Radio Engineering

DECEMBER, 1936

VOL. XVI NO. 12

DESIGN • PRODUCTION • ENGINEERING

- Broadcast Receivers
- Auto-Radio Receivers
- Electric Phonographs
- Sound Recorders
- Sound Projectors
- Audio Amplifiers
- P-A Equipment
- Electronic Control Devices
- Testing and Measuring Equipment
- Television Apparatus
- Loudspeakers
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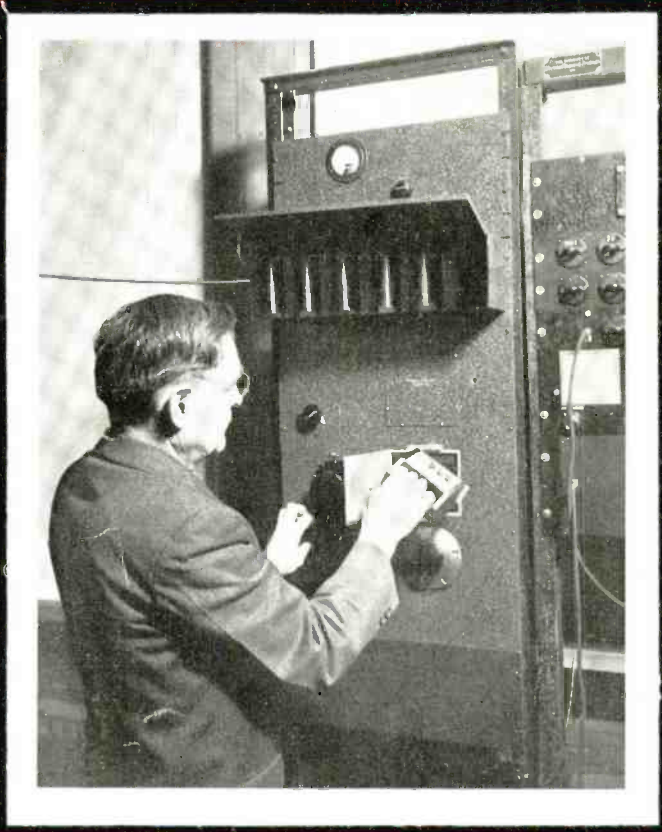
- Tubes
- Photocells



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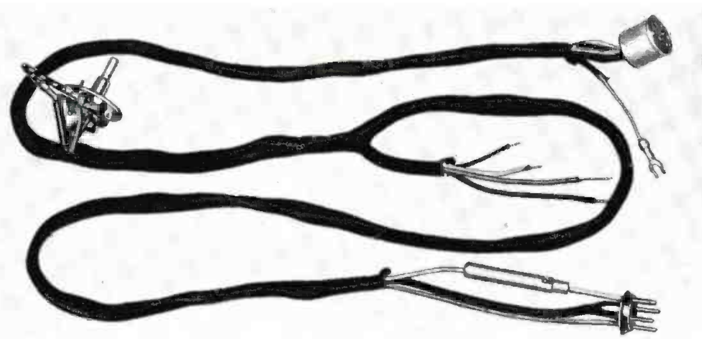

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VOL. XVI — *Member Audit Bureau of Circulations* — NO. 12

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Editorial

THIS MONTH

SOME MONTHS AGO, in August to be exact, we published an article on how television might affect the radio industry. The author of that article isn't, by the wildest stretch of the imagination, an authority on television. Neither is he an authority on radio, but in view of the favorable comments which his previous efforts aroused, we have asked him to look into the radio industry—or rather, into what the public expects from the industry.

Admittedly, such a look is bound to dig up some awfully trite and discouraging material. It is quite apparent that, to put it mildly, the public doesn't give a hoot about what radio receivers will do—yet. But some day there may be a change. With a younger generation growing up, a generation that has its ears as well as its eyes tested in school, and which, forcibly or otherwise, listens to music appreciation programs, we may expect eventually a demand for better quality radio reproduction.

Looking elsewhere, we find papers on molybdenum; on a method of handling silicon steel in strip form; and some notes on shielding.

The three charts or nomograms, will provide an easy way of handling some not difficult but awkward equations for the design of band-pass r-f circuits. Isn't it about time to start thinking of the sideband slicing that the r-f stages can, and do, contribute to poor quality?

STANDARDIZATION

IT HAS BEEN suggested to us that it would be an excellent idea if the RMA would retain some outstanding consulting engineers to draw up the standards for the various component parts of a radio receiver.

At the present time, this standardization is being tackled by committees of the RMA, the committees being made up of men most familiar with the design and manufacture of the part with which the committee is concerned. On the face of it, this may seem thoroughly practical. However, with human nature as it is, there are certain to be appreciable differences of opinion between the members of the committees with the inevitable result of delay and confusion.

If, as suggested, the consultants were to draw up tentative standards, the committees would at least have a starting point from which to start their criticisms and suggestions for changes. The idea is, of course, that those men actually making the recommendations would not be concerned with how much a proposed standard would affect their products—in other words, they should, and probably would approach the problems from a much broader angle than can those intimately associated with the manufacture of any given item.

Without claiming any originality for the idea, we pass the suggestion along for whatever consideration it may be worth.

TUBE NUMBERS

SIMPLY TO BE on record as still being interested in the question of tube numbering systems and the elimination of many of the older types of tubes, we are gratified to note that some of our earlier suggestions are being "plugged" by other publications.

Of our further thoughts—and the new numbering system—more later.

ENOUGH OF THIS!

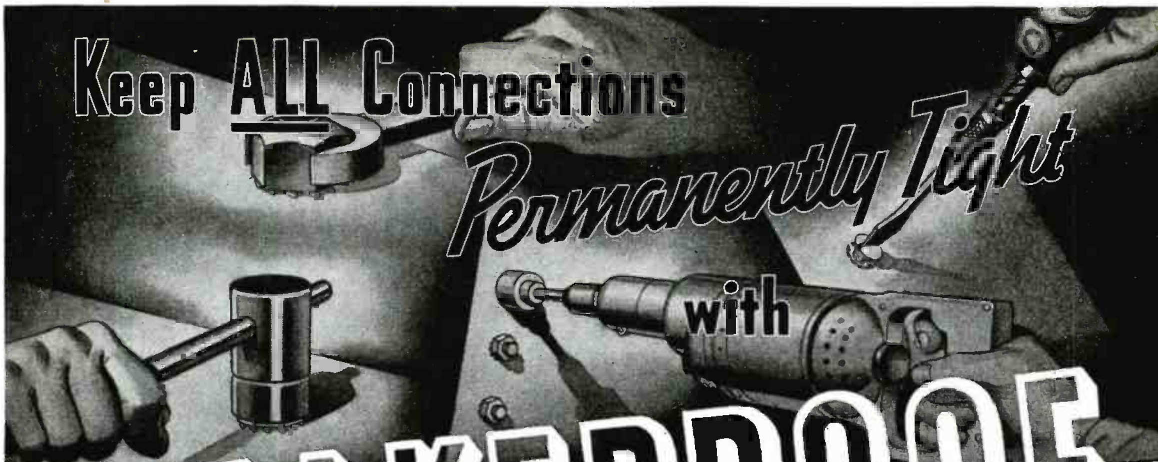
JUST ABOUT EIGHTEEN months ago one of our contemporaries announced, in a full-page editorial headed with 36-point type, that in about fifteen months television would probably have reached the stage where wide distribution of programs would be under way, and a new lease on life given to the radio industry by a flood of orders for television receivers.

It was further predicted that television would be replacing the physical transportation of films to the neighborhood movie houses, and out to the small towns.

Just how all of this was to be accomplished the writer of the editorial didn't explain. Nor did he attempt to indicate just where the necessary million$ were to be found.

This kind of publicity, especially when it reaches large numbers of embryo radio experts, is every bit as harmful as the kind to which we referred last month on this page.

We suggest that it might be highly illuminating for all those interested in television to read the paper delivered at Rochester by Dr. Goldsmith. Without attempting to be spectacular, the doctor has touched upon and discussed so many of the possible "headaches" of television, both technical and commercial, that there remains little for us to say on the subject. Some more material of the Goldsmith type, and a whole lot less of the kind mentioned earlier, will go a long way to keep the public reliably informed.



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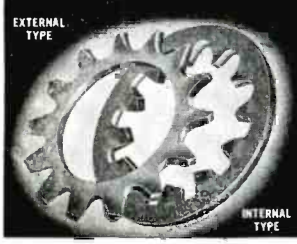

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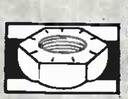

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RADIO ENGINEERING

FOR DECEMBER, 1936

THE ROCHESTER FALL MEETING

The Engineering Division of RMA joins the IRE in important technical sessions.

THE ROCHESTER FALL meeting of the Institute of Radio Engineers and the Engineering Division of the Radio Manufacturers Association, which was held at the Hotel Sagamore in Rochester on November 16, 17, and 18, more than lived up to the reputation established by past meetings.

With a registration that finally exceeded 300, the technical sessions got under way on the morning of the 16th. The following summaries of the various papers are given in the order in which the papers were presented, although without regard to the particular day.

Equipment and Methods Used in Routine Measurements of Loudspeaker Response, by S. V. Perry, RCA Manufacturing Co., Inc., RCA Victor Division. Since the response-frequency characteristic of a loudspeaker constitutes practically the only source of definite information regarding the direction and progress of a given loudspeaker development project, loudspeaker development work has been in the past and still is greatly affected by the performance of the measuring equipment. The magnitude of this effect was illustrated in a specific case and its importance briefly discussed. The essential elements of equipment for all response measuring set-ups are the same, but different laboratories have used different combinations of the possible variations. This has resulted in the development of three different methods of making these measurements. These three methods—manual, semi-automatic and full automatic—were discussed briefly, as were the various methods employed for eliminating the effects of room reflections from the curves. Different types of microphones are used, and different methods of calibration. All these variations in equipment produce differences in the measured response of a given loudspeaker.

Current Measurements at Ultra-High Frequencies, by J. H. Miller, Weston Electrical Instrument Corp. This paper discussed errors in thermocouple instruments at frequencies of upwards of 100 megacycles and pointed out that the skin effect errors are the dominant ones. The theory was checked through the use of straight filament incandescent lamps as comparators between low and high frequency using a photometer method. The experimental findings on a group of instruments of different makes were given showing the errors to be quite considerable. A correction curve for Weston instruments was shown. Ways and means of solving the problem and making instruments of reasonable currents go up to over 100 megacycles were explained.

Acoustic Networks in Radio Receiver Cabinets, by Hugh S. Knowles, Jensen Radio Manufacturing Co. The reasons for the poor frequency response, high steady state and transient distortion of the conventional speaker-cabinet combination follow from a consideration of the behavior of a combination of sound sources and the structure of the cabinets. The trend appears to be toward the design of cabinets which minimize this distortion. The cabinets include acoustic networks which couple the speaker to one or more auxiliary sound sources. By proper choice of the circuit elements in this network, the combined radiation from all sources may be made to exceed that obtained from a given speaker in an infinite baffle at low frequencies. The general theory which covers the various types now commercially available was developed, after which the detailed application of the theory to one type of unit was discussed.

Shot Effect in Space-Charge-Limited Vacuum Tubes, by B. J. Thompson and D. O. North, RCA Mfg. Co., Radiotron Division.

The paper presented a new physical picture of the nature of plate-current fluctuations in the presence of space charge, together with rigorous analyses of the space-charge-limited fluctuations in the cathode current of a vacuum tube and of the fluctuations in the distribution of current between positive electrodes.

The first analysis showed that in the case of normal operating conditions with oxide-coated cathodes the cathode-current fluctuations are approximately the same as the thermal agitation in a resistor having a resistance equal to the cathode resistance and a temperature equal to six-tenths of the cathode temperature. This is verified by Pearson's experimental results.

The second analysis explained the results of Seeley and Barden and predicted quantitatively that in a practical case where the space-charge depression of cathode-current fluctuations is considerable, and where the screen current is a considerable fraction of the plate current, the plate-current fluctuations are greater than the cathode-current fluctuations and are approximately equal to the fluctuations in a temperature-limited current equal to the screen current. This is verified by experimental data.

Automatic Control of Selectivity by Feedback, by H. F. Mayer, General Electric Co. The idea of automatically varying the selectivity of a radio receiver as the receiver approaches resonance with any given carrier frequency is not new. However, the author presented data and circuit schematics to illustrate how, with the use of feedback*, this could be readily accomplished.

The Federal Communications Commission and the Engineering Division of RMA, by T. A. M. Craven, Federal Communications Commission. The Commission's chief engineer in an informal talk indicated the willingness of the Commission to cooperate on RMA's recommendations for frequency allocation and other matters in which all are concerned.

Radio Tubes Today, by R. M. Wise, Hygrade Sylvania Corporation. Mr. Wise discussed matters pertaining to tube geometry in some detail. Curves were shown for the mu, plate current, plate resistance, etc., as functions of the spacing between elements; particular reference was made to the '27 type of tube, and finally the more recent development of a tube for use as an oscillator.

Characteristics of American Broadcast Receivers as Related to the Power and Frequency of Transmitters, by A. F. Van Dyck and D. E. Foster, RCA License Laboratory. In a system of broadcasting the conditions under which there is freedom from interference depend upon the characteristics of receivers in use and upon the frequency allocation and power of transmitters. The characteristics of American broadcast receivers now in use have been investigated to determine the permissible input and frequency separation for freedom from crosstalk, heterodyne beats and flutter. Other types of interference were also treated and data on the susceptibility of receivers to these types of interference given.

Seven types of interference were described separately with data on the susceptibility of present receivers to each type. Finally there were given quantitative conclusions and specifications covering the relations between signal input, frequency separation and receiver performance.

Commercial Television—and Its Needs, by Alfred N. Goldsmith, Consulting Engineer. Some of the major necessary factors in the successful commercialization of television broadcasting are liberal but firm regulations by the Government, the construction of high-quality television broadcasting stations, the establishment of interconnecting networks for national program syndication, the development of requisite program material, together with thorough engineering, progressive merchandising, and reliable servicing of the television broadcast receivers.

It is recommended that transmission standards suitable for acceptance over a period of years be promulgated; that commercial television broadcasting licenses in the ultra-high frequency range be granted in due course; that existing broadcasting agencies be encouraged to develop the new field; that the use of the highest available transmitter power be permitted; that interference with reception be systematically reduced; that nation-wide syndication facilities be established; that the term of the station licenses be increased; and that there be a minimum of political interference with the administrative activities of broadcasting organizations. The closest and most cooperative relations within the broadcasting industry are urged, and particularly between networks and outlet stations, and between the engineering and manufacturing associations. The establishment of progressive program-producing groups is necessary. It is felt that television broadcasting will be improved by excluding the public from the broadcasting studios.

Careful engineering design, thorough tests in actual service, controlled claims of performance, and the establishment of qualified servicing groups are necessary for the further successful development of the television field.

Latest Television Standards as Proposed by the Radio Manufacturers Association, by A. F. Murray, Philco Radio & Television Corp. Mr. Murray's paper covered in great detail the various proposals made by the RMA to the FCC in the matter of standardization for television transmission and reception. In addition to giving the recommendations, Mr. Murray told of the reasons for each, and thus extended his earlier discussions on this subject.

Applications of Nickel to Radio, by E. M. Wise, International Nickel Company. This paper described, as implied by the title, the various uses to which nickel and its alloys could be put in the modern radio receiver, tubes, etc.

Partial Suppression of One Side Band in Television Reception, by W. J. Poch and D. W. Epstein, RCA Mfg. Co., Victor Div. Contrary to the usual conception of single sideband reception, the method described in this paper did not pre-suppose suppressed carrier single sideband transmission. The method discussed involved tuning the receiver slightly off of the carrier frequency thus permitting the acceptance of a wider band.

Improvements in the Performance of Cabinet Type Loudspeakers at Low Frequencies, by Benjamin Olney, Stromberg-Carlson Telephone Mfg. Co. Response curves showing the performance of a typical cabinet speaker with and without a Labyrinth were given, as well as separate measurements of the radiation from the front of the loudspeaker and from the terminal opening of the labyrinth. The behavior of a non-absorbent tube driven at one end and open at the other was discussed and related to the performance of the absorbent-walled tube as actually employed in the labyrinth system. Measurements of the acoustic driving point impedance on each side of a cone in a conventional cabinet were compared with similar measurements of the labyrinth loudspeaker and indicate that the acoustic damping at low frequencies of the latter system is of the order of 100 times that of the former. Comparison measurements were reported of the acoustic impedance of labyrinths with and without sound-absorbent linings and the results indicated that the absorption at low frequencies is unusually large, due probably to the grazing incidence of the sound upon the absorbent material. Measurements of the electrical impedance of a loudspeaker with and without the labyrinth afford further proof of the strong damping obtainable.

Notes on Feedback Amplifiers, by R. B. Dome, General Electric Co. This paper was written in order to simplify, as much as possible, the subject of feedback amplifiers so that the average engineer may readily predict, by means of simple calculations and vector diagrams, the probable performance of any circuit in which feedback is present. It was shown how degeneration improves amplifier regulation and reduces distortion. The polar diagrams of the feedback vector were discussed in some detail with helps for sketching these. The criteria for oscillation, degeneration, regeneration, and passiveness in amplifiers were discussed. The paper concluded with a discussion of the prevention of oscillation in feedback amplifiers, especially of the multi-stage type.

Improvements in High-Frequency Receivers, by J. J. Lamb, American Radio Relay League. In bringing the technical sessions to a close, Mr. Lamb discussed the latest developments in the field of amateur radio receivers.

*Reference may be made to "Frequency Modulated Generators," by A. W. Barber, Radio Engineering, November, 1936. In this reference is described a method of frequency control which closely approximates that used in the so-called a-s-c system.

VACUUM TUBES

Elastic stretch, breaking strength and total elongation of molybdenum wire are determined on one testing machine.

and molybdenum sheet comparable with cold rolled steel or nickel is produced. Rods of molybdenum up to 5/16 inch diameter and sheet up to .030 inch thick, which are perfectly ductile cold, are also available. Annealed molybdenum of even greater ductility can be obtained.

To determine the suitability of molybdenum wire for a given purpose, the commonest method is to measure its tensile strength and elongation, or stretch by means of standard tensile strength testing machines to which scales for showing the stretch of the wire have been added. Using ten inches of wire as the standard initial length, the strength is read in kilograms and the elongation as percent of the initial length. In general, the strength and stretch are inversely proportional. The speed at which the wire is stretched may have some influence on the elongation, but has no effect on the strength. By observing the relative movements of the two indicators, the elastic stretch, the breaking strength and the total elongation may be determined.

Makers of vacum tubes usually order molybdenum wire of a given elongation specification, and reliable suppliers of the metal make strict inspection and test each spool of wire. It is only by such careful control that the tube maker is saved the cost of shrinkage and production losses.

With molybdenum sheet, the ductility is usually inspected by "cupping" on a device such as the Erichsen sheet tester. This test, which is destructive, draws a sample sheet into a cup-shaped die over a parabolic punch until the sheet cracks or tears. The corresponding depth of draw is read in thousandths of an inch on a scale, and is taken as an index of the character of the metal.

Sheet molybdenum is further subjected to bend tests, which are conducted substantially as follows: A sample of each lot is bent to 180 degrees around a radius equal to the thickness of the sheet, in the direction of rolling, at right angles to the direction of rolling, and at a 45 degree angle. If the metal cracks, it is rejected. Another test is often made at a 45 degree angle. The metal is bent to 90 degrees, and returned to substantial straightness without sharp fracture.

The maker of thermionic tubes usually uses molybdenum in sheet, wire or ribbon. The usual sheet requirements are .010 and .005 inch thickness. Wire for grids is usually .003 to .006 inch diameter, and ribbon is usually about the same thickness as wire. Molybdenum is used for plates, grids and support members, and is occasionally used in place of tungsten as heater filaments in indirectly heated cathode tubes.

An inherent property of pure molybdenum, and of some molybdenum alloys, is relatively small loss of strength at elevated temperatures, not only the operating temperatures of tubes, but the somewhat higher temperaures at which tubes are evacuated and bombarded.

Molybdenum welds readily to other metals, such as copper and nickel, and while it is not so easily welded to itself, the welding can be accomplished with reasonable care. The welding operation should be performed in such a manner as to produce adequate heat at the desired point of junction as rapidly as possible, without unduly heating the metal around the weld. An electric spot weld or percussion weld is recommended.

While on the subject of welding, it is worth noting that the use of molybdenum electrodes for spot welding operations is of advantage in certain cases. Molybdenum has good conductivity and, compared with copper, has much greater strength and rigidity, with little or no tendency to pit, wear or stick to the work. Molybdenum electrodes are especially desirable in spot welding vacuum tube parts. A difficulty often encountered with copper electrodes is that small particles of copper stick to the work and must be carefully cleaned away before the tube is assembled. Even if this condition should occur with molybdenum—which is unlikely—a deposit of molybdeum would do no harm.

Many tube makers use molybdenum wire in resistance wound furnaces for production operations. As a furnace wire, molybdenum will attain temperatures up to 1600°C, far beyond the melting point of iron, nickel, or any of the common resistance alloys. The use of hydrogen, or other reducing atmosphere is necessary, however, to protect the molybdenum wire from oxidation. The refractory, moreover, should be sufficiently porous to permit the escape of the reducing atmosphere into the furnace tube. Zirkite has been found to be a very satisfactory packing, and alundum is a suitable tube material. In fact, many of the operations in the production of metallic molybdenum are conducted in molybdenum wound furnaces.

COUPLED CIRCUITS AND

by W. E. Bonham

SIGNAL CORPS SCHOOL, FORT MONMOUTH, N. J.

The subject covered in detail in this article is, we suspect, one that has been learned, forgotten, and relearned, ad infinitum, by more than one engineer. This material should provide an opportunity for that well-intentioned, but neglected review.

THE SUBJECT of reflected load resistance and its importance in the impedance matching of inductively-coupled circuits is one that is seldom understood in the true sense as handed down through current literature pertaining to or having reference to it. It seems to be that in most cases it is not clearly understood whether "reflected resistance" acts as a pure resistance or as an impedance, and whether it should match the d-c resistance, the effective resistance or the impedance of the circuit into which it is reflected in order to obtain the optimum result.

It is the object of this article to point out in as simple a manner as possible, the relation that the secondary load bears to the reflected resistance and the nature of the conditions for the correct matching between the two inductively-coupled circuits. Since correct matching and the proper respect to the value and nature of the reflected load resistance is the essential basis for the design of coupling devices, it is hoped that this article, while elementary in form, will give a better insight to the subject for those interested in reviewing this phase.

The counter-electromotive force in any circuit is in opposition to the applied voltage and its position in the circuit seems always to try to become equal and opposite to the applied potential. In a transformer, the current in the secondary produces a magnetic field of its own which is in opposition to that produced by the primary current. With the reduction of the primary flux, due to the secondary current, the ability of the primary to establish the required counter-emf with the same current as before, is decreased and as a result the primary current must increase in order to re-establish the primary flux so that the counter-emf can again become equal to the applied voltage.

It seems that to decrease the primary counter emf is to aid the applied voltage; however the energy required to build the cemf back to its original value must come from the primary source of power. In this article, the amount that the counter-electromotive force tends to become reduced because of the secondary current, will be called E′. This voltage actually is equal in value to the component of the applied voltage which becomes effective in forcing current through the primary in order to maintain the secondary load. This voltage, E′, must be overcome by the cemf of the primary, and since this is accomplished by an increase of the primary current, it follows that E′ divided by this increase of primary current gives a value of resistance which will be called R′, and which in effect exists in the primary circuit and which changes in value with the secondary load current. Thus it is seen that the secondary load has the effect of introducing itself into the primary circuit as a load resistance equal to R′. The action of this reflected load resistance into the primary is the same as though the primary source of power were working directly into a resistance of the same value.

The voltage E′ is induced into the primary because of the secondary current, and like all induced voltages it is a maximum at the instant when the inducing current is passing through its zero value. Thus there is a 90-degree phase difference between the secondary current and the voltage E′. Now, the secondary voltage is 90 degrees out of phase with the inducing primary current; thus it follows that if the secondary current is in phase with the secondary voltage then the voltage E′ is in direct opposition to the primary counter-electromotive force, since the primary counter-electromotive force is induced by the primary current. This means that if the secondary circuit is operating at resonance, then the reflected load resistance into the primary is placed there as though it were a pure resistance load.

However, for conditions other than resonance in the secondary, the secondary current lags or leads the secondary voltage by an amount depending upon the ratio of the secondary resistance to secondary impedance. This ratio is written as R_s/Z_s. Thus the phase angle of the reflected voltage E′ relative to the primary cemf is also shifted by the same amount, so that the effectiveness of this voltage in decreasing the primary cemf is lessened by the amount R_s/Z_s. The reflected load into the primary no longer acts as a pure resistance load, but acts inductively or capacitively depending on whether the secondary phase angle is one of lag or lead.

Since the effectiveness of the voltage E′ in reducing the primary cemf is dependent upon the secondary current and voltage phase, to express the reflected resistance load in values equivalent to a pure resistance load the phase angle of the secondary must be considered. The induction of a voltage into the secondary of two inductively-coupled circuits takes place through the medium of the mutual reactance of the two circuits and it is well established that the secondary voltage is the product of the primary current and the mutual reactance; that is,

$$E_s = I_p \omega M \,, \quad \ldots\ldots (1)$$

and since the secondary current is equal to E_s/Z_s we have that the secondary current,

$$I_s = I_p \omega M / Z_s \,. \quad \ldots\ldots (2)$$

In a like manner the voltage E′ opposing the primary cemf is the product of the secondary current and the mutual reactance, and since its phase relation with the primary cemf is R_s/Z_s, it follows that the effectiveness of this voltage in the primary circuit is given by

$$E' = I_s \omega M \frac{R_s}{Z_s} \,. \quad \ldots\ldots (3)$$

Substituting in this equation the value for I_s given in equation (2) we have,

$$E' = \frac{\omega^2 M^2 I_p R_s}{Z_s^2} \,. \quad \ldots\ldots (4)$$

REFLECTED RESISTANCE

The primary current I_p enables the re-establishment of the primary cemf which is reduced by the amount E'; thus dividing this last equation by I_p we have for the effective or in-phase value of the resistance load reflected to the primary,

$$R' = \left(\frac{\omega M}{Z_s}\right)^2 R_s \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Since the voltage E' in equation (4) represents the in-phase component of the voltage reflected into the primary we must consider the effects of the component which is not in phase. The component E' being dependent upon the R_s/Z_s ratio of the secondary makes it evident that the reactive component is dependent upon the ratio of the secondary reactance to the resistance. Thus if we multiply the equation (4) by this ratio we have the reactive component of the voltage which is induced in the primary because of the secondary current; then dividing by the primary current we have for the reflected reactance,

$$X' = \left(\frac{\omega M}{Z_s}\right)^2 \omega L_s \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

The phase of this reflected reactance is directly opposite to the reactance of the primary so that the primary reactance is reduced by this amount. The primary reactance due to secondary load then is,

$$L_p - \left(\frac{\omega M}{Z_s}\right)^2 \omega L_s \quad \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

The essence of the explanation just given is that the secondary load current induces into the primary a voltage consisting of an active and a reactive component. The active component which we have designated as E' has the effect of increasing the effective primary resistance by the amount indicated in equation (5). The reactive component has the effect of decreasing the primary reactance by the amount indicated in equation (6). The word *decreasing* may be interpreted to mean an increase

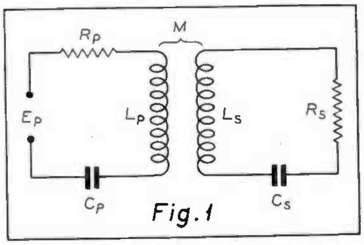


Fig. 1

in reactance. For example, if a small amount of inductive reactance normally exists in the primray and a large amount of the reactance indicated in equation (6) is reflected to the primary, the resulting reactance must be negative, that is, capacitive, and it is possible for the resulting capacitive reactance to be greater than the original inductive reactance. The result of the secondary current is that there is a change in the primary impedance. Now, if the increase of the primary resistance is much less than the decrease of the primary reactance, the result is a decrease in the primary impedance and a consequent increase in the primary current. But if the secondary load is reflected into the primary as an inductive load so that the decrease of the primary inductive reactance is greater than that present then the capacitive reactance of the primary predominates, and if the amount by which the capacitive reactance now predominates is equal to the original value of the inductive reactance, the impedance of the primary is the same as before the secondary was loaded and the result is that the primary current remains unchanged because of the secondary load. Also if the secondary load is either capacitive or inductive and the reflected reactance into the primary so results in a change of the primary reactance that it is greater than before, then since the effective resistance also increases, the result is an increase of the primary impedance and a consequent decrease in the primary current. This may explain a point that is so often observed in the coupling of circuits, that is, in some cases the secondary load causes an increase in the primary current, in other cases a decrease.

A solution for the condition of maximum energy transfer from the primary to the secondary of two coupled circuits can show that there is a definite relation between the reflected load resistance and the effective primary resistance and that the condition for both the tuned and the untuned circuit is purely one of correct impedance matching. Since there are cases where inductive coupling is employed (i.e., the primary is a tuned circuit and the secondary untuned, the secondary only is tuned, and in others both are tuned) it appears that the best approach is to make the solution for a general case where both circuits contain inductive reactance, capacitive reactance, and resistance, and where neither is operated at resonant frequency, then to modify this general case to comply with the specific case.

In the circuit of Fig. 1, L_p and L_s are assigned values with the effects of the coupling removed, and the resistances R_p and R_s are the effective resistance values (watts/current squared). The secondary current is indicative of the energy transferred to the secondary and since the most likely variable is the mutual reactance we shall for a certain condition hold the other circuit values as constant and determine the value of the mutual reactance which must exist in order to transfer the maximum current into the secondary.

The secondary current I_s reflects into the primary the resistance R' so that the primary effective resistance becomes,

$$R_p + R' = R_p + \left(\frac{\omega M}{Z_s}\right)^2 R_s \ldots\ldots\ldots (8)$$

It also changes the primary reactance as is indicated by equation (7), but this equation must be modified slightly because of the capacitive reactances in each circuit. For the sake of simplicity assume that in both circuits the inductive reactance is much greater than the capacitive reactance; then the inductive reactance of the primary minus the capacitive reactance of the primary gives the reactance of the primary which is still inductive. The same is true for the secondary. Subtracting the capacitive reactance from the inductive reactance of both circuits, the reactance of the primary due to the secondary load becomes,

$$\left(\omega L_p - \frac{1}{\omega C_p}\right) - \left(\frac{\omega M}{Z_s}\right)^2 \left(\omega L_s - \frac{1}{\omega C_p}\right) \quad \ldots\ldots\ldots\ldots\ldots (9)$$

The new primary impedance is the sum of the new values of the effective resistance and reactance. The primary current is equal to the primary voltage divided by the new value of impedance; thus we have for the primary current,

$$I_p = E_p / \left\{ \left[R_p + \left(\frac{\omega M}{Z_s}\right)^2 R_s \right]^2 + \left[\left(\omega L_p - \frac{1}{\omega C_p}\right) - \left(\frac{\omega M}{Z_s}\right)^2 \left(\omega L_s - \frac{1}{\omega C_s}\right) \right] \right\} \quad (10)$$

In equation (2) we have $I_s = I_p M/Z_s$, thus if we substitute the value given in (10) for the primary current we have for the secondary current,

$$I_s = \omega M E_p / \left\{ \left[R_p + \left(\frac{\omega M}{Z_s}\right)^2 R_s \right]^2 + \left[\left(\omega L_p - \frac{1}{\omega C_p}\right) - \left(\frac{\omega M}{Z_s}\right)^2 \left(\omega L_s - \frac{1}{\omega C_s}\right) \right]^2 \right\}^{1/2} \quad (11)$$

In order to find the condition at which the secondary current is a maximum as the mutual reactance is varied, we must assume a condition in which all values except the mutual reactance are constant. Since Z_s in the equation varies with frequency as well as ωM, the frequency must be fixed and ωM made variable by varying M alone.

Differentiating equation (11) in respect to ωM and dividing by the differential of ωM, and placing the derivative thus obtained equal to zero we find that,

$$\omega M = \sqrt{Z_s Z_p} \quad \ldots\ldots\ldots\ldots\ldots\ldots (12)$$

(The differentiation is simplified by holding the entire expression under the radical equal to Z_p for certain portions of the differentiation).

This shows that in general the mutual reactance must be equal to the square root of the mean proportion of the secondary and primary impedances, in order that the maximum energy can be transferred from the one circuit to the other. The impedance Z_s is equal to the secondary voltage divided by the secondary current and also equal to

$$\sqrt{R_s^2 + \left(\omega L_s - \frac{1}{\omega C_s}\right)^2}$$

The primary impedance Z_p is equal to the primary voltage divided by the primary current and also equal to the quantity indicated by the denominator of equation (10).

It often occurs that an untuned secondary circuit must be coupled to a tuned primary and it so happens that there can be two conditions to this case, one where the primary is first resonant without the presence of the secondary, and the other where the primary is resonant under the effects of the coupling.

Referring to the equation (11), we see that if the primary is first tuned without the effects of the secondary, the quantity

$$\omega L_p - \frac{1}{\omega C_p}$$

becomes equal to zero, so that the secondary current is, in simplified form,

$$I_s = E_p \omega M / \left\{ \left(\omega^2 M^2 + R_p R_s \right)^2 \left[R_s \left(\omega L_s - \frac{1}{\omega C_s} \right) \right]^2 \right\}^{1/2} \quad (13)$$

Differentiating this equation, keeping the same values constant as above, and putting the derivative with respect to ωM equal to zero, we have for the condition of maximum secondary current,

$$\omega^4 M^4 = \left[R_s^2 + \left(\omega L_s - \frac{1}{\omega C_s} \right)^2 \right]^2 R_p^2,$$

so that,

$$\omega M = \sqrt{R_p Z_s} \quad \ldots\ldots\ldots\ldots\ldots\ldots (14)$$

Possibly the most common example of an untuned primary inductively coupled to a tuned secondary is in a radio-frequency amplifier where the plate circuit of a vacuum tube feeds into the primary of a radio-frequency transformer, the secondary of which is tuned to the operating frequency. With the secondary at resonance, in the equation (11) the quantity Z_s becomes equal to R_s, and both the inductive reactance and capacitive reactance are equal, so the equation becomes,

$$I_s = E_p \omega M / \left\{ \left[R_p + \frac{\omega^2 M^2}{R_s} \right]^2 + \left[\omega L_p - \frac{1}{\omega C_p} \right]^2 \right\}^{1/2} \quad (15)$$

This equation shows that at resonance in the secondary, the secondary load does not change the primary reactance.

The derivative of this equation with respect to ωM placed equal to zero shows that the maximum value for the secondary current is obtained when,

$$\omega^2 M^2 = R_s \left[\left(\omega^2 M^2 + R_p R_s \right)^2 + \left(R_s \omega L_p - \frac{R_s}{\omega C_p} \right)^2 \right]$$

which simplifies to,

$$\omega M = \sqrt{R_s Z_p} \quad \ldots\ldots\ldots\ldots\ldots\ldots (16)$$

Z_p is the impedance of the primary under the effect of the coupling.

Possibly one of the most critical cases for obtaining optimum coupling is where both the circuits are tuned to the same frequency. If the two circuits are tuned separately then coupled, the condition is slightly different from when they are both tuned under the influence of the coupling. The first case is hardly a practical circumstance and results in a more complex expression, but the value is not much different from when they are tuned to the same frequency while coupled.

With both circuits at resonance while coupled, in the equation (11) the total of the reactance in both circuits become equal to zero, and Z_s equals R_s, so that the equation simplifies to the form,

$$I_s = \frac{E_p \omega M}{\omega^2 M^2 + R_p R_s} \quad \ldots\ldots\ldots\ldots\ldots (17)$$

The derivative of this equation in respect to ωM is,

$$\frac{d I_s}{d \omega M} = \frac{\left(\omega^2 M^2 + R_p R_s \right) E_p - 2 E_p \omega^2 M^2}{\left(\omega^2 M^2 + R_p R_s \right)^2} \quad (18)$$

which placed equal to zero shows that the maximum transfer of energy into the secondary takes place when,

$$\omega M = \sqrt{R_p R_s} \quad \ldots\ldots\ldots\ldots\ldots\ldots (19)$$

In the equation (5) we have the relation,

$$\omega M = \sqrt{\frac{R' Z_s^2}{R_s}}$$

and if the secondary is tuned to resonance R_s equals Z_s so that,

$$\omega M \text{ equals } \sqrt{R' R_s}.$$

If for the value of ωM we use the same as that which gives optimum coupling as indicated in equation (19) we have,

$$\sqrt{R' R_s} = \sqrt{R_p R_s},$$

so that R′ equals R_p, which shows that as long as the reflected resistance R′ is defined according to equation (5), when the condition of optimum coupling is obtained, the reflected resistance becomes equal to the effective primary resistance.

NOMOGRAMS FOR THE DESIGN OF BAND-PASS R-F CIRCUITS

(Charts by Carl P. Nachod)

ABOUT SIX YEARS ago, E. A. Uehling published some material on coupled r-f circuits which would give, in effect, the same results as a band-pass filter.

Up to that time the question of obtaining such a response characteristic had been given little if any attention. It was, of course, known that coupling, either inductive or capacitive, would result in a widened response characteristic under certain conditions. But these characteristics were such that the use of this type of circuit in a radio receiver would add materially to the complexity of tuning and adjusting for optimum response.

As was, and is, well known, capacitive coupling gives a band-pass characteristic which varies inversely with frequency, while the inductive coupling gives a characteristic which varies directly with the frequency. Obviously, what was needed was a combination of the two, so proportioned as to give a characteristic response curve having the same width over the entire broadcast frequency spectrum.

The circuit devised by Uehling is that shown along with the curve of Fig. 1. In this circuit, the inductances L_1 and L_2 are assumed to be identical, as are the capacities C_1 and C_2. The coupling which results in the constant band width is effected by means of the mutual inductance M and the mutual capacity C_m.

Since the band width is a function of both the mutual reactance and the resistance of the circuits, the circuit constants can be determined from equations in which these quantities are parameters.

However, these equations are awkward to handle, and the computations necessary for the design of receiver circuits amount to real work. For this reason, it has been felt desirable to have them put into graphic form.

The three equations for the solution of this type of problem are given on the pages with the nomograms from which the equations' solution may be obtained.

It may be of interest to point out the following example of the use of these charts: Assume that it is desired to know the values of mutual inductance and mutual capacity necessary to give a band width of 14,000 cycles throughout the frequency range of 540 to 1,750 kc.*

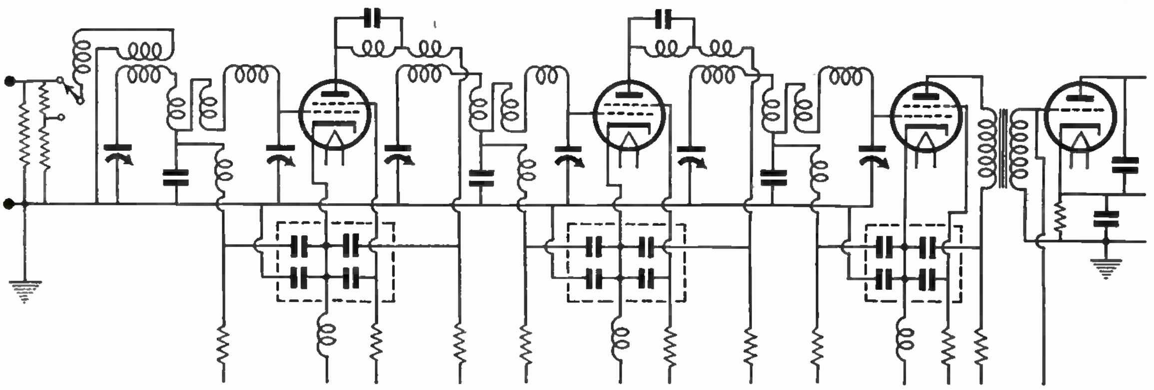
It was further assumed that the value of L, in equation (1), was 350 microhenries and that the effective resistance, R_n, was 40 ohms. Starting on chart I at 14,000 cycles on the lower side, a line is drawn from this point, through 350 on the "L" scale to the turning scale. The value of 40, on the "R_n" scale is then connected with the point on the turning scale. By projecting the length of this second line onto the "R_n" scale, a value of 50.5 ohms is read for the value of X_{m_a}. X_{m_b} is then computed for the other marginal frequency (i.e., 540 kc.). Assume that R_n has such a value that X_{m_b} is found to be 15.

With these two values we enter chart II; a line connecting the point 50.5 on the X_{m_a} scale with the point 15 on the X_{m_b} scale will intersect the M scale at —4.5 microhenries. This is the value of mutual inductance that will be necessary.

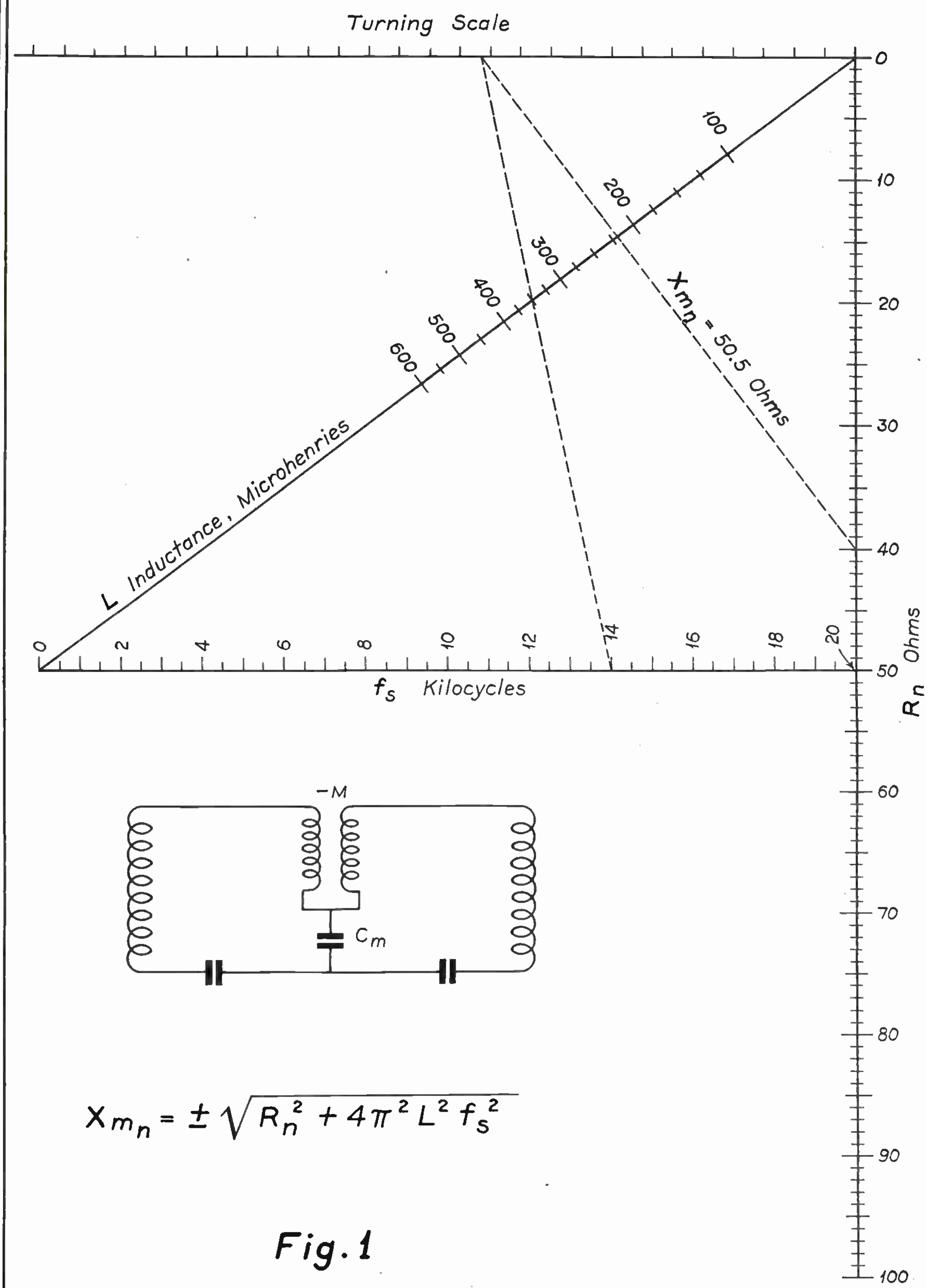
Chart III gives, in exactly the same manner, although the scales are transposed, a value of 0.4 mfd for the mutual capacity necessary to give a 14,000 cycle band width.

It will be apparent that there are conditions in which impossible values will be obtained; for instance, if X_{m_b} had been 20 ohms, the value obtained for C_m would have been off the scale. (Note: The diagonal, broken line on the chart of Fig. 3, page 16, is incorrect. If the line is drawn between the points mentioned above, the value of 0.4 will be obtained.)

*It was thought best to assume these values of 540 and 1,750 kc for the marginal frequencies of the broadcast band in view of the apparent extension upward to provide channels for the so-called high fidelity broadcast stations.—*Editor.*



Part of the Circuit Diagram of the Western Electric 10-A Receiver -(It is this type of R.F. circuit which can be designed by the charts on the following pages)

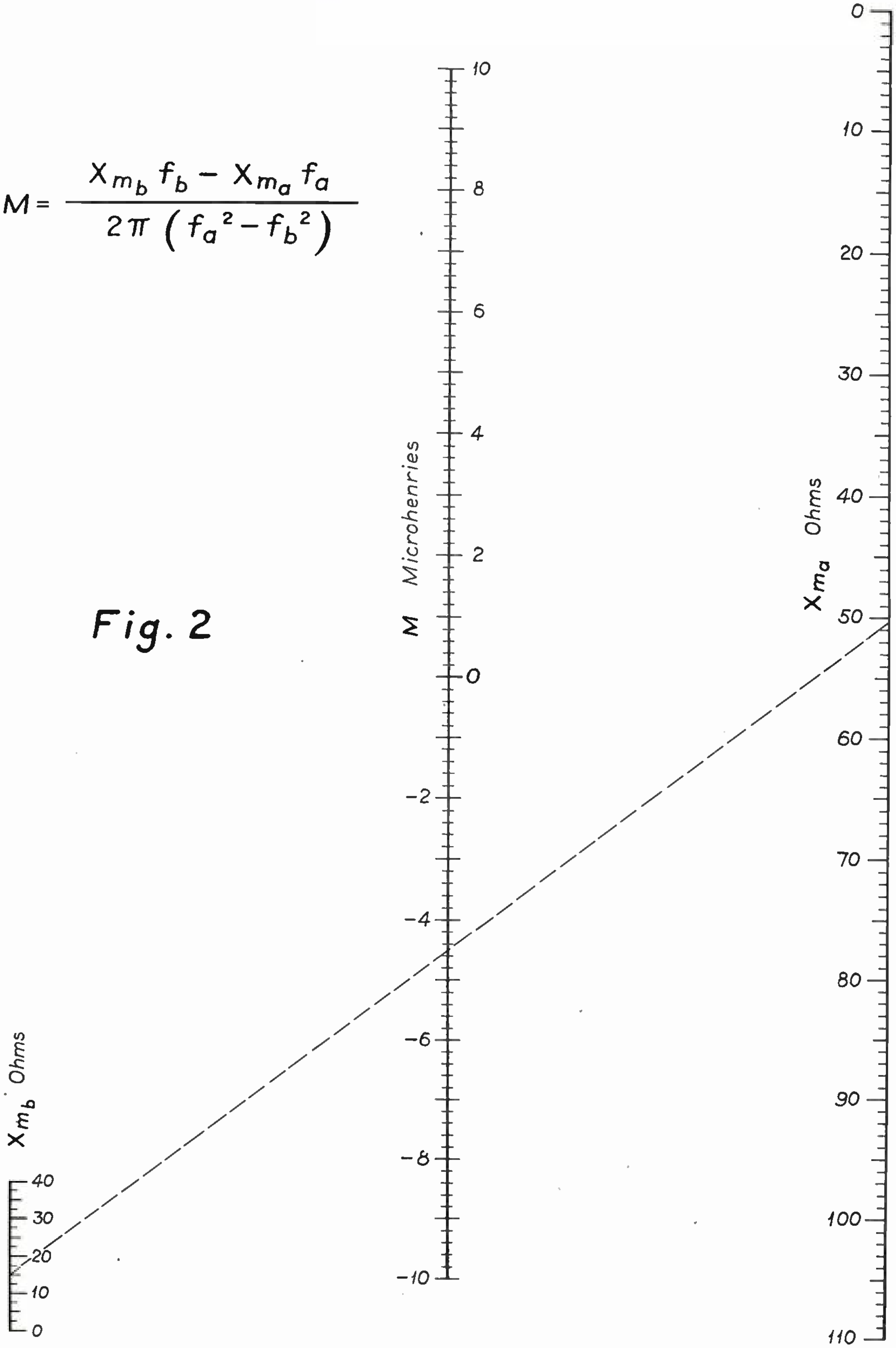


$$X_{m_n} = \pm\sqrt{R_n^2 + 4\pi^2 L^2 f_s^2}$$

Fig. 1

$$M = \frac{X_{m_b} f_b - X_{m_a} f_a}{2\pi \left(f_a^2 - f_b^2 \right)}$$

Fig. 2



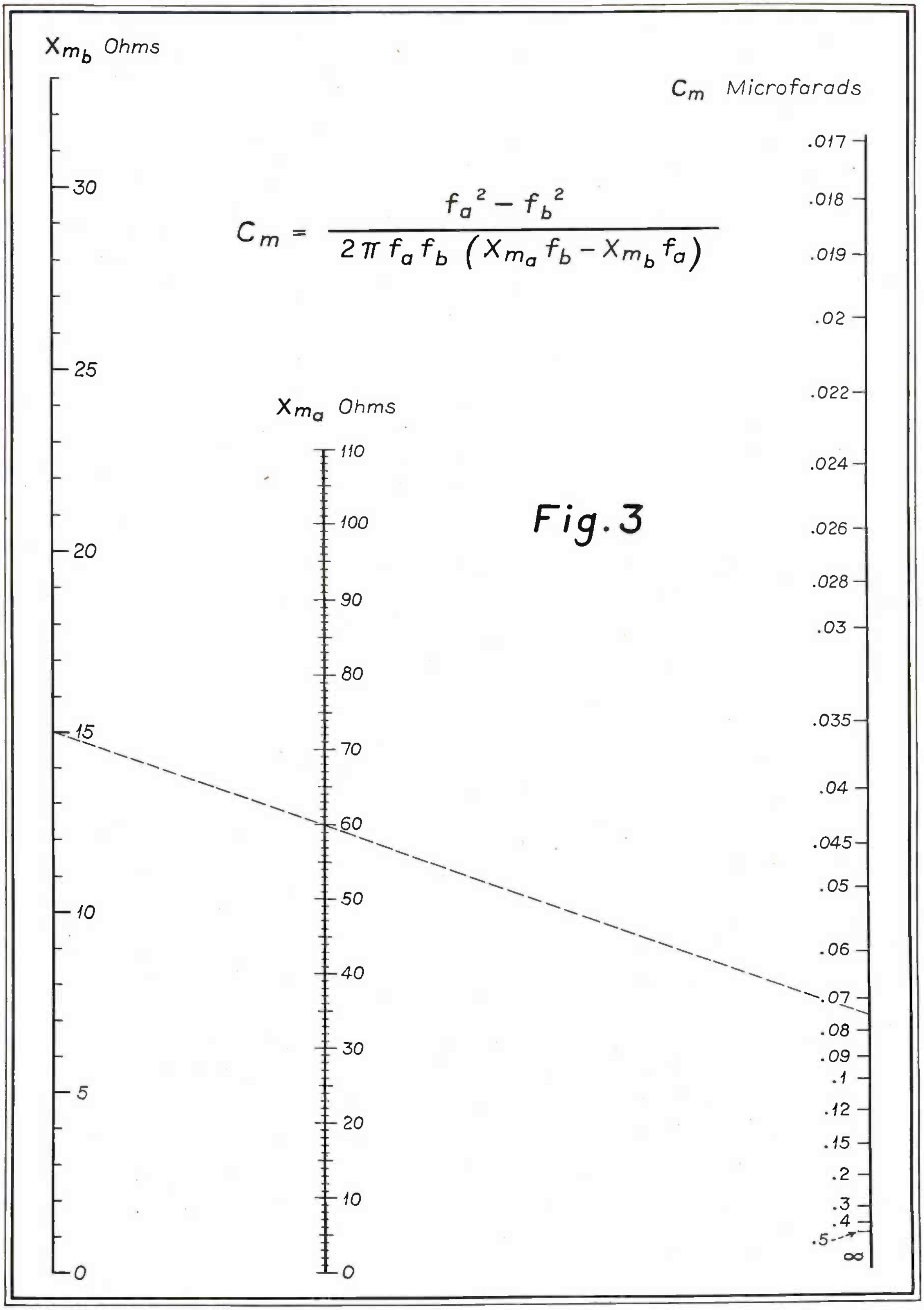

X_{m_b} Ohms
C_m Microfarads
$$C_m = \frac{f_a^2 - f_b^2}{2\pi f_a f_b \left(X_{m_a} f_b - X_{m_b} f_a\right)}$$
X_{m_a} Ohms
30
25
20
15
10
5
0
110
100
90
80
70
60
50
40
30
20
10
0
.017
.018
.019
.02
.022
.024
.026
.028
.03
.035
.04
.045
.05
.06
.07
.08
.09
.1
.12
.15
.2
.3
.4
.5
∞

Fig. 3

FORMULAS FOR SHIELDED COILS

In Which Data from Several Sources Are Combined for Ease in Reference

THERE IS CONSIDERABLE data available on the effects produced by enclosing an inductance in a shielding can; however, this information is inconvenient to obtain even though a great number of books and periodicals may be on file. It is the purpose of these notes to correlate enough pertinent data from various sources to give in a concise form, enough information for use by the design engineer.

It is a well-known fact that shielding a coil causes a decrease in the inductance. This decrease is due to the coupling that exists between the coil, as primary, and the shield, as a short-circuited secondary. Perfect coupling, of course, can not exist, so for all practical purposes it may be assumed that the coil in a shield is the electrical equivalent of the circuit shown in Fig. 1.

It will be seen that coil L_a is considered to be in two sections, one of which makes no coupling whatever with the shield. The parallel circuit L_s and R_s is the equivalent circuit of the shield. Now, designating the coefficient of coupling between the entire coil, L_a, and the shield as K, the mutual inductance between the coil and the shield is $-K\sqrt{L_a L_s}$.

Assume that the current I_a is flowing in L_a and the current I_s flowing in L_s. If e_a is the voltage drop across the portion of L_a which couples to L_s:

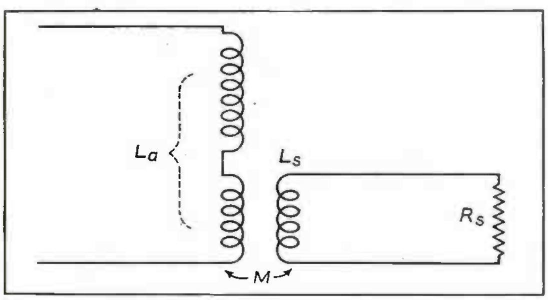
$$e_a = j\omega K^2 L_a I_a - j\omega K\sqrt{L_a L_s}\, I_s$$

$$0 = j\omega L_s I_s + R_s I_s - j\omega K\sqrt{L_a L_s}\, I_a$$

From these it can be seen that

$$e_a = \frac{I_a K^2 R_s L_s \omega}{R_s^2 + L_s^2 \omega^2}(L_s \omega + j R_s)$$

If $R_s = 0$, then $e_a = 0$. However, in order for this condition to obtain, a shield would have to be made of a perfect conductor. On the other hand if R_s is assumed to be infinite, then $e_a = I_a j\omega K^2 L_a$, in other words the value which would appear if the shield were absent.



Where R_s is finite, as is always the case, a certain amount of energy is transferred by coupling to the shield, where a part of the energy is dissipated by the resistance of the shield and the rest is stored as electromagnetic energy in the inductance of the shield. The amount of energy stored is indicated by the "j" term of the first equation given above; it can also be shown that this is likewise a measurement of the field which exists outside of the shield.

It has been shown, in one of the sources consulted for this material, that the efficiency of shielding is dependent upon the frequency and a parameter P which is the ratio of the resistance to the inductance of the shield. Using this parameter, the reduction of the external field due to the shield becomes,

$$10 \log_{10}\left(\frac{\omega^2}{1 + P^2}\right)$$

From the equations previously given can be derived the following expressions for the percentage change in both the effective resistance and the reactance of the coil:

$$\frac{\Delta R_a}{L_a} = -\frac{\omega^2 K^2 P}{P^2 + \omega^2}$$

$$\frac{\Delta L_a}{L_a} = -\frac{\omega^2 K^2}{P^2 + \omega^2}$$

$$\frac{\Delta R_a}{\Delta L_a} = -P$$

The decrease in the reactance of a shielded coil is given by $\frac{\omega^2 M^2}{\omega L_s}$ where M is the mutual inductance between the coil and the shield and L_s is the inductance of the shield. (It is assumed in all of the following, that the shield resistance is small compared to the reactance.)

If, in this expression, we substitute for M the value of K obtained above, the decrease in the inductance of L_a due to the shield is given by $L_a = K^2 L_a$. The actual inductance of the shielded coil is, then, $L_a(1 - K^2)$.

If values of K are calculated for various coil and shield diameters, the results can be plotted on log-log paper to give the "reduction factor," K^2, as a function of coil radius, winding length, and shield radius. The results hold with a fair degree of accuracy if the length of the shield is greater than the coil by at least the coil radius.

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RCA Radiotron Application Note No. 48.

COILED SILICON

LAMINATIONS FOR USE in the electrical apparatus industry have, until comparatively recently, been punched or sheared solely from flat steel sheets. These sheets, depending upon the application, contain varying amounts of silicon, from 0.20% to 4.00%, plus a minimum quantity of other metalloids. These steels are used by practically every manufacturer of transformers or rotating electrical devices.

In the United States there are ten mills making this product; in 1935 they produced nearly 150,000 tons. As would be expected, there has been a tremendous improvement in the quality of these sheets since the granting of the Hadfield patents in 1907. The prime factors determining the quality of silicon sheets may be itemized as follows:

1. Low core loss
2. High permeability
3. Freedom from loose scale
4. Freedom from brittleness
5. Flatness
6. Close adherence to physical tolerances
7. Good punching properties

Obviously, to secure a first-class sheet, every step in the manufacture of this product must be under very close control, necessitating skilled mill practice. The buyers of this material are demanding and obtaining far better quality than was thought possible ten years ago. Nevertheless, the basic mill operations have remained the same for some thirty years. Only with the advent of coiled silicon strip has there been any radical change.

Within the past five years there has been a tremendous growth in the use of coiled carbon steel strip as a substitute for flat carbon steel sheets, largely due to the demands of the automotive industry and resulting in metallurgical as well as mechanical advantages to the user. Applying the same reasoning to silicon steels, it was apparent that coiled silicon strip could displace, at least in part, the conventional flat silicon sheets; providing, of course, a satisfactory product could be made.

There were, however, many obstacles to overcome. First: The product must be processed in such a manner that it will lay flat when uncoiled, i.e., neither "coil set" nor "cross curvature" can be tolerated. Not only would mechanical difficulties be encountered in the punching of strip containing "coil set," but also (and this is of prime importance) the resulting laminations must be flat so that they may stack properly. This difficulty was solved by evolving an entirely new technique for the heat treatment or annealing of silicon steels. Ordinarily, silicon sheets are annealed by the conventional box anneal process whereby a pile of 30,000 to 40,000 is subject to heat in a sealed container. The heat is applied for a period of 25 to 42 hours, depending on the sheet size, gauge and silicon content. The closed container is essential to prevent over-oxidation. Gas is the fuel most generally used.

Such an annealing practice would not be suitable for coiled strip since the steel would have pronounced "coil set" if heated and subsequently cooled in coiled form. Therefore an electrically-fired, atmospheric-controlled roller hearth furnace was adopted through which the strip is pulled ribbon-like at a predetermined speed and temperature. The steel is then coiled at some distance from the exit end of the furnace and at room temperature. Thus the stock will lay flat when uncoiled at the user's punch press.

In addition to the furnishing of strip with all "coil set" removed, this type of furnace gives an exceptionally uniform anneal, as discussed below.

The second problem that had to be solved in order to produce an acceptable product was one dealing with the electrical properties of the strip. Silicon steel is generally employed in thicknesses of from .025" to .014" (24 to 29 U. S. Std. Gauge) which is considerably lighter than can be produced directly off the hot strip mill. This necessitates considerable cold working or rolling to obtain the desired finished gauge. As this cold reduction places the steel in a highly strained condition, destroying all electrical properties, a suitable subsequent anneal must be employed to restore the desired electrical properties. Again, it was found that the continuous electric annealing furnace previously referred to was a satisfactory vehicle to properly heat treat the strip so that the effects of the cold reduction strains are effectively removed. The electric anneal furnace control is sufficiently accurate to impart the same heat treatment to every square inch of strip.

Due primarily to the atmospheric control features of the electric annealing furnace, the type of mill scale or iron oxide produced on silicon strip is of a different nature to that characteristic of silicon sheets. Silicon steels, of necessity, require a continuous coating of some form of insulation, preferably mill scale, in order to reduce the eddy currents. It is of utmost importance, however, that the scale be tight so that it will not break off or become loose in fabrication. The oxide on silicon strip is both tight and light, the former precluding rupture of the scale while being punched; the latter offering less abrasion resistance to the punching dies, resulting in longer die life to the user.

While it is apparent that the many mill operations and processes necessary for the production of coiled silicon strip entail more expense than that incurred in the making of flat silicon sheets, the rate of production of this product (with the consequent operating economies) has reached such a point that it is possible to furnish coiled silicon strip at only a slightly higher price than that charged for the same gauge, width, and grade of silicon sheets. This differential is readily assimilated by the economies realized by the user. These economies are three-fold:

1. Saving in scrap
2. Cost of handling
3. Die life

Silicon strip is available in coiled lengths of 700 to 1700 lineal feet, depending upon the gauge desired. In-

STRIP

by Burton Longwell*

dividual flat, slit, silicon sheets, are rarely more than 124" in length. Due to the limitations in sheet mill practice, exact sheet lengths cannot be obtained without the payment of an extra charge. Hence, the user will have on his hands as scrap material either half-punched laminations or an excess of unused sheet at the end of each slit sheet. With the use of coiled strip this condition will be encountered only once in each coil—an obvious saving.

In many cases as well, side scrap is an item. Here again the use of coiled strip results in reducing this item since the width tolerances on this product are closer than obtainable in slit sheets.

Full weight coils of silicon strip weigh approximately 75 lb. per inch of strip width, or in other words a coil of strip 5 inches wide will weigh approximately 375 lbs. This weight standard has been found to be the most convenient in the majority of shops. These coils are easily unloaded from trucks or cars when received at the final destination, are convenient to stock, and are readily mounted upon reels at the punch press. Since the coils are delivered slit-to-width the slitting operation by the user is eliminated with the subsequent saving of two or three handlings in the customer's plant.

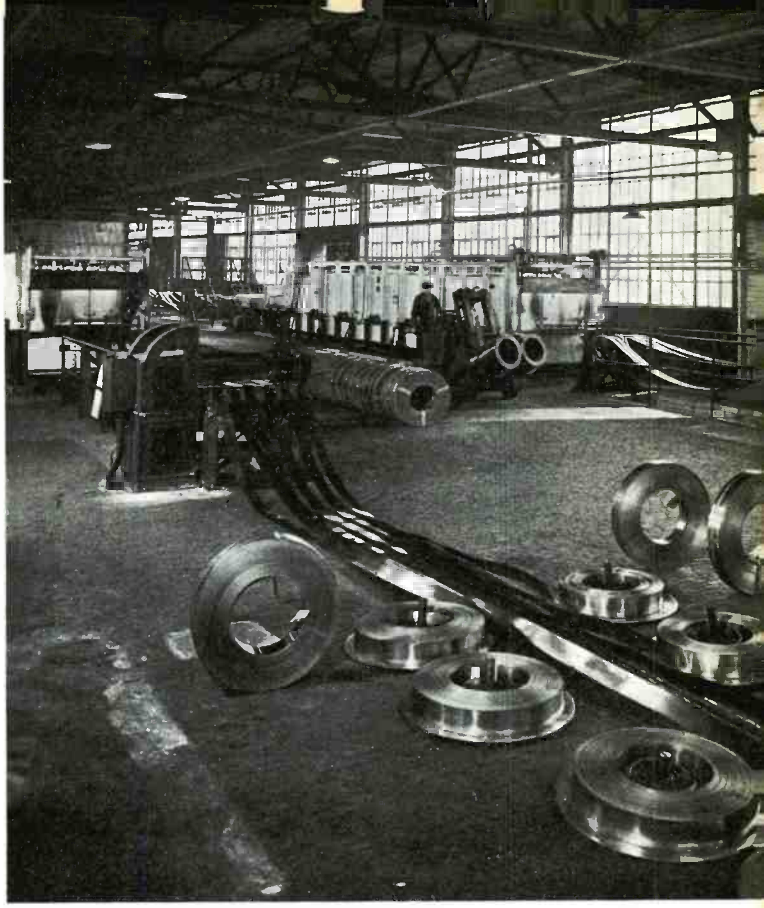
After being mounted on reels and in conjunction with the automatic feed, little or no attention on the part of the operator is necessary. Many plants employ only one punch press operator for two or more machines, a large labor saving.

The increased die life reported by silicon strip users is mainly due to four factors: the absence of half-punches, which half-punches cause more die wear than do ten full size punches; the nature of the mill scale on strip causing less die wear and abrasion; the closer gauge tolerances, allowing the user to employ closer die clearances; the fact that coiled strip is harder—having a higher Rockwell than has the equivalent grade of slit sheets, so that a cleaner punch or shear is obtained, resulting in less burr.

It must be admitted, however, that the subject of die life is a highly debatable one. Each shop has its own practice, and factors other than lamination steel must be considered. The die steel, the lubricant, the press speed—all have a direct bearing on die life.

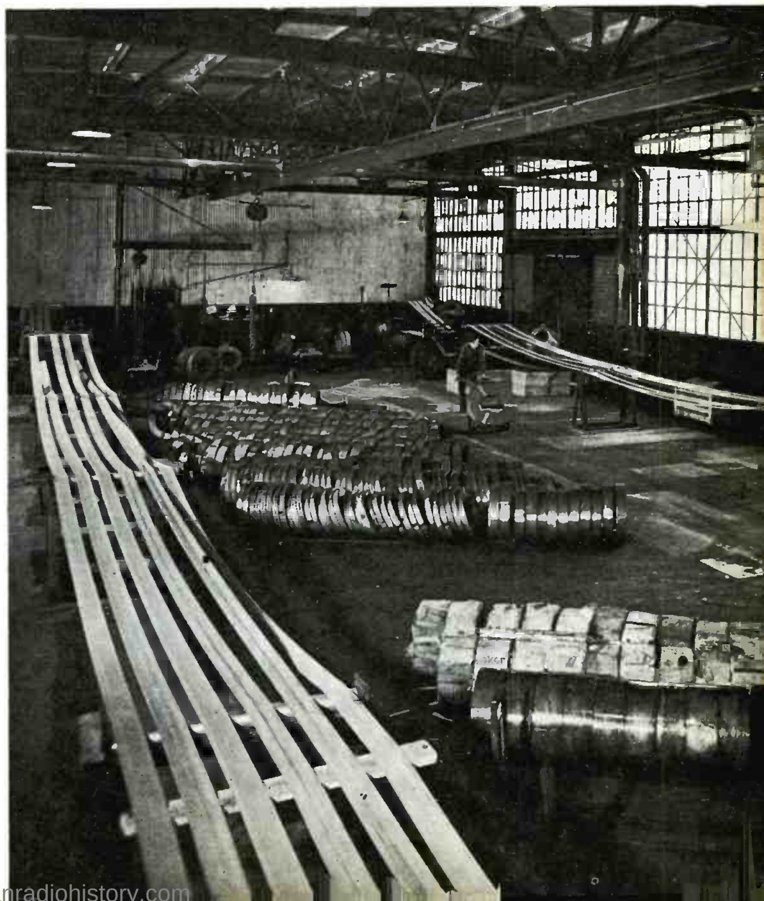
The advantages and economies of coiled silicon strip are best realized when the laminations can be punched on automatic dieing machines equipped with progressive dies. The necessary auxiliary equipment consists of an automatic centering reel, (either power-driven or static), an automatic roll feed, a suitable oiling device, and a scrap cutter. Such a set-up is ideal for the manufacture of small E and I transformer laminations such as are used by the radio industry. Properly engineered, a manufacturer of such a product should show considerable savings over the older method of employing flat sheets slit to size and fed by hand, with the resultant high labor and scrap costs.

* Republic Steel Corp., Cleveland, Ohio



Electric furnaces for annealing coiled strip.

Silicon strip leaving annealing furnaces, and cooling as it travels to the coiling machines.



Design . . NOTES AND

MOVIE DIAL

SOMETHING NEW AND unique in dials is being introduced by one of the large mail-order organizations. Called a "Movie" dial, it actually employs a miniature version of a motion-picture projector.

The method is to project onto a ground-glass screen the image of the figures on the dial. The figures are printed photographically on a motion-picture film, and projected and enlarged in a manner similar in principle to motion-picture projection.

This permits enlarging the dial so that the call letters and cities of 130 broadcast stations in the United States and Canada may be shown, each call letter being about ¼ inch long.

The stations are divided into three groups, East, Central and West so that the dial may be used in any part of the country.

The dial scale is printed on a strip of motion-picture film and is mounted on a drum which rotates in synchronism with the tuning condenser. A special projector lamp is mounted in the center of the drum. The light from the lamp passes successively through a condenser lens, the dial film, a color filter, and a projector lens, and is then reflected from a mirror onto the screen. The optical magnification of this system is about 10 times. If the entire length of the enlarged scale were visible at once, it would be more than seven feet long.

When the band change switch is rotated the entire film drum is moved vertically so that a new scale is projected on the screen. At the same time the color filter is changed to provide green and amber coloring on the two short-wave bands.

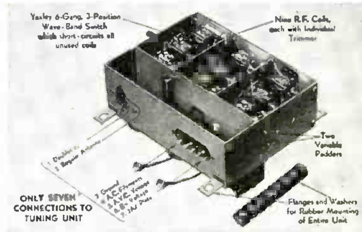
The short-wave bands contain a wealth of interesting information on the services available in these portions of the frequency spectrum. A large number of the principal short-wave stations are listed with their call letters and country. The location of amateur, police, aircraft, and ship bands are clearly marked.

The accompanying illustrations show the mechanism which is used in obtaining the images in the Movie Dial.

MONTGOMERY WARD,
Chicago, Illinois.

TUNING UNITS

ONE OF THE most difficult problems with which the foreign set manufacturer has to contend is that of getting the various tuned circuits properly aligned. Contrary to accepted U. S. practice, many manufacturers abroad are simply assemblers of parts and as such are not equipped, either by experience or inclination, to make the many precise measurements so essential to the proper functioning of a modern circuit. This is not so strange when it is considered that a few hundred sets may constitute a large output for one of these manufacturers; in all probability, one year's profits would not even begin to pay the cost of the test equipment.

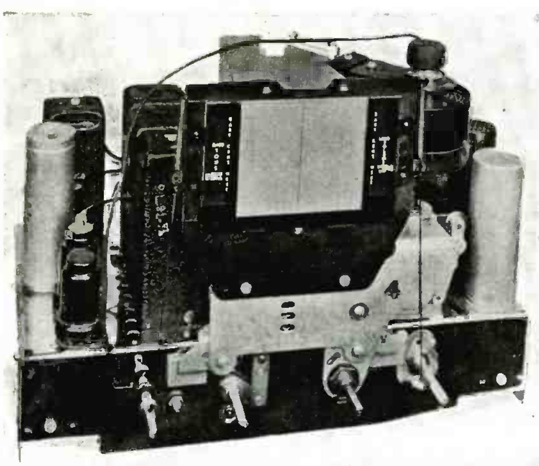


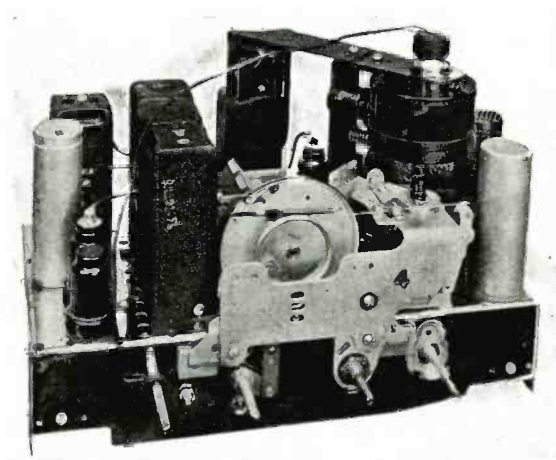
Interior of tuning unit.

In order to meet this situation, there has been developed a unit in which most of the critical tests are made by the American manufacturer, leaving only the relatively simple matters of i-f line-up, point-to-point wiring check, a-f checks, etc., to the final assembler. With the r-f and oscillator padding and trimming taken care of, the comparative ease in turning out a satisfactory receiver is obviously greatly simplified.

As can be seen from the accompanying illustrations, the tuning unit is entirely complete except for power supply. The two tube sockets provided are for the r-f stage—which functions on all bands—and the first detector-oscillator (mixer). Either glass, metal, or the so-called "G" types of tubes may be used, the difference being, of course, in the sockets (the same sockets are used for both the metal and the "G" type, but the glass tubes require the six- or seven-prong regular type) and in the alignment of the circuits.

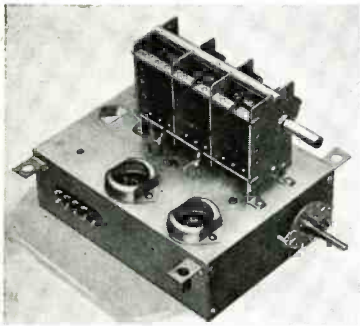
The tuning units are made in several





The Movie Dial (left) as seen from the front, and (right) the mechanism.

COMMENT . . *Production*



Top view of tuning unit.

different models; some differ only in the tube type for which they are to be used, others cover different wavebands, and some may be obtained for 220-volt d-c operation. In this latter case there is a slight difference in the circuits for the tube heaters.

The wavebands covered may be either of the following: 16.5 to 555 meters, or 16.5-52.6, 167-555, 780-2140 meters.

Geo. Breck,
AD. AURIEMA, INC.

A PRECISION RECEIVER

MANY UNUSUAL features have been incorporated in a new model of the Hammarlund "Super Pro" professional receiver.

One of the important features of this model is a five range, directly calibrated "Band Width" panel control. With the aid of this tuning device it is now possible to accurately select the actual band widths required. That is, if the operator wishes to tune a band width of 3, 4, 6, 10, or 16 kc., he can actually turn the knob to either one of these calibrations on the panel; in this manner, not only is a high technical precision achieved, but also the most effective results.

Graduated sensitivity and audio gain controls represent two more features. The calibrations of both these controls appear directly on the panel and enable the operator to select the proportionate sensitivity or audio gain required for each signal. Thus, an actual graph can be made for signals from any particular broadcasting station.

For c-w code, a calibrated beat oscillator control has been included. With this unit it is now possible to select a beat note of somewhere between 0 and 2500 cycles on either side of zero beat.

By adjusting the band-width control, a tone control effect is also available, since the high or low notes can be cut off or heard at will, depending upon the band selected.

An additional feature is the special cam-operated knife switch; in this switch are five shielded sections with five silver-plated bakelite knives in each unit. Each knife glides into four silver-plated phosphor bronze spring clips and each spring clip is broken into two sections. Thus, a positive 6-point contact is made every time a knife is moved.

Another feature is the band spread system, with a 12-gang condenser, which spreads each amateur band over practically the entire dial. High-frequency broadcast channels are similarly spread for easy tuning. Within the precision tuning unit, are twenty tuning coils on Isolantite bases, a four-gang main tuning condenser, and a 12 to 1 ratio direct-reading dial, calibrated in megacycles and kilocycles accurate to within ½%.

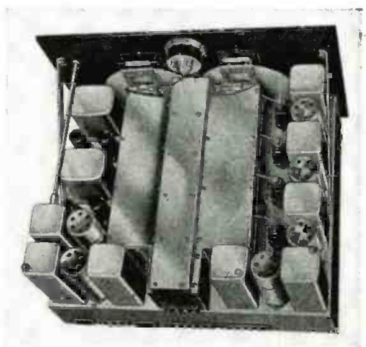
With the bandwidth control at the minimum setting, or with the primary and secondary of the i-f transformer most widely separated, the selectivity of a signal 10 times the input is only 5.5 kc, and at 1000 times the input only 11.5 kc. With the bandwidth control at maximum width or actually at minimum selectivity, at 10 times the input, a 25-kc band is available.

The signal-to-noise ratio on 14 megacycles is said to be only 8 db at 0.7 microvolt input with 30% modulation at 400 cycles.

The image ratio at 14 megacycles is 1600 to 1, and at 1000 kilocycles, it is 316,000 to 1.

The receiver which covers five ranges of from 2.5 to 5; 5 to 10; and 10 to 20 megacycles, and from 540 to 1160 and 1160 to 2500 kilocycles, uses 16 tubes, 8 metal and 8 glass, viz: two 6K7 in two tuned r-f stages; a 6J7 as a high-frequency oscillator; a 6L7 first detector; three 6D6's in 465 kc i-f stages; a 6B7 as a combination 4th i-f amplifier and diode second detector; a 6C6 low-frequency beat oscillator; a 6B7 for avc; a 6C5 as a resistance-coupled audio-frequency amplifier; a 6F6 as a class "A" driver; and two 6F6's operated as triode class "AB."

The "Super Pro".



The chassis.

The receiver is powered with a separate power supply in its own metal housing. Individual grid and plate voltages are supplied to eliminate hum and insure voltage constancy.

Hammarlund Mfg. Co., Inc.

NEW STANDARDS OF INTEREST TO THE INDUSTRY

THREE NEW STANDARDS in the field of sound measurement and nomenclature of sound will prove valuable to both engineers and musicians. One of these has resulted in a new "noise meter" to measure the sound of, for instance, typewriters or pneumatic drills. It may also be used in music studios to teach singers how to place their voices most effectively for radio, movie, and concert work. Before this specification became available there were 5 meters on the market, the results of which were in no way comparable.

An international standard for 16-mm sound-film now provides for complete interchangeability of this size film and equipment throughout the world, ending a two-year controversy between European and American manufacturers with universal adoption of the American practice.

American Standards Association

WHAT DOES THE PUBLIC WANT?

From the author of "How Will Television Affect the Radio Industry" come these observations which can lead only to the conclusion that the public neither knows nor cares.

IT IS AN undeniable fact that the public hasn't the slightest idea what it wants in radio receivers. This is illustrated perfectly by the following example; since a verbatim account would be about the silliest thing we can think of, only the salient points of what was an hour-long argument will be covered.

A man and his wife were looking at radios. The choice eventually narrowed to one of two models. Everything else being equal—price, number of tubes, amount of trade-in allowance, etc.—the final decision was arrived at by a line of reasoning (if such could be termed "reasoning") something like this: The man wanted the set made by A, since he knew of that company through its great advertising campaigns and its prestige in business. However, his wife picked set B for a reason which will be quite apparent to most men—it looked best with her present furniture, or her prevailing dress styles, or something equally ridiculous. However, friend husband pointed out that the dial on set B wasn't as modern as that on his choice—it didn't have as many pointers, or the numerals were black instead of green or red, and so on. That settled it! Their friends might mistake their brand-new radio for an old model set, and under the customary "keeping up with the Jones" idea of so many families, the matter of the dial decided the sale.

All of which is, as we warned a paragraph or so previously, entirely silly, but it is so typical of Mr. and Mrs. America buying a radio that it can serve to introduce this discussion on what we believe the manufacturer ought to try to give these "babes in the woods."

Probably the most common, and unquestionably the worst offense of the radio listener is carelessness in turning to a station. It is one of these things that are due both to ignorance and just plain indifference. Since it is just about hopeless to expect human nature to change, at least in one generation, it seems that the only answer lies in the prompt acceptance of automatic frequency control by the set manufacturers. Presumably, at the present time, it represents too much of an expense to include in any but the more costly receivers, although it is probably safe to assume that further investigation and research will aid materially in reducing this increased cost. As a matter of fact, automatic frequency control should enable the set manufacturer to eliminate some other features which are now incorporated in receivers to assure the user of reasonably satisfactory results. For instance, with a-f-c in a receiver, would it not be entirely feasible to do away with elaborate, laboratory-adjusted r-f circuits? We don't pretend to know, but offer this simply as a line of thought in connection with the consideration of a-f-c. Obviously, though, the tuning indicator should pass from the picture with a-f-c, so here is a saving of a *few* cents at least.

All of this has to do with quality, so we may as well continue in that vein. Just what the public expects in the way of quality can be judged very well from the slip-shod tuning, the neglect to call a service man until the set absolutely refuses to function, and other well-known traits of the listening public. Of course, there are those to whom good—and by "good" we mean quality, both in selection and reproduction—music is more or less indispensable. It seems that some manufacturer might be able to round up some rather nice business by catering to this type, supplying them with a set in which all of generally expected sales appeal items are missing. Such features as short-wave bands, long-distance reception, and so on, would necessarily be eliminated in favor of a circuit with which purely local reception would be the rule. Such a circuit might be nothing more involved than one or two stages of band-pass coupled r-f, a linear detector—*without* a-v-c—and a high quality audio system.

In such a receiver, some method for the reduction of cabinet resonance effects would be not only necessary but essential. This statement is made with a full appreciation of the fact that such a plan would materially increase the cost of the receiver, but after all, if a person really wants quality he will probably expect to pay for it.

Another point that would require more than the usual attention afforded by designers is that of an absolutely quiet power supply system. Many of the present day, high quality speakers are efficient enough at 120 cycles—especially when used with a baffle of appropriate size—

(Continued on page 25)

WIDE-RANGE OSCILLATOR FOR THE HIGHER FREQUENCIES

(*Continued from page 7*)

by differences in contact between the door and cabinet as it was successively opened and closed.

A single output transformer is used over the full frequency range of 50 to 5000 kc to couple the output amplifier to the load. Although tuned output transformers would give a uniformly greater output over this frequency range, tuning of the transformers would react upon the oscillator circuit and result in poorer frequency stability. Also in the interest of frequency stability, it was found advisable to control the output on the plate side of the output tubes rather than the grid side. In addition to this, the waveform of the oscillator was considerably improved by stabilizing the output impedance at a relatively low value by means of a resistance across the high side of the output coil. By making this resistance in the form of a potentiometer it is made to function also as an output control. This arrangement works well over the entire frequency range without greatly affecting the oscillator frequency when changing its output. An output of at least 100 milliwatts into 100 ohms may be obtained over the entire rated frequency range. The frequency change of the oscillator when the load impedance is changed from open to short circuit is only about 5 cycles in one megacycle. Although the normal frequency range of the oscillator with 6 plug-in coils is 50 to 5000 kc, the high-frequency coil may be used as high as 10 megacycles with some sacrifice in output and stability.

The arrangement of the apparatus in the cabinet is shown in Fig. 2. At the left center are the two oscillator tubes while at the other side of the shielding partition behind them are the two output tubes. Directly beneath the oscillator tubes are the air condensers with the vernier gear drive between them. At the right are the two decade condenser units, and at the upper right are the output potentiometers, mounted tandem and controlled from a single dial on the front. At the extreme lower left is the transformer for supplying filament current.

The maximum temperature rise inside the oscillator is only about 11° F. Temperature saturation is practically reached, however, in about an hour, and for most purposes the oscillator may be considered stable in half an hour. The maximum change in frequency of the oscillator during the warming up period is of the order of 100 cycles in one megacycle or about 0.01 percent.

The frequency change of the oscillator for one volt change in the plate power supply is of the order of one cycle at one megacycle, and automatic regulation is incorporated in the plate power supply unit to maintain the plate potential constant to within one volt for variations in the line voltage of ± 10 percent. Some change in frequency due to variations in line voltage is also caused by changes in the filament supply voltage, but the overall frequency change resulting from variations in line voltage of as much as ± 10 percent is only of the order of ten cycles at one megacycle, or about 0.001 percent. Radio-frequency energy radiated by the power supply unit and its associated supply line is practically negligible.

As a result of this development there is now available a wide range oscillator for the higher frequencies, which is simple to operate and has high frequency stability. By the use of six plug-in coils the frequency range from 50 to 5000 kilocycles may be covered with high precision of setting.

WHAT DOES THE PUBLIC WANT?

(*Continued from page* 22)

to make it essential that power supply hum be drastically reduced. Furthermore, it is well known that harmonics of the 60 cycle supply higher than 120 cycles are present in the output of rectifier tubes; the filter should, for this reason, be designed to afford a high degree of attenuation to *all* frequencies above the cut-off. The usual form of filter does this to a certain extent, but it might be wise to look into this matter more fully.

Pending the more or less universal adoption of a-f-c, we can suggest that circuits of higher stability would be in order. The trend towards better coils and condensers is decidedly in favor of such a design policy. Frankly, we can see no reason for the necessity of re-tuning a receiver after it has been in operation for a length of time, yet this is all to often necessary with some models, especially the so-called midget sets.

With a bow to the editor, whose pet subject this is, the early acceptance of the use of crystal-coupled circuits for intermediate-frequency amplifiers ought to go a long way to cure some of the headaches due to coupled tuned circuits. True, there is still sufficient reason for the use of band widening devices, or circuits, to make it advisable to investigate the possibilities of obtaining a crystal filter in which the transmitted band width may be varied at will. It is believed that this may be possible with certain of the filter sections that can be designed.

Suppose, then, that high fidelity response is assured up to the speaker. Something must be done to provide that the higher audio frequencies are distributed throughout the room in which the radio is located. This problem in theaters is quite well taken care of by means of multiple speakers, but this is, to say the least, not entirely feasible in the home receiver. The fact that many speakers are deficient at the low and high frequencies can be compensated for in the audio system, but it is still found that the high frequencies are concentrated in a more or less pronounced beam from the speaker. So little attention seems to have been given to this point that we find, in a widely advertised custom built radio, a so-called high-frequency "tweeter" located so that all of its sounds go off at a right angle to the front of the cabinet; then, the maker of the receiver recommends *that it be located in a corner*. It would be difficult to find anyone who could truthfully say that he had actually heard everything that this set was capable of reproducing, but any number of people evidently think that they have. Which is, perhaps, sufficient commentary on how little most persons actually know about tone quality. Theaters everywhere have had similar experiences; after spending thousands of dollars to improve their sound equipment, many of them have actually had complaints to the effect that the sound wasn't natural!

Be that as it may, some measure of success must follow on the heels of educational campaigns. All types of sound reproducing systems are improving—radically, in some cases—so that, sooner or later, there will be a reaction on the part of the public to this idea of buying a radio set on appearance, or some other entirely useless basis. The set manufacturer, most of whom, we believe, would conscientiously favor a trend towards better receivers, can aid materially in this campaign. Not by thinking up new gadgets to hang on a receiver, but rather in insisting upon an all-around betterment in his product.

RMA NEWS

RMA MERCHANDISING PROGRAM RECEIVES WIDE APPROVAL

Widespread approval and support, by the trade as well as manufacturers, has followed the proposed merchandising reform program developed by the RMA and submitted, in new trade practice rules, to the Federal Trade Commission.

Chairman E. F. McDonald, Jr. and the RMA Fair Trade Practice Committee have received many endorsements of the set manufacturers' plan to end prize contests, "spiffs," cruises and other undesirable practices in radio merchandising. The example and program of the RMA Set Division also promises to be followed by other radio groups. Other industries also are at work to abolish the "spiffs" practice and it is a matter under close government scrutiny, with possible developments also under the Robinson-Patman Act. The RMA has received formal resolutions from the National Electrical Wholesalers Association urging that manufacturers discourage subsidies or donations of any kind to salesmen of distributors or dealers.

A majority of RMA set manufacturers already have transmitted to Association headquarters signed agreements supplementing the new trade practice rules on prizes, "spiffs," etc., now pending before the Federal Trade Commission. The trade practice rule would apply to manufacturers, while the supplemental agreement would obligate manufacturers to use "all lawful means" for observance by their distributors of the proposed trade practice rule, thus making it effective in the trade as well as directly by manufacturers.

Chairman E. F. McDonald, Jr. and the RMA Fair Trade Practice Committee have received many favorable comments on the merchandising reform program which has been instituted. The formal signature of the supplementary contracts by a majority of the RMA Set Division, and within a few weeks after adoption of the clean merchandising program at the New York meeting of the RMA Set Division on October 21, has given further impetus to the merchandising program. Developments from the Trade Commission also are expected within a few weeks.

TREMENDOUS DEMAND FOR AUTO-RADIO

Universal use and factory equipment of automobile radio were given strong stimulus in the recent survey by the General Motors Company of consumer desires in automobile construction and equipment. The customer research division of General Motors, according to published reports, sent one million questionnaires to owners of all makes of cars. Tabulation of replies said that 85.2 percent expressed preference for solid steel tops on their next cars and that 71.8 percent wanted radio equipment. There was also a reported desire by 90.4 percent for streamline car design.

RMA PATENT SERVICE IMPROVED

The first quarterly index of the RMA patent service is being mailed to Association members. The index covers the first quarter of 1936, January to March, and is designed to increase the value to RMA members of the Association's weekly patent bulletins. Other quarterly summaries will follow.

OCTOBER EXCISE TAXES UP

U. S. Internal Revenue Bureau collections of the five percent tax on radio and phonograph apparatus (not including automobile radio) during the month of October 1936 were $869,136.57, an increase of 35 percent over the tax collections of $643,440.02 in October 1935. Excise taxes on mechanical refrigerators during October 1936 were $572,235.46, compared with $258,797.91 in October 1935.

For the ten months' period ending October 1936 the total radio and phonograph taxes collected were $4,968,909.93, an increase of 58.5 percent over such taxes collected of $3,134,941.04 during the same ten months of 1935.

AUGUST LABOR INDICES

The August report of the U. S. Bureau of Labor Statistics showed the radio industry prominent among those having seasonal employment increases. During August radio factory employment increased 8.9 percent over July and was 19.3 percent above August 1935 employment. The August index figure was 255.0 percent compared with the three-year official average of 1923-25.

Radio factory payrolls increased 14.9 percent last August over the preceding month and were 28.6 percent above August 1935. The August payroll index figure was 172.2 percent compared with the three-year official average of 1923-25.

Average weekly earnings during August of radio factory employees were $20.71 compared with $19.74 during the previous month of July, an increase of 5.5 percent, and were 7.8 percent above average weekly earnings in August 1935. The August average of $20.71 compared with a national average for all manufacturing industries of $22.66 and a national average of $25.03 in all durable goods manufacturing establishments.

Average hours worked per week in radio factories last August were 39.4 hours, an increase of 5.2 percent over average hours last July and 7.3 percent above average hours worked in August 1935. The average hours of 39.4 in August were the same as the national average for all manufacturing industry.

Average hourly earnings last August of radio factory employees were 52.8 cents per hour, an increase of 0.5 percent over July average of 52.4 cents and were 0.6 per cent above August 1935. The average hourly earnings nationally of all manufacturing establishments was 57.1 cents per hour, and the average hourly earnings in durable goods factories nationally were 61.4 cents.

NEW PAMPHLET TELLS ACTIVITIES OF RMA

In the RMA work on standardization of component parts meetings of the following sub-committees also were held at Rochester: Fixed Carbon Resistors, B. B. Minnium, chairman; Fixed Capacitors, Harry W. Hauck, chairman; Dry Batteries, L. S. Fox, chairman; Wire Wound Resistors, Jesse Marsten, chairman; Variable Control Resistors, Henry G. Richter, chairman; Variable Tuning Capacitors, J. S. Robb, chairman; Electrolytic Capacitors, J. S. Williams, chairman; Power Transformers, Arni Helgason, chairman, and I-F and R-F Transformers, Monte Cohen, chairman.

The principal work of the Radio Manufacturers Association, its many and varied services to members and activities in industry matters, are detailed in a new pamphlet now being distributed. Many functions of RMA are covered in condensed and quickly readable form. The pamphlet was prepared primarily for information of new companies joining the RMA, for use of the Association's membership committee of which Paul V. Galvin of Chicago is chairman, with Henry C. Forstor of Chicago, vice chairman of the western section, and N. P. Bloom of Louisville, Kentucky, vice-chairman of eastern membership activities.

ELECTRICAL WHOLESALERS PRESENT MERCHANDISING PROPOSALS TO RMA

Several merchandising recommendations have been received by RMA from the National Electrical Wholesalers Association which met at Buffalo, New York, last September. The NEWA committee on radio and tubes is headed by Mr. H. O. Smith, chairman.

In addition to recommending that manufacturers discourage "spiffs" for salesmen of distributors or dealers, the NEWA committee presented detailed recommendations to RMA regarding replacement and repair of defective cabinets and parts. Included was a recommendation that set manufacturers bring out fewer models, the NEWA committee stating that 25 percent of models account for 80 percent of set volume.

The NEWA recommendations will be presented to the RMA Board of Directors at its next meeting.

INTERFERENCE MEETING

Another meeting of the Joint Coordination Committee on Radio Reception of RMA, NEMA and the Edison Electric Institute will be held at the latter's head-

(*Continued on page 29*)

NEWS OF THE INDUSTRY

BURGESS ACQUIRES THORDARSON

Dr. C. F. Burgess, president of the Burgess Battery Company of Chicago, announces the purchase of the controlling interest in the Thordarson Electric Manufacturing Company of Chicago. The Thordarson Electric Manufacturing Company will continue the manufacture of transformers for the radio and neon sign industry as well as other products in the process of development. Chester H. Thordarson, founder of the company, is president and Jackson Burgess is vice-president. Dr. Burgess announces that this arrangement will free Mr. Thordarson and himself for research and development work.

— RE —

SYNTHANE BULLETIN

The Synthane Corporation of Oaks, Penna., announces a new 6-page general folder on the grades, physical, chemical, mechanical and electrical properties, shapes, characteristics and standards of quality of Synthane laminated bakelite tubing.

Interesting features of this folder are a 2-color quick reference comparison chart of the test values of rolled and molded tubes, including the tensile, compressive (axial and radial) and dielectric strengths, moisture absorption, power factor and dielectric constant.

— RE —

RECORDING BOOKLET

The Universal Microphone Co., Inglewood, Cal., late in October issued a 4-page instruction sheet, illustrated, for its new portable recording machine. A price reduction in the professional black recording discs, all sizes, was also announced during the month of October.

— RE —

METAL PREPARATION

A manual giving in detail methods for the application of sodium cyanide solutions in the preparation of metal surfaces is announced by The R. & H. Chemicals Department, E. I. du Pont de Nemours & Company. The manual gives a general outline for the various methods used in treating metal surfaces with specific information regarding the use and handling of sodium cyanide in that field.

The preparation of metal surfaces is discussed under the following general headings: Steel finishes, metal surfaces, direct application of sodium cyanide, cleaning ferrous metal surfaces, preparation of hot rolled steel surfaces, cleaning non-ferrous metal surfaces, preparation of steel surfaces for enameling, preparing metal surfaces, and safe handling of sodium cyanide.

— RE —

MITCHELL-RAND ISSUES NEW SCHEDULES

Revised price schedules on mica plate have just been issued by the Mitchell-Rand Insulation Co., 51 Murray Street, New York City.

PLASTIC DESIGN AWARDS

The field of radio figured prominently in the awards made in the First Annual Modern Plastics Competition. From over a thousand entries from all portions of the United States, the Sears-Roebuck Silvertone Radio received first prize in the decorative group (Page 23, RADIO ENGINEERING, September, 1936). The case is molded of Durez and Plaskon by the Chicago Molded Plastics Corporation, and the Tenite dial and tuning knob was molded by the injection process by the Erie Resistor Corporation. In the industrial group the third award was given to a bezel molded for Colonial Radio Corporation of Buffalo, by the Erie Resistor Corporation. It consists of a plastic rim injection molded of Tenite in one operation around a spherical glass 7 inches in diameter. Not only is the breakage of glass reduced to a minimum in the molding process, but also assembly costs are reduced by attaching the bezel to the set by the two gates formed in the molding process.

The rim of Tenite was designed by L. Berry of the Erie Resistor Corporation, and molded by them on an automatic injection molding machine made by the Index Machinery Corporation, Cincinnati, Ohio.

The awards were presented at a dinner held on October 29. The dinner also marked the opening of the Metals & Plastics Bureau, International Building, Rockefeller Center, New York City.

— RE —

SMITH NOW PRESIDENT OF SHAKEPROOF

The board of directors of Shakeproof Lock Washer Company on October 27, 1936, elected Harold Byron Smith as president of the company to succeed his father, the late Harold C. Smith.

The other officers of the company are now as follows: Frank W. England and Carl G. Olson, vice-presidents; Calmer L. Johnson, secretary and treasurer; Frank W. England, assistant secretary.

— RE —

CURTIS BULLETIN

A new catalog of electrolytic condensers has just been issued by the Curtis Condenser Corp., 3088 West 106th Street, Cleveland, Ohio. The catalog describes condensers for radio filter, audio by-pass, motor starting, and transmitting services.

WESTINGHOUSE BOOKLET

A booklet entitled "Micarta In The Radio Industry" illustrates uses of this plastic material in the industry including switch parts, coil supports, tube sockets, etc. Also, a publication entitled, "Where Can You Use Micarta" includes a description of Micarta, its mechanical and electrical properties and the standard forms available. Copies may be obtained from the nearest district office or direct from the Advertising Department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Penna.

— RE —

COPPER CONSUMPTION HIGH

"There has been a marked increase in the consumption of products made from copper and its alloys during the first nine months of this year, and the outlook for the fourth quarter is most encouraging," F. S. Chase, president of the Copper & Brass Research Association, announced at the 15th annual meeting of members, October 15. "Present indications," he said, "point to the tonnage for 1937 exceeding that of the present year by most consuming industries."

"The largest tonnage of copper is, of course, used in the electrical field. The mileage of rural lines being built this year will more than double that of 1935. Not only is this expansion consuming large amounts of copper for transmission lines, but the sale of all electrical appliances such as vacuum cleaners, electric irons and other labor saving devices exceeds that of any year since the depression was first felt."

— RE —

SHIPMENTS BY AIR EXPRESS AT ALL-TIME HIGH

Air express shipments set up a new all-time high monthly record in September, when 43,153 packages were picked up to be air-flown and delivered, the air express division of the Railway Express Agency announced. This was an increase of 14 percent over August, when 37,790 shipments were made.

The air express business for the eight months ending September 30 showed an increase of 66 percent over that of the contract air lines for the corresponding period of 1935, the announcement said.

— RE —

TURNER PLANT MOVES

The Turner Company, Cedar Rapids, Iowa, announce their removal to a new factory building at 909-17th Street, Cedar Rapids.

— RE —

STEINLE REJOINS TRIAD

George Coby, president of Triad Manufacturing Co., Inc., of Pawtucket, R. I., announces that Harry H. Steinle has again joined his organization as vice-president and director of sales.

RMA NEWS

(*Continued from page 26*)

quarters on Wednesday, December 2. Many problems of radio interference, including those caused by diathermy apparatus will be considered and a report made on interference work of the American Standards Association's joint committee.

CANADIAN SALES

Canadian radio manufacturers last September sold 36,529 receiving sets with a list value of $3,388,217, according to statistics of the Canadian RMA. Included were 24,256 a-c sets valued at $2,565,374; 11,808 battery sets valued at $795,299, and 465 automobile sets valued at $27,544.

Total set sales of Canadian manufacturers September 1935 were 31,356 sets valued at $3,189,030.

For the nine months ending September 30 last, reported Canadian sales were 144,833 sets valued at $13,595,670, compared with 107,101 sets valued at $9,859,260 during the similar nine months' period of 1935.

Inventories of Canadian manufacturers on September 30 last were reported at 42,540 sets and projected production by Canadian manufacturers from October 1 to December 31 was 77,381 sets, including 63,681 A.C. sets, 13,098 battery sets, and 602 automobile set chassis.

FCC CHIEF ENGINEER DETAILS WORK WITH RMA

Better broadcasting service for the public as well as industry engineering progress are resulting from cooperation between RMA and the Federal Communications Commission, Commander T. A. M. Craven of Washington, chief engineer of FCC, stated during an address November 17 at the Rochester meeting of the Institute of Radio Engineers.

"Co-operation between the Federal Communications Commission and the RMA has been a most valuable contribution to the art of broadcasting," said Commander Craven in discussing recent engineering recommendations relating to broadcasting and also future television which were submitted to the FCC by RMA. Commander Craven stated that the FCC looks to the RMA for information regarding performance of radio receivers and that at the recent FCC hearings most valuable data was presented by RMA.

"Almost daily we are co-operating with the engineering committee of RMA," said Commander Craven, referring to a meeting with an RMA committee regarding establishment of protected I-F frequencies which would develop more satisfactory broadcasting for the public and be a stabilizing factor also in set manufacture.

Important questions, in addition to the I-F frequency problem, which Commander Craven stated are now being given attention by cooperative effort of the FCC and RMA, are the ten-kilocycle separation program and high-fidelity broadcasting.

Dr. W. R. G. Baker of Bridgeport, Conn., chairman of the RMA engineering committee, presided at the IRE session at Rochester which was addressed by Commander Craven. At this session also the RMA television standards proposed to the FCC by the Association were detailed by Albert F. Murray of Philadelphia, chairman of the technical committee which developed the future television standards. These standards, it was indicated by Chief Engineer Craven, probably will be adopted formally and soon by the FCC.

Tube problems were detailed to the IRE Convention by Roger M. Wise of Emporium, Penna., chairman of the RMA Vacuum Tube Committee. He discussed the difficulties in multiplicity of new tubes and problems of standardization in numbering.

MANY RMA MEETINGS DURING IRE CONVENTION

Meetings of fourteen RMA engineering committees at Rochester, New York, during the annual fall convention of the Institute of Radio Engineers, from November 16 to 18, constituted a new record in RMA engineering activity. There was a record attendance also of radio engineers during the IRE meeting and capacity exhibition by parts and accessory manufacturers.

Progress on RMA standardization of component parts was a feature of the Rochester meeting. The parts standardization work has been in charge of L. C. F. Horle and a number of new parts standards were approved at a meeting of the RMA General Standards Committee of which Virgil M. Graham is chairman.

Official representation of RMA at the IRE meeting included President Leslie F. Muter. Directors W. R. G. Baker and George Scoville; Bond Geddes, executive vice-pres.-general manager of Washington, and Judge John W. Van Allen of Buffalo, general counsel of the RMA.

RMA engineering committee meetings at Rochester included sessions of the Broadcasters Receiver Committee of which E. T. Dickey of Camden is chairman; the Vacuum Tube Committee of which Roger M. Wise of Emporium, Penna., is chairman; the Sound Equipment Committee of which Hugh S. Knowles of Chicago is chairman; and the special conference Committee on Intermediate Frequencies of which G. E. Gustafson of Chicago is chairman.

SEPTEMBER EXPORTS INCREASE

Radio exports last September of $2,720,336 showed a large increase over the exports of $2,143,756 in September 1935, according to the September report of the U. S. Bureau of Foreign and Domestic Commerce.

Receiving sets exported during September 1936 numbered 60,949 valued at $1,549,838, compared with 50,275 sets valued at $1,255,867 in September 1935.

Tube exports during September 1936 were 809,933 units valued at $336,867, compared with 677,081 valued at $284,727 in September 1935.

Radio parts and accessories valued at $595,640 were exported in September 1936 compared with $485,010 in September 1935.

Loud speaker exports during September 1936 numbered 40,886 valued at $79,003, compared with 15,491 valued at $39,945 in September 1935.

Transmitting apparatus exported in September 1936 was valued at $158,988, compared with $78,207 in September 1935.

An increase of 10.8 percent in radio exports was made during the nine months ending September 1936 with a total of $19,476,736, compared with $17,585,946 during the similar nine months period of 1935.

Receiving set exports during the first nine months this year totaled 427,295 sets valued at $10,452,003, compared with 396,528 sets valued at $10,306,518 during a similar period last year, an increase of 1.4 percent.

NEW PRODUCTS

PORTABLE SOUND-LEVEL METER

The Type 759-A sound-level meter has been designed to meet a wide range of applications in the general field of sound-level measurement.

The performance characteristics are based on the specifications recently adopted by the American Standards Association. The sound-intensity range covered by this meter is from 24 to 130 decibels above the standard reference level of 10^{-16} watts per square centimeter at 1,000 cycles. The microphone is non-directional and can be used with an extension cord and tripod, if desired.

The calibration is stable, and provision is made for recalibration by a simple method. All three frequency-weighting networks accepted by the ASA are included. Power requirements are small, and batteries are self-contained. Mechanically, it is rugged, light in weight, easily portable and attractive in appearance. Provision is made for the use of accessories, such as a vibration pickup.

The Type 759-A sound-level meter is a product of the General Radio Company, 30 State Street, Cambridge, Mass.

— RE —

ARCTURUS ADDS 6B5 TUBE

To round out its line of duplex-triode power output tubes, already consisting of types 25B5, 25N6G, 6N6 Coronet and 6N6G, the Arcturus Radio Tube Company, Newark, N. J. announces the addition of the type 6B5.

— RE —

SPRAGUE "CASED" UNCASED PAPER SECTIONS

An important improvement in the design of uncased paper section cardboard dry electrolytic condensers which makes them unexcelled as compact, low cost transmitting units as well as for a wide variety of service replacement purposes has been announced by Sprague Products Company, makers of Sprague condensers, North Adams, Mass.

KEN-RAD 6V6G

The Ken-Rad Tube & Lamp Corporation, Owensboro, Ky., announces the type 6V6G as the latest development of the Ken-Rad engineering laboratories. This addition to the "G" series is an output tube employing the beam power principle as in the type 6L6 metal tube and it gives the high degree of performance which has made the 6L6 so popular.

The Ken-Rad 6V6G has a 0.45 ampere heater and when operated at 250 volts on the plate and screen will deliver 4.25 watts with about 5% total distortion. The distortion is largely second harmonic and is less objectionable than the odd harmonics found in other output tubes. A signal input of only 8.5 volts to the grid is required to obtain the output mentioned.

— RE —

PRECISION PLUG-IN RESISTORS

Precision resistors in handy plug-in form and of selected ohmages permitting of various combinations for any total resistance value, are now offered by Clarostat Mfg. Co., Inc., 285 North Sixth Street,

Brooklyn, N. Y. These plug-in resistors were originally developed for use in resistance bridges and other test equipment employed in the Clarostat laboratory and plant. Housed in a standard 4-prong tube base, these units are available in values of 1 to 10,000 ohms, with any accuracy up to 1/10 of 1 per cent. Due to the ingenious design, they are quite inexpensive.

— RE —

NEW RCA TUBE

The RCA-25L6 is a power-amplifier tube of the all-metal type for use in the output stage of "transformerless" (a-c, d-c) radio receivers, especially those designed to have ample reserve of power-delivering ability. This new tube provides high power output at the relatively low plate and screen voltages available for transformerless receivers. The high power output is obtained with high power sensitivity and high efficiency.

BURGESS BATTERIES

Burgess "B" Batteries are now effectively protected from cell leakage and outside moisture. Each cell is individually wrapped in three layers of moisture-resistant paraffined paper, and is in turn separated from other cells by a paraffined inner liner—in egg crate fashion. This construction gives maximum insulation between cells and prevents stray current losses which cause noisy reception. Furthermore, the individually sealed cells are totally covered with pitch to retain the electrolyte moisture. As a final protection against the passage of moisture, the heavy outside cartons are paraffined on both sides. A double wax seal on the top—reinforced by a gauze strip between the wax layers—assures double strength and resistance to chipping or breaking.

— RE —

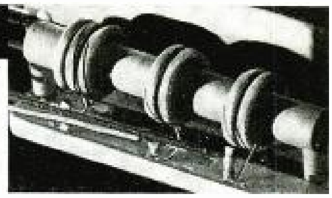
CLOUGH-BRENGLE COMBINATION VOLTMETER

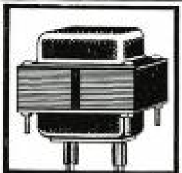
To meet the need for an instrument to measure potential in radio- and audio-frequency circuits, the Clough-Brengle Co., 2815 W. 19th St., Chicago, Ill., has just announced their new model 88 combination vacuum-tube voltmeter and peak voltage indicator. In this new and totally different instrument is embodied a vacuum-tube voltmeter of extremely high sensitivity and input resistance of 10 megohms, plus a peak voltmeter of the "slide-back" type operating from a self-contained power supply.

— RE —

EPCO ELIMINATOR

The Epco storage battery eliminator, recently introduced by the Electrical Products Company, of Detroit, provides a 6 volt 10-amp filtered direct current from 110-volt alternating current. This eliminator is specially designed for laboratory tests, demonstrating 6-volt auto radios and operating small d-c motors, magnets, solenoids, relays and similar apparatus. It can also be used as an efficient battery charger. The Epco storage battery eliminator is also manufactured in a model having a 6-volt 5-amp output.





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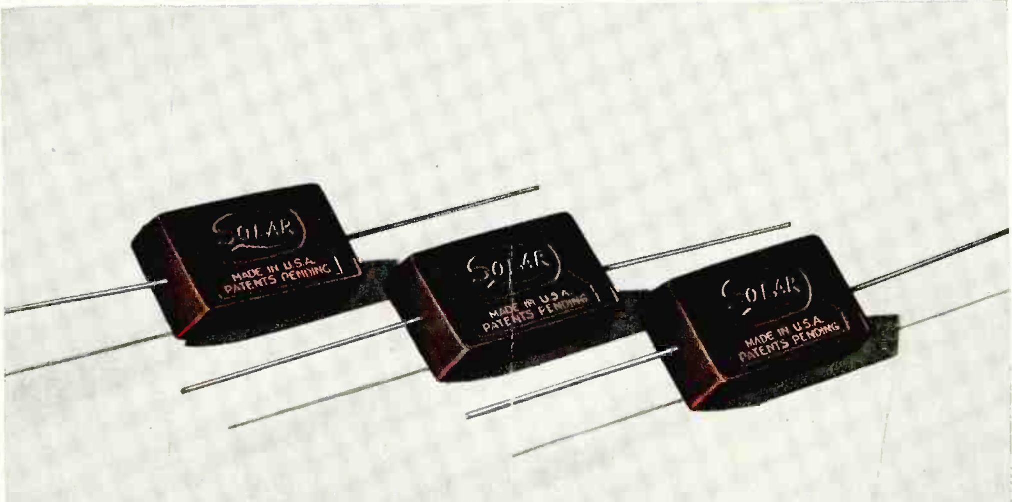
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PATENTS PENDING

A WIDE-RANGE OSCILLATOR FOR THE HIGHER FREQUENCIES

by L. Armitage*

THE RECENT INCREASE in importance of impedance and transmission measurements at high frequencies has required the development of special measuring equipment. To provide a source of power at these frequencies, an oscillator has been developed which covers the frequency range from about 50 to 5000 kc.

A balanced push-pull circuit was chosen as is shown in simplified form in Fig. 1. Such a circuit has the advantage of lending itself to a symmetry in the arrangement of its physical elements that is nearly as great as that indicated in the schematic. The wire connections can be made very short, and because of the very complete balancing, parasitic oscillations are greatly reduced. The circuit consists of a push-pull oscillator loosely coupled through small-capacity condensers to a push-pull amplifier, which in turn feeds the output transformer through a potentiometer across the high impedance winding. Pentode tubes, with indirectly heated cathodes, are employed for both oscillator and amplifier.

Besides the electrical requirements of stability and precision of setting, simplicity in design and control was felt to be of considerable importance. The output frequency is set by two decade condenser units and a vernier air condenser, but one of six plug-in coils must be selected depending on the portion of the frequency range being used. These coils are inserted through a small door in the front of the oscillator. The complete oscillator is housed in a metal box which may be placed on a table or mounted on a relay rack. A small plate power supply unit has been provided in addition to make the oscillator completely a-c operated. This, together with a box for holding the spare plug-in coils, is mounted directly above the oscillator.

Between the oscillator and amplifier tubes on Fig. 1 are shown the plug-in coil and the tuning condenser.

*Bell Telephone Laboratories, Inc.

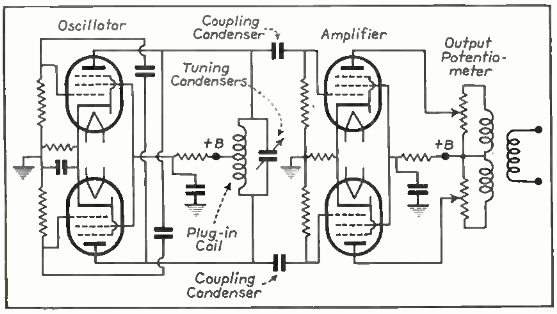


Fig. 1. Simplified schematic of the oscillator.

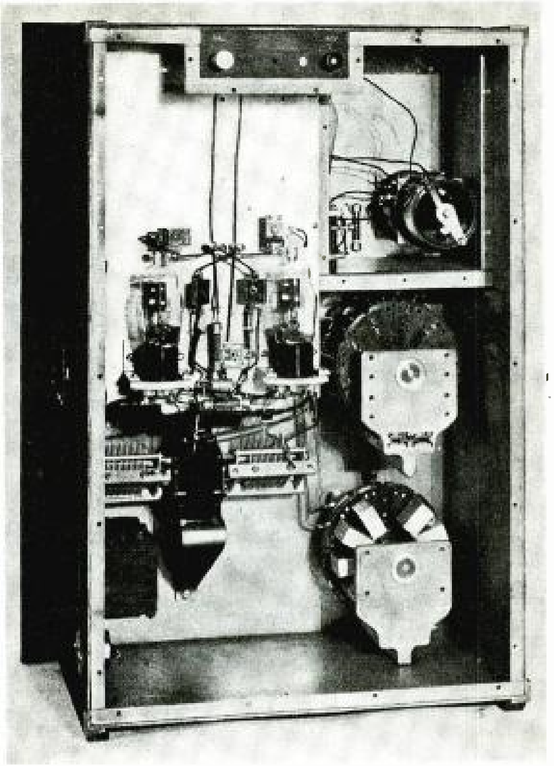


Fig. 2. Rear view of oscillator with cover removed, showing the compact arrangement of apparatus.

This latter really consists of three units: two decades of mica condensers, and an air condenser operated by a vernier dial. The decades are arranged so that there is only one condenser of each decade in the circuit at any one time. This construction, which has already been described[1] as applied to a resistance standard, has considerably less stray capacitance and inductance than the commutating type. The air condenser is turned by a commercial micrometer-type dial through a worm-gear drive. The dial is marked with fifty divisions, and makes ten turns for one rotation of the condenser, so that 500 divisions are passed over for one revolution of the condenser. Since the dial may be readily set to 1/5 of a division, extreme precision in the setting may be obtained.

The plug-in coils are wound on Isolantite forms two inches in diameter and four inches long. Four of them have single layer windings of bare tinned-copper wire, while the other two—used for the lower frequencies—have layered windings of insulated wire. The windings are put on under tension so that as the temperature rises there will be a reduction in the tension in the wire rather than a change in its length or position on the form. This reduces the effects of changes in temperature on the constants of the coil, which might otherwise be objectionable. Since the coils are of the solenoid type, their inductance will be affected by the configuration of nearby metal parts. Special precautions were taken therefore in designing the door on the front of the oscillator cabinet, through which the plug-in coils are changed, so that the inductance of the coils would not be changed

(*Continued on page* 24)

[1]Bell Laboratories Record, January, 1935, p. 136.

MOLYBDENUM—A METAL FOR

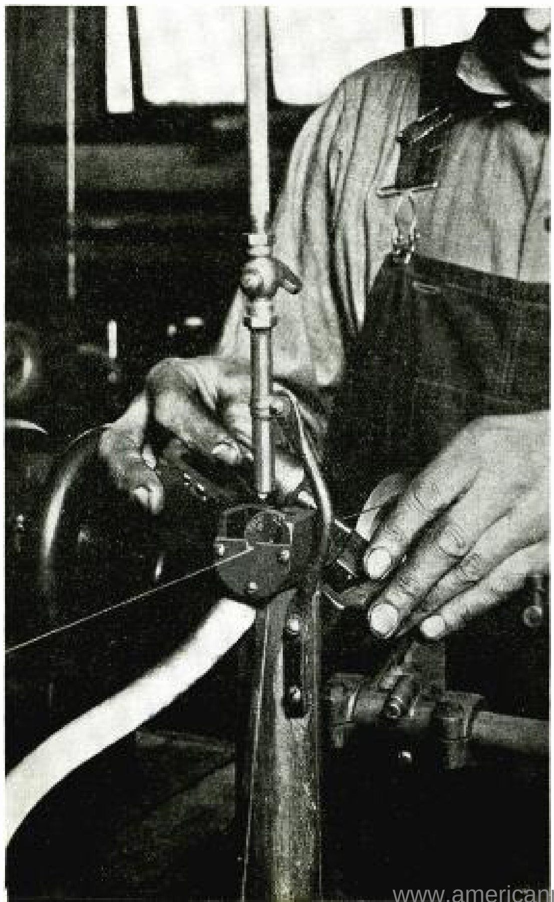
by T. G. Troxel*

PRACTICALLY EVERY RECEIVING tube contains molybdenum. True, not as much of the metal per tube is used as in earlier tubes. Base metals and alloys have been substituted, not because of better performance, but for economy. In spite of this, the annual consumption of molybdenum wire in electronic tubes may be measured in thousands of miles.

Important as it is, little has been written about this metal. Perhaps this is because only a few American suppliers of molybdenum manufacture their own metal. The remainder import molybdenum rod from Europe, drawing it down to diameters desired by tube makers.

Molybdenum is not a new material. The Greeks "had a word for it"—molybdenum. They used the same word for graphite and lead. The metal was definitely identified as an element by Hjelm in 1790, but was not produced on a commercial scale before 1909.

Fine diameter molybdenum wire is drawn through a succession of precision dies, the final diameter usually through drilled diamonds.



The ore, moybdenite (molybdenum sulphide) occurs in the oldest plutonic rocks, and is fairly well scattered over the world. The chief commercial sources are Australia, Norway, Canada, Japan and the United States.

Because of its extremely high melting point (2620°C) and its affinity for oxygen at high temperatures, molybdenum cannot be refined by ordinary smelting processes. Instead, the ore is treated chemically until a chemically pure molybdic acid is produced. This is ignited to form an oxide, which is reduced to powdered metallic moylbdenum by means of hydrogen.

By means of hydraulic presses, the powdered metal is pressed into bars, then sintered. Sintering consists of heating a bar to a temperature nearing the melting point in an atmosphere of hydrogen, which starts a metallic crystal growth. The crystal structure of the sintered ingot is in the form of polygonal blocks, and in this state the metal is, of course, not ductile.

Careful control of crystal structure is essential to produce the flexible wire and ductile sheet needed in tubes. This is accomplished not only in the working of the metal, but in the chemical purity of the metal itself. For example, as little as .02 of one percent of calcium oxide will render molybdenum so hard and brittle as to be unworkable, while the addition of as much as 30 percent of pure tungsten to molybdenum increases its strength without loss of ductility.

In molybdenum wire, the crystals should be in the form of long parallel threads, closely interlocked. In sheet, the crystals should be like tiny plates matted together with all their flat surfaces parallel to the faces of the sheet. In either wire or sheet, the crystals should be capable of bending or stretching without separating from their neighbors.

Many of the factors in the production of commercial 99.95 percent pure molybdenum go back beyond the physical working of the ingot into the chemical processes prior to the production of the powdered metal. These have a definite influence on the ductility and workability of the metal.

For example, molybdenum sheet is peculiarly susceptible to "diagonal brittleness," or cracking at an angle of 45 degrees to the direction of rolling. By careful chemical control in the refining of the metal, this is overcome

*Fansteel Metallurgical Corporation, North Chicago, Ill.