FEBRUARY, 1935

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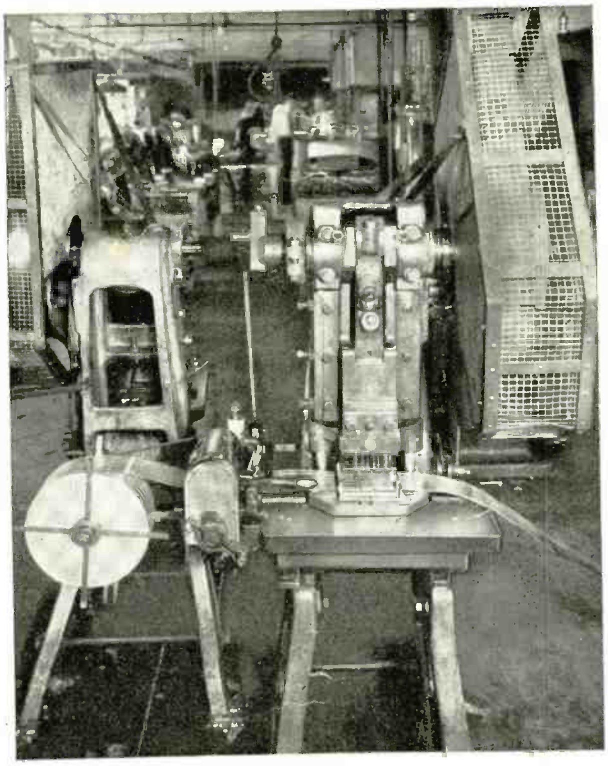

VOL. XV NO. 2

The Journal of the Radio and Allied Industries

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EDITORIAL

TELEVISION

SIMULTANEOUS ANNOUNCEMENTS to the effect that England and Germany are to institute national television services have created widespread interest in this country. The leading question is whether or not we will follow suit.

The English television system is to be set up by the British Broadcasting Corporation, an institution under the jurisdiction of the British Government. The financial outlay necessary for the establishment of a practical television network will be underwritten by the Government and maintenance costs more than likely will be derived from the radio tax.

The German television system may also be classed as a Government subsidy. The project may be paid for by taxation or through some form of special government appropriation. In any event, the system is presumably not to be supported by private enterprises.

The decisions of the English and German Governments to inaugurate television networks are most certainly not the reflections of radical developments in television design. English and German systems are moderately good but, on the whole, no better than American systems. The reasons, we take it, are much deeper and, surely with regard to Germany, the motive force is more political than social.

There has been offered the suggestion that Federal monies be appropriated for the setting up of a television system of sufficient magnitude to effectively serve the United States. In view of our Government's policies with regard to socialized projects of huge proportions, it would appear that such a proposal might be met with favor in Washington. There is no doubt that such a project would not only provide work for a great number of people, but serve as well to develop an industry—part radio, part motion picture, part theatrical and part advertising—that would assist immeasurably in healing our financial wounds.

The hitch in such a plan is that, so far at least, our Government is not quite so nationalistic in tendencies as some foreign Governments and has not reached that point of sensitiveness where it would feel impelled to compete with other Governments in the wholesale dispensation of personal propaganda. Moreover, our Government is more inclined to provide financial support to projects that either have more social significance or can in time repay the loans. Television does not seem to be in this class—at least, not so long as it remains the dream of private enterprise.

An English or a German television network would not serve the United States. It might possibly serve one State in the Union, no more. A nationwide television network would cost at least forty-eight times as much as an English or German chain, and probably more. Our centers of population are widely separated, we have huge areas that, though sparsely populated, must also be served. It has taken us years to build up a national broadcasting network capable of blanketing the country. These stations cannot be used for television broadcasts as they are. The cost of redesigning them would equal, if not exceed, the cost of a new, supplemental chain of television stations.

We may assume that were a complete chain of practical television stations made available, the system could support itse very nicely in exactly the same manner as broadcast chains obtain support. We may go even further in this assumption and say that practical television services would overshadow all other mediums of entertainment and advertising. It is a pretty picture and not one which private enterprise wishes to have lost to it. But, television design has not reached that stage where it could compete with the motion picture, the theatre, pictorial advertising in printed form and the newspaper. It is a pretty picture, to be sure, but one that is not as yet complete.

We continue to make advances in television—the special transmission line recently developed by A. T. & T. is a good example. In time we will have developed a system satisfactory for *entertainment purposes*. It will be good from the very beginning.

We have everything to gain and nothing to lose by waiting. We can well afford to do that.

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RADIO ENGINEERING

FOR FEBRUARY, 1935

Receiver Design Trends

KING SOLOMON might have been discussing radio developments during 1934 when he uttered his famous quotation, *"The thing that hath been, it is that which shall be; and that which is done is that which shall be done; and that there is no new thing under the sun."* In spite of the fact that most of the advances in the radio art during the past year have been in the nature of refinements of old circuits and old methods, there is no reason to believe that the art has not made as great strides as in any recent year. It has ever been thus in the radio art. First, a new tube is developed and followed by a rapid development of circuits. Then comes a period of adjustment, refinement, and revamping; and finally another new tube or new circuit, which starts the procession all over again.

ALL-WAVE RECEIVERS

Unquestionably this has been the year in which all-wave receivers have come into their own, and it seems very probable that their popularity will not wane during the coming year. Much has been done to simplify the tuning and control, both in the broadcast band and in the short-wave spectrum. Some manufacturers have even added a long-wave band above the broadcast spectrum, in which are located aircraft and marine beacon stations. Of course, there is little interest for the average listener in the normal beacon signals. However, the weather reports from the Department of Commerce beacon stations are the best that are available today. This information has proven such a boon to radio listeners that efforts are now being made to make these weather reports available for motorists along the leading highways of the nation. There is some evidence to indicate that two-band auto-radio receivers are in the offing. The bands would consist, of course, of the broadcast and long-wave beacon bands. This would permit the motorist to obtain his weather reports as he cruised about the country-side. There can be no doubt that information of this sort is of considerable value, and is destined to be more widely used both in home receivers and in receivers for automobiles and other mobile equipment.

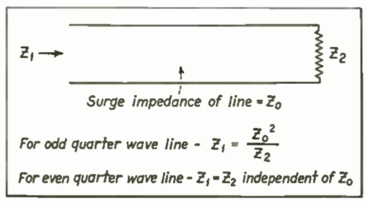


Fig. 1. Functional diagram of quarter-wave line.

ANTENNA SYSTEMS

Among the past year's developments, one of the most significant lies in the advances made in antenna systems both for the mitigation of interference and for improved results at the shorter wavelengths. It has been recognized for several years that man-made interference, whether set up by household appliances or by the ignition systems of automobiles, is largely vertically polarized. Because of this fact, horizontal doublets have come into considerable prominence for short-wave and broadcast reception. The horizontal doublets, naturally, not being responsive to vertically-polarized interference and having directional properties which may on occasion be utilized to advantage, have resulted in a far better signal-to-noise ratio than has previously been obtained. Of course, a doublet of given dimensions is highly efficient only as the wavelengths to which it is naturally resonant. As a result, good reception over a wide band of frequencies with a doublet have presented something of a problem. This problem has been attacked in two ways. One method has been to feed the radio receiver from the doublet (in some cases two doublets in parallel) through a transmission line of fixed length, but which is an odd quarter-wave length long at or about the center of each of the short-wave relay-broadcast bands. Since the odd quarter-wave line acts as a step-up transformer (see Fig. 1), it follows that at each of the odd quarter-wave points a high impedance will be presented to the antenna by the line if it is terminated at the receiver end in a low impedance. This system has resulted in a far better signal, together with a large reduction in noise, than has heretofore been possible.

The other method of attack has been

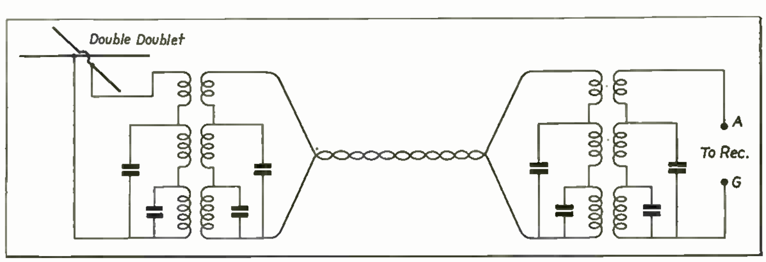


Fig. 2. Circuit of high-efficiency all-wave antenna system.

through the use of coupling transformers at each end of the transmission line. One transformer is employed for each band to be covered. The primaries and secondaries of the transformers at each end of the line are connected in series and the windings of the lower frequency transformers are shunted by condensers of appropriate size. This is illustrated diagrammatically in Fig. 2. In general the frequency bands of the transformers are designed to have a certain amount of overlap so that a nearly uniform efficiency results over a very wide range. Such systems have been proposed many times, but they have been reduced to practice only recently.

Fig. 3 illustrates an antenna coupling arrangement which is coming into increased use, especially in the broadcast band. This arrangement consists essentially of a high-inductance primary for coupling into the antenna circuit which resonates at a wavelength somewhat longer than the longest wavelength in the band. It is weakly coupled to the tuned secondary coil. Condenser C furnishes capacity coupling between the antenna circuit and the tuned secondary circuit. This tends to equalize the step-up from the antenna into the first tuned circuit over the band. Inductive coupling is most effective at the longer wavelengths, whereas capacity coupling through condenser C is most effective at the shorter wavelength end of the band. This condenser is adjusted once for any given antenna and thereafter is left unchanged.

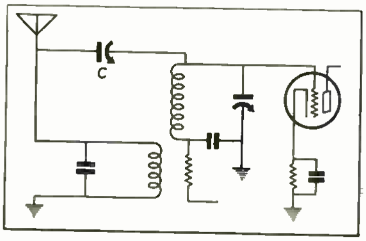


Fig. 3. Circuit of antenna coupling system.

COIL DESIGNS

During the past year there has been a noticeable tendency among manufacturers to swing from the tapped tuning coils in all-wave receivers to separately-wound and separately-shielded coils for each band. This has been an evolutionary process in that initially tapped coils were used almost universally. The next step was, logically enough, the use of a number of separate coils wound on the same form and (unfortunately) weakly coupled to each other. It became customary to short circuit the coils of adjacent bands in such systems to prevent reaction and dead spots. A still further step was taken when the longest wave coils were placed on the form near the shortest wave coils and arrangements made to short-circuit all coils not in use. Some slight improvement was had by using short-circuited rings or turns between coils wound on the same form as a decoupling unit. None of these systems, however, have proven entirely satisfactory, due to parasitic couplings which are unavoidable with such arrangements. The present tendency to use separate coils, separately shielded (even though the shielding may be far from perfect) is very gratifying to behold and promises much improvement in performance.

CONVERTER TUBES

It has been more or less usual to employ converter tubes to perform both the function of oscillator and modulator. This has proven quite satisfactory in the broadcast band. In short-wave bands, on the other hand, a certain amount of difficulty is encountered due to coupling between the oscillator and radio-frequency circuits through the converter tube, and to low transconductance, etc. To avoid these difficulties there has been a tendency in all-wave receiver design towards the use of a separate oscillator tube. This results not only in less coupling and consequently greater stability of the oscillator, but also in higher transconductance for the oscillator-modulator stage. It has even been suggested that push-pull modulator circuits be employed to further improve conditions and it is not too much to expect that something of this sort may appear. A decided improvement in cross-modulation can be effected through the use of linear modulators supplied with extremely high oscillator voltages. In some of the new tubes, such as the double-diode-triode tubes, balanced linear modulators, which can be supplied with extremely high oscillator voltages, together with one stage of amplification, might even come into use. At any rate, it is safe to predict that the modulators of future all-wave receivers are likely to be different.

TUNING ARRANGEMENTS

The circuit of Fig. 4 shows a typical example of one of the ingenious arrangements actually incorporated in receivers within the last twelve months to insure correct tuning. The circuit of Fig. 4 is both a tuning indicator and a squelch circuit. It can be seen that the intermediate-frequency transformer feeds the diode portion of the 6B7 which functions both as a secondary detector and for avc. The pentode portion of the 6B7 is fed from the diode load circuit in the usual manner. A neon tube in the plate circuit of the 6B7 is used as a tuning indicator. Under conditions of no signal the bias on the pentode portion of the 6B7 will be very low so that the neon tube will be ignited. Under these conditions the light column illuminates a small sign "detuned" in a small window on the receiver panel. When the station is tuned in and the grid of the pentode part of the 6B7 becomes more negative, the neon-tube light column will be diminished, and for strong signals may be extinguished entirely. Under these conditions only the word "tuned" will be illuminated in the small window.

This circuit is indicative of the efforts being made by design engineers and manufacturers to reduce the effort required in adjusting the tuning control of modern receivers. Of course, the use of neon tubes of the column type, and meters for indicating when the receiver is correctly tuned, have been in use for a number of years. It is evident, nevertheless, from the circuit just described that some effort is being made to give the operator a more positive indication than has heretofore been thought necessary.

Another circuit which has been proposed but, as far as the writer is aware, has not been used in any commercial receiver, is shown in Fig. 5. The operation of this circuit will be more or less obvious from the figure. It is of the hunting type and is intended to finish correctly a bad job of tuning. That is, if the operator tunes his receiver within plus or minus 5 kc of the desired station, the circuit of Fig. 5 is intended to adjust the oscillator circuit so that the intermediate-frequency signal falls in the center of the intermediate-frequency

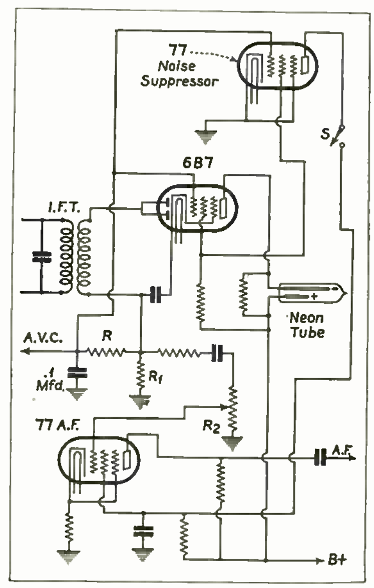


Fig. 4. Circuit of combination tuning indicator and squelch system.

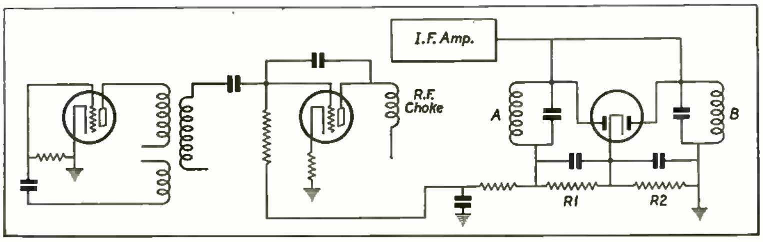


Fig. 5. A unique circuit of the self-seeking type that provides automatic tuning correction.

band. The operation of this circuit follows:

Tuned circuit A is adjusted 5 kc below resonance, while tuned circuit B is adjusted 5 kc above resonance. Both these tuned circuits are fed from the output of the intermediate-frequency amplifier. Each of these tuned circuits feeds separate diode rectifiers which in turn supply load circuits R1, R2. One end of the load circuit is connected to a tube so arranged that its input capacity is a function of grid bias. The input capacity of this loading tube is then coupled into the oscillator circuit. Obviously one rectifier will increase the bias on this tube, while the other will decrease it. This provides the necessary differential action for proper oscillator adjustment.

While the circuit shown is purposely simplified and given only as a matter of illustration, it is typical of the trend that is under way toward simplification of receiver adjustment. It is entirely possible that something of this sort may be incorporated in commercial receivers.

VARIABLE BAND-WIDTH I-F

Fig. 6 shows the arrangement used by one manufacturer to obtain a variable band-width intermediate frequency. Each intermediate-frequency transformer has three windings. The first and second winding in each case are the primary and secondary, respectively. The third winding is a trap circuit tuned to the exact center of the intermediate-frequency band. Since the trap is tuned to the same frequency as the primary and secondary and coupled to them, it will absorb energy from these circuits. Hence, when the potentiometer of the trap is out of circuit the band width of the intermediate-frequency transformer will be increased. As the potentiometer is cut into the circuit and the resistance increased the band width will be decreased correspondingly.

Another method which has met with some measure of success in accomplishing this result is the use of adjustable spacing between the primary and secondary windings of the intermediate-frequency transformer. This consists in moving either the primaries or the secondaries by means of a set of cams arranged on a rotary shaft.

HIGH I-F'S

It is desirable in fact (almost necessary) in all-wave receivers to employ a high intermediate frequency. Although a majority of receivers now in use, employ an intermediate frequency of 175 kc, there has been a noteworthy tendency toward the use of 460 kc. The higher intermediate frequency permits relatively good image-frequency selectivity even at the shorter wavelengths. This is a matter of considerable importance, since short-wave signals fade

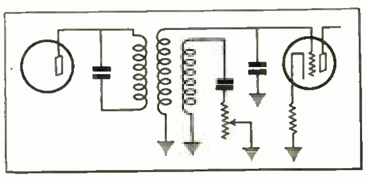


Fig. 6. Circuit of i-f amplifier having variable bandwidth.

badly and image-frequency interference may become very troublesome indeed.

There has also been discussion relative to the possibility of using two separate intermediate frequencies and switching the tubes of the intermediate-frequency amplifier between separate and distinct intermediate-frequency transformers. The well-known advantages of 175 kc for broadcast and longer wave reception indicates that double intermediate frequencies are a distinct possibility in the near future.

R-F AMPLIFICATION

In order to obtain better signal-to-noise ratios as well as to permit the use of several tuned circuits between the antenna and the modulator tube even small receivers use at least one stage of radio-frequency amplification. Since a relatively high gain may be had in this stage and since the use of relatively high-gain audio amplifiers is common, together with a diode detector, designers are leaning toward the use of one, high-gain stage of intermediate amplification. Of course, in the larger receivers in which economy of tubes and circuits is a matter of less importance, two i-f stages are usually used. It happens that one stage of i-f is hardly enough, whereas, two stages may be made to produce more gain than is usually required. The trend toward the use of higher i-f for all-wave receivers has tended to reduce the amplification per stage for a given coil dimension. In order to obtain the same sensitivity and selectivity at, say, 460 kc as at 175 kc, the Q of the coil must be increased almost three times. This necessitates a careful study of the form factors of i-f transformers. The usual thing has been to use solid-wire, basket-weave coils at 175 kc, at which point it is not particularly difficult to obtain adequate gain and selectivity. However, Litz wire is coming more into use for the higher i-f. In general i-f coils have a better Q if they are wound as narrow as possible and on a large diameter form. Moreover, increasing the number of cross-overs per revolution also increases the Q of the coil. On the other hand, the dimensions of the intermediate-frequency coil shield have if anything been reduced over those of previous years, and, of course, the closer the shield to the coil the lower the Q. In order to have the desirable effects of both, design engineers have started to use (rather widely) coils which are broken up into a number of sections. For a given diameter of core it follows that a higher Q can be obtained with a two- or three-section coil than one wound in a single section . . . this is especially true at a high i-f. As a matter of fact, the Q of a coil can be nearly doubled by winding a coil into three narrow sections rather than one section assuming the same coil and shield dimensions. In high-fidelity receivers in which gain and selectivity are largely off-set by the use of more tuned circuits, these matters are of less consideration.

IRON-CORE COILS

While the use of iron-core coils in so-called permeability, tuning systems has been a subject of discussion for several years, it seems no nearer being accomplished this year than last. There has been, however, a tendency toward the use of iron cores for intermediate-frequency coils, a material improvement

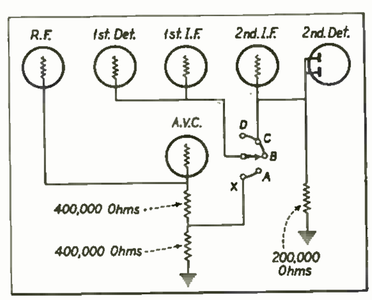


Fig. 7. The avc system in an all-wave receiver, with provisions for controlling the avc functions.

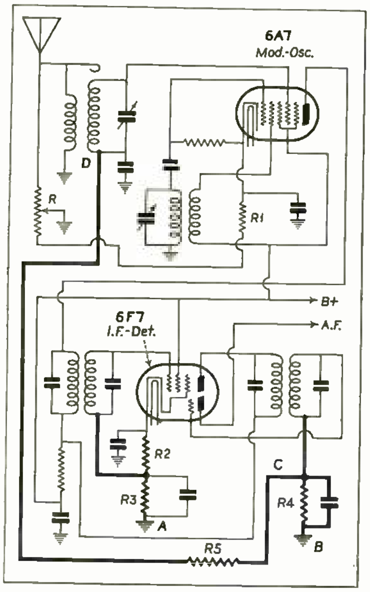


Fig. 8. Circuit, for small receivers, for the purpose of preventing overload.

being attained in selectivity and sensitivity by their use. Consequently, in small receivers of the ac-dc type in particular, iron-core intermediate coils have been used with success. In the higher priced receivers, however, the trend has been toward lower Q intermediate-frequency coils and close coupling to obtain a broad band.

AVC SYSTEMS

Fig. 7 shows an all-wave circuit in which two avc systems are employed. This is something of an innovation in receiver design and promises to become popular in the better class receivers. Two avc systems are employed because of the different receiving conditions existing in the different bands of an all-wave receiver. For example, in the broadcast and long-wave bands, signal levels are very high and a constant input to the secondary detector is very desirable. On these bands it is not essential that the avc function on an extremely weak signal. However, on the short-wave bands, signal strengths are usually very low and fluctuate widely. Consequently, it is desirable to have some avc action below the level at which the usual avc system operates. This is provided in the circuit of Fig. 7, by the diode avc of the second detector, which operates on the first detector and on the two intermediate-frequency stages when the receiver is switched to the short-wave bands. This system operates on the second i-f stage on all bands. The separate rectifier tube marked AVC in the figure, functions only on the broadcast and long-wave bands and operate on the r-f stage alone.

Small receivers containing only a few tubes ordinarily have not used avc because of the few tubes which are available for control. As a result some of the advantages of even a poor avc system have not been enjoyed with the "Universal" and other small receivers. At least one manufacturer, however, uses an overload prevention device which to a great extent overcomes the objection of lack of avc. A simplified circuit of this arrangement is shown in Fig. 8. It will be noticed that a 6A7 tube is used as an oscillator-modulator. The output of the modulator is fed to the pentode section of a 6F7 through a suitable i-f transformer, and the output of the i-f pentode is coupled back to the triode section of the same tube. The triode of the 6F7 functions as the second detector. The overload system components are the resistor R4 and its by-pass condenser in the grid return circuit of the triode detector and the filter resistor R5 which is connected to the low-voltage end of the modulator tube grid circuit. If an excessively strong signal, sufficient to overload the receiver, is applied, it will also be sufficient to overcome the grid bias on the detector tube which is supplied by the voltage drop in resistors R2 and R3 in the cathode circuit. This grid current will flow from cathode to ground at point A and thence from point B through resistor R4 and the secondary of the second i-f transformer back to the grid. This results in a voltage drop in resistor R4, which tends to bias the detector grid and also the grid of the modulator tube. Since the voltage is impressed on the modulator tube through resistor R15 from point C to point D, this increase in negative voltage on the detector and modulator grids decreases the gain in the modulator stage, and at the same time increases the bias on the detector to a point where grid current no longer flows. While this arrangement is similar in certain respects to an avc system, it is obvious that it is effective only for reducing instantaneous overloads which might cause distortion.

BEAT-OSCILLATOR CIRCUITS

Probably one of the reasons for the slow growth of all-wave receivers has been the critical adjustment always necessary for the short-wave bands. This has been especially difficult due to the fluctuation in intensity of most short-wave signals. To overcome this difficulty, beat oscillators have been rather extensively employed in some of the better grade all-wave receivers of modern design. In general, this consists of an oscillator tuned to the center of the i-f band and coupled into the second-detector circuit. When a station is tuned in, a beat note is heard between the signal and the beat oscillator. The latter being set to give a normal beat note of any desired frequency from zero beat to, say, 2,000 cycles. It is customary to provide a tuning adjustment for this oscillator so that it can be set for the desired beat note. When the station is tuned in properly the beat oscillator is switched off and reception goes on normally. This is a simple and straightforward improvement and it has done much to popularize short-wave reception and all-wave receivers.

DUAL A-F AMPLIFIERS

The proposal to use two separate audio amplifiers in high-fidelity receivers has received a certain amount of attention during the past year. So far it has not been used in radio receivers, although it is not too much to expect that such a system may make its appearance.

The thought back of the use of two separate audio amplifiers is that high-level signals occur only in the low-frequency range, say, below 800 or 1,000 cycles. It is a relatively simple matter to construct a good low-frequency audio amplifier capable of handling large outputs with low harmonic distortion and good efficiency when the band is restricted to, say, 50 to 1,000 cycles. The remainder of the range can then be handled by an amplifier of considerably less power capability. Each amplifier would, of course, feed a separate loudspeaker designed to cover the range of the amplifier only. It seems safe to predict that the use of two loudspeakers to cover the audible spectrum of 50 to perhaps 8,000 cycles, is likely to become more general in the future.

ACOUSTIC LABYRINTHS

One of the bugbears to high fidelity has been the practical impossibility of incorporating sufficient baffle area in the loudspeaker cabinet to permit adequate low-frequency reproduction. Actually, a baffle some 8 feet square is required for suitable low-frequency response. To compensate for this situation a de-

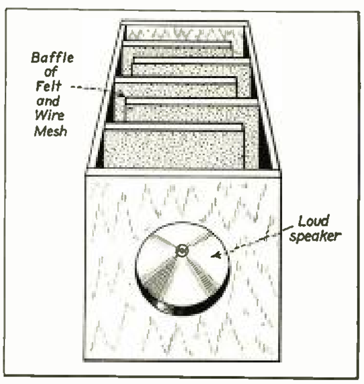


Fig. 9. Speaker with acoustic labyrinth composed of felt pads.

vice called the acoustic labyrinth is being used. A similar device is shown in the sketch of Fig. 9. Its purpose is to increase as much as practicable the distance through which a wave must travel from the front of a loudspeaker diaphragm before reaching the rear of the diaphragm. The baffles are constructed of hair felt, supported by wire mesh. In general an opening of about 1 inch is left between the free end of the baffle and the side of the cabinet. Likewise, the separation between the baffles is about 1 inch. Actually the sound wave from the rear of the speaker is largely absorbed before it reaches the rear of the cabinet, at which point an opening is inserted to relieve such pressure as remains at this point. At least one manufacturer has constructed a model employing an acoustic labyrinth and it seems probable that others will follow.

INCREASING LOW-FREQUENCY RESPONSE

Consideration of the action of the acoustic labyrinth suggests the possibility of various other means of increasing low-frequency response. Inasmuch as a loudspeaker diaphragm radiates approximately as much energy at the back as at the front it seems that if the loudspeaker were completely enclosed in a cabinet of suitable size, which was soundproofed to prevent radiation by the sides of the cabinet, that a material improvement in low-frequency response could be effected. By suitable introduction of the energy from the rear of the diaphragm to the front in such a way that it would be additive over a small low-frequency range should accomplish this result.

Similar methods of equalization have been employed in certain types of microphones to effect improvement in fidelity. While the principles involved are not entirely identical, there appears to be good reason why considerable improvement in loudspeaker response could be had in this way. Inasmuch as the energy radiated from the rear of the diaphragm is in phase opposition to that radiated from the front of the diaphragm, it is essential that either a reflected sound wave be mixed with the radiation from the front of the diaphragm or that a sufficiently long equalizing tube be employed to conduct the energy from the rear of the diaphragm to the front. Of course, if a reasonant cavity were employed, in all probability a very short tube could be used. It therefore seems reasonable to expect that something along this line may make its appearance. There appears to be no good reason why the sound energy could not be doubled in this way over a small frequency range, and there is some reason for believing that if a resonant chamber were used much better results could be obtained.

Since it is well known that most loudspeaker diaphragms are badly mismatched acoustically at low frequencies it appears that something might be done with an acoustic filter placed at the back of a loudspeaker diaphragm to properly match it at low frequencies. G. W. Stewart has shown in numerous publications that it is very practicable to build acoustic networks to fulfill almost any condition that may be met with in electrical circuits. Just how bad this mismatch is depends largely upon the design of the loudspeaker. However, it is not improbable that an impedance-matching circuit designed to be effective at low frequencies may come into use. At any rate, it is safe to say that considerable ingenuity is likely to be exercised by loudspeaker designers along this line at an early date.

LOUDSPEAKER DIRECTIVITY

Another important consideration which has only recently been given attention is the directivity of the loudspeaker. This is, of course, of little importance at low frequencies, but at high frequencies it may become very acute. Several manufacturers have inserted deflector plates in front of the speaker to obtain more uniform sound distribution. There is every reason to believe that if reasonable care is taken in the design and location of such plates that much improvement can be obtained. All too little attention has been paid in the past to this highly important detail. High fidelity is here to stay, and some of the results that have already been achieved are indeed worthy of note.

There is every reason to expect that next year's progress will lie largely in the line of improving the fidelity of reproduction.

BRITISH I. E. E. COMMITTEE ON RADIO INTERFERENCE

AN OFFICIAL STATEMENT on the work of the Institution of Electrical Engineers' Committee on Radio Interference in the United Kingdom suggests that it has been instrumental in fostering a desire to rectify this serious annoyance and bringing together in mutual effort those who are able to take action toward its elimination.

The committee finds that listeners and those who advise them have not yet done on their own receiving sets all that is possible to mitigate some of the effects of interference. A memorandum on features of design and installation that should receive attention has been prepared by the B. B. C. for the Committee, emphasizing the precautions which should be specially attended to by suppliers of radio sets and those who "service" them. This memorandum is to be published in the I. E. E. Journal.

To enable manufacturers to apprise interference and understand how to correct offending plant and apparatus by fitting choke coils and/or condensers, a specification, which should help to render new equipment interference-free, is to be issued early this year (1935) by the British Standards Institution as a British Standard Specification. (*The Electrical Review.*)

BRAZILIAN RADIO MARKET

IMPROVEMENT IN BUSINESS conditions in Brazil is being reflected in a keener interest and demand for radios. Sales have increased materially in 1934 and are expected to show wider improvement in 1935. Correspondingly, a number of new radio-broadcast stations have been inaugurated during recent periods, and it is indicated that many more will be established during 1935, as 82 applications to build radio-broadcast stations are now on hand in the Department of Posts and Telegraphs.

It is estimated by one trade source that importations of American radios into Brazil during 1934 numbered between 50,000 and 60,000 sets. The same source predicts that sales of American radios in 1935 will reach 80,000 sets, shared by more than 60 different American brands. Sales of radios of European make are estimated to reach less than 10 percent of this figure. Owing to the keener competition, it is felt that retail prices may decline, possibly as much as 20 percent. The lower customs duties, with the advent of the new tariff schedules, which levy duties on a weight basis instead of an ad valorem rate, also constitute a factor which has some influence on the price of radios. (A. A. Barrington, Assistant Trade Commissioner, Rio de Janeiro, in *Electrical Foreign Trade Notes,* No. 354, January 15, 1935.)

URUGUAY REDUCES DUTIES

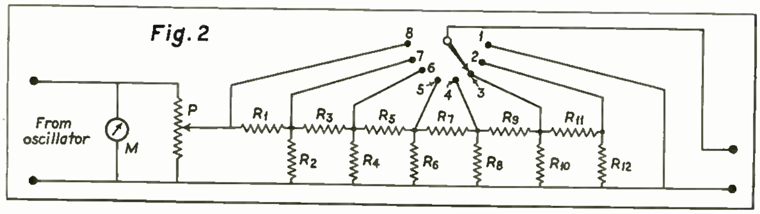
A REPORT FROM the Electrical Division, Bureau of Foreign and Domestic Commerce of the Department of Commerce, states that according to an official decree of November 3, 1934, customs duties on radio accessories have been reduced from 1.80 pesos per gross kilo to 80 centimos per gross kilo.

The decree was published in Diario Oficial of November 9, 1934, and covers "accessories and apparatus for radio." (Andrew W. Cruse, Chief, Electrical Division.)

SIGNAL GENERATOR

By RICHARD F. SHEA

WHILE CONSIDERABLE HAS been written upon the subject of signal-generator design, the matter of design of the attenuators employed in these generators seems to have been somewhat slighted. Apparently it has been assumed that the theory of attenuator design is too fundamental for elaboration, yet, when one realizes the importance of this part of the generator, and the multitude of variations it can assume, it at once becomes obvious that the subject can stand considerable emphasis. It is the writer's intention in this article to describe various types of attenuators commonly employed in signal generators, together with their various advantages and defects, and to give sufficient mathematical data from which satisfactory attenuators of the different types can readily be designed.



Attenuator with fixed input to the voltage-indicating device, M.

FIRST CLASS OF ATTENUATOR

Generally, attenuators fall into two classes. In the first we have the input to the indicating device variable, and the succeeding steps of the attenuator varying this input by constant ratios. This type of attenuator is illustrated in Fig. 1, where a signal from the oscillator (or amplifier, if a buffer is employed) is fed to the potentiometer P, and the desired portion of this voltage taken off P and applied to the input of the attenuator proper through the indicating device M. The attenuator following this indicating device has in this case eight steps, but, of course, there can be any desired number. The output is obtained by sliding a contact arm along contact points 1 to 8 and by varying the slider on P.

In Fig. 1, M1 is a current-measuring device, usually a thermo-milliammeter. If desired, however, a voltage-measuring device may be applied across the input to the attenuator, as indicated by M2 connected in by dotted lines. This may be a thermo-voltmeter, tube voltmeter, diode voltmeter, or any other device satisfactory for the frequencies at which the device is to be used.

In this type of attenuator the input potentiometer, P, is quite important. This potentiometer must be so designed that its input impedance is appreciably constant at all settings and at all frequencies at which it is to be used; otherwise it will affect the frequency of the associated oscillator . . . unless a buffer stage is used. To secure such design the resistance must be compensated, or so arranged that one part of the control adds resistance to compensate for the loss due to shunting the input of the attenuator across the whole potentiometer on the full output position. Obviously, this equalization depends upon the value of the input resistance of the attenuator, and no one potentiometer will serve in all cases that may be desired. Also, if this type of attenuator is to be used at very high frequencies the capacity of the arm to ground must be balanced, so that the effective input capacity to the potentiometer will not vary with its setting.

A serious limitation of this type of unit is the meter to be used for indicating the input to the attenuator proper. Usually a thermo-milliammeter or tube voltmeter with the characteristic square-law calibration is used. This limits the range on any one tap to 5 to 1, with satisfactory readability. In this type of attenuator the meter is customarily calibrated directly in microvolts, and the switch marked with multiplying ratios.

SECOND CLASS OF ATTENUATOR

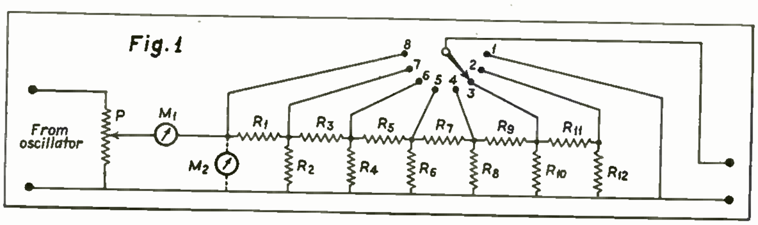
The second general classification of attenuator is that in which the input to the attenuator is fixed and the output is controlled by a combination of fixed and variable elements in the attenuator proper. Figs. 2, 3 and 4 illustrate three such attenuators. In Fig. 2 the fixed voltage is indicated by M, fed into the potentiometer P, and the variable output from P attenuated in finite steps by the rest of the step attenuator. In Fig. 3 the potentiometer P is in the output leg, and is connected into progressive sections of the ladder network by the switch. A fixed input is fed into the attenuator here, also. In Fig. 4 the potentiometer is again the last leg of the unit, and the fixed input to the attenuator, as indicated by M, is switched along the ladder network.

POTENTIOMETER CALIBRATION

One feature is common to all three of these systems. The potentiometer P must be accurately calibrated, must be non-inductive, must be compensated (preferably for the usual load with which it is to be used if it is in the output circuit), must have sufficiently low capacity to be satisfactory for high-frequency work and must be properly shielded. From the above it can be seen that the potentiometer is the very heart of these systems. In the system of Fig. 2 the potentiometer can have reasonably high resistance, whereas in the other two circuits it should be only a few ohms, as it will be used directly in the antenna circuits of the receiver under test.

ADVANTAGES

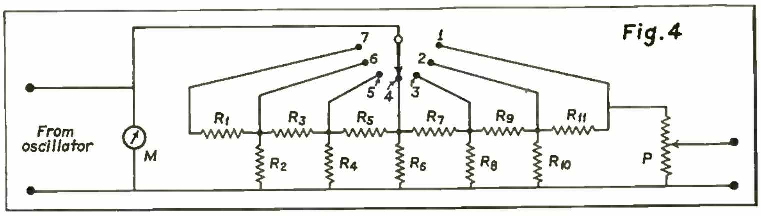
A distinct advantage of these latter systems is evidenced by the fact that



Circuit of attenuator having variable input to the indicating device. A current-measuring device, M1, may be used, or a voltage-measuring device, M2.

ATTENUATOR DESIGN

they do not require an accurately calibrated measuring device, for only the one voltage need be known. Thus this measuring instrument may be a thermo-meter, tube voltmeter or diode, with the only requirement being that of accuracy up to the highest frequency to be used. Another advantage is that the potentiometer can be very easily calibrated with good readability over a range of at least ten to one. The result is that less steps of the attenuator are required to obtain the same range of voltages than in the system of Fig. 1.



Similar to the circuit of Fig. 3 with the exception that the measuring device, M, is switched along the ladder network.

SELECTION OF PROPER RESISTANCE VALUES

Many factors enter into the decision of the proper values to use for the various resistances in these attenuators. Some of these factors are:

(1) Impedance of the circuits with which the generator is to be associated. If single-stage gain-measurements from grid-to-grid are to be made the attenuator may have an output resistance of several thousand ohms. However, if the generator is to be inserted in a tuned circuit this resistance cannot exceed a few tenths of an ohm. Usual practice is to have an output resistance of about ten ohms on the most used steps. Also, it is permissible to go considerably higher on the higher output positions which are usually used for preliminary alignment work.

(2) The frequencies to be used. If the attenuator is to be used at 20 megacycles or higher the design of the resistances becomes more complicated, particularly if they are either very high or very low, as in one case capacity enters the picture and inductance in the other.

(3) The available measuring instrument.

(4) The available voltage and power from the oscillator or amplifier.

(5) The range of output voltages required. This factor also determines the complications involved in the design of the rest of the signal generator. It is much more difficult to design and build a signal generator to give an accurate output of one microvolt at 20 mc than to build one for 1000 microvolts at 1000 kc, and the precautions necessary in the design of shields, disposition of grounds, etc., are determined largely by this factor.

CIRCUITS

In Figs. 5 and 6 are shown detailed circuits of two typical attenuators of the two types described above. These units are designed to provide (roughly) the same range of voltages. Fig. 5 shows a six-step attenuator, with the input to the meter varied by P. The attenuator is split up into two sections, in a shield with a partition to separate the high- and low-current sections and minimize capacity coupling to the output terminals. The potentiometer P and meter M are external to the attenuator, preferably in another shield, and connected into the attenuator through a shielded cable. The inside wire of this cable goes to R1, and the shield supplies the ground connection to point b. There is no connection between either a or b and the metal case. R5 is connected to R7 through another shielded cable, the sheath of which also serves to connect point b to point e. Point e, further, connects to the outgoing shield at f and at this point the outgoing shielded cable is securely grounded to the case. The switching system is so arranged that the high voltage does not enter section 2 except on the highest output positions.

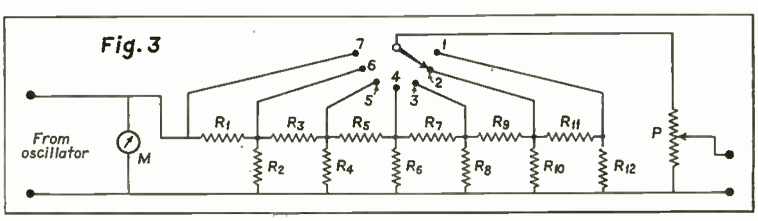
In the system illustrated in Fig. 6 the input to the attenuator is fixed and indicated by meter M. Potentiometer P varies the voltage to the rest of the system, and the output is switched along the various steps of the ladder. A similar segregation of high- and low-current sections is also employed here, and the grounding system is similar to that employed in Fig. 5.

In both of the above systems the resistances in the two sections return to point grounds, b and e respectively, and the can connects only to the outgoing shield at f and the sheath of the wire connecting the two switch sections, at g. All other sheaths passing through the can are insulated from it.

Now, referring to Fig. 5 again, let us compute the values of the various resistances, R1 to R12. Since we are usually limited in range by our measuring device we will take 5/1 as our greatest possible ratio between successive steps. Let us also decide that our lowest possible reading will be 1 microvolt. Then our respective outputs on the various taps will be:

Tap 7—1 to 5 microvolts
Tap 6—5 to 25 microvolts
Tap 5—20 to 100 microvolts
Tap 4—100 to 500 microvolts
Tap 3—500 to 2500 microvolts
Tap 2—2,000 to 10,000 microvolts.

Note that on taps 2 and 5 we have started slightly lower than the highest reading on the previous tap, i.e., on tap 6 we get 25 microvolts maximum, but on tap 5 instead of starting on a minimum output of 25 microvolts we start with 20. The reason for doing this is that thus we can use a meter calibrated in 0 to 5 microvolts, and our



Circuit of attenuator with the potentiometer in the output leg.

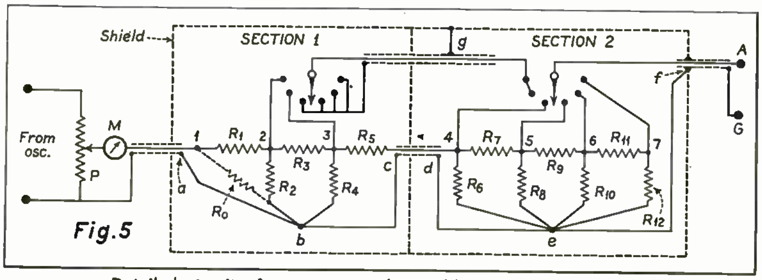


Fig.5

Detailed circuit of attenuator with variable input to the meter.

multiplying ratios will be 1, 5, 20, 100, 500 and 2000, respectively. In this manner we can easily read the actual output by simply reading the meter directly or dividing or multiplying by 2, thus avoiding the mental arithmetic necessary with other ratios.

Our total range in output, therefore, with this attenuator, is 1 to 10,000 microvolts. If greater range is desired more steps must be used.

CALCULATION OF RESISTANCE VALUES

Now, to obtain the values of the resistances we start at the output terminals and work back toward the meter. We must first decide on our desired output resistance on low-output taps. In the majority of cases it is not necessary to have any pre-determined value for this resistance, the only requirement being that it be less than such an amount as will affect set performance. Let us therefore arbitrarily set R12 to be 10 ohms. This means that our output resistance will be about 8 ohms. If the exact value of this output resistance is desired it can readily be calculated after the other resistance values are found. Now, we decided that the ratio between taps 6 and 7 was to be 5. Therefore, if R12 is 10 ohms, R11 and R12 must total 5 times this, or 50 ohms, so that R11 will be 40 ohms. Having decided that our output resistance should be under 10 ohms, let us further stipulate that it shall remain constant for the four lowest output taps. This means that looking into that part of the attenuator to the right of taps 4, 5, 6 and 7 the effective resistance shall be 10 ohms. Now, if we look to the right of tap 6 we see R11 and R12 in series, totaling 50 ohms, shunted by R10. If this, effectively, is also to be 10 ohms we can compute R10, knowing that

$$\text{Reff.} = 10 = \frac{R10(R11 + R12)}{R10 + R11 + R12} = \frac{50\ R10}{50 + R10}.$$

Whence,

$$R10 = \frac{500}{40} = 12.5 \text{ ohms.}$$

R9 can now be computed, since the ratio between taps 5 and 6 is 4. The resistance to the right of tap 6 is 10 ohms, therefore this plus R9 must total 4 x 10 or 40 ohms. This makes R9 equal to 30 ohms.

To compute R8 we use the same procedure as above. R8, shunted by 40 ohms this time, must equal 10 ohms. Therefore

$$10 = \frac{40 \times R8}{40 + R8}.$$

Whence

$$R8 = \frac{400}{30} = 13.3 \text{ ohms.}$$

The ratio between taps 4 and 5 is 5. Hence, R7, like R11, is 40 ohms. Since the resistance at tap 4 is also to be 10 ohms we obtain R6 in a manner similar to that used in finding R8 and R10. Thus

$$10 = \frac{50R6}{50 + R6}.$$

Whence R6 = 12.5 ohms.

We now go into section 1. Our ratio between taps 3 and 4 is 5. Hence R5 is 40 ohms. Now, let us use a somewhat higher resistance than 10 ohms. The main advantage of this is that much less power is required from the oscillator to supply 10,000 microvolts to 100 ohms than to 10 ohms. Therefore, let us decide that the resistance at tap 3 can be 25 ohms instead of 10. This means that R4, shunted by 50 ohms, is 25 ohms. This in turn makes R4 very obviously 50 ohms, even recourse to the slide rule being unnecessary. The ratio between taps 2 and 3 is 4, whence R3 is 3 x 25 ohms, or 75 ohms; and there is a total of 100 ohms shunting R2 to give the resistance at tap 2. If we decide to have 50 ohms for this resistance, R2 will be 100 ohms. If we wish, we can leave R2 out entirely, which would make the resistance at tap 2 equal to 100 ohms. We are now at the input circuit, and R1 is determined by our available voltage from P, the resistance of P, and the meter resistance. The total of the meter resistance plus R1 should be at least twice the resistance of P . . . this to avoid getting most of our variation in current near one end of P.

METER VALUES

Our next step is to determine the proper value of the meter to be used with the above attenuator. We know that the resistance at tap 2 is 50 ohms (with R2 equal to 100 ohms), and that the maximum voltage across this tap shall be 10,000 microvolts. Therefore the maximum current flowing into tap 2 is

$$I = \frac{10{,}000}{50} = 200 \text{ microamperes,}$$

or 2/10 of a milliampere.

Now, to get a thermo-milliammeter having a full-scale reading of .2 milliampere is quite difficult, so that we must use still another resistance, indicated as Ro and connected in dotted lines between point 1 and point b, to allow us to use a higher current couple, yet only have .2 milliampere flowing into tap 2. Let us assume we have available a meter having a full-scale reading of 10 milliamperes, and a resistance of 100 ohms. This 10 milliamperes must divide, .2 going to tap 2, and 9.8 through Ro. Therefore Ro is $\frac{.2}{9.8} \times (R1 + 50)$ or, conversely,

$$R1 = \frac{9.8\ Ro}{.2} - 50 = 49\ Ro - 50.$$

Thus, if Ro is 10 ohms R1 is 440 ohms, or if Ro is 100 ohms R1 is 4850 ohms. If R1 is high in resistance it

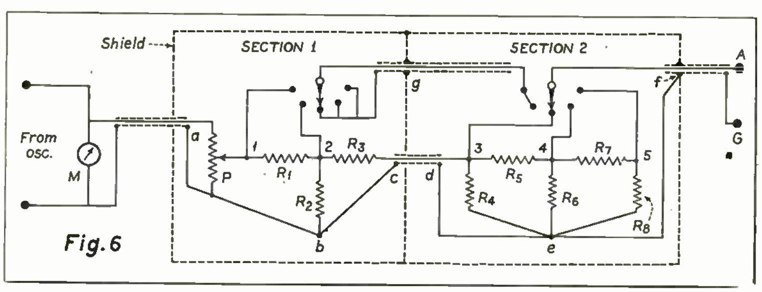


Fig.6

Detailed circuit of attenuator with fixed input to the meter but with the potentiometer remaining in the input leg.

Fig. 7. Showing construction of "figure 8" type of resistor.

can easily be a filament-type resistance, such as used in most radio sets, provided a reliable make and design is used. Let us, then, use a standard size unit for this resistance, say 5000 ohms. This will make Ro = 103 ohms. The effective input resistance to point 1 is now 103 ohms shunted by 5050 ohms, or 101 ohms. This is in series with the meter, and therefore we have 201 ohms across the slider of the potentiometer P to ground. A good value of P, then, would be about 50 to 100 ohms. The maximum voltage needed would be that required to pass 10 milliamperes through 201 ohms, or 2.01 volts. If we use a 100-ohm potentiometer the effective resistance of this, shunted by 201 ohms, is about 67 ohms, and the power required from the oscillator or amplifier is

$$\frac{(2.01)^2}{67} = .06 \text{ watt.}$$

Thus we have completed the design of this particular type of attenuator. This unit has a range of 1—10,000 microvolts, requires a 6-position switch, and has a resistance of 67 ohms to the oscillator. The required input is 2 volts (approximately), and .06 watt power is necessary. The meter used is a 10-milliampere couple.

Listing the resistances, we have:

R1 = 5000 ohms
R2 = 100 ohms
R4 = 50 ohms
R6 = 12.5 ohms
R8 = 13.3 ohms
R10 = 12.5 ohms
R12 = 10 ohms
Ro = 103 ohms
R3 = 75 ohms
R5 = 40 ohms
R7 = 40 ohms
R9 = 30 ohms
R11 = 40 ohms
P = 100 ohms

SUMMARY OF PROCEDURE

Summarizing the procedures used above in securing the values for the various resistances, the first step is to decide on the desired ratios between steps. Next decide on an output resistance value, or more accurately, the resistance of the final unit, (in this particular case 10 ohms). Then decide on the desired resistance at the various taps. From the above, to get the various values in each step the top resistances, R1, R3, R5, R7, etc., are equal to the ratio between their steps minus one, and times the value of the effective resistance following them. The other resistances are computed as giving the desired resistance at the various taps, when shunted by the effective resistance following them.

CALCULATION OF ANOTHER ATTENUATOR

Now, let us turn to the other type of attenuator, illustrated in Fig. 6, and quickly compute the values as done above. Let R8 be 10 ohms, and let the effective resistance at 3 and 4 also be 10 ohms. Our ratio between steps in this attenuator is 10 to 1 on all steps, as we can easily and accurately calibrate P to indicate this range linearly, or logarithmically. Every upper resistor will be 9 times the resistance to the right of it, whence R7 is immediately 90 ohms, as are likewise R3 and R5. R4 and R6 are equal, and of such value that shunted by 100 ohms they give 10 ohms, or 11.11 ohms. We can let the resistance at tap 2 be somewhat higher,

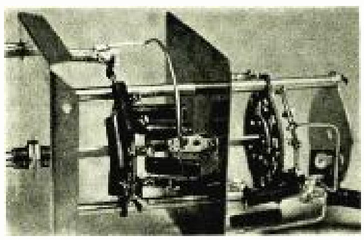


Fig. 8. Showing construction of the switching sections and manner of circuit connections.

say 25 ohms, so that R2 is obtained as 33.3 ohms. R1 is therefore 9 x 25 ohms or 225 ohms.

Our ranges with this attenuator are:
Tap 5—1 to 10 microvolts
Tap 4—10 to 100 microvolts
Tap 3—100 to 1,000 microvolts
Tap 2—1,000 to 10,000 microvolts
Tap 1—10,000 to 100,000 microvolts.

Obviously, in spite of using one less section of attenuator, we get ten times as much output. This is due to the greater range possible on each step. The maximum required input voltage from the oscillator is .1 volt. The input resistance to the attenuator proper is 250 ohms. Therefore it is suggested that P be about 50 ohms, to reduce the effect of moving the arm up and down. The required power from the oscillator is

$$\frac{(.1)^2}{42} = .00025 \text{ watt.}$$

PREFERENCES

It would seem, therefore, that from practically every angle the latter type of attenuator is greatly to be preferred, since less switch steps are required, computations are vastly simplified, and very much less power is taken from the oscillator. The only requirement is the calibrated potentiometer, and this presents no great difficulty, provided that it is borne in mind that it must be non-inductive, of low capacity, and accurately calibrated. In the above illustrations the latter type of attenuator also gave ten times as much output voltage as the first. If it is desired to obtain more output in the attenuator illustrated in Fig. 5 another tap may be employed on the switch, connected to point 1, which will make available a maximum voltage of 2 volts.

In the attenuator of Fig. 6 the indicating meter will always be set at .1 volt. If this is too low for available instruments a higher voltage may be obtained from the oscillator, and the meter used to measure this and a portion of this voltage tapped off for the attenuator. A simple way of doing this is as follows:

Since the input resistance across the terminals of P is approximately 42 ohms, connect a resistance of 9 x 42 or 378 ohms in series with the input leads to the whole unit. If now the meter is connected across this whole path, totalling 420 ohms, and the input from the oscillator set to 1 volt by this meter, we will have .1 volt across the terminals of P, when the slider is on full. However an error is introduced as the slider is moved, which can only be reduced by making the potentiometer smaller, say 10 ohms.

CONSTRUCTION

A word about the construction of the attenuator. For the man who winds his own units two methods of making the various fixed resistors are suggested. In one a thin piece of mica is obtained and the resistance wire wound around this strip. Since the strip is very thin there is practically no field in such a construction and the inductance is extremely low. Another stunt which the author has found very satisfactory is to double up the resistance wire, then loop it back and forth around two nails placed about ½ inch apart on a board. The whole unit is then slipped off the nails, wrapped with thread, and the unit sealed in a short length of cambric sleeving, thus making a very compact, self-supporting resistance.

Figs. 7, 8 and 9 illustrate the con-

(*Continued on page 26*)

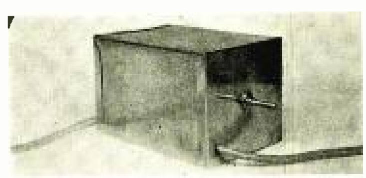


Fig. 9. The complete attenuator, with shielded input and output leads.

TRANSFORMER DESIGN

The concluding part of an article which covers general and fundamental factors in the design of transformers.

PART II

By LEO A. KELLEY

THE PREVIOUS ARTICLE of this series dealt with the derivation of generalized equations for the input impedance of a resistance-terminated transformer and also for the transmission-loss versus frequency-ratio characteristics of a transformer having generator and load resistances in the same ratio as the primary and secondary inductances. All of these equations were expressed in terms of two variables, the coefficient of coupling between the primary and secondary inductances and frequency ratio based on the frequency at which the reactance of the secondary winding becomes numerically equal to the load resistance. These results are applicable especially to those cases where the efficient transfer of energy is of primary importance, i.e., impedance matching.

VOLTAGE TRANSFORMERS

We propose to deal now with the same transformers but from a somewhat different point of view, namely, as voltage transformers. From the standpoint of our analysis the only difference is that we shall consider generator and load resistances which are not generally in the same ratio as the primary and secondary inductances and also load resistances which are shunted by capacitance. This analysis has particular application to input and interstage transformers for vacuum-tube amplifiers where the object is to achieve a high-voltage step-up together with a good frequency characteristic. The main difficulty here is that the input capacitance of the vacuum tube along with the distributed capacitance of the secondary winding may have a pronounced effect on the frequency characteristic which is not at all desirable. The effect is modified by shunt resistance which may be in the form of leakage, positive grid operation or a resistance purposely connected across the secondary terminals of the transformer. These effects will become clear later on in our discussion.

THEVENIN'S THEOREM

In deriving our equations we shall make use of a very old principle of electric-circuit theory known as Thevenin's Theorem. A detailed discussion of this theorem is given in Chapter VIII of K. S. Johnson's *Transmission Circuits For Telephone Communication*. Briefly, it states that we may regard any two points of a network composed of ordinary impedances energized by electromotive force in any of its branches as the open-circuit terminals of a generator having an open-circuit voltage equal to the voltage which would be measured between the two points and an internal impedance equal to the impedance which would be measured between the same points. Therefore, when another impedance is connected between the two points of the network it is the same as if it had been connected to the output terminals of a generator having the open-circuit voltage and internal impedance just specified. The current flowing through the added impedance is now very easily determined since the circuit consists merely of the voltage applied to the internal impedance and the added impedance in simple series connection.

DERIVATION

On the basis of this principle, we shall derive the equivalence between A and B of Fig. 7 and thus exemplify

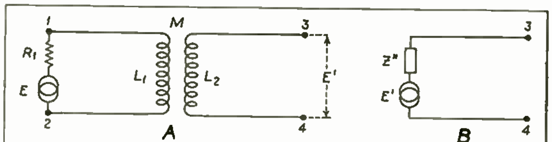


Fig. 7

The transformer circuit of A may readily be changed to the simple circuit of B which consists of an emf source and impedance in series.

the theorem and also lay the foundation for the derivation of the equations we are seeking. Referring to Fig. 7-A, terminals 3 and 4 are the two points of the network to which we shall connect another impedance. We can readily calculate the open-circuit voltage E′ across terminals 3 and 4 when the primary circuit is energized by the voltage E. It is easy to see that the voltage across the primary coil L_1 is equal to,

$$\frac{Ej\omega L_1}{R_1 + j\omega L_1}$$

If this is multiplied by the coefficient of coupling K to discount the leakage flux and also by $\sqrt{L_2/L_1}$ to refer the voltage to the secondary, the result is equal to the open-circuit voltage,

$$E' = \frac{KE\sqrt{\frac{L_2}{L_1}}\, j\omega L_1}{R_1 + j\omega L_1}$$

Divide the numerator and denominator by $j\omega L_1$, then,

$$E' = \frac{KE\sqrt{\frac{L_2}{L_1}}}{1 - j\frac{f_1}{f}} \quad \ldots\ldots\ldots\ldots (4)$$

where f_1 is the frequency at which the reactance of the primary winding is numerically equal to R_1. This f_1 is the same value as the f_1 of the previous article because, although it was there defined with respect to the secondary, it was also assumed that the primary and secondary resistances were in the same ratio as the primary and secondary inductances. The impedance which would be measured between terminals 3 and 4 is equal to,

$$Z'' = j\omega L_2 + \frac{\omega^2 M^2}{R_1 + j\omega L_1}$$

It was from the same equation with primary and secondary interchanged that equation (1) of the previous article was derived. There we rationalized the denominator but here it is convenient not to do so. Factoring out $R_1 \frac{L_2}{L_1}$ and substituting $K = \frac{M}{\sqrt{L_1 L_2}}$ and $f_1 = \frac{R_1}{2\pi L_1}$.

$$Z'' = R_1 \frac{L_2}{L_1}\, j\, \frac{f}{f_1}\left(1 - \frac{K^2}{1 - j\frac{f_1}{f}}\right) \quad \ldots\ldots\ldots\ldots (5)$$

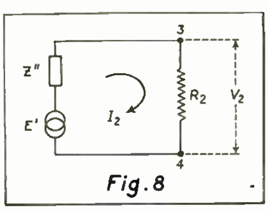
Consequently, in Fig. 7 we may by Thevenin's Theorem substitute for the circuit of A the simple series circuit of B where the generator voltage $E' = \frac{KE\sqrt{\frac{L_2}{L_1}}}{1 - j\frac{f_1}{f}}$

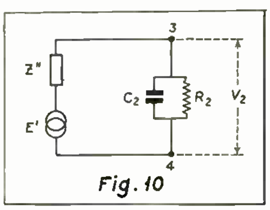
and the internal generator impedance

$$Z'' = R_1 \frac{L_2}{L_1}\, j\, \frac{f}{f_1}\left(1 - \frac{K^2}{1 - j\frac{f_1}{f}}\right)$$

VOLTAGE-FREQUENCY CHARACTERISTIC, ADDED IMPEDANCE IS RESISTANCE

The first case we shall take up is the one shown in Fig. 8 where the resistance R_2 of any value is connected to terminals 3 and 4.

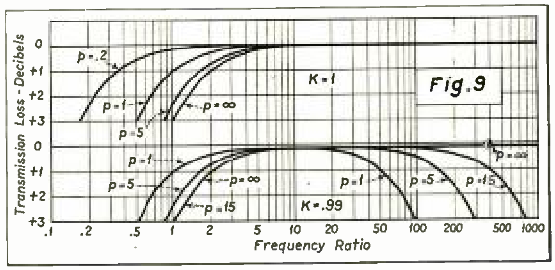




Left: The simple circuit of 7-B having added a resistance R_2 between terminals 3 and 4.

Right: Circuit of Fig. 8 having R_2 paralleled by C_2, the latter representing stray capacitances.

In treating impedance-matching transformers we made R_2 equal to $R_1 \frac{L_2}{L_1}$, but now since R_2 may have any value we put it equal to $pR_1 \frac{L_2}{L_1}$, where p is the ratio of R_2 in general to the particular value of R_2 chosen for impedance matching. The current I_2 flowing in the simple



Two families of transmission loss—frequency ratio curves plotted from equation 7.

series circuit of Fig. 8 is obviously,

$$I_2 = \frac{E'}{Z'' + R_2}$$

We are now interested in the voltage V_2 developed across R_2 which is equal to,

$$V_2 = I_2 R_2 = \frac{E' R_2}{Z'' + R_2} = \frac{E'}{Z''/R_2 + 1} = \frac{E'}{\frac{1}{p}\left(\frac{Z''}{R_1 \frac{L_2}{L_1}}\right) + 1}$$

As a standard of comparison we again use the ideal transformer with the same ratio of primary to secondary inductance terminated in the same value of R_2. Hence,

$$V_2 \text{ (ideal)} = \frac{E\sqrt{\frac{L_2}{L_1}}\, R_2}{R_1 \frac{L_2}{L_1} + R_2} = E \frac{p}{1+p}\sqrt{\frac{L_2}{L_1}}$$

It will be noted that V_2 (ideal) is not a function of frequency and is, therefore, a constant as far as frequency is concerned. V_2 for the real transformer is a function of frequency and, therefore, the ratio,

$$\frac{V_2 \text{ (ideal)}}{V_2}$$

will have frequency variations due entirely to the real transformer. Let us call this the voltage ratio of the transformer T_v and substitute the expressions for E' and Z" given in equations (4) and (5). Then,

$$T_v = \frac{V_2 \text{ (ideal)}}{V_2} = E \frac{p}{1+p}\sqrt{\frac{L_2}{L_1}} \times \frac{\frac{1}{p}\left[j\frac{f}{f_1}\left(1 - \frac{K^2}{1 - j f_1/f}\right) + p\right]}{\frac{KE\sqrt{\frac{L_2}{L_1}}}{1 - j f_1/f}}$$

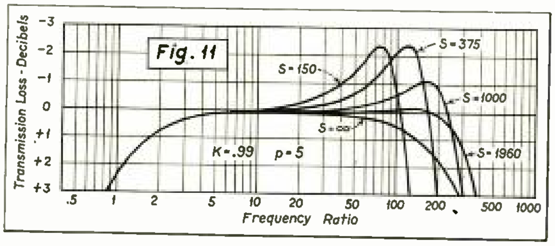
After simplification this becomes,

$$T_v = \frac{1}{K} - j\frac{1}{1+p}\left[\frac{p}{K}\frac{f_1}{f} - \left(\frac{1}{K} - K\right)\frac{f}{f_1}\right] \quad \ldots\ldots (6)$$

There are three variables in equation (6) all of which are ratios, the coefficient of coupling K, the frequency ratio f/f_1 and the resistance ratio p. This equation (6) differs from equation (2) of the previous article only in that it contains the additional variable p. Incidentally, when p is made equal to one, the two equations become identical. This serves as a check on our use of Thevenin's Theorem because the impedance-matching equation was derived in a different way.

CONVERTING TO DB

Equation (6) is complex, i.e., it has a real and an imaginary term. It has, therefore, a magnitude and an angle, but we are at present interested only in variations of the magnitude. As is well known, the magnitude is equal to the square root of the sum of the squares of the real and imaginary terms. Calling the magnitude



A family of curves plotted from equation 10, p having a fixed value and s being varied.

$|T_v|$ we can convert the result into decibels in the usual manner, as follows:

$$T_v\ (\text{db}) = 20 \log_{10} |T_v| \ldots\ldots\ldots\ldots\ldots (7)$$

It should be borne in mind that this loss is with reference to the voltage developed across R_2 when an ideal transformer having the same primary to secondary inductance ratio is substituted for the actual one. The decibel representation of the loss is adopted because it is in accord with the results obtained with the customary transmission-measuring equipment.

Two families of curves calculated from equation (7) are plotted in Fig. 9 against frequency ratio. One group shows how the loss curve is affected by assigning various values to p for $K = 1$, i.e., perfect coupling. It is seen that p affects only the lower limiting frequency. The curve for $p = 1$ is for the impedance matching case. When p is made greater than one, see curve for $p = 5$, the lower limiting frequency moves somewhat higher. The curve for $p = \infty$, the secondary open circuited, shows that the lower limiting frequency can not be raised higher than twice that for $p = 1$. When p is made less than one the lower limiting frequency is lowered, see curve for $p = .2$, and does not approach a finite limit, as is true when p is made greater than one, but rather approaches zero for its limit.

The other group of curves is for a coefficient of coupling slightly less than unity, namely, .99. The lower limiting frequency is affected by selecting different values of p in the same manner as indicated for $K = 1$. Turning our attention to the upper limiting frequency we discover that this is raised as p is increased at a more rapid rate than the lower limiting frequency because it has no finite upper limit as shown by the open-circuited secondary curve where $p = \infty$. If we define arbitrarily the limiting frequencies to be those where the loss curve equals one decibel, it is easy to show from equation (6) that the transmitted frequency range expressed as the ratio of the upper limiting frequency to the lower limiting frequency is closely equal to,

$$\frac{(p+1)^2}{4p} \times \frac{f_1}{2(1-K)}$$

Consequently, a wider range of frequencies is transmitted as p is increased. Considering resistance only, the voltage-operated device connected to the secondary terminals should preferably have as high a resistance as possible to obtain the widest range of frequencies efficiently transmitted.

STRAY CAPACITIES

Unfortunately, the choice is usually not as simple as that, because in striving to obtain as large a voltage step-up as possible, the reactance of stray capacitances becomes comparable in magnitude with other impedances in the secondary circuit and may have a marked influence on the frequency characteristic. We shall derive equations taking this into account, using the circuit of Fig. 10 where C_2 represents all the stray capacitances shunting the resistance R_2. As before, we place $R_2 = pR_1 \frac{L_2}{L_1}$. At some frequency ratio which we designate s the reactance of C_2 will be numerically equal to $R_1 \frac{L_2}{L_1}$. Therefore, the reactance of C_2 at any frequency is equal to,

$$-j \frac{1}{\omega C_2} = -j\, s\, R_1 \frac{L_2}{L_1} \frac{f_1}{f}$$

In terms of p, s and the frequency ratio, the impedance Z_2 of the parallel combination of R_2 and C_2 is equal to,

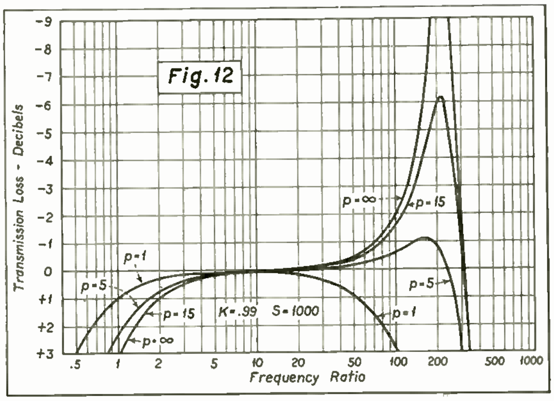
$$Z_2 = -j \frac{p\, s \frac{f_1}{f}}{p - j\, s \frac{f_1}{f}} \times R_1 \frac{L_2}{L_1} = q\, R_1 \frac{L_2}{L_1}, \text{ where}$$

$$q = \frac{1}{\frac{1}{p} + j \frac{1}{s} \frac{f}{f_1}}.$$

Consequently, the voltage developed across the combination is,

$$V_2 = \frac{E'}{\frac{1}{q}\left(\frac{Z''}{R_1 \frac{L_2}{L_1}}\right) + 1}.$$

As a standard of comparison we shall use the ideal transformer of the same primary to secondary inductance ratio substituted for the actual transformer but *without* the shunt capacitance C_2. The reason for leaving out the condenser C_2 is that to leave it in would introduce



Another family of curves plotted from equation 10, s having a fixed value and p being varied.

a frequency variation in our reference voltage . . . and that would not be desirable. Calling this new voltage ratio T_v', it is equal to,

$$T_v' = \frac{V_2\ (\text{ideal})}{V_2} = E\frac{p}{1+p}\sqrt{\frac{L_2}{L_1}} \times \frac{j\frac{1}{q}\frac{f}{f_1}\left(1 - \frac{K^2}{1 - j\,f_1/f}\right) + 1}{\dfrac{KE\sqrt{\frac{L_2}{L_1}}}{1 - j\frac{f_1}{f}}}.$$

Substituting the value of q,

$$T_v' = \left[\frac{1}{K} - \frac{p}{s\,(1+p)}\cdot\left(\frac{1}{K} - K\right)\frac{f^2}{f_1^2}\right] - j\left\{\frac{1}{1+p}\left[\frac{p}{K}\frac{f_1}{f} - \left(\frac{1}{K} - K\right)\frac{f}{f_1}\right] - \frac{p}{s\,(1+p)}\cdot\frac{1}{K}\cdot\frac{f}{f_1}\right\} \quad \text{.........(8)}$$

Comparing this with equation (6) it may also be written,

$$T_v' = T_v - \frac{p}{s\,(1+p)}\left[\left(\frac{1}{K} - K\right)\frac{f^2}{f_1^2} - j\frac{1}{K}\cdot\frac{f}{f_1}\right] \quad \text{..(9)}$$

The equation (9) shows that when R_2 is shunted by the condenser C_2 a complex term involving *s* is added to the voltage-ratio characteristic given by equation (6) which becomes smaller as *s* becomes larger and disappears when *s* becomes infinite. This is the same as saying that equation (9) reduces to equation (6) when *s* is made infinitely great, i.e., when C_2 is removed from the circuit. Again we convert the ratio into decibels,

$$T_v'\ (\text{db}) = 20 \log_{10} |T_v'| \quad \text{...................(10)}$$

There is an infinite variety of curves which may be plotted from equation (10) but we are showing for purposes of illustration in Figs. 11 and 12 groups of curves indicating the characteristic changes when *p* is given a fixed value and *s* is varied and also when *s* is given a fixed value and *p* is varied for a coefficient of coupling less than unity, namely, .99. Incidentally, for unity coupling C_2 has the effect of cutting off the higher end of the frequency range.

EFFECT ON FREQUENCY CHARACTERISTIC

Referring now to Fig. 11, this family of curves demonstrates the effect on the frequency characteristic when $K = .99$, $p = 5$ and *s* is given several values from 150 to infinity. The main difference between these curves and those of Fig. 9 is that here some of the curves have a pronounced hump near the upper end of the transmitted range. This is the familiar resonance peak and it occurs at a frequency ratio where the inductive reactance component of Z″ is equal to the equivalent series capacitive reactance component of Z_2. It will be seen from Fig. 11 that the peak is most in evidence for the smaller values for *s*, i.e., for the larger values of C_2. As *s* becomes larger the peaks flatten out and the upper limiting frequency becomes higher reaching a maximum at approximately $s = 1960$, then diminishing as *s* increases still further reaching a final value when *s* becomes infinite. The latter curve which is for C_2 removed is, of course, the same as the curve for $K = .99$ and $p = 5$ in Fig. 9. Thus we can see that while stray capacitance may complicate the problem it is not always harmful, providing it is properly related to *p* and K. The curve for $s = 1960$, for example, is certainly more desirable than the curve for $s = \infty$ where there is no capacitance, in that it indicates uniform transmission over a wider range of frequencies. The effect is analogous to the loading of a telephone line where properly proportioned inductance coils are connected in series with the line to compensate for an excess of shunt capacitance; whereas in the transformer the shunt capacitance when properly proportioned tends to compensate for an excess of series inductance, the coefficient of coupling being less than unity.

The curves of Fig. 12 are very similar to those of Fig. 11. Now, however, *s* is held constant at a value of 1000 and the coupling at .99 while the resistance R_2 is varied by selecting several values for *p*. Holding *s* constant has the effect of making the resonance peak occur at about the same frequency for all of the curves. There is a small change, however, because the frequency of the peak becomes slightly lower as *p* is decreased. The peak of the curve for $p = \infty$ has a maximum of about minus 13 decibels loss which is not shown in the figure. Between $p = 5$ and $p = 1$ there will be a curve where the peak just disappears which will represent the most uniform transmission for the widest range of frequencies for $s = 1000$ and $K = .99$.

CONCLUSION

It is not intended in these articles to do more than show how the factors affecting the transmission-loss characteristics of transformers may be preserved in the form of ratios so that the resulting equations have general applicability. A number of typical cases have been treated and the curves which have been given are suggestive of the power of analysis afforded by the method. By substituting other values for the variables in the equations derived it is a simple matter to cover any range of the variables desired. While there are no curves given for phase shift, this may be calculated from the equations by taking the angle whose tangent is the ratio of the imaginary term to the real term in each case. Analysis of other types of secondary load circuits may likewise be made by applying the method described above.

DIATHERMY INTERFERENCE

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TOBE DEUTSCHMANN CORP.

● DATA ON THE ELIMINATION OF RADIO INTERFERENCE PRODUCED BY HIGH-FREQUENCY, ELECTRO-MEDICAL APPARATUS

HIGH-FREQUENCY APPARATUS, such as is used in the medical profession, has long been one of the most prolific sources of radio interference. Unlike the majority of electrical devices which create interference in their immediate locality only, certain types of high-frequency apparatus set up interference which destroys reception over a large area. In fact, in some cases where the supply lines to the apparatus parallel the primary supply or telephone circuits, the disturbance may be spread over a considerable distance and even carried into cities several miles away.

In order to understand the reason for the somewhat complicated procedure which must be followed in overcoming Diathermy interference, it will be well to consider the principles underlying the operation of high-frequency, electro-medical apparatus. A Diathermy machine is a device for the production of high-frequency currents to be used in the treatment of certain diseases. The frequencies used in the earlier models were from 900 to 1400 kc, or practically the whole of the broadcast band. In some of the newer models an attempt is made to keep the frequencies used outside the broadcast band, but this is difficult due to the tendency of this apparatus to propagate a broadly tuned wave.

SIMILAR TO SPARK TRANSMITTER

The circuit used for obtaining these frequencies is essentially the same as that used in early spark transmitters whose operation is now forbidden by federal law. In the Diathermy machine a transformer, condenser, and adjustable spark gaps are used to produce high-frequency currents. These currents are carried along flexible leads to metal electrodes applied to the body of the patient. The similarity to a spark transmitter is obvious. The high-frequency generator is the Diathermy machine. The antenna consists of the electrode leads and the body of the patient. In the case of some types of treatment the body of the operator is also a part of the antenna system. The counterpoise is the power line.

The maximum high-frequency current used in Diathermy treatment is usually 4,000 milliamperes or four amperes. When it is understood that a radio transmitter with an antenna current of 4 amperes may have a working range of several thousand miles, it is obvious that a Diathermy machine can do considerable damage to broadcast reception. Fortunately, the "antenna system" of the Diathermy apparatus is not designed for maximum radiation at the frequencies used, and consequently, the area affected by the direct radiation from the electrode leads and the body of the patient is relatively small. This directly radiated interference seldom affects receivers more than 200 feet from the Diathermy apparatus.

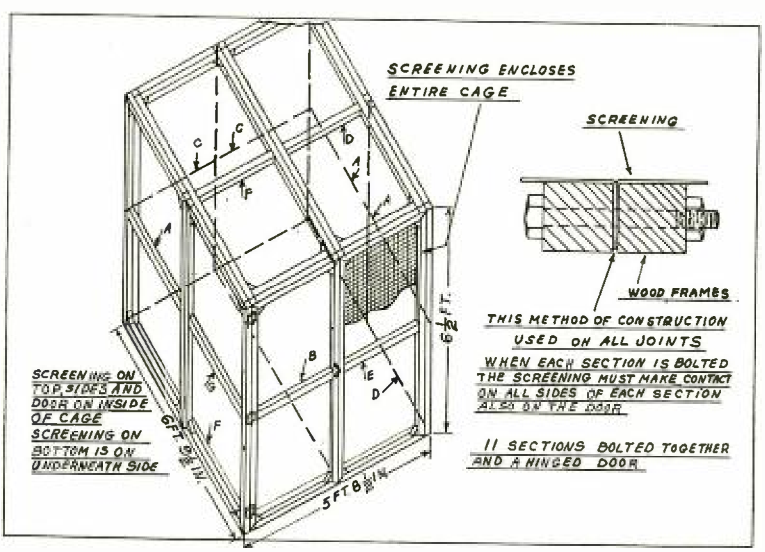


Fig. 1. Assembly drawing showing construction of Diathermy screen.

INTERFERENCE CARRIED ALONG WIRING CIRCUITS

The greater part of the Diathermy interference which affects receivers located at a greater distance from the apparatus is carried along wiring circuits in a manner similar to the carrier-current transmission. This disturbance is impressed upon the various wiring circuits in two ways. The first of these is by feedback from the Diathermy machine to the power line to which it is connected. The high-frequency currents flowing in the electrode circuit of the Diathermy machine cause voltages of the same frequency to be induced in the primary of the transformer used and thus to be superimposed on the power supply lines. The high-frequency currents flowing as a result of this induced voltage may travel back along the secondary distribution network for many miles, unless a suitable filter is installed in the power-supply line to the Diathermy machine. This filter must be of the special type, as will be outlined.

CHOICE OF LINE FILTER

In the choice of a line filter for application to a Diathermy machine, three factors must be considered. They are:

1. The voltage of the line to which the Diathermy machine is connected.

2. The number of amperes flowing in the primary circuit of the Diathermy machine.

3. The frequency of the power supply. (60 cycles is the frequency most widely used, but 50 cycles, 40 cycles 30 cycles and 25 cycles may also be encountered.)

In the development of line filters for application to Diathermy machines it was found that the single-section inductive capacitive type filter, widely used for other applications, was not satisfactory for suppressing Diathermy interference. In order to prevent the feedback of Diathermy interference into the power line it was necessary to construct a three-section inductive capacitive type filter. This was, of course, not commercially practicable because of the high voltage drop in the filter, the large size of the filter, and its excessive cost. If this construction were to be used, the first difficulty, that of excessive voltage drop, might be eliminated only by a procedure which would further increase the cost of the filter. It was, therefore, necessary to develop a filter which would combine, with high efficiency, the desired characteristics of compactness and low cost. This was successfully accomplished.

TYPES OF FILTER

There are three standard types of Diathermy filter. The first, for application to practically all of the portable Diathermy outfits, is only 7⅝" long, 6¾" high and 5½" wide. This filter will handle any six-ampere Diathermy machine operating at 110 volts, 50 or 60 cycles. The second type, contained in a metal housing 11⅛" long, 7" wide and 9" high is suitable for application to Diathermy machines drawing up to 15 amperes at 110 volts, 50 or 60 cycles. For application to the large size Diathermy machines requiring up to 25 amperes at 110 volts, 50 or 60 cycles, a third type has been constructed. This filter also is contained in a metal housing 16" long, 13" high and 8" wide.

DIATHERMY APPARATUS MUST BE SHIELDED

Although the use of a filter alone will prevent the feedback of interference from the Diathermy machine to the power supply line, it will not of itself entirely prevent the distribution of interference. Unless steps are taken to prevent the radiation of interference from the electrode leads and the body of the patient being treated, this interference will be picked up by the various wiring circuits in the building, such as the lighting or telephone circuit, and may thus be carried out into the neighborhood even though the correct filter is installed at the power input to the apparatus. It is, therefore, obvious that if the interference from a Diathermy machine is to be successfully eliminated, steps must be taken to prevent the radiation of interference from the secondary side of the apparatus.

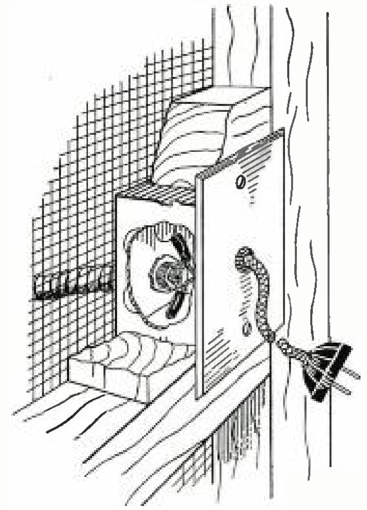


Fig. 2. Method of connecting Tobe Filterette to Diathermy screen.

It is not advisable to install filters in the output circuit of the Diathermy machine since, if these filters were effective in suppressing the interference, they would also prevent the passage of high-frequency currents to the body of the patient, and would thus render the apparatus ineffectual in the treatment of disease. It is, therefore, evident that the only remaining possibility is shielding, and that this shielding must enclose the Diathermy machine, the patient being treated and the operator of the machine.

DEVELOPMENT OF SCREEN

The following quotation from the laboratory report covering the experimental work undertaken in the development of this screen describes the necessary screening:

"A screen cage sufficiently large to contain both the apparatus and the patient was constructed. This cage was constructed of copper screening bolted to an angle iron framework, and to all appearances should have been entirely satisfactory. However, upon further experimentation, it was found necessary to solder screening across all the joints in the angle iron framework in order to prevent radiation. As this construction was quite complicated, a third shield was constructed.

"In the construction of the third shield, copper screening was again used. A wood frame, however, was substituted for the iron, and the screening was so arranged that firm metallic contact was maintained between screen sections. This shield proved entirely satisfactory.

"A fourth screen was then constructed on the same principle as that previously employed, with the exception that galvanized iron screening was used in place of copper screening. This screen was, if anything, more satisfactory than the copper screen."

The sketch of Fig. 1 shows the constructional details of the screen finally adopted as standard for preventing the radiation of interference from a Diathermy machine. The important feature in the construction of this shield is the continuity of the screening. The exact size of the screen cage is not important. Slight variations from the suggested construction are not likely to affect the results obtained from the use of the screen. It must be remembered, however, that the screen alone will not provide satisfactory suppression of Diathermy interference, since the interference which is fed back into the power line is sufficient to minimize the benefit obtained from the use of shielding.

INSTALLING THE FILTER

The filter should be contained in a metal housing and a short piece of BX, bonded to the filter housing, should be provided to facilitate connection to the 110-volt line.

A receptacle should be provided in the filter so that the Diathermy machine may be connected to the supply line by means of its attachment cord and plug. The filter may be located at any point within the Diathermy screen, although for best results it should not be located further from the screen than the distance allowed by the length of BX lead used with the filter.

In making the filter installation, standard wiring practice, as recommended in the National Electric Code, should be followed. A satisfactory method of making this installation is shown in Fig. 2. As this drawing shows a shallow flush switch box (such as G. E. catalog No. SP6976) is mounted in any one of the sections of the screen, being held in place by a wood frame of 1¾" material extending over the top and one side of the box. The bottom and other side of the box are supported by the vertical member and the cross member of the wood frame of the screen section in which the box is to be mounted. When the box is mounted in this manner, its back will be flush with the screening of the section. A small hole should be made in the screening at the point where the BX is to enter

(*Continued on page* 26)

IRON-CORE R-F TRANSFORMERS

THEIR CHARACTERISTICS AND ADAPTABILITY TO MODERN RECEIVER DESIGN

THE USE OF iron cores as a means of improving the performance of radio-frequency inductive coupling devices has been given serious consideration for many years. It has only been quite recently that their use has become widely accepted. We find that although their use has become quite general in the manufacture of receivers in Europe, the engineering fraternity in America is not as well informed as they might be, considering the distinct advantages they may secure in employing this material. It is the purpose of these notes to better acquaint radio engineers with the manner in which units employing iron cores may be incorporated into their designs.

TRANSFORMER DESIGNS

There are at present available in this country, intermediate-frequency transformers employing iron cores in the windings, which are designed to operate at the various frequencies now meeting with popular demand. Iron cores have also been employed in the manufacture of antenna transformers and interstage transformers to operate over the broadcast band. It is felt that many radio engineers regard them in the light that their use requires other than standard practice. For that reason it may be well to describe the construction of one of the iron-core transformers now on the market, designed for use at 456 kc.

CORE CONSTRUCTION

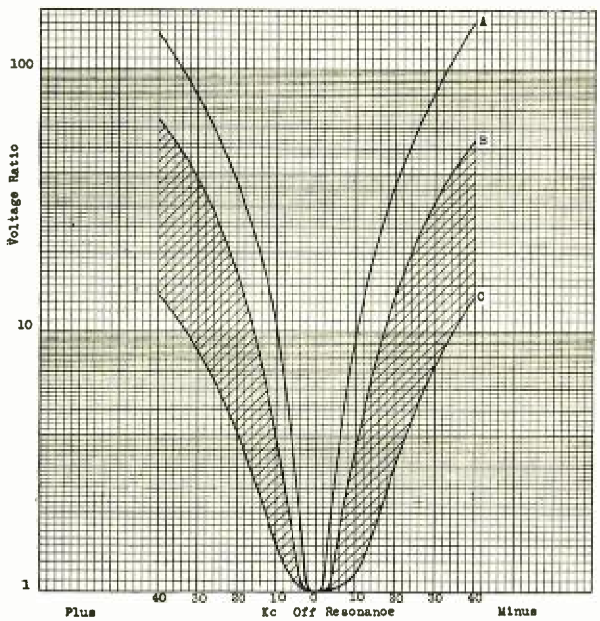
As an interstage unit this transformer has a one-to-one inductance ratio. The coils are wound directly on the cores and centrally located. These cores are made of finely divided particles of iron which are completely insulated one from the other by an insulating compound. This composition is then compressed in molds under very high pressure to form a homogeneous solid core. It is then heat-treated to insure its stability, with the result that the finished cores are not affected by temperature or humidity. This is of utmost importance because of the extreme conditions under which a receiver must sometimes operate.

They may be handled practically as one would treat a piece of cast iron, and will not dissolve when subjected to the solvents commonly found in coil "dopes." So finely are the particles of iron divided that it requires over 20,000,000,000 of them to form a core of the size used at intermediate frequencies, namely, 3/8-inch diameter by 1/2-inch long. Obviously, since the particles are so minute and are thoroughly insulated, it is unnecessary to resort to the practice of laminating, in forming the core, in order to hold the eddy-current losses to a minimum.

"IRON-AIR" CHARACTERISTICS

An intermediate-frequency core such as has been described, has an effective permeability somewhat less than two. This permeability has been arrived at as the best compromise value, since a certain balance must be struck in the use of iron and wire to secure a coil of improved Q. The majority of the flux path still consists of air and the saving in copper losses due to the fewer turns being used greatly outweighs the losses which the iron adds, consequently the r-f resistance for a coil of given inductance when wound on an iron core is much lower. The resulting coil may be likened to an air-core coil wherein the air had a permeability of about double its normal value, since the iron core is unaffected by saturation. The flux pattern of an iron-core coil using the core previously mentioned is very similar in appearance to that of an air-core coil of the same proportions.

From the above it may be seen that these coils may be treated in somewhat the same manner as the usual i-f coil. In the complete transformer, these coils are tuned to the resonant frequency by a mica condenser of proven stability as to its electrical and mechanical characteristics. Here again is another important feature and new designs to be offered shortly should be still further improved in this respect.



Comparative curves of one i-f stage at 456 kc; using 78 tube with 250 v. plate, 100 v. screen, 3 v. grid. Curve A: Iron-core transformer (1.5 mh at 1,000 cycles, in shield); gain, 263. Curve B: Good air-core transformer, gain, 172. Curve C: Poor air-core transformer, gain, 151.

Q OF TRANSFORMERS

To any engineer familiar with the design of intermediate-frequency transformers, it may readily be appreciated that more precautions must be exercised in using a coil having a Q of approximately 150 such as this iron-core coil possesses at 456 kc, than with the usual air-core coil having a Q generally below 100. All stray capacities must be kept to a minimum and definitely established, as the coupling between primary and secondary required to produce critical coupling is correspondingly lower. For this reason the mounting that supports these coils has provisions made for securely fastening the leads in position up to the point where they extend beyond the shield. Provision is made to allow for setting

COMMENT . . *Production*

the magnetic coupling at any desired value to produce the required gain and selectivity for the unit. At the same time care should be taken in placing the connecting leads when installing these units in a chassis so that the coupling will not be disturbed. Means for trimming these coils are provided through the top of the shielding container.

USE IN RECEIVERS

As to the use of these units in a receiver, it will be well to bear in mind that air-core coils cannot always be replaced by iron-core coils of the same inductance. Due to their higher Q's, the tuned circuit resonant impedance is much larger, and will not only result in higher gains and greater selectivity, but in some cases instability, due to stray capacities and inherent tube capacitances, which would otherwise be negligible. Therefore, the coil manufacturer may be in a better position to offer the correct iron-core unit if consulted than for the set designer to resort to past experience.

With the proper constants employed, however, the improvement in performance is quite surprising, and is usually the easy way to solve a difficult problem in selectivity and sensitivity.

COMPARATIVE CURVES

The accompanying curves serve to show what a substantial improvement results in the use of iron-core coils, as against well-designed air-core coils, taking a 456-kc i-f as typical.

The same improvements which characterize the iron-core i-f transformers, serve in the case of iron-core antenna and interstage tuning units. At broadcast frequencies, a higher grade core must be employed, since the iron losses increase exponentially with frequency. However, secondary coils are available which have Q's ranging from well over 200 to somewhat below that figure, over the broadcast band. It is readily apparent what the resultant gains will be, as an interstage unit may have a gain averaging around 175 over the band. In the antenna, consistent gains of around 20 are obtainable. These improved gains are accompanied by increased selectivity, bandwidths being about 50% at 10 times down of that encountered in the better air-core coils now in use.

ANTENNA GAIN

It is evident to the engineer what an improved antenna gain will do for him in reducing the signal-to-noise ratio of his receivers. The improved selectivity of both interstage and antenna units will markedly improve image ratios in superheterodyne sets. Here again, let it be said that these iron-core coils behave like air-core coils, so that they will track in the usual way with air-core units, if such a combination proves advantageous.

In conclusion, it may be said that the incorporation of iron-core coils in the design of radio receivers will unquestionably improve their performance, over that obtained with air-core coils, without presenting any unusual manufacturing difficulties.

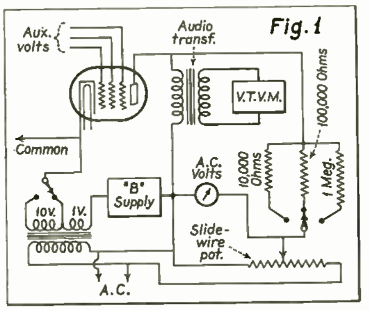
F. N. JACOB,
Engineering Department,
Aladdin Radio Industries, Inc.

A PLATE-IMPEDANCE BRIDGE

ONE OF THE MOST important tube characteristics is plate impedance. In amplifier tubes of the screen-grid type this characteristic together with the transconductance, S_m, determines the gain possible in an amplifier stage. If the plate impedance is sufficiently high, the gain per stage becomes simply S_mR_1, the transconductance times the load impedance. It is often important to be able to quickly ascertain values S_m and R_p on a given tube. The former characteristic can be easily measured by ammeter-voltmeter methods, on any of the various S_m meters, or on the older style General Radio bridges which are commonly found in most laboratories. R_p, however, especially when it is of the order of several megohms, can not be easily measured by changing plate voltage and noting the corresponding plate current change, nor can it be measured on any of the more common tube testers.

CIRCUIT AND ITS USES

In the absence of equipment designed to measure this characteristic, the writer has found the circuit of Fig. 1 a highly satisfactory and simple means for making this measurement with sufficient accuracy for most purposes.

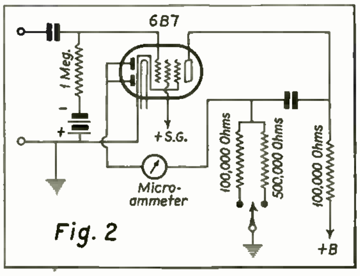


Schematic diagram of the plate-impedance bridge.

It is possible to measure impedances of a few hundred ohms up to 10 megohms with this, and the equipment can be checked readily by the insertion of known resistors. It is possible to notice and measure the loss of output impedance in tubes of the 58 type due to secondary emission from the walls of the glass envelope; to measure the ac impedances of the grid circuit and note the effects of the grid emission; and to measure negative resistances and the impedances that the elements of multi-electrode tubes, such as the 6A7, offer to their respective circuits.

VARIABLE VOLTAGE USED

Instead of using a thousand-cycle source as is usually done in bridge measurements, the 60-cycle ac mains voltage is employed. It is thus possible to neglect capacity effects entirely as the plate-ground capacity of the average tube has a reactance of 25 megohms or so at 60 cycles.



Schematic diagram of the vacuum-tube voltmeter.

Instead of using a fixed voltage source and varying a standard resistance, a fixed standard resistance is employed and the voltage source varied. A suitable fixed voltage is applied in series with the impedance to be measured and an adjustable out-of-phase voltage is applied in series with a standard resistor in such a fashion as to balance out the current through the unknown impedance.

This latter voltage is adjusted until the galvanometer, which can be any handy vacuum-tube voltmeter, indicates a minimum. The ratio of the voltages times the value of the standard resistor gives the unknown impedance. It has been found perfectly practicable to obtain the fixed voltage by means of a slide-wire potentiometer tied across the line.

ANODE VOLTAGE SUPPLY

It is also preferable to keep the anode

(Continued on page 26)

BRITISH PATENT POOL

ENGLISH COMBINE BANS IMPORTS OF AMERICAN RECEIVERS INFRINGING ANY OF POOLED PATENTS. NO LICENSES HAVE AS YET BEEN GRANTED OUTSIDE OF GREAT BRITAIN.

THE BRITISH RADIO patent "Pool" which consists of the British Thomson-Houston Co., Ltd., Electrical and Musical Industries, Ltd., Marconi's Wireless Telegraph Company Ltd., Standard Telephone and Cables Ltd., the Western Electric Co., Ltd., and Hazelpat Ltd., hold a number of patents, of which the 58 given in the accompanying list are the most important. The numbers in each case are the British Patent Office numbers:

275/15..Push-pull
15448/15..Center tap
119365..Neutrodyne
135177..Superheterodyne
141033..Tone correction
141046..Hartley oscillator
142115..Filter circuits
143583..Superheterodyne
150415..Cascade amplifier
151346..Resistance-capacity amplifier
195589..Radio-gramophones
209184..Automatic grid-bias
216114..Automatic grid-bias
216246..Metal deck
221868..Gang condensers
230150..Center-tap frame aerial
231420..Loudspeaker suspension
231421..Loudspeaker with baffle
233417..Tone correction
240851..DC mains eliminator
243371..Heterodyne receiver
245796..Loudspeaker
245839..Tone correction
246897..Mains drive
247213..Smoothing system
248731..Loudspeaker winding as smoothing choke
250931..Speaker with eddy current rings
259664..Volume control
260036..Amplifier
260148..Pickup
260537..Pickup volume control
266749..Grid-bias
279808..Superheterodyne
281740..H. F. transformer
283120..A. V. C.
285020..Screening
290239..Flat diaphragm
290559..Pickup
294250..Grid-bias
294285..Loudspeaker spiders
303105..Turntable drive
303758..Split condenser vanes
314669..Sectional radiogram cabinet
324169..Induction motor
331007..Constant reaction
334996..Gang condensers
340389..Mains aerial
348540..Automatic grid-bias
349576..Combination switch
355706..Remote control
358932..Reaction circuit
370030..Frequency correction
372155..A. V. C.
377307..A. V. C.
381847..Volume control
392230..A. V. C.
393318..A. V. C.
323983..Bandpass filter

MOST IMPORTANT PATENTS

The most important of these are the 275/15—the original push-pull patent which is extended until January 1935; 15448/15—the center-tap (November 1935); 135177, which covers the use of an intermediate-frequency amplifier in a superheterodyne; 363758, split and vane of a tuning condenser; 195589, combined radio and gramophone; and 259664, the Western Electric automatic volume control patent, which covers all the modern forms of avc and has still about 8 years to run.

There are numerous Haseltine patents which include those on push-pull circuits (Nos. 357286, 357306, 358887, and 358132, all of 1929); the use of trimmers in tuning circuits (Nos. 250-162 of 1925); automatic volume control (No. 293462 of 1927); H. F. transformer construction; Neutrodyne and Loftin White circuits and No. 284311 of 1925 on de-coupling receivers by means of resistances and condensers.

POOL DIRECTION

Marconi's Wireless Telegraph Co., Ltd., is the operating member of the pool and they may grant licenses on behalf of the pool. At present no licenses are issued for the sale of imported apparatus. This means that in theory the pool will not allow the importation and sale of American or other foreign radio receiving apparatus if that apparatus makes use of any of the features over which the pool has control. In practice some American sets are being imported but the Marconi Company threatens to bring suit against any company violating its patent rights.

WHOLESALER'S AGREEMENT

The Radio Wholesale Trading Agreement is another factor operating against the sale of American sets. This agreement, which began in 1931, is between a group of the largest radio manufacturers and about 170 wholesalers. It provides that the manufacturers may supply radio equipment only to the wholesalers who are signatories to the agreement, and the wholesalers, on the other hand, agree not to handle either foreign radio equipment, or equipment made by British manufacturers who are not subscribers to the agreement.

ROYALTY ON ELECTRON STREAMS

The pool will license British manufacturers only and each license expires on August 28, 1938. The royalty is 2 shillings 6 pence for each tube intended to be employed in complete broadcast receiving apparatus and radiogramophones, and 1 shilling 3 pence for each tube intended to be employed in sets of parts of such equipment. There is also an additional charge of 2 shillings 6 pence on each radio gramophone or set of parts. The royalty payable upon a battery eliminator sold as a separate unit is upon a flat rate of 1 shilling 3 pence, but no royalty has to be paid when a battery eliminator is incorporated in a complete broadcast receiver or radiogramophone. A tube is defined as being the cathode-anode stream and thus a multiple tube is one designed to operate with more than one cathode-anode stream and *its royalty has to be paid on each stream.*

BAN ON EXPORTS

Licensees are not permitted to export without special written permission and they cannot sell foreign sets. They have to pay as soon as they receive their licenses the sum of £150 each as the minimum royalty for one year and this sum is not returnable under any circumstances. This means that licenses are issued only to manufacturers with minimum annual production of 300 sets. Numbered plates indicating that the set has been manufactured under license must be attached to all apparatus subject to royalty under the terms of the license.

· RMA NEWS ·

CODE OPERATING PLAN ARRANGED BY RMA WITH NRA AND NEMA COMMITTEE

CONTINUED NRA-CODE operations of radio manufacturers under the present electrical code but with definite allocation of radio receiving set and other manufacturers into distinct radio and electrical industry groupings was arranged at the Washington conference on January 15 of NRA with code committees of RMA and NEMA.

No revision of the electrical code is in prospect. Therefore, the present wage and hour labor provisions, trade practices, etc., of the electrical code and the general code operations, reports, etc., promise to continue indefinitely.

At the Washington conference on January 15 the RMA presented and the National Recovery Administration accepted an agreement on a course of code action affecting radio manufacturers. A partial compromise settlement resulted. It provides for continued code operations as at present under the electrical manufacturing code, but with RMA and the radio "industry" officially recognized by the government and also by NEMA, to include manufacturers of radio receiving sets and a large number of parts and accessory manufacturers. These were definitely allocated, respectively, under the present code supervisory agencies (Messrs. Arthur T. Murray of Springfield, Mass., for set manufacturers, and Leslie F. Muter of Chicago for parts and accessory manufacturers, as now in effect). Provision was made also for future allocation (to the radio section) of tube and other parts manufacturers by majority vote of their respective groups.

Final agreement was not reached on the code status of manufacturers of audio and radio power transformers, long- and short-wave switches, public-address equipment, commercial receivers, including police, aircraft, government, etc., and a number of minor parts and accessories. These will temporarily continue their present code operation subject to further negotiations between RMA and NEMA with later decision by NRA. That transmitting apparatus and microphones were properly part of the electrical industry and under NEMA jurisdiction was conceded by RMA.

The specific parts and accessory manufacturers officially and formally recognized January 15 by both NRA and NEMA as belonging to the radio group and officially placed under Code Supervisor Muter of the parts and accessory division and, therefore, continuing their present code operations, included the following:

Carbon resistors, suppressors, wire-wound resistors and volume controls.
Fixed mica, electrolytic and paper condensers.
Variable condensers.
Sockets.
Loudspeakers.
Radio-frequency coils.
Vibrators.

An important feature of the RMA agreement which was approved by the National Recovery Administration exempts RMA members from any code expense or assessment by the NEMA code authority. It is provided that the RMA make such payment to NEMA in a lump sum for RMA members, the amount to be mutually agreed upon between RMA and NEMA, "if and when application is made for a supplemental code."

Another important clause of the agreement declares and recognizes that "trade association functions and activities are entirely distinct and separate from code authority functions and activities."

In consideration of the partial compromise settlement recited formally, and with the definite understandings for continued operations under the electrical code, the RMA withdrew, "without prejudice to the making of a new application," its request of June 19, 1934, for exemption of radio manufacturers from the electrical code and a separate radio code. However, this will permit RMA, if it is deemed desirable later after Congress revises the National Recovery Administration in June, to make further application for a separate radio industry code. NRA officials asked when a supplemental radio trade practice code, under the basic electrical code, might be submitted, but Chairman Sparks and the RMA Committee could give no definite opinion at present.

Agreement on procedure with the two supplemental codes submitted by NEMA, the first for transmitting, public-address and commercial receiver manufacturers, and the second for "specialty transformer" manufacturers, including audio and radio power transformers, also was reached at the conference. On the first supplement, the NRA will later decide regarding public-address manufacturers. Later also NRA will proceed with public hearing on the transformer supplemental code, possibly within a month.

The NRA conference at Washington was opened by William T. Witherow of the National Industrial Advisory Board and NRA Deputy Administrator Tutein and Assistant Deputy Administrator Howland. Many other NRA officials also attended. In addition to Chairman Sparks of the RMA Code Committee, the following represented the RMA: President, Leslie F. Muter, James M. Skinner of Philadelphia, A. S. Wells of Chicago, and Arthur Moss of New York, members of the RMA Code Committee, and also Messrs. Arthur T. Murray of Springfield, Mass., chairman of the RMA Set Division and code supervisor for set manufacturers; R. R. Kane of Camden, N. J.; John W. Van Allen of Buffalo, RMA general counsel, and Bond Geddes, RMA executive vice-president and general manager. The NEMA Committee included President Frank C. Jones, Messrs. W. E. Sprackling, E. O. Shreve, S. L. Nicholson, Robert Edwards, Francis E. Neagle, NEMA counsel, and W. J. Donald, NEMA managing director.

RMA DIRECTORS DEVELOP 1935 PROMOTION PROJECT

Substantial progress on the national radio promotion project of the RMA was reported to the RMA Board of Directors at their meeting January 10 at Chicago by Powel Crosley, Jr., of Cincinnati, chairman, and the trade promotion committee. President Leslie F. Muter presided at the directors' meeting at the Union League Club. The RMA Board provided for further development of its promotion project and considered important radio and other industrial legislation expected in the new Congress and forty-four State Legislatures now convening.

In its 1935 promotion plans, the RMA decided to include sponsorship by the Association of a radio public show next October in Chicago. Under private management, which has been successful in past years, the RMA will sponsor the Chicago public show. To Chairman Crosley's trade promotion committee, Commander E. F. McDonald, Jr., of Chicago, Mr. George A. Scoville of Rochester, N. Y., and N. P. Bloom of Louisville, Ky., were added as members to assist Chairman Crosley.

Various code problems also were considered by the RMA Board prior to the subsequent meeting on January 15 of the RMA and NEMA code committees with the National Recovery Administration at Washington.

Opposition to the thirty-hour week legislation in Congress or to any increase of the present five percent federal excise tax on radio was recorded. Paul B. Klugh of Chicago, chairman of the RMA legislative committee, advised the Board that the five percent excise tax probably would be continued because of government revenue needs but that any increase was improbable and would be opposed, if necessary. Arrangements to take prompt action on radio legislation expected from the many State Legislatures beginning their work also were made by the RMA Board.

Congress is preparing to enact the recommendations of President Roosevelt in his budget message of January 7 to continue the five percent excise tax on radio and phonograph apparatus and also all other excise taxes.

Citing the budget needs of the Government, President Roosevelt said it was necessary to extend the "nuisance" taxes which are estimated to yield $377,700,000 in the 1936 fiscal year. During this period the estimated returns from the radio tax are $3,600,000, Government actuaries apparently holding the opinion that radio sales will continue stable and at about the same rate as the past year.

STANDARDS COMMITTEE MEETS

For further discussion of tube standards, the RMA Tube Committee of the Engineering Division met January 25 at the Hotel New Yorker with Roger M. Wise of Emporium, Pa., presiding.

Many radio and affiliated organizations have responded most favorably to the RMA invitations for the cooperative campaign to remove and reduce sources of radio interference. Dr. W. R. G. Baker of Camden, N. J., chairman of the RMA Engineering Division, and Virgil M. Graham of Rochester, N. Y., chairman of the Standards Section, with Dr. Alfred N. Goldsmith of New York, chairman of the

(*Continued on page 30*)

SIGNAL GENERATOR ATTENUATOR DESIGN

(*Continued from page* 15)

struction of the "figure 8" type of resistance, and also show a complete attenuator unit, showing the sectional construction, location of the resistances and manner of connecting the sections and the shielding on input and output leads. The case on this particular unit is six inches long, and 4 inches square, of copper, but these dimensions can easily be considerably reduced, if desired.

It is felt that the above details should give sufficient information so that the experimenter and designer can readily build up signal generator attenuators which will work satisfactorily up to the highest frequencies employed in most present-day receivers, and that the treatment, while necessarily not very detailed, will suffice to guide in the design of any type of attenuator similar to the general types above described.

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DIATHERMY INTERFERENCE

(*Continued from page* 21)

the switch box and a BX connector, fastened to the end of the short piece of BX supplied with the filter should be used to hold BX in place.

It is suggested that a washer be placed over the BX connector in such a manner that the metal screening will be held in firm contact with the switch box when the BX connector has been fastened into the switch box. It is important that the BX sheath, the switch box and the metal screening be bonded together for most satisfactory results. To complete the filter installation, a short wire must be connected from the filter binding post to the metal screening. An excellent method of making this connection is to wrap the return wire around the BX connector so that it will be held between the screening and the washer which has been recommended.

CONNECTING FILTER TO BUILDING WIRING

There are several possible methods of connecting the filter installation to the power-supply line. The following method is recommended: Mount on the front of the switch box a flush plate having an outlet for a telephone cord. A composition plate (such as G. E. catalog No. GE2349) is recommended. Carry through this plate an attachment cord of sufficient length to reach the nearest baseboard outlet or wall receptacle. Note: Do not connect the apparatus to a lighting fixture, as the wiring of fixtures is not designed to handle the current required by Diathermy apparatus. The cord used should consist of two No. 14 conductors and should be type PO or its equivalent. A standard attachment cap should be connected to one end of this cord and the other end should be spliced to the conductors of the BX within the switch box. Whenever the Diathermy apparatus is not in use, the attachment plug of the entire installation should be removed from the baseboard or wall receptacle.

WIRING FOR LARGE MACHINES

In installing a filter for 25-ampere machines, a separate branch circuit of No. 10 wire should be run from the service entrance of the building to the Diathermy screen and an indicating switch opening the ungrounded conductor should be mounted on the outside of the screen booth. The filter should be mounted just inside the booth opposite this switch, and a short piece of flexible metal conduit should be connected from the switch box to the input side of the filter.

Terminals, protected by a metal housing, are provided at the output side of the filter to facilitate connection of the Diathermy machine to the filter. Be sure to protect the connecting cord by means of a porcelain bushing where it enters this housing. A switch is also provided in this type filter to compensate for the line drop when the Diathermy apparatus is used at its full capacity.

It is important to note that any wiring which enters the screen booth must pass through the filter, otherwise, interference will be picked up on this wiring and carried out of the booth, thus reducing the value of the shielding. In other words, any lighting fixtures used for illuminating the interior of the booth must be mounted above the top of the booth so that the light shows through the screen, or if they are installed within the booth must be connected to the load side of the filter. Doorbell, annunciator, or telephone wiring must also be kept outside the screen, otherwise, the interference will be picked up on this wiring and carried out into the building, thus nullifying the value of the filter and screening.

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"IMPEDANCE-MATCHING NETWORKS"

IN THE ARTICLE *Impedance-Matching Networks* which appeared on page 12 of the October, 1934, issue of RADIO ENGINEERING, there are certain discrepancies that should be called to the attention of the reader.

A typographical error appeared in the first and third lines of the example calculation where (250—50) has been written instead of (200—50) for R_s—R_L. This, of course, has in no way affected the actual values obtained for R-1 and R-2.

Further, the formulae derived by Mr. Ephraim are misleading in that the original premise of db loss being a power ratio is not carefully followed in the derivation. As a result the pad as calculated neither has a 15-db loss nor does it match the terminal impedances. This point may be proved by calculating the impedance looking into each end of the pad. From such a calculation it will be found that the high-impedance end presents a resistance of about 189 ohms, instead of 200, and the low-impedance end of the pad presents a resistance of 53.2 ohms, instead of 50.

The correct formulae for T-type pads are given by equations (1), (2) and (3) on page 12 of RADIO ENGINEERING for December, 1934 (*The Design of Resistance Pads*, by C. F. Nordica). These formulae yield values of 176.4 ohms (R-1), 16.5 ohms (R-2) and 36.8 ohms (R-3).—*Editor.*

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A PLATE-IMPEDANCE BRIDGE

(*Continued from page* 23)

voltage supply in the ground branch of the bridge. This voltage source can be an ac power pack but the auxiliary voltages applied to control grid, screen grid, or other electrodes had best be from batteries. When the impedance is of the order of several megohms even the most minute ripple in the screen or control-grid voltages will produce larger alternating currents in the bridge circuit than those caused by the desired voltage, and hence, a balance becomes impossible.

V.T.V.M. CIRCUIT

Fig. 2 is a schematic of a vacuum-tube voltmeter which the writer employed with the circuit of Fig. 1 and has found very convenient for low-frequency measurements. It is quite sensitive and requires no buck-out adjustment. For different sensitivities, different values of series R may be used with the microammeter. This is preferable to using shunts as the damping of the microammeter is not affected.

This equipment can be quickly set up. It has given the writer satisfactory service for a number of months.

EDWARD ATKINS

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MORE GERMAN LISTENERS

ELECTRICAL FOREIGN TRADE NOTES, No. 350, December 5, 1934, reports that the total number of licenses issued for broadcast listening in Germany totaled 5,725,394 on November 1, 1934. This is an increase of 151,395 over the figure of October 1. (*World-Radio*, Nov. 16, 1934.)

NEWS OF THE INDUSTRY

RADIO INSULATION FOLDER

The Synthane Corporation of Oaks, Penna., has issued a new four-page folder on Synthane laminated bakelite radio insulation. The folder, a copy of which will be sent on request, describes the characteristics and standards of quality for Grades X and XX Radioform tubing, coil forms, sheets, rods, tubes and panels. The facilities of the Company for assisting in the design of part and selection of the proper materials or in complete fabrication where desirable are also clearly presented.

G. E. SALES UP

Orders received by the General Electric Company during the year 1934 amounted to $183,660,303, compared with $142,770,791 for 1933, an increase of 29 percent, President Gerard Swope has announced.

Orders for the quarter ended December 31 amounted to $51,046,760, compared with $37,985,790 for the last quarter of 1933, an increase of 34 percent.

Sales billed and earnings for the year 1934 are not yet available. The complete annual report will be issued in March.

BELDEN OPENS EASTERN WAREHOUSE BRANCH

The new Belden Warehouse in Philadelphia, Pa., will carry complete stocks of Belden Magnet Wire and operate a new Soft Rubber Plug Assembly Division for the purpose of giving immediate service to the Eastern market. This announcement, just released by the Belden Manufacturing Company, 4689 W. Van Buren St., Chicago, Ill., also states that Mr. E. V. (Bob) Blake, for eight years connected with Belden in the capacities of territorial representative and Sales Service Manager, will be in charge, as Eastern Manager.

The new Belden branch is ideally located in the New Terminal Commerce Bldg., 401 N. Broad Street, Philadelphia, Pa., where important R. R.—Express—Post Office—and Trucking Terminals are in the warehouse building to facilitate shipments to any point in the territory.

COMMUNICATION ELECTRONICS AT COLUMBIA UNIVERSITY

The advanced course in electronics which is offered in the Engineering School at Columbia University has recently been expanded to cover a full year. The first term deals with those aspects of electronics which are of interest chiefly to the electrical engineer, while the second term's work is concerned entirely with communication electronics. Since the two terms may be taken separately, the latter portion is of particularly interest to the communication engineer.

Subjects treated in the second half year include resistance and transformer-coupled audio amplifiers, the output stage, push-pull and Class B amplification, motor-boating, circuit noise, etc. Radio-frequency amplification is also dealt with at length, as are such subjects as waveform distortion, cross-modulation, and the new feed-back amplifiers. The theory of linear detectors is developed and consideration is given to exponential conductors and other non-linear circuit elements. Vacuum-tube voltmeters and constant-frequency oscillators are also included in the course.

In addition to providing a comprehensive survey of the field of communication the course also gives 3 points of credit towards the Master's Degree.

Meetings are held on Thursday evenings from 7 to 9.

CHANGE OF NAME AND ADDRESS

Due to a continued increase in business the Bests Radio Service and Supply Co., announce that they have been compelled to move to larger quarters. With this move they have changed their name to one more descriptive of their business. However, this change in name has in no way changed the structure or personnel of the company.

The new name is Standard Radio Parts Co., and the new address is 25 North Jefferson Street, Dayton, Ohio.

MYCALEX BOOKLET

The Mycalex Corporation of America, 101 West 31st Street, New York, N. Y., have recently issued a very interesting booklet on Mycalex Low-Loss Insulator.

This booklet gives a brief history of Mycalex, telling of its composition, of processing, and where it was developed. Technical data on the mechanical properties and electrical properties of this insulating material are also given. Among the other factors considered in this booklet are: warping, form in which Mycalex is obtainable, machineability, and how to work the material. Three illustrated pages showing examples of machined Mycalex is included.

NEW SOLAR BOOKLET

The Solar Manufacturing Corporation, 599-601 Broadway, New York City, have just issued a new booklet designed to show why capacitors in the making can incorporate quality. This 36-page booklet gives the life history of their condensers by means of pictures taken in the Solar plant, and gives it in a very interesting manner.

The Solar Company are manufacturers of wet and dry electrolytics, paper capacitors, mica and trimmer capacitors, all of which are covered in this new publication. Of added value is a complete list of their sales offices.

STRUTHERS DUNN FOLDER

An attractive folder has just been issued by Struthers Dunn, Inc., with factory and offices in Philadelphia, which gives a birds-eye description of their entire line of relays, timing devices, electric counters, thermostats, electric pots and ladles, together with the engineering service they are prepared to render.

It has been artistically printed in two colors, and a copy will be sent anyone writing Struthers Dunn, Inc., asking for Bulletin P72, and mentioning this paper.

NICKEL JOINS HYGRADE SYLVANIA

Edwin A. Nickel, well-known for the past fifteen years in advertising and sales promotion circles, has joined the staff of Hygrade Sylvania Corporation. He will make his headquarters in the New York office of the corporation, and will also spend some time in the field in sales promotion activities for both Hygrade Lamps and Sylvania Radio Tubes.

Mr. Nickel has had wide experience in various branches of advertising and sales promotion. He has for the past six years been sales manager and advertising consultant in the Philadelphia and Chicago branches of Dictagraph Products Company, Inc. Previous connections were with the Lennen & Mitchell and Chas. W. Hoyt Advertising Agencies, and as assistant manager of Fada Radio Company.

NEW FLECHTHEIM APPOINTMENT

Mr. Arthur M. Flechtheim, President of A. M. Flechtheim & Co., Inc., takes pleasure in announcing the appointment of Mr. Harold E. Walton, of Saginaw, Michigan, as representative for the entire line of Flechtheim Products, in the State of Michigan.

Mr. Walton has been associated with the radio industry for many years and we are sure his many friends throughout join us in the hope that he will enjoy a long and prosperous association with his new affiliation.

INTERFERENCE-FILTER PRICES

In keeping with the far-reaching purposes of the interference-prevention campaign launched by the Radio Manufacturers Association during the recent I. R. E. convention at Rochester, N. Y., a marked reduction in list prices of interference filters is announced by the Aerovox Corporation, Brooklyn, N. Y.

RESINOX DOUBLING PLANT

At its December meeting the Board of Directors of the Resinox Corporation authorized expenditures for additional equipment which will practically double the present capacity of the Resinox factory at Edgewater, N. J. This expansion in manufacturing facilities has been made imperative by the increasing demand for Resinox Molding Powders, it is said. While Resinox has during the past year experienced a large increased demand for its standard types of molding powders, there is said to be particular interest on the part of molders in the recently introduced odorless and water-resistant materials.

NEW PUBLIC-ADDRESS CONCERN

Announcement has been made of the organization of the Morlen Electric Company, Inc., 100 Fifth Ave., New York, N. Y., manufacturers and engineers of public-address amplifiers and accessory equipment.

Morlen Electric Company will carry on the development and marketing of the amplifier products heretofore sold by the Simplex Electric Co., Inc.

The new Morlen Professional Line of public-address amplifiers has been designed especially to meet the rigid requirements of commercial operation under all conditions.

Amplifiers are available in chassis, rack and portable types and in power ranges from 3.2 to 175 watts audio output. In addition there will be a complete line of commercial field exciters, in various current ratings up to one ampere, at 125 volts.

Bulletin No. 4, covering the complete Morlen line of equipment, is now available. Copies may be had on request to the manufacturer.

NEW PRODUCTS

RADIOTONE RECORDING UNITS

The Radiotone Recording Co., 735 No. Seward, Hollywood, Calif., are manufacturers of sound-recording equipment, such as screw-feed mechanisms, motors and turntables, recording assemblies, amplifiers, acetate recording discs, studio installations, playback needles, aluminum blanks, and cutting styli.

The following features are incorporated in the Radiotone Recording Units: Positive overhead screw feed, mechanism belt driven; motors designed for recording; chassis designed for recording on Acetate or Aluminum; cutting heads damped and tested; special pulleys provided for cutting 96 or 115 lines per inch; standard cutting head impedance is 500 ohms, but can be supplied in 200, 50 or 15 ohms to match special equipment.

•

NEW MINIATURE RECTANGULAR INSTRUMENTS

A line of moderately priced direct-current, radio-frequency and rectox miniature instruments designed to harmonize with radio and communication equipment is announced by Westinghouse Electric and Manufacturing Company. Only one large hole in the panel is required for mounting and all visible mounting screws are eliminated by using mounting clamps. For ease in connecting and to save space, soldering clips are standard for electrical terminals of these instruments. These RX instruments have a scale length of 2.4 inches, are accurate within 2% (rectox types 5%) and flange dimensions measure 3x3-⅛ inches with zero adjusters on the outside. Vertical decorative lines give the dull matte Moldarta cases distinctive appearance.

•

NEW CRYSTAL MICROPHONES

A series of new diaphragm-type crystal microphones is announced by Shure Brothers Company, microphone manufacturers, 215 West Huron Street, Chicago. The instruments are intended for general-purpose use and have a higher output level than non-diaphragm type crystal microphones.

The crystal element is of the "bimorph" type, and is "cantilever" actuated—a new principle in crystal microphone construction. This principle, combined with proper design of the crystal-diaphragm coupling system, affords a "matched-impedance" mechanical circuit.

A low gain single-stage of amplification is generally sufficient to bring the electrical output level up to that of a high-quality two-button carbon microphone, it is said.

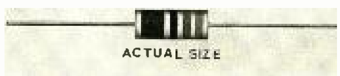
No coupling transformers are necessary, and the microphones operate entirely without polarizing voltage or exciting current. They are said to be quiet in operation, there being no background noise or "hiss" produced by the crystal element itself. The instruments are rugged and durable. Extreme conditions of heat and cold do not appreciably affect their operation and only moderate care in handling is necessary, they state. The microphones are licensed under patents of The Brush Development Company.

NEW ERIE INSULATED RESISTOR

The Erie Resistor Corporation, Erie, Pa., has recently placed on the market a new line of 1/4-watt insulated carbon resistors. This new product consists of a molded carbon resistance unit enclosed in a ceramic case. Leads are brought out at the ends to facilitate wiring and insulation with spaghetti, if necessary.

Many features hitherto unavailable in carbon resistors are incorporated in this new product, it is said. The ceramic insulation eliminates entirely the danger of "shorts" even in the smallest spaces. Including the ceramic shell, over-all dimensions are smaller than for the corresponding non-insulated Erie Resistor. Outside dimensions are 11/64" x 7/16". The use of these resistors simplifies many difficult installation problems and in many cases makes relocation possible with greater resultant efficiency. For example, they can be placed inside i-f tranformer cans without the addition of further insulation.

These resistors present a distinct improvement in respect to color coding. Difficulty in reading the resistance value when the conventional dot is not in clear view is a common occurrence. This is entirely overcome with the new Erie Resistor as the coding consists of color bands completely encircling the ceramic shell. The widest band, which is at one end, represents the first figure in the resistance value; the band next to it, the second; and the third band, the number of ciphers following the first two figures, in accordance with standard RMA practice. When the purchaser desires it, a fourth band specifying tolerance may be added.



The ceramic covering is so designed that it cannot be removed from the resistance pin, although it is purposely made slightly loose to compensate for contraction and expansion of the resistor inside it.

The ¼-watt unit is now available in production quantities; ½-watt and larger sizes will be offered in the near future.

For samples write the Erie Resistor Corporation, 610 West 12th Street, Erie, Pa.

•

BENCH AND PEDESTAL GRINDERS

Skilsaw, Inc., 3310 Elston Avenue, Chicago, announce an addition to their line of portable electric tools . . . a new and complete line of bench and pedestal grinders and combination grinder-buffers both bench and pedestal type. The selection of sizes available includes units for intermittent tool shop use and for production grinding and buffing.

Equipment on the grinders is complete. Guards on the larger models are the enclosed type of heavy, durable metal. Tool rest on all models is adjustable for wear of wheel; and tool rest, as well as guards, can be removed for buffing work. Switch in base, 10 feet of cord and plugs, one coarse and one fine grinding wheel are supplied. On the combination grinder-buffers, a tough, durable wire brush is standard equipment on the buffer side of the unit. Upon request, a buffing wheel will be supplied in place of the wire brush at no additional cost. A medium grit wheel is on the grinding side of the tool.

Units can be furnished in all popular voltages for the types and sizes of grinders available.

•

RESONANCE CALCULATOR

The Lightning Calculator Co., 8 Henry Street, Bogota, N. J., will soon have available their model LCP Resonance Calculator.

All Lightning Calculators are made up of a number of movable dials mounted on a backboard and provided with a celluloid indicator. These units are designed for various circuit problems and direct reading answers may be obtained by the proper dial and indicator settings.

The model LCP has been designed to calculate problems in resonance by simple dial settings and thus eliminates the necessity for the more laborious method of actual calculation. It is provided with the following ranges: Capacity, .001 mmfd to 10 farads; inductance, 1 mh to 1,000 henries; reactance, 1 to 10,000 ohms; and frequency, 1 cycle to 10 megacycles. Each of these ranges are engraved on separate scales and calibrated directly in the values given.

The following is a sample problem that may be easily solved by use of the Model LCP: What is the resonant frequency of a 10-henry choke and a 1-mfd condenser connected in series? What is their reactance in ohms?

Other Lightning Calculator Models available are: Radio Calculator (Model SWP), Wire Data Calculator (Model WDP), and Ohm's Law Calculator (Model OLP).

•

NEW TUBULAR CONDENSERS

The Federal Engineering Co., 286 Mercer Street, New York City, have just announced a new line of tubular condensers in all

sizes and capacities. A .5-mfd. 400-volt (working) dc unit is shown in the accompanying illustration.

•

CRYSTAL PHONOGRAPH PICK-UP

A new Crystal Phonograph Pick-up is announced by the Ansley Radio Corporation of New York, who are using it on their Radio-Dynaphone Combinations. In addition to the light weight and high fidelity, characteristic of crystal pick-ups, the manufacturer claims other advantages, such as, built-in sponge rubber suspension

New Components—
Advanced Designs—
Auto Radio—

These and many other timely subjects will be covered in early Spring numbers of Radio Engineering.

The advertising pages as well as the text pages will carry extremely interesting announcements.

(Radio Engineering's readers total well over 6,000)
A.B.C. audit statement on request

which insulates the pick-up from speaker and motor vibration, and a "vertical pivoting" arrangement which reduces friction to a minimum. While it was developed primarily for use in the Ansley Dynaphones and Combinations, the pick-up will also be sold separately to dealers and distributors.

•

BELL P-A SYSTEM

The Bell Model P. A. 2C Public-Address System, shown, has been developed to meet the increasing demand for a practical, high-quality, light weight and efficient single unit, twin-speaker portable public-address system, it is said. This equipment may be used for public address in auditoriums, funeral homes, night clubs,

hotels, for paging, in ballrooms, theatres, dance bands, for publicity, political speeches, advertising, etc.

The new Crystal Microphone is utilized to make this the most modern sound amplifying system ever offered at a moderate price, it is said. The frequency response is further said to be superior to the best carbon or condenser type of microphone.

Three-stage resistance-coupled, Class A amplifier, has a wide range frequency response. All filter components are built into the amplifier chassis. The tubes utilized are as follows: 1-type 2A6; 1-type 53; 2-type 2A5's and 1-type 80. The power output is 7 watts. The following controls are provided: ac, on-off switch, volume control, tone control, and a two-program selector switch.

The entire system nests into one case 16" by 19" by 13" and weighs 50 pounds.

Manufactured by Bell Sound Systems, 264 North 4th St., Columbus, Ohio.

•

TURNER LINE AMPLIFIER

The unit shown in the accompanying illustration is a Line Amplifier produced by the Turner Company, Cedar Rapids, Iowa, for broadcast station and public-address men. This is a two-stage unit using two 57's and one 80, and it has a total gain of 70 db.

The frequency response of this amplifier is said to be flat from 30 to 12,000 cycles. The input impedance is 5 megohms, while the output impedance is 200 or 500 ohms as specified. Other output impedances can be supplied. The power supply is for 110 volts, 60 cycles, the power consumption being 25 watts. The maximum output level is plus 5 db. The overall dimensions are 15" by 5½" by 7½", with the chassis finished in black crystalline.

The parts are mounted on an electro-metal, non-magnetic chassis, and it is said that the entire chassis and input is highly shielded, eliminating possibility of line pickups.

The New Turner Line Amplifier for public-address use.

•

NEW GATES CRYSTAL MIKE

The Gates Radio & Supply Company of Quincy, Illinois, announces the release of a new crystal microphone for general broadcast and high quality public-address service. This microphone incorporates a genuine Brush sound unit of latest design and frequency response is uniform from 30 to 10,000 cycles, it is said.

The microphone is supplied complete with pre-amplifier, which incorporates a pair of 6C6 tubes and the output impedance is 200 ohms. It is supplied with 20-foot cable, plug and socket and requires 6 volts A supply and 180 volts B supply. It is beautifully finished in baked black lacquer with fittings of nickel and highly polished.

Fully described on Bulletin 6D, which can be obtained by writing the Gates Radio and Supply Company of Quincy, Ill.

•

ALLIGATOR CLIP

The Alligator Clip, shown in the accompanying illustration, and manufactured by the Mueller Electric Co., 1583 East 31 Street, Cleveland, Ohio, is a small clip with slender, enlongated jaws for radio and electrical test work . . . a clip which is said to combine the design features of their Universal Clip with the advantages of an ordinary alligator clip for getting into tight places.

The following are the exclusive design features claimed for this clip: Meshing teeth on three sides of jaws, both screw and banana terminal connections, unusual strength, handiness, and an insulator (sold separately) to prevent short circuits and electric shocks. An internal recess at the end of the insulator automatically snaps around the tubular barrel holding the clip firmly.

Further information relative to this Alligator Clip, designated as No. 85, may be obtained from the circular 680-L.

RMA NEWS

(*Continued from page 25*)

organization committee, on the interference project, are arranging detailed plans for consideration by the general industry committee on interference.

Proposed standards on radio power transformers are receiving the attention of RMA and NEMA standards committees. A draft of proposed transformer standards has been received from NEMA and submitted to the RMA for consideration.

CREDIT COMMITTEES MEET

A meeting of the RMA Western Credit Committee was held at Chicago, January 16, in cooperation with the National Credit Office, the official credit reporting agency of the RMA. Vice-Chairman P. C. Lenz of the Western Committee presided and Art Goldrick represented NCO.

The RMA Eastern Credit Committee met January 22 at the Hotel New Yorker in New York and was in charge of Vice-Chairman Edward Metzger and Ken Tibbitts of NCO.

NOVEMBER 1934 EXPORTS

The November, 1934, report of the Bureau of Foreign and Domestic Commerce of the U. S. Department of Commerce on radio exports records 77,844 receiving sets valued at $1,906,271; 602,928 tubes valued at $274,698; 18,235 speakers valued at $35,171; receiving set components valued at $428,331, and other receiving set accessories valued at $49,647, together with transmitting sets, tubes and parts valued at $86,451.

BRITISH PATENT DATA

Details of the British radio patent pool have been published by the Bureau of Foreign and Domestic Commerce of the U. S. Department of Commerce and will be supplied to RMA members upon written request to Association offices. The British patent report details the various patents, the pool operation and the license plan directed by the Marconi Company.

SCOVILLE ELECTED TO RMA BOARD

George A. Scoville, Vice-President and General Manager of the Stromberg-Carlson Telephone Manufacturing Company, was elected a director of the RMA at the meeting January 10 in Chicago of the Association's Board of Directors. Mr. Scoville was chosen to fill the vacancy caused by the death last November of W. Roy McCanne of his company. The RMA Board adopted resolutions regarding the loss to the RMA and the industry of Mr. McCanne.

FRENCH IMPORT QUOTAS

A meeting of the RMA Tube Division was held in New York on February 11 to consider the recent request from the French Government to the RMA for cooperation in allocation of quotas for tube imports of France. The French Government's request was referred by the RMA Board of Directors to the Tube Division of which S. W. Muldowny of New York is Chairman, and a representative of the French Government is now in this country for a conference with RMA officials regarding action by the Association in the intricate problem of French tube allocations.

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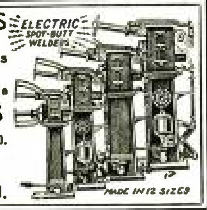

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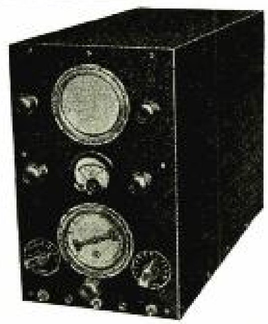


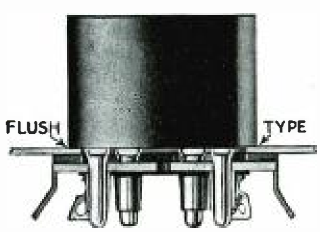
11400 Madison Ave., Cleveland, O.

INDEX TO ADVERTISERS

FRANKLIN

NEW *Flush Type* SOCKET

RESISTS *Vibration*

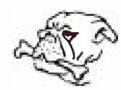


COMPARE the average socket with FRANKLIN'S new idea of the insulation ring, which permits insertion of tube shoulder so that bottom of tube **flushes** with metal chassis. No more howling and clicking during reception.

Improves Auto-Radio and All-Wave Reception—Ready for Immediate Delivery

VIBRATION is nullified, perfect electrical and mechanical contact is maintained, reception is improved, COSTS ARE LOWERED . . . by this simple, radically different socket. Designers and manufacturers who KNOW have enthusiastically approved its sensational new features.

COMPARE the bulldog grip of this new socket, insured by special attention to the design of the contacts—a distinct improvement over old methods—and a boon to the radio owner who wants noiseless reception! Tubes will not shake loose from Franklin sockets!



ECONOMY is the watchword for 1935 production. This masterly new vibration-resisting socket can actually be used to LOWER your production costs, as well as to heighten set efficiency. It will outlive the set itself. We invite fullest investigation of this claim.

Available for all types of standard prong arrangement and standard mounting centers. Let us have your specifications.

COMPARE the wide spacing of FRANKLIN contacts, which assures high insulation and leakage resistances. Made of **tapered** heavy spring brass, and how they **grip!**

ALBERT W. FRANKLIN MFG. CORP.

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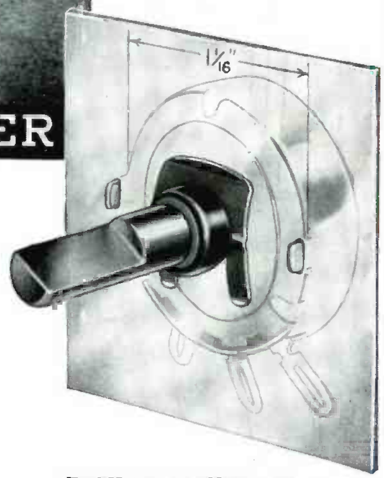
Factories: New York, Chicago, Toronto

WRITE FOR FREE SAMPLES—USE YOUR COMPANY LETTERHEAD

The Type J Bradleyometer is made in two types: Type J is a volume control without line switch; Type JS with line switch. Both units are amazingly compact. The solid molded resistor never wears out—it never changes. The dependability is inherent.

A Compact Volume Control
that is Unaffected by Wear and Extreme Humidity Changes



EASY TO MOUNT—The control is snapped into place on the panel with a C-washer. No threaded sleeves or nuts—no subsequent loosening.

The small size of the new Type J Bradleyometer is creating much favorable comment among radio engineers. Never before has so reliable a volume control been made so small.

But, even more important than its small size, is the resistor construction which makes the Type J Bradleyometer impervious to moisture and, therefore, unaffected by wide changes in humidity. Hard service and long wear have no deteriorating effects upon the remarkable solid molded resistors of the Types J and JS Bradleyometers.

Since the Types J and JS units are interchangeable with others built to R. M. A. standards, every radio receiver can now be improved with these dependable volume controls. Every radio engineer should have technical data on these units. Write today.

A SOLID MOLDED RESISTOR —NOT A FILM-TYPE UNIT— The Type J resistor is homogeneous—in longitudinal section the material is varied to suit specified resistance-rotation curves. After molding, the unit cannot change. Hard service cannot alter its performance. Practically any resistance-rotation curve shape can be provided including straight logarithmic, modified logarithmic, or linear.

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