protect the reliable service dealer from outside interests.

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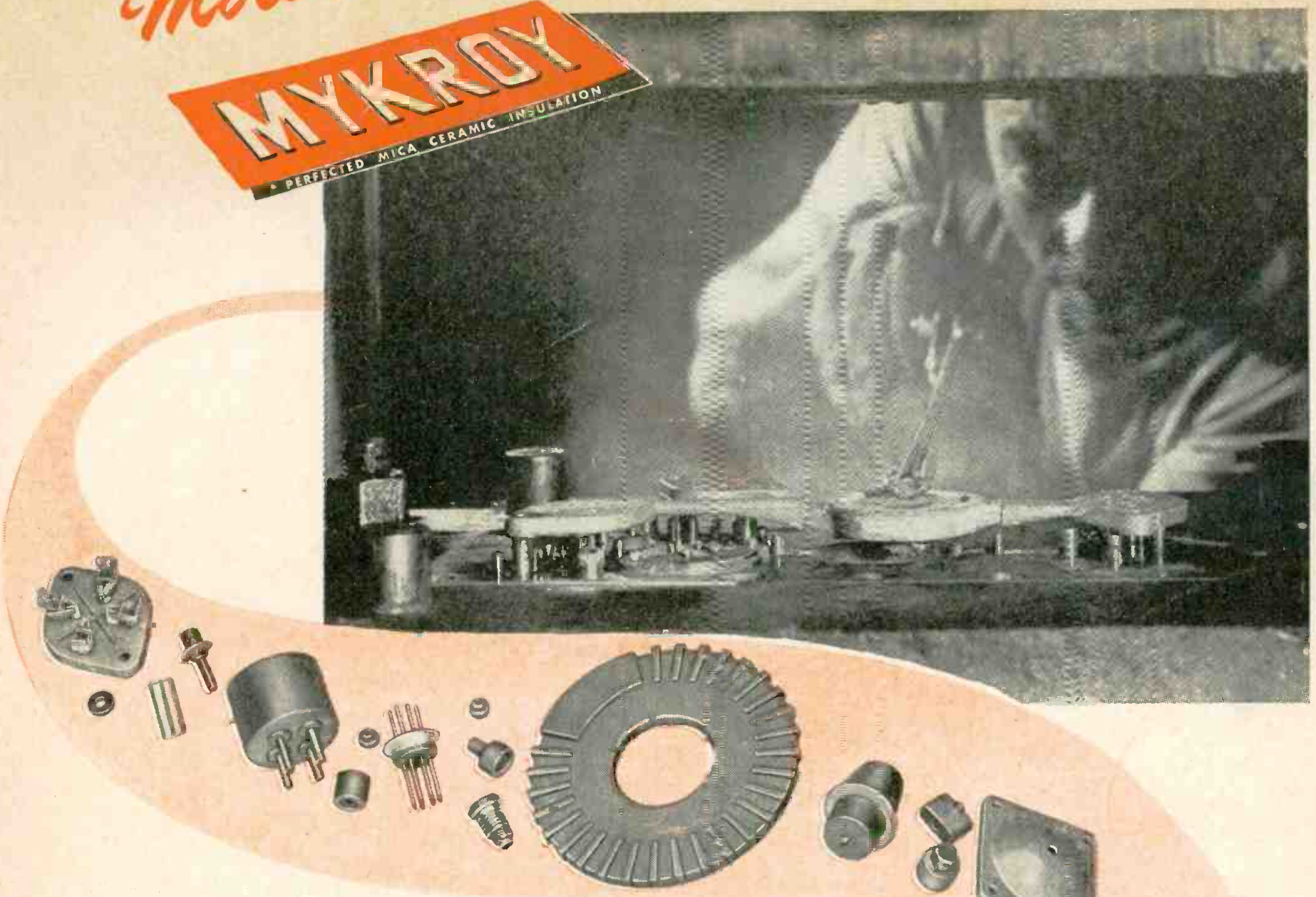

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RADIO

Published by RADIO MAGAZINES, INC.

John H. Potts .... Editor
Sanford R. Cowan .... Publisher

NOVEMBER 1945

Vol. 29, No. 11

CONTENTS

COVER

Placing 6AK5 vacuum tubes on a rotary aging rack. In one revolution of the drum, the tubes are completely aged for test. This type of tube is one of the most popular of the miniature size developed for war use. *(Western Electric Photograph)*

ARTICLES

MISCELLANEOUS

John H. Potts .... *President*
Sanford R. Cowan .. *Adv. Mgr.—Sec'y-Treas.*
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Transients

OPA MUDDLE

★Unquestionably the greatest hindrance to orderly reconversion in the radio industry is the failure of the OPA to take a realistic view of the cost structure in the production of radio sets and components. The percentage increases allowed in final pricing have failed adequately to reflect the enormously increased costs of production. While many manufacturers are going ahead with production with nothing to look forward to but a loss on each unit turned out, and the hope that this loss will be made up when prices are finally raised to a reasonable figure, others have elected to wait until the whole mess is straightened out on a satisfactory basis.

Although the OPA has agreed to readjust prices for manufacturers who show a loss after a six months' production period, this policy tends even more to unsettle the industry. It is renegotiation in reverse, with private industry, instead of the government, risking its money. It is an incentive to wastefulness, because those companies which can afford to take heavy losses with the assurance that they will be reimbursed when prices are readjusted, will feel under no great obligation to operate at top efficiency. It is unfair to the small manufacturer with no adequate reserves to finance himself during this period.

Yet those manufacturers who have decided to sit back and wait until a suitable pricing schedule has been evolved face the danger of loss of their markets to those who have gambled on the future. There is bound to be considerable deflation in the radio-electronic industry, and only those who fight for their place in the postwar picture can hope to survive. A public which has become accustomed to getting along without new radios during the war period may decide to wait a little longer if forthcoming sets seem overpriced. In fact, the volume of sales of the first midget receivers offered a few months ago at what seemed high prices was very disappointing. Despite the pent-up need, it is going to be necessary to do a good selling job, and to offer attractive features in the new sets, if they are to bring a satisfactory sales price and sell in quantity.

Many companies are shipping sets abroad to get away from price restrictions here, and apparently the same thing works in reverse because there has been some influx of receivers of foreign manufacture. At the present time there appears to be no danger that the quantity of receivers imported will be sufficient to blunt the consumer demand, primarily because those we have seen offer no attractive features and appear to be the loft-production variety. However, the threat exists that some enterprising foreign manufacturer may turn out a really good set at a reasonable price and make a name for himself while the industry here is trying to get over its OPA blues.

A definite pricing system which is fair to all concerned should be worked out immediately. If these prices are too high, loss of sales volume will result, and those companies which are able to produce more efficiently will soon be selling their products below ceiling prices. If these prices are too low, many companies will be forced out of business, unemployment will increase, and the whole radio industry will find itself in the midst of a depression. It is apparent that the latter danger is the more serious. The engineering skill and production ability which have been characteristic of war-time production will carry over into the postwar period, if given a chance. The radio industry has the right to demand that chance, and in all fairness the OPA should recognize this right.

LOOP RECEIVERS

★Recently, while your Editor was in Chicago, a remarkable demonstration of the advantages of the loop over the conventional auto antenna was given the writer by Fred Schnell, head of the radio division of the Chicago police organization. Using an iron-core electrostatically shielded loop on a frequency of 1740 kc, the writer found it possible to hear clearly signals which were hopelessly "down in the mud" on the usual antenna. On streets where the noise level had previously been so high that radio reception was heretofore impossible, satisfactory reception was obtained with the loop.

While either an air core or an iron core loop, if electrostatically shielded, will afford a greatly improved signal-to-noise ratio, the iron core type is so much smaller that it offers distinct advantages. The actual improvement in signal-to-noise ratio is of the order of four to one in favor of the loop.

An extension of this technique to home receivers should merit careful consideration. In an article appearing in this issue, the well-known authority on iron cores for radio applications, W. G. Polydoroff, presents some hitherto unpublished data which greatly simplifies the design of iron core coils, which had hitherto been a cut-and-try proposition. The loop used in the police radio demonstration was also designed by Polydoroff.

—*J. H. P.*

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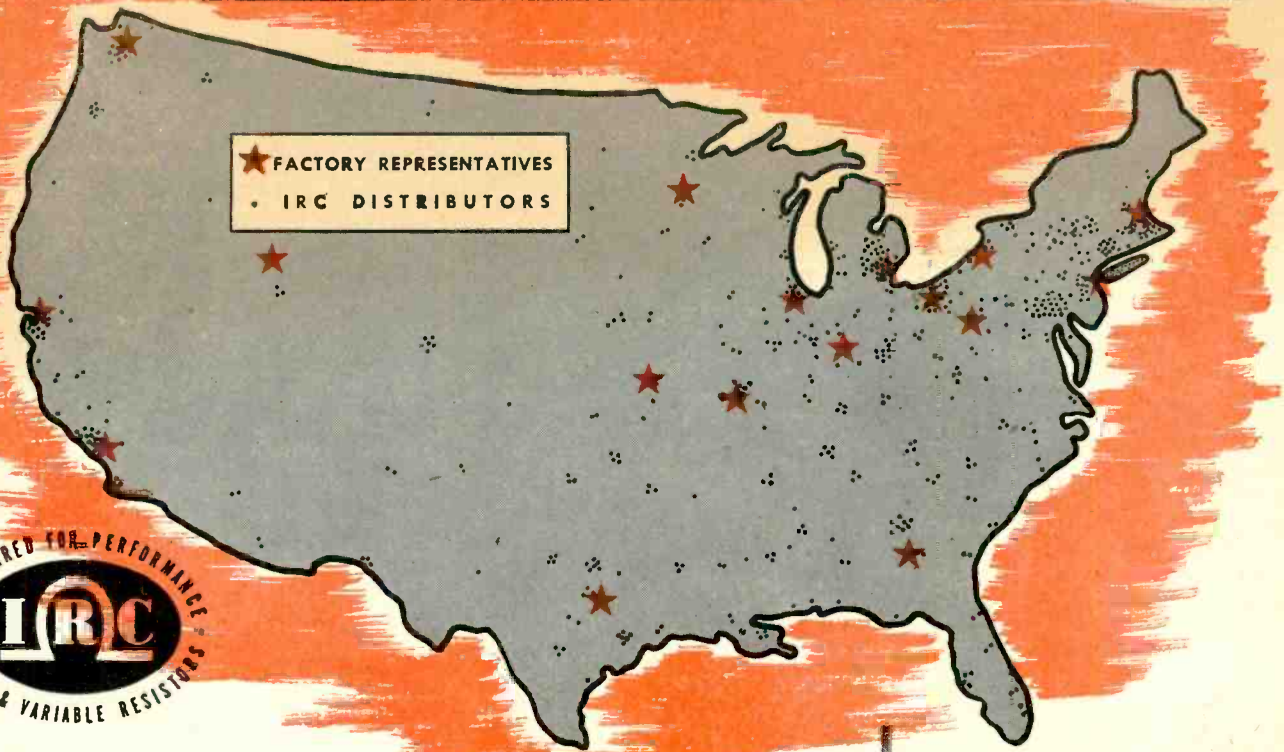

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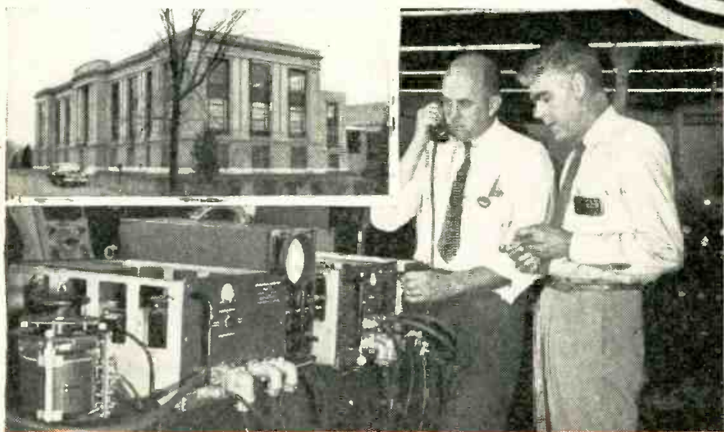
comes a *NEW* railroad communications



● Sperry's Research Laboratory where Railroad Communications System was designed and developed

● Rock Island's Mobile Electronic Laboratory where equipment was put to rugged test

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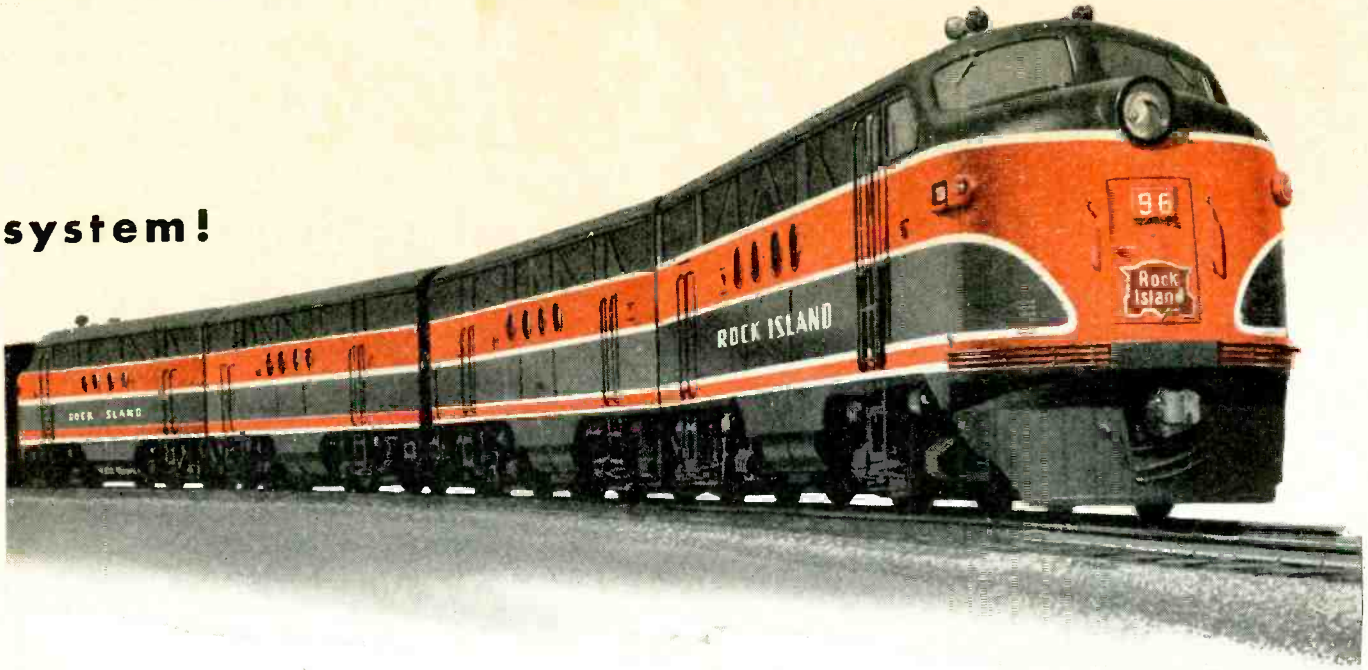

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TINY GIANT WITH A HISTORY

Long before the war, the men who design your Bell Telephone System were looking for an electron tube with frequency capabilities never before attained. With it, they could transmit wide bands of telephone messages — several hundred of them — simultaneously through coaxial cable—economically, and over long distances.

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6AK5

Cross-section of Electrode System (five times actual size)

When war came, this tube excelled all others as an amplifier in certain military equipment. It then grew into the 6AK5, one of the great little tubes of the war. Besides producing 6AK5's in large quantities, the Western Electric responded to emergency needs of the Army and Navy by furnishing design specifications and production techniques to other manufacturers, of whom at least five reached quantity production. On every battlefront it helped our ships and planes to bring in radio signals.

Developing electron tubes of revolutionary design has been the steady job of Bell Laboratories scientists ever since they devised the first practical telephone amplifier over thirty years ago. Now tubes like the 6AK5 will help speed the living pictures of television, as well as hundreds of telephone conversations simultaneously over the coaxial and radio highways of the Bell Telephone System.

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Ability to handle high current at high frequencies is the true measure of the performance of a capacitor. A high peak voltage rating based on low frequency measurements does not tell the whole story.

The chart on this page shows the results of tests at 50 Mc. conducted on a standard Eimac VC50-32 Vacuum Capacitor and three other 50 mmfd. vacuum capacitors, designated on the chart by "A," "B" and "C." At just over 17 amps. (approximately 1525 peak volts across the capacitor) Unit "A" (rated at many times the applied voltage) became sufficiently heated to melt the solder on the end caps. Under this same test, the Eimac VC50-32 operates at less than 70°.

Eimac introduced the vacuum capacitor in 1938. It is interesting to note that the original Eimac capacitor design is still outperforming all comers. Such outstanding performance is typical of all Eimac products, which is one of the reasons why they are first choice of leading electronic engineers throughout the world.

1113

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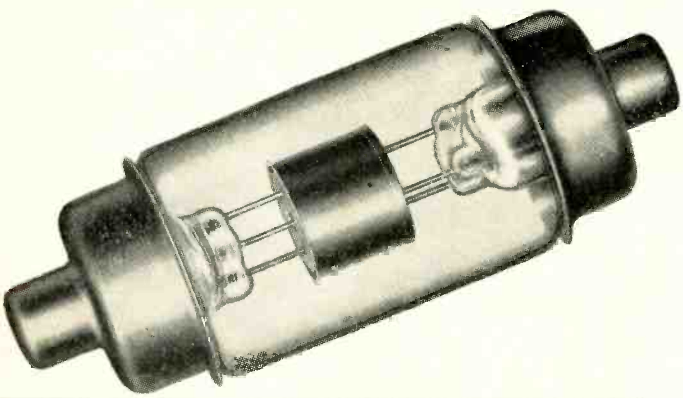

EIMAC VACUUM CAPACITOR TYPE VC50-32

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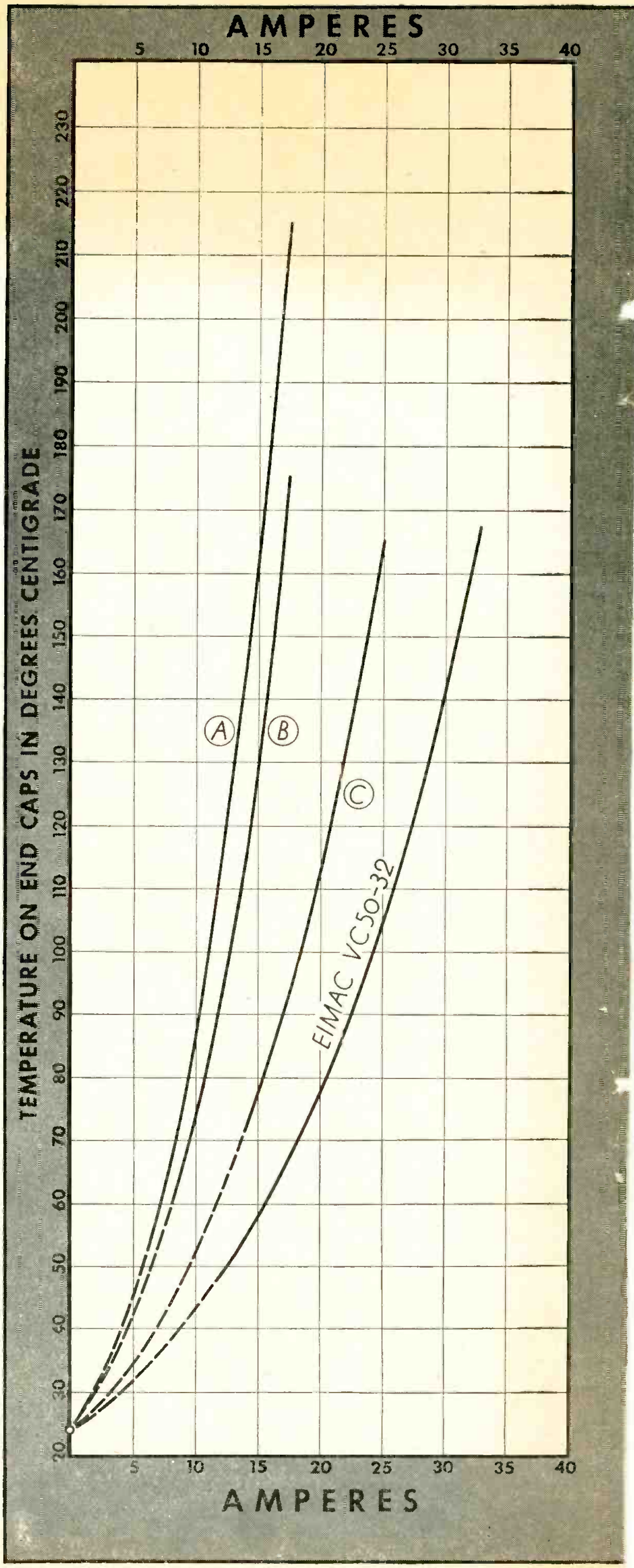
Electrical:

Maximum Peak Voltage	32,000 volts
Maximum RMS Current	28 amps.



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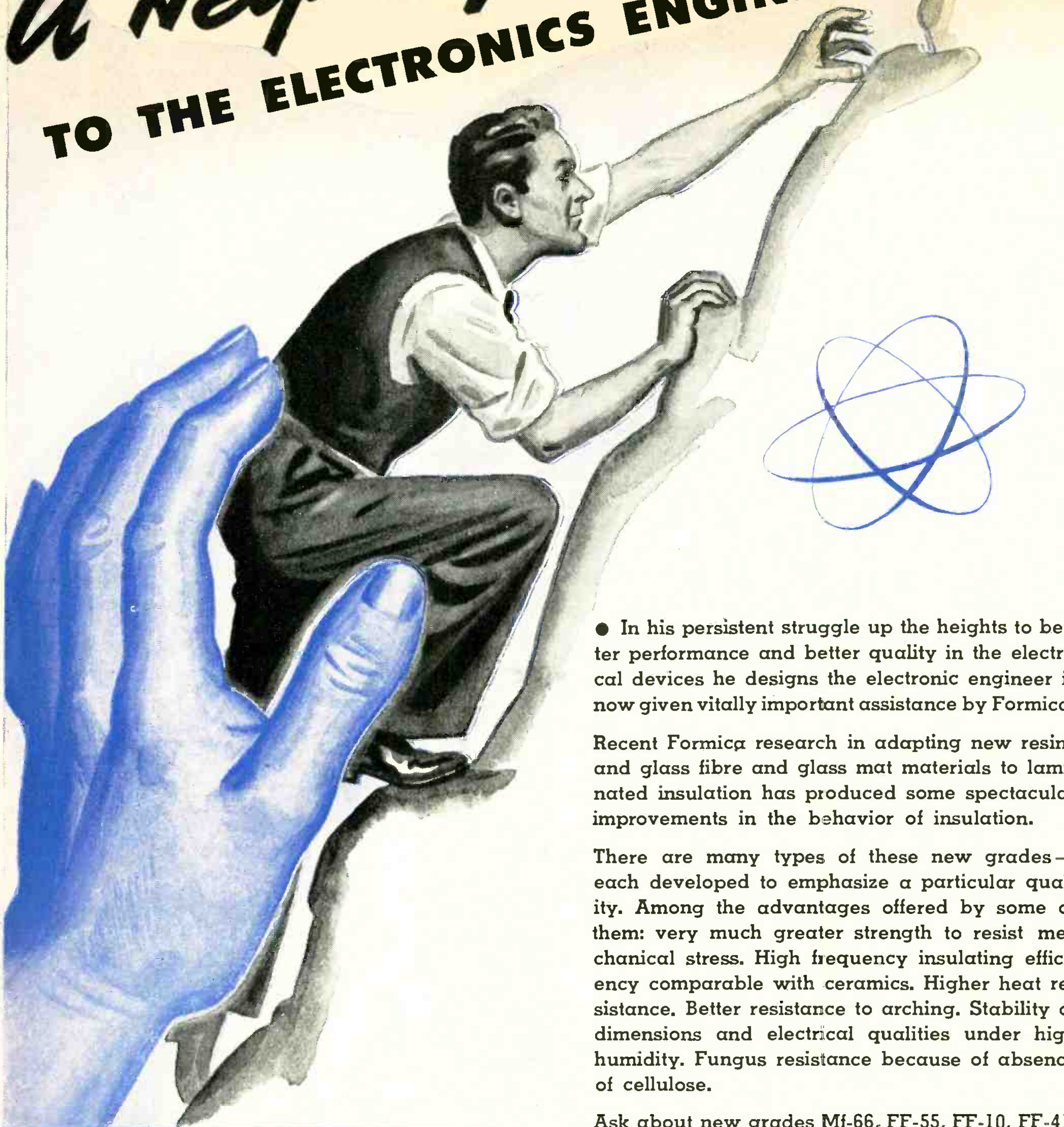

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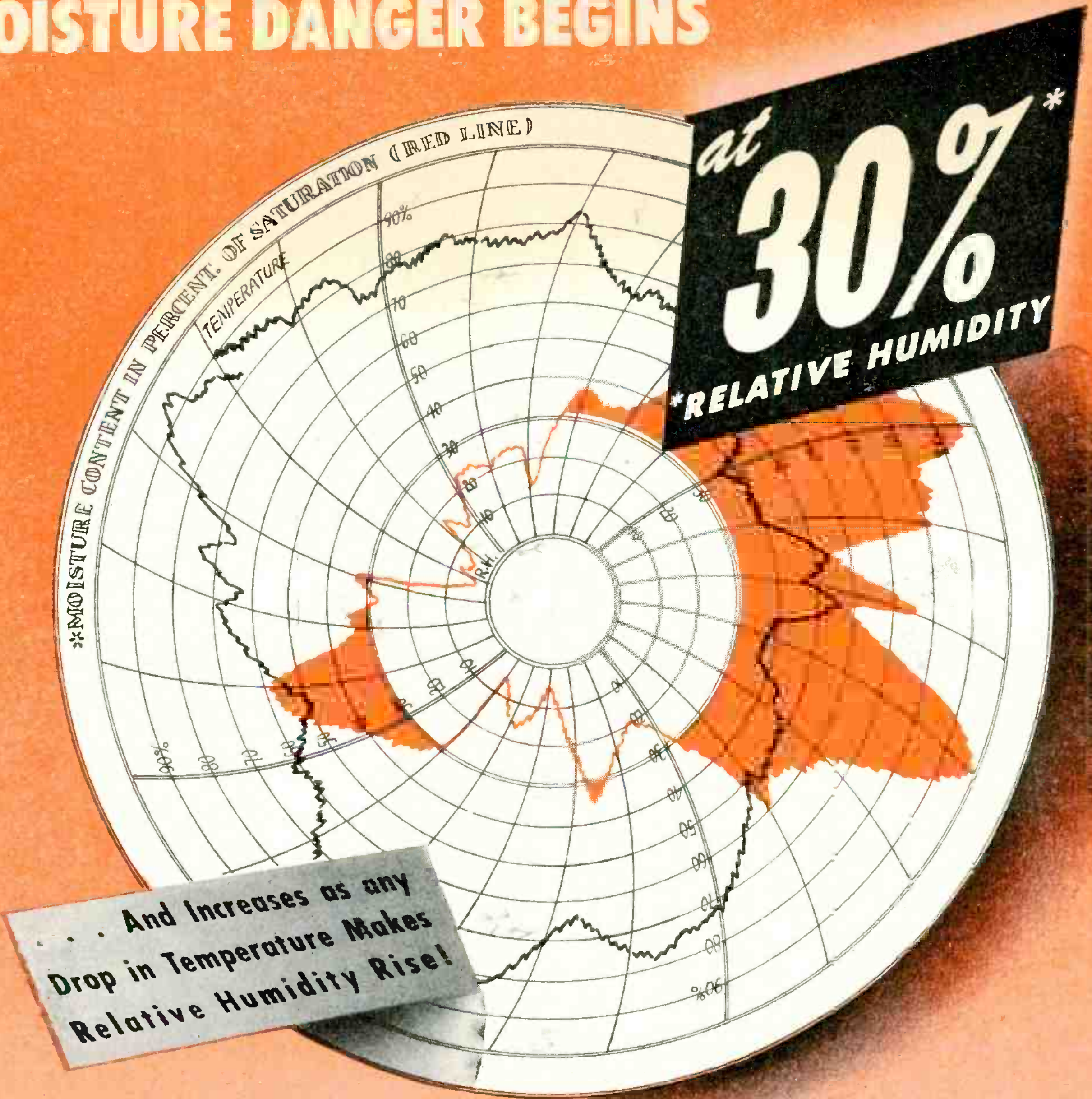

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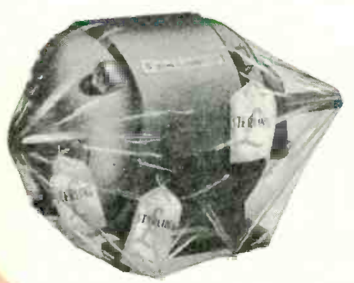

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TECHNICANA

CRYSTAL OSCILLATOR THEORY

★ The Q of a coil is given as $\omega L/R$, and its analog used to define the quality of a quartz crystal is $Q = \frac{\omega L_1}{R_1}$. The values refer to *Fig. 1A,* which is the equivalent circuit of a crystal at any frequency between its resonant frequency, ω_1, and its antiresonant frequency, ω_2.

This concept of Q is unsatisfactory for a study of crystal oscillators, and

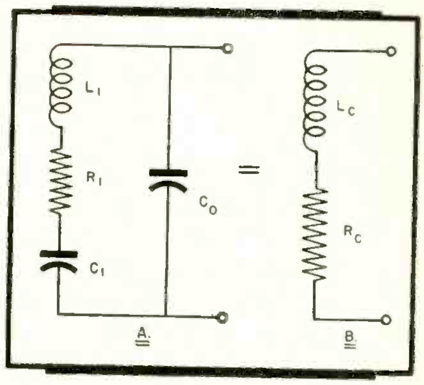


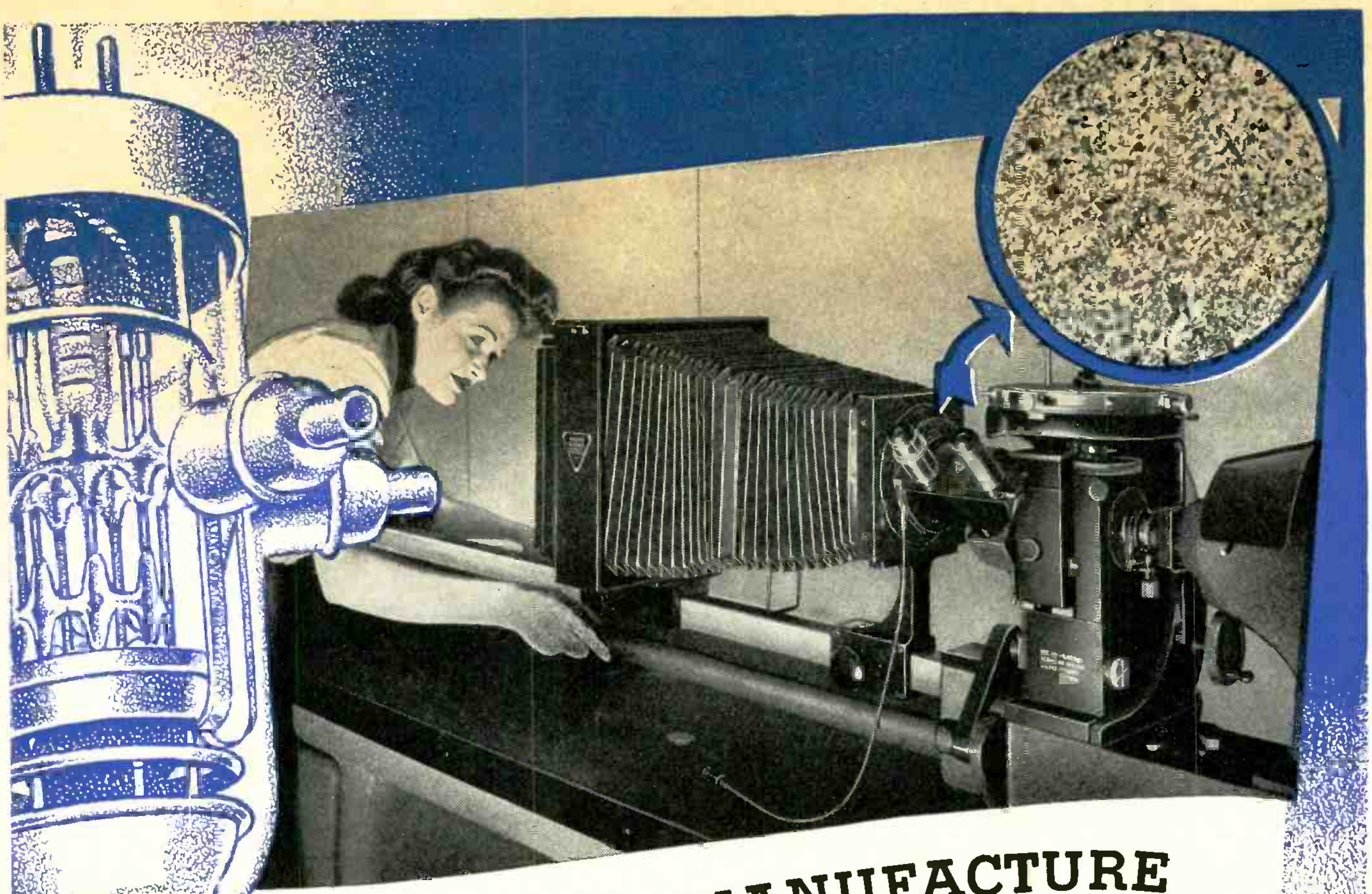
Figure 1

another term has been introduced. This term defines the quality of a crystal in its holder. The figure of merit $M = \frac{\omega L_1}{R_1} \cdot \frac{C_1}{C_0} = \frac{Q}{r}$, where $r = C_0/C_1$. The capacitance C_0 between the terminals of the crystal holder is in shunt with the effective inductance, resistance, and capacitance of the crystal.

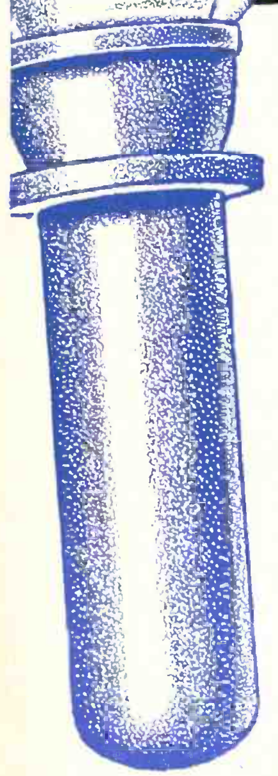
If the crystal, as viewed from the holder terminals, is given the equivalent circuit representation of *Fig. 1B,* then the effective Q is $\omega L_e/R_e$, but this circuit is equivalent only at the operating frequency, and the terms L_e and R_e are complex functions of the constants above. The paralleling capacitance is found in the oscillator circuit to which the crystal is attached.

A still more useful expression would describe crystal performance in an actual oscillator circuit, such as shown by *Fig. 2.* This is a generalized equivalent crystal circuit, containing a negative resistance ρ and a paralleling capacitance C_t, capable of sustained oscillations.

The new term, called the Performance Index, is based on the definition $PI = \frac{\omega L_e}{\omega C_t R_e}$, invoking the equivalent circuit values of *Fig. 1B.* In circuit units of *Fig. 2* this is given as



IN TUBE MANUFACTURE ALL SMALL DETAILS ARE LARGE TO *Federal*



From slender filament to anode block . . . *all* tube construction details, however small, are important to Federal. That is why this experienced and longtime manufacturer uses the illustrated high-magnification metallograph as part of its test equipment for checking raw material quality.

An example is the micro-photo inset. Here is shown oxide-free, high conductivity copper used for copper-to-glass seals . . . after the material has been reduced to a fine grain, non-porous structure through Federal's special metal-processing methods.

But whether copper, molybdenum or tungsten . . . they all are subjected to the same exclusive treatment and put through the same searching scrutiny . . . assurance that only the finest materials go to make up Federal tubes.

This exacting test is another good reason why Federal tubes are better tubes. Transmitting, rectifier, industrial power . . . they have a reputation that is deserved because they are *built to stay*.

Federal always *has* made better tubes.

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TECHNICANA

[*Continued from page* 16]

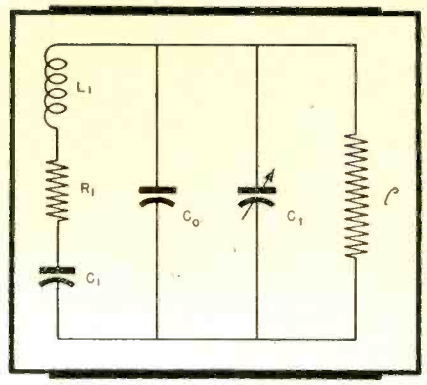


Figure 2

$$PI = \frac{M}{\omega C_o(1+\frac{C_t}{C_o})^2}$$, in which all quantities are measurable. This expression neglects the shunt resistive losses in the holder.

The need for a yardstick for measuring crystal performance which is more basic than the arbitrary determination of grid current activity has resulted in the appearance of two articles on this subject in the April, 1945, issue of the *Bell System Technical Journal.* The circuit theory is discussed by I. E. Fair in an article entitled "Piezoelectric Crystals in Oscillator Circuits". A second article on measurements is also reviewed in this column.

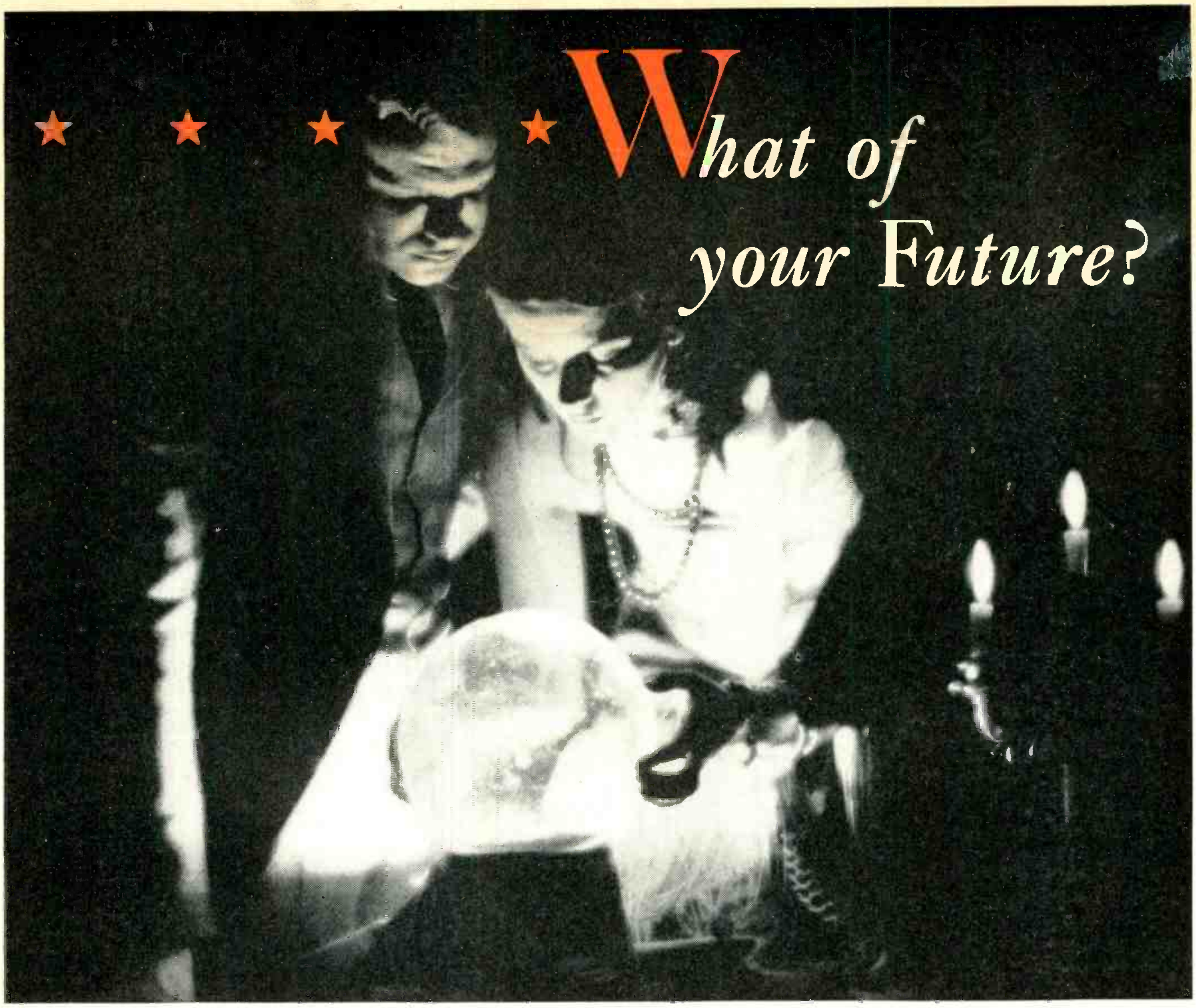
There are several methods by which crystal oscillator (as distinguished from crystal-control) circuits have been attacked. Each has been used to determine a specific type of information, generally of a qualitative nature. Mr. Fair has reviewed these methods in detail.

Frequency of operation has been tackled by the use of higher order differential equations, in which the differential coefficients are functions of the circuit elements. The conditions for sustained oscillations are also obtained.

These results, as well as conditions for oscillation and amplitude of oscillation, as determined by the use of complex function theory, are in general agreement with measured results. The vector method is also described.

The frequency stability coefficient of a crystal, defined as the rate of change of the reactance of the crystal, when placed in an oscillatory circuit, is shown to depend on the ratio C_o/C_1, of *Fig. 2.* This explains the relative stabilities of various cuts of crystals, and suggests how they can be adjusted. Additionally, the frequency stability of a crystal is di-

[*Continued on page* 25]



The developments in radar, radio, television, electronic and electrical apparatus of all kinds made during the past four years will have tremendous influence on your future.

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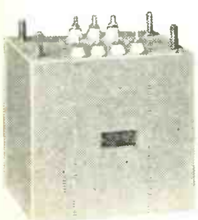

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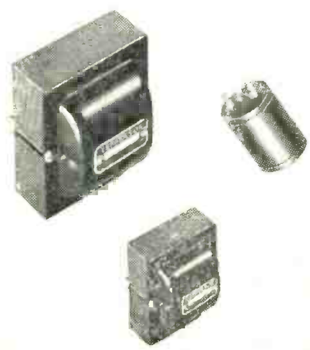

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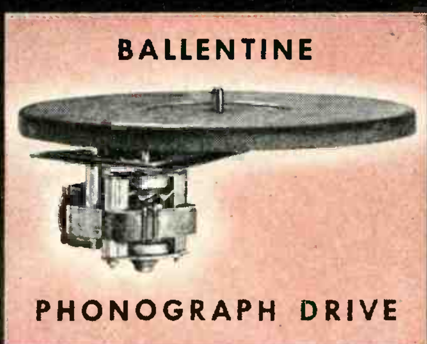

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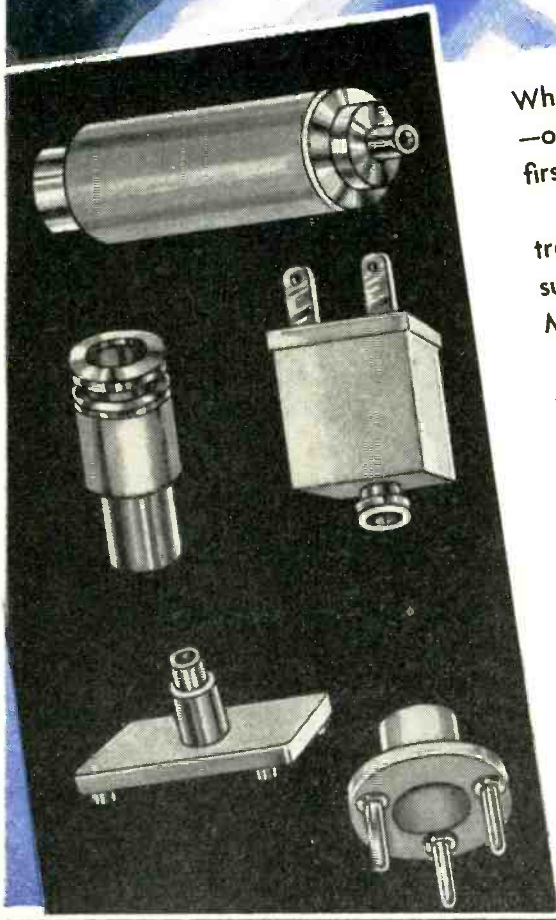

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TECHNICANA

[Continued from page 18]

rectly related to the figure of merit, M, and determines the maximum M that can be obtained.

The Performance Index of the crystal is based on the negative resistance method of analysis, from which the condition for oscillation is $\omega C_{t\varphi} \leq \frac{\omega L_c}{R_o}$. This refers to *Fig. 2*. Since the right-hand side of this expression must exceed the left-hand side for oscillations to start, the right-hand side is considered a measure of the crystal quality, and is defined as the Performance Index.

If Performance Index is plotted against C_t/C_o, the latter will decrease exponentially with PI. When $C_t = 0$, maximum performance can be expected.

Again, when R_o, the effective crystal resistance, decreases, performance increases.

The $PI - I_g$ circuit characteristics indicates that when I_g saturation occurs, no further improvement in circuit performance can be expected by changing crystals. By using the Performance Index as a guide, oscillator and crystal characteristics can be examined independently.

It is suggested that crystal activity, as a standard of measurement of crystal quality, be gradually discontinued in favor of the new Performance Index. This will eliminate the need for crystal manufacturers to maintain models of all oscillators for which they intend to make crystals.

Additionally, this proposal should induce circuit engineers to devise standards of quality for oscillator circuits in general, and to correlate these standards with crystal performance for a better overall understanding of crystal circuit operation.

SOUND DISTRIBUTOR

★ In a recent paper, Christian A. Volf, Director of Research for the Robinson-Houchin Optical Co., Columbus, Ohio, discusses a newly developed combination directional and non-directional sound distributor.

Herewith are some of the salient points of Mr. Volf's discussion.

"The present illustrated directional and non-directional resonator and sound distributor represents well-known acoustical principles and disobeys none of the acoustical laws. The relationship of air column, mass and quality of material as well as form has been fully considered as illustrated in *Fig. 3* from which all structural details can be observed. The dimension constitutes a 24" cubicle air column, the weight mass of this small chamber without any hardware or

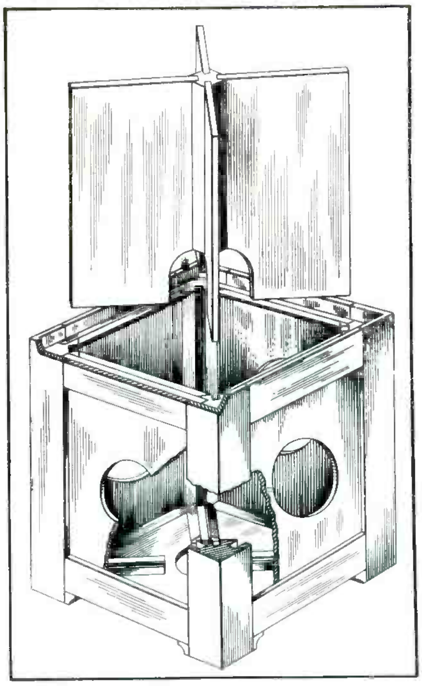

Figure 3

loudspeaker units installed is 90 pounds. In comparing this weight mass with any other empty reproducing chamber of similar size, it will be found three to four times heavier.

"Five loudspeaker units of various dimensions may be installed within the 24" cubicle space and a four-sectional dividing section divides into the grooved segments, thereby separating the back of each unit from the other. The resonating box contains no other electrical equipment. The total unit is preferably suspended from a ceiling height to a level most suitable and in proportion to the total ceiling height or, when employed in connection with motion pic-

Figure 4

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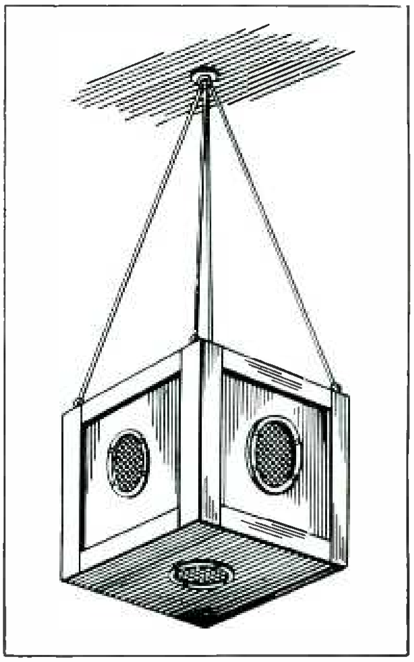
(*Continued from page 25*)

tures, is placed either directly above the screen or one unit on each side of the screen—depending on the size of the theater proper.

"The same unit may also be employed as a console cabinet upon which may rest a radio and public address amplifying system as illustrated in *Fig. 4*. In this way it forms a complete professional sound recording unit.

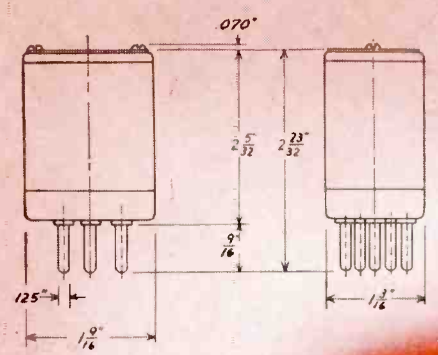
"A six-way switch is built into the amplifier section through which each independent unit may be controlled separately or all five jointly. In substance, it may well be defined as a five-dimensional sound system since each loudspeaker unit is sharply directional and yet, when all five units are operating, it introduces no directional characteristics whatsoever. This is particularly true when it has been suspended from the ceiling. One

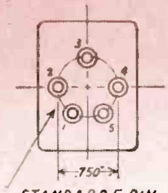


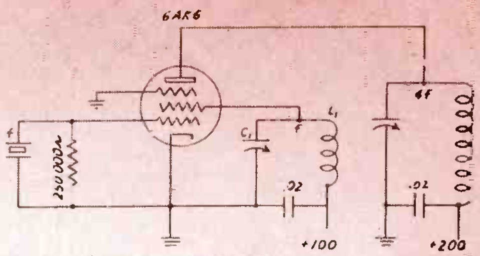
Resonator suspended from ceiling

becomes aware of a totally new sound effect—namely that of quantum or mass sound, which theoretically would be the same as the fifth dimension. Helmholtz (in "Sensations of Tone") gave much consideration to the combinational tones in music and it is precisely these qualities that are brought out. Actual tests were made of the sound values and it has been proven beyond a question of doubt that there is no predominance of higher or lower frequency response from any point within the enclosure but an absolute pure blending of the tonal response from the various units when measurements are taken at a reasonable distance from the sound source.

"From a practical aspect, the resona-

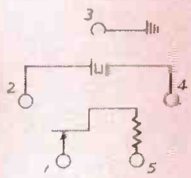


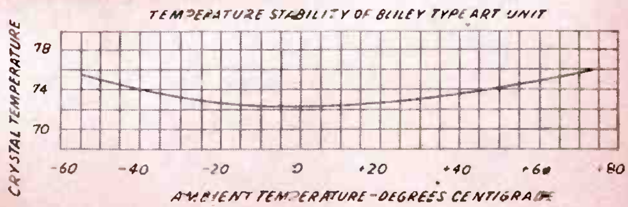




Announcing the BLILEY

type ART crystal unit for maximum VHF stability





This new Type ART acid-etched*, crystal unit is another Bliley "first", designed for VHF services, such as police and railway communications, where frequency stability must be maintained over temperatures ranging from -55°C. to +75°C. With a built in heater operating on 6.3 V. at 1 amp. crystal temperature is held within ±2°C. The unit will maintain an overall frequency tolerance of ±.005% or better including variations due to temperature change and tolerances required for crystal production. This rugged, compact crystal assembly is available for any frequency between 3500 kc. and 11,000kc.

A schematic diagram of the oscillator circuit and tolerance to be maintained should accompany requests for quotations. See above design for efficient frequency multiplication.

**Acid etching quartz crystals to frequency is a patented Bliley process.*

Radio Engineers — write for temporary Bulletin RA-2

Bliley CRYSTALS

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TECHNICANA

[*Continued from page 26*]

tor offers not alone a superior acoustical result but simplifies a sound installation in large auditoriums or theaters because it requires only one outlet for each unit and, as the distribution of sound may be considered perfect, it can readily replace an average installation where 25 to 50 loudspeaker units are generally employed toward the same end.

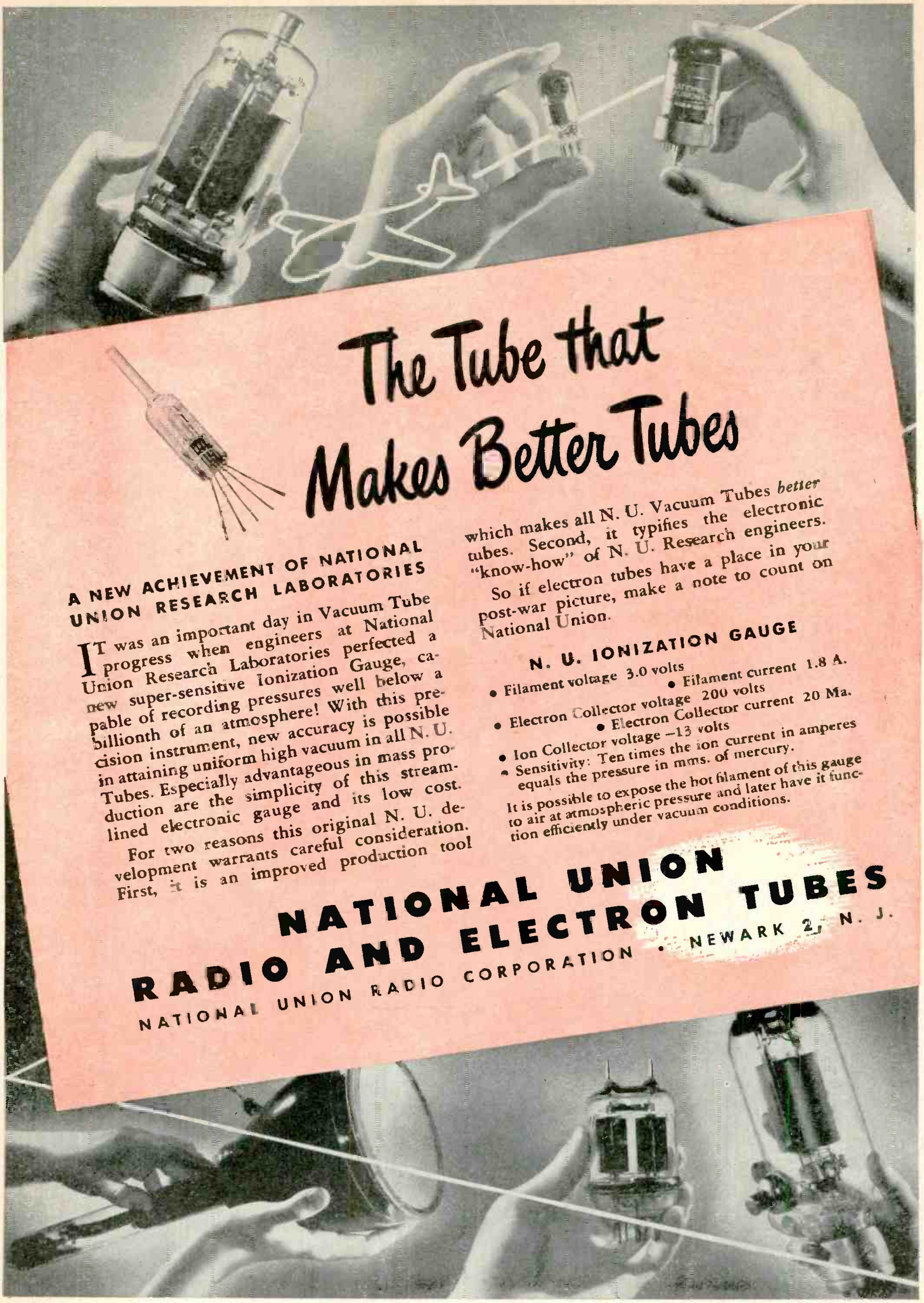
"In view of the structural simplicity, there is naturally little technical information necessary; the illustrations may be considered self-explanatory."

BOOK REVIEWS

THE ELECTROLYTIC CAPACITOR, by Alexander M Georgiev, published by Murray Hill Books Inc., 232 Madison Avenue, New York 16, N Y, 179 pages, cloth binding, $3.00.

The origin of the electrolytic capacitor can be traced to the latter part of the nineteenth century when Wheatstone discovered that a film can be formed on aluminum electrochemically which will exhibit uni-directional electrical conductance. One of the early attempted applications of the electrolytic capacitor was in conjunction with the starting of single phase induction motors. Later it was used for power factor correction in a-c power circuits. Extensive use of the electrolytic capacitor came with the advent of radio and electronics in the early 1920's when it was used in filter circuits for supplying rectified alternating current biasing voltages. The first electrolytic capacitors were of the wet type and were polarized. A few years later, dry type electrolytic capacitors of high capacitance and low voltage rating were introduced for use in A-battery eliminators. About 1929 the high voltage dry electrolytic capacitor was introduced and soon found extensive application in radio receiving equipment.

This book is one of only three on the subject of electrolytic capacitors. Since there has been a certain amount of secrecy surrounding the process of producing this type of device, as well as a noticeable lack of technical literature on the subject, this book should prove of considerable interest to many engineers. It contains 21 chapters each having 5 or 6 pages of text, and is profusely illustrated. The author has chosen to lead the reader through general capacitor data, comparison of capacitor types, electrolytic capacitor components, parts processing, testing, manufacturing difficulties, design, general uses of electro-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lytic capacitors and the common limitations of the device. Several of the known theories on the nature of the dielectric film are discussed briefly. The book is directed particularly to engineers and technicians engaged in the manufacture, use, and repair of electrolytic capacitors and those interested in the design of apparatus using them. This group of readers as well as others who desire a general knowledge of electrolytic capacitors will find that the book thoroughly covers most of the general information which they require, and will point out simple procedures for the determination of quality and characteristics of the device.

The author is to be particularly congratulated on the glossary and bibliographical data included in the book. The latter is very complete and contains a large number of patent references which should be helpful to specialists in this field.

The text is written in an interesting and easily readable style. It is practical and up-to-date, and appears to be free of errors. It is the best text on this topic that has come to this reviewer's attention and is recommended to anyone interested in the subject of electrolytic capacitors.

PULSED LINEAR NETWORKS, by Ernest Frank, published by McGraw-Hill Book Co., 330 West 42nd Street, New York 18, N. Y., 267 pages, cloth binding, $3.00.

This book is intended for a first course in transient phenomena for college students. It is essentially mathematical in character and requires a working knowledge of differential equations. The author states in the preface that the principal things to be gained through a study of the text are:

1. A feeling for the distinction between transient and steady state network behavior
2. An understanding of the underlying factors governing the transient behavior of networks
3. A familiarity with the interpretation of mathematical results in terms of the phenomena that they describe
4. A method of analysis which is applicable to a variety of networks and which does not involve unfamiliar mathematical concepts
5. A realization of the limitations of the classical method and an appreciation of the need for a more powerful method

There are nine chapters and an appendix containing tables of exponentials and hyperbolic functions. At the end of each chapter appears a series of exercises for the student intended to illustrate

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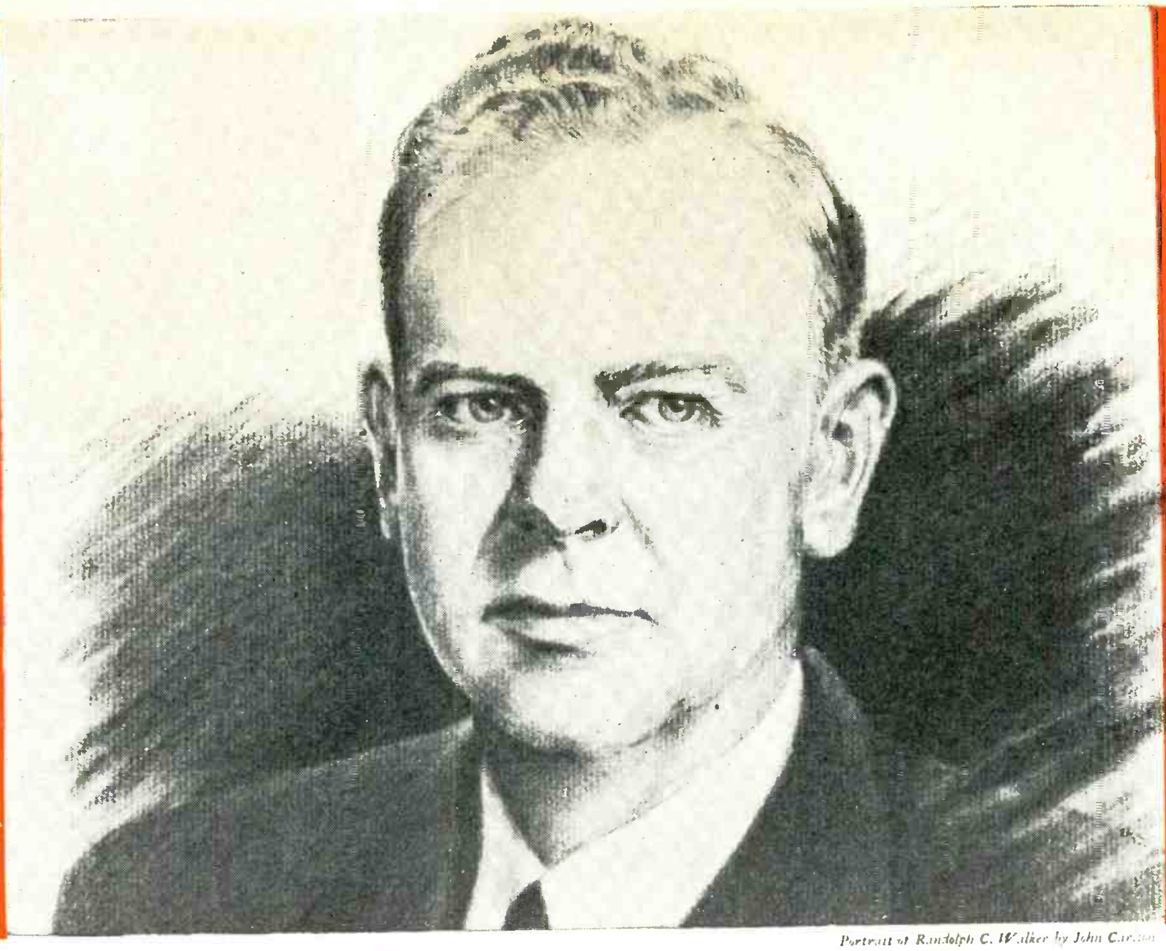

Portrait of Randolph C. Walker by John [illegible]

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"HIGH FIDELITY"

A. C. MATTHEWS

Some new slants, technical and otherwise, on a controversial subject

IT MUST BE RECOGNIZED that the problem of fidelity is a relative one, as consideration must be given to the quality of the program being transmitted as well as the conditions under which it is being reproduced. High fidelity in its true sense implies the faithful reproduction of the original transmission both as to frequency range and volume level, although the volume level need not necessarily correspond with that of the original. The term "high fidelity" has so often been associated with systems having an extended high frequency range that it no longer conveys its true meaning. Probably a new term should be employed which more nearly describes the practical attainable goal of reproduction with the systems available at present. Such a name would become inadequate, however, as soon as new systems were perfected, so for this reason it might be better to define "high fidelity" as understood at present.

In this article high fidelity shall be considered as the degree of perfection, for an average listener in an average residential room, which presents the illusion of hearing the program as it exists at its point of origin, insofar as frequency range and amplitude variations are concerned, but not insofar as being able to associate the source of the sound. It is assumed that distortion effects will be negligible and that the spatial distribution will be nearly constant over at least a 45 degree angle each side of the speaker system.

Before discussing what degree of perfection is economically practicable it might be well to review the characteristics of music and speech and determine the overall requirements for such a system.

Frequency and Power Range of Speech and Music

It is generally conceded by all engineers that a frequency range of 20 to 15,000 cycles is fully adequate to reproduce faithfully all fundamentals and overtones of any musical instrument or speech which are audible to the ear. Such a range is also sufficient to permit ready identification of such non-musical sounds as keys jangling, resin squeaks on bowed instruments and numerous other mechanical noises which are byproducts of the music. Not that these sounds are desirable, nevertheless they are discernible on a high fidelity system unless precautions are taken to minimize their pickup.

As can be seen from *Fig. 1*, there is little to be gained by reproducing frequencies above 11,000 cycles except perhaps in the naturalness of the cymbals, triangles, snare drums and similar instruments. Likewise the low frequency response need not extend below 65 cycles except for the organ, bass viol and some unusual sound effects. So much for the required frequency range; no attempt will be made to establish the most practical bandwidth at this time, since there are many other factors to be considered. Instead, the variations in amplitude or intensity of the sound to be reproduced will be discussed.

Measurements by Fletcher[1] show peak powers as high as 66 watts, with average powers of approximately 0.1 watt as representative of large symphony orchestras. Conservatively, then, a 70 db range would be satisfactory for reproducing an orchestra at its original sound level. This of course is the extreme; other programs of speech, dance music or instrumental solos obviously do not require such a range, probably something of the order of 20 db being entirely satisfactory. Except for studio programs being transmitted by FM sta-

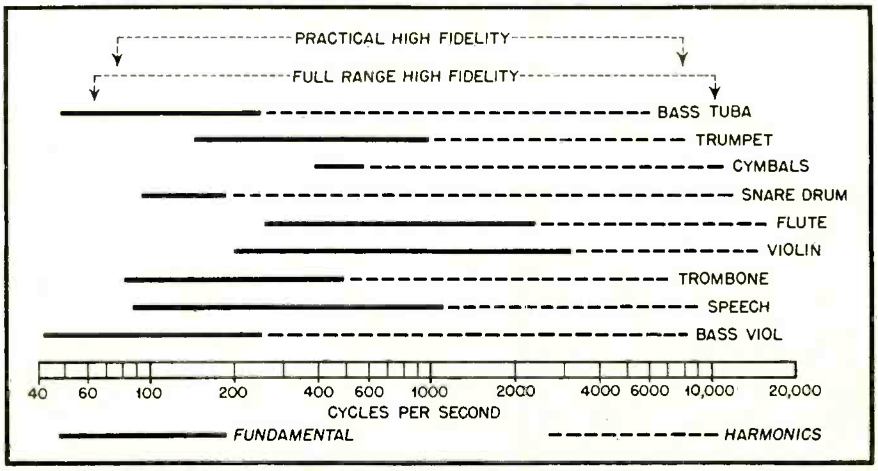


Fig. 1. Frequency range — speech and musical instruments

tions, the dynamic range is limited by the quality of the wire program line which may vary from 25 to 45 db according to the quality of the line employed. Although lines are limiting factors in many instances, they do not affect the overall maximum requirements and are only mentioned as an example of what is actually encountered in practice.

Summarizing we find a frequency range of 20 to 15,000 cycles and a volume range of 70 db capable of reproducing high fidelity programs in their original form.

FM Stations—Synthetic Vinyl Resin Recordings

Until FM stations came into existence very few programs were available capable of giving even so-called "high fidelity" reception. Modulating frequencies above 5000 cycles resulted in "monkey chatter" because of adjacent channel reception, and as mentioned previously, the volume range of most lines is quite limited because of noise considerations. FM stations, however, are capable of transmitting frequencies up to 15,000 cycles with a dynamic range of 70 db. This is due in part to the wide frequency bands available for this type service and also to the noise-reducing capabilities of the system in general.

According to the FCC Standards of Good Engineering Practice the FM station should be capable of transmitting a band of frequencies from 50 to 15,000 cycles, with certain prescribed pre-emphasis and with a noise level at least 60 db below the program at full deviation. Total distortion should be limited to from 2.5 to 3.5 per cent according to the modulating frequency. These specifications indicate the possibility of a true high fidelity service.

The same condition existed in the reproduction of phonograph records. The ordinary shellac disc had little above 3500 cycles and the surface noise was so high that the volume range was severely limited. With the introduction of synthetic vinyl resin recordings the surface noise has been tremendously reduced, and consequently the volume range increased accordingly. The recording of frequencies above 7000 cycles is also practicable. Thus, with these two new advances a big step has been made in the realization of high fidelity reproduction.

Characteristics of the Ear

Since the ear, in the final analysis, must be the judge of fidelity it most certainly should be taken into consideration when planning a true high fidelity system. Several of the more important characteristics, such as the frequency range, acuity, and the age of the listener will be discussed since these have an especial bearing on the problem.

The ear is a pressure-actuated nonlinear device capable of actually supplying deficiencies (under certain conditions) in the quality of the music being heard. Furthermore, the frequency range and sensitivity vary appreciably with such factors as the age of the listener, the intensity of the sound wave, and the presence or absence of undesirable noise.

Many investigators have contributed to the knowledge of the characteristics of the ear, as can be seen by reference to the bibliography at the conclusion of this article. However, tests made at the World's Fair on approximately 500,000 people of all ages and sexes[2] have provided data which when analyzed[3] results in a statistical average frequency characteristic as shown in *Fig. 2*. For comparison purposes a curve of the critical listener (best 5%) has been included. Note that the two curves follow each other quite well except for the additional frequency range perceived and the sensitivity. A seven to ten db difference between 20 to 8000 cycles, which gradually increases to approximately 17 db at 12,000 cycles, should be noted. These curves indicate that it is possible for persons with acute hearing to perceive frequencies as high as 22,000 cycles and as low as 20 cycles, provided the intensity is high enough.

An interesting family of curves is shown in *Fig. 3* and are known as equal loudness curves. These show the characteristic of the ear over the audible spectrum, using a 1000-cycle pure tone as a reference. The curves include the entire range of intensity from barely audible (threshold of audibility) to the point where a sensation of feeling is experienced (threshold of feeling). As can be seen these curves vary both with intensity and frequency, reaching a maximum in the vicinity of 3000 cycles.

It is evident from the hearing-contour curves that the response characteristic depends to a large degree on the in-

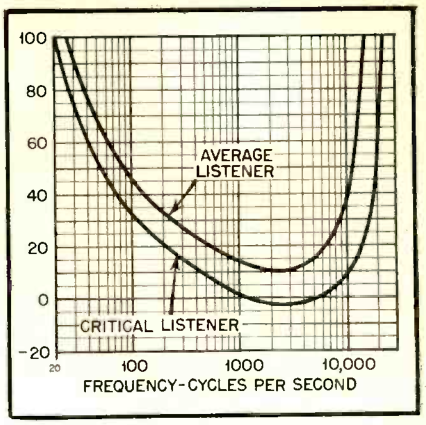


Fig. 2 Hearing contour curves for average and critical listener — no noise

tensity of the sound source. At low intensity levels, the low frequency response is comparatively poor. The high frequency response is similarly affected, although to a smaller degree. In other words, if the intensity of the sound source is increased a given per cent, the apparent increase will not be uniform over the entire frequency range; the apparent increase at the extreme low and extreme high frequencies audible at the lower level will be less than that of frequencies in the vicinity of 2500 cycles.

In addition to the above general characteristics, it has been found that there are variations in response due to the age of the listener. That is, as the age increases the high frequency response gradually decreases approximately as shown in *Fig. 4*. This has no important bearing on determining permissible fidelity range, however, since the system must be satisfatcory for all age groups.

Masking Effects of Noise

In actual practice we never have ideal listening conditions because of noise interference. Measurements[4] show the average residential room noise is approxi-

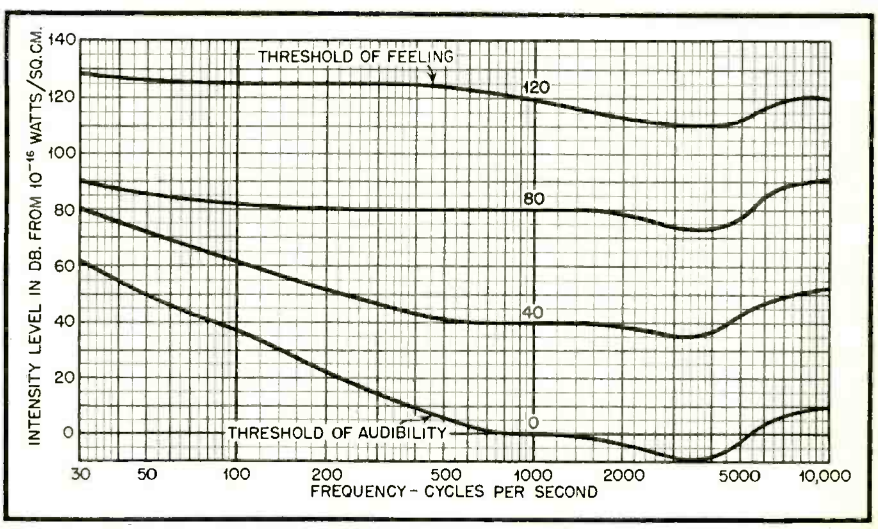
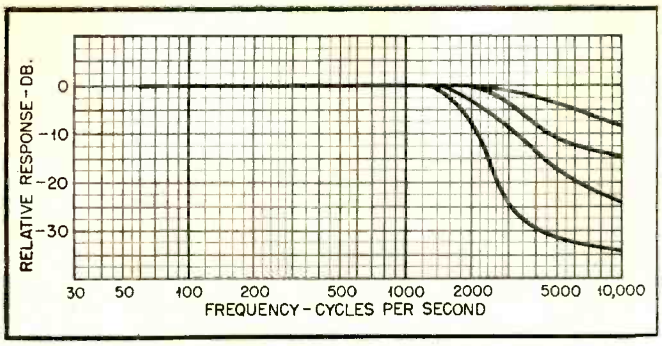


Fig. 3. Loudness level contours (after Fletcher and Munson)



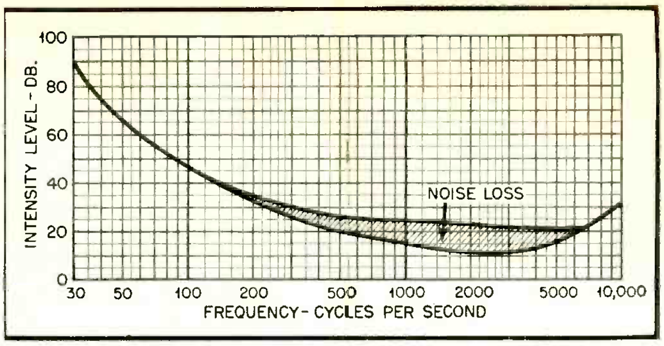


Fig. 4. (Above, left) Relative loss in high frequency for average listeners. Curves are for male listeners of ages 25, 35, 45, and 55 years, respectively. Fig. 5 (Above, right) Effective hearing characteristic due to masking effect of noise

mately 43 db.* Noise varies of course with conditions outside the home, the number of people in the room, etc., but probably never decreases below 33 db.* Its effect appears to be one of deafening the listener exposed to it and therefore must be considered in the overall result. Combining the masking effect of noise with the average ear characteristic results in curves as shown in *Fig. 5*.

Other noted effects are auditory fatigue, which may be caused by prolonged exposure to loud sounds, (an exaggerated example is the feeling of deafness after having taken a long airplane trip), temporary impairment of hearing due to illness and fatigue caused by listening to "narrow range" fidelity wherein the nerves of the hearing system attempt to supply those frequencies not present.

Determining Frequency Range

In the determination of the frequency range for a high fidelity system it is not enough to decide that since the greatest audible range extends from 20 to 22,000 cycles this should be the goal. From the previous discussion and associated curves it is evident that only a small percentage of listeners are capable of hearing such a range; furthermore this range can only be heard under certain conditions (high intensity levels) and granting it can be heard, there is very little to be gained in enjoyment or perceptibility. Obviously, then, the range can be reduced to at least 11,000 cycles at the high frequency end, and probably to 65 cycles at the low frequency end. Another factor, however, enters the picture at this point, that is, tonal balance.

*Above threshold of hearing.

TABLE 1

POWER OF VARIOUS SOUND EFFECTS

SOURCE	POWER-WATTS
75 piece orchestra	70
Bass drum	25
Pipe Organ	13
Snare drum	12
Cymbals	10
Piano	0.4
Bass voice	0.03
Average speech	0.000024
Violin (soft)	0.0000038

A few years ago, designing a high-fidelity receiver consisted of merely increasing the high-frequency response and extending the upper range a few thousand cycles on an otherwise normal receiver. This resulted in a very thin-sounding receiver because the balance between bass and treble response had been disturbed. Unless both extremes of the frequency pass-band are extended, the overall result is disappointing. The main problem is to obtain a balance between the high and low frequency cutoffs. Of course other factors such as practicability, psychological and physiological effects are important but unless the tonal balance is correct true high fidelity will not be achieved.

Balance requirements are not too critical; in fact, if the product of the low frequency and high frequency cutoffs fall within the range of 500,000 to 650,000 the results will be quite acceptable. This is shown graphically in *Fig. 6*. Statistics[3] show that a range of 75 to 8000 cycles will suffice for the average listener; it is then a matter of economics whether this should be the accepted range or whether the additional cost involved in obtaining a range of 65 to 11,000 cycles is justifiable. This latter range is considered adequate for critical listeners in very quiet surroundings. So much for the frequency range.

The power in watts of sound radiated, varies over a tremendous range, as shown in Table 1. Although the actual range in power between a full orchestra and a soft passage on the violin amounts to approximately 20 million to one, the sensation of loudness, being logarithmic, is only about 70 db. In other words a dynamic volume range of 70 db is required to reproduce fully an orchestra of 75 pieces.

In the average home a volume level of 85 db is about as high as can be tolerated with any degree of comfort. Quiet operation, or the other extreme would be a level of 40 db, or a dynamic range of 45 db. This takes into account the noise level of the room, and of course is subject to some variation, but it is representative of a range extending from very loud to very quiet (but listenable) volume. It is questionable as to whether levels much below 50 db are of any consequence for fidelity, although they are important so far as enjoyment of dynamic range is concerned.

Listening Habits

Because of shortcomings, either through lack of training or appreciation, the average listener does not fully realize the capabilities of high-fidelity reception. It must be remembered, however, that the general public is becoming more conscious of high fidelity through the medium of present-day advertising, and that the desire for tuning-in distant stations is gradually being replaced by the desire to obtain noise-free realistic reception.

The use of narrow-band receivers over a period of years has made them appear more preferable than many high fidelity units. There are several possible reasons for this preference: (*1*) Distortion is more prevalent in a wide range receiver unless special precautions have been taken to minimize its effect. (This is not always due to the receiver but is very frequently caused by the broadcasting station using poor recordings.) (*2*) The permissible amount of distortion

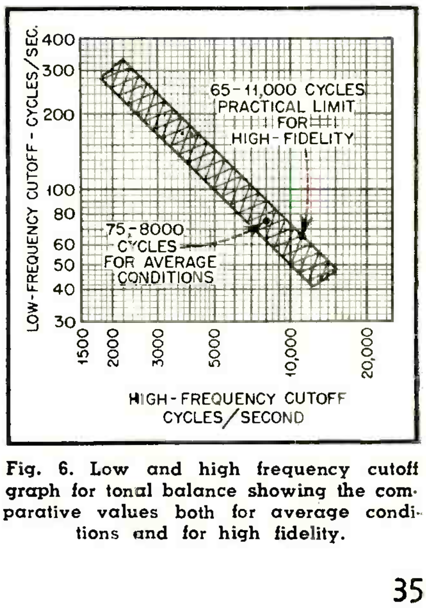


Fig. 6. Low and high frequency cutoff graph for tonal balance showing the comparative values both for average conditions and for high fidelity.

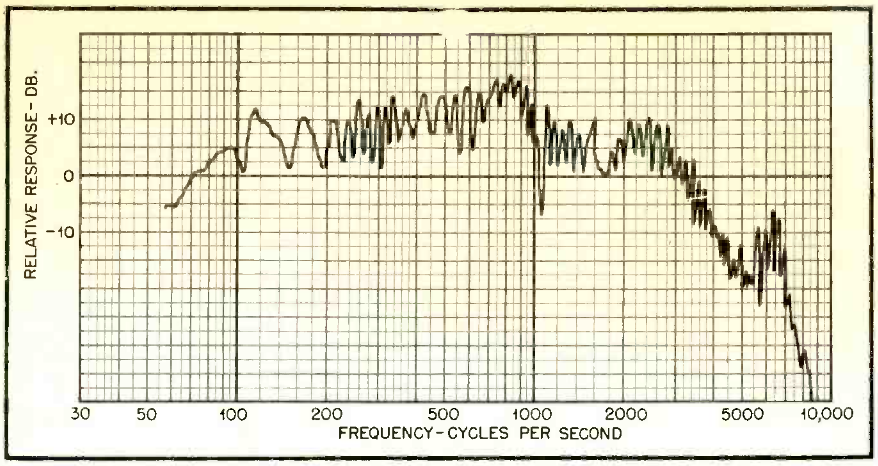


Fig. 7. Sound pressure curve showing effects of reflections in live room

and noise decreases as the width of the frequency pass-band increases. (*3*) The signal strength of the station is also a factor. If this is not strong enough to override the noise induced into the receiver, the program fidelity is very definitely reduced. Many listeners have grown accustomed to a so-called "mellow" tone because it has been necessary to retard the tone control in order to eliminate unwanted noise and distortion. Items such as these can and are gradually being corrected as the appreciation for high fidelity increases. At present only a few programs require high-fidelity receivers because, unless the quality is transmitted, it cannot be received.

High fidelity must be demonstrated to the listener under ideal conditions for full appreciation and the naturalness must definitely be pointed out. A simple test for high fidelity is the ease with which it can be listened to for long periods of time. Inferior quality puts a strain on the nervous system because the ear attempts to supply the deficiencies and gradually becomes fatigued.

General Considerations

Having discussed the characteristics of the ear, the desired frequency and volume range, and the listening habits of the public, the next step is to determine what technical problems are involved in obtaining high fidelity reproduction.

The requirements are obviously as follows:

1. The overall reproducing system (transmission is assumed to be ideal) must be free of amplitude distortion or limiting at the required output level.
2. Spurious harmonics must not be introduced at any operating level.
3. Noise, phase distortion, and cross-modulation products should be minimized.
4. The acoustics of the listening room should be satisfactory (without excesssive damping or reverberation) and the spatial reproduction should be as nearly uniform as possible.

Measurements can be made of all characteristics including overall sound pressure curves, but the latter can be very misleading if not properly interpreted. Sound pressure curves indicate the acoustic response under a given set of conditions and, unless these conditions are exactly the same when the listener is using the unit (the listener being in the same position as the microphone) the measured curve will not be a true picture of the acoustic output. Even under the above conditions some discrepancies are bound to occur because of the fact that the listener has two ears which makes possible the localization of the sound source. Due to reverberation in the ordinary room the sound is reflected from the walls, ceiling and floor and therefore reaches the listener from many points with different phases and amplitudes and, due to the binaural effect, results in a quite different response from that measured with a single microphone. This is particularly true when listening to high frequencies. It is possible to walk around a room when listening to a single high frequency note and be able to distinguish readily nodes and anti-nodes due to reflections. A typical sound pressure curve showing the effects of reflections in a small room is seen in *Fig. 7*. Out of doors the same condition exists except the time lag is longer; resulting in echos. This of course assumes there are reflecting surfaces nearby.

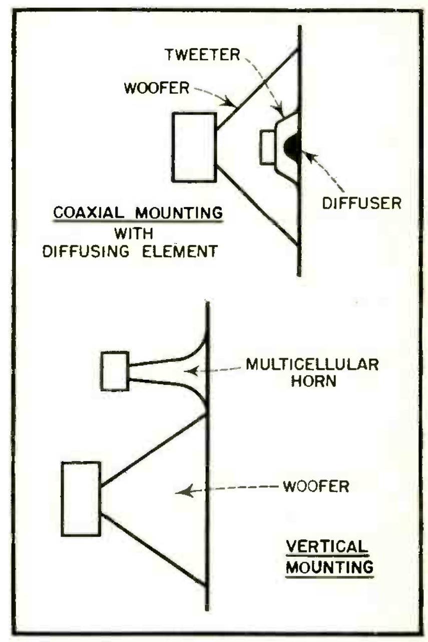


Fig. 9. Dual Speaker arrangements

All these phenomena clearly indicate that the final checking of a high fidelity system must be made by exhaustive listening tests.

Acoustic Considerations

Very little can be said about the acoustic characteristics of the residential room, since the average listener will do nothing about it anyway, except perhaps to locate the receiver in a corner or to avoid putting it where a hard wall surface close by might cause severe reflections. Other than a few minor changes such as these the room acoustics are beyond control. Therefore, it is up to the designer to make the unit flexible enough to compensate for these faults. This can be accomplished by adequate tone controls and uniform spatial distribution of the sound.

Unfortunately, sound waves emanating from an ordinary speaker do not

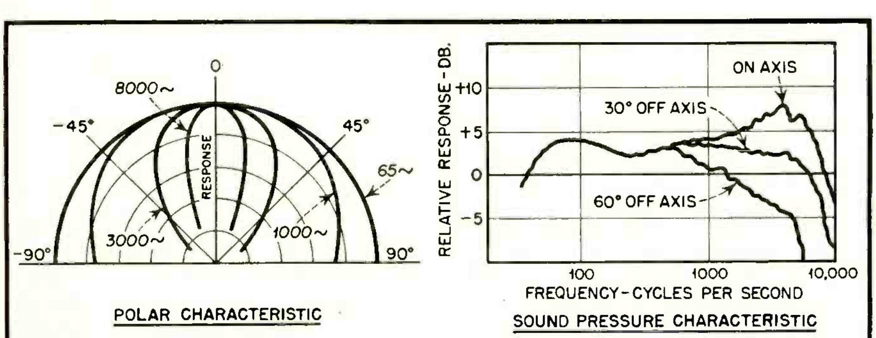


Fig. 8. Polar distribution of sound for typical speaker

have a uniform spatial characteristic. In other words, the listener cannot move to different places in the room without noting a difference in the quality of the reproduction. A typical polar characteristic is shown in *Fig. 8* together with sound pressure curves. These curves have been smoothed up a bit for clarity. It is evident then that steps must be taken to provide a better polar characteristic, otherwise it would be necessary to sit directly in front of the speaker if the high frequencies are to be heard in their right proportion.

This brings up another point; it is impossible to cover a range of 65 to 11,000 cycles with one speaker. Instead, dual speakers are required with an appropriate network which divides the electrical power at approximately 1000 cycles. Several arrangements are possible with dual speakers (commonly called woofer and tweeter) as shown in *Fig. 9*. One method necessitates the mounting of the high frequency tweeter coaxially within the low-frequency speaker. The tweeter then acts as a diffuser for the large speaker. A small diffusing unit may then be placed in front of the tweeter for better high frequency distribution. Another method uses separate mountings for each speaker with the tweeter being of the multicellular horn type which has an improved polar characteristic. Sound diffusers, when properly designed, are more practical since they simplify the design problems and are less expensive.

Of equal importance to the acoustic properties of the room is the speaker enclosure or cabinet. This can be altered to a certain extent by the designer. A square, flat, symmetrical speaker baffle, for instance, should never be used because its symmetry results in the cancellation of frequencies at its cutoff point as shown in *Fig. 10*[5]. This is caused by the radiation from the front and rear of the speaker cone arriving at the listener exactly out of phase with each other. The simple expedient of mounting the speaker on an irregularly shaped baffle will, for all practical purposes, eliminate this fault. Another common error, when two similar speakers are used, is to mount them equally spaced from the edges of the baffle and as far apart as possible. The two speakers should be located close together and somewhat off center. The cones, which are in phase of course, then load each other more effectively and a more efficient coupling to the air is obtained which results in better low frequency response.

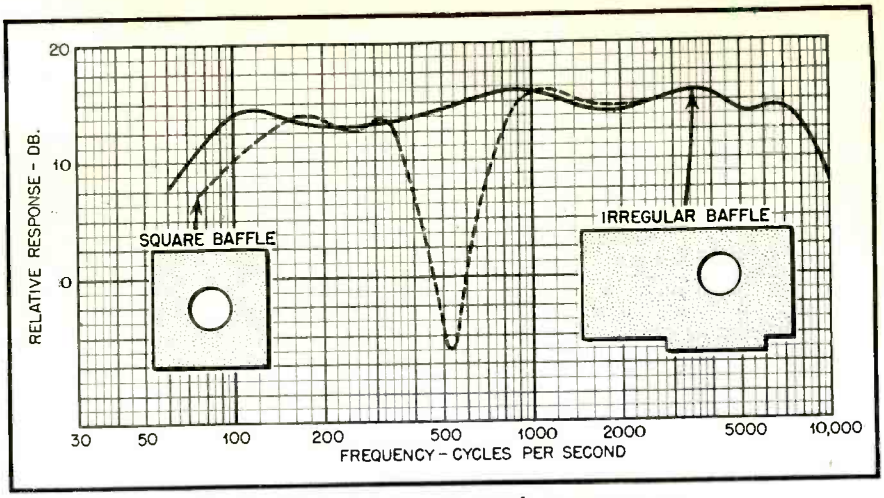


Fig. 10. Effect of baffle on sound pressure curve

Because of the physical size required, open baffles do not function well much below 125 cycles and it was for this reason that acoustic labyrinths and bass-reflex enclosures were developed. Adequate descriptions of these are to be found elsewhere and therefore will not be discussed at this time. (See bibliography for further details.)

Electrical Considerations

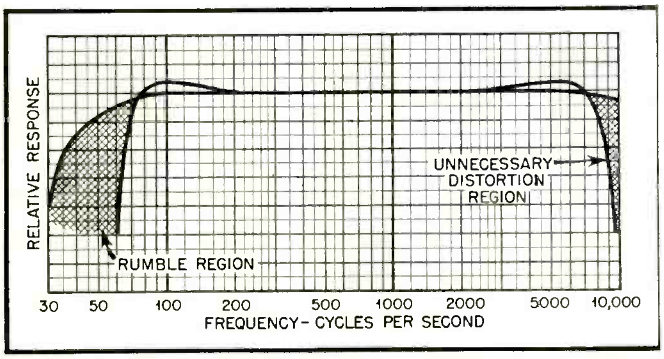
Granting that there is no particular difficulty in obtaining a frequency range of 65 to 11,000 cycles, the major problems are those of distortion, hum, noise and amplitude relations.

The presence of hum or noise in the output of a high fidelity system is particularly objectionable because of the large volume range required. Assuming a dynamic range of 45 db is required, the hum or noise level must never exceed —45 db compared to maximum output. It is desirable to design the system to much better standards; —70 db below maximum output being a more practical value, since it can be attained, and results in a good safety factor.

Beam power tubes are the logical choice for the output stage. These provide high power output with good power sensitivity, but unfortunately the distortion generated by this type tube (principally third harmonic) is rather high. Of course, when used in a push-pull circuit and properly balanced, the even harmonics are effectively eliminated. The third harmonic remains, however, and this is very objectionable to the ear; much more so than the second harmonic distortion.

The logical solution to the problem lies in the use of degeneration.[6] In fact a degenerated amplifier is the only practical solution to the problem. The degree of degeneration of course determines the magnitude of the distortion. Not only does degeneration reduce distortion but it effectively minimizes hum and noise components; it also reduces amplitude distortion resulting from saturation of iron-cored components which often produce false harmonics when working at full capacity. In addition to these almost Utopian qualities, degeneration is noted for the improvement it makes in the frequency characteristic without objec-

[*Continued on page 72*]



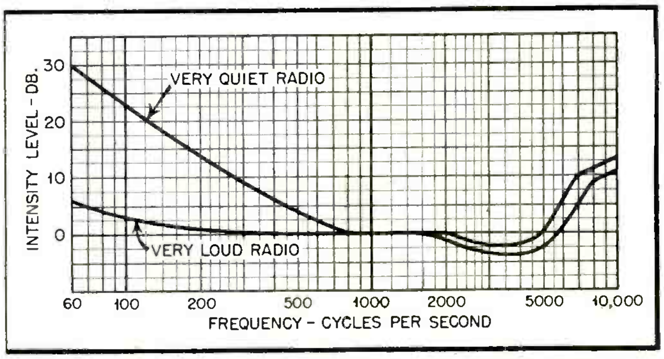


Fig. 11. (Above left) Amplifier having desirable sharp cutoffs. Fig. 12. (Above right) Compensation required over volume limits in the home. Listener on axis of speaker

Effective Permeability of High Frequency Iron Cores

W. J. POLYDOROFF and A. J. KLAPPERICH

Consulting Engineers, Chicago, Illinois

For the first time, a complete set of curves on this subject, and their interpretations, are presented in this article

THE USE OF HIGH FREQUENCY coils containing magnetic core material is well established in the radio industry. Permeability tuning, resulting in compact units, immune to microphonics, and having high electrical stability is rapidly gaining favor. The efficiency of iron cores can be best judged from data announced by G.A.W.,[1] where savings up to 80% in space and 33% in weight can be realized with such cores simultaneously, and at the same time achieve a large increase in Q and a gain in inductance. Great strides are being made in the production of iron powders, both in increasing the permeability and extending the high frequency range, now in the region of 200 mc.†

Until recently the characteristics of powdered iron coils were determined by cut and try methods. There did not exist formulae upon which the designer could predict the electrical characteristics of a proposed design. This left the engineer to a great extent at the mercy of the core manufacturerer as to geometrical configuration, permeability of core, coil and wire size, etc.

It is true that the core producer, with a large background of empirical data is able to make an optimum choice, yet the gap between theoretical considerations and practical applications still exists. This can be clearly indicated by the dearth of data, under the heading of iron cores, in any radio engineering handbook. Only recently this laboratory, among others, undertook a systematic investigation with the view of narrowing this gap and hence achieving a more complete utilization of iron cores and a better understanding of the phenomena associated with high frequency magnetic fields.

†IRN-8, George Mepham Company.

Deriving Q and Mu

What is needed by the radio industry is practical data on Q and permeability for the purpose of guidance in arriving at optimum coil design. These two essential characteristics should be deducible from the geometric configuration of the core and coil, and the electric and magnetic properties of both components.

The magnification factor or Q, which is defined as $L\omega/R$ can be measured on a Q meter. Various formulae have been proposed to define Q as a function of basic properties of coil and core. Foster[2] proposes the lumping of the iron losses ρ (inherent in the term R of the expression $L\omega/R$) as an iron loss factor in the formula.

$$R_i = L_0 \frac{4\pi \mu^2 b_i^2 l_i \rho}{b_0^2\sqrt{4b_0^2 + l_0^2}}$$

Where:
- R_i = equivalent resistance added to coil due to iron
- L_0 = coil inductance
- l_i = core length
- b_0 = mean coil radius
- μ = composite core permeability
- b_i = core radius
- l_0 = coil length
- ρ = iron loss factor

He arrives at this iron loss factor ρ after measuring a coil and core of a given form; this is valid for the coil of that given shape, but we are no closer to evaluating Q for any other type of coil than we were with the $L\omega/R$ procedure. Furthermore it is indicated that ρ is a complex function of frequency and cannot be determined from the magnetic properties of the iron slug.

Other investigators clearly indicate dependence of iron losses on magnetic induction, or in other words on the permeability of the core material. Howe[3] in close agreement with Latour[4] expresses eddy current losses as being proportional to

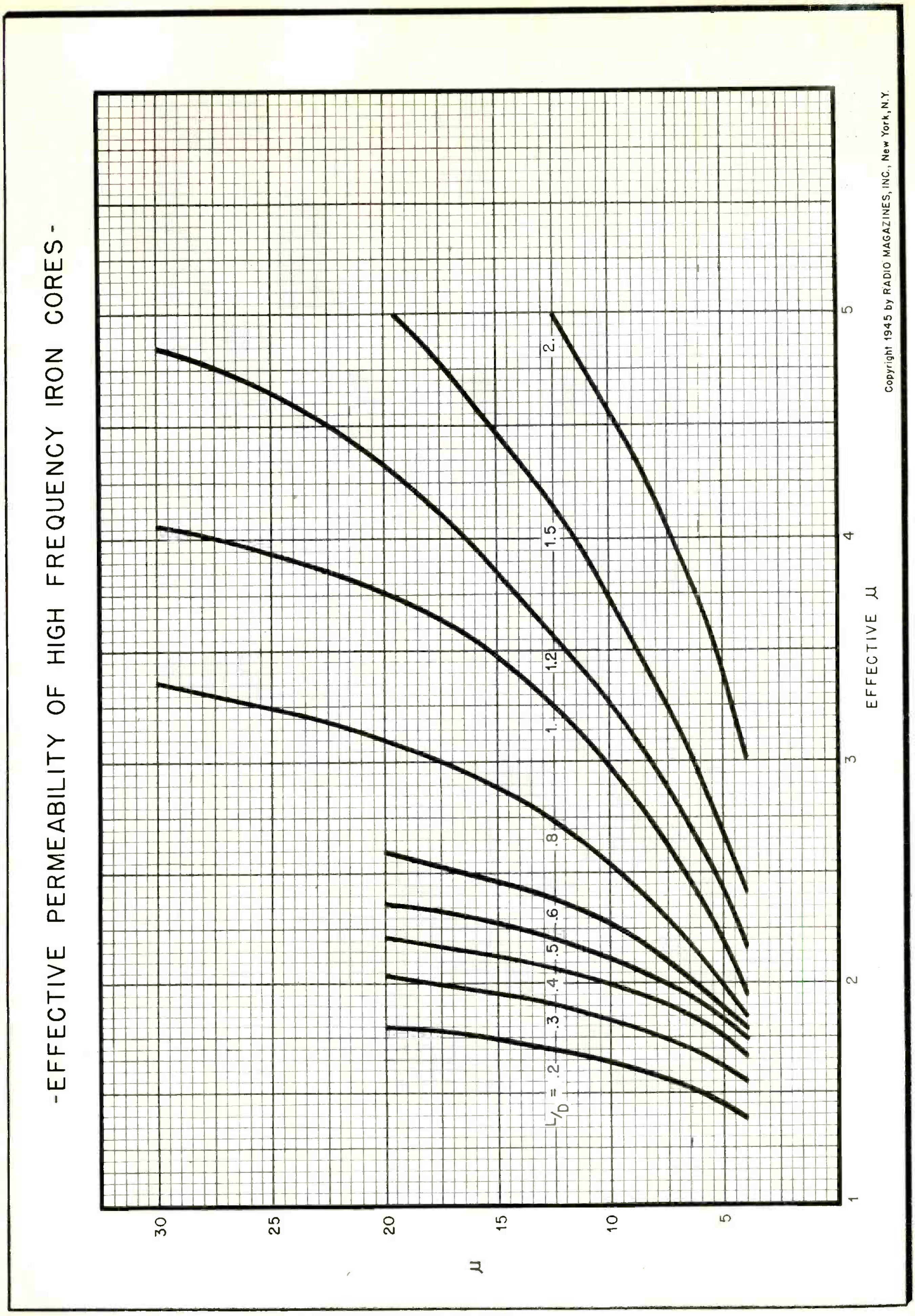
$$B^2\, t\, f^{1.5}\, \mu^{-1/2}\, \rho^{-1/2}$$

Where:
- B = magnetic induction
- t = lamination thickness
- f = frequency
- μ = permeability
- ρ = resistivity

It is clear, therefore, that the iron losses are dependent on the mutual geometry of core and coil, core material permeability and its utilization in the coil.

Measuring Mu by Toroidal Ring Method

The true permeability, μ, defined as B/H of solid ferro-magnetic material, is measured most accurately by the standard toroidal ring method, wherein a ring of magnetic material is uniformly wound with a toroidal winding. The H in the ring can be determined by well known formulae from the measured magnetizing current. Due to the fact that a toroid has no free poles the calculated magnetizing force is the H that gives rise to the magnetic induction B in the sample. This B can be suitably determined by ballistic methods. Corrections


-EFFECTIVE PERMEABILITY OF HIGH FREQUENCY IRON CORES-
L/D = .2
.3
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1.
1.2
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μ
30
25
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EFFECTIVE μ
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must be made for the difference in the cross-sectional area of the toroid and the mean turn area of the coil and also for the unequal distribution of flux through the ring.[5] Thus we have an exact value of the true permeability of the solid ferro-magnetic metal, but in the case of comminuted and compressed ferro-magnetic material the solid metal permeability cannot be directly applied.

It has been indicated by Howe[6] that on theoretical grounds (assuming uniformly distributed cubic particles which are separated by an insulating relative volume δ) the composite permeability is

$$\mu' = \frac{\mu - 0.667\delta\,(\mu - 1)}{1 + 0.333\delta\,(\mu - 1)}$$

where μ is the permeabilty of the solid ferro-magnetic metal and μ' is the composite permeability of the powdered material bonded with a relative volume δ of insulating media. The formula indicates that μ' is a function of solid material permeability μ, but with a small volume of binder the rate of change of μ' is decreasingly smaller as μ increases beyond a value of 100. We should keep the amount of binder to a minimum in powdered, bonded and insulated cores that are used in radio industry for achieving maximum composite permeability.

Fortunately, the standard toroidal method of measuring can be used again, as indeed it is with composite iron core materials. A few words of precaution should be presented here. In actual measurements, on a ring of powdered material, the amount of binder must be the same as in the actual sample, i.e., both samples must have the same magnetic content, density, and degree of insulation.

It is also of prime importance to measure powdered iron cores at flux densities low enough so that they are in the region of the initial permeability plateau. This is best done by using an inductance method of measuring, rather than a ballistic method.

So far we have mentioned rings with no free poles. With open type cores as used in the radio industry, a magnetic pole appears at each end, when longitudinal magnetization is being applied (an infinitely long core, in an infinitely long solenoid would theoretically approach a toroidal ring). Because of these poles the actual magnetizing force H' is always less than the calculated magnetizing force H, by a factor containing N, the demagnetization coefficient and I, the intensity of magnetization.

$$H = H' - NI$$

This formula can be reduced to

$$\frac{1}{\mu} = \frac{1}{\mu'} - \frac{N}{4\pi}$$

the value of the factor N is a complex function of length L and diameter D of the cylindrical specimen.

Bozorth and Chapin[7] have published interesting curves based on computations of Stablein, Schlectweg, Neumann and Warmuth. These curves give the demagnetization coefficient and apparent permeability for various L/D ratios (5-2000) of material having permeabilities ranging from 10-100,000. Unfortunately their data does not cover small L/D ratios and low permeability values encountered in ferro-magnetic radio frequency cores. Furthermore, their evaluations are based on ballistic methods, hence the validity at high frequencies is questionable.

New Attack on the Problem

Therefore we have studied the problem from both a practical and theoretical viewpoint, for the purpose of evolving data that will predict the behavior of an iron core from basic magnetic quantities and physical measurements.

In this investigation we measured the permeability of composite material by the toroidal ring method, at 1000 cycles; the materials having the same composition as the slugs which were used in determining effective permeabilities. The effective permeability μ_e of such slugs defined by $\frac{L\ iron}{L\ air}$ was measured by the change in inductance produced by the iron slugs.

The effective permeability of a cylindrical core is defined as $\frac{Li}{La}$ when the winding is of infinitely thin wire and the wire is tightly wound on the cylindrical surface, throughout the entire length of the core, (core length = coil length). This quantity represents the maximum inductance increase obtainable from a given cylindrical core, and as such is never realized in practice. There is always a difference in core area and mean turn coil area which results in a reduction in effective permeability. This difference can be evaluated as shown. Therefore, it is possible to measure the inductance of solenoidal coils with and without iron, and with certain corrections to arrive at a family of curves as presented herewith.

This family of curves shows the effective permeability μ_e of cylindrical slugs, which have various $\frac{\text{length of core}}{\text{diameter of core}}$; $\frac{L}{D}$ ratios; and are made of composite material of permeability μ.

It is apparent at a glance that the material of high composite permeability (μ = 30 to 40) suffers the most when used in cylindrical cores. For it requires a slug 8 times longer than its diameter to obtain an effective permeability of the order of 16. Quite to the contrary, the material of low composite permeability (μ = 5) is almost fully utilized with a slug which has an L/D ratio of only 4. In this case an effective permeability has a value of 4. Thus we may already deduce from these curves the desired shape of the cores when the composite permeability is known.

We may also see that for a given L/D ratio of a core there is an optimum composite permeability, and that any further increase yields decreasing returns in effective permeability. For instance in a cylindrical core of L/D = 1, maximum effective permeability of 3 is reached at a composite permeability of 10. In order to further increase the effective permeability one should increase L/D ratio. In our example, doubling the length of the slug yields an increase in effective permeability to 4.5, whereas doubling the composite permeability will increase the effective permeability to only 3.6. Only high ratios of L/D will justify the use of an iron of composite permeability above 35. The effective permeability of a slug having an L/D ratio equal to 8, is 16 when the composite permeability is 33. This can be increased by only a small factor, (to 16.3) if the composite permeability is increased to 40. This last example is of particular interest as the users of cores for permeability tuning are clamoring for a higher effective permeability Q not realizing the fact that the core producer is unable to meet their demands because of this inescapable fact. There is always a practical upper limit of effective permeability, *which is a function of composite permeability at a given L/D ratio.* In the last cited case, theory indicates that if the infinite composite permeability could be obtained, an effective permeability of 50 would be realized with an L/D ratio of 8. This should be of interest to the designers of electrical machinery when closed magnetic circuits cannot be realized.

It is to be repeated again that the effective permeabilities shown on the graph will always be reduced in practice due to the difference of core area and mean coil area, but is increased due to "free ends", i.e., where core length is greater than coil length. We have developed an empirical formula that holds true for a very wide range of variations of core and coil lengths. If we assume the coil length to be l, and the core length as L (where $L \geq l$) then μ'_e, the corrected effective permeability of

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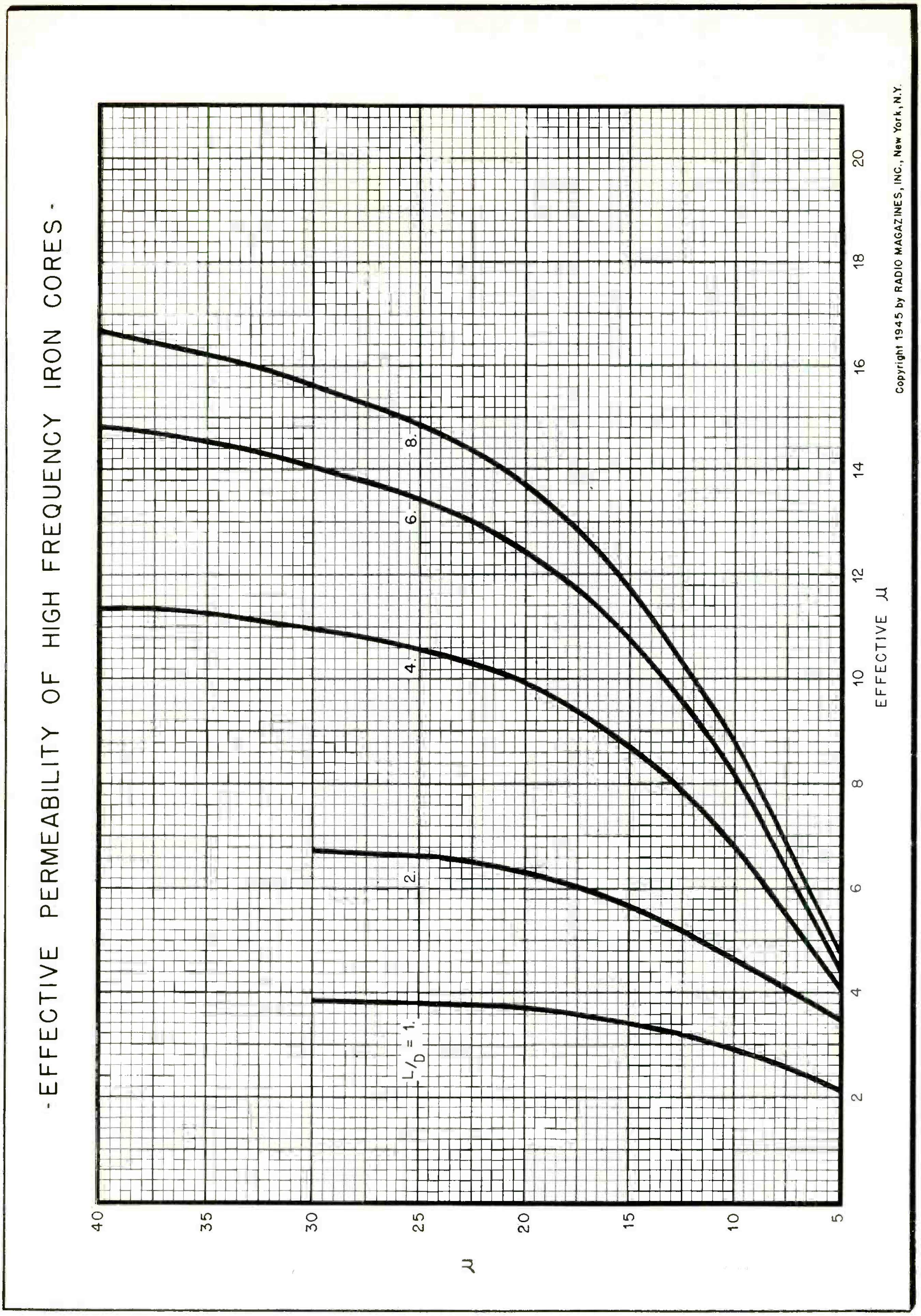
-EFFECTIVE PERMEABILITY OF HIGH FREQUENCY IRON CORES-
EFFECTIVE μ
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Radio Insulating Materials

ALBERT H. POSTLE

Engineer, Mycalex Corporation of America

Ceramic materials introduced; limitations of plastic insulation

PART 3

OUR CONSIDERATION of radio insulating materials to date has been confined to the laminated thermosetting plastic forms and, in specific, to the phenolic or modified phenolic types. That our scope has not been broad in terms of the whole field of electrical insulation is admitted.

Certain other forms of electrical — and, in particular, radio — insulation will be considered. We shall in turn introduce the ceramics, the high frequency thermoplastics, the molded thermosets, and other types.

That the thermosetting plastics have limitations has been pointed out in our previous discussions. We shall pursue further the subject of these limitations so that we can introduce a new group of materials called ceramics.

Both the word "plastic" and the word "ceramic" defy rigorous definition. Most definitions of the word plastic introduce the thought that the material is capable of being formed or molded, or of being pliable. Still other definitions of the word plastic include the fact that the material under certain conditions is pliable and is thus capable of being shaped into the desired form.

Most all materials, however, will meet the tests given above since these statements are too generalized. Mica, quartz, and a few other similar materials are exceptions to this rule. However, it has been the convention to limit the descriptive term to organic or synthetic materials. Ceramics, in a sense, possess the quality of being pliable in an unfinished state; but thermosetting plastics likewise are pliable only in an unfinished form. Ceramics, however, are identified by the fact that they are made of earthen materials through the agency of fire or heat.

Typical ceramic forms are steatite, porcelain, glass, glass-bonded mica, and rutile forms.

Limitations of Plastics

Plastics, as we know them, are organic in nature. As such, temperature limitations seriously affect the maximum useful working range. Most plastics are usable to approximately 100°C., although certain others such as nylon do not deform up to 200°C.

Materials can be prepared among the plastics which will extend the maximum operating temperatures. Such materials, as a rule, must become complex molecularly since plasticity of the molecule arises from the simplicity and symmetry of its structure. Lack of simplicity of molecular structure leads to lack of stability of the material's dielectric structure.

Examining the stability of the material's dielectric structure, as we have in our preceding discussions, shows that high dielectric constant and high dissipation factor are commonly associated with a non-symmetrical molecular structure.

Perhaps the easiest explanation of

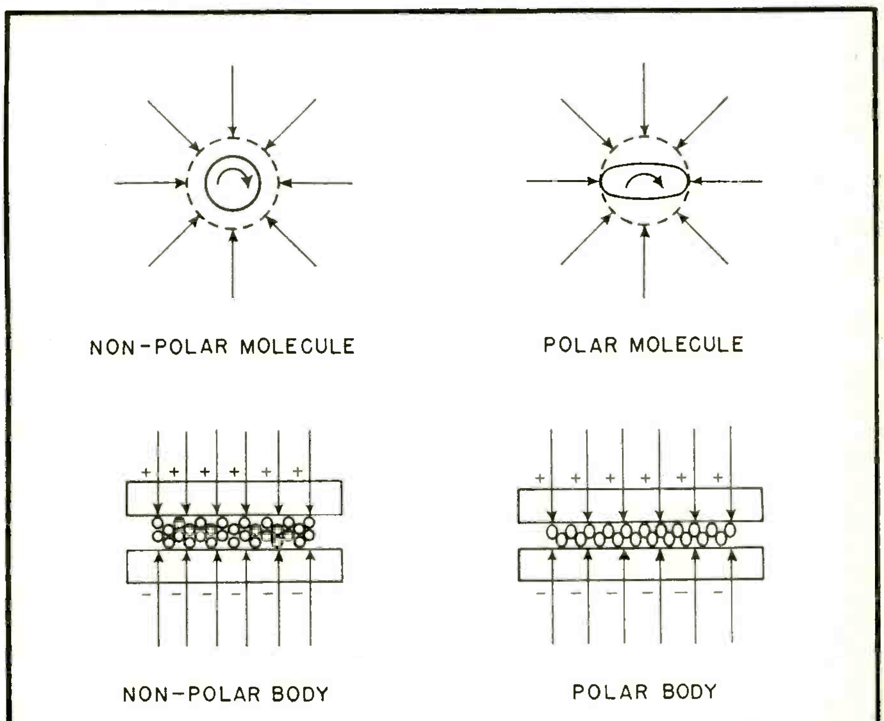
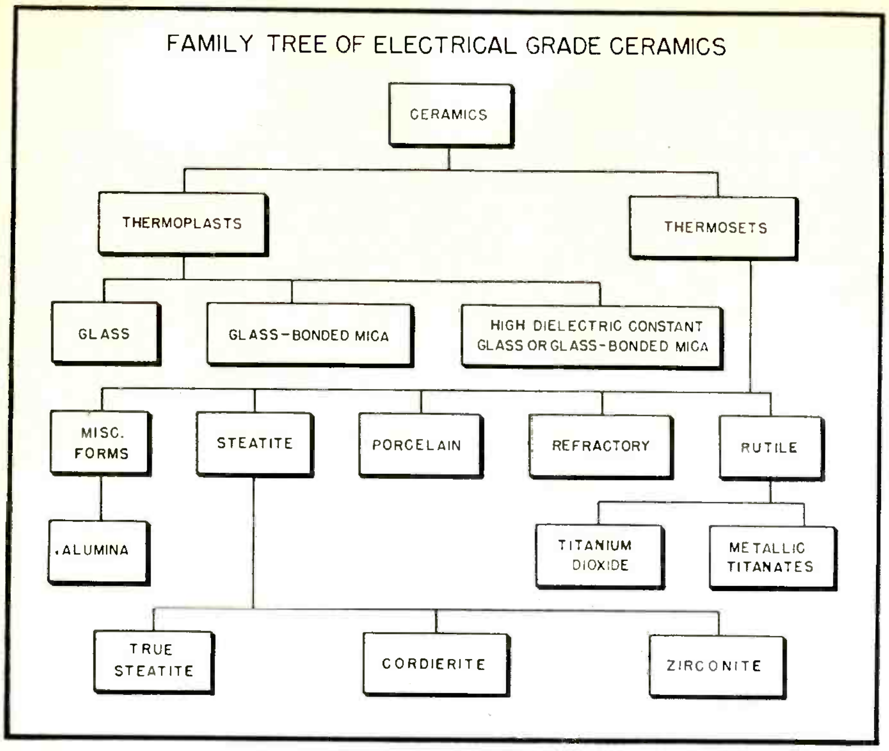


Fig. 1. Simplified analysis of the freedom of a non-polar low-loss body to rotate when placed in an electric field; polar bodies cause higher electrical loss since they cannot respond as quickly to an electrical charge.



this statement can come from the examination of two geometric forms rotating through an arc. Assume a perfect circle rotating through a circular space and assume an elliptical shape rotating through the same space. As the enclosing boundaries approach the limit of the geometric forms rotating, the perfect circle moves with little difficulty while the elliptical shape begins hitting the walls, causing energy loss and heat of friction dissipation. This is graphically illustrated in *Fig. 1*.

A simple C-H shape in the organics is typical of the circular shape in the example above; a C-H organic with certain OH, chlorine, or metal salts present is typcal of the elliptical shape. Since the former is a simple shape—an evenly balanced shape, if you will—it is easily charged or discharged with an electric current; thus, it has a relatively low dielectric constant, the quality which defines the amount of electrical charge a material will accept. At the same time, the ability of this material to rotate freely on its molecular axis contributes to a relatively low loss factor since energy is not wasted in its response to an electric charge.

The more complex shape regularly accepts more electrical charge and has, by virtue of this characteristic, a higher dielectric constant. Its lack of mobility in rotating on its molecular axis leads to a relatively high loss factor.

(The author is quite aware that this discussion tends to oversimplify the problem of dielectric constant and dielectric loss factor. Certain rules have been promulgated in classical dielectric theory which explain the increased dielectric constant and losses when certain organic radicals are added to the basic synthetic. That these rules are beyond the scope of this article is acknowledged. The reader, however, should be aware of the fact that a material's polar behavior can be predicted fairly well by the number of complex radicals added to the basic compound and the position assigned to these additional radicals.)

Similar reasoning concerning complexity of molecular structure does not apply to the same extent when basic materials other than carbon are analyzed. Thus the ceramics, which are primarily simple or symmetrical forms molecularly, have low loss factors associated with their simple molecular structure, but they have higher dielectric constants associated with their higher molecular weight and metal salt content.

We shall further explore this subject at a later date in this series—but first we wish to investigate other limitations of plastics.

Other Plastic Limitations

Physical strength properties are other limitating influences against the use of plastics in certain designs. Consider the formation of the plastic forms versus the formation of the ceramic forms.

Plastics and ceramics can each be subdivided into two groups: thermoplastic and thermosetting. Polystyrene and glass-bonded mica are examples of thermoplastic plastics and ceramics respectively; phenolics and steatite are examples of thermosetting plastics and ceramics respectively.

Usually the thermoplastic plastic forms originate in a polymerization action. Two inactive materials, with the proper catalyst, and proper temperature and perhaps pressure, blend chemically to form a new material. This chemical action is not usually reversible by renewed heat or pressure; such heat and pressure usually cause the material to flow, but to become solid when it recools.

Glass and glass-bonded mica, the two thermoplastic ceramic forms, are prepared in a similar fashion. Here certain raw materials are fused at relatively high temperatures and then quenched in water. The shattered particles are called "frit" and do not decompose or revert to their natural state. This material, when heated under pressure, will melt but will return to its normal solid state on recooling. This does not imply, of course, that it will reassume the shape it had before the application of heat and pressure.

The thermosetting plastics are formed under heat and pressure and do not melt or return to their basic stages. Here two inactive materials, again with a suitable catalyst, form a new material at the time of molding under the proper conditions of heat and pressure. In this respect, the thermosetting plastics differ from the thermoplasts; thermoplasts can be successfully remolded because molding causes no chemical change in the material. This is not true of the thermosets. In addition, the thermosets, once molded, cannot be re-formed. The only exception to this rule is a "green" or partially-cured molding where post-forming operations can be completed before the material sets up hard.

The thermosetting ceramics are similar to the thermosetting plastics in that chemical change takes place under the heat. Pressure is not applied during the firing process, since the material has already been preformed (pressed or extruded) to shape. During the firing operation, the water of crystallization is slowly driven off the ceramic, and the material solidifies.

Each of these processes, you will note, is slightly different. The density, the hardness, the physical strength and the resiliency of the finished material will be defined by the process of forming as well as by the chemical structure.

For example, resiliency is an outstanding property of the plastics as compared to the ceramics. Consider the gamut of flexibility and resiliency that can be found in the plastics: from the elastomers such as vinyl chloride or synthetic rubber to the somewhat solidness of the phenolics or cellulose acetate. Yet, each of these materials possesses

[*Continued on page* 68]

HERMETIC

GEOFFREY HERBERT

Hermetic sealing is not novel and can be achieved by existing methods. It is possible to use the same manufacturing facilities to make the cases of hermetically sealed components that are also used for making the tin can containers for foods. Moisture, fungus, dirt and lowered atmospheric pressure are the main attacking forces that climate uses against electronic devices. The effects of these conditions are discussed below.

Effect of Moisture on Insulation

The greatest enemy of electrical insulation is moisture. The insulation of electrical coil windings in relays and transformers is principally organic. The organic cellulose products, paper and cotton cloth or sleeving, are still the most versatile and frequently used forms of insulation. Though the coils are usually vacuum impregnated with varnish and baked, the varnish only retards the entrance of moisture and reduces the amount of moisture which can accumulate inside the coil by filling the pores of the paper and the voids between turns with varnish. Many of the varnishes are natural resins dissolved in a volatile solvent. When the coil is impregnated, the mixture of resin and solvent fills the void. Subsequent baking drives out the solvent and leaves residual voids whose size is proportional to the percentage of solvent in the original mixture. Newer solventless varnishes employing tung oil, phenolic resins, or similar polymerizing vehicles leave almost no voids.

Kraft paper, fish paper, grey fibre, paper or cotton-based laminated phenolics do not have any residual voids, but the cellulose fibres of the paper or cotton will absorb moisture and have lower insulation resistance.

The best explanation for the moisture damage is based on the assumption that there are slight traces of acids, alkalies or neutral salts which are left in the paper or cloth by the manufacturing operations. Some of these impurities may be deposited on the insulation during assembly. The fingertips and palms of the average person's hands are continually perspiring, especially while at work. This perspiration is rich in organic acids and the salt, sodium chloride. Acids, alkalies and salts cannot conduct electrical currents unless they are ionized. They cannot ionize unless they are dissolved in water. Therefore, the presence of absorbed moisture changes these chemicals from non-conductors to conductors.

This theory agrees well with the observed behavior of insulation resistance to drop in value as the relative humidity and ambient temperature are raised. In a unit having open windings, such as a motor, the insulation resistance will drop as the unit warms up and then rise again after the unit has been continuously operated for a sufficient length of time. This secondary rise in insulation resistance is due to the absorbed moisture being driven off by the heat losses generated in the unit.

When insulation resistance falls below a certain level, the current leakage creates high-temperature spots in the insulation. Cellulose products decompose rapidly at temperatures above 100 degrees C. The decomposed cellulose at the hot-spot leaves particles of carbon which form a low resistance path for further destructive currents. Periodic insulation resistance tests on large pieces of equipment will reveal incipient failure by a sudden drop in insulation resistance before total failure occurs.

Effect of Moisture on Conductors

Moist insulation will not only ruin itself but may destroy the conductors of the winding. Many midget or high voltage units contain windings whose wire size is #40 A.W.G. or smaller. The enamel coating on any magnet wire is not absolutely continuous. There are a random number of breaks per foot in the coating, caused by flexing during the enameling of the wire or during the assembly of the coil. Through these fissures the acid, alkali or salt solutions come in contact with the copper wire. In operation, there is a voltage difference between each turn and the adjacent turns or layers due to the induced e.m.f. and d-c resistance of the windings. The electrolysis between conductors through these solutions liberates acids and alkalies which react with the copper and sever the wire.

When very small diameter wires must be used and every possible precaution must be employed, cellulose acetate foil, a plastic product, may be used as interlayer insulation. This material is not porous, does not decompose at as low

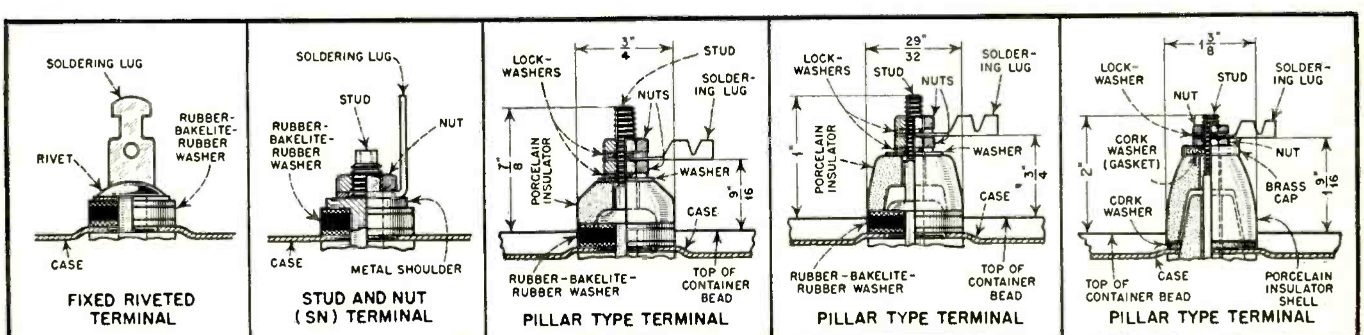


Fig. 1A — Fig. 1B — Fig. 1C — Fig. 1D — Fig. 1E

Typical terminal constructions used in sealing capacitors and transformers. (*Courtesy Aerovox Corp.*)

SEALING

This article reviews the problems encountered in radio-electronic apparatus where moisture and altitude affect operation

a temperature as paper, does not absorb moisture and will not deteriorate in the presence of mild acids and alkalies.

Effect of Dust

On transformers, resistors and other electrical units which have no moving parts, dust does not cause any trouble by itself. But the soluble materials in the dust dissolve with moisture to form a low resistance leakage path. As previously mentioned, organic dust combined with fungi and moisture is difficult to prepare against.

On small relays and vibrators for d-c power supplies which have moving contacts, the thinnest film of dust can prevent the contacts from making a low resistance metallic contact in the closed position.

Effect of Fungus

Fungus is a microscopic form of plant life whose spores are carried in the air. When these spores settle on a moist surface, they form a mold that grows and spreads over the entire surface within a few days. Moist places are required for the breeding of fungi. Organic materials such as paper, cotton, fibre and wood supply nourishment to the fungi. These species of fungi exist all over the world. In our temperate climate with its predominantly dry weather, these fungi find only a few hot humid days in summer suitable for rapid growth. In tropical climates, even those within our borders, the warm moist air is ideal for the growth of fungi. Even though all inorganic materials are used, fungus will grow on the organic dust and small dead insects that settle on the surface.

The moisture and fungi together create electrical leakage paths, causing signal attenuation or stray pickups and flashover. Essentially, the insulating properties of terminal boards, insulating strips, coil forms and sockets are lost. The weakness of the fungi is its inability to exist without moisture. Deprive it of its moisture and its ability to do damage is ended.

Effect of Atmospheric Pressure

Where equipment is expected to perform at high altitudes, the reduced atmospheric pressure will require larger air gaps and greater surface creepage to give the same minimum flashover voltage as was obtained on the ground. To design the equipment for this increased insulation would be prohibitive for high voltage equipment of over 2500 volts. By maintaining sea level pressures in the unit despite the altitude, conventional insulation practices can be followed.

For some applications it is desirable to use internal pressures, higher than atmospheric, that will conduct heat better and effectively insulate higher voltages.

For certain high voltage switches and capacitors, it is impractical to build an air gap adequate for the operating voltage. These are built with a sealed-in vacuum that does not contain any gas which can be ionized and thus support flashover.

Definition

The term "hermetically sealed" has been expressed in so many ways that it no longer covers one method or one set of performance conditions. Some of this confusion is due to the frequent changes of qualification tests which made previously satisfactory methods fail under later tests. The most general definition is this:—A hermetically sealed unit is one which is enclosed in a protective metal case to withstand at least 5 cycles of temperature change from plus 85 degrees C. to minus 55 degrees C. and at least 5 cycles of immersion in salt water at plus 85 degrees C. and 0 degrees C., without the insulation resistance falling below the minimum limit. It can be inferred from this definition that a seal which permits a very small amount of moisture to leak in would still meet these requirements.

Units which contain large amounts of insulating material, such as transformers and capacitors, frequently pass with a slim margin although their seals are imperfect. For units which must maintain internally a special gas pressure for several years, such as vacuum switches and vacuum capacitors, there must be a perfect vacuum-tight seal. For units having a normal gas pressure inside, such as vibrators and relays, the seals can be slightly less than perfect. These three grades of seals are difficult to classify because of the lack of sharply defined acceptance limits.

The objective of all hermetic sealing is to provide a perfect environment for

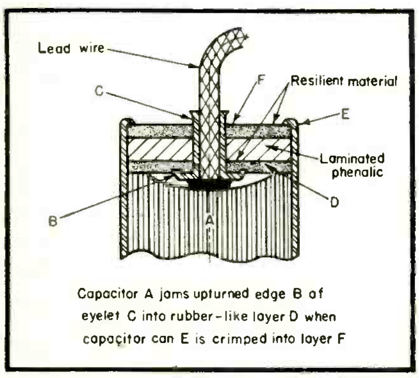


Fig. 2. Another method of using a laminated gasket on a tubular capacitor. *(Courtesy Stupakoff Corp.)*

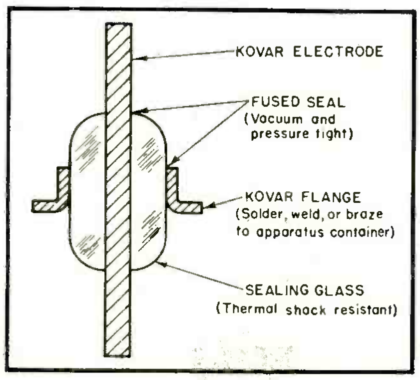


Fig. 3. Typical metal-to-glass seal. *(Courtesy Synthane Corp.)*

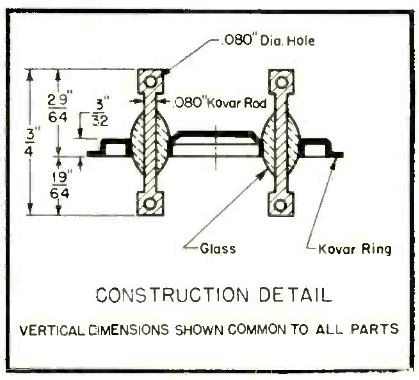


Fig. 4. Multiple conductor glass-to-metal terminal. *(Courtesy Stupakoff Corp.)*

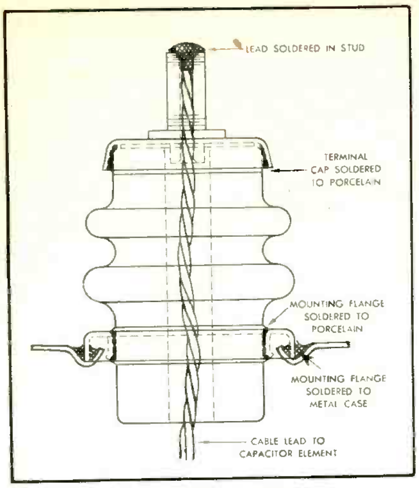


Fig. 5. Metallized solder seal.
(Courtesy Westinghouse Electric Co.)

the functional unit and to maintain that condition through all external changes.

Basic Construction

There are two distinct parts to the enclosure. The case construction is the less difficult since it usually involves only joining metal to metal at the seams. The insulated terminal for making electrical connections requires much more skill because a central metal conductor must be joined to an insulator which in turn is joined to the case, and each of the attachments to the insulator must be a hermetic seal.

Several drawings are shown of typical hermetically sealed units which show methods of construction.

Gasketed Terminals

In *Fig. 1* are shown several of the terminal constructions which are widely used in sealing capacitors and transformers. These are very flexible in arrangement, low in cost, and can be installed with ordinary assembly tools. All these terminals employ rubber or resilient packing material as a gasket between the metal conductor, the insulators, and the case cover. The gasket can be a single material, as shown in *Fig. 1E*, but will have a tendency to flow sideways under the clamping pressure. The rubber-bakelite-rubber washer is made by bonding sheets of rubber to both sides of a laminated phenolic. The laminated phenolic reinforces the resilient material and provides additional rigidity.

Another method of using this laminated gasket on a tubular capacitor is shown in *Fig. 2*. In the illustrations of *Fig. 1*, the clamping pressure between gasket and case is supplied by the shoulders of the center conductor or its insulator. In *Fig. 2*, the clamping pressure between gasket and case is provided by crimping or spinning over the edge of the can. A supporting shoulder in the tubular case can be rolled-in if the internal parts will not withstand the clamping pressure. After assembly, many manufacturers coat the outside diameter of the rubber-bakelite washer shown in *Fig. 1* with a waterproof varnish to reduce moisture absorption at the edges of the paper-based laminated phenolic.

The terminal shown in *Fig. 1A* is the most widely used for capacitors whose working voltage does not exceed 600 volts. Due to its small size, it heats up rapidly when a soldering iron is placed in contact with it. The use of an oversize soldering iron or a prolonged application of the iron can cause the gasket material to deteriorate and spoil the seal. Rubber and all plastics are permeable by water vapor and other gases. The rate of permeability is very low but they cannot be used for sealing special gas pressures where no replenishment of the pressure or gas can be made.

The features of each of the terminals shown in *Fig. 1* are as follows: The terminal and soldering lug in *Fig. 1A* are permanently riveted to the case, making a fixed riveted assembly with the lug in permanent position. The terminal in *Fig. 1B* is a riveted stud-type terminal with the soldering lug held in position by a nut. With this type of terminal the lug may be turned any way most convenient for wiring purposes without loosening the terminal insulator assembly. The terminal in *Fig. 1C* employs an additional steatite or porcelain insulator to provide additional creepage distance and is suitable for working voltages up to and including 2000 v.d.c.; that in *Fig. 1D*, for 3000 V.; and that in ***Fig. 1E* for** 7500 V.

Glass-to-Metal Seals

In *Fig. 3* is shown a fundamental arrangement of a glass-to-metal seal. Common metals, such as steel and brass, cannot be sealed to the usual soft glasses because of the difference in coefficient of expansion. Glass will not deform and shatters when stressed beyond its tensile strength.

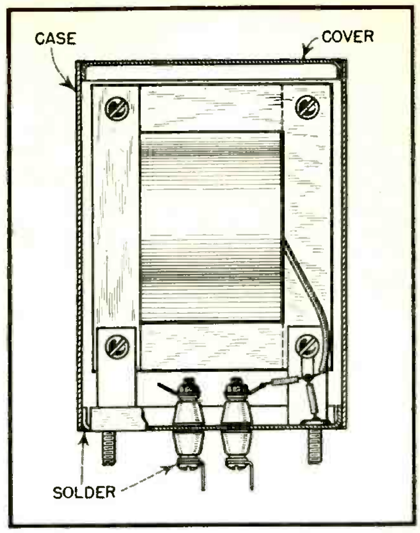


Fig. 7. Typical construction of a sealed transformer.
(Courtesy Thordarson Elec. Mfg. Co.)

Beginning with the electric lamp of Edison and through the subsequent development of the vacuum tube industry, there has been the problem of sealing electrically conducting vacuum-tight leads into the glass bulb which acts both as an insulator and a vacuum container. Seven types of metal alloys suitable for use as lead-in wires are now in use. However, each requires a different sealing glass whose thermal coefficient of linear expansion matches that of the metal alloy. Since the matching of the coefficient between a particular metal alloy and its related sealing glass is never perfect, most of the alloys satisfactorily used as lead-in wires in electric lamps cannot be used as a large diameter flange as shown in *Fig. 3*. The best

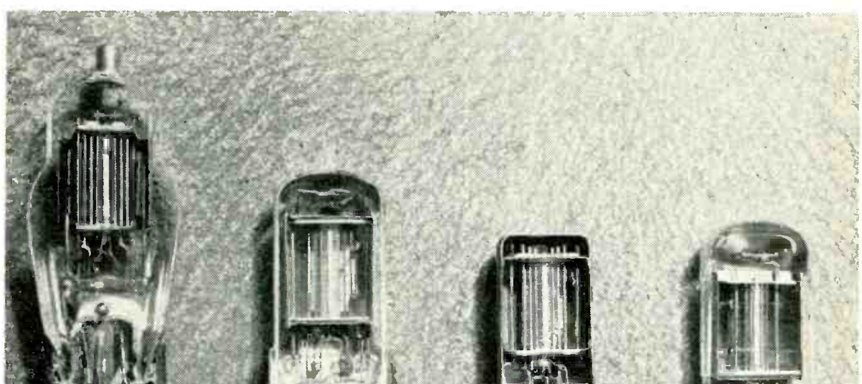
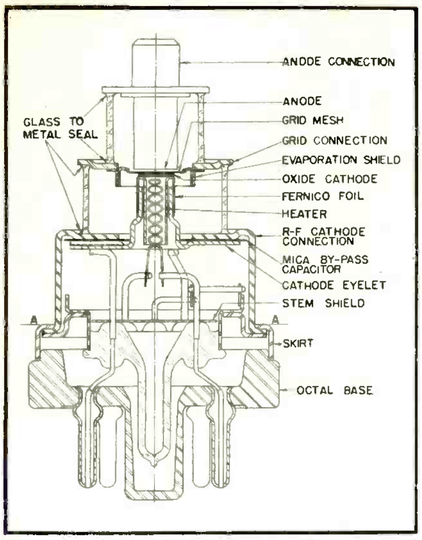


Fig. 6. Four basic constructions of electronic tubes.
(Courtesy Sylvania Elec. Co.)



Details of General Electric type 2C40 lighthouse tube, showing method of sealing terminals

match is to use Kovar, an iron-nickel-cobalt alloy, and a Pyrex heat-resisting glass. There is a strong chemical bond at the joint of the metal and glass due to the oxide coating on the surface of the metal being dissolved into the glass while the glass is in a molten state.

The terminal shown in *Fig. 3* has a single flange. By perforating a disc to produce a series of flanges, a multiple conductor terminal can be made as shown in *Fig. 4*. This arrangement is very advantageous on small transformers and relays where a large number of terminals are required.

The metal-to-glass terminal is not always made with an external metal flange. The conductor and glass insulation can be fused directly into a cover plate made of suitable material for the unit. The metal flange is assembled to the cover of the case by a simple soldering operation.

This type of terminal makes a vacuum-tight joint and is suitable for sealing vacuum or above atmospheric pressures.

Metallized Terminals

Ceramics, like steatite and porcelain, make excellent insulators but cannot be fused directly to metal. Heavy glass pressings can be formed into terminals with barriers to provide longer surface creepage paths but would require further expensive glass working to seal on a metal mounting flange and conductor. A thin metallic coating is fused into the surface glaze of a ceramic or into the surface of the glass tubing or pressings by applying sufficient heat to the insulator to bring the glass to the softening point. The metallic coating, which is extremely thin, is built up by tinning. The thermal coefficients of expansion of the glass or ceramic, the metallized coating, the tinning and subsequent solder are not important since the metals used are so malleable that they easily conform to changes in the dimensions of the insulator.

In *Fig. 5* is shown a porcelain terminal with barriers. A metal mounting ring and terminal stud hardware have been soldered to the metallized bands to form the complete terminal. The terminal assembly is then threaded over the lead and soldered to the case. The lead is soldered at the top of the terminal stud. This hollow terminal design enables a very compact installation of the leads to be made, since useless space is not required for the slack in the leads when the cover is put on the case. By riveting as well as soldering the terminal stud to the top of the terminal insulator, the terminal can be protected from injury due to careless soldering at final assembly. A broken hollow terminal can be replaced without disassembly of the unit.

Sealing of Electronic Tubes

The tube manufacturing industry has contributed many techniques to the art of hermetical sealing. The tube engineer is concerned with securing a vacuum-tight seal. All hermetical sealing is not required to be as effective as this, but some of the methods may suit other problems.

Four basic constructions of radio receiving tubes are shown in *Fig. 6*. The views are a cross-section through the envelope and base.

In tubes 6J7G, 6SJ7GT, and 6SJ7

Fig. 9. Sealed relay. Air is exhausted from housing, which is filled with dry nitrogen.

(Courtesy Automatic Elec. Co.)

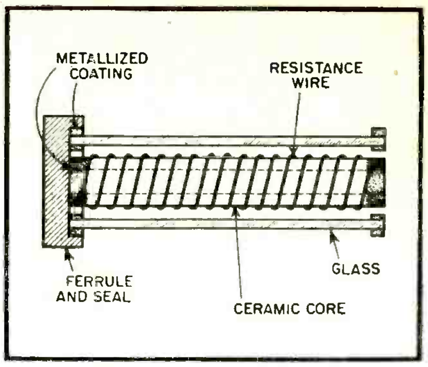


Fig. 8. New type of sealed resistor construction.

(Courtesy International Resistance Co.)

the lead-in wires are sealed into the flare by pressing the glass while it is still soft from heating, around the leads. Next, the flare, which carries the leads and the support rods, has the remaining internal tube parts added to it. The flare is then fused to the envelope. The tube is then evacuated through the stem.

The G type of tube is larger than the GT because of the envelope shape and the length of the press to seal the leads. The still smaller size of the metal (6SJ7) and lock-in (7C7) is a result of changing from a flat press to a header type of construction. Instead of the lead wires being sealed into the glass in a single plane, they are sealed in the glass header in a circular pattern. In a metal tube the glass header is sealed to a metal ring which in turn is welded to the metal envelope. The glass header permits shorter leads and reduces the capacity between leads. The spacing between leads in the glass header is much greater than with the leads through the press and this permits higher operating voltages without flash-over.

The glass header construction used in the metal tube is almost identical in construction to the multiple glass-to-metal terminal used for sealing transformers.

Transformers

Hermetic sealing of a transformer requires a new concept of case design. In most of the enclosed designs, the transformer could be mounted in any manner and the terminals brought out at any point. In *Fig. 7* is shown the typical construction of a sealed transformer. Since the case walls are soldered to the bottom and top covers and cannot carry the weight of the unit safely, brackets are provided to support the coil and core on the mounting studs. Cases are constructed of folded sheet metal with welded and soldered seams, or of a drawn case and drawn cover, heavily tin-plated to facilitate soldering.

[Continued on page 68]

RECENT RADIO INVENTIONS

These analyses of new patents in the radio and electronic fields describe the features of each idea and, where possible, show how they represent improvements over previous methods

Radio Receiver

★ In a patent issued on June 19, 1945, to George O. Striker, is described a superheterodyne radio receiver which may well be illustrative of the attention to details which can make future production very superior to anything that has been seen in the past. The invention consists of a careful combination of many elements including, in particular, a multiple antenna system. It is claimed that these innovations of construction allow superior input signals to be applied to the receiving circuits when the receiver is used under difficult conditions and are required to be operable over all normal broadcast and short-wave bands.

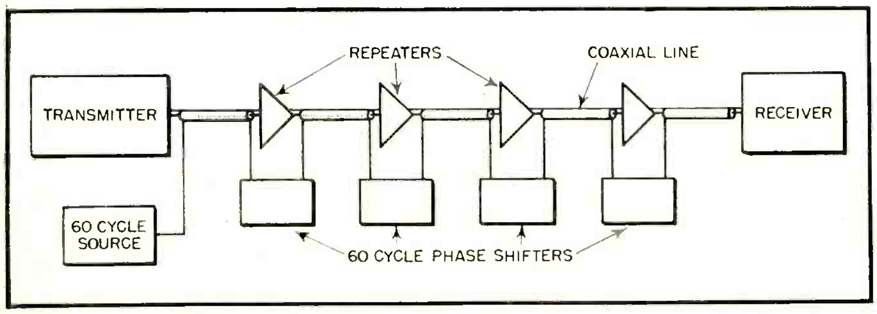
In addition to provisions for the connection of an external antenna, both a fish pole and a loop antenna are provided integral with the receiver cabinet. The loop antenna is actually a double loop so as to be suitable for either broadcast or short wave reception and is designed to be fastened to a window pane. Link coupling is provided in such a manner that the loop may be independently tuned to give best reception for a desired frequency. It is very likely that because of the large amount of compromise necessary and because of the crudeness with which many external antennas are constructed, that accurately tuned loops may often give superior reception.

The receiver described is claimed to give optimum reception in metal-enclosed conveyances, such as airplanes and railroad cars, as well as in more open locations. It is capable of operating from a-c or d-c mains as well as from self-contained batteries. It covers bands from 16 meters up. The patent is assigned to Zenith and is numbered 2,378,663.

Distortion Correction in Wave Transmission

★ When a broad-band transmission line such as a coaxial cable is used in conjunction with repeater stations to transport intelligence over long distances, it is desirable to supply power to the repeaters by means of the transmission line itself. On June 26, 1945, William R. Bennett was granted a patent on a method for minimizing distortion that may accumulate because of a mixing of the power frequency with that of the desired signal. It is assumed that 60 cycle power is carried over the line and a fraction of it successively used at each repeater station to supply plate and filament voltage. The present invention suggests a phase shift of this 60 cycle power at each repeater station so that a given point on the transmitted signal wave will at various times be exposed to different phases of the power wave. This causes a partial cancellation of any effect which the power wave might otherwise impress on the signal.

Because mixing produces harmonics as well as simple difference frequencies, it is pointed out in the patent it is not enough simply to reverse the power phase midway along the line. It is stated that optimum cancellation will be obtained if the phase shift at each repeater station is $360/n$ degrees where n is the number of repeater stations. The patent is assigned to Bell Telephone Laboratories and is number 2,379,211.

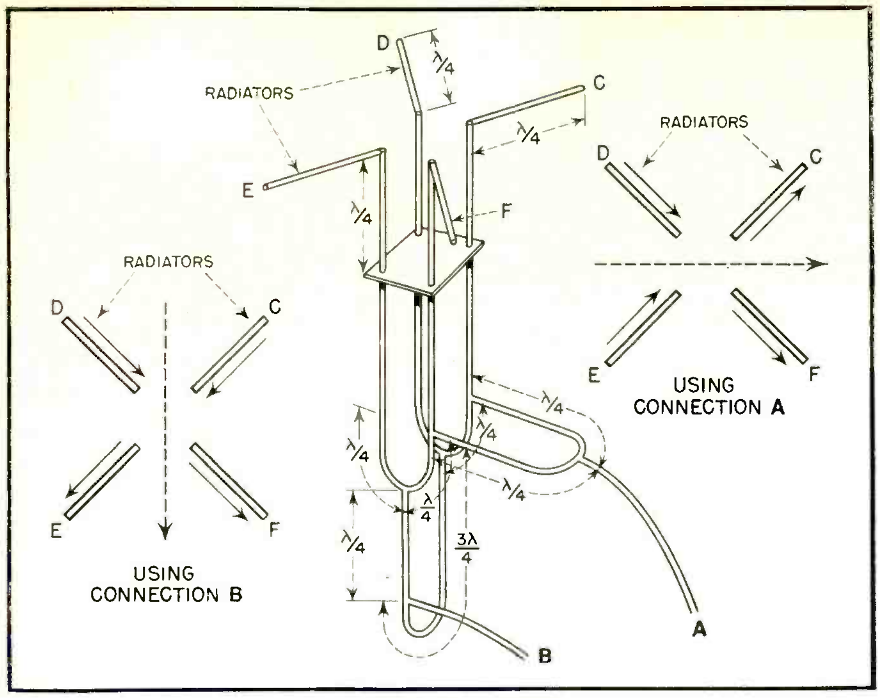


Patent No. 2,379,211

Antenna System

★ George H. Brown was issued a patent on April 24, 1945, which covers an antenna to which two distinct connections are provided. The use of one causes energy to be radiated with one polarization while the other connection makes the radiation effective in a polarization plane that is rotated through 90 degrees. The use of such polarized antennas for the selective reception and rejection of intelligences sent with the same carrier frequency is unfortunately limited because polarization is often changed by incidental reflections during transit, but over certain links one type of polarization may be superior to another and it is at least a convenience to be able to change easily a given antenna so that it is more sensitive either to vertically or horizontally polarized radio waves.

The present invention constitutes four quarter-wave radiators which are situated in a manner about as shown in the drawing. The directionality of such an antenna is not high, being in effect much the same as that of a center-fed half-wave antenna, which actually is what any selected pair of the quarter-wave radiators taken together constitute. High directionality can, however, be obtained by utilizing an array of such antennas arranged in the usual way so that cancellation occurs in all but the desired direction. This can be made to eliminate from consideration those directions in which one or more of the dipoles are naturally ineffective



Patent No. 2,374,271

and hence assure that the whole pattern is uniformly polarized.

To visualize the principle of operation, let it first be considered that radio-frequency power is inserted into connection *A* and connection *B* is left unattached to anything. As in any alternating current connection, a charge flows in and out of *A* and, during the time between reversals of polarity, is able to move a distance equal to one wavelength. Specifically, a charge is made to move back and forth along radiators *C* and *F* and, since these radiators are equally distant from the feed, the charge in the two moves in and out in unison. The charge in radiators *D* and *E*, on the other hand, moves out when that in *C* and *F* moves in because an additional half-wavelength of transmission line must be traversed before energy from the feed reaches those radiators. The net result is that when connection *A* is used, currents flow in the radiators so that at any instant they are directed as shown in the properly labeled auxiliary view. Alternatively, they are all moving in the opposite direction, which of course amounts to the same thing at a different point in the cycle. Radiation from each radiator has its electric field oriented in the same direction as the currents move and, since all the currents are equal, the total field is determined as a vector sum. In the auxiliary view for connection *A*, all the current vectors are pointing essentially to the right, and the up-down component of any one is just cancelled by a down-up component in another. The total field is therefore oriented like the broken arrow shown.

When feed *B* is used a similar argument may be made to show that the radiation is polarized the other way. Radiators *E* and *F* are now fed in unison and *C* and *D* encounter a 180-degree phase shift. The radiators therefore have current flows like those shown in the other auxiliary diagram and produce an average current which is again shown by a broken arrow which, however, is now oriented differently.

The patent, No. 2,374,271, is assigned to RCA.

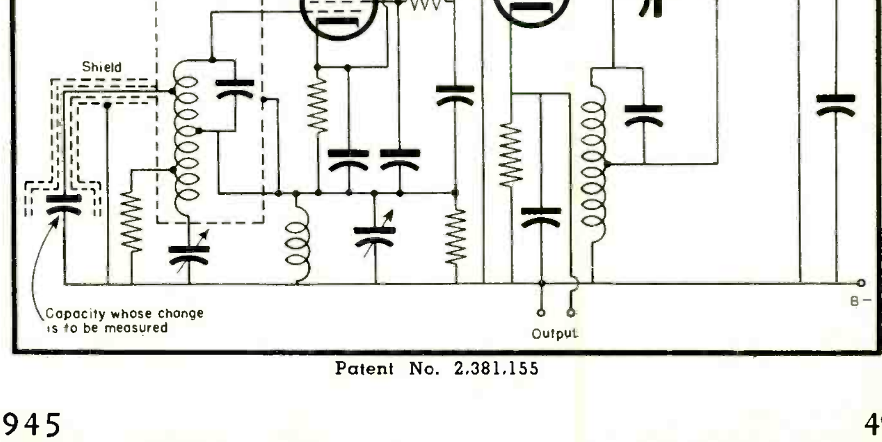
Electric Circuits

★ Joseph C. Frommer received a patent on August 7, 1945, for the circuit of a device which is designed to detect relatively small changes in capacitance. The letter of patent indicates that the device is particularly suitable for assembly lines and other places where a change in capacitance is utilized to indicate some fault or abnormal condition. The circuit, shown in the accompanying diagram, is particularly designed to make the indication independent of other capacitance changes in or near the apparatus, and to balance out fixed capacity so that a given change is equally well observed in the presence of a large fixed value.

The system consists of obtaining a high frequency voltage at the plate of an electron-coupled oscillator and connecting that voltage in series through a coil (linked to a rectifier) and the capacitance whose variation it is wished to observe. The circuit is completed by the ground connection between one side of the unknown capacitance and the ground connection of the electron-coupled oscillator. A variation in the unknown capacitance causes an impedance change in this series circuit and, consequently, changes the strength of the current which is linked to the rectifier and indicating meter or output circuit.

In order to cancel out unwanted steady capacity indication, the series circuit to which we have just referred also contains a vacuum tube which, with its external circuits, is able to apply signals of any desired and fixed amount but in opposite phase, so that zero on the indicating meter is surpassed only by capacitance in excess of a given amount. A doubly shielded cable is connected to ground and to a proper point in the series tube circuit so that capacitance changes in the lead to the unknown capacitance are compensated for. Other similar features are also incorporated into the circuit.

The patent, No. 2,381,155, is assigned to the Rolling and Engraving Mills, Inc.



Patent No. 2,381,155

Radio Transmitter

★ In a patent granted August 7, 1945, Thomas Henry Price of Chelmsford, England, shows a system for using low power level phase modulation signals so that when they are amplified in a pair of high power transmitting tubes, a corresponding amplitude modulated carrier becomes available for use in supplying power to an antenna. It is claimed that the system allows more efficient use of the high power transmitting tubes than would otherwise be possible because the voltage swings of the tube grids are always the same amplitude and the phase shifts change only the power transfer into the plate circuits. This allows full class C operation.

As it is shown in the letter of patent, the actual circuit used is moderately complex but the essential method of its operation without including all the features necessary to achieve highest efficiency may be described with less difficulty. Such a discussion is perhaps enough to give some evaluation of the invention although it should not be used to judge the claim of high efficiency.

As is shown in the accompanying block diagram a low powered continuous wave r-f signal is first produced and split into two parts. Its magnitude and phase are arbitrarily represented by a vector pointing to the right and 10 degrees above the horizontal. One part of the original c-w signal is fed directly into a phase modulation circuit and the other part is subjected to a constant phase shift of 160 degrees before being inserted into a phase modulator. Because of the fixed phase shift inserted into one branch of the circuit, two identical phase modulators receive r-f input signals whose vector representation is like that shown in the drawing. Both phase modulators receive the audio modulation and shift the phase of their respective r-f energies in accordance with that modulation signal. Specifically, the vectors representing the r-f voltages are made to change about their mean positions while remaining always within 10 degrees of that angle. After amplification, the phase modulation signals, now at high voltage, are again each shifted 90 degrees in phase by being allowed to pass through a quarter-wave section. When the waves are then combined much of the voltage is cancelled, but at little power loss because the quarter-wave section has so transformed the impedance that the cancellation is equivalent to a reactive reflection of energy. The portion of the voltage which does not cancel produces a voltage in the antenna that varies in amplitude as shown and in accordance with the original modulation.

The patent, which is assigned to RCA, is number 2,381,181.

Signaling System

★ In a patent issued to Lee Hollingsworth on August 14, 1945, the distortion of an amplitude modulated broadcast transmission which arises from selective and variable interference, due to reflections from the Heaviside layer, is considered. Because the territory served by a broadcast station may be divided into two parts served respectively by energy traveling from the transmitter to the receiver, either directly or by the way of a reflection from the Heaviside layer, and because the best modulation percentage for the two service areas is different, it is proposed that separate transmitting antennas be used for transmission into the two areas. The one used for the ground wave is to have greater gain than is normal and is to be restricted to low angle transmission. The sky wave energy, on the other hand, is fed to an antenna whose pattern is tilted upward so as to make its major contribution to more distant areas of reception.

The reason that a lower percentage modulation is desired for sky wave reception depends upon the fact that radio energy reaching a point over two paths may at times be cancelled out because the effective length of one path is a half-wave length longer than that of the other. Specifically, it may happen that at a given receiving location, two transmission paths may differ in length by a distance equal to a half-wave length of the carried frequency without causing interference effects on the sidebands which are of a sensibly different wave length. The inverse case, in which one sideband is removed by interference effects while still leaving the carrier and the other sideband, is not serious since the resulting distortion is relatively small. However, when the carrier is reduced and the sidebands are left at high level, a condition of more than 100% modulation is obtained and extreme distortion results. To overcome this, it is desirable to keep down the percentage modulation of the signal sent to areas where this can happen.

The present invention shows circuits for obtaining suitable signals to be applied to the two antennas. Both must stem from the same r-f source, and the one limited to 40% modulation is preferably arranged so that 40% is only a limitation which is smoothly applied when the intelligence would otherwise demand a higher percentage.

The patent, number 2,382,567, is assigned to RCA.

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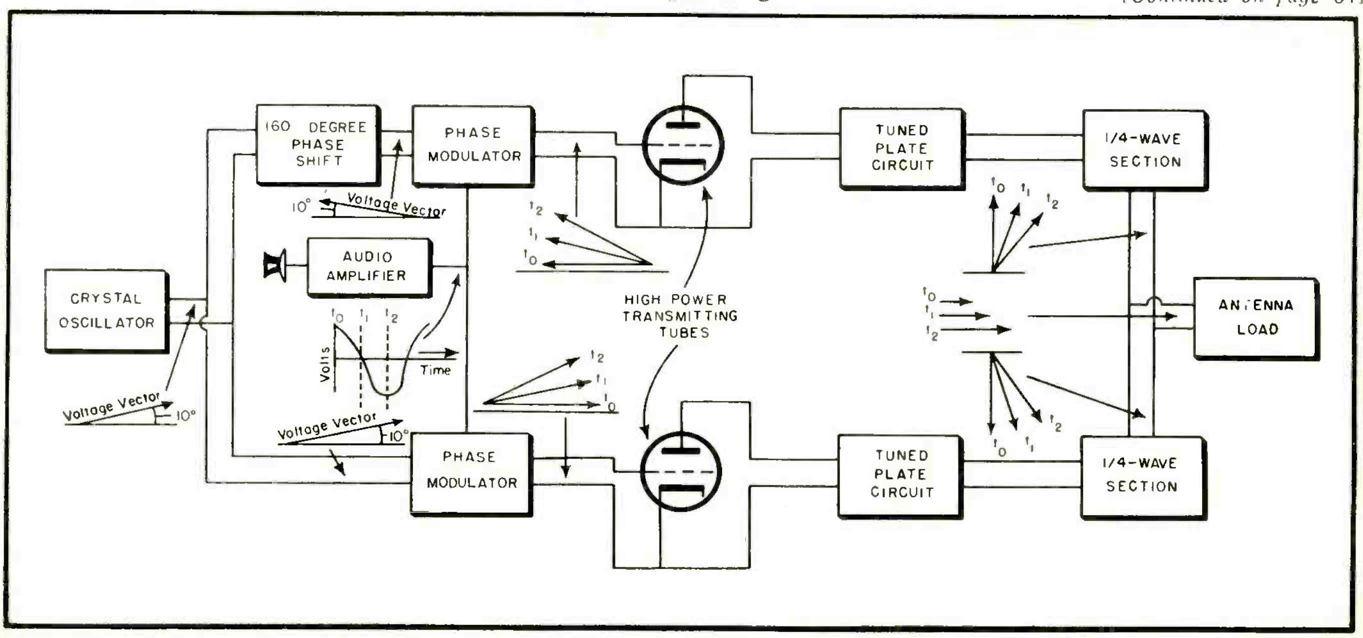


Patent No. 2,381,181

RADIO DESIGN WORKSHEET

NO. 42 — SOME NOTES ON AUTOMATIC VOLUME CONTROL; PARALLEL RESONANCE

SOME NOTES ON AUTOMATIC VOLUME CONTROL

When the initial automatic volume control circuits made their appearance, three element rectifier tubes were commonly used to supply a-v-c bias. These tubes were commonly biased to approximate cutoff. Since the applied voltages were usually relatively small, the a-v-c tube operated over the parabolic portion of its characteristic. Thus the rectified d.c. in the load circuit was approximately proportional to the square of the applied voltage. As a result, if one input signal were twice as large as another, the rectified d.c. it would produce in the load circuit of the a-v-c rectifier, would be four times as great as that of the original signal. As a result the voltage fed back to the control grids of controlled tubes would be four times as great as for the original signal. That is, if a signal of 0.1 millivolt produced a bias voltage of one volt then a signal of 0.2 millivolt would produce a bias voltage of 4 volts. Obviously this is not a satisfactory arrangement. However, by proper choice of initial bias and the number of tubes controlled, such circuits were able to perform quite acceptably. *Fig. 1* illustrates such a circuit arrangement.

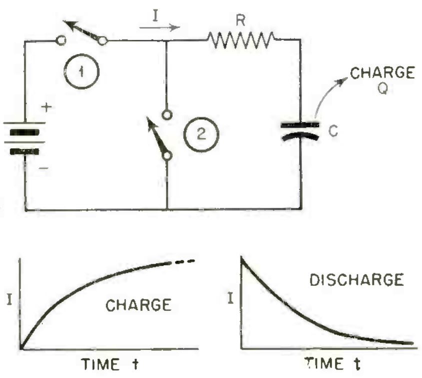


Figure 2

In order to understand the significance of the constants of a-v-c circuits, refer to *Fig. 2*, in which a capacitor is charged through a resistor with a suddenly applied d-c voltage and then discharged through the same resistance. If switch *1* is closed and switch *2* is open, we have:

$$E = RI + \frac{Q}{C} = R\frac{dQ}{dt} + \frac{Q}{C}$$

Since I is a function of time and decreases in magnitude as the capacitor becomes charged:

$$\frac{dQ}{dt} + \frac{Q}{CR} = \frac{E}{R}$$

$$Q\epsilon^{\frac{t}{RC}} = \int \epsilon^{\frac{t}{RC}} \frac{E}{R} dt + K$$

$$= \left(\frac{E}{R} \times RC \times \epsilon^{\frac{t}{RC}}\right) + K$$

$$= CE\epsilon^{\frac{t}{RC}} + K$$

and:

$$Q = CE + K\epsilon^{-\frac{t}{RC}} = Q_M + K\epsilon^{-\frac{t}{RC}}$$

When

$$t = o,\ Q = o \text{ and } K = -Q$$

Whence:

$$Q = Q_M\ (1 - \epsilon^{\frac{t}{RC}})$$

$$I = \frac{dQ}{dt} = \frac{Q}{RC}\epsilon^{-\frac{t}{RC}}$$

$$Q_M = CE$$

and:

$$I = \frac{E}{R}\epsilon^{-\frac{t}{RC}}$$

If switch *1* is opened and switch *2* is closed, the resulting current by reasoning similar to the above will be:

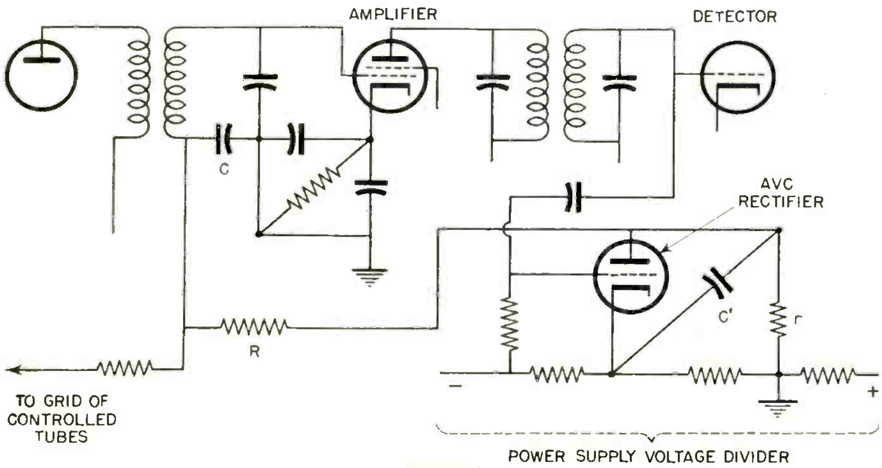


Figure 1

$$I = -\frac{E}{R}\epsilon^{-\frac{t}{RC}}$$

The quantity RC is known as the time constant. It is obviously the time required for the capacitor to change to 63% of its maximum or for the charge to fall to 37% of its maximum.

Applying this to *Fig. 1* we find the time constant of this circuit to be:

$$CR + C'R = \text{time constant}$$

Common values for these constants are:

$$C' = C = 0.25\ \mu f$$
$$R = 0.1 \text{ megohm}$$
$$r = 0.3 \text{ megohm}$$
$$CR + C'r = \frac{.25}{10^6} \times 10^5 + \frac{.25}{10^6} \times 3 \times 10^5 = 0.1 \text{ second}$$

This is a fairly common value for

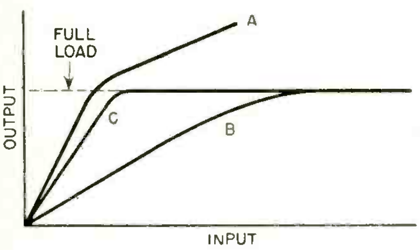


Figure 3

the time constant and means that 63% of the rectified a-v-c voltage is applied to the grids 0.1 second after the signal impinges on the antenna. Likewise, when the applied voltage drops, the gain comes up to 63% of maximum in 0.1 second.

By proper choice of load circuit the triode a-v-c rectifier can be made to approach linearity so that the voltage fed back through the filters to the controlled amplifier grids is about proportional to the incident carrier voltage and independent of percentage modulation. However, a diode a-v-c ceiver employing a.v.c. from a diode erally used for this purpose.

Fig. 3 shows the overload on input-output characteristics of a radio receiver employing a. v. c. from a diode rectifier compared to a receiver with no a.v.c. Curve *A* of *Fig. 3* illustrates the overload characteristic of a receiver without a.v.c. and set for maximum sensitivity. If a.v.c. is applied, increases in incident signal carrier will tend to reduce the receiver sensitivity in proportion to the strength of the carrier. This is shown by curve *B* of *Fig. 3*. As a result the output will not rise as fast as that of the receiver with no a.v.c.

A more desirable characteristic would be a combination of curve *A* and curve *B*: that is, one that would coincide with curve *A* up to the value of full load and then flatten off at this point as does curve *B*. This is sometimes accomplished by means of delayed

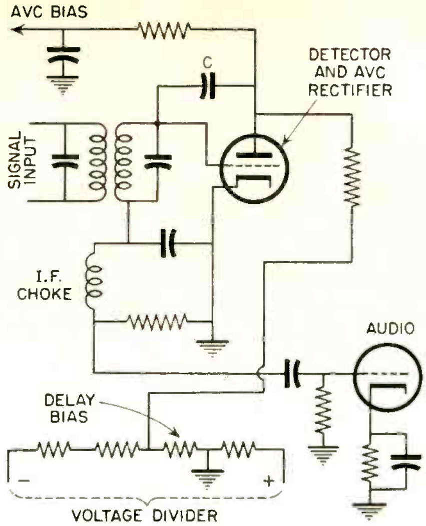


Figure 4

a.v.c. This circuit which is illustrated in *Fig. 4* prevents a.v.c. from acting until a definite input is achieved and permitting it to act at all greater inputs. The characteristic of such a circuit is shown by curve *C* of *Fig. 3*.

In the circuit of *Fig. 4*, a triode is used for detector and a-v-c rectifier. The grid-cathode circuit of the triode functions as the detector and the plate-cathode circuit of the triode functions as a-v-c rectifier fed by coupling capacitor *C*. A sufficient negative delay bias is used in the rectifier circuit to permit fully loading the receiver before a-v-c action starts. Of course a single diode may be and has been used for both a-v-c rectifier and detector in common, but improved performance results if separate diode circuits are used. This is particularly true if delayed a.v.c. is used.

If sufficient input is impressed on the receiver the a.v.c. can be overloaded. When this occurs the output will rise above the full load value

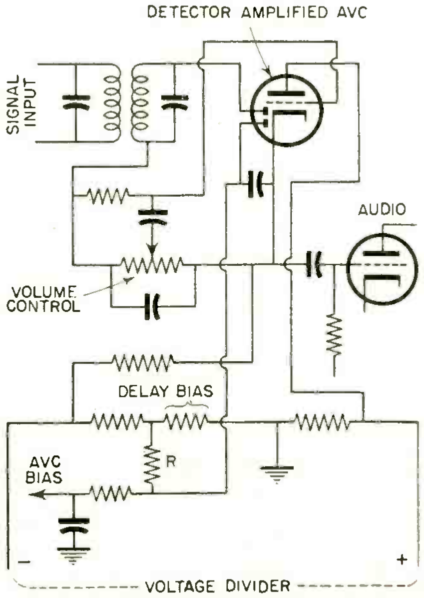


Figure 5

shown in *Fig. 3*. This has been overcome by the use of amplified a.v.c. A circuit employing amplified a.v.c. and using a double diode triode for the purpose is illustrated in *Fig. 5*. With such a circuit the input required to overload the a-v-c system is increased by an amount equal to the amplification of the triode. In *Fig. 5*, the diode detector circuit is conventional. The grid of the triode is fed from the detector load circuit through an isolating resistor and resistor *R* is the load circuit of the a-v-c rectifier which feeds the a.v.c. bias back to the amplifier grids.

PARALLEL RESONANCE

Let it be required to find the frequency of unity power factor (i.e. resonant frequency) and the impedance *Z* looking into the parallel resonant circuit of *Fig. 6* at the frequency of unity power factor.

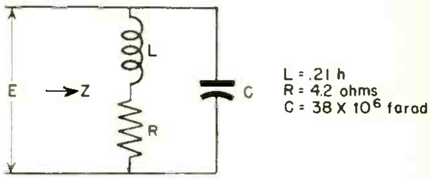


Figure 6

Fig. 7 represents the vector relationships of the currents and voltages of the circuit of *Fig. 6*.

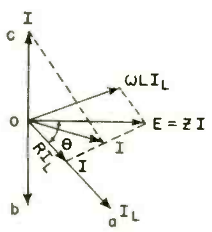


Figure 7

$$I_1 = \frac{E}{\sqrt{R^2+\omega^2L^2}}$$

$$I_C = -\frac{E}{\frac{1}{\omega C}} = -\omega CE$$

$$ba = I_L \cos\theta = \frac{E}{\sqrt{R^2+\omega^2L^2}} \times \frac{R}{\sqrt{R^2+\omega^2L^2}} = \frac{ER}{R^2+\omega^2L^2}$$

$$ob = I_L \sin\theta = \frac{E}{\sqrt{R^2+\omega^2L^2}} \times \frac{\omega L}{\sqrt{R^2+\omega^2L^2}} = \frac{\omega LE}{R^2+\omega^2L^2}$$

$$I_C - I_L \sin\theta = \omega CE - \frac{\omega LE}{R^2+\omega^2L^2} = I'_C$$

$$I = \sqrt{I_C^2+I_L^2} = E\sqrt{\left(\frac{R}{R^2+\omega^2L^2}\right)^2 + \left(\omega C - \frac{\omega L}{R^2+\omega^2L^2}\right)^2}$$

At unity power factor I will be in phase with E, whence:

$$\omega C = \frac{\omega L}{R^2+\omega^2L^2}$$

And:

$$I_R = \frac{ER}{R^2+\omega^2L^2}$$

$$\omega CR^2 + \omega^3LC = \omega L$$

$$\omega \neq 0$$

Therefore:

$$CR^2 + \omega^2L^2C = L$$

$$\omega = \sqrt{\frac{L - CR^2}{L^2C}}$$

$$f = \frac{\omega}{2\pi} = \frac{1}{2\pi}\sqrt{\frac{10^6}{38 \times .21} - \frac{4.2^2}{.21^2}} = 56.2 \text{ Cycles}$$

$$Z = \frac{R^2+\omega^2L^2}{R} = 1310 \text{ Ohms}$$

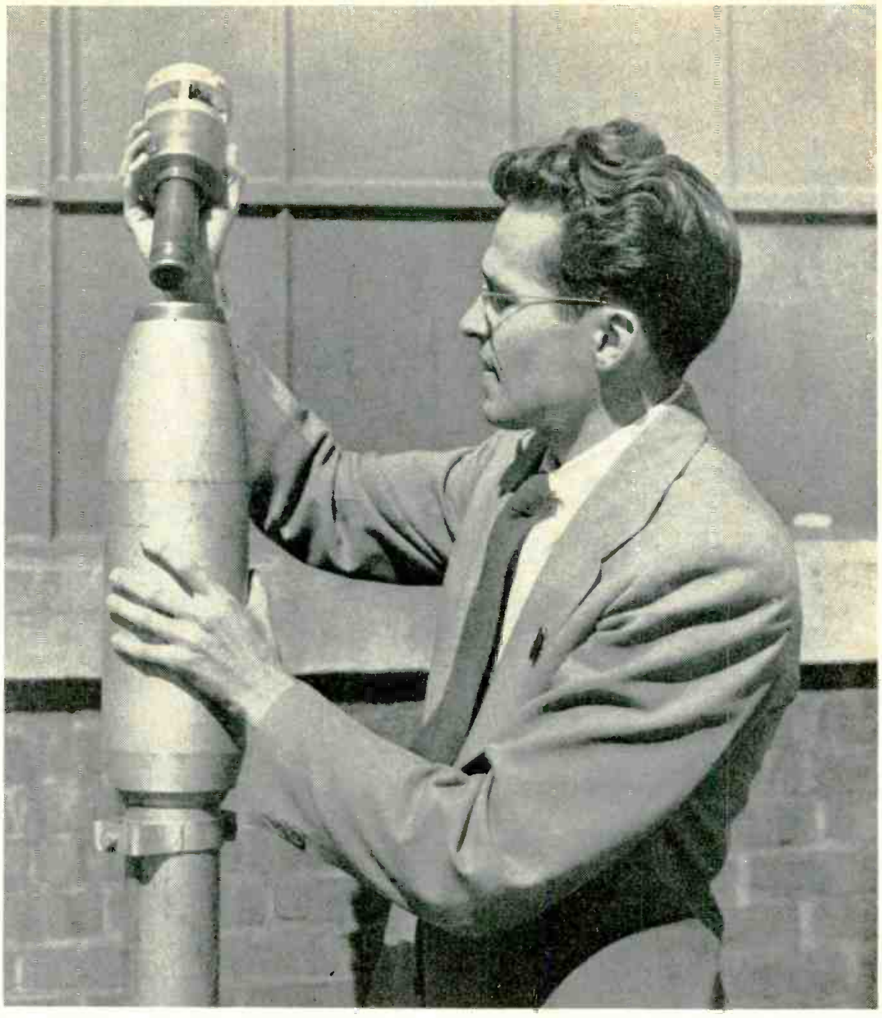
This Month

FM VS. AM TESTS

Frequency modulation and amplitude modulation radio systems were tested simultaneously under identical operating conditions, utilizing equipment of comparable engineering specifications in experiments concluded recently by the Atchison, Topeka & Santa Fe Railway Company and the Farnsworth Television & Radio Corporation of Fort Wayne, Indiana.

The tests, conducted in the Santa Fe Corwith yards on Chicago's south side, indicated that both FM and AM systems are capable of rendering satisfactory service in railroad operation, according to engineers in charge of the experiments. Both systems, it was pointed out, have certain inherent advantages, and a choice would depend on the economic, installation, operation and maintenance factors involved in individual projects.

The equipment tested for both AM and FM employed a new development called the "auto pulse" checking system, in which a small light flashes in the locomotive cab every few seconds when the engine is in operating range of another radio-equipped unit. Because of its safety factor, it was pointed out, this new check system will have many applications in the railway field. The pulse technique employed in this system is an adaptation of a wartime identification development whereby friendly aircraft can automatically identify each other.



S. D. Epstein, G-E electronics engineer, places a radio proximity fuze in the nose of an aircraft rocket. Heart of the fuze is a vacuum tube which sends out electromagnetic waves that are reflected back to the tube by any target which gives radio reflection, causing the projectile to burst at a distance where the most damage will be done.

OPA CABINET PRICING

Pricing cabinets for manufacturers of wood radio cabinets were announced today by the Office of Price Administration. The cabinets will be used in household radios and electrical phonographs, which will soon be returning to the civilian market.

An order, effective October 16, 1945, bases manufacturers' ceiling prices on the prices they charged for cabinets delivered to radio set manufacturers between July 1, 1941, and October 31, 1941.

To determine their ceiling prices for the same models, manufacturers apply a price increase factor of 18 per cent to their 1941 prices for models delivered between July 1 and October 31, 1941. If a cabinet was not delivered during this period, but has an established ceiling under the consumer durable goods regulation, an increase factor of 12 per cent may be applied to each price to determine the new ceiling price. In line with OPA's reconversion policy, these increase factors reflect lawful increases in material prices and basic wage rate schedules since October 1941. together with the industry's average 1936-39 percentage margin over total costs.

The following pricing methods are provided for new models of cabinets and for the output of new manufacturers:

(1) For new models comparable to models on which ceiling prices are fixed by the order, an automatic pricing technique is established. The manufacturer figures his own ceiling price by computing his unit direct cost for the comparable model and for the new model, based on current costs, and applying the mark-up he would realize on the comparable model.

(2) For new models not comparable to other models with established maximum prices, and for all models produced by new manufacturers, ceiling prices must be obtained by application to OPA. The agency-approved prices will be in line with the price level set for other models under the order.

OPA pointed out that no provision is made for resale prices, since the greater part of all cabinet production is sold directly to radio set manufacturers. A survey of the radio industry now is in progress, however, to determine the increase factor to be applied to this group. Price increases allowed for cabinet manufacturers will be included in the increased materials costs used to compute the increase factor for the radio set industry.

The pricing technique for comparable models, by permitting manufacturers to determine their own ceiling prices, does away with the loss of time involved in securing positive approval in each specific case. Unit direct costs for new and comparable models must be reported to OPA, together with the resulting ceiling prices within five days after entering into a sales contract. Sales may be made immediately at the reported prices, but OPA reserves the right to adjust these prices later. No adjustments will be retroactive if the manufacturer has complied with the order.

Manufacturers who are required to apply to OPA for ceiling prices may not sell the models affected until they have received specific authorization from the agency.

Today's order, OPA added, provides for the establishment of ceiling prices to classes of purchasers other than radio set manufacturers. It also authorizes the agency to act on its own initiative in setting ceiling prices when manufacturers fail to make application or to file complete records.

(Order No. 2 under Secton 1499.159e of Maximum Price Regulation 188—Maximum

Prices for Specified Building Materials and Consumer Goods Other Than Apparel— effective October 16, 1945.)

AMATEUR TRANSMITTER CONTEST

The 1st Annual All Amateur Transmitter Contest is being inaugurated by Taylor Tubes, Inc., of Chicago, Illinois, together with nine other radio-component manufacturer-participants as an expression of appreciation for the outstanding work done by the thousands of servicemen in the Communications Branches of the military, and the many amateur radio operators, or "hams".

The prizes consist of two transmitters, designed by the contestants, complete from microphone to antenna post, plus $1125 in Victory Bonds, furnished by the participating manufacturers. Two prizes will be awarded: one in final power input classification up to 250 watts, and the other in power input classification of from 251 watts to 1,000 watts.

The participating radio-component manufacturers, who are donating the $2250 in Victory Bonds ($1125 to the winner in each class) are: Aerovox Corp., New Bedford, Mass.; American Phenolic Corp., Chicago, Ill.; Barker & Williamson, Upper Darby, Pa.; Bliley Electric Co., Erie, Pa.; Gothard Mfg. Co., Springfield, Ill.; International Resistance Co.: Philadelphia, Pa.; E. F. Johnson Co., Waseka, Minn.; Solar Mfg. Corp., New York, N. Y.; and United Transformer Corp., New York, N. Y.

Eight well-known men in radio are acting as judges. They are: Fred Schnell, W9UZ (Former Communications Manager of ARRL and now Chief of Radio Dep't., Chicago Police), Oliver Read, W9ETI (Editor, *Radio News*), Cyrus T. Reed, W9AA (Former Asst. Secretary ARRL), John H. Potts (Editor *CQ* and RADIO), Lewis Winner (Editor, *Communications*), Frank J. Hajek, W9ECA (President, Taylor Tubes, Inc.), Rex Munger, W9LIP (Sales Manager, Taylor Tubes, Inc.), and Karl A. Kopetzky, W9QEA (Former Managing Editor, *Radio News*).

Official Entry Blanks, which must accompany every entry, are available from any radio parts jobber or distributor. The contest opens November 1, 1945 and will close February 15, 1946. The contest is being managed by Magazines, Incorporated, of Chicago, Illinois.

Personal Mention

RIEDEL RESIGNS

★ A veteran merchandiser in the radio industry of radio receiving sets, speakers and tubes, Edgar S. Riedel, for 13 years general sales manager of the Receiving Tube Division of Raytheon Manufacturing Company, Newton, Massachusetts, announced his resignation from the company today. "Eddie" Riedel is a popular nationally-known pioneer in the field of radio distribution, advertising and sales. He was one of the nine original organizers of the Radio Manufacturers' Association in the Sherman Hotel at Chicago in 1923. He has been engaged in Radio Merchandising since the first day of broadcasting, when he manufactured Thorola sets, parts and speakers.

Edgar S. Riedel

During the first four years of Broadcasting in radio he manufactured and marketed over two million Thorola and Thorophone horn-type loudspeakers, leading the speaker industry.

During the "B" eliminator days for Raytheon, as general sales manager, he was active in licensing the 45 manufacturers who built their "B" eliminators around the Raytheon BH gaseous rectifier, which at that time was Raytheon's only product. This was the first step toward a-c radio sets. After several million of these BH tubes were on the market in "B" eliminators, Eddie established Raytheon's first replacement sales policy through jobbers whose outgrowth is Raytheon's present replacement tube distributors.

During the period that National Carbon had an option to buy Raytheon and handled Raytheon tube sales marketing 4 Pillar radio tubes under Everready-Raytheon's name, Eddie Riedel resigned and accepted the position as Vice-President and General Sales Manager of Utah Radio Products Company, Chicago, and again made an outstanding merchandising success of Utah dynamic speakers. In 1933 National Carbon Company canceled their contract with Raytheon giving up their option and receiving tube sales were turned back to Raytheon; Eddie Riedel was again induced to rejoin Raytheon as their General Sales Manager, which position he has held until his present resignation.

The new Raytheon replacement tube sales plan to be announced shortly to the parts and tube industry is one of the most revolutionary tube merchandising plans ever to be offered the tube distributors and service dealers in radio tube history, and is the crystallization of Eddie Riedel's dream for the past three years, of something to offer the parts distributors and service-dealers on tubes that was entirely new, helpful and constructive in post-war tube merchandising that would elevate their business and protect them from outside interests cutting into the reliable radio-service profession in the new era of electronics.

Before his radio days Ed Riedel was for several years in charge of national accounts and manufacturers' sales for B. F. Goodrich Rubber Company, Akron, Ohio. During his high school days, he was one of Oak Park High School's greatest athletes. His straight form of hurdling, new at the time, enabled him to break the world's interscholastic record. During each of his four years he was captain of all four major sport teams winning 16 Oak Park monograms. In his freshman year, when Oak Park won the Central States championship of the West in basketball, he was honored as the greatest prep player in the middle West. He pitched Oak Park to many baseball victories, and in his last year of high school he won the Cook County tennis championship. In his freshman year at the University of Chicago, he set a new world's record in the Olympic tryouts to represent the United States in the high hurdles at the Stockholm Olympics. For eleven years following college, as a member of the Chicago Athletic Association track team, he consistently won in the National track championships in the high hurdles.

During the first World War he served as a United States Naval officer. At the time of his discharge, he held the rank of Lieutenant Senior Grade. He specialized in navigation and studied at Annapolis.

E. S. Riedel will announce his business plans in the near future.

ELECTRONIC MECHANICS INC. CELEBRATES 10TH ANNIVERSARY

★ D. E. Replogle, founder and president of Electronic Mechanics Inc., manufacturers of Mykroy—glass bonded mica ceramic—is a pioneer in the twin fields of radio and electronics. His long, successful career which began in 1916 when he erected a two kilowatt wireless sending station at Noorvik, Alaska, continues to the present day.

Electronic Mechanics Inc., formed in 1935, is a continuation of the Communications Products Company of New York City. Its success and tremendous expansion in the past decade attests to the administrative ability of its founder and the high quality of its product Mykroy.

D. E. Replogle

Electronic Mechanics Inc. is celebrating a decade of service to the ever-growing electronic industry. It has produced several informative engineering bulletins on Mykroy showing the many uses to which it can be put. Those wishing copies are invited to write directly to Electronic Mechanics Inc., 76-82 Clifton Blvd., Clifton, N. J.

BROWNING APPOINTS SPINDELL

★ At a company meeting held Octbber 5, 1945, it was announced that Freeman A. Spindell had been appointed Chief Engineer of Browning Laboratories, Inc. Mr. Spindell was graduated from Tufts College

Engineering School in 1938, following which he spent three years as an instructor of electronics. He became associated with the Browning Laboratories in the Spring of 1941, where he has devoted his time to the design of radar and radar test equipment. Mr. Spindell is married and lives in Tyngsboro, Mass.

A. O. Seehafer

★ A. O. Seehafer has been appointed general sales manager of Russell Electric Co., Chicago, manufacturers of Ballentine record changer motors, phonograph drives, and other fractional horsepower electric motors.

A 1930 alumnus of Northwestern University's engineering school, Seehafer received his M.S. in physics in 1931, continued his research in electrical physics on a fellowship in Europe for one year, served for a time on the faculty at his alma mater, and then went into sales development work with Container Corporation. He has been with Russell Electric since 1944, and was instrumental in handling many of Russell's war contracts. He is a member of Tau Beta Pi, honorary engineering fraternity, and Sigma Xi, honorary scientific fraternity.

A. O. Seehafer

He, his wife, and their two children live in one of Chicago's North Shore suburbs, Wilmette. His hobby, when he can spare the time, is skiing, and he has sampled nearly all the great ski courses in this country and Europe.

Sculptor Charles Bradley Warren of Pittsburgh puts the finishing touches on the statue to be presented by the radio manufacturing industry to the broadcasters of America "in recognition of a quarter century of public service by the broadcasters and for their contribution to world peace and harmony." Presentation of the statue, which will be on permanent display in the Washington headquarters of the National Association of Broadcasters, highlighted the observance of National Radio Week (Nov. 4-10). R. C. Cosgrove, president of the RMA, represented nearly 300 radio manufacturing companies in giving the statue to Justin Miller, president of NAB, representing both the networks and individual stations.

NEW RCA APPOINTMENTS

Appointment of J. B. Coleman as Assistant Director of Engineering for the RCA Victor Division and the naming of M. C. Batsel as Chief Engineer of the Engineering Products have been announced by D. F. Schmit, Director of Engineering for the RCA Victor Division.

J. B. Coleman

Mr. Coleman, who will make his headquarters at the company's home office in Camden, N. J., joined RCA in 1930. He progressed through the Engineering Division holding a series of responsible positions until 1939 when he was appointed Chief Engineer of the Engineering Products Department, a position he held until his new assignment.

Mr. Batsel is widely known in the radio and motion picture industry. He became associated with RCA in 1929. Previous to his new assignment, Mr. Batsel was Chief Engineer at the RCA Victor plant in Indianapolis, Ind.

WU PLANS RADIO RELAY SYSTEM

A plan to establish super-high frequency radio relay systems with towers about 30 miles apart between the major cities of the United States during the next seven years was announced today by A. N. Williams, President of the Western Union Telegraph Company.

Radio relay systems ultimately will replace many of the familiar pole lines and hundreds of thousands of miles of wire in the 2,300,000-mile telegraph network, Mr. Williams predicted, but no lines will be removed on this account until an established radio system along the route has proved satisfactory, government approval is obtained and existing contracts permit.

The use of radio relay system will provide a larger number of channels than are now available for the handling of telegraph traffic and also will provide circuits for new uses such as Telefax (facsimile) operation and for special leased networks required by large users of the telegraph.

In its first major move to use radio relays, the telegraph company has applied to the FCC for permission to establish experi-

[*Continued on page 67*]

New Products

ULTRA HIGH-SPEED RELAY

The new Stevens-Arnold Millisec relay is a hermetically sealed sensitive relay capable of speeds up to 1000 operations per second.

The basic design of the moving elements is quite different from conventional relay

practice and it is this new design which makes the ultra high speed possible, at the same time assuring great reliability if operated in the usual speed ranges.

In the illustration a cut through section shows the glass envelope which surrounds all the moving parts and protects them from moisture, dust or corrosive fumes.

With this new type of construction, sensitivities down to ½ milliwatt are possible. Ratings up to 5 amperes can be obtained. Closing time can be less than one millisecond.

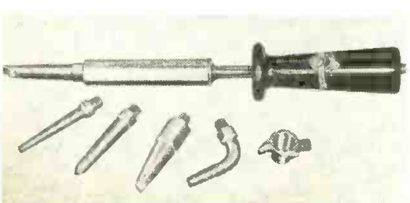
The outside dimensions of the 115 volt a-c 1 ampere rating are three inches high and one and one-half inch base diameter.

For further data, write the Stevens-Arnold Co., Inc., 22 Elkins St., So. Boston, Mass.

SOLDERING IRON

The Kwikheat Thermostatic Soldering Iron has a thermostat self-contained — maintaining constant heat at all times and preventing overheating.

The Kwikheat Iron has an unusually long life expectancy because it eliminates the excessively high temperature acquired by the conventional electric soldering iron when in "idle" condition . . . the major contributing factor in soldering iron de-



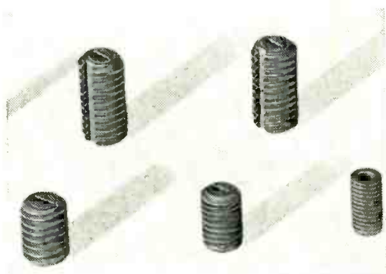
terioration. Tips, too, last longer because they are never overheated and consequently need less retinning in this modern tool.

This unusual soldering iron is called "Kwikheat" because it heats up, ready-to-use only 90 seconds after plugging in. This is made possible by a special powerful 225 watt quick-heating element—held in check by the thermostat.

Although the Kwikheat Thermostatic Soldering Iron has been proved in use for several years by large industrial users it is now available generally for the first time on a nationwide basis through supply houses. It is manufactured by Sound Equipment Corporation of California, 3901 San Fernando Road, Glendale 4, California.

SCREW TYPE IRON CORES

Screw type molded iron cores now being made generally available for the first time by the Stackpole Carbon Company, St. Marys, Penna., offer many engineering and constructional advantages by virtue of the fact that the cores themselves are threaded. Thus, no brass core screw is necessary for their adjustment. There is no metal in the field of the coil and the cores



themselves are not grounded. Considerably higher Q is the result.

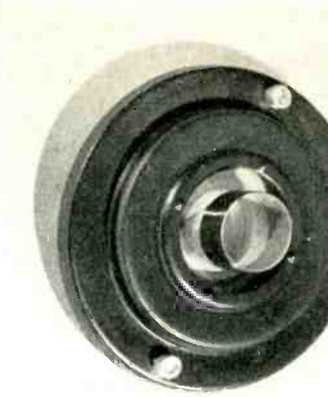
Smaller assemblies are readily possible because the overall length of a coil and screw type core is less than that of the conventional core, machine screw and bushing. Smaller cans can be used. Threaded coil forms are unnecessary in many cases. Instead, "C" clips extending through slots in the coil forms can be used to contact the core threads.

The design of i-f and dual i-f transformers for AM and FM, is greatly facilitated due to the fact that screw cores may be tuned from one end of the transformer simply by placing the coils side by side. Antenna, r-f and oscillator coils for each band of multi-band sets become small and compact by use of screw cores and may be mounted in groups for each band.

Complete details will gladly be sent upon request to the manufacturer.

LOUDSPEAKER FEATURE

An entirely new and patented feature, called the "Adjust-A-Cone", will now be included in the entire line of postwar loud-



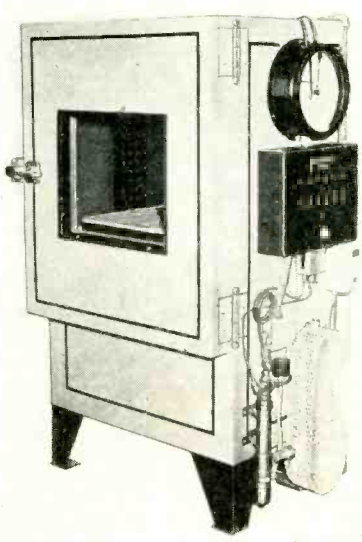
speakers being marketed by Quam-Nichols Company, 33rd Place & Cottage Grove Avenue, Chicago, Ill., it was announced by J. P. Quam, president of the firm.

In this new unit, the spider of the loudspeaker, instead of being permanently glued or fastened to the basket or pot, is kept in position with a pressure or clamping ring, which is in turn held down by two machine screws. By loosening the screws holding the pressure ring, a small lateral movement of the spider is permitted by which the voice coil can be re-centered concentrically around the pole-piece and within the gap.

This new feature will be of great advantage to the serviceman, as the screws holding the clamping ring in this unit are so positioned that it is often unnecessary to remove the loudspeaker from the chassis to re-center the voice coil. Neither need a rubbing voice-coil assembly be replaced as heretofore.

HUMIDITY CHAMBER

A new insulated variable temperature and humidity chamber for the simulation



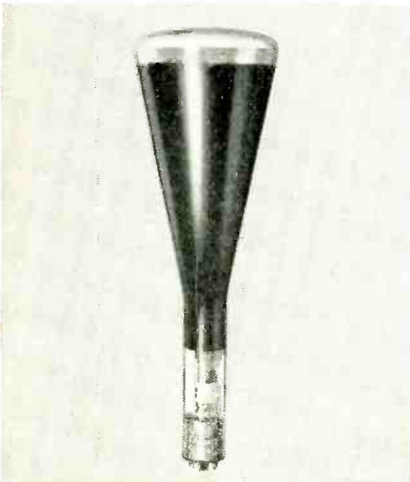
SYLVANIA NEWS

ELECTRONIC EQUIPMENT EDITION

NOV. *Published by* SYLVANIA ELECTRIC PRODUCTS INC., Emporium, Pa. 1945

RADIO AND ELECTRONIC EQUIPMENT MAKERS GETTING SET FOR FULL-SCALE PRODUCTION

Will Receive Highest Quality Tubes From Sylvania Electric To Meet Pent-Up Demand



CATHODE RAY TUBES

With the period of reconversion taking active form and spreading over the nation, the radio industry is looking forward to what promises to be one of the most expansive developments in its history. Millions wait for radio sets of improved design and, consequently, of more complex construction. Industries will turn to greater use of electronic equipment.

Manufacturers are rapidly getting set for full-scale production to meet this pent-up demand. Of course, in radio there's the problem of obtaining an adequate supply of component parts.

However, as far as dependable, precision-built radio tubes are concerned, set makers are assured of receiving the benefits of Sylvania's more than 40 years' research experience and wide-scale production facilities. Note this list:

LOCK-IN RADIO TUBES

Television—experience in design and the production of untold thousands of Sylvania Cathode Ray Tubes for war requirements has contributed greatly to peace-time applications.

High frequency sets (FM, Television)—the Sylvania Lock-In Tube is so electrically and mechanically perfect in construction that it can handle ultra-high frequencies with ease. Besides, it is more than perfectly suitable for *all* types of radio sets.

"GLASS" RADIO TUBES

Radio—manufacture and distribution of the famous high quality Sylvania lock-in "Glass" and miniature tubes will continue to satisfy the exacting circuit requirements of modern radio receivers.

Electronic devices—the same laboratory and manufacturing resources that served our government so well, are now available to the manufacturer of electronic devices of every description.

SYLVANIA ELECTRIC

Emporium, Pa.

MAKERS OF RADIO TUBES; CATHODE RAY TUBES; ELECTRONIC DEVICES; FLUORESCENT LAMPS, FIXTURES, WIRING DEVICES; ELECTRIC LIGHT BULBS and control of atmospheric conditions has been announced by Tenney Engineering, Inc., 26 Avenue B, Newark 5, N. J., makers of automatic temperature, humidity and pressure control equipment.

Cabinets are designed to provide accurate simulation and control of any desired temperature, humidity and air circulation condition in laboratory or production testing operations. Batches or parts can be tested under standard or variable conditions. Temperature, humidity and air circulation can be controlled to close preselected limits.

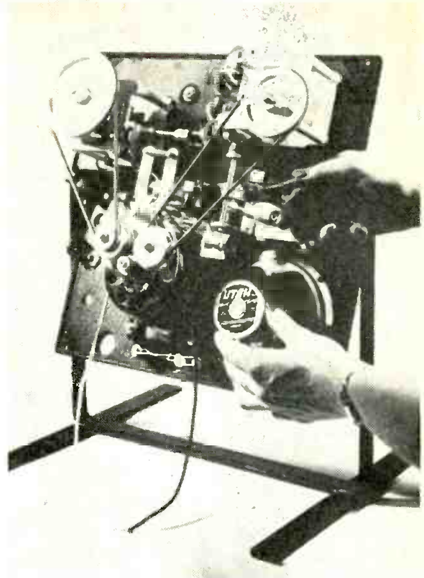
Conditioned air is kept in continuous forced circulation without undesirable draft. Uniform wet and dry bulb temperatures throughout the cabinet are thus provided.

Dry bulb temperature of the air can be set from room temperature to any desired point. When unit is operating, this temperature does not vary in any part of cabinet by over 1°C. plus or minus.

Relative humidity can be controlled up to 90% and atmosphere will not vary over plus or minus ½°C. from the wet bulb of the humdity required.

Under any set conditions, temperature and humidity will remain constant during operation. A simple resetting of controls brings cabinet to a new equilibrium within ten to fifteen minutes.

WIRE RECORDER



The "Magicwire", as manufactured by Utah Radio Products Company, Chicago, is a portable recording reproducing device capable of making recordings on a moving steel wire and reproducing them immediately. It accomplishes this by producing small magnets along the moving wire according to the frequency and intensity of the audio signal, and converting the "peaks" and "valleys" of the moving magnetic field thus produced into sound by suitable electrical and mechanical means.

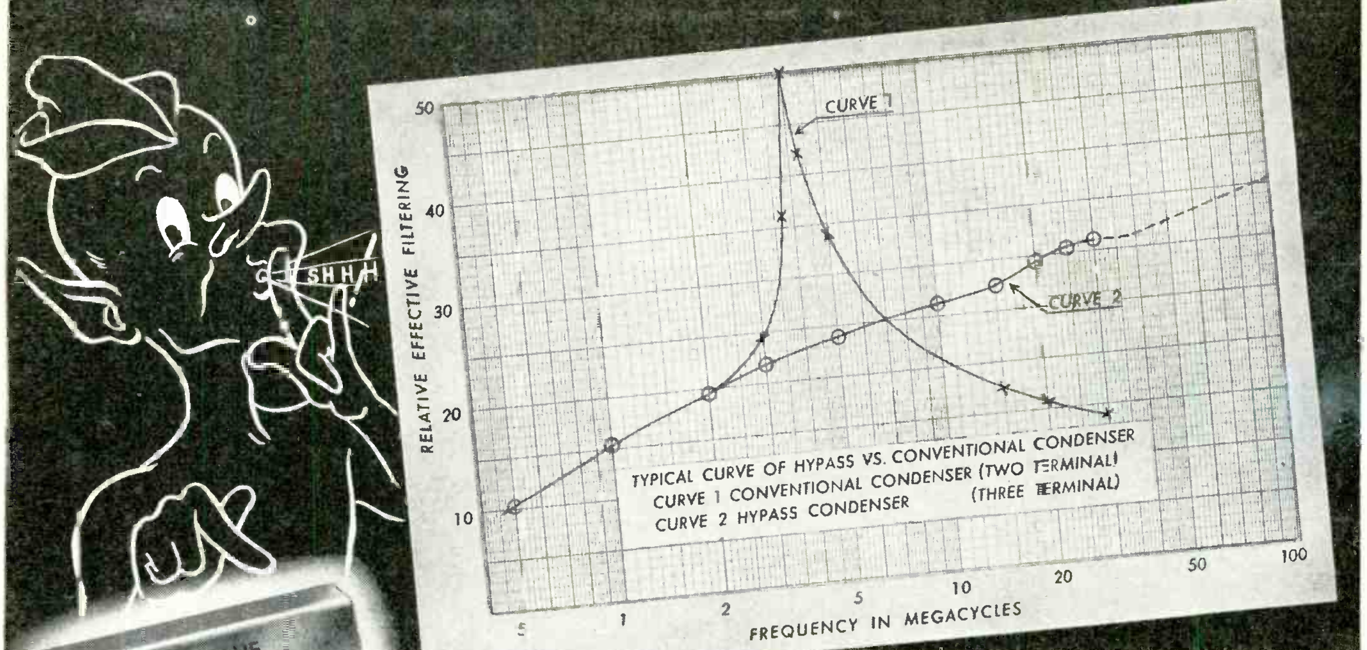
The complete unit is contained in a small carrying case and is always ready for instantaneous use. It is designed to operate on 115-volt, 60-cycle alternating current. Provision is made at the rear of the unit for connection to a source of power.

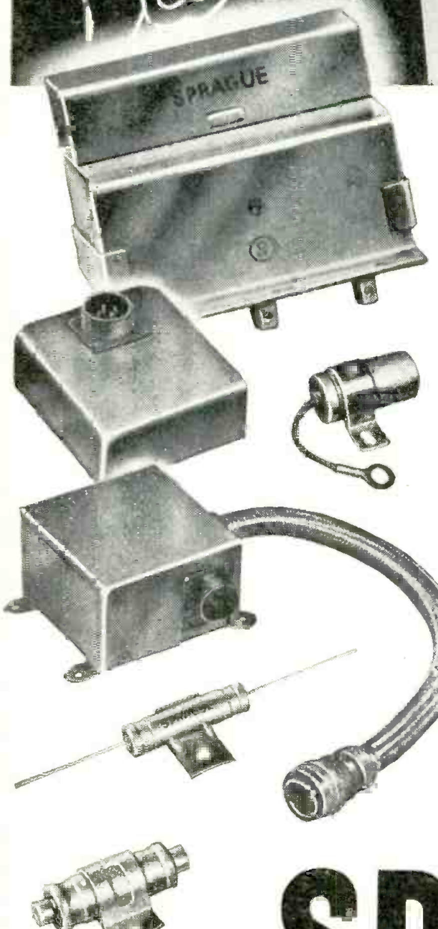
A full-wave rectifier tube (5W4), a three-stage audio amplifier, a 30-kilocycle oscillator tube (6V6), a record-listening mechanism, a drive motor and associated mechanism, and necessary accessories comprise the recorder and reproducer. The rectifier tube supplies plate voltage for the audio amplifier and oscillator. During a recording period the output of the audio amplifier is connected in series with the oscillator-transformer and to the coil in a unit on the front of the machine called the record-listen head. This device produces the small magnets along the moving wire during recording operations, and picks up these same magnetic impulses for conversion into sound during listen periods. During a play back period, the audio output of the third stage is connected to the coil in the loudspeaker. Earphones may be connected, if desired, to an audio output jack located at the control panel. This earphone connection may be used also to listen in on programs when the machine is recording directly from a radio. The wire used on the machine is only .004 of an inch in diameter, and each spool, which is about 3" in diameter, will take 66 minutes of recording.

C-D COLOR CODE CARDS

Since the capacitor industry has adopted the practice of marking mica capacitors by a color code, a chart giving the RMA standards for the Six Dot Color Code and the Three Dot Color Code as well as the Army and Navy Standards has been a necessity to users of mica capacitor types. Cornell-Dubilier Electric Corporation has

RADIO INTERFERENCE?





SPRAGUE HAS *the Answers!*

From inexpensive noise suppression capacitors for automotive use, to heavy-duty designs for service on power equipment, and for current ratings from 5 to 200 amperes capacity, Sprague produces modern filter units for practically any need. An unsurpassed background of engineering experience in dealing with all types of radio noise interference problems, is here at your disposal. Write for Sprague Capacitor Catalog 20.

ANTI-RESONANT FREQUENCY PROBLEMS SOLVED

Have you a vibrator "hash" problem that a conventional by-pass capacitor shunted by a mica capacitor only partially solves? Write for details on Sprague* HYPASS Capacitors, the 3-terminal networks that do the job at 100 megacycles or more!

SPRAGUE ELECTRIC COMPANY
North Adams, Mass.

*Trademark Reg. U. S. Pat. Off.

SPRAGUE

ARMY E NAVY

5-Times Cited for Distinguished Wartime Service

PIONEERS OF ELECTRIC-ELECTRONIC PROGRESS

prepared a small card to fit into the pocket which incorporates all three of these standard color codes as well as a larger wall chart. The basis of the code is the use of a distinct color for every number from zero to nine inclusive.

Copies of these Color Code Cards may be obtained free by writing to Cornell-Dubilier Electric Corporation, New Bedford, Mass.

HIGH-SPEED COUNTER

An improved two-decade Electronic High-Speed Counter, designed to fill the need in fields unable to employ conventional mechanical counters, has been announced by Potter Instrument Company of 136-56 Roosevelt Avenue, Flushing, N. Y.

This counter unit is particularly applicable for counts exceeding 10 cycles per second, a rate which is too fast for conventional counters, and in installations where mechanical counters would wear out prematurely because of the high-speed continuous operation.

Used alone as a two-decade instrument, the maximum count capacity of the electronic counter is 100. A tube-operated relay is provided for cases where the quantity to be counted exceeds 100. The relay has a single-pole, double-throw contact which is brought out to terminals on the front panel of the unit, and operates once for each 100 counts.

An electro-mechanical counter may be connected in series with these terminals and an appropriate external power source, such as the a-c line. Each 100 counts of the electronic counter will then cause one operation of the electro-mechanical counter.

When operation of the relay and an external mechanical counter are not in-

volved in the application of the two-decade electronic counter, it may be used alone, at counting rates up to 20,000 per second.

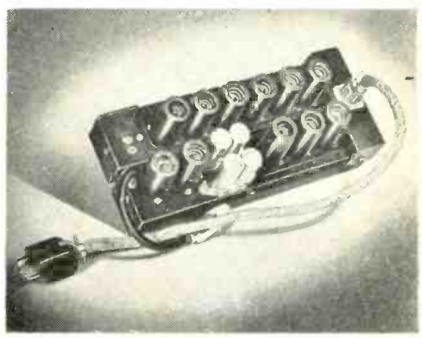
The two-decade electronic counter is complete with power supply, and is ready for operation from a nominal 115 volts, 60 cycle a-c power line. No special types nor special selection of vacuum tubes are required for the counter's 12-tube complement.

For complete information on the counter, write the manufacturer for their bulletin. For individual application problems, the company's staff of field engineers is available for consultation.

U-H-F AMPLIFIERS

Compact, rugged, high-frequency amplifiers for center frequencies between 30 and 70 mc, with any bandwidth from 2 to 10 mc are announced by Sylvania Electric Products, Inc., Industiral Electronics Division, Boston, Mass. These sets are designed particularly for use as i-f amplifiers in u-h-f and s-h-f receiver applications.

A typical amplifier has an overall gain of 100 db with a center frequency of 60 mc



and a half-power bandwidth of 9.0 mc. An external gain control is easily provided. Unless otherwise specified, a standard 500 ohm input impedance is supplied. The output stages are cathode followers designed to operate into impedances of 75 to 100 ohms with voltages ranging from 0.5 to 2.0 volts, negative or positive.

The video detector may take one of several forms according to the special application of the amplifier. In broad-band circuits the frequency characteristics of the rectified video components will be such that the output at 8 mc will be reduced not more than 3 db from the output at 1 mc. These amplifiers will thus pass a square top

Here's the easiest way to get 10 WATTS OUTPUT at 156 Mc!

Build your Xmtr around HK-24G *Gammatrons*

JAN 3C24

Designing transmitters for the 152 to 162 megacycle region can be greatly simplified through the use of HK-24Gs. In the circuit below one of these tubes produces 10 watts at 156 Mc; more than ample to excite a pair of HK-257Bs in a 400 watt final.

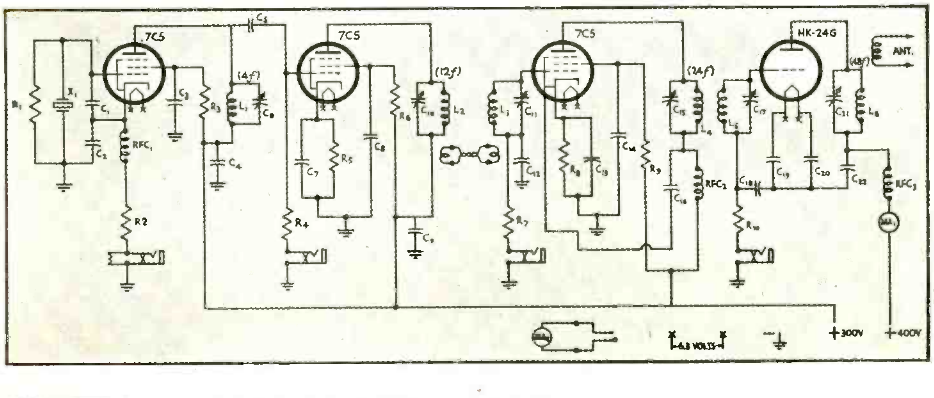
These efficient Gammatrons, with low inter-electrode capacities and short plate and grid leads, are the answer for those who are engineering 1.9-meter equipment for railroads, police point-to-point, fire, press or broadcast relays, maritime, geophysical, urban telephone, and experimental use. They are also ideally suited for amateur transmitters on the 144-148 megacycle band, authorized as of November 15.

Not only will HK-24Gs do the job, but they will do it at low cost. Made with tantalum elements, without internal insulators, they can withstand heavy overloads and have a long operating life. And they are offered at a new low price made possible by improved production methods.

HK-24Gs are available now in quantity . . . and are one of Heintz and Kaufman's *standardized* types. Maximum plate dissipation 25 watts. Write today for data.

Now ONLY $6.00

HEINTZ AND KAUFMAN LTD.
SOUTH SAN FRANCISCO · CALIFORNIA
EXPORT AGENTS: M. SIMON & SON CO., INC., 25 WARREN STREET, NEW YORK CITY, N. Y.



COMPONENT PARTS FOR WIRING DIAGRAM

C_1—35 mmfd.
C_2—250 mmfd.
C_3, C_4, C_7, C_8, C_9, C_{12}, C_{13}, C_{14}—.002 mfd.
C_5—50 mmfd.
C_6—APC 100
C_{10}, C_{11}, C_{15}, C_{17}—APC 25 mmfd.
C_{16}, C_{18}, C_{22}—100 mmfd.
C_{19}, C_{20}—250 mmfd.
C_{21}—15 mmfd.
R_1—100,000 ohms, ½ watt
R_2—200 ohms, 1 watt
R_3—10,000 ohms, 1 watt
R_4—250,000 ohms, ½ watt
R_5, R_8—500 ohms, 1 watt
R_6, R_9—20,000 ohms, 1 watt
R_7—100,000 ohms, ½ watt
R_{10}—15,000 ohms, 2 watts
RFC_1—2.5 mh.
RFC_2,
RFC_3—Hf choke, approx. 50 turns No. 32 on ¼" form.
MA_1—0-100 ma.
MA_2—0-25 ma.
X_1—3.5 Mc. crystal
L_1—19 turns No. 22 DCC ⅝" form
L_2—7 turns No. 14 enamel, 3/16" dia. Length ¾" air, link
L_3 coupled to L_2 with one turn.
L_4—6 turns No. 14 enamel, dia. ⅜", length 7/16" air, induc-
L_5 tively coupled on same axis.
L_6—4 turns No. 12 copper, dia. ⅜", length ⅝"

Note: Grid and plate by-passes on driver and doubler final should be returned directly to tube cathode. All jacks are closed circuit jacks.

pulse having a duration of 0.15 microsecond or greater without appreciable frequency or phase distortion, making them particularly suited to television receiver applications.

Either single ended or balanced input circuits are supplied. The balanced input circuits are designed for use with dual input systems and will distinguish between in-phase and out-of-phase signals from two channels. In one such unit this discrimination is 33 db.

Power supply for a typical amplifier inclues + 105 volts d.c. at 90 ma, + 300 volts d.c. at 20 ma, and 6.3 volts a. c. or d.c. at 1.7 amperes. External gain control requires 0 to — 12.5 volts d.c. at 1.5 ma.

CONNECTOR BULLETIN

A new revised edition of the Cannon Electric Type "K" Bulletin on electric connectors is now ready for distribution. This new and revised edition contains 64 pages of valuable information on "K" and "RK" plugs, receptacles, dust caps, junction shells, stowage receptacles for aircraft, instruments, radio, motors, geophysical equipment, and general electrical applications.

The bulletin contains many photographs, exploded views, production illustrations, orthographic dimensional sketches, and application pictures, in addition to the data on the various styles of "K" connectors.

The bulletin will be sent free upon request from Cannon Electric Development Company, Catalog Dept., 3209 Humboldt St., Los Angeles 31, California.

FINE WIRE BOOKLET

A new 8-page booklet titled "Fine Wire of Special Materials" has been announced by North American Philips Company, Inc., 100 East 42nd Street, New York.

The text material was written by Robert L. Zahour, Technical-Commercial Manager of the company's Wire Division, and brings the reader up to date on manufacturing methods and problems connected with wires 0.002" to 0.0007" diameters and smaller.

Among the subjects treated are:

1. Important steps in producing a good diamond die
2. Drawing the wire
3. Methods for checking diameter, elongation, tensile strength and ohmic resistance
4. X-ray diffraction examination of atomic structure.

The booklet contains ten photos which make the text easy to understand.

MIDGET JACKS

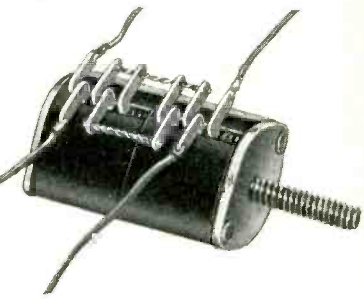
Completely reconverted to peacetime production, within eight days after V-J Day, the Insuline Corporation of America has recently released a post-war series of midget-sized jacks, designed to function wherever space is at a premium.

Three different models make up the line: single closed-circuit, single open-circuit, and a three-way microphone type. Excepting the molded bakelite separators, all materials are non-ferrous. The tooled-brass body and the phosphor-bronze spring members are nickel-plated.

Various new engineering features are incorporated into the design. Arched spring members minimize tension fatigue. Construction holds creepage and dust accumulation to a minimum; and interlocked component parts prevent turning and shorts. Easier wiring, provided for by hook-type soldering lugs, offers another important advantage.

COPPER-OXIDE RECTIFIER

A new full wave, copper-oxide rectifier, rated at either 12 volts a.c. and 50 milliamperes d.c., or 6 volts a.c. and 100 milliamperes d.c. has been added to its line of "Coprox" rectifiers by Bradley Laboratories, Inc., 82 Meadow Street, New Haven 10, Conn.



This new item is actually a double unit of Bradley's Model CX-4D4-F23, recently redesigned to handle much greater capacity than the original version. The single unit is now rated at 6 volts a.c. and 50 milliamperes d.c. continuous. It mounts on a single screw, is fully enclosed and completely sealed with a special plastic compound. Pre-soldered lead wires prevent overheating during assembly.

NOVEL FASTENER

The Rivnut, a one-piece internally threaded and counterbored tubular rivet which can be upset or headed from one side with a simple tool and used as a blind rivet, nut plate for attachment, or both, is now being made in steel, it is announced by The B. F. Goodrich Company, developers of the fastener.

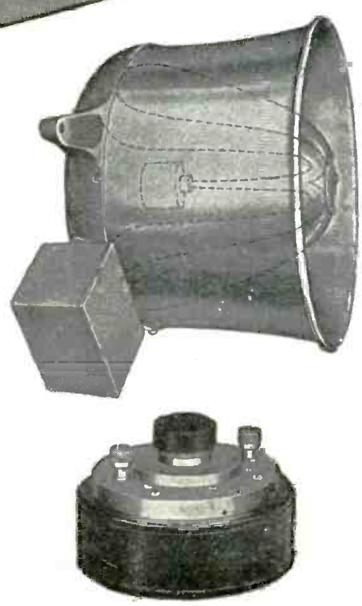
Originally made only in aluminum and then also in a brass alloy, extension to steel will allow much greater utilization of the product, the company believes. The aluminum Rivnut was initially used for airplane industry applications, but the field has been broadened to include many other services.

The new standard steel Rivnuts are made in 6-32 thread, 8-32 thread, 10-32 thread, 12-24 thread, ¼"-20 thread and 5/16"-18 thread. They can be made in special sizes on order.

An additional head style, the brazier head, is introduced; the trailer and bus industry using this because of the ease of cleaning, there being no sharp edges around the head.

CORRECTION

In the vector diagram shown on page 44, third column, of our October, 1945 issue, the designation of one leg of the triangle should have read, $1/\omega C$, instead of $1/\omega^2C^2$. We regret that this draftsman's error slipped by us.



The RACON Marine Horn Speaker is used both as a loudspeaker and as a microphone. Approved by the U. S. Coast Guard for all emergency loudspeaker systems on ships. A double re-entrant type speaker, completely waterproofed and weatherproof. Ideal for general P.A. and Marine use. Several sizes available. RACON Permanent Magnet Horn Units are available in operating capacities of from 10 to 50 watts.

In judging the value of sound reproduction equipment, the month-after-month, year-after-year dependability and efficiency of loudspeakers are prime considerations along with fidelity, output and initial cost.

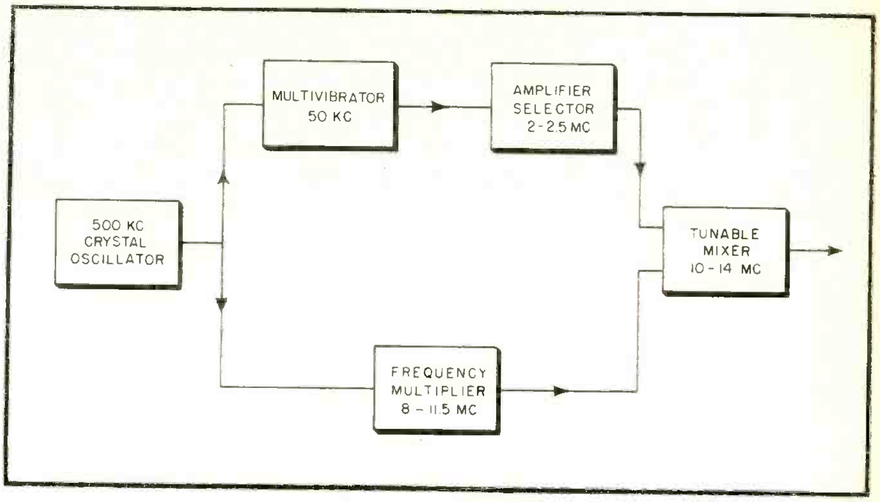
RACON has never compromised with quality. RACON Speakers and Driving Units are recognized as the standards by which other loudspeakers are judged. RACONS are used on U. S. Army Transport and Navy vessels — by other branches of the Military — in factories, schools, auditoria, shipyards, etc. RACONS are available for every conceivable application. Specify RACON when planning your next sound or public address installation

RACON ELECTRIC CO., 52 East 19th St., New York, N. Y.

RACON

INVENTIONS

[*from page* 50]



Patent No. 2,383,005

Frequency Control System

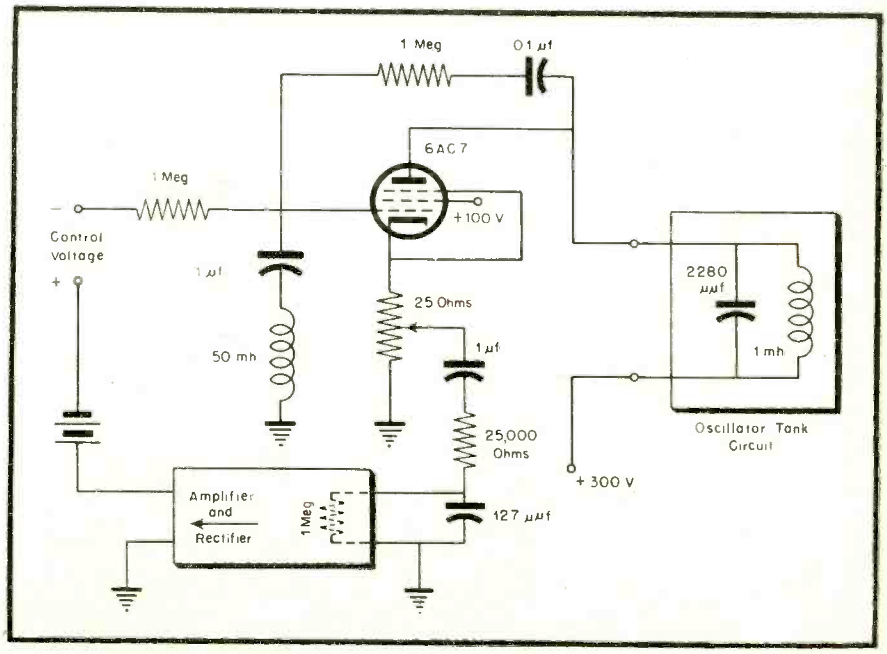
★ In a patent issued to William S. Marks on August 21, 1945, a method is shown whereby a single quartz crystal may be used to establish frequencies for several adjacent channels at frequencies higher than that conveniently reached by the crystal itself. The system is designed to avoid the use of multiple crystals in either the control of a multiple channel transmitter or in a heterodyne receiver which obtains push-button tuning by virtue of switching the frequency of a crystal-controlled local oscillator. A feature of the system is the avoidance of using high multiples or submultiples of the crystal frequency.

The figure shows a block diagram of the system as it is arranged to provide channels of 50 kc spacing between 10 and 14 megacycles. The 500 kc crystal frequency is multiplied to obtain any desired multiple between 8 and 11.5 mc. To the one selected is added a frequency which is a chosen multiple of 50 kc that lies between 2 and 2.5 mc. The addition is performed in a tunable mixer of the usual heterodyne type which is capable of helping to choose the 50 kc multiple desired. The 50 kc multiple in the 2 to 2.5 mc range is obtained by choosing a harmonic of a 50 kc multivibrator which runs with its frequency locked in with the 500 kc crystal oscillator.

The patent, which is unassigned, is number 2,383,005.

Reactance Tube Circuit

★ A method of using a reactance tube to produce a variation of frequency which is linear with control voltage over a greater range is claimed by Frank G.



Patent No. 2,383,436

Marble in a patent granted August 14, 1945. A well-known reactance tube arrangement is used except that, instead of directly grounding the cathode as is usually done, a small resistor is inserted and the voltage across a part or all of that resistor is amplified and rectified in a new circuit. The resulting d-c voltage is used to correct the controlling voltage so as to aid linearity.

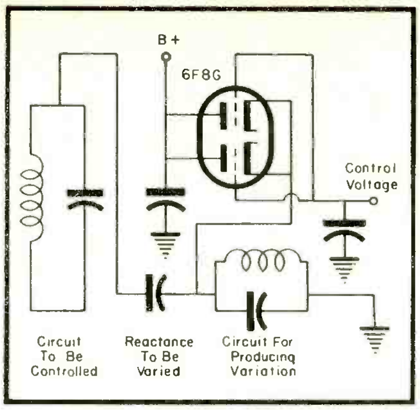
The circuit is shown in the accompanying figure. Numerical values of the components given illustrate the circuit for use when frequency control in the neighborhood of 100 kc is desired. The L and C values chosen for the tank circuit are such that more capacity is needed to tune to 100 kc. The reactance tube and its accompanying circuits, therefore, are required to act like a condenser in parallel with the one shown in the tank circuit. This means that the tube must draw a plate current which leads the a-c plate voltage supplied by the r-f oscillation and do this in a variable amount. This is what a variable condenser does, and if the reactance tube can introduce a variable component of current in such phase relation with voltage and if the strength of that component can be controlled by a d-c grid voltage, then the task of the reactance tube is accomplished. A feedback link between the plate and grid is connected so that the grid voltage follows the plate although with a 90° phase shift. Added this this is the usual 180° phase shift between grid voltage and plate current. These together produce the desired 90° phase advance of plate current over plate voltage, and the d-c level of the grid controls the magnitude of the plate current and, hence, the magnitude of the resulting capacitive effect.

All this has long been well known. The present invention recognizes that in such a device the grid control voltage is not linear with frequency but, instead, follows an S-shaped curve. Furthermore, it recognizes that the cathode current of the tube can be used to correct the grid voltage so that linearity is obtained for a reasonably large frequency range. The method of making the correction is shown in the drawing.

The patent, numbered 2,382,436, is assigned to the Bell Telephone Laboratories.

Reactance Control Circuit

★ An improved method of frequency control obtained by effectively varying the magnitude of a resistance placed in series with a reactance, is claimed in a patent issued to Murray G. Crosby on August 28, 1945. It has long been well known that if a condenser (or inductance) is connected in series with a resistance and then the pair connected



Patent No. 2,383,848

across a resonant circuit, the resonant frequency of the circuit can be varied by changing the value of the resistance. Methods have also been known which make use of a vacuum tube as the resistor, so that a d-c voltage can be made to change the resistance value and, hence, the resonant frequency. The present invention is considered to be an improvement on prior methods of using such a vacuum tube.

In the figure it may be seen that the resistance is really two resistances connected in parallel. These are together connected in series to a condenser so as to form the shunting network of the resonant circuit. One resistor is the impedance of the tuned circuit in the cathode connection to the tube and the other is the r-f impedance from cathode to plate and cathode to grid. The impedance of the tuned cathode circuit is actually very close to a resistance because, taking into account the cathode to ground impedance of the tube, the circuit is tuned to the mean resonant frequency of the resonant circuit to be controlled. The internal resistance between cathode and plate or cathode and grid is only the effective resistance presented by the beam characteristics of the tube because both plate and grid are held at r-f ground potential by large condensers. This resistance in the case shown has a minimum value of 300 ohms, and may be increased by using a control voltage to make the grids more negative than they are when the tube is passing the maximum for which it is rated.

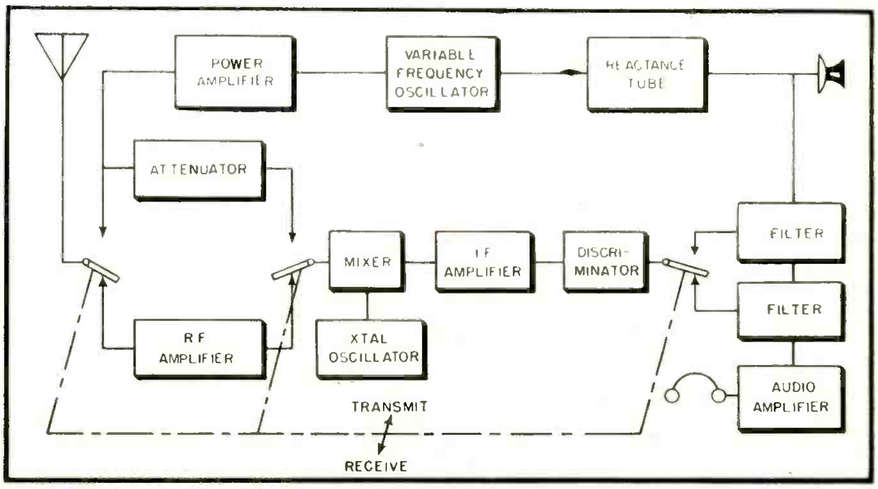
The patent, number 2,383,848, is assigned to RCA.

FM Transceiver

★ On June 26, 1945, a compact and light-weight frequency modulation transceiver was patented jointly by Marc Ziegler, Juan F. Visscher, and Luis J. Cavallero, all of Buenos Aires, Argentina. The design, which is shown in one form in the accompanying block diagram, features crystal control of both the transmitting frequency and the receiver calibration. It obtains simplicity and compactness by using many of the components in both transmitting and receiving operations.

When the three ganged switches are in the position shown, a normal heterodyne receiver with a crystal-controlled local oscillator results. When the switches are changed to the other position, an FM transmitter which uses the main components of the receiver to stabilize the average transmission frequency is obtained. A small portion of the output from the power amplifier is carried back into the i-f strip. If the frequency of the variable frequency oscillator is correct, this feedback signal, after conversion by the crystal oscillator, will produce the correct intermediate frequency to create no discriminator voltage. On the other hand, if the variable frequency oscillator drifts to a new frequency, the i-f signal will change and cause the discriminator to generate a voltage which is applied to the reactance tube so as to correct the drift in frequency.

The patent, number 2,379,395, is assigned in trusteeship to the Hartford National Bank and Trust Company.



Patent No. 2,379,395

THIS MONTH

[*from page* 55]

mental radio relay systems between New York and Washington, New York and Pittsburgh and Washington and Pittsburgh, and a secondary system between New York and Philadelphia.

This first step, a part of Western Union's extensive postwar improvement program, is known as "The New York-Washington-Pittsburgh Triangle." Its establishment in time will permit the removal of approximately 2500 miles of pole lines, with some 54,000 miles of wires and 180 miles of aerial and underground cable.

The system planned for the "Triangle" would provide radio beams in each direction. Each beam could be equipped to provide 270 multiplex circuits, so that 1,080 operators could transmit telegrams simultaneously over a beam in one direction, but there is no present likelihood that traffic between any two cities would require such a large capacity. The radio relay facilities, however, may be used for various kinds of circuits, including multiplex, facsimile and teleprinter.

The FCC has been asked to permit the operation of the "Triangle" on some of the high frequency bands recently allocated for use by radio relay systems. Authority also has been requested to handle commercial telegraph traffic as part of the test program.

The new system is expected to improve the quality, dependability and speed of service provided to the public. It also will make possible substantial savings in the present costs of maintaining and replacing pole lines.

Establishment of the "Triangle" involves the installation of terminal equipment in the four cities and the construction of 21 intermediate relays in towers on mountains or hills ranging from 14 to 54 miles apart and having elevations up to 2900 feet. The towers will be from 60 to 120 feet in height. The sites for the relay stations have been acquired.

The 24-story Western Union Building at 60 Hudson Street will serve as the New York tower, with transmitting and receiving equipment on the roof. A 90-foot tower will be constructed on 41st Street near Wisconsin Avenue in Washington, D. C., and linked with the company's main operating room in that city. A tower will be erected on a bluff overlooking Pittsburgh from which radio circuits will be operated to equipment on the roof of the Chamber of Commerce Building which houses the main operating rooms there. In Philadelphia the roof of the Market Street National Bank Building will be used.

On top of the other radio relay towers, which will be square, will be cabins 12 by 12 feet in size in which reflectors will be mounted for the purpose of directing the radio beams. Most of the equipment, however, will be housed in a building at the base of the tower. Normally the relay towers will be unattended, and will be surrounded by high fences.

An experimental radio relay circuit was established between New York and Philadelphia last spring in cooperation with the

Radio Corporation of America and with the sanction of the FCC. It has been successful in meeting all of the tests imposed, it was stated, and provided the experience required as a foundation for the proposed nation-wide radio relay system. Under an agreement with R.C.A., the telegraph company has the right to use all inventions of R.C.A. and those under which R.C.A. has the right to grant licenses. The experimental circuit is in operation between the Western Union Buildings in New York and Philadelphia, with intermediate relay towers at New Brunswick and Bordentown, N. J.

HERMETIC SEALING

[*from page* 47]

The usual method of assembly is: (1) Solder glass-to-metal terminals to bottom cover and attach internal support brackets; (2) fasten core and coil to brackets and solder leads to terminals; (3) slip on case walls and solder to the bottom cover; (4) pour in potting compound, and solder on top cover; (5) finish with zinc chromate primer and a salt-water resistant lacquer.

Resistors

Wire-wound resistors have been constructed for many years by winding a cylindrical ceramic core with a helix of resistance wire of a nickel-chromium alloy. At full load rating, the maximum operating temperature is 275 degrees C. At this temperature, only inorganic coatings, such as vitreous enamel or a ceramic cement, could be used to protect the wire from corrosion. These coatings were not able to withstand the test thermal shocks without cracking; subsequent cycling in salt water would corrode the wire and change the original resistance.

Fig. 8 shows a new type of sealed construction in which the wire-wound ceramic core is enclosed in a pyrex glass tube. The ends of the glass tube are metallized and the monel metal ferrules are soldered to the metallized bands with pure lead. These resistors will meet Army-Navy Specification JAN-R-26 for Type GRW Grade 1—Class 1 resistors.

Sealed Relay

The sealing of relays is very similar to that for transformers. The same methods of mounting and terminal construction are used. Relays, however, cannot be potted. The best treatment is to dry them thoroughly before sealing them into the case. If a metal tube is attached to the case, the case can be evacuated and filled with an inert dry gas such as nitrogen. The metal tube can then be pinched off and soldered to maintain this inert gas. *Fig. 9* shows the steps in the sealing of a standard telephone relay.

BOOK REVIEWS

[*from page* 30]

the fundamental principles embodied in the preceding chapter. These are not practical problems or applications of the theory. Indeed the only practical applications of the theory appear in the last chapter which deals with elementary applications of the theory alone.

The first chapter deals with elementary electrical network theory involving Kirchhoff's Laws, impedances in series and parallel, the basic laws of electricity, Thévenin's Theorem, dimensions of electrical quantities and the general behavior of linear and non-linear circuit elements. This chapter is essentially non-mathematical for the most part and while somewhat brief, does serve as an excellent introduction to succeeding chapters which are essentially mathematical in character and deal with differential equation, hyperbolic functions, resistance-capacitance networks, resistance-inductance networks and networks containing resistance, capacitance and inductance. Transient analysis is essentially a complicated mathematical subject. Even this treatise which is intended largely as an introduction to the subject is greatly mathematical. However, classical treatment of the subject, involving conventional differential equations only, is employed throughout the book.

In spite of its mathematical nature, the book is not difficult to read. It does, however, require more attention and concentration than is likely to be given by the casual reader. The text is written in interesting style: it appears to be free from errors and it covers its field extremely well. The author develops each point in sufficient detail so that the reader is unlikely to misunderstand the intent. The text is particularly well illustrated, employing some 179 figures. It is recommended to all communication engineers interested in this absorbing subject.

INSULATING MATERIALS

[*from page* 43]

more flexibility than any of the ceramics.

We must therefore repeat the statement made at the beginning of this series of articles: there is no perfect insulation: each must be weighed on its own merits for the specific application.

Ceramics Classified

Considering properly only the ceramics, the distinction must be drawn between the glass or thermoplastic forms and the steatite or thermosetting forms. Certain likenesses exist between them, but certain marked dissimilarities also exist.

Glass is formed at many temperatures, from about 700°C to about 2000°C. Steatite forms are fired between 1000°C and 1500°C.

It is almost axiomatic that closer tolerances on dimensions can be held at the lower firing temperatures: and that certain other properties must be affected deleteriously by lower temperatures of firing. Porosity of the final structure for a given form of material will usually vary inversely as the firing temperature: harder, denser material will result from the higher temperatures, likewise. These statements are correct until overfiring of the body occurs.

The thermoplastics may be divided into two major sub-groupings: glass and glass-bonded mica. Each of these groups may be re-subdivided in turn. Glass may be a silica, silicate, borosilicate, or borate form: glass-bonded mica may be a compression-molded material, an injection molded material, or may occur in combination with other ceramic forms with a resultant higher dielectric constant.

The thermosetting forms may be divided into several groupings for ease of identification: steatite, porcelain, refractory, and rutile. Steatite, as a generic term, encompasses true steatite, cordierite, and zirconites. Refractory, as a term, also includes porous bodies such as alumina. Rutile (titanium dioxide chemically) is used to include the titantates.

The Thermoplastic Ceramics

Glass, as indicated above, is prepared from pure silica in combination with certain metal salts. Most commonly allied metal is boron, whose salt forms a low-melting-point glass itself. To glass is added certain metal combinations such as lead, aluminum, potash, soda, or lime. These materials, when added, will cause the firing temperatures and thermal expansions to change greatly, in addition to major changes in the electrical properties.

Borates or borosilicates, when fused in combination with mica, form glass-bonded mica, known by several proprietary names. As a thermoplastic the material lends itself to either compression or injection molding, a characteristic of the borate or borosilicate glass itself. Because of the extreme pressures and relatively high temperatures of molding, mechanical difficulties in extrusion molding this material, have been encountered. When other ceramic forms are added to the basic mica and glass, variations in the dielectric constants can be obtained.

The Thermosetting Plastics

Steatite—including the cordierite and zirconite types—is made from silicon dioxide in combination with other metal oxides. In the case of pure steatite, it is made from magnesium dioxide and silicon dioxide in combination. The raw material is known as talc.

Zirconite is made from zirconium dioxide-silicon dioxide; cordierite is made from a magnesium aluminum silicate.

Each of these materials has separate properties. Steatite is known for its extremely low electrical loss but also for its inability to resist extreme thermal shock conditions. Both zirconite and cordierite are known as relatively low loss materials with good thermal shock resistance. Both cordierite and zirconite have been used successfully in metal-to-ceramic sealing applications.

Again it is almost axiomatic that a low-loss material will resist thermal shock inversely proportional to its dielectric loss factor. Any thermal shock requirement will mean a compromise with the loss factor.

Porcelain is again a metal silicate. A similar material, fired at a lower temperature and therefore having more porosity is the refractory body. Electrical porcelain has been successfully employed for power frequency applications, but it is virtually unusable for extremely high frequency applications; refractory has been used frequently for heater plates where good dimensional tolerance and freedom from warpage is required. Alumina, a porous aluminum oxide form, has been used for high heat applications, such as vacuum tube electrode spacers, etc.

The most recent addition to the thermosetting ceramic family is the rutile form. Although known for some time, its properties were not fully exploited until the war. During that time, it was used successfully as the basic material for ceramic capacitors. Moderate use was made of this material before the war.

Rutile (titanium dioxide) has a dielectric constant of approximately 85. However, when procured in the titanate form with calcium, barium, etc., dielectric constants over 3000 have been obtained. Loss factors rise out of proportion to the dielectric constant, and the more over-compounded the material the higher the dissipation factor.

All of the thermosetting ceramics are capable of wet or dry pressing(defined only by the moisture content of the raw material) or of extrusion. After the initial forming by one of these processes, the part is slowly passed through a superheated oven and allowed to cool gradually. During this time, all moisture is driven from the body and chemical change takes place; if the drying-out process is carried far enough, the material becomes hard and vitrified.

The reader, I am sure, appreciates the fact that any introductory article must scan the field and leave more detailed analyses until a later time. Succeeding discussions will survey the glass-bonded micas, the glasses, the steatites, and the rutiles.

IRON CORES

[*from page* 40]

the core due to the free ends, is related to μ_e (from the graph) as follows:

$$\mu'_e = \mu_e \sqrt[8]{\frac{L}{l}}$$

Thus increasing the core to twice the coil length will yield a 26% increase in effective permeability; and a core 8 times longer than the coil will double the effects.

Typical Problems and Their Solution

Let us take a practical problem: a core material of permeability 10* in the form of a cylindrical slug having an L/D ratio of 2(.950 cm dia. by 1.9 cm long.) is put inside of a coil of mean turn diameter of 1.18 cm and also 1.9 cm long. The graph gives a value of μ_e as 4.6 at this L/D ratio. What is the resultant change in inductance?

Two corrections now need to be applied. The free end correction $\mu'_e = \mu_e \sqrt[8]{\frac{L}{l}}$ where μ'_e is the corrected value of effective permeability, μ_e is the graphical determined effective permeability. l = coil length; L' = core length. Substituting in the formulae, we find $\mu'_e = \mu_e = 4.6$. Now to correct for the area. The actual inductance change due to iron

$$\frac{L\,i}{L\,a} = \frac{(D^2)}{(d^2)} (\mu'_e - 1) + 1$$

D = core dia.
d = coil dia.

μ'_e is the graphical determined effective permeability corrected for end effects. In our case d = 1.18 cm and D = .95 cm. Substituting in the formulae:

$$\frac{L\,i}{L\,a} = \frac{.90}{1.39} (4.6 - 1) + 1 = 3.32$$

This value 3.32 which we have defined as effective permeability is the actual increase in inductance due to iron and agrees very closely with the measured value of 3.34.

Another case† where the core length 1.94 cm is much greater than coil length .42 cm. The graph for L/D = .45 and

*Core material permeability for different grades of materials is usually given in the catalogues of reliable core makers. See bulletin of Stackpole Carbon Co.

†Coils made by S. W. Inductor Co., Chicago, Ill.

a composite permeability of 10, gives the effective permeability μ_e as 2.07. Applying the end correction

$$\mu'_e = 2.07 \times \sqrt[3]{\frac{1.94}{.44}} = 3.38$$

In the above case the mean turn diameter of the coil is .95 cm, the core diameter being 1.35 (diameters are used as they are easier to handle than areas). The actual inductance change is given by

$$\frac{L\,i}{L\,a} = \frac{(.95)^2}{(1.35)^2} \times (3.38 - 1) + 1 = 2.17$$

Here the calculated μ_e is 2.17, the measured value is 2.35, a slight disagreement due to the leakage in the pancake type of coil.

Conclusion

Thus we now have at hand the figures for the expected inductance increase: for an entirely closed core (toroid) in which the effective and apparent permeabilities are the same, and for an open core having free ends: the enclosed graphs fully covering the determination needed. But there is also a wide variety of semi-closed magnetic cores, such as the pot type (pill box), E & I shaped cores and binocular pairs. Obviously the effective permeability of these structures will have a value lying between the closed toroid and the open cylindrical slug type. The analysis of such forms is also possible but has not been undertaken by the writers, due to the multitude of shapes and sizes and the complete lack of standard sizes.

It remains to mention that there are compressed materials composed of flake type powder (electrolytic iron) which is so pressed that the flakes lie substantially along the magnetic axis of the core. In such case we have directional permeability, greater in the direction of its intended use and care should be taken in measuring such slugs so that the magnetic axis is in the right direction.

It is hoped that with the completion of this study of effective permeability the engineer will find consideration of the different applications of iron cored coils an easier task. He can then more quickly arrive at the optimum coil design from the standpoint of: (a) coverage in movable tuning cores; (b) efficiency in iron cored loop antennae; compactness and efficiency of fixed coils.

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"HIGH FIDELITY"

[from page 37]

tionable phase shifts so prevalent with other circuits.

A further improvement in amplifier design results when balanced feedback[7] is employed. The advantages of the usual degenerative feedback are then maintained without an appreciable loss in amplification and with a much sharper cutoff characteristic at the ends of the desired frequency range. Abrupt cutoffs as shown in *Fig. 11* are particularly desirable for both radio and phonograph reproduction. A sharp cutoff at the high frequency end of the range eliminates distortion that might be present due to higher order harmonics, while a sharp cutoff at the low frequency end will materially reduce turntable rumble.

The sound waves of music and speech are not pure tones but consist of fundamentals and often many harmonics or overtones. These harmonics are the means by which the various instruments are distinguished from one another and provide the individuality and quality of the music or speech. Such complex waves, which are not often harmonically related, give rise to intermodulation products if at any point in the system a non-linearity exists. The result is quite harsh and disagreeable to the ear. Distortion of this type (often called two-frequency distortion) may not show up in the ordinary harmonic analysis: in fact, higher harmonics of the usual amplitude type are often outside the range of audibility and are therefore not important. But intermodulation products may lie anywhere in the band, and for this reason it is imperative that they be measured and minimized if necessary. A common complaint when listening to a system having appreciable intermodulation products is that when an entire orchestra is being reproduced the sound seems mixed up or run together, yet when a solo part is heard the quality suddenly becomes clear. This is because fewer intermodulation products are formed. A common source of two-frequency distortion is often due to inadequate low frequency carrying capacity, so the power capacity of the unit should be of the order of 20 or more watts.

If it were not for the non-linear characteristic of the ear, especially when the volume level is changed, the problem of designing a high fidelity system would be comparatively simple. A common fault with many high fidelity receivers lies in the fact that proper compensation for the ear characteristics have not been taken into account at all volume levels. The ear has a comparatively flat response only at extremely high volume levels; this condition is reached at approximately the same point where the sensation of feeling begins and the sensation of hearing stops.

Referring to the equal intensity contour of the ear it is apparent that a system having a frequency characteristic which is flat is not to be desired. At volume levels corresponding to that of a very loud radio, sound reproduction usually seems to be quite good. This is true for two reasons: the level more nearly represents that of the original, and the ear characteristic is more nearly flat. However, even at levels of 85 db above threshold an increase of approximately 6 db is required at 65 cycles to make it equivalent to that at the middle frequencies. In the region of 3000 cycles (most sensitive region of the ear) a decrease of 3 to 5 db is desirable. As the frequency is increased up to 8000 cycles the amplitude must again be increased, as at the low frequencies, by approximately 10 db. These corrections are required to make up for deficiencies of the ear at high intensity levels. As the sound intensity is decreased to very quiet, additional compensation is required. As much as 30 db at 65 cycles and 12 db at 8000 cycles being required.

It is obvious that with such a non-linear characteristic as this some sort of compensated volume control must be used, which automatically adjusts the frequency response as the sound output is changed. Without compensation, the quality becomes unnatural at low volume levels and, since more persons listen at these levels, it is important that compensation be correct. Bass compensation has long been more or less standard practice but little attention had been given to correlating the compensation with the characteristic of the ear. Automatic treble compensation has not been so widely used. *Fig. 12* shows how the frequency response of a high-fidelity system should vary over the volume range ordinarily used in the home.

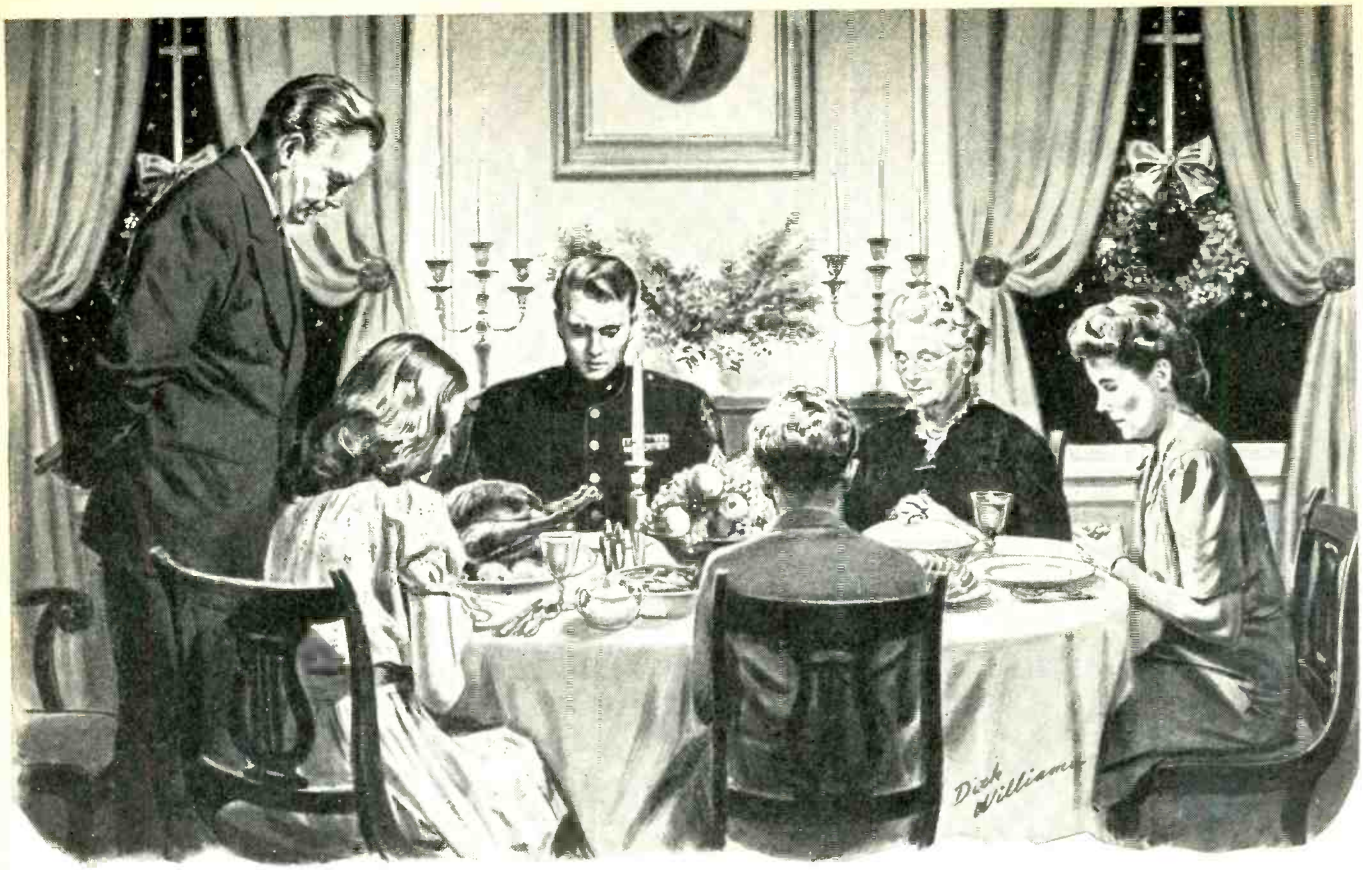
Summarizing we find the following points of interest:

1. A frequency range of 65 to 11,000 cycles having a relatively sharp cutoff at each end of the range is the most desirable. Practically a balanced range of 70 to 8000 cycles will be entirely adequate for most programs.
2. The amplitude characteristic should follow the equal loudness contour curves of the ear at their respective levels.
3. Amplitude and intermodulation distortion should not exceed two percent.
4. The acoustic response should be as nearly uniform as possible, at least over an angle of 90 degrees.
5. Power capacity to handle peaks of power with a dynamic volume range of at least 45 db.

Recommendations for accomplishing these requirements are:

1. Beam power amplifier of at least 20 watts output.

[Continued on page 74]



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It must be recognized that the ear is the final judge of the faithfulness of reproduction and that psychological, physiological and physical (room acoustics) effects must be considered.

The goal for the designer of high fidelity equipment is reached when the reproduction sounds like the original and not like a radio. True high fidelity has then been achieved.

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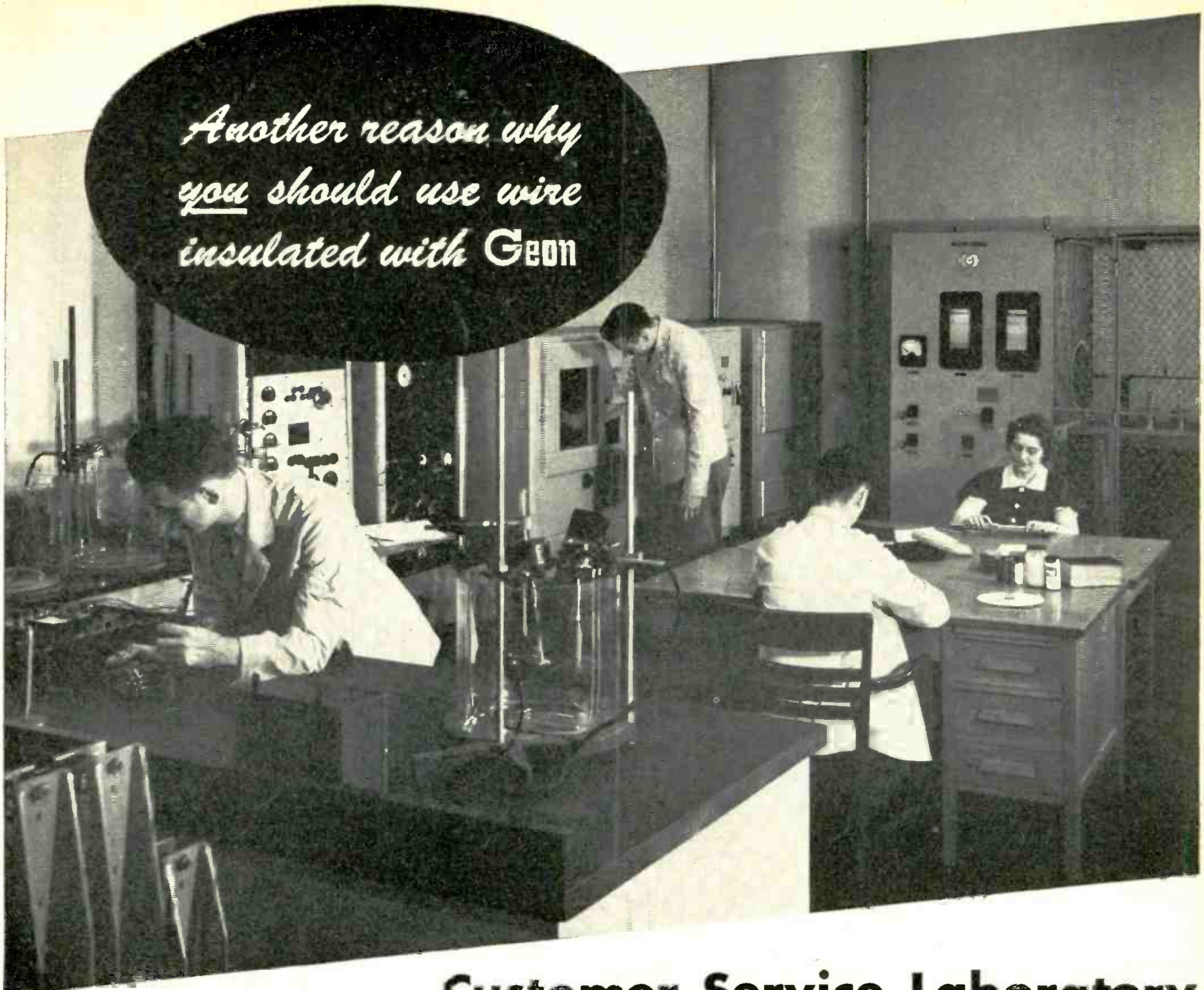
ADVERTISING INDEX



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