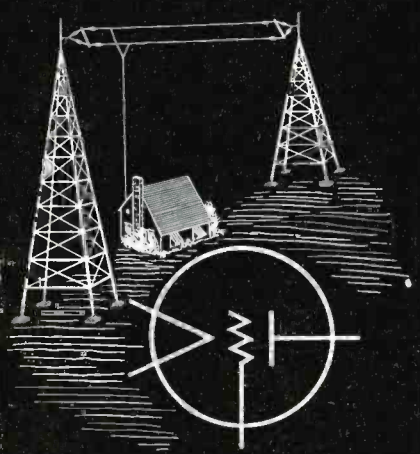
SEPTEMBER, 1932

# Radio Engineering



IN THIS ISSUE



TWELFTH YEAR OF SERVICE

The Journal of the Radio and Allied Industries

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# RADIO ENGINEERING

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Vol. XII . SEPTEMBER, 1932 Number 9


## Contents



## Departments



### TRADE ASSOCIATIONS

RECENTLY at the headquarters of the Chamber of Commerce of the United States, the Trade Association Department held an all day conference discussing the department's program for the immediate future.

Detailed plans were discussed, involving:

a. Trade association publicity program
b. Study of organization structure
c. Classification of activities
d. Analysis of trade association statistics
e. Cooperation with unorganized groups
f. Study of trade promotional activities.

The committee recommended that:

a. *The National Chamber should take such steps as may be deemed advisable to urge leading business executives to actively participate in association affairs and not turn such responsibility over entirely to secondary officials.*
b. Trade associations and the National Chamber should consider present and additional activities as they may pertain to the elimination of uneconomic practices and the establishment of a "profit-consciousness" in industry.
c. Trade associations individually should be urged to inaugurate or enlarge a program which will make known to the public the public welfare aspects of their particular efforts.

A report of the action of the committee was submitted to the board of directors of the National Chamber.


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*Secretary*

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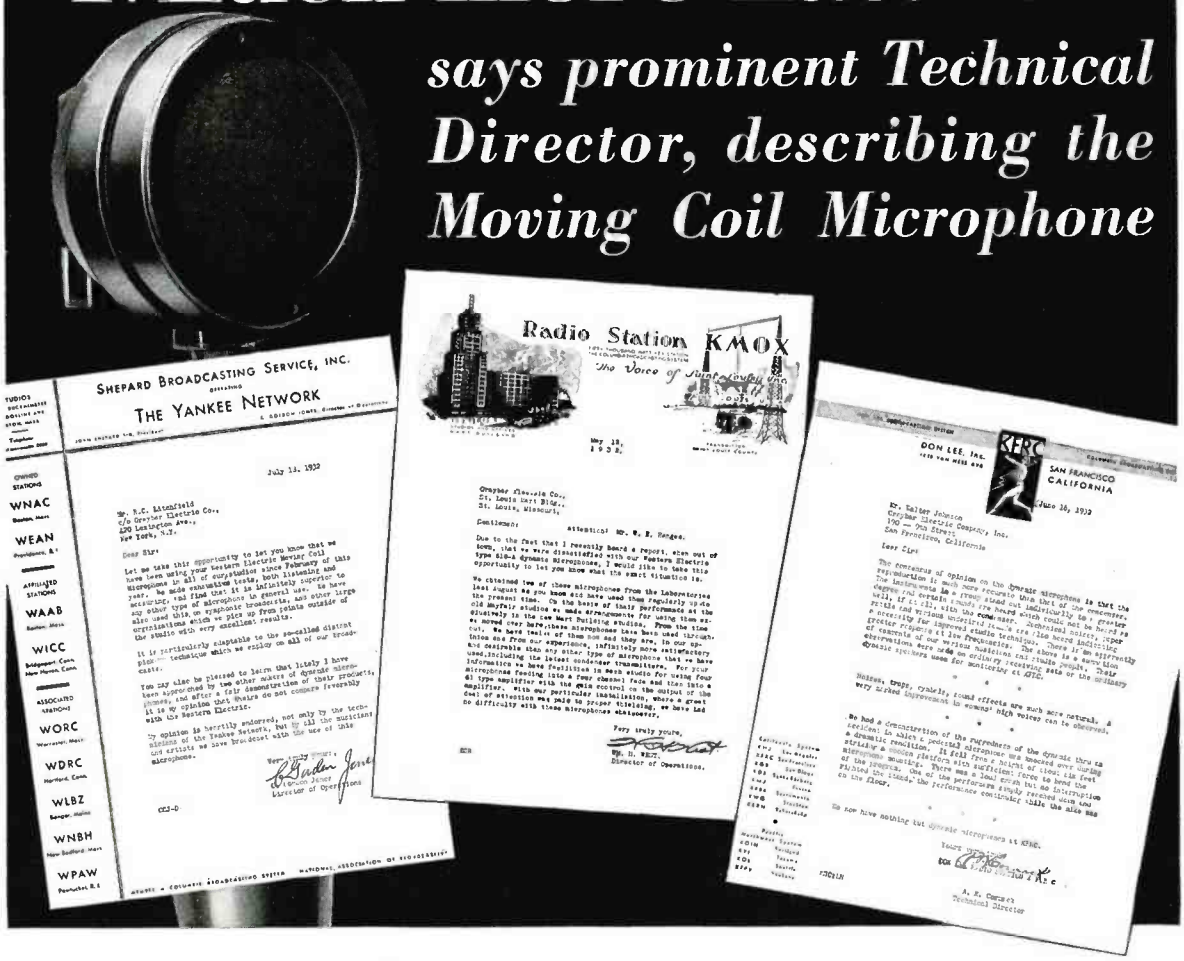
# "Much more natural"

## *says prominent Technical Director, describing the Moving Coil Microphone*




Complete satisfaction is expressed by the Broadcasting Directors whose letters are reproduced above. With uniform response throughout the audible frequency range, the new Western Electric Moving Coil Microphone provides clear, undistorted pick-up whether it is used to cover one or many artists—whether the program is instrumental or vocal or both.

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# Editorial

SEPTEMBER, 1932

**RADIO INDUSTRY COOPERATING FOR PROSPERITY**

AMERICAN publicists of a sociological turn appear to feel that we shall not make an approach to the millennium until, and unless, correction is effected of the many wrongs which have developed and accumulated throughout the years. Citizens of secure independent means and citizens whose needs are limited; that is, those who have least fear for the future, identify the current wrongs as "blocs," "lobbies," "corruption of the courts," "political graft," "disregard for laws," "organized panhandling," "rackets" and so on.

Other citizens, among whom are numbered men identified with government and with industry hold to the practical view that the first essential is material prosperity, even if every last person does not participate in its blessings. They believe that so far as our country is concerned there will always be balances of public opinion which in time will either right the wrongs, or hold them in check so that there shall be no national disaster. They believe that in any event wrongs may be righted more sanely while the mass of the people enjoy prosperity than when millions of them are on the bread lines.

This is about the situation at the present time. Governmental and industrial leaders are now engaged in a strongly supported, widespread drive to restore material prosperity. That the radio industry has faith in and is supporting this constructive movement is now evident on all fronts.

▲

**THE FEDERAL RADIO COMMISSION**

THERE are many persons asking the question, whether the Federal Radio Commission has not served its purpose to completion, so far as that can be accomplished by a Commission.

The wide analysis to which governmental expense is being subjected no doubt has directed attention to the million dollars per year it costs the taxpayers to maintain the Commission. In five years the Commission's staff at Washington has grown from a dozen employees to 137.

General C. McK. Saltzman, who recently resigned as chairman of the Commission, answering a question of a member of the budget committee of Congress, said: "I do not see why they should not pay the expenses of this commission." He referred to the broadcasting companies. Presumably General Saltzman believes that the Commission should be continued but that its cost should be shifted from the taxpayers.

Those who recall the ethereal chaos which obtained prior to the enactment of the 1927 radio law and its enforcement by the Radio Commission in the years that followed surely should recognize that vast improvement took place. Radio engineers were aware that much of the constructive change that occurred was a credit to the expert cooperation contributed by the radio section of the Department of Commerce. Others thought that the radio law itself —the heavy hand of Washington—was the main corrective element. There was much adverse comment on the makeup of the first Commission, certain members thinking mainly of the rare opportunity for personal publicity to be capitalized later when they ceased membership thereon. But, so far as that is concerned, it is not likely that other applicants for the commissionerships, considered at the time, could have accomplished more than was worked out during the first two years. It is history also that as the original members dropped out they have been replaced by others said to be even less fitted for the duties involved.

The present popular revolt against governmental commissions of all kinds could hardly avoid including the Federal Radio Commission, but it is to be hoped that it will survive in a form equal to the task of preventing a return to the chaotic conditions of 1920-26.

Donald McNicol

*Editor.*

# HAVE YOU HEARD THIS ONE?

**(Read the story outlined below. This is an expensive way to drive home a point, but we think it will prove a mutual benefit.)**

A farmer owned a horse that required a bucket of oats for feed every day. The harvest was poor, so the farmer fooled the horse by holding out some of the oats and by putting in some sawdust instead. The trick worked so well, the farmer kept it up; each day he increased the sawdust and decreased the oats. The horse's hide looked sleeker than ever . . . but he died.

Receiver manufacturers have the same problem as the farmer. To keep up the exterior beauty of their line or to keep down the price, they sometimes skimp on the inside. They forget . . . it's the inside of the set that counts.

Because the majority of sets get most wear on their volume controls, it is foolhardy to gamble with cheap, untried controls, . . . especially when the finest controls available—Clarostats—can be had at a cost no higher than others.

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RADIO ENGINEERING

Production, Administration, Engineering, Servicing

Vol. XII SEPTEMBER, 1932 No. 9

# Gang condensers of variable capacity for modern receivers

By E. D. KOEPPING*

**Comparison is made between inductance tuning and capacity tuning of radio receivers. Microphonics—acoustic modulation—of tuning condensers is analyzed.**

OF several possible ways in which the resonance frequency of a tuned circuit may be varied through a frequency spectrum representing a ratio of approximately 3 to 1 the evolution of receiver design rather quickly chose the fixed inductance and the variable condenser. That the choice was a wise one is evident from the fact that all the improvements, advancement and refinement of the last eight years have failed to dislodge this system from its position as the one exclusive method used commercially. Tubes have come and gone, the regenerative receiver ran its course, tuned radio-frequency amplification rose to its pinnacle and passed away when the superheterodyne took the field—but through it all the little fixed coil and the variable condenser continued as the basis of the tuning systems of them all.

Much midnight oil has been burned by industrious investigators in efforts to find other means as efficient, as economical, reliable and simple as the fixed coil and the variable condenser for a tuning system, but so far these efforts have been productive of nothing commercially competitive. The coil designers, the manufacturers of insulating material and the manufacturers of variable condensers had also been laboring mightily, and rapid strides were made which greatly improved the electrical characteristics and the mechanical perfection of the coil and condenser system. So much so that perhaps a few measurements and some calculations, inserting r and $C_d$ into the formulas, might somewhat discourage some who venture too blithely where the disillusioned will not tread. It makes an engaging picture to consider $\frac{L}{C}$ — and say that the larger the value of L the greater the voltage, the sharper the resonance curve and consequently if we eliminate C and tune by inductance only we shall have perfection.

Inductance coils are made of metallic conductors and these conductors have area and consequently they have the property of capacity and so you cannot eliminate C from the equation. These conductors also have resistance and the larger the inductance the higher the resistance and this property of resistance is the rock on which schemes for tuning by inductance variation have nearly always been wrecked. A coil suitable for receiver design probably has from 150 to 240 microhenrys of inductance and by careful designing its resistance may be held down to 12 ohms at 1,500 kc. and perhaps 5 ohms at 550 kc. Contrast with this the equivalent series resistance of its companion, the variable condenser, which at 1,500 kc. is 3 ohms and at 550 kc. is 1.5 ohms, and it becomes obvious that the inductance element is not a solution that a formula or law unilluminated by the light of experience might lead the unwary to believe. So the coil and condenser have continued as the generally acepted tuning means.

The fixed coil and variable condenser system for tuning may be readily and economically designed so that the frequency distribution follows any given law, or even any desired combination of laws. So a receiver for any class of reception may readily be designed to meet the exact needs of its field and afford easy manual separation of channels. In the broadcast field this is a fact of no small consequence. The desired frequency distribution is obtained, of course, by shaping the variable condenser plates in such a way that capacity is introduced into the circuit at a rate, in relation to the axial rotation, that gives the desired result. The laws governing such designs need hardly be discussed here. Most of them are well

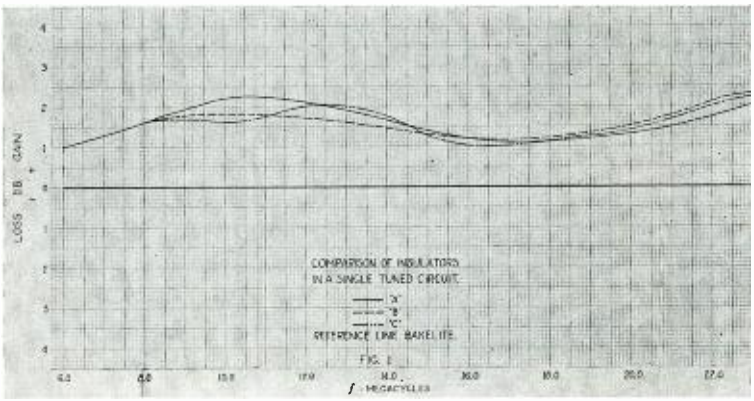


Fig. 1.

*Chief engineer, Radio Condenser Co., Camden, N. J.

known and they are quite suitable for use in actual commercial condenser design and the resulting condenser unit seldom needs very much, if any, correction. In this art, as in any other, the proper handling of design constants is necessary to secure the exact results desired.

### Evolution of Condenser

The variable condenser has passed through an interesting evolution in the past ten years. The earlier receiver designs used single units, each turned by its individual dial. About six years ago the multiple or "gang" condenser came into its own and has continued in use ever since. An interesting point is that the gang condenser seems to have reached its zenith of size in the era of 1929, and the effect of the midget receiver and the depression are reflected in the more compact and less expensive designs of 1930 and 1932. Though the size has been decreased all the very real mechanical and electrical improvements have been retained in the smaller designs, and some have been added.

Design problems of today cover not only receivers built for reception on the regular channels but also involve converters, automotive receivers, short-wave receivers and combination receivers which will provide reception of the illusive high-frequency broadcasts.

For short-wave receivers special gang condensers have been designed. These gang condensers are small in size and have a very low minimum capacity. The selection of insulating material for supporting the stators brought to light the fact that up to 20 megacycles, at least, there was but little difference between two expensive insulating materials and another much cheaper one. Comparisons were made by setting up a tuned circuit and substituting in this circuit condensers identical in every way except for the stator insulators. The reference, or zero line, was taken from the circuit when using a condenser unit having insulators made from an exceptionally good grade of laminated Bakelite. The results are shown as the improved gain plotted in decibels in the chart, Fig. 1. The results very definitely prove that neither a nor b is worth the additional cost if the condenser is not to be used at frequencies higher than those considered.

The design of these combination short-wave and regular channel receivers and the housing of both in a single cabinet and also the regular midget receiver has brought to the front a condition peculiar to the superheterodyne. In common parlance it has been called "microphonics," though acoustical modulation is perhaps a better and more descriptive term. When this condition first came to attention the variable condenser was criticized in no uncertain terms. This conclusion was based on the assumption that either the stator or rotor plates of the condenser units vibrate due to coupling of the speaker and chassis. If this vibration takes place it would cause a continuous swing, or beat, of the intermediate frequency and so the audible frequency of the note produced would depend on the frequency change of the oscillator circuit and is a frequency modulation of the oscillator.

Some of the expedients that have been used in efforts to eliminate acoustical modulation by changes in condenser design are the use of solid outside rotor plates, heavy outside rotor plates, dead soft metal for all rotor plates and felt dampers across the rotor plates. The degree of success attained in suppressing acoustical modulation by the use of any of the foregoing methods varied with individual receiver design. In cases where the tendency toward acoustical modulation was only slight any one of these methods might have reduced the tendency to a point where it was no longer troublesome. In the majority of cases where violent acoustical modulation difficulties are encountered changes in the oscillator tuning condenser design have only a limited effect on the acoustical modulation. So it is quite plain that such methods can never completely eliminate this condition, and elimination of the cause is the proper procedure rather than the application of partial remedies.

### Tests for Microphonics

To further check the assumption that vibrating condenser plates are responsible for acoustical modulation a series of experiments were carried out with a well-designed superheterodyne midget type receiver. Starting with the oscillator circuit, the tuning condenser was disconnected. A single unit variable condenser was connected in its place, by means of flexible leads, and suspended from the ceiling by means of a cord and spring, close to the chassis. With this structure there could be no possibility of mechanical vibration of the condenser plates being caused by any chassis vibrations. The receiver was realigned and tuned to a 1,000 kc. unmodulated carrier. The condition of acoustical modulation was still present.

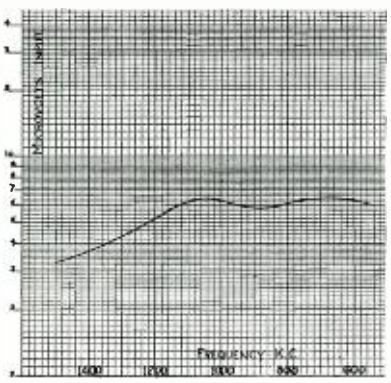


Fig. 2. Sensitivity. Superheterodyne receiver. 507.5 kc. i-f. amplifier.

The original oscillator circuit was reconnected and the above experiment was repeated with each of the two remaining tuned circuits which were the radio frequency input and the first detector input circuits. In each of these cases a slight decrease in sensitivity to acoustical modulation was noted.

A fourth experiment was then carried out in which a mica compression condenser was used for tuning the oscillator circuit. It was still possible to secure acoustical modulation.

A fifth experiment to check all the components of the oscillating circuit was to substitute an entirely separate oscillator circuit, operated by batteries, for the one in the receiver. It was still possible to secure acoustical modulation.

Further experiments were conducted in which the resistors used in critical circuits, coil mountings and tubes were in turn flexibly connected to their respective circuits instead of being rigidly anchored to the chassis. None of these tests had any appreciable effect on the degree of acoustical modulation obtained.

Complete elimination of acoustical modulation was possible only when either the chassis or the cabinet was suspended above the table thus preventing any vibration of the cabinet and speaker from being transmitted to the chassis.

So, we can believe only that acoustical modulation is caused by mechanical coupling between speaker and chassis, through the medium of the cabinet, and the only good remedy is the insertion of a mechanical filter between chassis and cabinet. Such a filter consists of live rubber pads in which the chassis is held free from any rigid contact with the cabinet at any point. With such a mounting it is unlikely that any acoustical modulation will occur on modulated signals, and with an unmodulated signal only under conditions of extreme overload. Of course it is assumed that all regeneration in both the radio frequency and intermediate stages has been eliminated. Regeneration has been one of the chief causes of acoustical modulation in midget receivers in which a single high gain intermediate stage was used.

### Gang Combinations

At the present time there is a tendency on the part of engineers who are working on designs of receivers for both short-wave and broadcast reception

to combine the two condensers, and dials formerly used, into a single gang of an equivalent number of units, and a single dial carrying the required tuning scales. Shifting from one tuning scale to another is then accomplished by means of a switching mechanism operated from the panel. It is quite possible to build a gang condenser carrying units of different capacity values and even with widely different capacity curves. Such a gang condenser is probably somewhat less expensive than the two separate gangs, and its use makes for a more compact and economical receiver design. A typical case is a five gang condenser carrying two identical units for tuning the signal frequency circuits of a broadcast superheterodyne receiver, a unit having specially shaped plates to tune the oscillator circuit and two units of lower capacity which are used to tune the circuits for short wave reception. The material of which the stator insulators of the units used for tuning the high frequency circuits are made may, if desired, be different from that used for the other units. In this way circuit losses may be minimized. Probably the only real improvement in performance secured in this way is that of improved selectivity as the increased sensitivity is not very important, for, as a general rule, a short-wave broadcast signal is either "in," in which case sensitivity is of small moment, or it is "out" and increased sensitivity will never bring it "in."

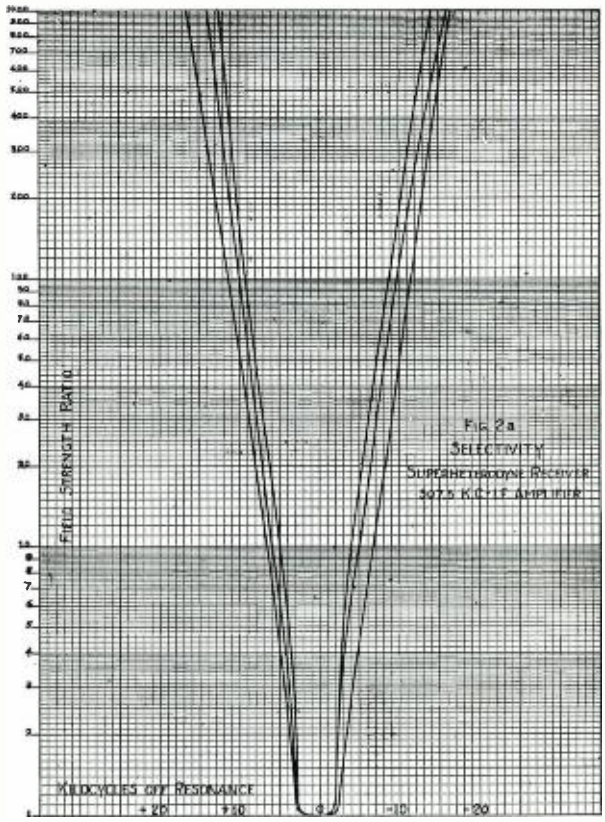


Fig. 2a.

Fig. 2a
Selectivity
Superheterodyne Receiver
507.5 K.C. I.F. Amplifier

### Superheterodyne Receivers

The superheterodyne receivers of the present time fall into two general classes of design, those which use the so-called "padding" system for tracking the oscillator and those which use an oscillator condenser specially designed to give the correct capacity values throughout the range. The two systems are quite different. The padding system requires that the oscillator tuning curve be "tied" at two widely separated frequencies. The special condenser system requires merely alignment at a single point in exactly the same manner as a tuned radio frequency receiver. This is not only more simple as a manufacturing operation but it is a decidedly easier problem for the serviceman. The cost of the special condenser design is somewhat less as no padding condensers are required. Tracking is more uniform with the special condenser and consequently the overall sensitivity curve is smoother. Stability and freedom from "drift" are far more likely to be attained with the special condenser than with the padding system.

When this type of variable condenser was first introduced it was given the same sort of greeting that almost any pioneering effort gets. The cry was "it won't track." But several engineers who knew superheterodyne design rather well had no difficulty in applying this type of condenser. The others soon learned. This specially designed condenser was originated by the writer in 1929 and first sold commercially in 1930. Since then it has steadily grown in favor and is rather widely used at the present time. Some effort was made to effect a standardization of oscillator inductance, r. f. inductance and capacity and thereby effect standardization of the oscillator plate shape. It was pointed out that departures from the suggested frequency distribution accomplished nothing of any consequence. These suggestions were not followed very closely. Most condenser manufacturers offer condensers of this type and for some reason best known to themselves each one has chosen a slightly different oscillator inductance and thereby made necessary a different plate shape for the oscillator condenser. About all this really accomplished was to make each condenser manufacturer spend money for unnecessary tools to make the various plate shapes.

### Intermediate Frequency Value

At the present time there is a pronounced tendency on the part of design engineers to increase the intermediate frequency from the rather generally used 175 kc. to a value of 507.5 kc. Nearly a decade has passed since the writer first advocated this value as an intermediate frequency for broadcast superheterodyne receivers. The reasons are obvious. With such an intermediate-frequency pre-selection and band pass tuners become unnecessary and a stage of radio-frequency amplification need be used only for the additional sensitivity it provides. So far as the tuning condensers are concerned no changes from present practice are involved, except if a gang condenser using a specially shaped oscillator plate is to be used in which case the capacity curve of this unit will be radically different from that for the 175 kc. intermediate frequency.

This intermediate frequency, however, has the disadvantage that the channel selectivity of the intermediate amplifier is not as good as it is at 175 kc., and this makes the use of an additional intermediate stage, with a very loosely coupled transformer and low gain, almost a necessity except for the cheaper designs. Some characteristic curves of receivers using this intermediate frequency are shown in Fig. 2. The problem of image interference disappears entirely when an intermediate frequency on the order of 500 kc. is used. Pickup in the intermediate ampli-

fier of commercial stations transmitting on adjacent channels may cause some interference in some localities.

The mechanical designs of modern gang condensers have been improved to a point where it may safely be said that the only losses introduced into a tuned circuit by the condenser are those caused by the power factor of the stator insulating material. If the power factor of this insulating material is large it will cause the variable condenser to have a high equivalent series resistance. Any losses in the tuning condenser as used in broadcast receiver design appear to the tuned circuit as a resistance in series with the coil. It is important that the insulating material have a low power factor so that this series resistance may be kept at a minimum value.

To actually measure the equivalent series resistance of a tuning condenser at radio frequencies is a tedious laboratory procedure. Extreme precautions have to be taken to insure the accuracy of the measurements because the power factor of a good tuning condenser at 1,200 kc. is only .087 per cent. and the phase angle is approximately 89° 57′. Differences in the equivalent series resistance due to differences in the insulating material used can be shown by this method but it is not suitable as a method for factory control of the insulators being used. The standard method of the American Society for Testing Material (A. S. T. M. Bulletin D150-31T) gives an excellent idea of the comparative properties of insulating materials. This method requires pieces of insulating material 6 inches by 6 inches. Stator insulators are seldom over 1 inch by 1 inch, so again it is impossible to use this method for factory control purposes. For these reasons we have developed the following method for rapidly checking the insulators just as they are used on the condensers. Fig. 3 shows the design of the test fixture and Fig. 4 is the schematic circuit diagram. The test fixture consists of two electrodes, one of which is adjustable, mounted on a porcelain base. The insulator to be tested is placed between the electrodes. The adjustable electrode is then pressed firmly against the insulating material and locked in place by means of the thumb-screw. This forms a small fixed condenser the dielectric of which is the insulator under test. Actually the effective area of such a condenser is 0.756 square inch and the thickness of the dielectric to be tested is quite generally .094 inch.

These factors may vary but if the insulators are being used for factory production they will remain the same for long runs so that a single calculation will serve for a long period of time. The average capacity of the fixture and its insulating material dielectric is 10.9

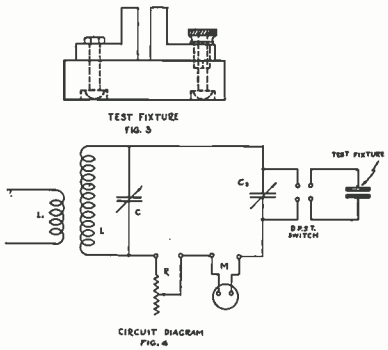


Fig. 3. Fig. 4.

micromicrofarads. This value, for all practical purposes, remains the same for all commonly used insulating materials of the same physical dimensions and once determined it may be regarded as a constant. With this capacity constant it will only be necessary to measure the equivalent series resistance of the condenser so formed at some chosen radio frequency in order to determine the electrical qualities of the various materials as insulators to high frequency currents.

### Coupling

Referring to Fig. 4, $L_1$ is a small inductance and is used to couple the tuned circuit to the oscillator. The oscillator should have a power output large enough to permit very loose coupling to be used. The coil L has an inductance of 60 microhenrys. C is a variable air condenser of good characteristics and is used to tune the circuit to resonance. $C_1$ is a standard calibrated air condenser the figure of merit of which is known so that its series resistance can be calculated for any capacity and frequency. The meter is a thermogalvanometer which has a resistance of 2.5 ohms. R is a decade resistance box adjustable to tenths of an ohm. The highest frequency of the broadcast spectrum, 1,500 kc., is chosen as the test frequency because the losses in the insulating material will be higher at this frequency than at any of the lower broadcast frequencies.

The actual test procedure is as follows: with the decade box resistance at zero the test fixture with the insulator to be tested inserted between the electrodes is connected across the standard condenser. The circuit is tuned to resonance by adjusting condenser C and the maximum deflection of the meter is noted. The switch connecting the test fixture across the standard condenser is then opened and the circuit is returned to resonance by adjusting the standard condenser $C_1$. Resistance is then added to the circuit by means of the decade box until the deflection of the meter is the same as it was when the test fixture was connected across the standard condenser. The resistance so added to obtain an identical meter deflection is then equal to the actual equivalent series resistance added to the standard condenser by the test condenser. Because the actual capacity of the test condenser is so small the difference in equivalent series resistance of the standard condenser between its two settings can be neglected, at least for control work. If the circuit resistance is kept low excellent sensitivity can be obtained and resistance differences of 0.1 ohm can very readily be read.

This method of testing insulators makes it very practical to be sure that the production condensers are of uniform quality in regard to their equivalent series resistance.

The mechanical construction of any gang condenser must be such that the precise capacity values of each individual unit will be maintained during the shipment of the condenser, through the receiver manufacturing processes and throughout the life of the receiver. The gang condenser as built today fully meets all these requirements.

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## REGULAR TELEVISION PLANNED FOR JAPAN

REGULAR television programs in connection with the daily radio broadcast are projected for Tokyo, according to plans being made by the Japan Radio Broadcasting Association in cooperation with the research laboratories of Waseda University and the Hamamatsu Technical College. Practical results have already been achieved by experts of the two laboratories. Research has been conducted for a number of years, the experiments at Waseda evidently being more successful than at Hamamatsu, as the university is now giving television programs at the exhibition of inventions now being held at Ueno. It is reported that an agreement has already been signed whereby the broadcasting association will contribute 50,000 yen (about $15,000) to finance further study along this line. Dr. Tadaoki Yamamoto will study television development in the United States.—— (*The Japan Advertiser,* Tokyo, 5-10-32.

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## IMPROVEMENTS RELATING TO ELECTRIC IMPULSE TRANSFORMERS

THE core material is of permalloy or other suitable material, the core comprising a plurality of sections. Structural details.

Burton, E. T. (Assigned to Standard Telephones and Cables, Ltd.) British Patent 357,049.

# A chronological history of electrical communication —telegraph, telephone and radio

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**This history was begun in the January, 1932, issue of RADIO ENGINEERING, and will be continued in successive monthly issues throughout the year. The history is authoritative and will record all important dates, discoveries, inventions, necrology and statistics, with numerous contemporary chronological tie-in references to events in associated scientific developments. The entries will be carried along to our times.**

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### Part IX

**1869.** (332) Daniel F. Drawbaugh, in America, exhibits an instrument by means of which he transmits speech over a wire, using pulverized charcoal and carbon to form the variable contact of the transmitter.

(333) French-American submarine cable is landed at St. Pierre, Miquelon, and at Duxbury, Mass. The French terminal being at Brest. The Duxbury landing made on July 23.

(334) The Central Pacific and Union Pacific Railroads joined at Promontory Point, Utah, May 10.

(335) The British Indian Submarine Cable Company lays a cable between Suez and Bombay, India.

(336) Thomas A. Edison arrives in New York from Boston.

(337) William Thompson's siphon recorder is introduced in submarine cable operation.

(338) Franklin L. Pope, J. N. Ashley and Thomas A. Edison form a partnership in New York, October 1, as consulting electrical engineers.

(339) Robert Sabine, in his book, "The Electric Telegraph," published this year, states on page 129: "The reason that duplex and quadruplex telegraphs have been regarded as impracticable is that the electromotive forces employed, and the resistances of the lines vary so greatly. . . . Both these systems of telegraphing in opposite directions, and of telegraphing in the same direction more than one message at a time, must be looked upon as nothing more than 'feats of intellectual gymnastics'—very beautiful in their way, but quite useless in a practical point of view."

(340) Zenore Theophile Gramme, of Belgium, constructs a dynamo electric machine in Paris, France.

**1870** (341) Herman Sprengel, in Germany, constructs a satisfactory mercury air-pump.

(342) Emile Baudot, in France, invents a multiplex printing telegraph system.

(343) Augustus Matthiessen dies. (Born Germany 1831.)

(344) Van Bezold discovers interference phenomena produced in conductors by advancing and reflected oscillations; the oscillations being produced by condenser discharges.

(345) The British government takes over the operation of the country's telegraph lines, under the management of the post office department.

(346) K. A. Steinheil dies. (Born Germany 1801.)

(347) In the United States there are now eighteen schools having engineering courses, with a total of 117 graduates.

(348) The family of Alexander Graham Bell emigrates from England to Brantford, Ontario, Canada (August).

(349) Congress charters the Northern Pacific Railroad.

(350) The Kansas Pacific Railroad is completed to Denver, Colo., August 15.

(351) Gramme's closed-coil armature, the "Gramme ring" for electric generators, is introduced.

**1871** (352) Stevens Institute of Technology, Hoboken, N. J., organized.

(353) A large statue of S. F. B. Morse is unveiled (June 10) in Central Park, N. Y.

(354) Disastrous lightning storms prostrate telegraph lines throughout the New England states, August 14, 15 and 16.

(355) Georges De Infreville, a French mathematician and electrician, is brought to the United States by the Franklin Telegraph Company, and employed as electrical engineer and expert. (He remained with the company and its successors until 1892.)

(356) The number of telegrams handled daily in the New York office of the Western Union Telegraph Company, this year, is 3,500.

(357) The duplex system is applied to the Gibraltar-Lisbon cable.

(358) The Society of Telegraph Engineers, in the British Isles, organized.

(359) H. Van Hovenberg invents a "Unison" stock ticker system.

(360) T. A. Edison makes improvements in stock ticker systems.

(361) Alexander Graham Bell arrives in Boston (April) to carry on a series of experiments with his father's system of visible speech, or physiological symbols for the deaf.

(362) The Great Northern Telegraph Company lays submarine cables along the eastern coast of Asia, connecting Hong Kong, Shanghai and Nagasaki with the terminus of an overland line extending across Siberia and Russia. These land lines had been built as a part of the Collins project of 1865.

**1872** (363) The Anglo-Mediterranean Telegraph Company merged with the Eastern Telegraph Company.

(364) Charles Alexander Gherardi appointed manager of the Direct Spanish Telegraph Company. Mr. Gherardi was on board the steam frigate *Niagara* during the 1857 and 1858 attempts to lay a transatlantic cable. He was attached to the Newfoundland station until 1859.

(365) The Telegraph Supply Company, Cleveland, Ohio, build dynamos designed by C. F. Brush.

(366) E. H. Johnson, P. B. Delany, T. A. Edison and George Harrington make important improvements in the chemical automatic telegraph system, invented by George Little. Tests are carried on over a compound wire between New York and Washington.

(367) Moses G. Farmer obtains a United States patent covering improvements in dynamos.

(368) Smith introduces a one-wire weight-driven stock ticker.

(369) S. F. B. Morse dies in New York, April 2, aged eighty years. Memorial services are held in his honor in the National House of Representatives.

(370) Mahlon Loomis, a Washington, D. C., dentist, is granted a United States patent (No. 129971) for an an improvement in telegraphy—the system proposed for use without conducting wires.

(371) The officers of the International Ocean Telegraph Company (Cuba cable) elected this year are: Gen. W. F. Smith, President; James T. Sanford, vice-president: Alexander Hamilton, Jr., secretary, and Thomas P. Bladen, treasurer.

(*To be continued*)

Mechanics at work on construction of a new broadcast station in Minneapolis, Minn.

*Photo. courtesy V. V. Gunsolley*

# Radio manufacturers cooperating for business improvement

IT is widely realized that better days for radio manufacturers and for radio engineers will come with improved buying power on the part of those still getting along without radio receivers and those who desire to replace antiquated receivers with modern units.

Improved buying power should materialize out of the constructive program recently launched under government sponsorship. Increased employment should follow the extensions of credit provided for to the end that again regular employment and regular payrolls may be the order of the day.

In the radio industry there are many evidences of renewed confidence in the future of the business. In the following are quotations from communications received by RADIO ENGINEERING within the past two weeks from men in the industry well placed to observe what is taking place.

**Stromberg-Carlson will be rewarded for maintaining high standards of receiver construction.**

R. H. MANSON, vice-president and chief engineer of the Stromberg-Carlson Telephone Manufacturing Company, Rochester, N. Y., advises as follows:

"The Stromberg-Carlson Company is continuing its policy of designing and manufacturing its radio receiving equipment to meet high standards of audio quality, efficiency and reliability. While these design requirements place our product in the higher price classification, we are pleased to note that there is a decided tendency on the part of other manufacturers to advertise their best design and their more complete equipment. This procedure has been encouraged by the public showing a decided preference for the better radio receiver designs.

"Radio listeners are gradually learning from experience that a satisfactory radio receiver must have certain fundamental design features in order to give natural and satisfying reproduction. For example, it is now becoming well known that the cabinet must have as large a front area as practicable around the loudspeaker opening to give truthful reproduction of the lower fundamental audio tones; that the chassis and loudspeaker must be of such designs as to give a long range of audio-frequency response, free from peaks and valleys so as to avoid boominess, raspiness and other artificial effects.

"The public has learned from operating experience how to recognize values in automobiles, and through comparative tests is now commencing to appreciate the operating values of radio receiver equipment. This should be encouraging to both the manufacturers and dealers of radio receiver equipment, as it places radio in a quality classification, with profit possibilities, where it belongs."

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**Vice-President George Lewis, of Arcturus, believes radio business will be good. He says:**

"WE have been fortunate in that more set manufacturers use Arcturus tubes as initial equipment than any other tube on the market. In addition to this, there are many set manufacturers in foreign countries who also use the blue tube as initial equipment, giving us a formidable international lineup of manufacturer customers. These sets, Arcturus-equipped, are finding their way into every state in the union, as well as in 76 foreign countries.

"We have built a strong distributing

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**Leaders of the industry tell RADIO ENGINEERING how they have planned during the slump, and what they propose to do toward restoring prosperity.**

organization in all these points and look forward to a substantial blue tube replacement business.

"During the past year we have developed and put into production the new Wunderlich tubes, as well as the new 2.5 volt and 6.3 volt series of tubes, giving us a complete line to meet the diversified requirements of set manufacturers.

"1932 also marked our entry into the high power amplifying and transmitting tube field. This division of our business is showing a steady growth in sales to broadcasting stations, the sound picture industry, industrial users, etc.

"With the world-wide acceptance that Arcturus tubes enjoy, we look forward with considerable optimism to a very busy radio season."

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### Zenith Going Strong

PAUL B. Klugh, vice-president and general manager of Zenith Radio Corporation, Chicago, says:

"During the past twenty-four months, because of the depression, we have turned our attention more particularly to engineering and development. Our personnel has been increased and our expenditures in these departments have been larger than at any previous time in our history. We believe that periods of manufacturing inactivity present an opportunity for intensive development work. As a result of this program our present line contains many advancements in construction. In fact, our pride in what the laboratory has achieved has caused us to issue the following:

> "'We challenge any one to name a single demonstrable improvement known in radio which is not found in the Zenith 1932 line, and we further challenge any one to name a radio line which contains all the improvements found in our Zenith 1932 line.'

"We are engaged in an aggressive campaign to get our share of the radio business. Our distribution has been increased by the addition of a number of new wholesale distributors. With our manufacturing and distribution so thoroughly worked out, we stand ready to participate in the resumption of business which we feel sure is coming. As an evidence of our faith in the future, our plants are now in production on full time and we expect to sell all of the sets we are making. Under no circumstances will we overproduce, it being a keystone policy with Zenith that our production will be held strictly in step with sales so that at the end of the season there will be no distress merchandise to worry about.

"The future of radio was never brighter. We believe that two and one-half million electric midget sets are ready to be replaced—that one million battery sets in homes with electric current are ready for replacement. In addition, there are five million obsolete electric sets, and another six million wired homes without any radio, the owners of which can be sold new radio receivers. Here is a tremendous market for fourteen million receivers. Dealer's stocks are low. Distributors have little, if anything, in their warehouses.

"Yes, we are optimistic. We feel that radio is today a stable industry, with all the romance and thrill of "wireless," unsubdued as yet by Father Time."

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### General Radio Company Has Profited from the Dull Times

H. B. RICHMOND, of the General Radio Company, Cambridge, Mass., reports that his company has ready for receiver manufacturers a complete line of new precision instruments, the use of which will make saleable receivers easier to make. Mr. Richmond writes:

"The dual demand for lower prices and at the same time more exacting technical requirements in the production of radio receivers and sound equipment has placed a great responsibility on the manufacturers of research and testing equipment. Never before in the history of this company have so many new instruments and have such high degrees of precision been obtained as in the work of our laboratories during the past six months. These new instruments are now being made available to the set manufacturers that they may be in a position to meet the very exacting competition of this season."

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### Silver-Marshall Notes Upturn

IN a statement prepared for RADIO ENGINEERING, McMurdo Silver, president of Silver-Marshall, Inc., Chicago, reports improvement in business activity. Mr. Silver says:

"It has been the experience of Silver-Marshall, Incorporated, that there is an active demand for high quality radio products at attractive prices even during periods of subnormal business activity.

"At present there are definite indications of an upturn in the radio industry. Recent technical developments by Silver-Marshall, such as improved all-wave and broadcast superheterodyne receivers, completely all-electric sound on film amplifiers, class A prime high-efficiency audio amplification and other noteworthy achievements in radio and sound will be important factors in the future business of this company."

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### I. R. C. Has Done a Good Job and Believes Business Increase Imminent

PRESIDENT ERNEST SEARING, of the International Resistance Company, Philadelphia, Penna., reports that his company has created new records of accomplishment. Mr. Searing says:

"In the firm belief that the normal demand for radio and sound equipment cannot be permanently dammed and that sooner or later this pent-up demand must overflow the walls of enforced or pessimistic personal economizing and hoarding, we have, since the first of this year, steadily and persistently labored to prepare for this anticipated development by improving our products and increasing our production facilities.

"Meanwhile, much of our sales effort has been concentrated upon the replacement field, based upon the theory that until conditions permit the public to invest in new equipment, they would be compelled to keep their old sets in working condition. We have refused to believe that the dealer and serviceman were interested only in cheap merchandise of known poor quality and our success in building up a steadily increasing demand from jobbers for high quality and dependable material at fair prices has been very gratifying.

"Now, we firmly believe that we are on the verge of an upturn in business that will be felt by all branches of the industry. In our opinion, the gradual loosening of the public's purse strings, resulting from greater optimism and increased confidence will be translated into increased buying as the radio season advances. It will be cautious and conservative buying, but it will grow if it is intelligently and systematically cultivated."

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### Philco Profited by the Depression

PRESIDENT J. M. SKINNER, of the Philco Company, Philadelphia, Pa., in a recent talk explained Philco success. He said:

"Paradoxical as it may sound, the depression gave us the opportunity to win leadership. The depression has brought about no change in business fundamentals. Business always looks tough. Before the depression, we had powerful competition to meet. During depression, we have reluctance to buy to overcome. I had rather have reluctance to buy to overcome because always there are people with money to buy what you want to sell if you make it good enough, price it right, tell them about it through advertising and then place it so that you can make it convenient for them to buy what you offer."

# A new beat frequency oscillator

By SAMUEL M. BAGNO*

IT is always desirable to have a handy source of audio-frequency oscillations in any laboratory. Almost any instrument which is used directly or indirectly for acoustical work must be designed and checked with some source of audio-frequency oscillations. It may be desirable to check the frequency response of a microphone amplifier or speaker. It may also be desirable to check the undistorted output or the amount of distortion inherent in any of these instruments.

There are several sources of audio-frequency oscillations. The most convenient, probably, being the beat-frequency oscillator. This oscillator consists of two radio-frequency generators which beat against each other at an audible frequency. This audio-frequency signal is detected to make it audible and amplified to the volume desired. It is possible, in such an instrument to get the complete audible range within the spread of a single dial. The beat-frequency oscillator has, however, certain distinct disadvantages, and it was with a view of overcoming these disadvantages that it was decided to investigate, undertake research and design an inexpensive oscillator which would eliminate these disadvantages:

1. A frequency response which enables the operator to set to high frequencies to an accuracy many times greater than the accuracy at low frequencies. The construction of the ear would necessitate that from ten to one hundred cycles should require the same number of divisions on a dial, as from one hundred to one thousand, or from one thousand to ten thousand cycles. This naturally calls for a logarithmic frequency scale instead of one that is almost linear. Inherently, if a straight line capacity condenser is used to tune the beat-frequency oscillator, the dial setting will be almost linear with frequency. The first one thousand cycles will require as many divisions on the dial as the last thousand.

2. Harmonic content: A beat-frequency oscillator, because of its complication, has more sources of harmonics than any other type of oscillator. Each of the radio-frequency generators can generate its own harmonics, which are further accentuated by the detector and amplifier portions of the instrument.

3. Frequency instability: It is extremely difficult to design any instrument to have an accuracy of one part in several hundred thousand, and to maintain this accuracy over an extended period. That, however, is the problem encountered here. The two radio frequencies which beat against each other are in the neighborhood of several hundred kc. A variation of one cycle per second in either one of these oscillators means a corresponding variation in the audio-frequency signal. Whereas at radio frequencies such a variation may be less than one thousandth of one per cent, at twenty cycles per second, audio-frequency, this variation is five per cent of the entire frequency.

4. Frequency tie-in: Two independent oscillators when oscillating almost at the same frequency, tend to lock into step, so that it is very difficult to isolate both oscillators so that they should tie into step at a difference of less than ten cycles per second.

## Check for Frequency Response

It is the purpose of this paper to outline the methods used in the correction of these sources of error, and to detail the final results. At first it seemed simple to correct poor frequency response. A properly designed condenser could possibly give a logarithmic frequency scale. However, since the average condenser has only 180

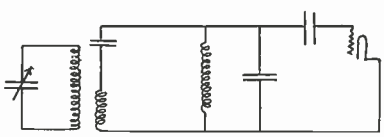

Fig. 1. The tuning arrangement.

(one hundred eighty) degrees of rotation or one hundred divisions on the dial, each division must of necessity represent a definite percentage of the frequency to which the condenser is tuned, at that setting. Since the capacity is roughly proportional to the frequency over the range used, a change of one division at the lower end of the scale would mean a change of one cycle in ten cycles, and at the higher end of the scale, one thousand cycles in ten thousand, or the change in capacity or area of the plate of the condenser at the lower portion of the scale must be one one-thousandth of the change at the maximum frequency. This would entail such accurate machining of the plates of the condenser as to make such a scheme entirely impractical.

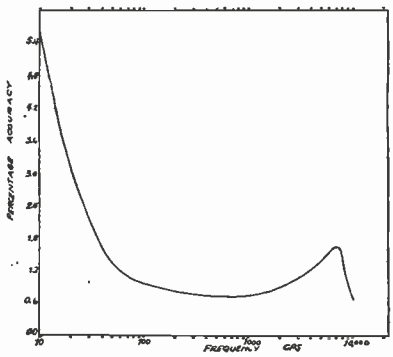

Fig. 2. Dial accuracy curve beat frequency oscillator.

Another possibility which showed great promise consisted of tuning one or two condensers in series. If the variable capacity could be made very large in respect to the fixed scale capacity, a relatively large change of rotation with variable condenser in full mesh, would produce a relatively small change in the resulting total capacity. After investigating the capacities needed for the response desired, it was found that the variable condenser must have a maximum capacity at least five hundred times as great as the fixed capacity in series with it. The size of the fixed capacity was fixed by the radio frequencies, and the initial value of condenser used. The largest variable condenser that could be obtained on the market was a .002 microfarad condenser. This limited the fixed capacity to .00004 μfd.

Here again was an impractical combination. It was finally decided to use an ingenious arrangement of a variable capacity transformer, which by reflecting the variable capacity from primary to secondary as the square of the turn ratio of the transformer, enabled us to get an effective capacity several hundred times the maximum capacity of the variable condenser, by using such a transformer across a .0005 microfarad straight-line wavelength condenser in series with another fixed condenser. A response was obtained almost that desired. The .0005 μfd. variable condenser was converted into a .1 μfd. variable condenser, as it was reflected from the primary to the secondary of the transformer. The tuning arrangement used is shown in Fig. 1.

*Engineer, Wireless Egert Engineering, Inc., New York.

**Proper design and inspection of amplifiers and other acoustical equipment are facilitated by the use of an audio-frequency oscillator**

### Dial Setting Against Frequency

Over the most important range, from forty to four thousand cycles, the response was truly logarithmic. Above and below these values the percentage accuracy to which the frequency could be read, dropped off slightly. Fig. 2 shows a curve of dial setting against frequency. The oscillator was designed to cover the frequency range commonly used in radio from ten to ten thousand cycles per second.

In order to overcome the harmonics to the greatest possible degree, use is made of very heavy tank circuits in the oscillators (large capacities and lower inductances). This combined with linear detection and an excellent audio-frequency amplifier, gave a very low harmonic content.

The frequency fluctuations were overcome by balancing the resistance capacity and inductance of both oscillators as closely as possible. In spite of these precautions, this problem was not entirely overcome, and in order to compensate for variations in the frequency that may occur, a zero setting condenser was introduced. This condenser combined with a switch, to throw sixty

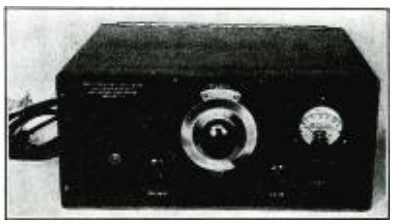

Fig. 3. The oscillator complete.

cycles a-c. across the output, enabled us to set the oscillator correct to a fraction of a cycle for any individual observation.

In order to overcome the possible locking into step of both oscillators, each oscillator was thoroughly shielded, and the pickup leads were connected across the grid and filament of the detector. The detector tube was biased strongly negative so that the least possible grid current would flow. It was found that under these conditions the oscillators did not tend to lock into step above a difference of three-quarters of a cycle per second.

Since ruggedness was one of the most important requisites of such an instrument it was decided to use a cathode heater type tube. These tubes are operated from a filament transformer. This transformer is also the source of the sixty cycle a-c. that is used to set the frequency of the instrument. The plate voltage is supplied by three forty-five volt batteries which are enclosed in the cabinet. Since the maximum drain of plate current is under ten mils, these batteries last for several months of continued use.

An 0-3 volt output meter is employed to measure the a-c. output voltage, and the harmonic content of output is independent of the output load. However, for a uniform response at all frequencies it is advisable to use an output load of not less than 1500.

The results of these investigations more than compensated for the cost of research. Here is an oscillator that can spread the entire useful audio-frequency range over a single dial in such a manner as to give the greatest accuracy for all frequencies. With its low harmonic content, frequency stability, and the enormous range it covers, this new beat frequency oscillator makes a valuable addition to any laboratory.

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# New velocity microphone promises revolutionary broadcast advances

THE development of a radically new kind of microphone which promises to bring about revolutionary improvements in the quality and technique of radio broadcasting, has been announced by the laboratories of the RCA Victor Company, at Camden, N. J.

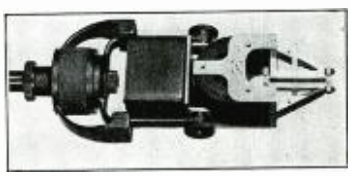
The new microphone, according to the engineers who designed it, reproduces sound with a fidelity never before possible, and, in addition, embodies technical advantages which will solve many pressing studio problems. Unlike existing types of microphones which utilize diaphragms, the new "velocity" microphone utilizes a sensitive ribbon of duralumin, the heart of the mechanism, which vibrates exactly with the minute variations of the air particles set in motion by the sound waves.

RCA Victor engineers liken the operation of the new "velocity" microphone to a fine mirror which does not add or subtract from the original image, but presents an exact likeness. It responds uniformly to the entire audible range of sound from zero to 14,000 cycles and over, which means that all of the subtle overtones and shadings which give vitality and life to sound are faithfully reproduced to give the illusion of absolute reality. Accordingly, the new microphone is free from a defect of existing microphones which tend to either over or under emphasize certain tones that are in resonance with the vibrating mechanism, producing the artificial whistles and hissing sibilants which acoustical experts have dubbed sound "whiskers."

Another important advantage of the velocity microphone is its positive directional characteristics. In radio and in recording work this means that it will no longer be necessary to crowd entertainers on one side of the microphone. Performers may speak their lines while facing each other on opposite sides of the microphone and large orchestras may be more advantageously placed for the best ensemble effects. It also simplifies the problem of studio acoustics, because reverberation pickup may be varied simply by adjusting the angle of the microphone. In sound motion picture recording, it is possible to place the camera at absolute right angles to either sensitive side of the microphone where sound pickup is almost down to zero, and eliminate entirely the noise of the camera grinding, and even permit whispered directions to performers which this most sensitive of microphones will not transmit.

Although delicately responsive, the new microphone is extremely rugged and impervious to changing atmospheric conditions because of its all-metal construction which includes no paper or fibre material at critical points to give any trouble.

Engineers of the National Broadcasting Company have for some time been studying experimental models of the velocity microphone with the view of making them standard equipment in all their studios as soon as they are available. Arrangements have been completed with the owners of station WCAU, Philadelphia, for installing the first of these new microphones in their new studios.



The RCA Victory "velocity" microphone with the outer cover removed to show the thin strip of metallic ribbon suspended between the pole pieces of the permanent magnet. Other microphones utilize diaphragms which tend to over or under emphasize certain tones which resonate with the mechanism. The vibrating mechanism of the new "velocity" microphone is actuated by the velocity of the minute air particles set in motion by the sound waves.

# Directional broadcasting at WFLA and WSUN

THE success of the new antenna system at Clearwater, Florida, will determine whether or not the jointly operated station of WFLA-WSUN will be permitted to resume operation at a power of one kw. night. The station was required to reduce its power to 250 watts last year in order to restore the 620 kc channel, occupied by both WFLA-WSUN and WHMJ of Milwaukee, Wisconsin, to its former condition prior to the placing of the Florida station thereon. The Milwaukee station's service area was, by this reduction in power, restored to normal but this arrangement did not prove satisfactory to WFLA-WSUN, and Walter Tison, director of the station proceeded, with the permission of the Federal Radio Commission, to conduct tests with a directional antenna system.

The system now in use at Clearwater was designed by Raymond Wilmotte, a radio engineer of Great Britain. It consists of two steel towers, insulated at the base and guyed half way up. Each is 200 ft. high and resonated to act as a quarter wavelength radiator. They are spaced exactly one quarter of a wavelength apart and excited from the transmitter through a phase-shifting circuit so that the current in the reflector tower leads the current in the radiator tower by 90 degrees, or a quarter of a wavelength. A line drawn through the two towers follows the great circle path between Milwaukee and Clearwater. Transmission lines are used to transfer the radio frequency energy from the phase shifting equipment in the attic of the transmitter house, to a tuning house located at the base of each tower. The tuning houses contain the necessary equipment for properly terminating the transmission lines and for loading the antenna to resonance. The phase-shifting equipment is arranged so that the towers may be fed either in phase or ninety degrees out of phase without interruption of service. The plan is to operate the towers in phase during the day when no interference is had around Milwaukee and out of phase at night when suppression in the direction of Milwaukee is required.

Preliminary tests made by Mr. Walter Tison, director of WFLA-WSUN, indicate that a distinct dark sector covering about ninety degrees is obtainable through the use of this system. The service area of the Florida station is so situated with respect to Milwaukee that only a few local listeners will suffer by the introduction of this no-signal area. A large portion of it extends out over the Gulf of Mexico. It is interesting to note how clearly defined are the boundaries of this sector. A receiving set in an automobile driving across its boundaries, loses volume almost instantaneously. It requires but thirty or forty feet of travel to encounter a change in signal intensity from one that is capable of producing good loudspeaker volume down to a signal well below the noise level. One resident of Clearwater whose home is located about three miles from the station and exactly on one boundary of the no-signal area, was unable to receive anything from the Clearwater station until he changed the direction of his receiving antenna so that it ran into the signal area. Previous to this change, his antenna was entirely in the no-signal area.

The results of measurements made by the Department of Commerce on the Florida station's signal intensity in Milwaukee, have not yet been revealed. Everyone is anxious to learn whether the system is suppressing the sky wave in the direction of Milwaukee as well as it has eliminated the direct or ground wave in that direction.

This scheme of setting up an additional antenna to serve as a reflector for the purpose of controlling the direction of propagation of radio waves has long been known to the art of radio, and has for many years been used in the design of short wave directional antenna systems for both transmission and reception in the communications field. However, the experiment at Clearwater is a new application in that it is an attempt to eliminate interference between broadcast stations operating on the same frequency, by the use of directional transmission. The staff of WFLA-WSUN is to be complimented on their initiative and foresight in starting this investigation.

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## RADIO STANDARDS

TWO new national standards for radio have just been approved by the American Standards Association, it has been announced by Dr. P. G. Agnew, secretary of the Association.

The standards were developed by the technical committee on radio working under the procedure of the American Standards Association, with the Institute of Radio Engineers and the American Institute of Electrical Engineers directing the technical work. Alfred N. Goldsmith, vice-president of the Radio Corporation of America, is chairman of the committee.

The first of the standards applies to certain details in the manufacture of broadcast receivers which it is desirable to have uniform in the sets of all manufacturers.

The second standard specifies dimensions for many of the principal types of bases and sockets of vacuum tubes used in both receiving and transmitting. The types of bases covered in the standard are four-pin bases of the large and small type; large four-pin base without bayonet pin; large five-pin base without bayonet pin; four-pin transmitting tube bases; large transmitting tube base; four-pin sockets for receiving tubes and five-pin sockets for receiving tubes.

The standard also specifies dimensions for terminal caps for both receiving and transmitting tubes and for connections between the tube elements and the pins.

The manufacturing standards applying to broadcast receivers establish a national standard for the frequency range of receivers from 550 kilocycles (545.1 meters) to 1,500 kilocycles (199.9 meters). The rating and design of socket-power devices and electric radio receivers are to be standardized for operation on voltages from 105 to 125 volts. A standard test for quality of soldering of cord tips or terminals to radio cords is also provided. This test is a straight pull of five pounds applied to the cord tip or terminal. Other details for which standard dimensions are established are cord tips, binding posts, cable terminals, radio plugs and jacks, and pilot lamps. There are also standard definitions for the various parts of radio receivers.

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## NEW RADIO CIRCUIT OPENED BETWEEN THE U. S. AND HAITI

A NEW transoceanic radio-telegraph circuit connecting New York with Port-au-Prince, Haiti, was officially opened July 1 by R. C. A. The circuit is 1,500 miles in length. The concession granted by the company by the Haitian Government also includes the right to operate other international circuits, and to establish service connecting the island with ships at sea and planes in the air.

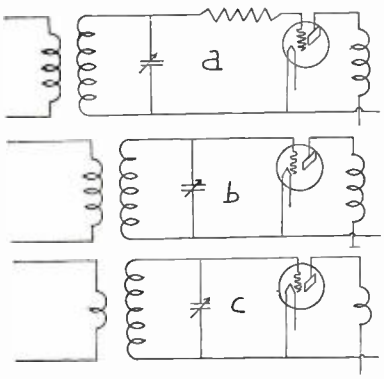
# Balancing radio receiving circuits

By D. M. TENNIL

THIS term has often caused much misunderstanding with radio workers. Before explaining the methods to be followed in balancing radio receivers, it will be well to state what the term balancing means. The word balance is used in ordinary speech in two ways; in one sense it means simply an orderly and well-proportioned arrangement. In another sense of the word, its true meaning, to actually balance one thing against another, as the weight of one pan of a weighing instrument is balanced against the weight of the other.

The two meanings are generally confused when applied to radio receivers. We speak of a well-balanced receiver; in which the various parts, or components, work well with each other; for instance: the transformers have been designed to work well with particular tubes, or the loudspeaker has been designed to work well with a particular type of amplifier, etc. The word balance also is applied to the adjustment of a receiver so that it will not oscillate. When used in this sense it must not be confused with the word neutralize which will also be explained.

There are many ways in which a receiver may be balanced against oscillation. Most of the methods are applied in the construction of the set, but it is better to know something of them, should the receiver become faulty or uncontrollable. The most common methods are: (a) placing high resistances—somewhere about 1000 ohms—directly in series with the grid of the radio-frequency amplifying tubes; (b) designing the tuned circuits so that they have so much resistance, or losses, that the circuits cannot oscillate; (c) by constructing the primary coils of the radio-frequency transformers to have very little self-inductance, or very few turns of wire; (d) by making the coupling in these transformers between the primary and secondary, very loose; (e) by making this coupling change as the tuning condensers are rotated.



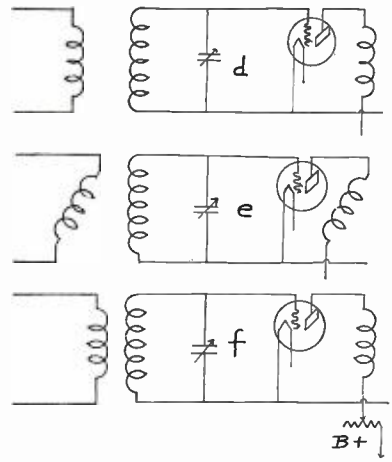

(c) Stabilizing by putting very few turns on the primary coils. This keeps the inductance in the plate circuit below that required to make the tube oscillate.

With receivers that employ these methods of stabilization, or balancing, there is usually plenty of amplification on the shorter wavelengths, but the sensitivity generally drops off as the set is tuned to the longer wavelengths. It is possible to make the set equally sensitive over the whole range, but this comes after considerable experience at balancing. There is no reason why one should not aspire to this. To do it, a nice proportioning of the various parts of the radio-frequency amplifier is required. There is no way of predetermining the adjustment. It is simply a matter of cut and try.

There are three other methods, which permit the operator to make the adjustments himself. They employ: (f) the adjustment of the plate voltage by what is generally known as a volume control, which is simply a variable resistance in the plate circuit, and this stops the set from oscillating; (g) a variable rheostat in the filament circuit, which, when turned sufficiently low, will cut down the electron emission from the filament, and so stop the set from oscillating; (h) a potentiometer, which was popular a short time ago, is used to control the grid bias on the radio-frequency amplifying tubes. These three methods permit the operator to make the set oscillate, and he can then make an adjustment, that it just ceases oscillating, which is the point of greatest sensitivity of the receiver.

Various methods are illustrated in the accompanying diagrams.

Now the question is asked "How can I choose a method of balancing?" This depends upon other conditions in the receiver, and no exact advice can be given as to the choice. The question resolves itself into two parts, which are dependent upon the operator. The first is whether it is to be balancing against




(d) Stabilizing by making the coupling between the primary and secondary coils very loose.
(e) Stabilizing by varying the coupling as the tuning condensers are tuned.
(f) Stabilizing by adjusting the plate voltage, by means of a variable resistance—about 100 to 100,000 ohms.

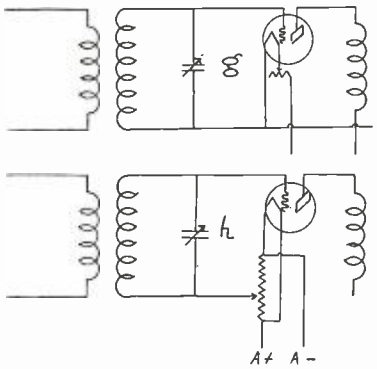
oscillation of a permanent nature. This is the better method for the average broadcast receiving set, for it does not add an extra control—modern design makes for simplicity in operation. The second is whether the operator wishes to control the oscillation himself by means of a potentiometer, or any other method requiring additional controls on the panel. This method should not be advised, unless the operator is familiar with the principles of radio; for he may unknowingly cause considerable interference to nearby receivers. This method will give better amplification, and permit working the set at its highest efficiency, but should not be unwisely used.

When any receivers using these methods become unbalanced, and oscillate, then the problem resolves itself into finding the difficulty and rectifying it. It may be a broken resistance, or potentiometer, or an open circuit, etc.

Now there is the other type of receiver, which is balanced in the true sense of the word, but is usually termed "neutralized." These receivers employ the Wheatstone bridge method of stabilization. To put it briefly, should the capacity between the grid and plate, and between the grid and filament, of an electron tube be neutralized, then the circuits will not oscillate. For this purpose one of these capacities, or both, are so connected as to form one, or more arms of the bridge; and the balancing is obtained by adjusting a small variable condenser in one, or the other arms of the bridge. Each tube has its own neutralizing arrangement, and each is balanced separately. Some of the neutralizing circuits are not true bridge circuits, but the method of bal-

ancing is always the same.

To consider the method of balancing. In this process each stage is balanced separately, and for an example a neutrodyne receiver will be taken. Start with the first radio-frequency tube. Place a piece of paper between one filament prong, and the corresponding spring in the tube socket, so that it will not make contact. The filament should not light. With all the other tubes alight, tune the receiver to the strongest station that can be heard. Adjust the neutralizing condenser until the signal disappears. The dials must always be kept tuned accurately to the station being received. Next take out the piece of paper, and return the tube to its socket. Then proceed to neutralize the rest of the radio-frequency stages in the same way. After they have been adjusted, go over the process again, to make sure that the neutralizing is complete. It is best to neutralize a receiver on a wavelength below 300 meters, if possible, for some




(g) Stabilizing by adjusting the temperature of the r-f. amplifier tube.
(h) Stabilizing by means of a potentiometer, adjusting the grid bias to such a positive value that the tube just stops oscillating.

receivers have a tendency to unbalance when neutralized on higher wavelengths.

Should a tube be burned out, which necessitates a new tube, then that circuit will have to be neutralized again. In some commercial receivers the neutralizing condenser is sealed, and if it is necessary to break this seal to readjust the condenser, then particular care should be taken not to damage this component.

Concluding, one will see how misleading this term balancing is. Its various meanings are so different that one requires a complete understanding of its principles to thoroughly appreciate its meaning. However, there is nothing very difficult in it and most radio workers have come in contact with its methods; but, when given under the term *balancing*, do not quite understand what is meant.

The a b c d e methods do not permit the operator to adjust the receiver to its most sensitive condition at all wavelengths but makes its impossible for the set to oscillate and cause heterodyne squealing and howling.

The f g h methods permit the operator to make the stabilizing adjustments while he operates the receiver.

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# New material for radio tubes

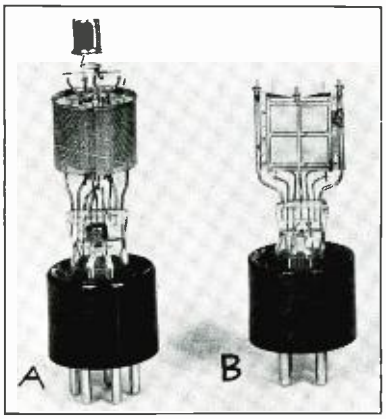
By Harold C. Todd*

WITH the recent rapid development and expansion of the electronic tube industry, the advent of new tubes and keenest competition there has been of necessity an increasing demand for new materials at lower prices to meet the conditions. It goes without saying that new materials and lower prices at the sacrifice of quality were out of the question. Manufacturers of receiving and power tubes, neon lights, television tubes, mercury vapor lamps, photo-electric cells and similar apparatus have, for a number of years. been seeking a material which would be readily available, low in price, highly efficient and of finest quality.

Practically all of the more common types of metals have been tested and few adopted. Iron, because of its abundance and cheapness, was tested and tried in nearly every laboratory. Not only was experimental work conducted with domestic irons, but imported materials as well. Swedish iron, which has been noted for its uniformity and purity, was found to be the nearest approach, but it. too, had its drawbacks consisting mainly of carbon hard spots, slag and similar inclusions; too much gas and too low a resistance to oxidation. This research work covered many years and until a short while ago availed but little.

There now comes on the market a new material. It is known as "Svea" plate and "Svea" wire. It is a special type of exceptionally pure Swedish iron made by a secret process to approach a chemically pure iron. By a reduction of impurities, the elimination of gas, and a modification of structure, it has been made to possess those chemical and physical characteristics which are most desirable for electronic purposes.

Exhaustive tests made thus far by some of the largest and most particular laboratories in the East have indicated that it is a superior material for electrodes, plates, getter cups, screens, lead-in and support wires and similar parts. These tests indicate that "Svea" contains approximately one-half of the occluded gas found in nickel, and requires fifty per cent less bombardment. This means at the outset a more efficient tube with less gas to hinder the electronic emission, and a greater energy of motion converted to heat. It means a longer life of the tube since a low gas content means less ionization by collision which interferes so badly with the normal operation of a tube and consequent reduction of its normal life. Likewise, less gas in the metal pores means less pumping and easier and more complete bombardment at an appreciably lower cost.




A. Type 24-A tube showing plate, mesh screen, getter cup, support wires and all parts except filament and top cap made of "Svea."

B. Type 26 tube showing plate and supports made of "Svea."

*Engineer, Swedish Iron and Steel Corpn., New York.

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**A new metal for radio tubes, television tubes, hot cathode mercury vapor lamps, and other electronic tubes.**

### Heat Resistance

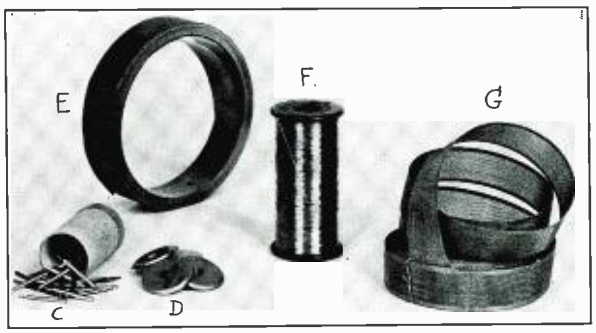
The heat resistance of this material is greater than that of nickel. Not only does the lesser gas content permit liberated electrons to travel from filament to plate with considerably fewer collisions with the atoms of gas (thereby developing plate heat especially where high plate voltages are involved), but "Svea" plate has a higher heat resistance over nickel by about 140 degrees, and this enables it to withstand greater heat.

The material can be readily carbonized in plate form and also in continuous process so that the heat may be dissipated by proper radiation. Another advantage over other materials used for electrodes, is its lighter weight. It has a specific gravity of 7.85 as compared with 8.60 for nickel and 8.91 for copper. Being approximately 10% lighter in weight than nickel, it gives a correspondingly greater plate surface area for a given weight. This is advantageous in the heavier tubes and particularly power tubes in connection with radiation. Likewise, of course, less weight per plate means less material and lower cost.

### Co-efficient of Expansion

Such factors as low gas content, high heat resistance and less weight are important, but to these may be added other advantages. The coefficient of expansion of this material is nearer to that of glass than that of nickel and when glass is fused around it there are practically no bubbles or holes because of the freedom of the material from occluded gas. On the count of adaptability, this plate and wire is readily stamped and formed, blanked or welded with only slight changes from standard practice. It can be welded easily to nickel or copper and makes a firm, clean, strong weld. It may be hydrogen annealed with a bright clean surface similar to nickel, or finished by rolling to either bright or dull surface—in fact, the surface finish can be controlled by rolling and annealing and other miscellaneous treatment so as to be either bright or dull, matte, oxidized, carbonized, carburized or brilliant. It may be plated with ease by nickel, copper, cadmium or similar metals and responds nicely to such a finish should it be desired. In wire form it is readily enameled. However, none of these coatings is required in a radio tube as the material, because of its extreme purity, gives finest results when used without coating or plating. Both the plate and wire may be given any desired degree of hardness or softness, or tempered to the required rigidity.

Heretofore, the tendency of iron to corrode readily has been such as to preclude its use in electronic tubes. "Svea," by reason of its purity and special method of manufacture, practically overcomes this objection. It has a high resistance to oxidation and by a simple treatment and method of handling this feature can be entirely overcome.




C. Cathodes for type 27 tube made from "Svea" plate.
D. Screen-grid tube top plates made from "Svea."
E. Coil of .005 in. x 1 in. "Svea" strip.
F. Spool of "Svea" wire .006 in. diameter.
G. Coil of screen-grid mesh strip with selvedged edge.

Ordinary irons have oxidized quickly not merely because of their impure chemical composition and structure, but also by reason of their finish. In the original laboratory work on "Svea," it was found that as the impurities were reduced through additional processing, the resistance to oxidation and corrosion increased. Normally, all irons when in contact with moist atmospheric conditions tend to oxidize rather rapidly. Where the impurities are large and material porous, galvanic action begins and this becomes a serious problem. Ordinary Swedish iron resists corrosion quite well, but it was found necessary to further purify it and modify the process of manufacture from time to time. Not only have injurious impurities been removed by further processing, but annealing and rolling, particularly the latter, have resulted in a surface which is uniform, compact and highly resistant to oxidation. With a little care and precaution the material may be properly protected so that both the strip and wire will enter the tube without oxidation.

In these times, when competition is severe and tube makers are seeking through every legitimate channel to lower costs without sacrifice of efficiency or quality, this plate and wire stock offer exceptional advantages.

Of course, as has been the case with all materials entering into the manufacture of electronic tubes, a long period of time has been devoted to tests and experimental work. This was true with nickel and has been true with this pure type of iron. One by one the faults of the iron were discovered and corrected through additional methods of purification, processing and annealing. "Svea" plate is entirely different from domestic irons or any other Swedish irons. It is the result of many years of research which began with the neon light industry.

### Sputter Factor

When it was found that metals working in gases such as neon tended to throw off small particles of themselves which blended with the gases, the makers of neon tubes immediately sought to procure a material which would not have a high gas (or sputter) factor. In neon tubes for television the metal, which is the plate, caused considerable difficulty. The sputter action darkened the glass and as the tube impedance increased the pictures became dimmer. Many metals were tried, including aluminum, which was much too soft. Likewise, such metals as copper, gold, silver and lead had sputter factors varying from 75 to 100. "Svea" plate upon tests was found to have a factor of appreciably *less* than 5 and its use made possible the production of an inexpensive tube having long life and steady brilliancy. The largest neon light manufacturers in the country adopted its use. It soon followed that radio tube manufacturers hearing of the results obtained began to make similar tests. This interest has increased to a point where two of the largest manufacturers have reported satisfactorily, and commenced the use of the material on a production schedule. Others are likely to follow and it is predicted that it will not be long before "Svea" will be appreciated and utilized to a very large extent.

Probably no other factor in the development of a pure iron for vacuum tubes has been so hard to overcome as the natural prejudice formed by those who for years have been working with ordinary irons. To many manufacturers the word iron means difficulties of all kinds. This feeling is the result of the grief which has been suffered by those who have attempted to use the best known qualities of iron.

The development of a pure, clean,

homogeneous iron with low gas content and high resistance to corrosion has been slow, and had to have its beginning in trouble. Sweden is fortunate in containing the purest deposits of iron ore known. That country also contains less pure deposits and not only does some of the finest iron come from Sweden, but also some of very ordinary quality. It was necessary, therefore, to procure in the beginning the purest natural ores. This was the starting point. Iron manufacturers are sometimes prone to lessen costs by adding a slight amount of steel scrap to the melt. Here again care had to be taken so that no scrap was permitted to contaminate the original pure ore. This having been accomplished, it remained to reduce these ores with the highest quality of willow charcoal such as is found in the great forests of Sweden. Then came into play the skill and years of experience of the Swedish puddlers upon whom much depends.

### Process of Working

In a Lancashire hearth iron is worked and reworked into a large mass still preserving all of its natural purity, no coal or coke having been permitted to add their deleterious ingredients. When this part is properly completed we have a fairly pure mass of iron which is rolled into billet or bar form. Here is where ordinary Swedish processing stops. The material is suitable at this point for most purposes. The makers of "Svea" follow this operation with utmost care up to this point, but, it is here where they *begin* their special processing. There must be a modification of the structure and a further elimination of impurities and gas. The method by which this is accomplished is not divulged, but it may be said that it involves a series of steps beginning with remelts and carried through until the final product is rolled here to meet this country's requirements. It is these additional refinements that permit of the application of "Svea" to the vacuum tube industry. What is accomplished may be surmised when it is known that this material has been drawn down in wire form to one and one-half thousandths of an inch in diameter and in strips to one thousandths in thickness.

Those interested in technical data may obtain complete and detailed information upon application to the suppliers. The strip is available in all standard thicknesses and widths for radio plates, neon lights, television tubes, or electrodes. In wire form it may be obtained in spools in any diameter. For hot cathode and mercury vapor lamps it may be obtained in rounds or flats of any standard dimensions. Fortunately the suppliers carry substantial quantities on hand at all times for prompt shipment. Samples may be had for test purposes and it is hoped that some of the readers of this article will be interested in this new and highly desirable material.

### Characteristics

SPECIFIC

| | |
|---|---|
| Atomic number | 26 |
| Atomic volume | 7.10 |
| Atomic weight | 55.84 |
| Boiling point | 2450 C. |
| Brinnel hardness at 500 Kg | 86 |
| Coefficient of expansion, linear per degree C. | $12 \times 10^{-6}$ |
| Coercive force low | .90 C. G. S. to 1.00 C. G. S. |
| Cold bend | 180° |
| Compressibility per unit volume per $Kg/Cm^2$ | $60 \times 10^{-6}$ |
| Conductivity. Thermal cal. per cm. per $cm.^2$ per sec. per° at 18° C. | .161 |
| Density, at 20° C. | 7.86 |
| Electrical resistance microhms per cm. cube at 20° annealed | 10.2 |
| Elongation | 40% |
| Hardness, Sceleroscope | 14 |
| Brinnel at 500 Kg | 86 |
| Heat resistance (melting point) C. | 1535 |
| Heat. Specific heat cal. per gm. per degree C. at 0° C. | .1150 |
| Impact strength. Charpy test. lbs. per sq. inch | 718 |
| Melting point—Centigrade | 1535 |
| Permeability—Initial permeability | 180 |
| Reduction of area | 65% |
| Resistance. Specific resistance microhms per cu. cm. | .10 |
| Resistance. Temp. coefficient of at 20° C. | .0052 |
| Resistance. Electrical-microhms per cm. tube at 20° annealed | 10.2 |
| Resistance. In ohms per foot. Wire .010 diameter | .707 |
| Resistance. In ohms per foot. Wire .015 diameter | .318 |
| Resistance. In ohms per foot. Wire .020 diameter | .207 |
| Specific gravity | 7.86 |
| Tensile strength—pounds per square inch | 44,000 |
| Vapor pressure | 760 mm. at 2450 C. |
| Watt loss. Per Kg. at 60 cycles | .070 |
| Weight per foot. Size .005 x 6 inch strip | .102 |
| Yield point. Pounds per square inch | 23,000 |
| Yield point. Per cent of ultimate | 55.5% |

GENERAL

Aging. Does not age (change in hysteretic quality) through carbon or nitrogen action.
Conductivity. Very high.
Corrosion. High resistance to corrosion and electrolytic or galvanic action.
Distortion. Free from undue distortion after annealing.
Gases. Unusually free from occluded gases.
Hysteresis loss. Very low.
Magnetism, residual. Extremely low.
Magnetic shield. Excellent for low frequencies. Better than aluminum.
Permeability. Exceptionally high.
Structure. Fibrous, compact, uniform—very homogeneous.
Toughness. Extreme toughness at low temperatures.

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## BELGIAN RADIO TRAFFIC

DURING the first nine months of 1931 the number of radiotelegraphic messages transmitted to the United States was 25,118 and the number received from the United States was 8,528. For the corresponding period of 1930 the number of messages amounted to 32,161 and 11,899 respectively. The number of telegrams from Belgium to the Belgian Congo during the first nine months of 1931 totalled 17,656, while 29,587 were received from the Congo. The new shortwave service to the Argentine was inaugurated May 20, 1931. Up to September 30, 1931, a total of 2,548 messages were sent from Belgium to Buenos Aires and 2,281 were received. Maritime Radio Communications: The coastal station at Ostend continues to assure connections with the fishing craft. At the present moment 80 steam trawlers are equipped for radiotelephony as compared with 25 in 1930. A similar station exists at Antwerp, where 10 ships are said to be equipped for radiotelephony. The question of telephonic connection with the Ostend-Dover mailboats is under consideration.——*Department of Overseas Trade, London,* 1932.

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## BRITISH RECEIPTS FROM RECEIVING SET LICENSES

TOTAL receipts from radio receiver license fees during the year ended March 31, 1932, amounted to £2,294,438, of which ten per cent was retained by the Post Office to cover the cost of collection and administration. The payment to the British Broadcasting Corporation, which under the terms of its license was based on the wireless license revenue of the previous year, amounted to £1,225,709.

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## RADIO CITY MOSAICS SHOW BEAUTY OF MANY METALS

THE brilliantly decorative mosaic figures which will adorn the exterior walls of the two theatres in Rockefeller Center are the work of a woman who has won international renown in the field of design—Miss Hildreth Meiere. She decorated the dome of the National Academy of Sciences in Washington, and has executed seven separate commissions for ornamentation of the Nebraska State Capitol. She is one of two women upon whom the Architectural League has bestowed its gold medal.

In designing the medallions for Rockefeller Center, Miss Meiere is employing mediums she has not used before, enamel and metals. Among the metals to be used will be alloy steel, ordinary steel, bronze, copper and nickel-bronze.

"I shall bring out the metallic quality most vigorously," she said. "The enamel will be used sparingly. I shall try to bring out the beauty of the material itself, the color, sheen and texture of the different metals."

# A full-wave mercury vapor rectifier†

THE new tube is for use in suitable rectifying devices designed to supply d-c. power from an a-c. power line. It is particularly recommended for supplying power of uniform voltage to receivers in which the direct current requirements are subject to considerable variation. Typical of such receivers are those employing class B power amplifiers.

The excellent voltage regulation characteristic of the 83, as it is called, is due to its low and practically constant voltage drop for any current drain up to the full emission of the filaments. Under normal operating conditions, the tube voltage drop is only about 15 volts. This desirable feature makes it possible to attain very high overall operating efficiency.

The coated filaments employed in this tube provide an efficient source of electron emission, and reach their dull red operating temperature quickly.

Under operating conditions, the 83 has a bluish-white glow filling the space within the plates and extending to some degree into the surrounding space. This glow, caused by the mercury vapor, is an inherent operating characteristic of the 83.

## Mercury Vapor Rectifier Considerations

The effect of the mercury vapor in the 83 is to neutralize the space-charge voltage drop so that it amounts to only about 15 volts at normal operating temperatures. This drop remains practically constant with any current drain up to the full emission of the filaments. It is apparent, therefore, that this tube under operating conditions has very low internal resistance, and that the current it delivers depends on the resistance of the load and the regulation of the power transformer. Sufficient protective resistance or reactance must always be used with this tube to limit its current to the recommended maximum value.

If current in excess of the total effective emission of the filaments is drawn, the tube voltage drop increases rapidly with current and thus causes harmful positive ion bombardment of the filaments. This bombardment may be so great as to cause permanent damage to the coating on the filaments in a short time.

It is characteristic of mercury vapor rectifiers that no appreciable plate current will flow until the plate voltage reaches a certain critical positive value. At this point the plate current rises steeply to a high value in a small fraction of a second. This surge of current recurring each time either plate becomes positive, may excite circuits in the vicinity of the tube to damped oscillation and result in noisy radio receiver operation. In receivers of low sensitivity, this noise may not be apparent but in very sensitive receivers it may be necessary to enclose completely the mercury vapor rectifier tube with perforated metal or wire screen shielding to eliminate objectionable noise. The shielding must be designed to provide sufficient ventilation to prevent overheating of the tube. It is usually necessary to place within the shield, small radio-frequency choke coils of low distributed capacity in series with each plate lead of the rectifier so that the slope of the current wave front to the filter is reduced sufficiently to eliminate impact excitation.

A further consideration in the operation of this mercury vapor tube is that the full plate load must not be applied until its filaments have reached their normal operating temperature. Under normal conditions of operation, they heat quickly when the set is "turned on" and are ready to supply the full load current before the tubes in the receiver require it.

### TENTATIVE RATING AND CHARACTERISTICS

**R.C.A.-Radiotron RCA-83; Cunningham CX-83**

| | |
|---|---|
| Filament voltage | 5.0 volts |
| Filament current | 3.0 amperes |
| Maximum a-c. voltage per plate | 500 volts (r.m.s.) |
| Maximum peak inverse voltage | 1400 volts |
| Maximum d-c. output current (continuous) | 250 milliamperes |
| Maximum peak plate current | 800 milliamperes |
| Tube voltage drop (approx.) | 15 volts |
| Maximum overall length | 5¾" |
| Maximum diameter | 2 1/16" |
| Bulb | ST-16 |
| Base | Medium 4-pin |

## Installation

The base of the 83 is of the medium 4-pin type. Its pins fit the standard four-contact socket which should be installed to operate the tube in a vertical position with the base down. Only a socket making very good filament contact and capable of carrying 3 amperes continuously should be used with the 83. Unless this precaution is followed, poor contact at the filament pins will cause overheating at the pins and socket, lowered filament voltage, and also high internal tube drop with consequent injury to the tube.

The bulb becomes hot during continuous operation. Provision should be made, therefore, for adequate natural ventilation to prevent overheating. This point must be given proper consideration if shielding is employed around the tube.

The filament is intended for a-c. operation from one of the secondary windings of a power transformer. This winding provided with a center-tap or center-tap-resistor should supply at the filament terminals the rated operating voltage of 5.0 volts when average rated voltage is applied to the primary.

The high current taken by the filament and the danger of damage to the tube caused by applying plate voltage to the tube with its filament insufficiently heated, make it imperative that all connections in the filament circuit be of low resistance and of adequate current-carrying capacity. All wire connections should be carefully soldered.

The plate supply is obtained from a center-tapped high voltage winding on the power transformer. This winding should be designed so that the maximum a-c. input voltage per plate will not exceed 500 volts r.m.s. under varying conditions of supply line voltage. The return lead from the plates, i. e., the positive bus of the filter and load circuit, should be connected to the centerpoint of the filament transformer.

The secondary windings of the power transformer should be adequately insulated from each other to withstand the full peak voltage of the high voltage winding. Under recommended maximum operating conditions, the full peak voltage will be about 1400 volts. The resistance of the transformer windings should of course be low if full advantage of the excellent regulation capabilities of this mercury vapor rectifier is to be obtained.

Shielding of this tube, particularly in sensitive receivers, may be necessary to eliminate objectionable noise.

Radio-frequency choke coils, connected in series with each plate lead and placed within the shielding if used, are usually necessary in receivers having high sensitivity. The inductance of the

†*By Engineering Staff, R. C. A. Radiotron Co., and E. T. Cunningham, Inc.*

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**Description of a new, heavy duty, full-wave, mercury vapor rectifier tube of the hot-cathode type.**

chokes should be of the order of one millihenry or more.

A fuse having a rating approximately 50 per cent in excess of normal load requirements should be inserted in the primary of the power transformer. This fuse is necessary to prevent damage to the power transformer in case of excessive current which may flow under abnormal conditions.

### Application

The 83 is recommended for supplying d-c. power to receivers, particularly those employing class B amplification in the audio output stage. The direct-current requirements of such receivers are such as to cause considerable variation in the load impressed on the rectifier tube. Unless the tube and its associated circuit can take care of the load demand with good regulation, unsatisfactory receiver performance will be obtained. To meet this operating requirement for extremely good regulation even though the load current is subject to considerable variation depending on the signal, the 83 is especially suited.

In order to take full advantage of the regulation capabilities of this mercury vapor rectifier, the resistance of the transformer windings (refer to Installation) and the filter choke windings should be as low as practicable. Since the drop through the tube is practically constant, any reduction in rectified voltage when the load is increased, is due to the drop in the transformer and/or the filter windings.

If it is impracticable to use a transformer with sufficiently low resistance to give the desired regulation, improved regulation of the output voltage may be obtained by employing a bleeder across the filter circuit.

Filter circuits of the condenser input or the choke input type may be employed provided that the maximum voltages and currents tabulated under Rating and Characteristics are not exceeded.

If the condenser input type of filter is used, consideration must be given to the instantaneous peak value of the a-c. input voltage which is about 1.4 times the r.m.s. value measured from plate to filament with an a-c. voltmeter. It is important, therefore, that the filter condensers (especially the input one) have a sufficiently high break-down rating to withstand this instantaneous peak value. It should be noted that with condenser input to the filter, the peak plate current of the tube is considerably higher than the load current. With a large condenser in the filter circuit next to the rectifier tube, the peak current is often as much as four times the load current.

When, however, choke input to the filter is used, the peak plate current is considerably reduced. This type of circuit, therefore, is to be preferred from the standpoint of obtaining the maximum continuous d-c. output current from the 83 under the most favorable conditions.

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## WKAQ, PORTO RICO

PUERTO RICO'S broadcasting station, WKAQ at San Juan, is now an up-to-the-minute plant as a result of a complete replacement of equipment. Governor James R. Beverley and other officials and prominent citizens of the Island and of the City of San Juan participated in the program which inaugurated the new station.

WKAQ is owned and operated by the Radio Corporation of Puerto Rico, a subsidiary of the International Telephone and Telegraph Corporation which originally established this station in 1922. The station has a power rating of 1,000 watts and is equipped with the most advanced apparatus throughout. The studios have been remodeled and the antenna rebuilt. According to dispatches from listeners to the inaugural program, excellent reception for every part of the Island has been achieved.

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## INSTALLATION OF RADIO BEACONS ON THE URUGUAYAN COAST

THE Uruguayan and Argentine press announce that Uruguay had decided to install seven radio beacons along its coast, three of which were considered absolutely essential and were to be constructed immediately, chiefly as the outcome of repeated representations made by shipping circles. It has now been learned that the work on the first three beacons at Lobos Island, at the English Bank lightship, and at Cap Polonio is already quite advanced and that the two former are expected to start operating. Work on the third beacon at Cap Polonio has been started. Construction of the beacons is being done by a British company, which concern also supplied all the necessary equipment. The contract price for the first three beacons is 103,000 Uruguayan pesos. (The Uruguayan peso averaged $0.4754 in May, 1932.) It is planned, as soon as circumstances permit, to construct the remaining four beacons on the lighthouses at Punta Brava, La Panela, Punta Negra, and Punta Coronillas. *Vice Consul Leo P. Hogan, Montevideo, Uruguay.*

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## NAVY ORDERS AIRCRAFT RADIO SETS

AN order amounting to more than $100,000 has been received by the Westinghouse Electric and Manufacturing Company from the Navy department for aircraft radio transmitting and receiving equipment. The equipment will be built in the Chicopee Falls Works—radio products division of the Westinghouse Electric and Manufacturing Company.

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## CHINA CONCLUDES RADIO AND RADIOTELEPHONE AGREEMENTS

THE Ministry of Communications has concluded an agreement with the China Electric Company for linking China in the near future with North and South America and Europe by radiotelephone. The contract calls for the erection of four radiotelephone transmitting and receiving stations for communication within China, one to be at Shanghai and the other three at important cities in that country. In addition to these an international radiotelephone station will be built at Shanghai so that the rest of the world can be connected to the more than 100,000 telephones now in China. An agreement was also concluded between the Chinese Ministry of Communications and the Mackay Radio and Telegraph Company for the exchange of radiotelegraph traffic between China and the United States, Cuba and the Philippines.

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## AUSTRALIAN GOVERNMENT BROADCASTING COMMISSION

THIS commission will control radio broadcasting over the Government A class chain of stations. The new commission is as follows: C. Lloyd Jones, Sydney, chairman, business man; Herbert Brookes, Melbourne, vice chairman (former Australian commissioner to the United States); Mrs. Claude Couchman, Melbourne, teacher of music; Professor R. S. Wallace, Sydney, Professor at Sydney University; and R. B. Orchard, Sydney, entertainment organizer. The chairman of the commission is to receive £500 per annum, the vice chairman £400, and the three remaining members £300. The members were appointed after the new Act relative to broadcasting had been passed by parliament and after several important amendments were made in the original bill. The new commission has held its first meeting and took over the control of the broadcasting from A class stations on July 1 from the Australian Broadcasting Co. which was organized three years ago for that purpose. *Assistant Trade Commissioner H. B. Van Blarcom, Sydney, Australia.*

# Radiothermy†

By Dr. Willis R. Whitney*

VACUUM tubes place in our hands the remarkable power of generating an electromagnetic field traveling through space at high velocity, akin to light, and, like it, composed of radiations of many different wavelengths, but far more comprehensive in the scope of its spectrum than visible light can possibly be. Tubes of the radio type can be used to produce electromagnetic waves as long as a thousand meters and as short as one ten-thousandth of a meter. It is not difficult to believe that within this range many invisible assets await only further research to disclose them. Radio broadcasting is only one use for the principles involved.

In earlier days, and indeed from its very beginning, the greater part of radio tube research was carried out along the definite and narrow lines dictated by, as it was then supposed, its greatest application—that of broadcasting. Vacuum-tube phenomena, as they were disclosed, permitted the use of certain types of sending tubes, and the development of other specializations, such as magnifying, rectifying, amplifying, and receiving tubes. In a word, the best talent was expended on the development of the radio tube for radio use, and little thought was given to the broader aspects of the powerful tool in our possession.

One of the important applications of radio tubes quite apart from, and, indeed, tangential to, their use in radio, concerns their employment in biological, and possibly in therapeutic fields. Our interest was early attracted to the heating and destruction of living matter in an intense radio field, and we undertook much investigational work in this connection, for it seemed clear that sooner or later radio fields must find biological use. The form of apparatus which we most commonly used in this work consisted of an oscillating circuit with a condenser and reactance activated through vacuum-tube oscillators.

†*A paper presented at the International Electrical Congress, Paris, France, July 4-12, 1932*

**Vice-President and Director of Research, General Electric Company.*

The three-element tube permits the production of undamped sine-wave oscillations, or very high-frequency sine-wave alternating currents, by suitably connecting it into a circuit in which an electrical capacity and a reactance are in parallel. This oscillating current charges a second condenser, and it is in the field of this condenser that the heating which we are considering in this article is produced.

The electrical engineer, thinking at first of the dielectric constants of condensers, is apt to confine his thought to what is broadly called dielectric hysteresis, and to use the word to cover the various losses in the space between the condenser plates without reference to their origin. This article is not the place to analyze losses in dielectrics. For our purpose it may be enough to know that we are dealing largely, if not entirely, with a relatively simple case of electrical resistance. We may look at our arrangement as a condenser field in the midst of which a certain resistance is placed. If the ends of that resistance are looked at as connected in any way, as by static induction, to the condenser plates, it is clear that some certain current will flow in the resistance, and so cause corresponding heating.

## Electrolytic Resistance

If electrolytic resistance is commonly looked at as the frictional effect opposing the motion of the ions of the electrolyte, we may still attribute the heating effects to this motion, even though the actual migration which can take place in a ten-millionth of a second is very small and the amount of actual electrolysis entirely negligible.

The "influence" of the condenser plates themselves, which we have called static induction effect, may be as easily interpreted as our experience with radio waves and antennas. We think of the radio antenna as picking up the magnetic field changes, but the two changing magnetic and static fields are closely interlocked. The fact is that the heating of such resistances as those of aqueous solutions in the static field of alternating circuits becomes very considerable when the frequency of alternation reaches the ranges above ten million cycles. The more accurate determinations of relation between frequency and resistance in such cases, and with reference to the significance of the dielectric constants, have been shown by various writers, such as Patzo'd[1] and McLennan.[2]

Miss Hosmer[3] in 1928 studied the effect of the radio field upon salt solutions contained in glass tubes placed between condenser plates which were connected to the radio power supply. It was found that the salt solutions were heated in the field, and that solutions of equal electrical resistance heated at the same rate, regardless of the salts used. Solutions similar in their constitution to the blood were particularly studied, and it was found that effective heating occurred in a range of alternating frequency of the order of fifty to ten million cycles, or six to thirty meters wavelengths. Experiments were also made with solid jellies, to determine the extent of their heating in the field, and also to observe the remarkable phenomenon of orientation between the plates.

This heating effect was found to be much more general than a mere application of the field to salt solutions might indicate. Apparatus of the type described by De Walt[1] and by McLennan[2] was found to permit a variation of the heating effect in the resistor with the variation of oscillation frequency in the circuit. McLennan and Burton[5], indeed, have shown the mathematical relationships which explain the dependence of the rate of heating of the resistor upon its electrical resistance (for dilute solutions). They have shown that the frequency of the electrical oscillations for maximum heating can be expressed by the formula

$$\frac{2\,C}{n\,K} = 1,$$

where C is the conductivity and K the dielectric constant of the resistor, and n the frequency. More general mathematical studies of such heating effects have been made by Christie and Loomis[6], Drake, Pierce, and Dow[7], Patzold[1], and a general treatment of the subject by Schliephake was published in Germany in 1929.[8]

## Effect on Living Matter

When we transferred our attention from salt solutions to living matter, it seemed wisest at first to work with non-human material—insects, mice, rats, rabbits, and other animals. Alternating current of several hundred thousand cycles, to be sure, had already been used therapeutically, contacts of one sort or another being always attached directly to the person or animal treated. In these interesting cases, it seemed probable that the contact resistances and differing specific resistances of various parts of the body produced unevenly distributed heating effects—a condition well delineated by Westermark[9] and by Schliephake[10]. Because of this, and because we were not

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**Application of vacuum tubes in biological and therapeutic fields—heating effect on solutions akin to the blood—effect on animals—on humans**

perfectly certain that internal high-frequency heating might not produce far-reaching, but subtle, ill effects similar to those obtaining in some of the early x-ray exposures, we preferred to approach the subject of human therapeutic treatment with caution.

We soon found that all animals could easily be killed in an intense radio field, but only after evidence of overheating, so that death was apparently due to passage of the thermal limit of viability. Small insects such as fruit-flies, when submitted to fields of a few watts of radio energy, apparently died instantaneously, and the deposition of moisture from their bodies on the walls of the tube near them indicated that death was due to overheating. When the same insects were exposed to the field in the dormant condition produced by a surrounding temperature of zero degrees Centigrade, it was impossible by careful manipulation to revive them, and to make them fly about in the zero air exactly as though midsummer temperatures prevailed. A slightly greater energy application killed them. Throughout this work, quartz tubes were used, it being found that glass itself heated in the field—an effect perhaps due in part to absorbed moisture.

## Artificial Fever

At about this stage of the work we became acquainted with the remarkable work of Dr. Wagner-Jauregg, of Vienna,[11] who had made a fundamental clinical research on many cases of paresis by using fevers. He had employed particularly a malarial infection, and thereby had produced at least 30 per cent recessions of the paresis. It naturally seemed desirable to apply the radio fever in place of the infection. Dr. Carpenter[12] took up work on syphilis in rabbits, and later, after it was evident that no danger was involved, extended his work to include humans. In the meantime, the work of other researchers on the physiological and biological changes brought about by radio heating—notably that of Dr. Knudson[13], of Albany—gave increasing confidence that experiments on humans might be safely carried out. So work on a "fever-machine" was extended, and it has been found possible, with increasing perfection of design, to control rises in human body temperature as great as 8.5° F.

A powerful tool was thus placed in the hands of medical men in the combating of various diseases, such as syphilis, in which excessive body temperature may be an alleviant, or even a cure. Such work, however, can be properly done only by experts in well organized institutions. Several such institutions, having learned of the preliminary researches, requested loan of experimental apparatus. This seemed the best way to carry out the clinical studies. It was logical to attack immediately the identical disease which had yielded to the malarial treatment. The New York State Psychiatric Institute, already using that method, were willing to use the electrical process, and an outfit was loaned to that institution. Some of their results have been published.[14 15 16] Other organizations have been loaned other outfits, and the plan has, in general, been one of supporting or assisting the researches of experts already acquainted with the field of paresis or some kindred disease where internal heat might be "indicated." In this way sufficient data have already been obtained to warrant further work along this line.

Arthritis, as mentioned, seems to lend itself well to this work, and several experts are actively experimenting. Dr. Schliephake[17] has recently published accounts of favorable experiments on surface malformations such as boils and carbuncles, and on such swellings of joints as occur in certain arthritis troubles. Several friends made use of our apparatus in the study of tumor growth under controlled temperature in the mouse and rat. The results here were not promising, however.

It developed through the experiments in hospitals that there were studies of internal body or joint heating which might be made of value without producing a fever for raising the temperature of the whole body above the temperature produced by its normal control mechanism. For this reason a number of smaller short-wave generating outfits have been made by which induced local heating, as within arm and leg joints, is accomplished. Several clinical centers are now operating in this way.

## Focusing the Effect

The work also soon raised the interesting question: Can the heating effect be "focussed"? There are at least two ways of localizing, more or less, this energy application. One is by the shape, size and positions of the condenser plates, because the greatest heat effect, other things being equal, is where the field is the most intense. Another way consists in controlling the frequency so as to fit the particular specific resistance of the part concerned. Not much has been done in either field, but it was shown by Hosmer[3] that while aqueous solutions of different salts and equal resistances heated equally, there was for each frequency a particular resistance or salt concentration which heated most rapidly. A tadpole in water which heated but slightly alone caused heating of the water because of the tadpole's rise in temperature when in the water.

Schliephake[18 19] has made comparisons between the rates of heating of various parts of the body, like fat, bone, muscle, etc., when submitted to diathermy as commonly applied (using contact-electrodes), and when submitted to the radiothermy here described. This selective method has been well illustrated by a recent article by McLennan and Burton,[19] in which the local heating differences in dead flesh in this static field has been disclosed very ingeniously by changes in the colors of thermo-sensitive organic dyes.

In all such work good judgment and careful planning are necessary, and it has been our plan to depend entirely upon the medical organizations using the outfits to report their results, and that without undue haste. As similar devices are also now in use in European hospitals, it is probable that their value for the diseases in question will soon be determined.

The question of action of radio energy, as distinct from simple heating, upon micro-organisms, bacteria, transplanted tissue cells, etc., is very important. A number of workers have undertaken researches with this in mind, but so far as we know the results might be attributable to the specific effects of the rise in temperature of the body or culture medium in which the living matter was planted.[18 20 22 23 24 25]

As the methods of production of radiant energy of shorter and shorter wavelengths in the unexplored "radio" region are extended, such experiments will probably have to be repeated.

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## W. M. C. A.

BROADCASTING station WMCA, New York, has taken advantage of dull times to add to its facilities. The management lists seven points of interest.

1. Erection of a new transmitter plant on Flushing Bay. A project involving an expenditure of more than $100,000, employing many men.

2. Installation of a new control system, with connections for sixty remote spots, now in operation.

3. All studios have been completely remodeled and decorated and equipped with air conditioning systems.

4. An additional floor of the WMCA Building, Broadway at 53rd Street, has been taken over. 5,500 square feet of new space for offices and studios. Total floor space nearly 18,000 square feet.

5. Started the construction of a new auxiliary transmitter, permit for which has just been issued by the Federal Radio Commission.

6. Completed construction of a new 100-watt portable transmitter and a one-watt low-wave transmitter.

7. Despite so-called "conditions," WMCA has not reduced its staff, nor has it reduced the wages of employees. In fact, it has added to its staff, which numbers more than 100 persons.

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## ACTIVITY AT KQV

FRED R. THOMAS, JR., plant manager of station KQV, Pittsburgh, is busily engaged in revising and enlarging the speech-input facilities of the station. Additional program amplifiers, a new monitoring amplifier, interlocking studio controls, and other revisions combine to occupy an entire additional equipment rack in the studio control room.

Benjamin Soby, known for the origination of the Soby yardstick of audience value, has joined the staff of Station KQV. as promotion manager. Soby's duties are public relations and sales promotion. He was until recently connected with Westinghouse Radio Stations—KDKA, WBZ-WBZA, KYW-KFKX—as sales promotion manager.

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## COMMUNITY RADIO IN INDIA

E. DUNCAN SMITH, wireless consultant to the Government of India, has drafted a scheme for the installation of radio in villages in the Bombay Presidency. Indian gentlemen have undertaken to provide receiving sets and a European business man has promised to pay a substantial donation to defray part of the cost. It is proposed to choose villages in the center of well-populated areas and establish listening posts in them. A listening post will consist of a reinforced concrete cubicle about 8 feet high with a loudspeaker in the roof. The receiving set in each listening post will be of the superheterodyne seven-valve type and entirely automatic, so that when the operator of the transmitter at Poona switches off, the receiving set will be automatically switched off, and vice versa. Transmission will all be done on a 49-meter wave length.

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## IMPROVEMENTS RELATING TO ELECTRIC-DISCHARGE DEVICES

THE cathode is of nickel and may be coated on one or both sides with electronically active substances, such as may be obtained by heating barium carbonate, or other suitable salts of the alkaline earth metals, in order to increase electron emission.

Steiner, A. C. and Livingston, O. W. (Assigned to British Thomson-Houston Co., Ltd.) Britsh Patent 355,728.

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## AIRWAYS RADIO

THE radio-phone facilities of Transcontinental & Western Air, whose planes fly over Pennsylvania on their coast-to-coast mail and passenger routes, have been of great value to the state in its efforts to prevent forest fires and preserve the forest resources, according to George W. Wirt, chief fire warden at Harrisburg.

"Pilots of TWA," Mr. Wirt reports in a recent bulletin, "have come to our assistance many times by reporting the discovery of forest fires by means of their two-way radiophone facilities. The pilot reports the discovery of the fire to his ground radio stations at Harrisburg, Pittsburgh, or Philadelphia, and within a few minutes the fire wardens are in possession of the information.

"Often the pilots render particularly valuable service by giving details of location which could not be gained from the warden's observation towers. The pilot, of course, can see the evidences of the fire many miles ahead and is able to get the report to us long before our observation posts are aware of the fire.

"In one instance a radio report from a plane of a fire a short distance outside of Pittsburgh was in the Harrisburg fire warden's office six minutes after the pilot spotted it. The aid of the pilots gives a modern touch to our old game of fire fighting and offers a thrill of many possible new developments in the future."

Along the route of TWA, whose trimotor passenger planes and smaller mail planes operate over the shortest route from coast to coast, there are nineteen radio ground stations. The pilot of each plane is in constant radio communication with the ground through the radiophone transmitter and receiver on his plane and on the ground.

## SIX-FOOT MODEL YACHT RADIO CONTROLLED

By L. D. RICHARDS

THE model yacht here illustrated, was exhibited recently at Denver, Colo. The boat is automatically controlled by radio from a shore transmitter.

The model is the result of experimentation by B. E. Moritz, Jr., sound transmission engineer, and incorporates numerous new ideas and practices in the reception and utilization of radio impulses. It answers instantly and unfailingly to commands for all regular changes of speed and direction, blows a whistle and turns lights off and on.

The transmitter ashore is a portable type. The receiver employs three tubes, equipment to this point being entirely conventional. A highly sensitive relay

B. E. Moritz, Jr., sound transmission engineer of Denver, Colo., shown with the radio controlled model yacht which has been through a series of successful trials.

is operated by the receiver output. The relay in turn operates a selector switch which has been remodeled from automatic phone equipment by the addition to it of three delay-action relays in such manner that it employs a two instead of three wire circuit and opens and closes only the desired control circuits. Left rudder, for instance, may thus be signalled to the boat while the propellor drive motor still continues to function in either of two speeds ahead. Numerous problems of filtering and shielding were presented.

The model is not in any sense a toy, it having cost in the neighborhood of $1,000 to design and construct.

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## RADIO SHOWS

A RADIO and refrigeration show will be held September 19-25, this year at the Hotel Edison, New York. There will be various exhibits.

At Chicago, October 1 to 16, there will be numerous displays of radio products at the Modern Age Exhibition, to be held in the Travel and Transport Building at the World's Fair grounds.

# Radio tube progress

SOME laboratories, because of lack of understanding, or knowledge, continue to rely on the 235 rather than the 58 tube. The 58 of one company was announced in the June, 1932, issue of RADIO ENGINEERING.

The Arcturus 58 is intended for use in the radio- and intermediate-frequency stages of a-c. receivers where it efficiently reduces cross-modulation and modulation distortion and eliminates the necessity for local—distant switches. It is an ideal tube for use in receivers employing automatic volume control, and is also recommended as a first detector in superheterodyne receivers to assist in controlling volume. The suppressor grid in this tube may be used to control receiver selectivity.

As an r-f. amplifier the 58 is very efficient because its long "cutoff" feature effectively reduces cross-modulation. The screen voltage may be obtained from the plate supply or from some other high intermediate voltage which should not exceed 250 volts. Where the series resistor method of obtaining screen voltages from a high voltage supply is used, the variable cathode-resistor method of volume control should also be used, thus fully obtaining the remote "cutoff" advantage of this tube. If grid coupling resistors are used, they should not exceed 1.0 megohm in value. As a frequency converter, or first detector in a superheterodyne, the 58 permits a gain of about one-third that in an intermediate-frequency amplifier stage. The d-c. grid bias, obtained either from a separate supply or from a variable resistor in the cathode circuit, can be varied to control this gain—an advantage in automatic volume control receivers.

When the first detector is used with a variable grid bias, it is advisable to apply a peak oscillator voltage about one volt less than the grid bias to obviate cross-modulation resulting from the first detector drawing grid current.

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### The 55

The 55, announced in RADIO ENGINEERING, July issue, is referred to as a duplex, triode, diode unit which may be used as a full-wave diode rectifier, independently of the triode function, or as a half-wave rectifier. Further, it may be employed as a triode amplifier independently of its use as a diode rectifier.

#### Application

The RCA Radiotron 55 is recommended for performing the simultaneous functions of automatic volume control, detection, and amplification. This three-in-one feature is of decided practical importance to the set designer.

The application of this tube to receiver circuit design gives the engineer wide latitude in possible tube-unit connections. Since the 55 really consists of two diodes and a triode, each of these tube-units may be used in a circuit just as though it were in a separate bulb.

For detection, the diodes may be utilized in a full-wave circuit or in a half-wave circuit. In the latter case, one plate only or the two plates in parallel may be employed. The use of the half-wave arrangement will provide approximately twice the a. v. c. voltage as compared with the full-wave arrangement.

For automatic volume control the controlling bias voltage may be obtained by either of two general methods. In one case, the required voltage is obtained from the detector circuit by utilizing the voltage drop caused by the rectified current flowing through a resistor in the detector circuit. In the other case, the required voltage is obtained by utilizing one diode for the sole purpose of automatic volume control. This latter method is of particular interest since it confines the sensitivity and time delay function to the a. v. c. circuit. Time delay action is, of course, determined by the use of a resistance and condenser combination having the desired time constant. The sensitivity control action is determined by applying a negative voltage to the a. v. c. diode plate of such a value as to accomplish the desired reduction.

For amplification, the triode may be employed in conventional circuit arrangements. Grid bias for the triode, depending upon circuit design, may be obtained from a fixed voltage tap on the d-c. power supply or may be obtained by utilizing the variable voltage drop caused by the rectified current flowing through a resistor in the detector circuit.

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### The 58

#### General

| | |
|---|---|
| Filament voltage | 2.5 volts a-c. or d-c. |
| Filament current | 1.0 ampere |
| Grid-plate capacitance with shield-can) | 0.010 micromicrofarads |
| Input capacitance | 5.2 micromicrofarads |
| Output capacitance | 6.8 micromicrofarads |

#### Class "A" Amplifier

| | |
|---|---|
| Plate voltage (max.) | 250 volts |
| Screen voltage (max.) | 100 volts |
| Grid bias (min.) | —3 volts |
| Plate current | 8.2 milliamperes |
| Screen current (max.) | 3.0 milliamperes |
| Plate resistance | 800000 ohms |
| Transconductance | 1600 micromhos |
| Transconductance (at —40 v. bi.) | 10 micromhos |
| Transconductance (at —50 v. bi.) | 2 micromhos |
| Amplification factor | 1280 micromhos |

#### Superheterodyne First Detector

| | |
|---|---|
| Plate voltage (max.) | 250 volts |
| Screen voltage (max.) | 100 volts |
| Grid bias (min.) | —10 volts |
| Oscillator peak voltage | 1 v. less than grid bias |

#### Installation

The base of the 55 is of the small 6-pin type. Its pins require the use of a standard six-contact socket which may be installed to operate the tube either in a vertical or in a horizontal position. For horizontal operation, the socket should be positioned with its heater pin openings one vertically above the other.

The bulb surface temperature on the hottest part of the bulb under operating conditions should not exceed 150°F. as measured by a small thermocouple. Shield-cans, if used, should provide sufficient ventilation to prevent the bulb temperature from rising above the recommended maximum value.

The heater is designed to operate at 2.5 volts. The transformer winding supplying the heater circuit should be designed to operate the heater at this recommended value for full load operating conditions under average line voltages. A transformer having primary taps is recommended so that adjustment may be made to give 2.5 volts to the heater for the particular line voltage at each installation.

The cathode should preferably be connected directly to the mid-tap of the heater winding. This practice follows the recommendation that no bias be applied between heater and cathode, and that the resistance between them be kept as low as possible in order to prevent hum in the circuit. When this practice is not followed, the heater may be biased negative with respect to the cathode by not more than 45 volts. If the use of a large resistor is necessary between heater and cathode in some circuit designs, it should be by-passed by a condenser of at least 4 microfarads or objectionable hum may develop.

Complete shielding of detector circuits employing the 55 is generally necessary to prevent r-f. or i-f. coupling between the diode circuits and the circuits of other stages.

In the case of full-wave detection, with circuits balanced to ground, shielding and i-f. by-pass filters are not theoretically required. However, due to the practical difficulties of circuit balancing, their use is desirable. In the case of half-wave detector circuits, their use is always necessary.

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### Full-Wave Rectifier Tube 82

The type 82 tube, announced by RCA Radiotron Company was developed to supply the need for a rectifier tube for use in circuits requiring good voltage regulation and high efficiency. It is a full-wave rectifier tube differing from the well-known high-vacuum types in that mercury vapor is used in the tube. The bulb size is smaller than that of high-vacuum tubes of equal rating.

The principle of operation employed in the type 82 is essentially that of a high-vacuum, electron-conducting tube rather than a gaseous, ion-conducting tube. When positive voltage is applied to the plates of this tube, the start of the electron flow ionizes the mercury vapor. The positive mercury ions reduce the negative space-charge due to the electrons surrounding the filament. The resulting low space-charge-voltage drop is an essential feature of the tube.

When the space-charge-voltage drop is less than approximately 22 volts, the mercury ions do not have sufficient velocity to affect the active surface of the filament. The result is that the normal high-vacuum performance of the filament is obtained without the high space-charge-voltage loss occurring in other types.

When the tube is operating at normal temperature with sufficient electron emission from the filament to adequately supply the peak current demands on the tube, the space-charge-voltage drop in the tube will be approximately 15 volts. Since the voltage drop in the tube is practically constant for any current within the emission limits of the filament, the regulation of the output voltage is that of the supply voltage, transformer and circuit.

High efficiency results from the low voltage drop and the low power loss in the tube. The power dissipated at the plates is only a small fraction of the value occurring in other rectifier types. Due to the low power dissipation in the tube, a small S-14 size bulb is used. The small size of the tube is an advantage where space is limited.


THE Group Subscription Plan for RADIO ENGINEERING enables a group of engineers or department heads to subscribe at one-half the usual yearly rate.

The regular individual rate is $2.00 a year. In groups of 4 or more, the subscription rate is $1.00 a year. (In Canada and foreign countries $2.00.)

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***(Radio Engineering)***

**Bryan Davis Publishing Co, Inc.**
**19 East 47th Street**
**New York, N. Y.**

Los Angeles Chicago St. Louis

# NEWS OF THE INDUSTRY

### NEW RADIO SCHOOL OPENS IN PHILADELPHIA

J. C. Van Horn, formerly vice-president of RCA Institutes, Inc., announces that he will open a completely equipped school for instruction on radio and refrigeration. Mr. Van Horn brings with him in this work a wealth of valuable experience in the radio field. He was the owner of the Philadelphia School of Wireless Telegraphy from 1912 until the absorption in 1929 by the RCA Institutes and the consequent enlargement of the Philadelphia School under his able direction.

A feature of this new school will be that the courses include not only the latest developments of the radio field and television but service problems in electrical refrigeration which Mr. Van Horn believes will enjoy unprecedented growth not only in the home, but, due to the increased use of home and industrial types of air cooling requiring attention of service men qualified in refrigeration. He further believes, that the radio service man is the one to prepare for this work since the radio dealer has taken an active interest in sales and service of refrigerators.

The location of this new school will be at 1533 Pine Street, Philadelphia, at the former quarters of the Philadelphia School of Wireless which have been renovated for the opening of the new school early in September. He will personally conduct the classes this Fall.

Many I.R.E. members will remember Mr. Van Horn as the chairman of the Philadelphia Section for three and one half years of rapid growth. he is a member in both the I. R. E. and A.I.E.E. and a Lieutenant in the U. S. Naval Reserve, having served as a commissioned officer in the Fourth Naval district during the World War.

▲

### BOOKLETS ON TUBES

RCA Radiotron Company and E. T. Cunningham, Inc., Harrison, N. J., have issued complete booklets listing and illustrating all of these companies' modern tubes.

This information has been prepared in a form useful to those who work or experiment with radio tubes. Of particular help to many will be the "characteristics chart" on pages 40 and 41 and its correlated material on pages 39 and 42.

It is the desire to make these manuals easily accessible to those who will benefit by having them. Although each manual carries a price of twenty-five cents, the company will be glad to supply service men, experimenters and others actively interested in radio tubes with a copy gratis upon request.

▲

### VOLUME CONTROL REPLACEMENTS

The Central Radio Laboratories, 900 East Keefe Avenue, Milwaukee, Wis., has available a useful service sheet listing a variety of products, including volume controls, power rheostats, resistors, "L" pads, plugs and tone controls.

### ARCTURUS TUBE EXPORTS REACH 76 FOREIGN COUNTRIES

The world-wide acceptance of Arcturus blue tubes is evidenced in a recent address made by W. A. Coogan, export sales manager of Arcturus Radio Tube Company, Newark, N. J., in which he states that his company is now exporting to 76 countries throughout the world. Mr. Coogan said:

W. A. COOGAN

"In most countries which we serve the best jobber located in the domain is usually an Arcturus jobber and we are proud of this fact. In a survey which we have recently completed it has been definitely established that in many countries throughout the world Arcturus tubes lead not only in acceptance but in volume sales. Our export sales have shown a constant increase from year to year in spite of the depression, tariff walls and foreign exchange restrictions."

▲

### BAKELITE FOR RADIO USES

The initial resin—which is the basis of the several phenol resin products sold under the trade-mark—results from the interaction of formaldehyde and phenol. Reacting at suitable temperature, these two chemicals yield a new chemical substance which is a clear, amber-hued, resin-like solid. In this first stage it can be melted, and will dissolve in solvents such as alcohol and acetone. Further application of heat, with pressure, advances it to a further chemical stage at which it becomes permanently infusible and insoluble. The importance of this peculiar change may well be emphasized. The properties of the resin in its initial stage, permit of its being dissolved and fused, and variously adapted to industrial processes; while its later transition to a strong, insoluble, and infusible substance renders it peculiarly serviceable for a great variety of applications.

The laminated form of Bakelite is used in radio for front panels, subpanels, coil forms, insulating bushings, etc. It is manufactured by a number of companies under special license from Bakelite Corporation, and is sold under their well-known trademarks: "Dilecto," "Fibroc," "Formica," "Micarta," "Phenolite," and "Spaulding Bakelite."

▲

### FOR BROADCAST STATIONS

A simple alarm system for radio broadcast stations by means of which variations of 50 cycles from assigned frequency are instantaneously and automatically signaled to attendants is announced by the Egert Engineering Company, 179 Varick St., New York. The system may be set for any operating frequency.

▲

### SOLAR EXPANDS

Solar Manufacturing Corporation, 599 Broadway, New York City, manufacturers of electrolytic and mica condensers, announces the appointment of the following district sales managers:

William F. Seeman, 763 Tacoma Ave., Buffalo, N. Y.; Wm. B. Masland, 105 East Franklin St., Baltimore, Md.; Harvey T. Cory, 1712 Carter St., Dallas, Texas; J. W. Van DeGrift, 623 Charles Bldg., Denver, Colo.; Arthur S. Detsch, Security Bldg., Portland, Ore.

▲

### C. R. C. AGENTS ALL OVER

Central Radio Corporation, Beloit, Wisc., announces the appointment of The Lew Bonn Company, 2504 University Avenue, St. Paul, Minnesota, as agents for C. R. C. sockets in North Dakota, South Dakota, Minnesota and western Wisconsin. Other representatives of Central Radio Corporation are: L. A. Dernier, 408 F. P. Fay Building, Los Angeles, California; L. H. Jackman, 2043 E. 77th Street, Cleveland, Ohio; R. C. James Co., 2321 Second Avenue, Seattle, Washington.

United Carr Fastener Company of Canada, Ltd., Hamilton, Ontario, are Central Radio Corporation licensees in Canada.

### 6 VOLTS D-C. TO 110 V., 60 CYCLES

A converter by means of which six-volt storage battery current is changed to 110-V. a-c. to 60 cycles is announced by Federated Purchaser, Inc., 25 Park Place, New York.

With this device one can use a standard 110-volt alternating current midget radio set in any automobile, boat or aeroplane. Use the radio in the automobile while traveling and then merely pull the plug and take the set into the home, cottage, bungalow, or hotel room to use there.

This device also lends itself to small public address systems, drawing from 40 to 65 watts. Eliminates the necessity of gasoline or other expensive types of generators. This enables one to use the public address on an automobile for advertising purposes, outdoor meetings, picnics, etc.

This unit mounts on to the cowl under the hood of the automobile, and the control and receptacle for plugging in the radio set mounts on the dash. The actual installation is so simple that any one can do it without trouble by merely following the very clear instructions furnished with each device. No drilling is necessary on the dash, as the control mounts by means of a positive set screw.

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### THERMIONIC LABORATORIES MOVE

E. B. Cunningham, general sales manager of Thermionic Laboratories, announces the removal of their office and manufacturing plant to larger and more suitable quarters at 102 North Fifth St., Harrison, New Jersey. Thermionic Laboratories manufacture a complete line of hot cathode, mercury vapour rectifiers as well as standard and special type transmitter tubes

▲

### A STEP-DOWN TRANSFORMER

The Acme Electric and Mfg. Co., 1440 Hamilton Ave., Cleveland, Ohio, announces a new step-down transformer which will have a wide field of usefulness.

When shipped into the export field, a step-down transformer is necessary to reduce the prevailing voltages of 200-220-240 down to 115 volts.

This Acme transformer has a very low voltage drop between starting and full load operation and for normal operating loads the temperature rise is extremely low. Special primary voltage taps for 200-220-240 volts give this transformer universal application.

Due to the rigid requirements of electrical inspection bureaus in many countries, the primary lead cord is the SJ, three-wire cable, with the white wire grounded to transformer frame.

No plug is furnished because of the great variety of pin, flat and bayonet applications.

### HAMMARLUND'S PRECISION PRODUCTS

The Hammarlund Mfg. Co., Inc., 424-38 West 33d Street, New York, has issued Catalog No. 33, containing information about Hammerlund precision products for the season 1932-1933, for ultra short wave. short wave and broadcast receiving and transmitting purposes.

▲

### INSULATING COMPOUNDS

Zophar Mills, Inc., manufacturers of electrical insulating compounds, have appointed Ralph B. Clark, of 2007 Calumet Avenue, Toledo, Ohio, as their district sales representative, covering the States of Ohio, Indiana and Michigan. Mr. Clark is an engineer whose experience will further acquaint his friends and customers with the well known products of Zophar Mills.

▲

### NEW LOUDSPEAKER UNITS

The Brush Development Company, 3715 Euclid Avenue, Cleveland, Ohio, announces several new items for the radio and public-address field.

All of these devices are operated by Rochelle salt crystal and utilize the piezo-electric effect as displayed in this crystal. As they are voltage-operated, they require no field current or polarizing voltage.

The P.A.-4 and P-12 loudspeaker units are driven by four of the regular crystal speaker motors, the former designed for use with a ten-foot air column and the latter for use with horn-type baffle.

The exponential unit has a remarkable range, responding well over the entire frequency range from 60 to 10,000 cycles. The P-12 speaker, in addition to its use as a single unit, can be advantageously connected in parallel with a dynamic speaker increasing the entire range of the installation.

▲

### HEADPHONES FOR AIRCRAFT

The Trimm Radio Mfg. Co. of 1528 Armitage Ave., Chicago, are now marketing a lightweight headset for aircraft. The units are less than ¾ inch in depth and slightly more than two inches in diameter. They weigh less than 1½ ounces each. The magnets are of cobalt steel which is recognized as the best magnet steel on the market. The headband is arranged that the phones may be worn either over or under the helmet as preferred. Phones may be secured in any resistance desired to meet the necessary requirements. The cords are the regulation type or a special "bail out" cord of stranded rubber may be had.

▲

### RCA VICTOR STANDARD SIGNAL GENERATOR

RCA Victor Company, Incorporated, announces a new standard signal generator, Type TMV-18-C. This instrument covers a frequency range of 90 to 10,000 kilocycles by means of 6 standard plug-in coils easily removable from the front of the panel. The range can be extended down to 25 and up to 25,000 kilocycles by means of special coils. Voltages from ¼ microvolt to 2 volts are available at the output terminals of the instrument. A 400-cycle self-contained oscillator is capable of modulating the output up to 80% as indicated by a percentage modulation meter on the panel. A new type of precision vernier dial using a planetary gear system gives 4,500 scale divisions for 270 degree rotation of the tuning condenser. The oscillator circuit is voltage compensated to give a minimum of frequency modulation. Heavy aluminum castings isolate the oscillator and attenuator circuits. The use of a 3-legged high resistance thermocouple provides a means of accurately measuring the voltage input to the attenuator even at the extreme high frequencies covered by the instrument. The attenuator network is designed to give substantial constant attenuation ratios over the entire frequency range. External modulation may be applied through an input transformer and controlled from the front of the panel. The output impedance of the attenuator is 0.7 ohm except for the higher multiplier settings.

▲

### GATES TYPE G CONDENSER MICROPHONE

The Gates Radio & Supply Company, of Quincy, Illinois, offers their model G bullet type condenser microphone for either table or suspension operation. This microphone is featured by no background noise, freedom from blasting, and a uniform response from thirty to eight thousand cyles. It uses two UX 864 tubes in connection with a special condenser head sealed to prevent sudden humidity changes from seriously affecting the frequency response of the microphone or freezing of the diaphragm.

▲

### ATLAS RESISTOR FORMED

The Atlas Resistor Company, specializing in the manufacture of pack-wound tubular resistors, has been formed, with headquarters at 423 Broome Street, New York. W. A. Merrill, general manager of the organization, was for five years chief inspector for F. A. D. Andrea, Inc., Long Island City, and in a like capacity for three years with the Polymet Mfg. Co., New York. The firm is producing enamel coated and variable resistors, and is prepared to ship any quantities, large or small.

Associated with Mr. Merrill as sales manager is W. John Killoch, formerly of the David Killoch Company. Mr. Killoch has sold radio parts since the crystal set days, and is familiar with most major accounts throughout the country.

▲

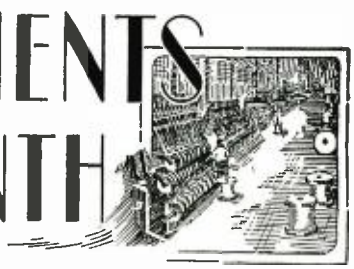
### KESTER SOLDER ELECTS NEW SALES MGR.

An announcement of interest to users and buyers of solder is the election of P. C. Ripley to the office of general sales manager of the Kester Solder Company, of Chicago.

Mr. Ripley has been associated with the Kester Solder Company for nearly eight years, having been in charge of industrial sales and product development.

During this period he has been of great service to manufacturers and other solder users all over the country. His widespread knowledge of the uses of solder have caused manufacturers to call him into their plants on specific production problems, where he has been of material assistance in successfully solving them, with their production executives.

# NEW DEVELOPMENTS OF THE MONTH



## NEW PHOTO-CELL RELAY

A new low-cost photoelectric relay, the Foto-Switch, is announced by G-M Laboratories, Inc., 1735 Belmont Avenue, Chicago, Illinois. This unit embodies an electro-magnetic switch which is opened or closed by the interruption or variation in the illumination on the photoelectric cell. With the Foto-Switch, any sort of electrical device, such as motors, electric signs, signals, or alarms, can be controlled through the medium of a light beam.

The Foto-Switch is capable of handling many commercial applications which do not require the ruggedness demanded of industrial installations. Door-opening in-

stallations, automatic illumination control, burglar alarms, control of electrical displays in store windows, signals for customers entering stores, counting people or products, control of electric sign illumination, and many other uses are entirely within the range of this unit.

Burglar alarm systems have been devised in which a single interruption of a beam of light will cause the alarm signal to operate until an authorized attendant turns it off. Such systems can also be provided with an invisible infra red light beam so that trespassers are entirely unaware of its presence.

Full information on the Foto-Switch and available accessories can be obtained from G-M Laboratories, Inc.

▲

## STUDIO SPEECH EQUIPMENT

The RCA-Victor Company, Camden, N. J., is introducing a high grade line of studio speech equipment, known as Type S-2. This equipment is an assembly of standard unit panels providing a high-quality audio channel with complete mixing, switching, and monitoring facilities. Differing from the finest RCA Victor installations only in elaborateness, it makes economically available to smaller stations equipment of the same quality and dependability as that used in the best-known cleared-channel stations. Noteworthy features include:

1. It is composed entirely of standard panels which are also available separately and which may be added from time to time when additional facilities become necessary.

2. It makes use of high-quality program and monitoring amplifiers which are free from objectionable distortion and harmonics and which have a substantially flat frequency response from 30 to 10,000 cycles.

3. It provides the necessary switching facilities for satisfactorily handling a number of microphone positions and several remote lines and for mixing the outputs of two or three microphones.

4. It employs a highly-accurate volume indicator for visual monitoring and a two-stage amplifier for driving a monitoring loudspeaker.

5. It includes a fuse panel which furnishes adequate protection of all units and control of power supply voltages and a meter panel for checking these voltages.

6. It is furnished with the necessary rectifiers for direct a-c. operation, or with batteries and motor-generator charging equipment, as desired.

▲

## I-F. UNIT NO. 2001

The Gen-Ral i-f. unit No. 2001 was designed with the purpose in mind of providing a unit in which it would be possible to furnish highest quality component parts at a very low cost, due to the rapidity of the assembly.

A trimming condenser mounted on Isolantite having a variation from 70 to 140 mmfd is used to peak the coil at 175 kc. or 465 kc. as required. The unit is provided with two 6-32 studs to be mounted into holes 1½ inches center to center and with soldering lugs ½ inch long which protrude sufficiently far through the chassis to facilitate the operation of

soldering. The coils are wound with No. 36 SSE wire of special type insulation to provide maximum inductance and low distributed capacity.

The coil and condenser assembly was designed to fit either a round coil shield 2 inches in diameter and 3 inches high, or a 2 inch square shield of the same height, and can be supplied with grid lead for top or bottom assembly. No additional labor is required for the assembly of the above shields to the chassis, since the unit is designed with two snap-clips on the sides of the brackets on which the coil is mounted, which hold the shield rigidly in place merely by placing it in position over the assembly.

The Isolantite used for the mounting of the trimming condenser and the special treated hollow tubing used in the mounting of the coils produce a unit which is very satisfactory for use under conditions of severe variations and temperature, such as in automobile receivers, which make it a satisfactory unit for this type of set, and also for all other assemblies requiring a rigid and stable operating unit.

▲

## NEW VOLUME INDICATOR

A new line of volume indicators for the broadcast field is announced by The Daven Company, Newark, N. J. The instruments are of the copper oxide rectifier type and are furnished mounted in a box for laboratory use or on standard rack panel.

The multiplying network is of the L type and is made with a constant impedance of 5,000 ohms. Standard units are furnished with 2 db. per step.

The Daven volume indicators are obtainable in two sensitivities. The standard unit, most suitable for ordinary purposes, has a range from —10 db. to +46 db. Besides this there is also available a special meter having a range from —20 db. to +36 db. The first has a sturdy movement which will stand much abuse, while the latter is very sensitive and should be used only where such sensitivity is expressly required.

Although the meters are calibrated to read directly on a 500-volt line, they may easily be used on lines of other impedances as there is a simple mathematical relation between the losses. A chart is furnished with each meter where corrective values may be found directly without calculation.

▲

## COLD FORGED WING NUTS

The Parker-Kalon Corporation, 200 Varick St., New York, announce a line of cold forged wing nuts which will have wide application.

These wing nuts are produced by a new and improved high-speed automatic process developed through many years of experience in the manufacture of precision screw products. They are free from flaws, roughness and other imperfections common to stamped, pressed steel, cast iron

and malleable iron nuts. They are neater, stronger and better finished.

The wings of the nuts are uniform and so shaped as to provide ample finger grip for drawing them up tight and to facilitate removal. They have no sharp corners or rough edges that may cause injury.

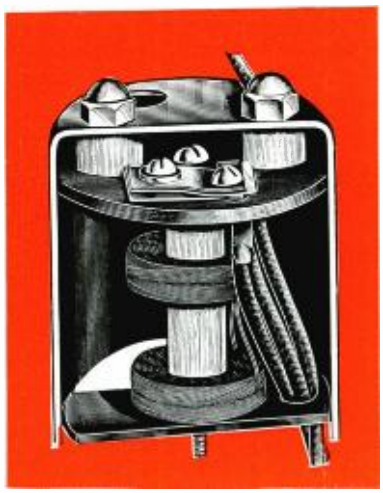
The holes are centrally located and accurately punched which assures a clean-cut uniform thread. The base of the wing nut is perfectly smooth (no thread burrs) and square with the top so that it will draw up tight and flush with the work.

# INDEX OF ADVERTISERS

# THREE *NEW* COILS

# BY GEN-RAL

*(Registered U. S. Patent)*



CX200D V.M.I.F. UNIT

Has exceptionally high gain. Requires space of only 1⅞" by 2¼". Screw lugs provided.

Mounted in same size shield as R.F.B. 10 S. Coil, thus furnishing compact and uniform coil ensemble. Peaked at either 175 K.C. or 465 K.C.

A combination of an I.F. transformer and an oscillator coil shielded in the same unit, utilizing one tube as the first detector and oscillator.

Recommended for 5-tube supers where efficient operation and economy of space are factors.

CX200 D.V.M. COMPOSITE UNIT

R.F.B. 10 S. COIL

Considered by many engineers the ideal coil for tuned radio frequency and super-heterodyne requirements.

Considerable research and effort was expended in designing this special coil before we gave it our complete approval.

Illustrated herewith are three developments by GEN-RAL engineers which have won the instant acceptance of the Radio Industry.

Exhaustive laboratory tests have proven their superiority and our large scale production facilities enable us to quote extremely interesting prices.

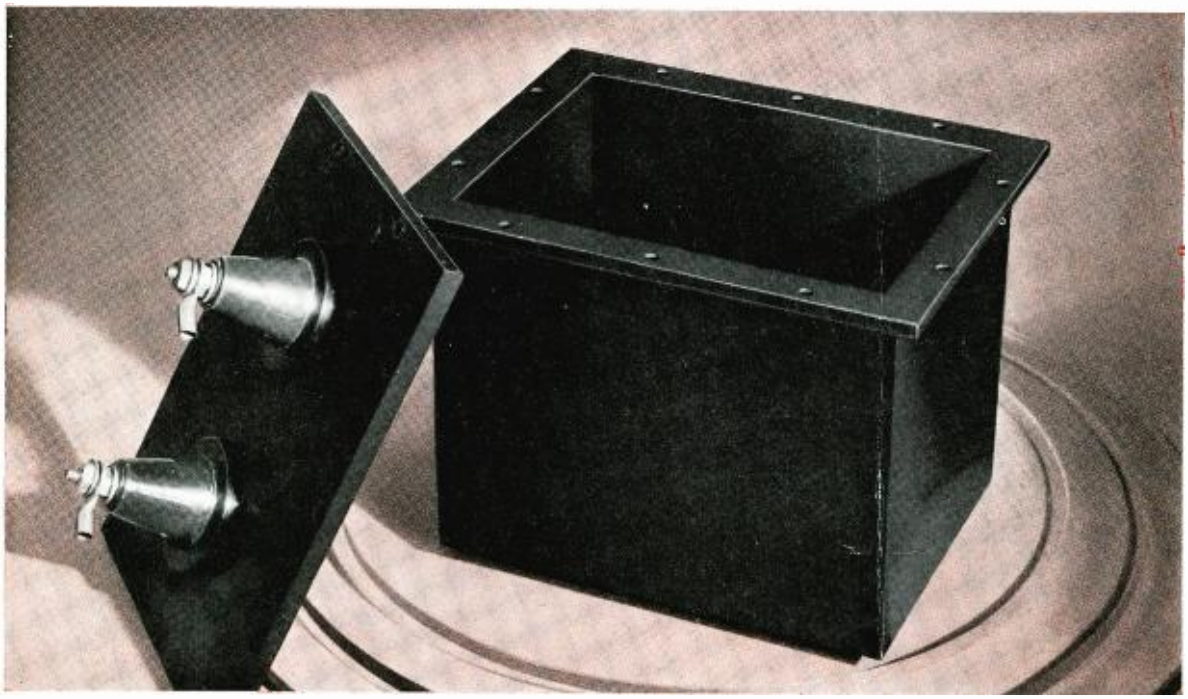
Engineering specifications and other data will be sent upon request.

## GENERAL MANUFACTURING CO.

8066 SOUTH CHICAGO AVE. CHICAGO, ILL.

# A Seamless, Oil-tight Bakelite Molded Box

## ....*housing Radio Transmitting Condenser*



*Bakelite Molded box and cover for Transmitting Condenser, made by Girard Hopkins Laboratories, Oakland, Cal.*

AN EXCELLENT example of how a product may be improved in quality and appearance at a reduction in cost through the use of Bakelite Molded, is provided by the Girard Hopkins Transmitting Condenser. The box was formerly made of metal with a lining of insulating material. Now it is formed of Bakelite Molded in one seamless piece. Dimensions 6¼ x 4⅝ x 5⅛ inches. Because of the high insulation value of Bakelite Molded, no lining is required. As this material also is unaffected by oil, the box provides a leak-proof container for the oil bath.

The box cover is a separate Bakelite Molded part, with insulators molded in, assuring a leak-proof assembly. The new Bakelite Molded construction eliminated many assembly operations formerly required, and resulted in a superior design, and more attractive appearance.

Whether in the Molded, Laminated or Varnish form, Bakelite Materials possess ideal properties for use as insulating materials in the electronics industry. Strong, highly insulating, non-corrodible and non-hygroscopic—these materials give constant and dependable service for a long period of time. We invite you to avail yourself of the assistance of our Laboratories and engineers. Write for illustrated Booklet 12M, "Bakelite Molded", which fully describes this material.

BAKELITE CORPORATION, 247 Park Avenue, New York, N.Y...635 West Twenty-Second Street, Chicago, Ill.
BAKELITE CORPORATION OF CANADA, LIMITED, 163 Dufferin Street, Toronto, Ontario, Canada

**BAKELITE**

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The registered trade marks shown above distinguish materials manufactured by Bakelite Corporation. Under the capital "B" is the numerical sign for infinity, or unlimited quantity. It symbolizes the infinite number of present and future uses of Bakelite Corporation's products.

THE MATERIAL OF A THOUSAND USES