EIGHTH YEAR OF SERVICE

RADIO ENGINEERING

Vol. VIII JANUARY 1928 Number 1

IN THIS ISSUE

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The TECHNICAL MAGAZINE of the RADIO INDUSTRY

For 1928

YOUR engineers have been working for some time on new circuits and products which you will present to the public during the next radio season.

Although it will be some time before the question of material to be purchased is settled, may we offer our services *now* to aid in the solution of problems involving resistors and rheostats.

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We both will be aided materially by this plan. Your costs, production objectives and advertising schedule can then be straightened away for a truly prosperous season.

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RADIO ENGINEERING

52 Vanderbilt Avenue, New York, N. Y.

EDITED BY M. L. MUHLEMAN

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Vol. VIII JANUARY 1928 Number 1

EDITORIAL

WE are strong in the belief that 1928 is to be an engineering year in the radio industry. Engineering ability will count for more than any other one factor and in line with this, engineers will have to shoulder a greater portion of the responsibility.

The year 1928 marks the beginning of a new era—an era that promises in no small measure the rapid arrival of the long awaited stability which eventually crowns every successful industry.

This is no time to debate the question as to whether or not the announcement of socket power operated receivers was a bit premature. The important point is reflected from the public who have accepred the announcements at face value and are ready to buy. Publicity campaigns have definitely set the public to thinking in terms of "batteryless receivers" and nothing short of a miracle could alter the trend.

The introduction of A. C. tubes has cast the die. The development of practical "A" eliminators had much to do with accelerating matters. "A-B-C" eliminators designed to couple with "series filament" receivers strengthened the story. Now the radio industry is faced with a public demand for socket power receivers and the demand must be met. Anything else is doomed to failure.

The arrival of the new screen grid tube has created a peculiar situation. The tube has such excellent qualities that it cannot be ignored. It offers the highly advantageous possibility of economic relief since its pronounced sensitivity permits equal results with a lesser number of radio frequency stages.

It is not easy to determine what its effect may be on the design of receivers for this year as we have yet to strike up an intimate acquaintance with its idiosyncrasies. However, whether or not it proves to be highly successful, it can be worked into the picture without conflicting with the general trend towards "electrification." Having a filament of low current consumption it is readily adapted to socket power operation by utilizing a series filament arrangement and an "A-B-C" eliminator with a high current rectifier tube.

Undoubtedly, present conditions are rather confusing and we find opinion divided in respect to electrification systems. There are three definite schools and discussion is bound to arise as to the relative advantages and disadvantages of A. C. tubes, series filament arrangements, with either standard or screen grid tubes, and "A" eliminators. There is much to be said for and against each system and now is the logical time to review the subject.

RADIO ENGINEERING believes that a full and open discussion of systems of "electrification" is of vital importance to the field in general. Public demand cannot be taken lightly. It is absolutely essential that the demand be met and met promptly. The sooner the whole matter of engineering practice is brought out into the open, the better.

RADIO ENGINEERING attaches sufficient importance to the movement to throw open its pages to the industry for the purpose of presenting the subject from every angle. We shall continue the program for the entire year and invite the co-operation of all the many branches of the industry whose activities are closely linked with these developments.

M. L. MUHLEMAN, *Editor*.

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Departments

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HELP!

Some time ago an advertisement appeared in *Radio Engineering* under this heading, offering a *free* service to subscribers when *they* needed help.

THIS TIME WE NEED IT!

The circulation of *Radio Engineering* has grown tremendously during the past year. Every day, scores of questions reach us, such as:

"How would you set up a one man service department?"
"Give the measurements of each foot for a 44 ft. Exponential Horn."
"Provide layout and circuit diagram of complete Broadcast Station."
"Supply calculations for power dissipation in an A.B.C. eliminator."

If they are answered a few days late we are properly "sat upon" in a following communication.

We have had to increase our technical staff to handle this correspondence. Many of the questions require research work and laboratory analysis, which devolves upon the editorial staff.

Effective at once, the following scale of charges will be made:

Average Questions	$0.25 ea.
Standard Circuit Diagrams	.50 ea.
Special Circuit Diagrams	1.00 ea.

Prices on diagrams and questions requiring research work or application of special reference work will be quoted at time of receipt of inquiry.

NOTE

We will, of course, be glad to continue to answer requests for information on sources of supply, technical publications, manufacturers lines, etc., without charge.

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READER'S SERVICE BUREAU
JOHN F. RIDER, *Mgr.*

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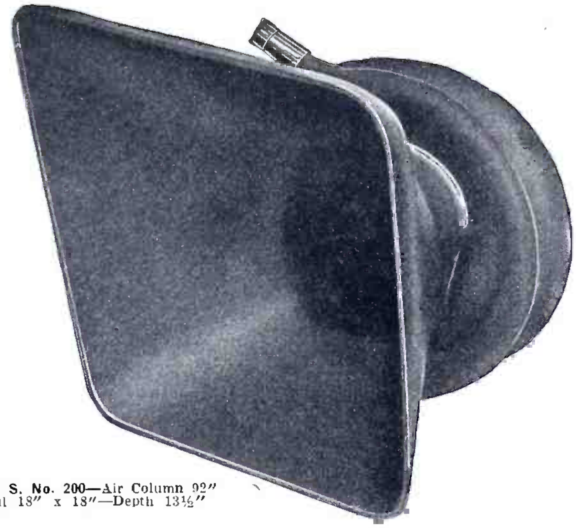

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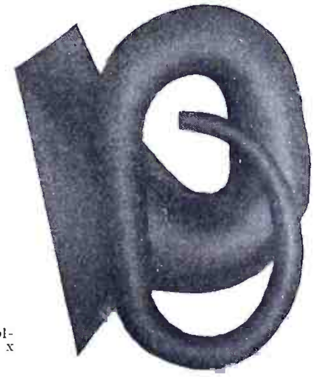

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No electrical apparatus or instrument is any better than the wire used in its coils, and no magnet wire is any better than its insulation.

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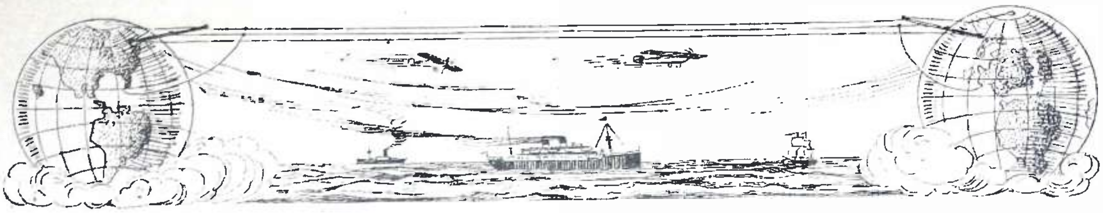


The Problem of Radio Set Power Supply

The Effect of Various Types of "A" and "B" Power Supply Units on the Radio Receiver

*By George B. Crouse**

PART I

WHEN considering the problems in the design and operation of Power Supply Devices for radio sets, it must be remembered that the supply device and the circuits of the radio set must be considered together and as an integral whole. To be sure, it is generally true, in any electrical circuit that the system must be considered as a whole. It has long been recognized, for instance, in telephone work, that the terminating impedance must bear certain relationships to the line impedance for proper operation. It does not seem to have been so generally recognized, however, by the radio designers, that the circuits of the power supply were an included part of the circuits of their radio set. Many of the difficulties experienced with the early substitutes for dry "B" batteries were caused by the lack of recognition of this important point.

It is the purpose of this article to analyze the effect of circuits and characteristics of various power supplies on the radio set, and the necessary conditions to be met if the two units are to cooperate and bring about a satisfactory result.

Effect of Plate Supply Devices

In considering the effect of devices for supplying energy to the plate circuits of radio receivers it is no longer necessary to consider the effect of residual A. C. ripple in the output, since the filters of such units have been brought to a high state of perfection, and the amount of residual ripple is negligible.

The effect of the impedance which such devices introduce into the plate circuits of radio receivers, however, is still important and will only be finally solved by close cooperation between the designers of the power supply units and the radio set designers.

The effect of this impedance may best be understood by reference to the diagram, Fig. 1, which shows schematically the essential elements of a multi-stage receiver. The terminating mesh of the usual or garden variety of "B" battery eliminator comprises a potentiometer 1 tapped at the proper points for taking off the various voltages required together with the by-passing capacitors C1, C2 and C3.

Obviously, by the use of a capacitor C4 in the radio set, of say 0.5 mfd. capacity, practically all radio frequency generated in the plate circuits of the radio frequency amplifiers will pass through this condenser, leaving practically no radio frequency in the 90 volt lead to the power supply. Since it is now standard practice to use such a condenser in the radio set, the use of power supply devices ordinarily does not affect the operation of the R.F. amplifier. In the case of the audio amplification, however, the frequencies are so much lower that the use of a small short-circuiting capacitor is out of the question, and we must consider the terminating mesh of the power supply as a part of the audio amplifier circuits.

The most common difficulties experienced may be best understood by considering the effect of a small disturbance, from any cause, in the plate circuit of the last tube. The path which this disturbance must take includes the terminating mesh of the power supply, and therefore a portion of the disturbance would be impressed upon the plate circuit of the detector tube. The disturbance will then be amplified by the intervening stage and finally impressed on the grid of the last tube. As a general result of this action distortion will be caused. The quantitative result will depend upon the frequency of the disturbance, the efficiency of the amplifier, and the phase relation existing between the disturbance and its amplified result. It may either build up, in which case sharp resonance peaks will be caused in the response curve of the audio amplifier, or, in the worst case, singing and instability will be caused.

If the phase of the amplified result is opposite to that of the original disturbance, depression will be caused in the response curve, and since the impedance of the output mesh is largely capacitative and therefore increases with a decreasing frequency, its effect will generally be noticed as a sharp falling off in the amplified response at low frequencies.

Prevention of Inter-Coupling

Various methods of preventing or reducing these effects have been pro-

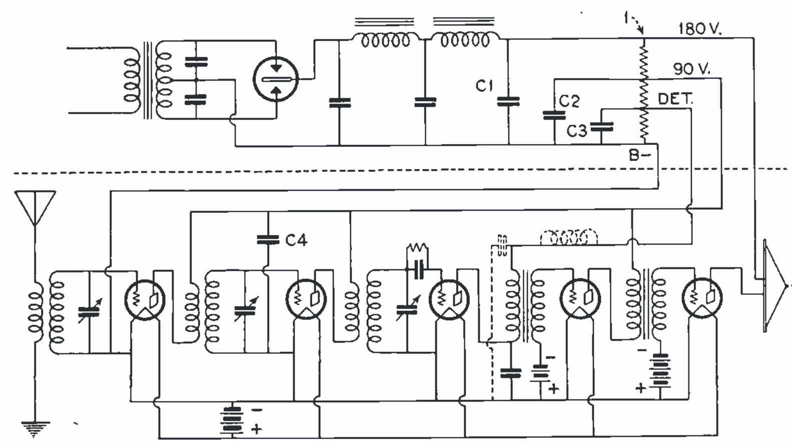
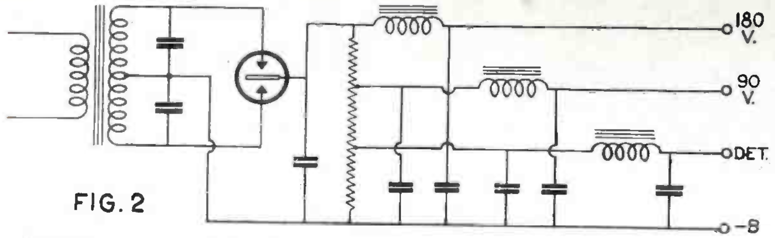


FIG. 1

Schematic diagram of receiver and "B" power unit with optional one-section audio filter in the detector plate circuit for the prevention of inter-coupling

* Vice-president and Chief Engineer, Conner-Crouse Corporation.



A "B" power unit employing three separate filters for the prevention of audio inter-coupling

posed. Much may be done by properly designing the amplifier to cooperate with the output mesh of the power supply.

Another method is to insert a one-section audio filter in the detector plate circuit, as shown in dotted lines in Fig. 1.

Another very satisfactory method is incorporated in a power supply designed by the author, which is shown diagrammatically in Fig. 2. In this arrangement the detector circuit, the 90 volt circuit and the 180 volt circuit are all separately filtered and effectively separated so that audio inter-coupling cannot take place. Because of the small current which each filter section is required to pass, the design is very economical to build and has the advantage that it requires no re-designing of, or addition to parts to, the radio set. This is an important point, inasmuch as considerable money is often invested in the design of an audio amplifier and it is just as serious, financially, to obsolete such a design as it is to scrap tools.

The effect of variations of output voltage on plate supply devices, when the supply device is designed for a particular radio set is ordinarily not very serious. Where some form of neutralization is used in the radio stages to prevent inter-stage coupling, the set will not be very sensitive to such voltage changes, and the variations resulting from differences of line potential may ordinarily be tolerated.

This, however, depends somewhat on the type of volume control used. The present standard practice of volume control is to vary the plate-filament impedance by reducing the emission of one or more of the radio frequency tubes. Under these conditions variations of plate supply potential has little effect.

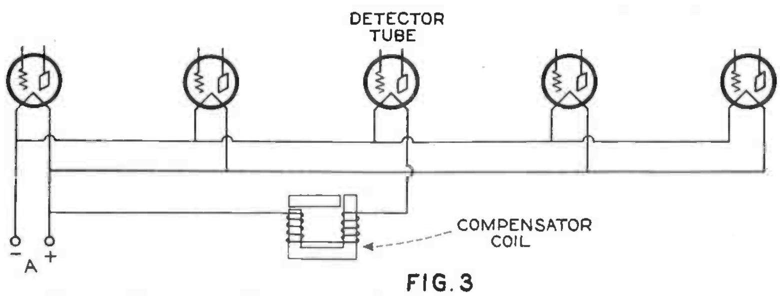
However, if this increase in plate-filament impedance is achieved by reducing the plate potential on the radio frequency tubes to a critically low value, then some form of voltage regulation for variations of line must be employed. The various devices available for this purpose will be discussed in a later article.

It should be pointed out that when the plate supply device is designed as an accessory, wide differences of voltage output will be encountered, due to differences in current drain between the different sets on which the device may be used. These differences may be greatly reduced by the use of efficient filters having low values of resistance in series between the rectifier and the output, or by the use of taps in the primary winding of the transformer. The latter solution is not a very satisfactory one, however, as it requires adjustment on the part of the user and since the switching device is subject to full line voltage, it often adds considerable to the expense of the unit.

Power Supply for Filament Circuits

No problems of inter-stage coupling ordinarily occur in the filament circuits of modern receivers. The design of such devices ordinarily dissolves itself into the effect of residual alternating current ripples in the current supplied to the filaments.

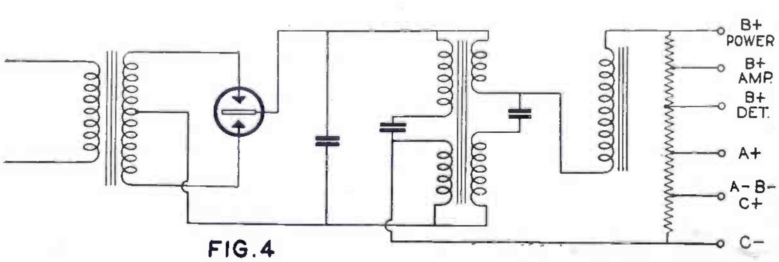
The maximum ripple which can be tolerated in a rectified and filtered source for filament supply is fixed by the effect of such ripple on the radio frequency stages. It may be stated roughly that in a tube having a standard 5 volt, .25 ampere filament and an amplification factor of 8 or 9, that a ripple in excess of .025 volt will cause noticeable modulation of the received signals. This amount of ripple may ordinarily be tolerated in the output tube of the audio amplifier, but it is far too large to be used on the earlier stages. In this connection, however, it is to be noted that the effect of a ripple on the filaments of the earlier stages of the audio amplifier in the loud speaker is not necessarily a measure of the efficiency of the amplifier at the frequency of the ripple. This comes about from the fact that the ripple is introduced in every stage, and the shifts in phase caused by the repeater impedances may cause this disturbance to add or subtract.



A filter section in the filament circuit of the detector for the reduction of A. C. ripple

The order of magnitude of ripple which may be ordinarily tolerated on the detector tube filament is about .005 volt. Here again, cooperation between the radio set designer and the designer of the power supply results in a benefit to both. Since it is difficult to satisfactorily filter the large currents required in parallel filament operation, and since different degrees of filtering are required for the different stages, the arrangement shown in Fig. 3 has proven very satisfactory In this arrangement an additional one stage filter section is introduced in the detector filament circuit, the additional part comprising a small coil, the other elements of the radio set functioning as the shunt element of the section. This arrangement has proven very satisfactory in practice, considerably reducing the size of the filter required, and in no way affects the operating characteristics of the receiver.

Where the radio set employs the filament emission type of filament control, a voltage regulator capable of substantially reducing the fluctuation of the power supply is essential to the successful operation of the unit. A wide-spread investigation of line condi-



A very satisfactory form of circuit for the supply of "A," "B" and "C" power to receivers employing D. C. tubes with series filament connection

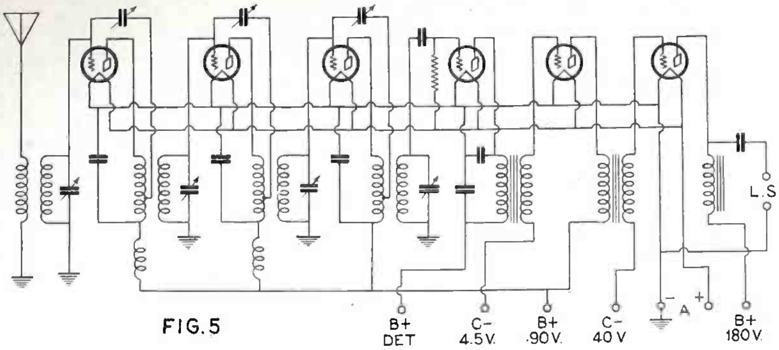


FIG.5

The circuit of a standard neutrodyne receiver employing the usual parallel filament arrangement

tions throughout the east and middle west has shown that line fluctuation over any short period, such as half an hour, or so, is rarely in excess of 10%, and it has been found in practice that if the variations in output of the power supply device is reduced to 5% for a 10% line variation, that no complaint will ordinarily be received from the user. A number of devices have been put on the market in which for a 10% variation in line a 20% variation in output was caused. Such a difference is, of course, not satisfactory and has been the cause of much complaint on the part of the user.

Heating Filaments with A. C.

Another method for heating the filaments which has recently come into widespread use is to apply alternating current direct to them, using the so-called mid-point connection of the plate and grid returns to the filament, originally proposed by Heising. The difficulties introduced by this method are many and various. In the first place, a special type of tube is required, having a very low voltage drop across its filament. It was discovered in the early experiments with the alternating current filament supply that, even with the midpoint connection, a ripple was introduced into the plate circuits of the tube. It seems to be the prevalent opinion that this was caused by the alternate heating and cooling of the filament every half cycle, resulting in a difference of emission. Some years ago the author conducted a series of experiments which showed conclusively that this view was incorrect. In these experiments tubes having filaments of widely different ratios of mass to radiating surface were used, and the resulting output disturbances carefully corrected for the varying characteristics of the tubes were measured. It was found that, except with tubes having a very low ratio of mass to radiating surface, the ripple was independent of this ratio and dependent upon the drop across the filament. This is accounted for by the fact that the grid voltage.—plate impedance characteristic of the tube is not a straight line and is, therefore, different at the points of zero and maximum current through the filament. Obviously, the less the voltage difference between the ends of the filament, the less this effect would be.

In modern A. C. tubes this voltage has been reduced to a point where no noticeable modulation of the signal is produced. Unfortunately, difficulties in the radio amplifier design are encountered, due to the fact that the filament excitation in A. C. tubes cannot be varied without introducing modulation, with the result that make-shift arrangements of filament control have to be used. It also seems to be true that the ripple in the output of these tubes at a low frequency is so great that the audio amplifiers must be designed with a comparatively high cut-off frequency at the lower end, which results in poor and thin quality of reproduction.

Most of these difficulties are overcome by the use of the equal potential cathode, or so-called heater tube, in which the alternating current is caused to heat an element, which, in turn radiates heat on to the cathode. At the present writing these tubes look to be inherently expensive to construct.

The effect of line variations on A. C. tubes has apparently not been taken into account by set manufacturers, and it is an example of the evils resulting from rushing into the market with an incomplete design. The voltage variation affects notably the life of the tubes in the radio set.

Series Filament Connection

The most economical and generally satisfactory method of supplying power to radio sets is undoubtedly by the use of series arrangement of the filaments, using standard D. C. tubes and rectifiers and filtering all of the energy in a single unit.

In Fig. 4 is shown diagrammatically such a power supply. It will be seen that the same number of elements and general arrangement is used as for a plate supply device, the transformer and inductive elements being somewhat larger to carry the additional current. Such a series set supply may be built for a cost not exceeding 30% or 40% additional to the cost of a good plate supply device. By a very simple arrangement, not shown, the voltage may be regulated automatically and without moving parts to accommodate the full range encountered in commercial supply lines.

Wide experience on the part of the author's organization in the re-wiring of ordinary parallel filament sets to series filaments shows that the series filament arrangement is in all respects equal to the parallel arrangement and, in many cases, better. A good idea of the changes involved may be gotten from Figs. 5 and 6. Fig. 5 shows a 6 tube neutrodyne receiver wired in parallel, and Fig. 6 shows the same receiver wired in series. A careful check shows that no change in the operating characteristics of the set was brought about by the change in wiring, and the combination made an excellent "electrical receiver." The changes involved in series wiring in no case change the physical elements of the radio set, and the designer has the same latitude of design which he had with battery supply and can use all of the experience gained with the former method. When the cost of servicing radio sets and the speculative factors involved in turning out radically new models are considered, this series wired arrangement becomes exceedingly attractive.

The second article by Mr. Crouse will cover rectification devices. This will include data on tests of various types of rectifiers, tables of characteristics and life data.

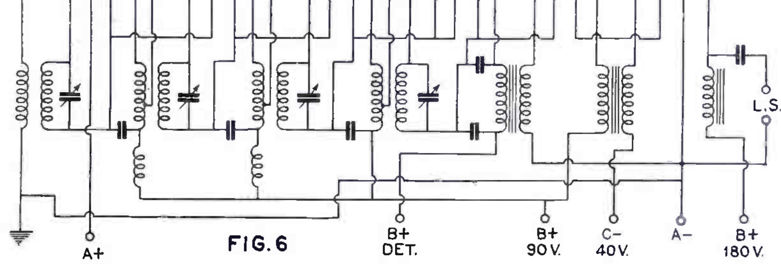


FIG.6

The same circuit as Fig. 5 re-wired for series filament operation. The operating characteristics remain the same

Your Money's Worth in Radio*

A Plea for the Abolition of Hocus Pokus Radio Advertising and Publicity, and Suggestions for Bettering Present Conditions

By Prof. L. A. Hazeltine

THERE has recently appeared a book whose title "Your Money's Worth," furnished the text for this paper. The authors, Stuart Chase and F. J. Schlink, give, on the one hand, many horrible examples of deceptive advertising, and, on the other hand, several outstanding examples of corrective measures and exposes by trade and technical associations. The cure advanced by these authors for the present deplorable conditions is to give the public the true facts about the commodities they buy, these facts to be determined by scientific tests. Their descriptions and prescriptions are both eminently applicable to the radio broadcasting field.

Inconsequential Superlatives

Perhaps we have become so hardened as to feel little shock at claims for an inexpensive receiving set covering "coast to coast with enough volume to fill a theatre" and getting "*All* the stations on the wave band with ease," of course, with "ultraselectivity." Or at the invitation to assemble "the world's finest loud-speaker in less than an hour at a fraction of the cost" of a manufactured speaker.

Perhaps the public has learned to discount such superlatives, but what about an advertisement of a little device that "will boost your volume from three to twenty times on distant stations, making it possible to cut through interference and bring in stations that were infinitely out of your reach before. Made especially for single and two dial radios: can also be used to great advantage on three dial tuned radio frequency receivers. Decreases 'A' and 'B' battery consumption." Though the advertisement gives no clue as to the nature of this device, nor as to how it is to be used, yet the laboratory of the magazine in which it appears reports it as an antenna loading coil (adjusted by a sliding contact) and gives it a certificate of merit!

And what a help to the untutored is the following advertising dissertation! "The same radio waves that you have always taken out of the air, also travel through the ground. The only difference between the air and ground components of the broadcast wave, is that the latter is practically static free, while the air component is always accompanied with static or noise of one kind or another. Scientists have long recognized this fact, and know that if some device could be perfected for the reception of ground waves, clear, loud, long distance reception would be a reality for the owner of the modest three or four tube set as well as for the possessor of the larger, more powerful set. ———— is the answer —— tried, tested and proved by thousands of owners of all kinds of sets, and recommended to you by such leading radio laboratories as" etc.

PROFESSOR L. A. HAZELTINE

Radio Prevaricators

No wonder the radio section of a newspaper stated recently: "It may be taken for granted that any manufacturer who advertises his product as the best is making an inferior grade of merchandise and is himself a poor merchandiser." Or that a radio magazine contributor remarks: "It has been truly said that radio has made more 'prevaricators' than golfing and fishing combined."

During the World War we were confronted with the theory that the honesty expected of individuals did not apply to nations. Is this the theory back of lying advertising—that it is proper for executives to authorize statements about the products of their companies that if made in private would ostracize them from the society of gentlemen?

Worse, if anything, than misleading advertising are misleading magazine and newspaper articles, for the reader does not as readily guard himself by the recognition of underlying self-interest. A recent article by an officer of a radio magazine shows the characteristic of a "standard" tuned radio-frequency amplifier in which the amplification per stage is 13 at 200 meters, drops rapidly to about 2 and tapers off to zero near 600 meters. It is stated that if it were not for regeneration, the curve would start near zero at 200 meters and never rise much above 2. Of course, the receiver developed by the magazine had a very much better characteristic. Does it help the manufacturer of a good receiver to have his advertisement appear in such a magazine?

The same article (headed "advance information") is full of other misinformation—for example: that stabilizing by resistance in series with the grid does not constitute a "losser" method; that "the plate circuit is much more readily tuned to the frequency of the following grid circuit when the impedance of the valves is of a low order" (actually the plate circuit is not of itself tuned at all); that the well known law of maximum amplification when the plate resistance is matched by the input resistance of the transformer means simply that a blocking condenser in series should have a low impedance!

Radio No Longer a Mystery

Radio is the most intimate of electrical commodities and its requirements the most exacting. But the

* Paper presented before the Mid-Winter Meeting of the Radio Division of the National Electrical Manufacturers Association.

public should know that it is no longer shrouded in mystery—that radio design is a well understood art, with quantitative results that can be predetermined by theory and verified by test. The day of the revolutionary experiment and the world-beating new circuit has passed.

The radio receiving set has become a standard article. It employs a tuned multistage vacuum-tube amplifier ahead of the detector to give suitable sensitivity and selectivity (whether at the wave frequency or at a lower frequency, as in the superheterodyne), with stabilizing means to prevent disturbing self oscillation, then a vacuum-tube detector, and finally a vacuum tube amplifier following the detector, to develop the power needed by the loud-speaker. The loud-speaker, in turn, is an electromagnetic motor actuating a diaphragm, which is either large itself or is associated with a large horn so that the mass of air set in motion matches the characteristics of the motor at all useful wavelengths of the sound in air.

Advances in the radio art have lessened the differences among receiving sets, which now lie in the details of design and construction. That this will be the future trend as well is indicated by an inquiry into the qualities desired and the natural limitations.

Sensitivity in a radio receiving set is limited by disturbing noises, partly in the vacuum tubes and power supply, but in a large measure external, in the form of natural or man-made strays. Many sets today have greater sensitivity than can be used under ordinary circumstances.

Selectivity is limited by the fidelity required in broadcast reception. A certain band of frequencies must be covered at each tuning adjustment, corresponding in width to the frequency band present in music and speech. Today it is readily possible to bring each radio stage close to this limit. Increased selectivity then is a matter of a greater number of tuned circuits and therefore of greater cost.

(It might be mentioned in passing that the same limitation applying to selectivity in receiving sets applies also to the frequency spacing of broadcasting stations, which must be great enough to avoid audible heterodyne whistles. No improvement in radio receiving apparatus can make it permissible to narrow broadcasting channels.)

Fidelity. Absolutely faithful reproduction of music and speech over the entire audible range is not desired by the listener. Comparatively little of the important components of music or speech, but a great deal of disturbing noise, is comprised in frequencies above 5000 cycles per second. Likewise, components below about 100 cycles per second are hardly recognized, but may include objectionable alternating current hum or may give rise to serious over-loading. Good engineering calls for some discrimination against the highest and lowest frequencies. Today, audio amplifiers are being designed for any desired degree of fidelity; and loud-speakers of the better sort are made to cover the necessary frequency band.

Convenience of Operation. Today, receiving sets are being sold having only two adjustments, the station selector and the volume control. Even the latter may be eliminated by an automatic volume control*, as described by Mr. Wheeler at the last meeting of the *Institute of Radio Engineers.* Reduction in the number of controls may mean some increase in cost, the user properly paying for the convenience. The same is true relative to the convenience of having a self-contained antenna and self-contained power supply. Together with convenience comes low maintenance expense,

THE USE OF A. C. TUBES IN RADIO RECEIVERS.

We are pleased to announce a decidedly interesting and authoritative article on A. C. tubes by Lieutenant Victor Grieff, of the Radio Receptor Company, which constitutes an exceptionally valuable contribution at a time when information on the subject is in such demand.

There is much to be said regarding the uses and operating characteristics of A. C. tubes and we know of no one who is in a better position than Lieutenant Grieff to present the subject in its true aspects.

The article will appear in the February issue of Radio Engineering.

which calls for sound engineering, careful manufacture and proper testing. The limitations are primarily economical, not technical.

Now with these limitations in mind, what are the present deficiencies in commercial receiving apparatus? We certainly can not claim perfection, and yet we may say that practical perfection is in sight. The usual radio receiver is relatively deficient in sensitivity at low radio frequencies and in selectivity at high radio frequencies. The latter is probably the most glaring technical fault, too many sets on the market using "losser" methods for stabilization. But these defects have been remedied in laboratory models, by the use of complete neutralization and a radio-frequency coupling system which automatically changes the step-up voltage ratio with the tuning adjustment—not a radical nor untried step, merely a logical improvement. Perhaps the user cannot count on receiving the most for his money that is technically possible until the radio industry follows the automotive industry and removes the incubus of conflicting patent rights.

When the present technical deficiencies have been removed as indicated, there remains only reduction in cost by improved methods of manufacture. The radio receiving set will be in a position analogous to the status of the direct-current motor or the squirrel-cage induction motor, which have been refined in construction but not changed in fundamental form since their earliest development. We need not fear the introduction of some new vacuum tube or new circuit, for the most that these could accomplish would be a decrease in cost and that does not ordinarily accompany added complications.

* *Article appears in this issue.*

Educational Campaigns

But it is not enough to know that radio apparatus *can* be made of high quality. We must be able to test its quality so that engineers, technical writers, dealers and the public can be given exact information. Fortunately, the *Institute of Radio Engineers* has nearly completed the standardization of test methods, preliminary reports having been printed in the third edition of the "*NEMA Handbook of Radio Standards.*" With these methods available, we will be able to substitute definite numerical values for sensitivity, selectivity and fidelity, in place of "coast-to-coast" reception, "razor-edge selectivity," and "magnificent cathedral tone quality" (to quote a single recent advertisement).

With this snap-shot of the situation, what can be done by NEMA to bring the radio industry to the level which radio technology has established? An answer is *education.*

Engineers, technical writers, and *radio editors* need to be informed of all available improvements and to be warned against fallacious methods of a persuasive sort (such as the supposed narrowing of broadcasting bands by "frequency modulation"). The natural vehicles are the proceedings of technical societies, particularly the *Institute of Radio Engineers.* Radio standards should be given wide currency.

Dealers need full technical information from the manufacturers as to the quantitative performance of the apparatus which passes through their hands, and of competing apparatus, so that they can do their duty in giving the public its money's worth and in protecting it from deception.

And finally, the *public* has a right to know what it is buying and what it may expect in results. Not only is truthful advertising necessary, but publicity of a more general nature, perhaps prepared by NEMA committees, should be secured through the radio magazines and newspapers. When honest apparatus is supplied to a discriminating public, radio will come into its own.

1927—Review of Radio Industry—1928

By H. B. Richmond

Director of Engineering Division, R. M. A.

RADIO has arrived at the position in the arts where its progress must naturally be gradual, rather than sudden and spectacular. It is this very stability of the art that makes it difficult, at such an early date, to review the outstanding technical features. However, there are some items that have already proven their value so well that they stand out noticeably.

Particular attention should be called to the fact that developments have not been of an individual nature. They are the result of accomplishments of large groups working on common problems, and also the joint activities of large bodies, such as technical societies and trade associations.

The Federal Radio Commission

One association that has been given us this past year by act of Congress is the Federal Radio Commission. While not strictly an engineering body, many of the problems before the Commission are of a strictly engineering nature, and must be handled as such. The principal problem that the Commission met was that of heterodyne interference between broadcast stations. The forcing of the Commission of stations to adhere to their assigned wavelengths has stimulated the art in broadcast station development. Quartz crystals for frequency control have come into great prominence during the past year.

A rapidly developing art naturally becomes involved in patent difficulties. A tremendous advance during 1927 can be registered in the clearing up of these patent difficulties. The first step in this direction came with the announcement that the Radio Corporation of America and associated companies were prepared to license legitimate manufacturers on all of their patents involved in the construction of receiving sets and power amplifier devices, with the exception of the superheterodyne group. Before this announcement, it may be safely stated that it was an impossibility for any manufacturer to construct a modern receiving set without interfering with one or more of the RCA patents. Many manufacturers had pinned their faith on fundamental circuit design on the possibility of invalidating the Alexanderson tuned radio frequency patent. The decisions on this patent, however, have all upheld it, so that the confusion existing regarding its validity no longer exists.

Cross Licensing of Radio Patents

The Radio Corporation and associated companies control something less than half of the radio patents. Confusion exists regarding the use and control of the rest of the radio patents. They are held by a very large number of individuals. Some of the holders have been perfectly willing to license others on a reasonable basis, whereas others have held out in a way that has embarrassed the art. The Radio Manufacturers Association has taken a tremendous step in this direction by authorizing the investigation of a plan for the cross licensing of radio patents. If a cross licensing arrangement can be worked out on a royalty basis, similar to that of the RCA, or on an exchange basis, the advance of the art will be tremendous. There is now every indication that this plan can be worked out, and if this becomes a reality, we may well look upon it as one of the outstanding developments of 1927.

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A. C. Tubes

1927 will go down as the year in which alternating current tubes were generally introduced. Practically all of the new designs for receiving sets call for the use of these tubes. It means that the purchaser of a set need only plug it into his light socket, and thereafter give no thought to batteries or battery substitutes. This advance should not be taken to mean that all other sets have become useless and obsolete. The advance only applies to a method of heating the tube filaments. It does not in any way improve on the radio parts of the circuit. At the present time, the general operating characteristics of the battery-operated type of sets are equal, if not superior, to the present alternating current sets. This means that for some time to come these battery-operated sets will find popular favor. As the alternating current tubes are improved, it is of course evident that in years to come the alternating current type of set will be the one most generally accepted.

Almost without exception the tubes that have been brought out during 1927 are of the oxide filament type. The ability to manufacture these tubes cheaply shows a real advancement in the art of tube construction.

The year should not be passed over without mentioning the advances in commercial transmission, as opposed to broadcasting. Beam stations, short wave development, the trans-Atlantic telephone, and television are among the items that should receive comment.

American Engineering Standards Committee

Another source of confusion that has been brought to an end in 1927 is the standardization situation. Previously there existed considerable feeling as to whether the radio industry should stand as a separate industry, or should be considered a branch of the electrical industry, because of the construction of sets, or of the musical industry, because of the output of the sets. By the steps taken during the past year, it has been pretty definitely agreed that the radio industry is thoroughly capable of standing on its own feet. It has learned, however, that it must recognize its neighbors. In this respect the standardization of radio parts became involved. Under the leadership of the American Engineering Standards Committee, a program was arranged, whereby the so-called strictly radio standards and the strictly electrical standards applying to radio would be reviewed and out of them a new radio industry standard developed. This new standard is to be drawn up jointly by the radio trade association and the radio division of the electrical trade association.

Radiotelegraphic Conference

No review of the year can be complete without paying tribute to the marvelous work done by the International Radiotelegraphic Conference held in Washington. Many important engineering matters, such as frequency assignment, were covered by the Conference. They will all have a helpful and stabilizing effect on the future of radio.

1927 has developed a decided keynote of stability for the radio art. With such an accomplishment to start from, how can the outlook for 1928 be anything but bright?

Automatic Volume Control for Radio Receiving Sets[1]

A Method for the Automatic Control of Radio Frequency Amplification to Give a Nearly Constant Radio Frequency Voltage at the Detector, Independent of Differences in Antenna Signal Voltage

By Harold A. Wheeler[2]

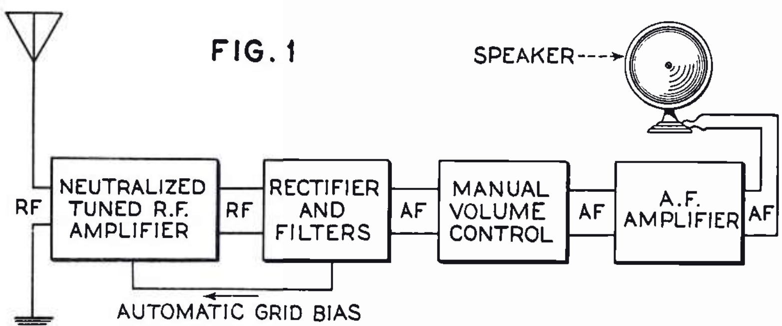
IN the present radio receiving sets employing high amplification, it is necessary to adjust carefully a "volume control" in order to reproduce signals of different intensities with the same audible intensity from the loud speaker. There are various devices which could be employed to regulate automatically the amplification of the signal, some of which employ moving mechanical parts. It is the purpose of this paper to describe a simple electric circuit, without moving parts, in which the amplification is regulated automatically by the signal, and the loud speaker intensity reaches approximately the desired level for each signal, independent of the signal intensity and therefore irrespective of a reasonable amount of fading.

Any device to accomplish this object without introducing distortion of music or speech must operate by the signal carrier wave. Any variations in its intensity must be compensated by reciprocal variations in its amplification. The method to be described provides for controlling the radio-frequency amplifier, thereby maintaining the desired signal level in the detector or rectifier, audio-frequency amplifier and loud-speaker.

Automatic Grid Bias

Fig. 1 shows the outline of a set which has been constructed for broadcast reception, embodying this automatic volume control, comprising the following component sections. (1) A four-stage radio-frequency amplifier of the well-known neutrodyne type, with 201-A type tubes, the antenna circuit tuned by one dial and the four coupling transformers tuned simultaneously by a second dial. The total amplification is controlled by varying the negative grid potential of the first three tubes. (2) A two-element rectifier with simple filter circuits to reject the radio-frequency currents and to segregate the direct and audio-frequency components of the pulsating rectified voltage. (3) A manual volume control in the form of a voltage attenuator connected to the grid of the first audio-frequency amplifier tube. (4) A four-stage audio-frequency amplifier and loud speaker. The entire set, excepting the last two audio-frequency stages, was enclosed in a grounded metal box divided into compartments, one for each tube with its preceding coupling circuit.

FIG. 1



Representative arrangement of broadcast receiver embodying automatic volume control system

Fig. 2 shows the essential circuit details pertaining to the control system. The direct component of the rectified voltage, free of audio-frequency variations, is applied to the grids of the first three tubes. If the radio-frequency rectifier voltage could exceed a value of about ten volts, this automatic grid bias would thereby cut off the signal through the radio-frequency amplifier, so the rectifier voltage cannot exceed this value.

Fig. 3 shows graphically the comparison between the performance of the radio-frequency amplifier with and without the automatic control. With the system described, the rectifier voltage and the audio-frequency voltages are nearly independent of the antenna voltage, when the latter exceeds the threshold value. The curves I, II, and III show the performance of the system when the automatic grid bias is applied to one, two, or three tubes, respectively, of the radio-frequency amplifier.

The degree to which the signal can be cut off in one tube is limited by two factors. First, any error in neutralizing the gridplate capacity permits signal current to pass through the tube, even when its mutual conductance is zero. Secondly, the sharp bend in the plate-current grid-voltage curve causes distortion of a strong signal on the grid, when the mutual conductance is reduced too far by the grid bias. In view of such limitations, it is undesirable to reduce the amplification ratio per stage below about 1/10 of its normal value. When controlling several tubes, these limitations become unimportant. The last radio-frequency stage is not controlled because it must

Illustrating the comparative performance of a radio frequency amplifier with and without the automatic volume control

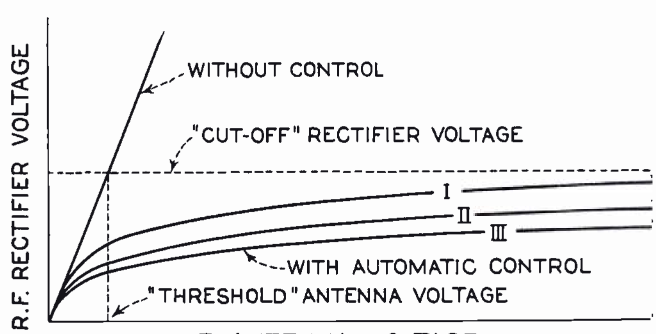


FIG. 3

[1] *Reprinted from January 1928 Proceedings of The Institute of Radio Engineers.*

[2] *Hazeltine Corporation.*

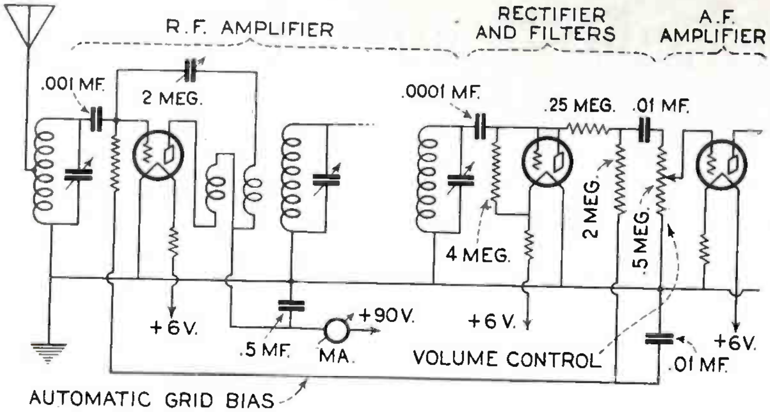


FIG. 2

Basic circuit arrangement of receiver designed to include automatic volume control

supply as high as ten volts to the rectifier.

Properties of the Two Element Rectifier

The properties of the two-element rectifier contribute largely to the simplicity of the control system. **Fig. 4** shows the nearly linear proportionality between alternating and rectified voltages in this form of rectifier, as contrasted with the irregular performance of the three-element detector. The signal modulation is rectified without distortion. Also the average rectifier voltage, while with a "voltage-squared" detector the average rectifier voltage is proportional to the average total power of carrier and sidebands. This last feature is worthy of mention in connection with the control system, since the automatic grid bias should depend only on the carrier amplitude, independent of the modulation.

With the circuit constants shown in Fig. 2, the time constant of the circuit which connects the rectifier to the grids of the control tubes is 1/40 second, so that the control system comes nearly to equilibrium in 1/20 second. This time can be reduced further if necessary, but is ultimately limited by the allowable reduction of the signal modulation at the lowest audio frequencies.

In consequence of the automatic control action, it becomes difficult to tune the receiving set accurately by ear to a desired signal. The amplification is decreased as the response to the signal is increased by tuning, and vice versa, so that the point of resonance is indicated by minimum plate current in the radio-frequency amplifier. Taking advantage of this fact, a milliammeter (*M. A.*, Fig. 2) is connected in the plate circuit of the first tube, to be used as a resonance indicator, and also to give an indication of relative signal intensities.

There is an incidental problem in supplying the plate current to all tubes of the set described from a common rectifier and filter system. In the controlled radio-frequency amplifier tubes, when operating at low plate current, the signal carrier is modulated appreciably by small fluctuations in the plate voltage. Such fluctuations are caused by plate current pulsations in the audio-frequency amplifier. In the presence of a strong carrier wave, these

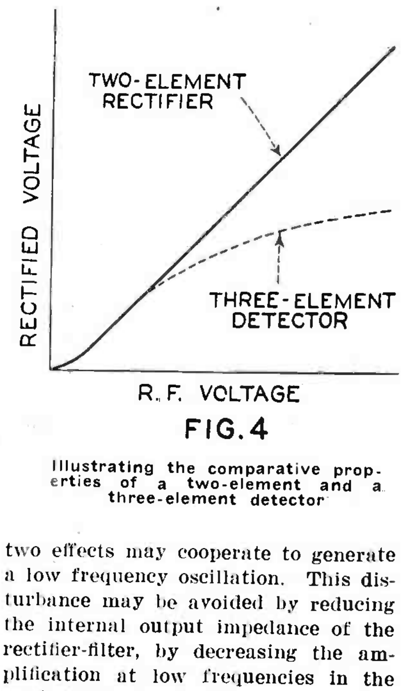


FIG. 4

Illustrating the comparative properties of a two-element and a three-element detector

two effects may cooperate to generate a low frequency oscillation. This disturbance may be avoided by reducing the internal output impedance of the rectifier-filter, by decreasing the amplification at low frequencies in the audio-frequency amplifier, or by using separate rectifier-filter systems to supply the plate currents of the radio- and audio-frequency amplifiers, respectively.

Performance

The performance of the automatic volume control as described can be summarized briefly as follows. A maximum variation of signal voltage in the ratio of 1:1000, corresponding to differences in distance, fading, or tuning, results in a maximum variation of the rectified carrier voltage in the ratio of only about 1:3. This small variation, together with possible differences in the degree of modulation of different stations, can readily be compensated if necessary by adjusting the manual volume control for the audio-frequency amplifier, which also determines the "volume level" for the automatic volume control.

The name "Audiostat" has been selected for this device, by reason of its tendency to maintain the audible intensity at a constant value.

Attention might be called to British Patent 259,664 (Western Electric Co., July 14, 1925), in which a somewhat similar system is presented. This other system is applied to a super-heterodyne receiving set, and is more involved in several respects than the system described in this paper.

It is desired to acknowledge the cooperation of the Howard Radio Company of Chicago, in whose laboratory the set described was assembled.

R. M. A. to Provide Radio Manufacturing Statistics

FOR the first time in the history of the radio industry, official information regarding radio manufacturing is to be made available to the public and to the industry through cooperation of the United States Government and the Radio Manufacturers Association. The Federal Government, through the Department of Commerce, has accepted a plan proposed by the Radio Manufacturers Association to gather statistics from the nation's manufacturers of radio receiving sets, accessories and parts.

With the assistance of the R. M. A., the manufacturing statistics will be gathered, compiled and published by the Electrical Equipment Division of the Bureau of Foreign and Domestic Commerce, Department of Commerce, of which Mr. Marshall T. Jones is chief. Comprising as it does more than 300 or virtually all of the leading manufacturers of radio of the country, the R. M. A. is fortunately in a position to give the utmost service to the Government in securing manufacturing data hitherto unobtainable.

The Department of Commerce is now engaged in sending to manufacturers a questionnaire showing in detail their factory shipments for the last three months of 1927. The information will be published by the Department of Commerce early in January. This and subsequent quarterly publications of manufacturing statistics will inform the public regarding the progress of the radio industry and be a valuable guide to manufacturers in determining their production.

Railroad Radio Equipment

New Developments in Transmitting and Receiving Apparatus for Communication Between the Front and Rear of Freight Trains

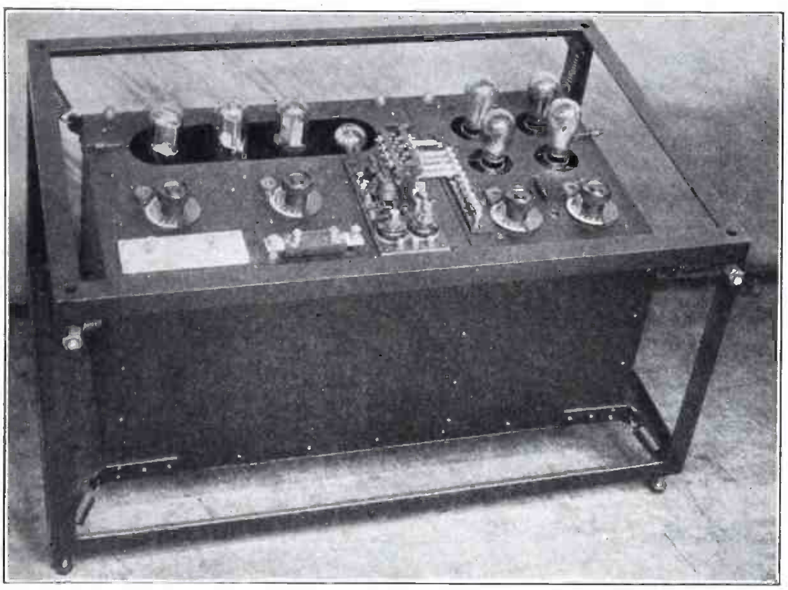
AFTER many months of developmental work on the lines of the New York Central, the radio engineers of the *General Electric Company* have designed an effective and reliable system of radio communication between the front and rear ends of trains, particularly of long freight trains.

Preliminary investigation was carried on at Schenectady on engine and caboose. Several different types of antenna were investigated on the locomotive and it was found that the most effective type consisted of a wire running parallel to the boiler, and about fifteen inches from it. This was stretched between the stack and the rear end of the cab roof, as far as possible from the boiler and at the same time within the clearance limit of the right-of-way. The caboose antenna was placed four and a half feet above the roof, running parallel to the caboose. Antennas of the type used on engine and caboose do not possess any marked directional characteristic, but they are inefficient radiators, due to their low effective heights, and for this reason require more power for a given transmission range, than would be necessary if higher antennas were available.

Tests showed that the 2300 to 2750 kilocycle band offered the best transmission frequency. In order to provide a strong telephone signal at a distance of from one to two miles a power of 50 watts delivered to the antenna, was found necessary. While communication is possible on less power, there must be sufficient margin to care for unusual conditions.

Calling System

A radio telephone system must incorporate an effective calling system if it is to have a maximum degree of utility. The original work included the use of a bell actuated by a relay for calling purposes. This arrangement was later discarded because it was comparatively easy to secure false indications of calls. Excessive jars caused relay contacts and it was also possible for static and other disturbances to cause the bell to ring. The calling system finally developed utilized a loud speaker which produces a shrill note whenever a push button is depressed at the transmitting end. The pitch of this note is adjusted so that it is easily heard above the usual train noises. In addition the loud speaker may be used in place of earphones for receiving conversation when the running noises are not too great.



The transmitter and receiver of the simplex train communication equipment. The transmitting unit, which utilizes three 50-watt tubes, is on the left. Four 7½-watt tubes are used in the receiver.

Radio telephone equipment is classified as either simplex or duplex. The simplex system requires that a small button or similar device be depressed when one wishes to talk and upon releasing the button the apparatus is automatically transferred to the receiving condition. With a duplex installation, full automatic telephony may be carried on similar to that with an ordinary telephone. In order to secure the latter condition, considerable complication is introduced into the equipment and, in addition, the radio transmitter must operate while receiving is taking place.

After a number of comparative tests were carried out it was agreed that the advantages of simplex operation outweighed the additional convenience of a duplex installation. The simplex sets require less power, will not set up as much interference as the duplex, and more simplex installations can be operated within a given frequency band than those of the duplex type.

Transmission Phenomena

A great many tests were made with the preliminary equipment along the Mohawk Division of the New York Central Railroad. Very successful telephone communication was carried out and many instances were recorded where great assistance was rendered because such communication was available. Much interesting data was secured with regard to transmission phenomena. Fading such as commonly occurs in broadcasting, or wherever transmission over a considerable distance is attempted, does not take place with the train sets. Communication is, however, interrupted or reduced in volume, by the presence of steel bridges or signal towers along the right-of-way. While the effect of such structures on the received signal is equivalent to fading, it might more properly be classified as shielding or absorption effect. When the locomotive antenna is directly beneath a steel signal tower there is likely to be a marked reduction in the strength of the received signal at the caboose. If transmission takes place from the caboose under these conditions it is still more difficult to receive in the locomotive. As long as the locomotive or caboose antennas are not directly beneath a steel structure, no apparent reduction in signal is obtained. Curves along the right-of-way do not have any apparent effect on the transmission, nor do passing trains seem to exert any interfering influence.

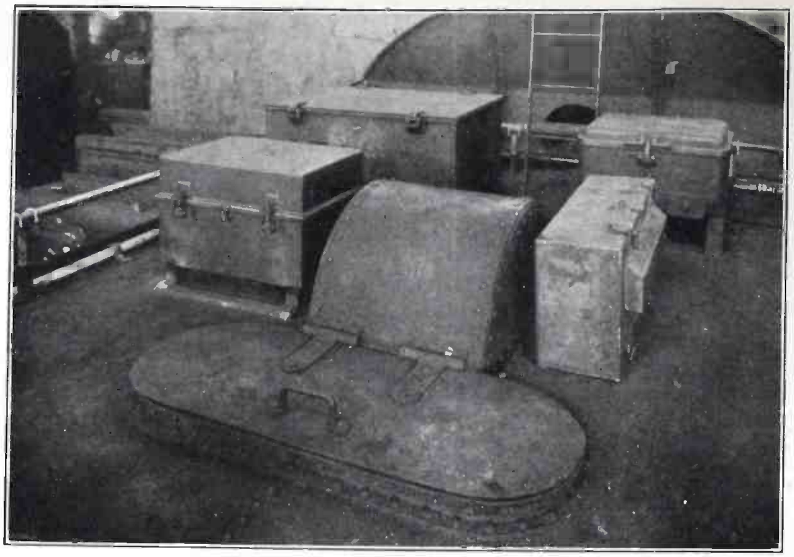
After operating the first set for a period of months, under actual running conditions mechanical weaknesses in the first set were worked out and several improvements made in the circuit and in the calling system.

Description of Apparatus

The metal box, enclosing the transmitter and receiver, is made of steel boiler plate, welded together and is intended for installation on the deck of the tender. It is completely weather tight, being made to exclude water or other foreign material. The equipment is built for simplex operation only, and a relay is provided on the front panel for interchanging the circuit from transmission to reception and vice versa. The entire assembly is supported by eight springs, and in addition a system of snubbers is provided to prevent excessive oscillation.

The transmitter compartment contains three of the 50 watt size tubes and one of the 7½ watt tubes. Four of the latter size tubes are used in the receiver. The 7½ watt tubes are the standard train control type which are already in use on many railroads. The 50-watt tube is known as type UV-211 and is a standard design used for aircraft and marine applications for a number of years.

The power unit for the equipment, which contains the necessary dynamotors, filter condenser, reactors, etc., is housed in a metal container. The dynamotors, or two-bearing motor generator sets are utilized. The larger one only operates when transmission is taking place, and supplies plate voltage at 1000 volts D. C. to the transmitter. The smaller machine runs at all times when the equipment is on the road and delivers plate voltage and bias voltage for the radio receiver. The use of this smaller machine permits the elimination of all batteries.



Installation on tender of locomotive. The transmitter-receiver, power unit and battery charger are encased in weather tight housing. At the left, and running around three sides of the tender is the brass rod antenna

Special Loud Speaker

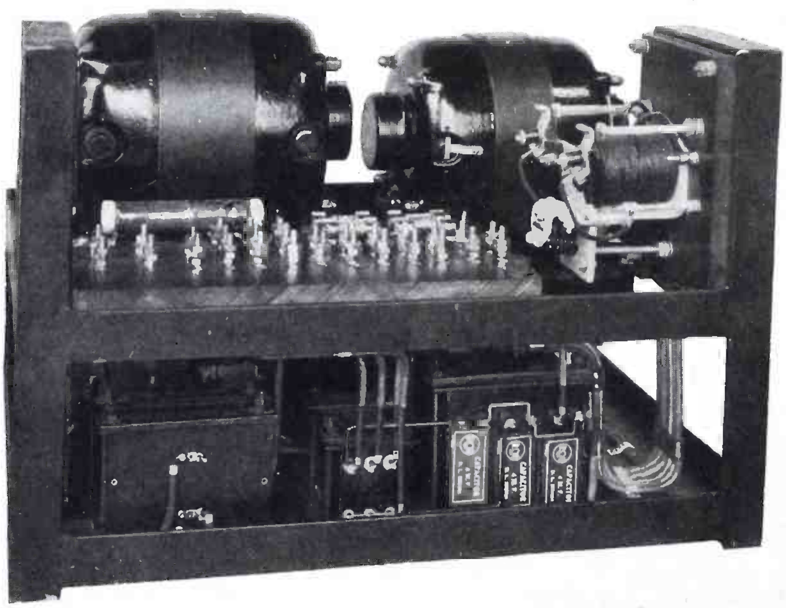
An especially strong type of loud speaker, capable of producing a maximum amount of volume, was developed for the sets. This loud speaker may be bolted to any convenient metal support inside the locomotive or it may be fastened to a bracket anywhere in the caboose. The opening for the sound is protected by means of a heavy wire screen so that an accidental blow will not damage the sound producing unit inside. Excellent speech quality may also be obtained from this loud speaker obviating the use of a head-set under average conditions.

In adopting the new equipment for train installation it was found advisable to mount the antenna on the tender instead of along the locomotive boiler. The antenna consists of a brass pipe mounted about twelve inches above the tender tank. This can be seen in one of the accompanying illustrations. The antenna is low enough so that it does not interfere with taking water or with coaling operations.

The total amount of power drawn by the equipment when transmitting is approximately 30 amperes at 32 volts D. C. while in receiving the current drawn from the 32-volt battery is approximately 5 amperes. This is the current required by the receiver dynamotor and the receiver filament.

Radio for Yard Service

A second application of radio other than front to rear end communication is an installation for hump or classification yard service. A radio telephone transmitter similar to the first type has been installed at the Selkirk yard of the New York Central. The hump locomotive is equipped with a radio receiver and a loud speaker and receives voice signals and instructions from the yardmaster at the transmitting end. This apparatus has been in service for several months and is giving very satisfactory results, particularly in stormy or foggy weather, when the old methods of signaling are difficult to carry out.



The power unit, including two dynamotors, which supplies plate voltage to the transmitter and receiver. The filter equipment is mounted underneath the dynamotors

Metric Standards Urged at Pacific Conference

CALLING upon Congress to adopt the decimal metric weights and measures in the United States, the Pan-Pacific Standardization Conference met recently in San Francisco during the Pacific Trade and Travel Exposition. A series of round-table discussions were held, at which reports were presented from Japan, Australia, Mexico and South America, indicating a world-wide trend to the metric units.

The Orient has definitely decided upon metric units, and has rejected the so-called English units. China, for instance, is making rapid progress in adoption of the metric standards.

Endorsement was given to the Britten-Ladd Metric Standards Bill, which will be introduced on the first day of the new Congress providing for gradual establishment of metric measures in merchandising throughout the United States.

The High Art of Condenser Manufacture

An Account of the Interesting Means Employed in the Making and Testing of Filter Condensers

*By J. R. Francis**

HAVE you any idea of how a filter condenser is made . . . how linen and tinfoil are combined into a unit which permits more convenient operation of your receiver? . . . Would you care to take a jaunt with me through a condenser plant . . . Fine,— let's go . . . Perhaps we'll learn about the innards of a filter condenser.

The condenser consists of the dielectric and the active metal surface, so we'll push our way through this legion of workmen and go to the department handling the basic essentials and watch the process . . . Watch out for that moving crane, and extinguish that cigarette . . . Smoking is not permitted with all this inflammable material on hand . . .

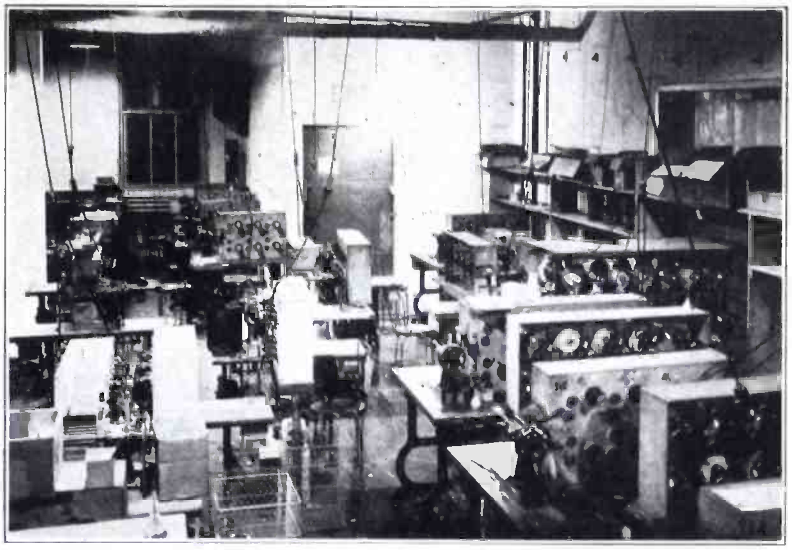


Fig. 1. A view of the winding department, showing the winding machines which automatically "roll" layers of paper and tinfoil to the desired capacity

Measuring Ten-Thousandths of an Inch

That chap in the corner is "miking" a new batch of linen paper dielectric. The micrometers he is using are graduated in ten-thousandths of an inch and the paper is measured to assure correct thickness. The various types of filter condensers, use different gauges of paper, the thickness depending upon D. C. working voltage rating of the condenser unit. The other fellow opposite is "miking" the tinfoil and measuring it to determine the square inch yield per pound. The man who just entered the laboratory tests the paper for pin holes. They exercise every precaution to use paper with the minimum number of pin holes. You see, the best paper has pin holes, and its simply a matter of selecting stock with the minimum amount of holes. A fine stock of 100% pure linen paper is used.

Winding the Condensers

This is the winding department (Fig. 1). The rolls of paper and tinfoil are mounted upon the rollers. The number of layers of dielectric placed between each two active surfaces depends upon the D. C. working voltage rating of the condenser. If, for example, a total thickness of 1.5 mils is required, three sheets of .5 mil paper are used. The machines are equipped with automatic counters, each condenser being calibrated in turns. When the counter indicates a certain number of turns, the unit is removed from the spindle and a new one is wound. The condenser as it comes from the machine is round and is then flattened by the operator.

Here the girls place a heavy wrapper around the outside of the condenser. The reason for this wrapper will become evident to you as we move along. The girls stamp an identification figure on each wrapper so that condensers of different capacitance will not be placed into the wrong containers. These upright presses for the condensers function as the racks when the condensers are placed into the impregnating tanks. You can see some of the filled racks adjacent to the tanks (Fig. 2 and Fig. 3).

Impregnating Process

The cranes attached to the ceiling lift and hold the covers of the impregnating tanks. These tanks are automatically controlled. The meters you see associated with the tanks register and control the heat and the pressure. The three pumps in the corner are used to create the vacuum in the tanks required during the process of impregnation. The fact that

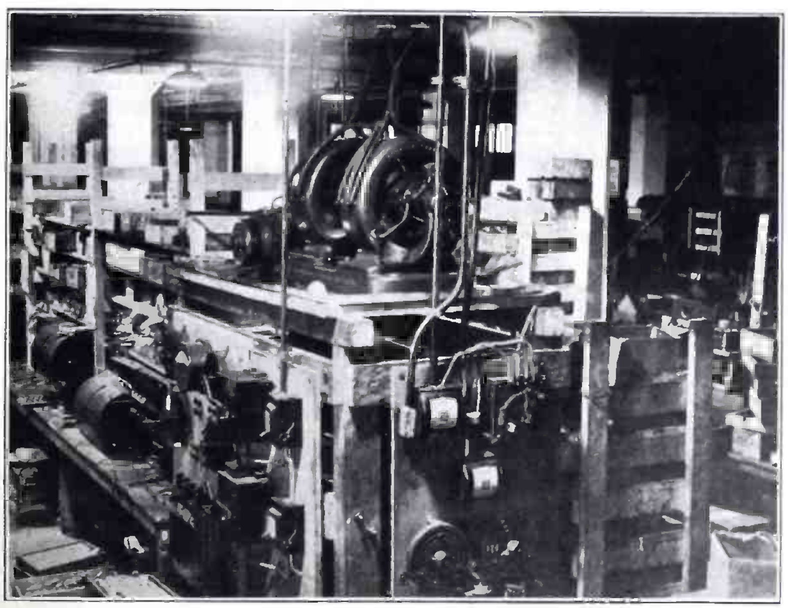


Fig. 3. A view of the 4,000 watt testing equipment which feeds the row of test benches where the condensers are put through their paces

* *In consultation, Aerovox Wireless Corp.*

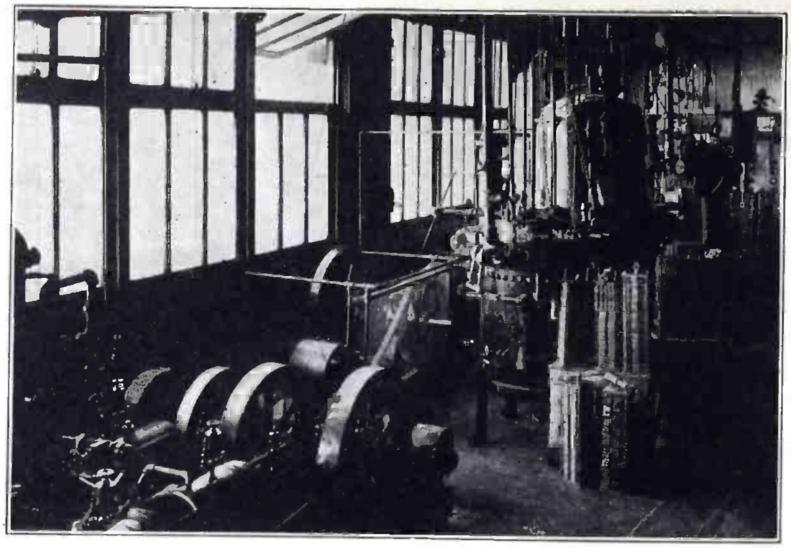


Fig. 2. A view of the high vacuum pumps and, in the background, a battery of impregnating tanks

single master switch simultaneously applies the correct testing voltage to each one of these sections.

The small meters you see on the other side of the bench determine the insulation resistance of each individual section. Surprising as it may seem, particularly when the insulation resistance is several thousand megohms per microfarad, only a small tolerance is allowed.

There are small bulbs associated with the voltage and capacity tester, connected into the voltage test circuit, and these flash in the event that any one of the condensers in a bank under test, breaks down or punctures. Each bulb indicates one circuit and the operators know at a glance, just what condenser ruptured under the test voltage. To assure continuity in the bulbs and the circuit, the system is shorted several times during the day. When the system is shorted all the bulbs light to full brilliancy. A defective bulb is instantaneously noted.

the tanks are automatically controlled mean removal of any errors due to the vagaries of the human being. Consistency and uniformity is the result.

Testing the Condensers

From the impregnating tanks, the condenser is taken for a voltage capacity and resistance test. The voltage and current required for this test is obtained from the power plant you see located in the center of the room. This test plant has a 4000 watt rating and all sorts of voltage and current combinations are obtainable (Fig. 3). The feeders from this power plant are carried to various parts of the room. This plant is augmented by several small 500 watt generators supplying current of various frequencies utilized in testing.

I am sorry that we missed the department which solders the connecting leads to the condensers. This department functions after the condenser is removed from the tank and before it goes to test.

That grimy workman is one of the members of the dipping department where the condensers are taken after the first test. The condensers are dipped in a solution developed for the purpose and placed into racks to dry. You see that each condenser is individually sealed. No matter how many units comprise a bank, each section is dipped individually. Let's follow that batch of condensers. It is taken to the test department for another voltage, capacity and insulation resistance test. This test will be interesting.

There is a jig with multiple switch handles and a round cover with a single switch, placed above each operator, constituting a very novel testing unit. After the condensers have been connected to the multiple switches, a single throw of the switch in the round can, applies the correct test-voltage to each and every condenser connected to the test block. That in itself is not sufficient. Each condenser of a block is simultaneously tested at its required voltage. That is to say, if a condenser bank consists of 2 sections rated at 300 volts, 3 sections rated at 600 volts and 2 sections rated at 1500 volts, the combination of the multiple switches and the

Final Steps

That motley crew places the sections into the cans, and the tanks located on the benches in that far corner contain the compounds poured upon the condensers. First a low flash is poured around the contents of each can. This is permitted to settle and solidify in each nook and corner. After a short period a higher flash wax is poured into the container and permitted to settle and harden. Then a third layer of still higher flash wax is poured into the can. The flash of this final wax is about 175 degrees fahrenheit.

The completed condenser, can and all, undergoes a final test for capacity, voltage and insulation resistance.

I am sorry I haven't sufficient time to take you through the plant which produces the mica condensers moulded in Bakelite, or through the plant which produces the power resistances. You will find the enamel baking process very interesting, and also the moulding machinery. Some future day we'll make the trip.

Isolated Circuit Wiring

Cabled Wiring Offers Improvement Over Other Methods

*By W. F. Osler, Jr.**

FOR the last few years, those who have an interest in the building of radio receivers have given a good deal of thought to the matter of "low-loss" instruments—the subject has been discussed, and re-discussed in the radio press—we have had low loss condensers—low loss coils of all shapes and descriptions—"low loss" this—and "low loss" that—we've even seen advertisements of "low loss" panels.

The subject may have been overworked—we may have become wearied by the various statements, pro and con, but the fact remains, just the same, that the elimination of "losses" in one way or another has been the greatest achievement in radio. Five or six years ago, when there were few stations on the air—when KDKA was the one best bet, and "interference" was practically unknown, 50% loss in the receiver was nothing to be worried about—we were glad to get what we could—when we could—but nowadays, with a station (or two or three) at every point on the dials, losses are more serious, and it's only the approximately "low-loss" receiver that will give us anything but the nearby "locals"—with the quality that we demand in these particular times.

"Interference" is our worst enemy,

* Cornish Wire Co.

now—and it may be natural "static" which we cannot control to any appreciable extent—or "man made" static, which is the interference from electric power devices—all the way from a station which is "off its wave" to an X-ray machine or a flasher sign on a movie theatre.

The natural static—the rumblings of an approaching thunderstorm—can't be helped—yet—, the local interference from beauty parlors, dentists' motors, etc., can sometimes be helped—sometimes by a change in aerial location or length—but oftenest by eliminating internal coupling between instruments and wiring—*inside the set.*

Putting aside the instruments in the receiver—let's agree that the manufacturers have done their best to reduce losses by careful construction, proper insulating, adequate shielding, and all that—there still remains one detail that seems to have been overlooked to a very large extent—and that is the *wiring*—and that is a larger cause of trouble in the way of unwanted noises in the set than is generally supposed.

Methods of Wiring

There have, so far, been two methods of wiring a receiver whether "factory built or made at home. One was the "right angled" plan—every connection made of tinned busbar, carefully paralleled with accurate 90 degree angles at the turns—a beautiful piece of work from the standpoint of appearance. The other was the "point to point" method which came in with the "under the sub-panel" construction and which meant the shortest line from point to point—and made the under side of the base-board look like a map of the recent Chinese rebellion and the army routes through the deserts in Mongolia.

The general result was, with either of the methods, that circuit after circuit looped round and round—so it was a half hour's job to trace any wire back to its starting point and learn what it was supposed to carry.

Of course the length of wire—in a set 18 inches long wasn't serious—but the "looping" of the wiring and the excess of wire over that absolutely necessary is serious—all one has to do to prove for himself just what a small loop of wire will do is to take a six or eight inch length of insulated wire—and fasten the two ends to variable high resistance, making a loop of wire about three inches in diameter, with the variable resistance connecting the two ends.

Place this loop of wire between a primary and secondary coil in your set—or if it is a regenerative set, between the secondary and the tickler coil—or, if your coils are wound on a tube, run the coil around the outside of the secondary windings. Reduce the variable resistance to its lowest value and note the effect in your reception—it will either reduce it or possibly "blank out" reception entirely. Increase the resistance slightly so as to place some resistance in the loop circuit—and the "damping" of the reception will be less and less as the resistance is increased.

Now that is an "absorption coil"—which has been used by the writer as a regeneration control for several years—and is nothing more or less than a method of "losing" some of the induction in the regeneration circuit—BUT—and here's the point—while you have not that absorption circuit deliberately placed in your set, yet— if you have a loop of wire, forming one of the necessary circuits in the set wiring, and that loop happens to be within the field of one of the coils (particularly if it should happen to be carrying the A negative current for the tubes) it will act continuously as an "absorption circuit" and subtract in a greater or less degree from the efficiency of the coil and of the receiver output.

In some cases, a loop of wiring, carrying another circuit, other than the filament circuit, will *add* unwanted radio frequencies to the coil circuits (or transformer windings) rather than subtracting from them, and the result will be a whistle—or squeal—that cannot be eliminated without a loss of efficiency and which is annoying, if not very detrimental to the reception.

The "right angled" method of wiring is usually full of these partial "loops" and they may occur in positions where their effect is serious—or they may not—but in nine cases out of ten a set so wired can be materially improved by careful and consistent wiring—and the elimination of loops and excess wiring.

"Point-to-Point" Wiring

The "point to point" method is less liable to trouble of this kind—principally because such wiring is usually under the sub panel—and more or less insulated from the coils and condensers by the sub-panel—but even this is a haphazard method, used because of its apparent simplicity and economy of wire—which last may be important to a factory making sets by the thousands, but not to the individual builder. What's three feet of wire more or less? The answer? The answer is to so lay out your wiring that there may be no confused mess of circuits of widely different kinds looping round and round, one over the other, and exchanging impulses indiscriminately. Lay it out as carefully as you lay out the instruments on the panel and sub-panel. Try to follow the idea of some of the most efficient sets on the market today—which "cable" their wires—carrying a branch to each point—but never returning on itself, or making a "loop"—or running hap-hazard from one point to another, back and forth and round about—and the difference will be immediately noticed.

Branch Wiring

It is not easy to diagram this method—as sets differ in the location of their instruments, but the following method was used on a standard five-tube tuned radio frequency set with results that were surprising. The set was originally built with "point to point" wiring under the baseboard, all battery wiring, and the antenna and ground wires starting at the terminal strip on the rear of the board. About fifteen feet of wiring was removed—cleaning the board from a mess of apparently tangled wiring that seemed to have no reason for being—then it was re-wired. Starting with the A—, terminal post, wires were run both ways to the extreme points which were A— connections, and branches taken off for intermediate A— points, until all were connected, each with its own "branch" off the A— main line. The A+ was then run parallel to the A—, around *one* end to the filament switch and then to the rheostats—thence separate branches to the tubes—being careful to see that no A+ wires formed even half a circle—or more than two sides of a square.

The B+ detector line then paralleled the A+ wires to the last transformer—and ended there. The B+ intermediate voltage paralleled the A+ and A— wires in another direction, to the R. F. tube connections, and the B+ amplifier paralleled the filament wiring in the *other* direction to the amplifying tube connections. Any other long wiring (from tubes to jacks, etc.), were also paralleled to those wires and carried along with them to *their* terminals—and then the entire bunch of wires was "cabled together" by tying them at about one-half inch intervals with ordinary wrapping twine.

Less Wire Required

There were no returning circuits—no loops of wiring—no doubling up of two or three instruments on the same wire—each terminal had its own branch from the "cable" as straight and direct from the nearest point in the "cable" as possible. The amount of wire used was more than *one-third less* than the point to point method—and it looked as if there were less than half the wire that had been there previously.

The results were surprising—both in comparison with what the originally wired set had done, and also in comparison with another set of the same make which was still wired point to point as it came from the factory.

The rewired set had more volume (with the original tubes and batteries and aerial connections); the quality of the reception was vastly improved—there was almost an entire absence of noise, and the selectivity of the rewired set was fully 50% greater than it had been—or than the sister set with the point to point wiring. There were no R F squeals in the rewired set—and its sharpness of tuning was immeasurably improved—in fact the rewired set would receive DX stations that it had not picked up before rewiring—and stations that could not be picked up by the sister set at the same time, and under the same conditions.

Of course it is possible that some of the improvement might have been due to new and carefully soldered connections but it is certain that this could not account for more than a small proportion of the very evident improvement—for several other sets (one a 9 tube "super") have also shown equally marked improvement after the rewiring along these lines.

Naturally, uninsulated wire cannot be used—and a solid wire is hard to handle—the best proposition is a tinned, stranded wire, with a high grade insulation. This can be bent and "cabled" with ease, and makes a neat and satisfactory appearance, besides being "safe" from any possible short circuits which might possibly develop.

Prime Requisites

The two main requisites in this wiring method are first, to keep all wiring as short and direct as possible from the proper terminal to the nearest point on the "cable"—and eliminating any double connections—or looping of the wiring around the base or subpanel—for the induction between two straight wires carrying different currents is very slight, while the induction between two such wires that are looped—and reasonably close together is sometimes very great.

The second requisite is to have all the necessary wiring parallel the A negative line somewhere—and for as long a distance as consistent. All bypass condensers, designed to remove conflicting impulses in a set are *always* connected to the A-line— the A-line is the common "dumping ground" for unwanted and stray frequencies—and the paralleling of other lines with the A-lead gives a very slight by-pass condenser effect that is often sufficient to clear up an annoying R F whistle as well as other unidentified noise.

There is still one other point in favor of the method suggested—and that is; in a receiver located fairly close to a powerful local station and wired with an excess of wiring—looped and returning circuits will very frequently pick up that local broadcaster without aerial or ground connections.

"Cabling" or "isolating" the wiring from the instruments in the set by paralleling them as described effectually prevents this unwanted pick-up and you are at least certain that you have eliminated losses inside the set, and that you will get all that your locations and local conditions will allow to any receiver.

Audio Frequency Amplification

Power Amplifiers as a Means for Bettering Reproduction

By H. G. Cisin, Associate Editor

PART III

IN the previous article we attempted to bring out the point that equal results can be obtained from transformer coupled, resistance-capacity coupled and impedance-capacity coupled audio frequency amplifiers if the characteristic requirements of each system are adhered to. Obviously, it is not possible to gain much amplification from a three stage resistance-capacity coupled unit with a plate potential of only 90 volts as the voltage drop across the plate resistors is so large that the actual voltage on the plates of the tubes, with the exception of the last stage tube, is very low. On the other hand, a "B" potential of 90 volts on the plates of the tubes in a two stage transformer coupled amplifier, and even an impedance-capacity coupled amplifier, will give a fair amount of amplification. This, for the fact that the voltage drop across the primary winding of the transformer or across the plate impedances, as the case may be, is not excessive due to the low direct current resistance of the windings. Ergo, it can be stated that one of the primary limitations of a resistance coupled amplifier is the voltage requirements.

This is an economic factor. Likewise, the fact that three stages are required to provide sufficient amplification. (With tubes having a mu of 40, or 60 such as the new UX-222 and CX-322, two stages are sufficient. However, a "B" potential of 135 to 180 volts is required for best results.)

Blocking, motorboating, low frequency oscillation or any of the other ills of audio amplifiers are more or less common to the three types. In any event they cannot be considered as limiting factors as the cures are comparatively simple.

Frequency Characteristics

All three amplifiers have normal frequency characteristics which are good enough to meet all practical requirements. Poor quality is directly due to improper application of voltages and nothing else. Distortion produced in the detector circuit is due to overloading of the detector tube; at any instant when the signal voltage on the grid is sufficient to make the grid go positive and alter the tube characteristics.

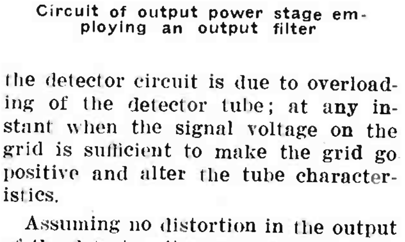


FIG. 1-A

Circuit of output power stage employing an output filter

Assuming no distortion in the output of the detector, it very seldom happens that the first amplifier tube is overloaded for the reason that the signal voltage is not large enough to make the grid of the first amplifier tube go positive—or excessively negative, in value. The same holds true for the second stage if the amplifier is of the resistance-capacity or impedance-capacity coupled type. Practically all the numerous difficulties encountered occur in the last or output stage. By the time the signal voltage reaches the input of the last tube, it has considerably increased in proportion and may have a value anywhere from 8 to 30 volts, depending upon the value of voltage output from the detector and the amplification or voltage step-up in the audio amplifier.

If distortion is to be prevented it is necessary to employ a tube in the last stage which is capable of handling the input signal voltage without overloading. By this we mean a tube whose voltage characteristics are such that the normal grid or "C" bias employed for a given plate voltage is sufficient in negative voltage value to maintain the grid at a negative value when the signal voltage goes positive. If the positive value of the signal voltage exceeds the negative value of the biasing voltage the grid of the tube will draw current and thereby produce distortion.

Since the whole matter is based on the average signal voltage impressed on the grid of the last tube it becomes immediately apparent that a power tube in the last stage is not necessary to handle the output of a single regenerative detector receiving circuit nor is a super-power tube, such as the 210 type, necessary in connection with the usual five tube tuned R.F. receiver. The fact that a comparatively insensitive receiver is located close to a powerful broadcast station has no bearing on the matter for the simple reason that unless means were taken to cut down on the regeneration or

R.F. amplification, the detector tube would be overloaded equally as much as the last amplifier tube. Unfortunately, this is a common occurrence.

Power Tubes

We have the choice of five tubes which can be used. They are: 201-A, 120, 112, 171 and 210. The 201-A in the last stage of a 3 tube set will not produce an appreciable amount of distortion providing the correct relative "B" and "C" voltages are employed, which may be 90 and 4.5 or 135 and 9. However, an output of considerable volume cannot be expected.

The 120 is the only logical tube to employ in a receiver utilizing dry-cell tubes. The 199 type is out of the question for the last stage unless two are used in parallel or in a push-pull amplifier.

In cases where the signal voltage at the output of the detector is comparatively high (8 to 10 volts) a 112 type tube should be used in the output stage with "B" and "C" voltages of 135 and 9 respectively. It is safe to run this up to 180 and 12 but is not suggested.

When the signal voltage at the output of the detector exceeds 10 a real power tube should be employed in the output stage of the audio amplifier. We have, for this purpose the 120, for dry-cell operation, the 171 and the 210. This brings us to the subject of power amplification which is so essential to excellent quality reception.

So far we have merely considered the prevention of normal distortion in the audio amplifier by the use of a tube in the last stage capable of handling the amplified signal voltage without overloading. The result, in any case, will be an amplification of the signal frequency free from distortion created by overloading. This does not necessarily mean that the output from the loudspeaker will be a faithful reproduction of the original speech frequency. There remains frequency distortion to contend with—that is, the unequal distribution of energy over the normal audio frequency band. Here is where the power tube comes into play.

Voltage amplification is highly desirable in the first stages of an audio frequency amplifier as the vacuum tube is a voltage operated device. A voltage step-up, therefore, is essential if we are to obtain amplification; it is essential just so long as one vacuum tube is working into another. On the other hand, a loudspeaker is a current operated device and since the last tube of an audio amplifier feeds the loud speaker directly or indirectly we are interested not in the voltage that can be built up but rather the amount of wattage or actual power fed to the speaker. In the main, speakers are inefficient devices with rather unsatisfactory frequency characteristics. The amount of sound pressure or volume obtainable with a given input drops rapidly at the lower audio frequencies, due primarily to a rapid drop in the impedance of the speaker winding, and therefore requires an additional boost. This can be accomplished only by use of a power tube such as the 171 or the 210. The 171 is capable of supplying approximately 700 milliwatts at a plate voltage of 180 and the 210 as high as 1500 milliwatts at a plate voltage of 425. These respective outputs are sufficient for accomplishing the objective; i. e., effective amplitude of low frequencies.

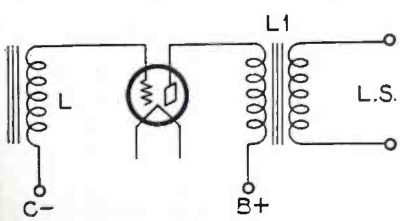


FIG. 1-B

Circuit of output power stage employing an output transformer.

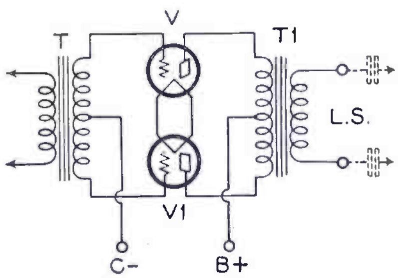


FIG. 2-A

Circuit of push-pull power stage employing a push-pull output transformer.

Output Impedance

There is another point in regards power tubes which is very important and that is the output impedance or resistance. Since the greatest transfer of energy takes place when the local impedance (the output impedance of the tube) is equal to the load impedance (the impedance of the loud speaker) it is desirable to employ a tube having a low output impedance so as to come close to matching the low impedance of the loud speaker at low frequencies.

The output impedance of a 171, at a plate potential of 180 volts, is 2000 ohms. The 210 has an output impedance of 5000 ohms at 425 volts. Obviously, the 171 is the most suitable tube since it has a much lower impedance at normal operating voltage than the 210. As a matter of fact the 171 will deliver proportionately more energy to the loud speaker at low frequencies than the 210.

For average purposes a single 171 in the output is sufficient to handle the output of any set but if the signal voltage at the output of the detector is extremely high it may be more fitting to employ a 210. Either the circuit of Fig. 1-A or Fig. 1-B can be employed, they being identical except that in the first circuit an output filter, composed of a choke and a condenser, is used to protect the speaker windings from the excessively high direct plate current and in the second circuit an output transformer is used. Both methods are satisfactory but it should be remembered that in either case the output filter or output transformer should be one designed for the tube used.

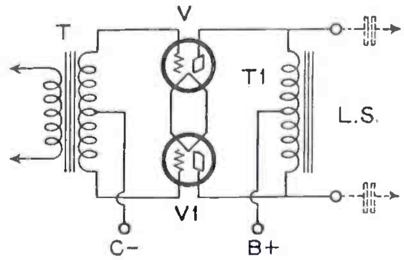


FIG. 2-B

Circuit of push-pull power stage employing a push-pull output impedance.

Push-Pull Amplification

Having gone so far there is very little serious distortion left to contend with. Harmonic distortion is not at all serious unless the power tubes are working to capacity and considerable volume being delivered by the loud speaker. In the event that it is noticeable or that actual distortion due to overloading is taking place a push-pull amplifier should be used. Since the input voltage to a push-pull amplifier is divided between two circuits, twice as much input voltage is required to affect the same output as obtained from a single circuit. However, the tubes stand less chance of being overloaded.

Since the harmonic voltages are opposite in value in the grid circuits they cancel each other out in the plate circuit, while the fundamentals are additive. Due to this action it is permissable to supply the filaments of these two tubes with raw A. C. and experience no hum.

The circuits of Figs. 2-A and 2-B are equally as good, but the same precautions should be taken regarding the design of the output filter or output transformer, depending on whether tubes V and V1 are 171's or 210's.

The condensers shown in dotted lines in Fig. 2-B are not essential, since the direct plate current will take the plate-filament paths only, but will prevent anyone from receiving a possible shock from the loud speaker terminals. This is not possible in the circuit of Fig. 2-A as an output transformer with an insulated secondary winding is used. The condensers shown in dotted lines are employed only in the event that an electro-dynamic speaker is used, this type of speaker having its own input transformer to match the impedance of the moving coil unit to that of the output tube. In this case, the condensers insulate the secondary winding of the output transformer, T1, from the primary of the transformer in the speaker.

The Mathematics of Radio

Further Applications of Ohm's Law. The Calculation of Resistance Values for "B" Eliminators, Etc.

By John F. Rider, Associate Editor

PART II

Let us consider another example, that of a plate coupling resistor such as used in a stage of resistance coupled audio frequency amplification. Fig. 3 shows an average circuit. "Res." represents the plate coupling resistor and MA is the milliammeter. Assuming a resistance of 250,000 ohms for the plate coupling resistance and a flow of .00028 ampere, what is the voltage drop across the resistance. Substituting our figures for the signs in formula 3, given in the last article, we have

$$E = 250{,}000 \times .00028$$

$$E = 70 \text{ volts.}$$

Thus far we have been solving for the voltage drop. Let us now reverse the procedure, and consider that we desire to produce a definite voltage drop. This situation is encountered very often in everyday radio practice and a thorough understanding of the principles involved will clarify many puzzeling situations and problems.

In formula 3, E or voltage is the unknown factor, resistance and current being known. This time, however, voltage is known, that is, we know just what voltage drop is required, and therefore just what voltage we wish to apply across certain points. We know or at least must know the current flow, and the problem is to solve for the value of resistance which will produce the desired voltage drop when the known value of current is flowing through the resistance. The formula for solving such problems is No. 5, given in the last article, and the utility of the formula is very extensive.

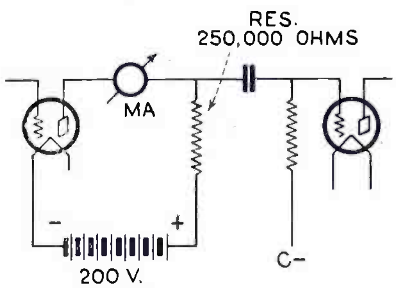


FIG. 3

Circuit for determining the voltage drop across a resistance

Studying the formula we find that resistance is equal to voltage divided by current. Let us apply it to practice. We will take a well known example. Suppose we have a vacuum tube or a number of vacuum tubes, and a certain voltage is required to heat the filament or the filaments to correct brilliancy. Our source of voltage and current supply is greater than the voltage value required. We require a resistance which will reduce the voltage to the proper value. Expressed differently we must select a resistance which will produce a definite voltage drop. Suppose the tube filament requires 5 volts and consumes .25 ampere. The voltage of the potential source is 6 volts. We must produce a voltage drop of 1 volt, in the line supplying the tube filament with voltage and current. We know the value of voltage drop required and the current flow in the circuit. We therefore solve for resistance. Substituting our values in formula No. 5 we have

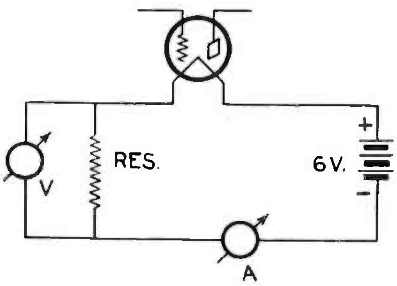


FIG. 4

A circuit incorporating an ammeter and voltmeter for indicating electrically the functions of Ohm's law.

$$R = \frac{1}{.25}$$

$$R = 4 \text{ ohms}$$

An example of the above is shown in Fig. 4. Here we have the average tube filament circuit, with an ammeter in the line and a voltmeter connected across the resistance, which produces the voltage drop. If we applied the figures mentioned above to the units in this circuit, the voltmeter V would indicate 1 volt, when the tube filament was lighted to normal brilliancy.

From the above, we can safely state that producing a certain voltage drop is equivalent to solving for a required resistance, since the function of the resistance in all such circuits is to produce a certain predetermined decrease in voltage. For example in "B" eliminator circuits.

Calculating Resistance Values for "B" Eliminators

Many readers have displayed interest in the methods utilized to produce definite output voltages and therefore definite voltage drops. For some reason however, the appearance of the circuit seems to magnify the problem into an insurmountable obstacle. Admittedly, it is more difficult to ascertain the available voltage, but the actual process of solution is identical for the tube filament circuit and the "B" eliminator output circuit. Let us consider the concrete example illustrated in Fig. 5. We see the filter system and the output voltage reducing resistances R and R1. The problem at hand is to ascertain the values of resistances required to reduce the available voltage to predetermined values required as plate voltage for the various tubes. In other words we must produce various values of voltage drops, this value being the difference between the available voltage and the required plate voltage.

In order to satisfactorily select the proper resistance it is necessary that we know the values of E and I for formula No. 5. But before we can decide upon the voltage drop we must know the available voltage. In "B" eliminators this is a variable factor, a very unfortunate condition, but which

Circuit, including a milliammeter, for the calculation of resistance values for "B" Eliminators.

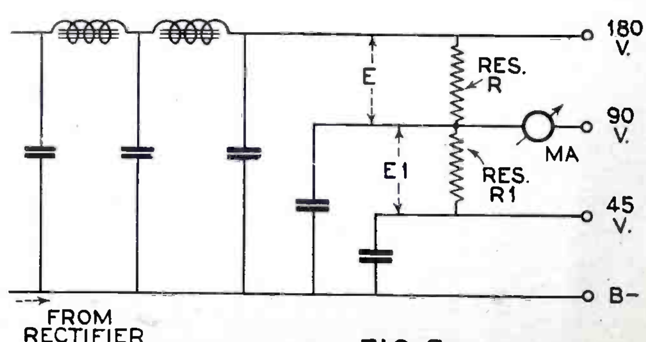


FIG.5

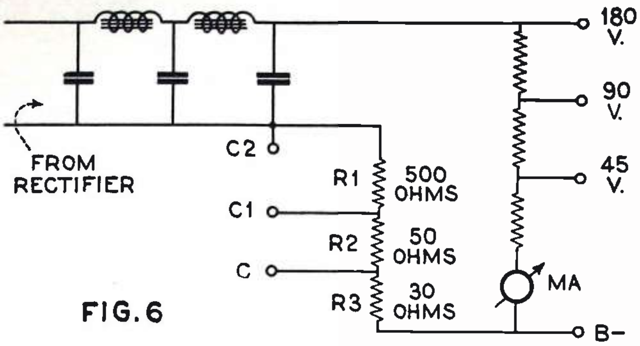


FIG. 6

Circuit, including a milliammeter for the calculation of "C" bias voltages.

cannot be remedied. It is characteristic of "B" eliminators of all types to vary in output voltage as the current drain is increased or decreased; an increase causing the voltage to drop and a decrease causing it to rise. The first problem therefore is to decide upon the total current drain which will be imposed upon the eliminator circuit. This is not a difficult problem. The fan who desires to select these resistances is usually in a position where he can determine the maximum drain upon the eliminator. This value is governed by the number of tubes used and the plate voltages applied to the tubes. These two factors, in addition to the "C" bias, govern the plate current consumed by the tubes. By referring to tube charts which have been published innumerable times, it is a very simple process to determine the maximum drain. Let us assume that the maximum drain will be 33 milliamperes or .033 ampere. Let us further assume that with this drain the maximum output voltage is 190 volts. This determination is again a problem which must be solved and is usually solved by the designer of the unit who advises the operating characteristic of the rectifier system. It is customary to state how much the maximum output per milliampere increased drain.

Our problem calls for a tap which will supply 90 volts plate voltage for four tubes, 45 volts plate voltage for one tube and the full 190 volts is being applied to the output tube, which for purpose of illustration is a 171. The four tubes consume 14 mils and the one tube with 45 volts on the plate, consumes 1 mil. In order to supply these two voltages we require two resistances, one of which must produce a voltage drop of 100 volts and the other must produce a voltage drop of 45 volts. Let us refer to the wiring diagram in Fig. 5 and call these resistances R and R1 respectively.

Substituting the known values into formula No. 3 and solving for R we have

$$R = \frac{100}{.014}$$

$$R = 7143 \text{ ohms}$$

Solving for R1 we have

$$R1 = \frac{45}{.001}$$

$$R1 = 45{,}000 \text{ ohms}$$

Resistance R1 is called upon to produce a voltage drop of 45 volts only, because it obtains its voltage from the 90 volt tap and the additional drain of 1 mil. is practically negligible.

"C" Bias Voltages

The calculation of the "C" bias voltage is carried out along the same lines. Again we must know the total

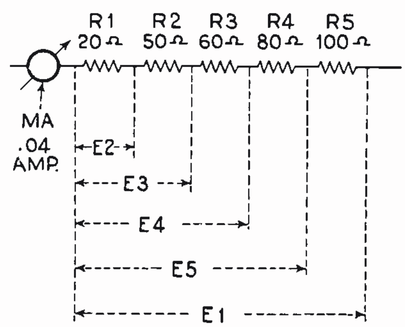


FIG. 7

An example circuit illustrating the functions of Ohm's law. With 40 milliamperes flowing through the circuit and knowing the values of the five resistances it is a simple matter to find the voltage drop across each resistance by progressively substituting the values in formula No. 3.

current flow in the circuit and the various bias values required. Examine Fig. 6. Here we have three "C" bias resistances R1, R2 and R3, supplying "C" bias voltages C, C1 and C2. R1 is a 500 ohm resistance, R2 is a 50 ohm resistance and R3 is a 30 ohm resistance. Suppose we forget for a moment that we know the values of these three resistances, and consider that we require three values of "C" bias.

The requirements call for a 40.5 volt bias (negative), a 9 volt bias and a 4 volt bias. The total plate current flowing in the circuit is 33 mils. What value of resistance is required to produce a voltage drop of 40.5 volts? It is best to figure the maximum voltage first, inasmuch as the other smaller resistances can be an integral part of the main resistance. Substituting our figures into formula 5 we have

$$R = \frac{40.5}{.033}$$

$$R = 1227 \text{ ohms}$$

R = is the total resistance required to produce the voltage drop of 40.5 volts which is used as the negative bias.

Solving for the resistance required to produce the 9 volt bias we have,

$$R = \frac{9}{.033}$$

$$R = 271.5 \text{ ohms}$$

Solving for the resistance required to produce the 4 volt bias we have

$$R = \frac{4}{.033}$$

$$R = 120 \text{ ohms}$$

By tapping the major resistance at the proper points, the correct voltage drops can be obtained with the single unit. Let us now figure the voltage drops available with the resistances shown in the drawing (Fig. 6). The voltage available at point C2 is the drop across the three resistances or the drop across.

$$R1 \text{ plus } R2 \text{ plus } R3 = 580 \text{ ohms}$$

$$E = 580 \times .033$$

$$E = 19.1 \text{ volts}$$

At point C1 the drop is that across R2 plus R3 or 80 ohms.

$$E = 80 \times .033$$

$$E = 2.64$$

At point C the drop is that across R3 which is a 30 ohm unit, and

$$E = 30 \times .003$$

$$E = .99 \text{ volts}$$

In a series circuit such as the above, where a number of resistances are connected in series and a constant amount of current flows through all the resistances, the voltage drop across each resistance is proportional to the resistance, and the sum of all the voltage

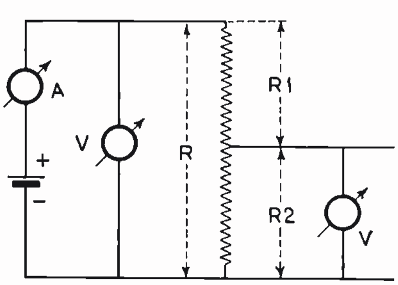


FIG. 9

Example circuit illustrating the function of a voltage divider.

drops or IR drops, as it is often mentioned, is equal to the total voltage. The illustration shown in Fig. 7 is very similar to the C bias resistance arrangement shown in Fig. 6.

With 40 milliamperes flowing in the circuit, the voltage E1 is equal to the IR drops across R1 plus R2 plus R3 plus R4 plus R5. One fact must be remembered in such series circuits, where a number of resistances are in series. If the voltage applied remains constant, the current in the circuit is inversely proportional to the total resistance of the circuit. That is to say, if we place a current limiting device such as an incandescent lamp into a circuit, which, without, the lamp would consume much more current, the current in any part of the circuit will be inversely proportional to the total resistance. In other words if we place an iron requiring 3 amperes with a 50 watt bulb, which consumes approximately .5 ampere, and the line voltage remains at 125 volts, the lamp will limit the current flow. It is because of this phenomena that we can operate a 201-A tube filament from the regular house line, if we have a 25 watt lamp in series with the tube filament. This arrangement is utilized in the many A. C. oscillators which are arranged for both "A" and "B" supply from the 60 cycle house supply.

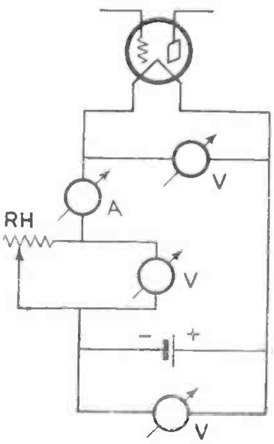


FIG. 8

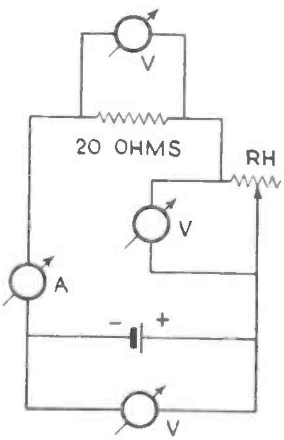


FIG. 8A

Fig. 8. Example arrangement which will indicate the values of voltage current and resistance in a simple series circuit.

Fig. 8A. A similar arrangement indicative of the results obtained from the circuit of Fig. 8.

Further Application of Ohm's Law

The mention of current leads us to the discussion of the third member of Ohm's law, that pertaining to current and designated as formula 5.

An analysis of the formula

$$I = \frac{E}{R} \qquad (5)$$

shows that for a constant voltage, across a varying resistance, the current is inversely proportional to the resistance. That is to say, if the voltage is constant, doubling the value of the resistance will halve the current; halving the resistance will double the current.

On the other hand if the resistance remains constant and the voltage is varied, the fluctuation in current will be directly in line with the fluctuation of the voltage. With a constant resistance, doubling the voltage will double the current; halving the voltage will halve the current. It is well to remember that current has the same value in any part of a series circuit. This fact can be utilized to good advantage when wiring the D. C. circuits of receivers, particularly the filament circuits. The IR drops may vary because of variations in resistance, in the various parts of the circuit, but the current remains uniform throughout the circuit.

Voltage Divider

We cannot overlook the voltage divider or potentiometer as it is often called. This is a device which permits in a convenient and easy manner, the attainment of a voltage lower than the voltage of the source. This arrangement is shown in Fig. 9 and will be recognized as the arrangement frequently found in the output circuit of "B" eliminators. We discussed a system of selecting voltage reducing resistances for use in "B" eliminators. There is, however, another method, when the voltage reducing resistances are arranged in the fashion shown. You can imagine the resistance R in Fig. 9 to be the resistance shunting the output circuit of the eliminator. The function of this resistance, as in the case of the other, is to produce a certain voltage drop. We observe the resistance R shunting the source of potential. The voltmeter V indicates the IR drop across R. By means of the slider we can divide R into two parts, which we can call R1 and R2. The voltage drop across the whole resistor we can call E, and this is constant while the current is constant. The voltage drop E1 across any two points of the resistance R, for example, the points indicated by the dotted lines associated with the portion designated as R2, is equal to the product of the complete voltage drop E (across the whole resistor) and the ratio between the part designated as R2 and the whole resistor R.

Expressed differently, in the form of a formula it reads as follows:

$$E1 = E \times \frac{R2}{R} \qquad (6)$$

Let us now consider some simple combination which will illustrate voltage, current and resistance in a series circuit. In Fig. 8 we show a tube circuit, with meters connected to the various parts of the circuit. We find the battery equipped with an indicating voltmeter. We find a voltmeter connected around the resistance controlling the flow of current in the circuit. We find an ammeter which will indicate the amount of current flow and we find a voltmeter connected across the tube filament terminals to indicate the voltage drop across the tube filament terminals to indicate the voltage drop across the filament terminals. Let us assume that we know from records (books, circulars, etc.), that the tube filament voltage should be 5 volts. The potential available from the battery is 6 volts. We bring the rheostat RH into play and note that when the tube voltmeter indicates 5 volts, the ammeter A indicates .25 of an ampere and the voltmeter shunting the rheostat indicates 1 volt and the voltmeter shunting the battery shows 6 volts. We note that the two voltage drops as indicated on the rheostat and the tube voltmeters is equal to the voltage shown by the battery voltmeter. (The voltage drop across the resistance of the ammeter is classed as negligible.) Solving for resistance with the voltage drops indicated on the rheostat and the tube filament voltmeters and the current indicated on the ammeter, we find that the resistance of the rheostat is 4 ohms and the resistance of the tube filament is 20 ohms. Let us replace these two units with fixed resistances of like value and observe the meters. This is shown in Fig. 8A. The results are identical.

(To be continued)

Test Sheet for A. C. Tubes Being Made

THE new A. C. tubes have come on the market with so little preparation so far as service is concerned that the Wisconsin Radio Trade Association, Milwaukee, Wis., is planning a service data sheet for their care and operation. These will be available to all radio merchants in the state who care to send for them.

The data sheet, besides telling just how the tubes operate, goes into detail concerning their adaptation to the various sets, which one goes in which socket, and all the necessary information concerning their installation in sets as well as the installation of the set itself.

Better Radio Reception†

Home-Made Static and How to Produce—or Avoid—It

By Robert J. Casey*

Mr. Casey presents to you a glowing sermon on Interference. In addition, he stages a very exciting side show where one may enter, view the unrestrained gyrations of Fatima, in a new role, and leave with a sense of growing wisdom.

The first act, presented herewith, reveals the diabolical plot.

Do not miss the coming performances, when the Roaring Devil will be effectively hog-tied, gagged and put in his proper place.

We are confident that Mr. Casey's sermon on Better Radio Reception will assist you in solving your own very personal interference problems.

PART I

IT IS part of the credo of the American Radio Public that all queer little buzzes and hums inside the receiving set come from two causes:

Item: Static.

Item: A leak in that doggone transformer out there on the post in the alley.

Fair enough: No stickler for simplicity could demand a more simple disposition of a difficult problem. No classification of trouble could be more nearly all-embracing. No other solution could appeal so strongly to such a variety of minds. It springs squarely from the genius of the race; somebody told it to the first radio fan and that great love of truth which characterizes all receiving set owners has fostered it in record and tradition until it is the most widely quoted axiom in all this so-called science. It is magnificent in its broad generality ... And like so many other beautiful but broad generalities it isn't so.

About four hundred harried interests have made a study of the important subject of interference during the past few years. Far-sighted gentlemen in laboratories long ago took time off from the problem of radiating heat from rheostats, peaking intermediate transformers, mortising cabinets and keeping condenser plates from scraping, and turned their attention to noise—domestic and imported. They realized that no other circumstance or combination of circumstances could affect the future of radio so vitally.

It was discovered that rumors of crackles, rumbles and roars in radio sets were true. There were such annoyances.

It was likewise discovered that Old Man Static had been blamed for many a disastrous attempt at reception when as a matter of fact he was nowhere in the picture.

It became evident when the first tabulation of statistics was made that most of the complaints regarding loud and painful noises might be placed in the same category as that of the dog that sat on his own tail and howled, but was too lazy to move.

It was the consensus that the home-brew-noise industry proceeding so blithely natural static might be dismissed from consideration. A man with the hives is not likely to complain much about a mosquito bite.

Home-Made Static Our Theme

So in the present survey of this sprightly topic static that really is static will be ignored. Nobody knows much about what it actually is, but there is a growing fund of information on how it can be overcome and at present writing it ought to be the least of the set owner's worries.

As for the other brand of static it had best be considered after the plan of the Scotch preacher who took as his text: "The devil goeth about as a roaring lion" and announced:

"I shall discuss this text under three heads:

"First—Who the devil he is ...

"Second—How the devil he goeth ...

"And third—What the devil is he roaring about."

Item No. 1 is easy. If you hear a roaring in headphones or loudspeaker or a sound suggestive of eggs being fried in butter that is eliminable interference.

There is, of course, another brand of interference—a curse quite noticeable and persistent in large cities—the interference of one spirited broadcasting station with another. Nothing can cure this short of dynamite or activity on the part of the federal commission, so it will not be treated here. Crackles, hums, moans, roars and spurters are something else again and their source may be sought right close to home.

Item No. 2 is somewhat less easy. But the answer will be supplied. Weary engineers have learned a lot about how interference is transmitted and they have learned also how such transmission may be stopped.

Item No. 3 is an outgrowth and corrollary of No. 2. Power plant executives are just as much concerned as radio listeners in finding out if and why their equipment is wasting enough current to put the broadcast sopranos out of business. They are interested in learning not only what "that doggone transformer out on the post is roaring about," but also what the public is roaring about. And they have found out. They thank heaven for it.

Sources of Home-Made Interference

Sources of home-made interference are so numerous that one blushes to enumerate them. But, oddly enough, though they are legion and generally unsuspected, most of them may be eliminated in a few seconds, with no great demand for skill or knowledge of electricity, and at a few cents cost. A concerted drive by the interested public would put all of these nuisances out of business over night.

It probably should be stated in this preliminary observation that "that doggone transformer out on the post in the alley" is quite likely to have nothing at all to do with the disturbance. In thousands of cases investigated it was found that transformers generally were about as prolific a source of noise as the mummy of the late King Tut. Power line engineers, despite the general belief, are strictly against any continuation of leakages. To the radio public it may seem logical enough that power companies should burn coal at present prices just for the fun of pumping current through holes in the line to the ground. But they don't. They'd much rather sell electricity than broadcast it.

The real offenders in the manufacture of parasitical noises are the handy electrical devices so widely used in office and home. Not all of these are static makers, but all of them have the power to be if not properly safeguarded. And so they might as well be listed at once and completely:

Arc lights
Electric heaters
Electric irons
Electric pads
Automatic railway signals
Electric curlers
Marcelling outfits
Soldering irons
Waffle irons
Shaving mug heaters
Percolators
Vibratory rectifiers
Mercury arc rectifiers
Flash signs
Elevator controls
Small motors
Violet ray machines
X-ray machines
Electric vibrators
Electric meters
Telephone dialers
Telephone magnetos
Leaky transformers
Doorbells and buzzers
Annunciators
Dishwashers
Dough mixers

† Courtesy of Radio Manufacturers' Association.
* Staff-writer, Chicago Daily News.

Soda mixers
Electric typewriters
Electric addressing machines
Electric phonographs
Electric dictating machines
Electric computators
Printing presses
Dust precipitators
Hair clippers
Automatic towels
Oil burning devices
Refrigerators
Vacuum cleaners
Motor brushes
Starting commutators
Leaky cables
Farm lighting systems
Electric cigar lighters
Street car switches
Breaks in third rails
Defective light sockets
Bad connections in home lighting systems.

Classification of Interference

An analysis resulting from this survey tends to show that interference from such devices may be placed in one of four classes:

Motor noises
Thermostatic controls
Bad contacts
Leaks

All such interference may be further classified according to the method used in its elimination:

Simple condensers
Center tapped condensers
Condenser and choke

The crackling emanations from most of the electrical household devices come from the little motors required to operate them. The bulk of them are really nothing but a small motor put to various uses. What will silence one of them will silence nearly all.

Thermostatic controls have a certain reluctance about getting down to business. They are prompted by some sort of a heat-responsive device and are supposed to make or break a connection when a given temperature is reached. Thus they may maintain a refrigerator at freezing point or a hot water heating plant at 300 degrees Fahrenheit. But when they hesitate they cause a good deal of sputtering and each sputter is registered in the loud speaker—"with volume enough to dance by—hear it all over the house."

Bad contacts in fuse boxes, light sockets or in the interior mechanism of electrical devices, act much the same as thermostats except that the action is wholly voluntary and for no good purpose. Such defects call for repair (generally simple) instead of exterior appliances.

Leaks are only another manifestation of bad contacts with this difference—the contacts are wholly unintentional. Generally they spring from broken insulation bridged to the ground by moisture.

On the whole, in analyzing these four classifications of noise production, one is struck by the fact that there is actually only one cause—a vagrant spark. The motor that is shielded electrostatically causes no disturbance even when sensitive radio apparatus is quite close to it. The thermostatic control that is properly bridged by condensers is similarly silent. A bad contact becomes increasingly objectionable as its sparking becomes greater. And it is not so much the increase in the monthly light bill as the static effect of the power-line leak that makes it worthy of attention.

Noise-Makers Out of the Kitchen

Of course, all interference that puts the curse on one's radio set is not to be located in one's own kitchen. There is a care-free omnipresence about interference that for a time almost baffled the distracted engineers assigned to discover the "How-Come" of it. We may as well pause here to consider this phenomenon under the heading: "How the Devil He Goeth."

There might be no appreciable difficulty with such crash-makers as violet ray machines and power line leaks were it not for the antenna effect of the wires leading to and from the point of disturbance.

It is this feature of the case that in the past has made life so much of a burden for the noise detectives. If, for example, there is a serious leak in a trolley line equipment a radio compass might indicate its presence in a north and south street, whereas after laborious searching it might be discovered a mile away on an east and west portion of the line.

Every power line is surrounded by its own electromagnetic and electrostatic fields, variations in which may cause similar variations in wires placed near them. Under normal conditions where lines are carrying alternating current there are variations at a rate of from twenty-five to sixty pulsations (or cycles) per second. Such variations, contrary to general belief, are of small importance to radio listeners. They do not travel very far from the line and unless the aerial equipment is parallel and close to the power carrier will seldom get through to the loud speaker with any volume.

However, sudden changes in the line current result in an electrical surge—sometimes at a high frequency—and the output from such surges is thrown far from the source of trouble and far from the line itself.

It seems silly to repeat here that old chestnut about keeping the antenna as far as possible from the power lines. For years that suggestion was the stock answer of the 'radio expert" to all inquiries regarding interference. Half the time—perhaps ninety per cent of the time—the interference arose from causes quite remote from this diagnosis. However, the advice is not without its merit in certain cases and so we mention it—well aware while doing so that the status of probably not one aerial will be changed as a result.

Well, let us get on with this lecture.

We have seen that spark discharges may result:

First—from defective apparatus or from devices improperly guarded against such activity.

Disturbance may be caused with equal effect and no greater malice when the propogation is part of the legitimate function of the apparatus such as:

Second—from circuit breakers, vibratory rectifiers, and rotary interrupters.

In these discharges there will result not only a direct radiation from the point of propagation, but a broadcasting of high frequency currents along the wires leading from that point. The effect of this form of interference is quite the same as that of the spark transmitter which in the early days of radio was such a sprightly nuisance.

Power currents are alternating at a low frequency which as a general rule will not be picked up by the R. F. end of the receiving set. However, all radio sets have in them an audio frequency amplifier which takes a great interest in the moan of the sixty-cycle line.

This leads to the consideration of magnetic coupling between power lines and apparatus and the A. F. amplifier

Merely another manifestation of the truth of the wheeze "Keep your aerial away from the power lines."

Possibly in a lesser degree interference arises from a broadcasting of low frequency energy quite aside from that brought to the set by induction as is brought about when power circuits are brought into oscillation. Oscillating circuits radiate . . . It seems that somebody has mentioned this before.

That probably covers all of the story of how the good old power line electron leaves the dynamo with a certificate of character and develops lamentable qualities in transit. It virtually exhausts the subject of How the Devil He Goeth and brings us to the subhead of What the Devil He Is Roaring About.

NELA's Classification of Interference

The National Electric Light Association, which investigated the problems of radio interference at considerable effort and expense roughly classified its worries as follows:

POWER CIRCUITS

1—Lines
2—Insulators
3—Lightning arresters
4—Transformers
5—Generators and motors
6—Induction voltage regulators

INDUSTRIAL APPLICATIONS

1—Arc light circuits
2—Telephone and telegraph lines
3—Pole changers and converters
4—Street cars and electric railroads
5—Smoke and dust precipitators
6—Motors
7—Sign flashers

HOUSEHOLD APPLIANCES

1—Electric pads
2—Violet ray machines

3—Flat Irons
4—Door bells, light switches and motors

(This list is manifestly much shorter than the one which appears near the beginning of the present survey, but an analysis will show that it very nearly covers the field inasmuch as with electric pads may be classified all thermostatic control devices; with the violet ray machine any other form of high frequency generator; with flat irons, all types of resistance wire heaters—such as curling irons, percolators, soldering irons, waffle griddles, etc.; and with door bells, light switches and motors, all of the loose contact disturbances and the emanations from apparatus with moving parts, such as fans, vacuum cleaners, washing machines, etc.)

MISCELLANEOUS

1—X-ray machines
2—Storage battery chargers
3—Annunciator systems
4—Stock tickers
5—Ignition systems
6—Electric elevators
7—Electric furnaces
8—Moving picture equipment
9—High voltage testing equipment

Coping With Interference Causes

Fortunately, plans for coping with these manifold trouble-makers began when radio was young and continued in pace with the new industry. So complete is the knowledge on the subject at the present date that it is far more simple to choke off a trolley line than to perform a tonsilectomy on an obnoxious tenor. All of these secrets will be revealed in due time—plus a lot of rare old Rembrandts with crosses marking the spot where the body was found.

The old time solution—the hurling of dynamite with a time fuse—is now frowned upon as too elementary and crude. With all that is now known of this important and interesting topic one would as soon try to get music out of a one-tube single circuit set as blow up a power plant.

Briefly, let us consider the cause of howling, humming, and all the rest of the volunteer symphony. We may summarize what the National Electric Light Association discovered in its survey.

Power Circuits

1—Lines—In this connection it is pointed out that lines generally consist of a primary network of from 220 to 220,000 volts stepped down for practical uses through a transformer to 110 to 220 volts. Admittedly the disturbance from radio frequency generation in the high voltage lines is serious on account of the amount of energy they carry. Disturbance from secondary lines is less because the energy is less, but none the less must be considered because it is carried close to the receiving set. Engineers investigating line emanations reported their conclusion that no trouble is caused unless there is a discharge or partial ground—in other words, when some abnormal condition develops. Arcing, through defective insulation, partial contact with trees or other conductors or the sheathing of conduits, are advanced as typical causes of trouble.

2—Insulators—Insulators defective in themselves or coated with ice or sleet make possible an arcing discharge with a highly damped effect that is transmitted for long distances along the line and radiated to a degree dependent on the extent of the leak. Light association engineers reported that the arcing of a 66,000 volt insulator obliterated radio reception within a radius of six miles.

3—Lightning Arresters—Difficulties from these devices are of sporadic occurrence and may be left among the worries of the engineers.

4—Transformers—While a leaky transformer capable of doing all the damage accredited to it by the average radio listener would undoubtedly blow up early in its career, it has been found that its core hum may be picked up by an audio amplifier. If, in addition to a core hum, it has also bad insulation or corroded connections it will sing sufficiently to make all the radio listeners in any one neighborhood buy phonographs.

5—Motors—Again the problem is arcing and the broadcasting of high frequency energy along the power line. Sparking of the brushes of a rotary converter was heard by the noise finders at a point on the line nine miles away. However, a superheterodyne receiver 150 feet from the line did not seem to be aware of the disturbance.

6—Induction Voltage Regulators—These appliances are used in lines which otherwise might be subject to severe drops and jumps in voltage. They consist of a contact-making voltmeter, relay switch, line drop compensator, and some transformers. All of these elements, the engineers reported, are capable of creating weird noises if contacts are bad or windings or leads are grounded. Arcing of relay switch contacts produces customary results.

Normally there is no activity in the regulator, but if there is a jump or a drop in voltage the meter moves to close a contact and starts the motor of the control device.

All in all the ills of the gadget seem to be the concern of the company that owns it. The National Electric Light Association recommends that in testing the device, the best method is to take it out of the line and see if the noise stops. Elimination of its various components then follows, step by step. All of this work, of course, has to be done by power company electricians if the fire department is to be saved the trouble of picking corpses off of electric light poles.

If we are about to forget the voltage control business forever we may append the finding of the engineers to the effect that regulator interference may be eliminated by connecting two one microfarad condensers in series between the outgoing feeders and grounding their common connection.

We come now to that amazing contribution to the true and the beautiful entitled

Industrial Applications

1—Arc Light Circuits—And we find that this delightful topic is not treated en masse, but is divided into three intriguing sub-topics, reading from left to right: A—Line; B—Arc Light, and C—Mercury Arc Rectifier or Direct Current Generator.

We may as well skip item "A." It is merely an iteration of the fact that the line may act as an antenna to distribute noise or may cause the noise of its own volition.

"B" has a more novel look. The engineers point out that an arc light consists of two electrodes between which current flows with a brilliant flare, and devices for moving the electrodes as they burn. Normally, it is said, this adjustment occurs about once an hour and so quietly that even sensitive sets in the immediate neighborhood do not pick up the resultant click. Loose connections and grounds are cited as the chief causes of woe, plus a third known to the trade as "lamp-jumping." This as nearly as can be determined is a spasmodic contortion of electrodes generally resulting from broken globes. All three difficulties are easily remedied.

"C" is probably the most important of the three subdivisions inasmuch as such rectifiers in use in battery stations are less likely to receive attention than disturbers which are peculiarly the property of the light company. They are used also to supply direct current to ordinary arcs and so have a pretty fair distribution in cities. Normally they cause no trouble. In operation they may develop fading characteristics due to changes in vacuum and consequent alteration of the voltage curve. The fading or pumping results in a very spirited output of radio frequency interference. Choke coils in both sides of the circuit are recommended as a cure for such activity. Heat treating and resting the mercury tube are also suggested by the engineers. The average radio listener will no doubt feel a perfect neutrality about this unless he is a stockholder in the power company. It is further recommended that the power company's trouble shooters report the difficulty to the manufacturers of the arcs—which seems to be as good a solution as any.

Commutator trouble is listed as the chief cause of trouble in direct current generators. Inasmuch as this same ailment comes up for treatment elsewhere it might as well be passed here.

If you live in Van Wert, Ohio, you will have wasted your time with this valuable information concerning the life and habits of the mercury arc. Such devices are forbidden by law as are bootleg Scotch, vibratory charges, and prussic acid.

Van Wert has taken the leadership in this great reform, but possibly will stand alone for some time, inasmuch as the use of a few dollars' worth of condensers will eliminate all the effects which tend to make arcs unpopular.

And so we come with palpitant interest to:

No. 2—Telephone and Telegraph Lines—It was discovered in the survey that owing to the low energy in such lines they are not a source of serious annoyance. Disturbances which they seldom produce themselves, but sometimes convey by induction are easily eliminated when the collector system of the receiving set is changed.

Possess your soul in patience and we shall take a look at:

No. 3—Pole Changers—These gadgets are used in small telephone exchanges to produce a pulsating direct current for ringing polarized bells or an alternating current for use with common bells. They are a source of trouble through sparking of interrupting contacts.

Pole changers operate from a D. C. source, generally a storage battery and if an A. C. source is desired a new difficulty is introduced in the shape of a frequency converter with two mechanical rectifiers in it. Operation is similar to that of the vibratory battery charger so its principles, if any, need not be exposed at this time. Its trouble-making ability comes from the fact that it may radiate not only from the A. C. line but from the ringing line which it supplies.

The pole changer disturbance is carried out and distributed among the avid radio listeners by telephone line pickup which may be prevented if the device is properly shielded and kept out of the way of magnetic coupling. The frequency converter buzzes around over the secondary lighting feeders supplying the exchange.

Some success has been had in the detection of the source of such noises by the use of a 25 turn honeycomb coil on a long pole with leads in series with a crystal detector and head phones.

Once the trouble is located it can be eliminated by filters and here again the investigators direct that the telephone company employing the troublesome devices state their woes to the manufacturer who supplied them. He will provide the necessary remedies. The report tends to show that telephone companies have much to worry about aside from wrong numbers.

Steel Railway Conductors and Non-Conductors

Which brings us expectantly to:

No. 4—Street Cars and Electric Railroads—It is generally supposed that the chief trouble on street railway lines is caused by the conductors. We now have it on good authority that it is the non-conductors which disturb the public peace.

Arcing grounds, broken insulators, sparking commutators, arcs at trolley wheels, arcs at car wheels . . . Arc! Arc! The Larks. . . .

All of these sizzling products are distributed across cities — possibly across counties — by the hard-working trolley lines.

The investigators are a bit saddened at the noises of trolley lines. They are not so bold as to suggest that the public walk to work and force the operating companies into bankruptcy as a means of silencing them. But they hint that nothing short of that process will do much good.

However, some hope is at hand if chokes are placed at intervals in the power wires and condensers are hooked in between the power wires and the ground. If these heroic measures do not eliminate the noises the radio listener is at liberty to move out into the country and buy a flivver.

5—Motors—Let us forget them until later.

6—Smoke and Dust Precipitators—Here we have the mystery element entering into the engrossing narrative for the first time. The engineers seem to be a bit undecided both as to "How the Devil He Goeth" and "What the Devil He Is Roaring About." Such devices are of varying types, but in principle they are alike. They establish a highly charged electrical field inside the chimney or chute so that particles moving into the field are charged and driven against precipitator plates where they stick. The investigators have not yet determined just how they cause interference, but they know the habits of some of the components—notably the rectifiers used with them. Here as elsewhere arcing contacts are responsible for a good deal of the racket. The Bureau of Standards suggests that the rectifier be kept close to the precipitator and housed in a grounded metal shield with a tuned circuit between sparking terminals. Otherwise, it is pointed out, the smoke elimination may have its effect on sets twenty miles away.

7—Sign Flashers—Once more the arc! Make-and-break contact devices are the basis of all these devices with consequent generation of radio frequency currents. In cities they are a peculiarly persistent offender particularly if used near large apartment buildings. But they may be silenced and their beauty, if any, kept intact for the community if a simple filter is connected across their contact points. Electric lines feeding the sign should be enclosed in metal conduit.

So ends the discussion of General Classification No. 2. Looking back at the debate so far it seems to prove nothing except that it is very worrisome to be trouble shooter for a power company. The next classification is of more immediate and poignant interest to the lads who own the sets. To wit:

Household Appliances

1—Heating Pads—As has been mentioned earlier in this interesting narrative, these things are kept at a constant heat by means of thermostats; otherwise they would burn up—and why not? Contacts in the thermostats open and close and in doing so arc.

The best method for stopping interference from heating pads is to turn them off. One can also toss them into the waiting ash-can and buy a hot water bottle, but such extreme methods are hardly necessary if the radio listener retains sufficient energy to turn the switch. Condensers across the thermostat points will cut down the interference to a minimum, but inasmuch as it is hardly practicable for an ordinary householder to get inside the pad and make such adjustments he can compromise by putting a larger condenser between the two lines of the input.

2—Violet Ray Machines—These things must be heard to be appreciated. They sound like all the static in the world augmented by hard coal falling through a chute. Generally, a vibrator in the apparatus is the cause of the annoyance and, of course, the good old "Turn-it-off-and-put-it-away" method is supremely effective. If any investigative soul desires to use his violet ray outfit and listen to radio at the same time he may eliminate the noise by hooking a tapped condenser between the input terminals of the machine and grounding the center tap.

3 — Flatirons — Interference from such appliances with resistance wire heating elements is generally the result of bad insulation and may be eliminated by the purchase of a new heating element.

4—Doorbells, Motors, Light Switches—Motors will be dealt with separately. Light switches cause only slight clicks when turned on or off unless they are so defective that they cause a sputtering arc. If they are they have to be fixed. Doorbells are generally only a sporadic source of interference. If the antenna system is kept some distance away from the bell wiring the difficulty is virtually nil. (In one case investigated for the R. M. A. it was found that the radio receiver picked up the ringing of the telephone bell. . . . Tracing of the collector circuit shows that the set and the phone system were using a common ground.)

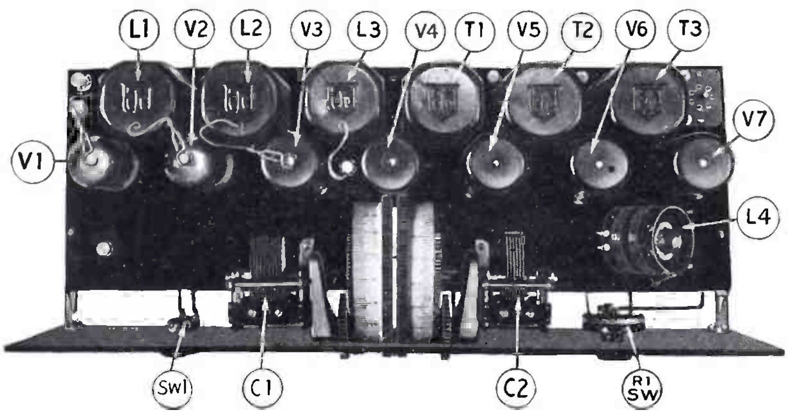
Possibly it should be pointed out here that most of the troubles arising from the use of electricity in the home are simple to trace and simple to remove. At present household electrical devices are possibly the most persistent nuisances in radio, but this is 99 and 44/100 per cent due to the neglect or ignorance of operators.

(To be continued)

The Tyrman Shielded-Grid Seven

THIS receiver, which is fully described in the January issue of *Radio News*, is not an experiment or a laboratory design but is a finished product which is known to operate satisfactorily. It is the result of several months of intensive experimental work, and provides an ideal set for one who desires the utmost in sensitivity. Another feature is that standard parts are used throughout in the construction.

It will be noticed that the receiver consists of a circuit employing an oscillator, a first detector, two stages of intermediate-frequency amplification, a second-detector and two stages of audio-frequency amplification. Although three stages of intermediate-frequency amplification are required in the average superheterodyne receiver it has been found that two stages are more than ample when shield-plate tubes are employed.



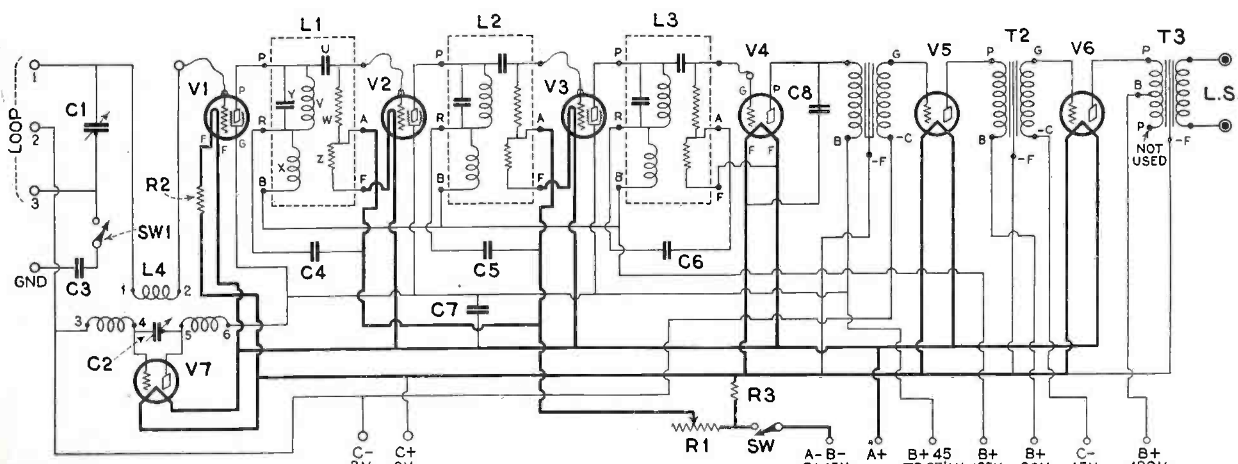
Interior view of the Shielded-Grid Seven. The I.F. units and A.F. transformers are lined up along the rear of the sub-base. L4 is the oscillator coupler. Note the vernier drum dials

The three shield-plate tubes are shown in the diagram as V1, V2 and V3, and are used in the first-detector circuit and the two intermediate-frequency stages. V4, the second detector, may be a standard 200A- or 201A-type; V5, the first audio tube, and V7, the oscillator tube, are standard 201A-type tubes; and V6, the second audio tube, is a type-171 power tube.

The schematic diagram of the shield-plate tube shows that it has one more element than the standard tube. In construction the filament of the tube is similar to the one used in the 120-type power tube. It draws a current of 0.125 ampere and its maximum operating voltage is 3.3 volts. The filament is a single straight wire, surrounded by the circular grid of the tube. This grid corresponds to the grid of the average tube, but it will be called the control-grid in this article. The fourth element of the tube, i. e., the plate shield or screen-grid, is a double spiral enclosing the plate. It is placed between the plate and the control-grid and outside the plate; thus shielding the plate entirely.

The addition of a fourth element to the new tube makes necessary five terminals to each tube. The tube is mounted in a standard UX base and the terminals are connected as usual, except that the screen-grid is connected to the grid terminal and the control-grid is connected to a special terminal which has been mounted on the top of the tube. When the tube is used in a receiver connection to the control-grid is usually made with a flexible wire and a clip.

A theoretical explanation of the operation of the tube would be too lengthy to include in this article. However, it may be explained that the use of the fourth element reduces the in-



Schematic diagram of the Shielded-Grid Seven, which is designed for use with a loop aerial. Three screened plate tubes are used; one as the first detector and two as the I.F. amplifiers. Note that impedances are employed in place of the usual I.F. transformers.

ternal capacity of the tube to a minimum and eliminates oscillating disturbances in R.F. circuits without the necessity of neutralization. The plate resistance of the tube is approximately 500,000 ohms when a potential of 135 volts is used on the plate and a potential of 45 to 50 volts is applied to the screen-grid. The negative bias potential applied to the control-grid is from 1 to 3 volts.

To obtain the highest possible efficiency when using tubes of the shield-plate type an external shield must be placed around each stage. This was found necessary in order to avoid oscillations and to obtain maximum amplification. A comparison between a standard receiver and one using shield-plate tubes will show the outstanding advantage of the latter. When 201A-type tubes are used in an R.F. amplifier, it is difficult to obtain a gain greater than seven per stage; but properly-designed circuits using the shield plate tubes will give an R.F. amplification of thirty per stage, and considerably more when lower frequencies are used as in all intermediate-frequency circuits of superheterodyne receivers.

In connection with the second detector and audio amplifier circuit it is not necessary to enter into a lengthy description of the apparatus used, as it is similar to the standard design. The two audio transformers and output transformer are connected in the usual manner, except that the core is grounded to the filament in each case. A glance at the diagram will show also that one terminal on the output transformer is not used.

Either batteries or a power unit may be used for the operation of the receiver. As the three shield-plate tubes require a current of only .125 ampere each, the total current required by the filament circuits of this receiver is only 1.625 amperes, which makes the set very economical to operate. Also, the plate current is not excessive, as it is usually less than 35 milliamperes. For the grid circuit two "C" batteries are required; one of 45 volts, and the other 3 volts.

For the operation of this receiver a loop antenna is employed as a pick-up. The sensitivity of the receiver is sufficient to allow distance reception without the necessity of an outside aerial, and the use of the loop provides the additional advantage of directional selectivity.

LIST OF PARTS REQUIRED

- L1, L2, L3—3 Tyrman I. F. Impedance Units
- L4—1 Camfield Oscillator Coupler
- T1, T2—2 Tyrman A. F. Transformers
- T3—1 Tyrman Output Transformer
- C1—1 Camfield .0005 Mfd. Variable Condenser
- C2—1 Camfield .00025 Mfd. Variable Condenser
- C3—1 Carter .0001 Mfd. Fixed Condenser
- C4–C7—4 Carter 1. Mfd. By-pass Condensers
- C8—1 Carter .0005 Mfd. Fixed Condenser
- R1–SW—1 Yaxley Combination Rheostat and Switch
- R2—1 Yaxley 15 Ohm. Fixed Resistance
- R3—1 Yaxley 1 Ohm. Fixed Resistance
- SW1—1—Yaxley S.P.S.T. Switch
- 4 Tyrman U.X. Sockets with Shields
- 3 Tyrman U. X. Sockets with Special "22" Shields
- 1 Tyrman Double Vernier Drum Dial
- 1 Yaxley 7-Wire Battery Cable
- 8 X-L Binding Posts
- V1, V2, V3—3 Shieldplate Vacuum Tubes
- V4, V5, V7—3 Cunningham CX-301–A Tubes
- V6—1 Cunningham CX–371 Tube
- 1 Duro-Metal Tapped Loop Aerial
- 1 Lignole Front Panel, 7" x 24" x 3/16"
- 1 Formica Sub-panel, 8" x 23" x 3/16"
- 2 Benjamin Metal Brackets
- 1 Roll Acme Hookup Wire

The Vitrohm D. C. Eliminator

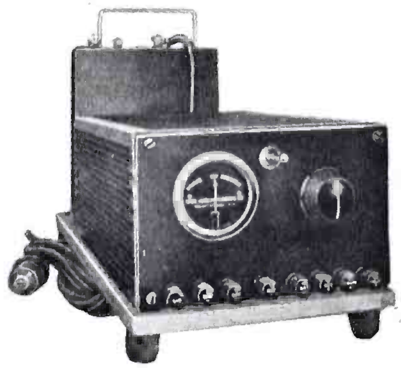
THIS is not an attempt to discourage the man in a D. C. district who hasn't a set and who is about ready to buy one of the new models for D. C. light socket operation. Rather, this article is presented for the benefit of the many thousands with direct current in their homes, and who have a radio set that satisfies them perfectly. The Vitrohm D. C. Eliminator to be described in the following paragraphs provides A, B and C voltages for any set employing up to 8 ¼-ampere tubes.

It is no exaggeration to say that no power supply unit for direct current work on the market today corresponds to the Vitrohm D. C. Eliminator. To the best of the writer's knowledge there is no direct current A, B, C eliminator available as one unit in assembled form at any price.

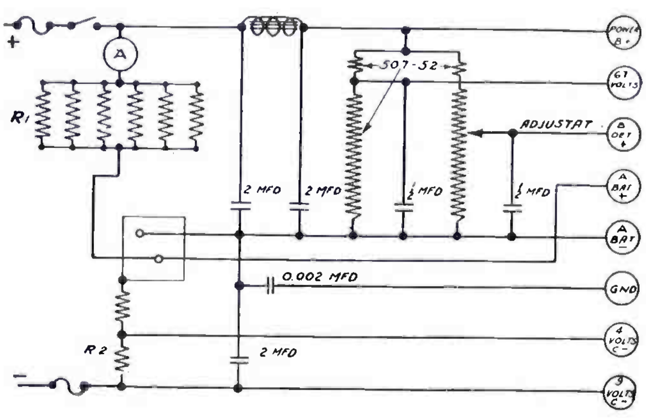
The design feature of outstanding interest and importance in this new Vitrohm D. C. Eliminator is that the tubes in the receiving set cannot be burned out, paralyzed or damaged through the Eliminator. That is, with five tubes in a 5-tube set, one or more may be removed with the Eliminator operating with no fear of injury to the tubes left in the set. Regardless of how few or how many tubes are in the set at any time, the "A" voltage always remains constant.

During the past year several worth while D. C. eliminators have been presented to the building public, but in all of them the danger was always present of blowing or paralyzing tubes in the set should the load be altered by removing one or more tubes. Caution in this regard need not be taken with the Vitrohm Eliminator, since constant "A" voltage is assured, regardless of tube changes.

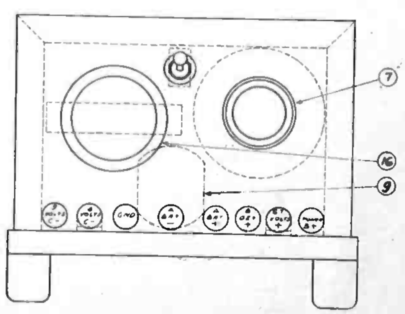
To be worth the time and money spent building it, an "A" eliminator



Front panel view of the Vitrohm D.C. Eliminator



The schematic diagram of the Vitrohm direct current A, B and C Eliminator, employing an Abox filter



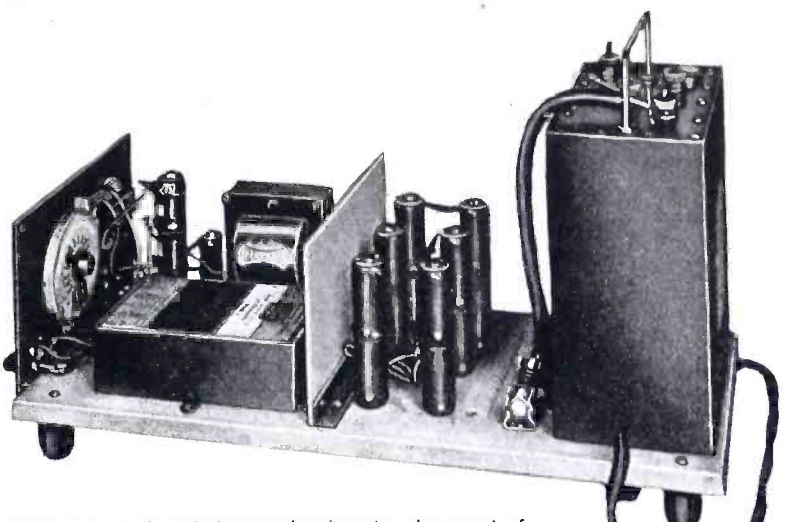
A detail drawing of the front panel. Note the condenser mounting (9) must have one feature which can be absolutely relied upon. That is constant unvarying voltage.

Now in the Vitrohm D. C. Eliminator constant "A" voltage is taken as a consideration of first importance. Regardless of incoming line voltage within wide limits the constant-voltage feature of the Eliminator makes certain that the output will always remain the same on the "A" side, hour after hour, week after week.

Glancing at the schematic circuit diagram you will notice the use of the Abox Filter. The Abox device consisting of a high capacity electrolytic condenser and filter combined as a unit, is an unusually effective voltage regulator. Incoming line voltages may occasionally vary from ten to twelve volts and even more where current is generated in a small independent plant, such as for hotels and other large buildings. Such incoming voltage fluctuations need not worry the owner of the Vitrohm D. C. Eliminator, for the output on the "A" side of the unit always remains constant.

Freedom from hum and troublesome noise can be attributed generally to the design features of the Eliminator, and specifically to the new type audio choke used, along with the high value electrolytic condenser and filter. The choke, incidentally, has several important features which make it especially suitable for use in the Vitrohm Eliminator. It has a low D. C. resistance along with a current carrying capacity of over 50 milliamperes. A special type of winding on a core of a newly developed metal alloy of extraordinary permeability along with its low resistance and current-handling capacity, contribute definitely to the final satisfying performance of the Eliminator.

In the detector leg of the "B" voltage supply a Vitrohm Adjustat is employed to permit ready adjustment of detector plate voltage whereby 16 separate adjustable voltage steps are available, giving extremely flexible control of detector plate voltage. With this wide range available, it is rapidly possible to find just the right voltage for the particular detector tube in the set, and once the value is found, the

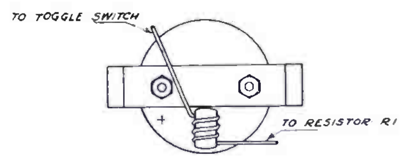


Side view of the eliminator showing the placement of parts. Note the heat baffle plate between the current carrying resistors and the rest of the parts

Adjustat is left fixed until the tube is changed.

Two grid bias voltages are available, one at 4.5 volts for A. F. or R. F. tubes and the other at 9 volts for the A. F. tubes.

The B side of the eliminator is equipped with three separate taps: one



Rear of indicating meter. Note direction in which wire is wound

connects to the Adjusrat providing detector voltage, which is adjustable from 0 to 67; another furnishes 67 volts; and a third, maximum voltage of from 100 to 110, depending upon the incoming line voltage. It should be remembered that direct current cannot be stepped up, and consequently no more than about 110 volts maximum is possible with any D. C. eliminator working from the customary 115 volt house mains. However, if higher voltages are desired, a 45 volt B battery or two hooked up in series with the Eliminator output will provide ample voltage for, let us say, a 171 in the output socket.

If carefully followed, the drawings accompanying this article should enable the experimenter to build the Vitrohm Eliminator with no trouble. Two or three hints and suggestions may be helpful in saving time.

Note the 0.002 mfd. fixed condenser mounted behind the instrument panel on the ground post. This is done by screwing the condenser on the ground post in place of a nut. Then the remainder of the posts may be mounted in place.

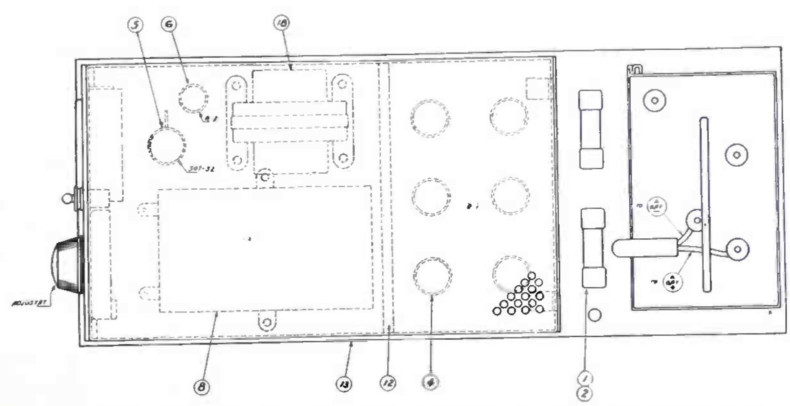
Mount the rest of the parts on the bakelite front panel, but do not wire them until the other apparatus has been mounted and wired.

The wiring may be done with No. 14 rubber covered wire, or with an asbestos covered wire. Ordinary spaghetti-covered wire is not recommended.

With the wiring of parts in Sections 1 and 2 completed as far as possible set the Abox Unit in place and run one duplex (twisted) lead as short as possible to it. The clips for the 5-ampere line fuses should be mounted and wired.

Now complete the rest of the wiring. Wire the binding posts and the other parts on the front panel. With all the wiring done, fasten the metal case to the two end panels, as shown in the accompanying sketch.

There are four connection points for the Abox Unit. Only two on the top are used. This is important. The other two connections, which are common, form a connection with the case, and the lead is taken from one of the



Constructional layout of parts. The indicating numbers are identical to those given in the list of parts tapped rods holding the case to the baseboard.

Now with the line fuses in their clips, and the Abox made ready by adding water, the Eliminator is ready for use.

Before connecting the Eliminator to the receiver, bear in mind that the ground post on the set should not be used. The ground wire should be disconnected from the set, and the ground connection made instead to the ground post on the front panel of the Vitrohm Eliminator.

This change must be made before the Eliminator is placed in operation with the receiver. To disregard it means the danger of burning out tubes in the set.

Once the simple change of ground connection is made, the rest of the set connections may be made safely.

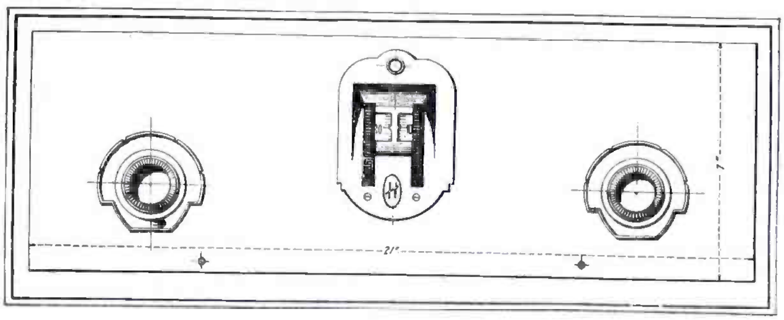
The small meter on the front panel of the Eliminator gives a quick check on the polarity of the plug in the lamp socket or wall outlet. If the wiring diagram shown here is followed, this meter will indicate "Charge" when the polarity of the plug is correct. Even should the polarity be reversed, no harm will result to set or Eliminator. To correct polarity simply reverse the position of the prongs of the plug in the receptacle or socket.

LIST OF PARTS REQUIRED

Item	Quantity	
1	2	Fuse, 5 Amp., 250 Volt
2	4	Fuse Clip, 30 Amp., 250 Volt, N.E.C.S.
3	1	Cord and Plug
4	6	Ward Leonard Vitrohm Resistor, B-300
5	1	Ward Leonard Vitrohm Resistor, No. 507-52
6	1	Ward Leonard Vitrohm Resistor, A-5 Tapped Center
7	1	Ward Leonard Vitrohm Adjustat, 10,000 Ohms
8	1	Parvolt Condenser Block, 2, 2, 2, 0.5, 0.5 Mfds.
9	1	Sangamo Mica Condenser, 0.002 Mfd.
10	8	Eby, Binding Post
11	1	Abox Filter Unit (6 Volt)
12	1	Heat Baffle Plate, Transite, 4⅜"x⅛"x6¾"
13	1	Baseboard, Transite, 7¼"x½"x17 13-16"
14	1	Front Panel, Bakelite, 4 7-16"x⅛"x7"
15	1	Toggle "On-Off" Switch, 110 Volt
16	1	Polarity Indicator, (Charge-Discharge)
17	1	Stamped Metal Case
18	1	Ferranti Filter Choke
		Incidental Hardware, Including Threaded Rods, Mounting Feet, and Mounting Brackets for Stamped Steel Case

The "Optimum" Five

By T. B. Rhodes



Above: Panel layout of The "Optimum" Five. Below: Layout of apparatus on the panel and baseboard

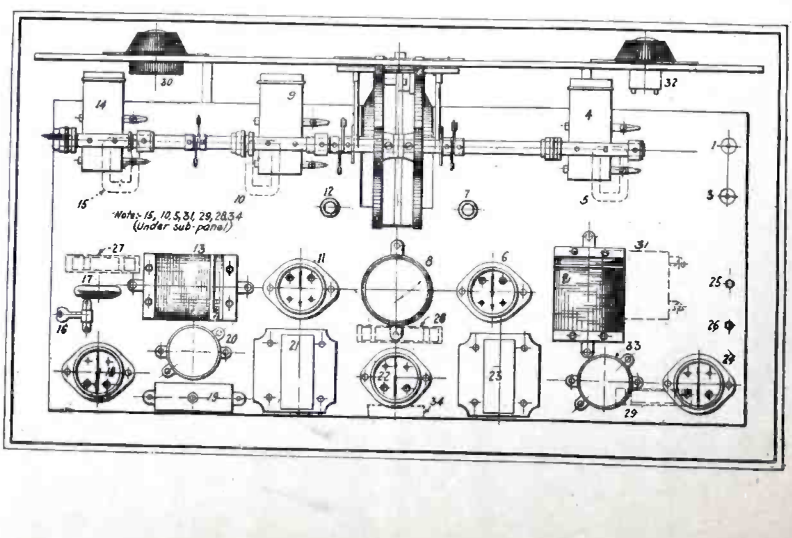
IN the "Optimum" Five, it has been found possible to combine many recent advances made both in radio and in audio frequency amplification practice.

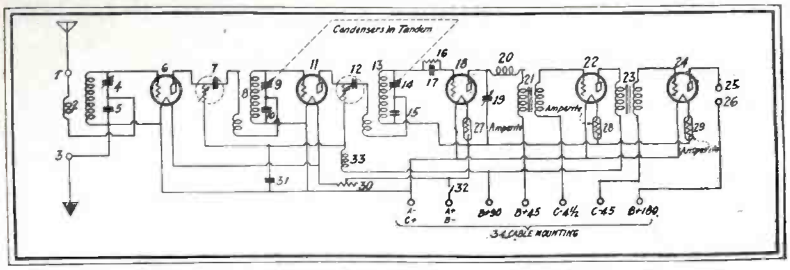
On the radio frequency side, the matter of constant coupling has been receiving more and more attention. The principles involved are easy to understand. In operating an ordinary radio receiver many have noticed that at the higher wave lengths the set is not quite sensitive enough to receive distance, that it operates exceptionally well between about 35 and 60 on the dials, and that it shows a tendency to oscillate or squeal on the lower dial settings. The reason for this is that the energy transfer between the primary and secondary of the radio frequency transformers increases rapidly as the frequency increases. That is to say, energy transfer is much greater at short wave lengths than at long ones. As a result the relative selectivity is less, ordinarily, on the shorter wave lengths.

The two principal methods which have been developed for eliminating this condition and obtaining constant coupling may be classified under the headings of "mechanical" and "electrical." "Mechanical" systems of obtaining constant coupling involve the use of an "auto-couple" coil, in which the coupling between the primary and the secondary is automatically varied by the rotation of the associated tuning condenser. The outstanding example of this type of constant coupling is the Hammarlund Hi-Q.

The "electrical" method of obtaining constant coupling and the resultant constant energy transfer, utilizes a system of electromagnetic and electrostatic coupling between radio frequency stages. This method, which was first introduced in the Loftin-White circuit, has been the subject of considerable experimentation and study on the part of the writer, culminating in the development of the "Optimum" Five. In the "Optimum" circuit, not only is there a continuously equal transfer of energy between the primaries and secondaries of the radio frequency transformers at all wave length settings between 200 and 600 meters, but the amount of energy transferred is at all times maximum. Furthermore, due to the utilization of phasatrols in the plate circuits of the radio frequency tubes, disturbing potentials are equalized, distortion is prevented and perfect stability and balance are attained.

On the audio frequency side, the most radical improvement centers about the use of new audio transformers. These transformers have cores constructed of a special alloy having a permeability many times greater than the best of silicon steels. An unusually large core cross-sectional area is used. The design is such that there is "Optimum" amplification over the entire musical frequency range. A curve showing the relation between amplification per stage and frequency in cycles per second, plotted from an actual test of the transformer, shows a remarkable flat top characteristic. Stated more simply, uniform and maximum amplification is obtained from the lowest audible bass notes to the





Circuit diagram of the "Optimum" Five. This is a modified form of the original Loften-White constant coupling circuit.

highest trebles. There is a sharp cut-off just above the musical range, minimizing any tendency towards oscillation at high frequencies and eliminating the undesirable background of noise often encountered with mediocre transformers. Although no speaker filter is shown in the illustrations, this may be incorporated very readily by connecting a 30 henry choke between the plate of the last tube (24) and the "B" plus 180 (that is shunted across the output jacks). A 4 mfd. condenser should also be inserted between (25) and the point where the choke connects to the plate circuit. This combination of choke and condenser will act as a tone filter and will give adequate protection to speaker windings, where high voltages are to be used.

In adjusting the set, it should be connected up and the phastrols turned counter-clockwise, all the way out. Set the rheostat (30) about half-way. Move each phasatrol just a little in order to make contact and tune in a strong local station, preferably a short wave one. Loosen screws on the left flexible coupling (facing rear of panel) and set both condensers (9) and (14) by hand until maximum volume is obtained. Then increase phasatrols, taking care to make equal increases in both, until an adjustment is reached just below the point of oscillation. When trying for distant stations, increase rheostat until set oscillates, otherwise leave rheostat about half-way at all times.

LIST OF PARTS REQUIRED

2—Sangamo Audio Transformers, Type A, (21. 23)
3—Precision R. F. Transformers, Type 4 D (2. 8. 13)
3—.0005 Mfd. Hammarlund "Mid-Line" Variable Condensers (4, 9. 14)
3—Hammarlund Insulated Flexible Couplings
1—Illuminated Drum Dial, Hammarlund
2—Hammarlund R. F. Chokes, Type RFC-85 (20, 33)
2—Electrad Phasatrol (7. 12)
5—Eby Sockets, new style (6, 11, 18, 22, 24)
1—X-L Variodenser, Type G-1 (19)
3—Amperites (27, 28, 29)
2—.004 Mfd. Sangamo Fixed Condensers, tested to within 5%
1—.004 Mfd. Sangamo Fixed Condenser (15)
1—.00025 Mfd. Sangamo By-Pass Grid Condenser (17)
1—2 Meg. Durham Metallized Resistor Grid Leak with Vertical M'ting (16)
1—½ Mfd. Acme "Parvolt" series "A" cubical Condenser (31)
1—6 Ohm Carter Rheostat (30)
1—Carter "Imp" Filament Switch with Knob (32)
2—Eby Engraved Binding Posts (1, 3)
2—Carter Tip Jacks (25, 26)
1—Yaxley 7-Strand Cable, complete with Connecting Plug and M'ting Plate (34)
2—Rolls Acme Celatsite Wire
1—Can Kester Radio Solder (rosin Core) By the Chicago Solder Co.
1—Panel, 7"x21"x3-16", Westinghouse Micarta
1—Sub-Panel, 9"x20"x3-16", Westinghouse Micarta
2—Brackets, low type
4—"Speed" Super Emission Tubes, Type 201-A (6, 11, 18, 22)
1—"Speed" Super Emission Tube, either X112 or X171 (24)

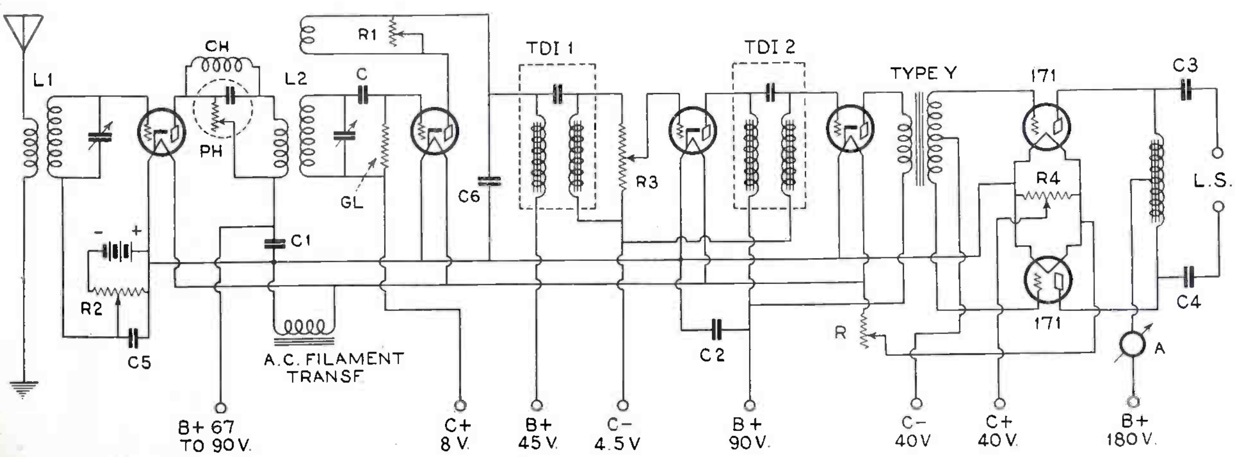
An A.C. Phasatrol Receiver

THE advent of the Federal Radio Commission and its activities have wrought a decidedly favorable influence upon the wavelength situation throughout the country. The station interference problem, which was so prominent, has been greatly clarified. The strained broadcasting situation has been greatly relieved. With the authority vested in the commission, broadcasting stations have been allotted new operating frequencies, with definite advantages to present and prospective receiver owners.

One of these advantages is found in the fact that the need for a multi-stage tuned radio frequency amplifier is not imperative, in the quest for satisfactory selectivity. The stringent regulations pertaining to broadcasting station wavelengths, have produced beneficial results to all concerned. These regulations have shown their influence upon radio receiver design, with the final result that an economical receiver can be constructed by the radio fan, with the assurance that the results will be satisfactory.

Such a radio receiver is the A. C. Phasatrol unit, designed by *John F. Rider* and shown herewith. Not only is the receiver economical and efficient but it is designed along the most modern lines. In step with modern development, it includes some of the latest innovations of the art. The receiver is arranged for A. C. operation, alternating current tubes being utilized. The audio system includes both tuned double impedance audio amplification and push-pull output.

The receiver as a unit, is of excellent design, possessing a high degree of stability, sensitivity, selectivity and amplifying power. Several new improvements are incorporated. The radio frequency amplifying tube grid is



Circuit diagram of the A. C. Phasatrol Receiver. Note the manner in which "C" bias is obtained for the first A. C. tube.

controlled by means of a variable negative bias. The bias is variable from 0 to 6 volts, but it is always negative, hence the disadvantages of a positive bias are eliminated, despite the fact that the radio frequency amplification is under control.

The use of the tuned double impedance units provides the possibility, if desired, of tuning the audio system to compensate for speaker deficiencies in the lower audio register. The push-pull output provides for decided advantages, in the form of increased output with minimized distortion, and more silent operation, due to the operating characteristics of push-pull systems.

Stabilization of the radio frequency system is effected by means of the Phasatrol system. The operating characteristic of the Phasatrol has been improved upon by means of a little choke, shunting the phase shifting condenser. This choke is external of the unit, and when operated with the Phasatrol affords more uniform response of the broadcast frequency spectrum.

The construction of the unit is not difficult, neither is the cost of the parts prohibitive. The receiver is of course designed for use with an outdoor aerial, and in tests with an outdoor elevated aerial 60 feet long, its performance was very creditable. The audio amplifying system is exceptionally powerful, and arranged to introduce the least amount of distortion, despite the high gain.

As was mentioned the receiver is A. C. operated utilizing the new Arcturus 15 volt, .35 ampere tubes. This type of tube utilizes a heater filament and is very effective. The entire receiver is designed for "B" eliminator operation, with the exception of the "C" voltages for the R. F., detector and first two audio tubes.

LIST OF PARTS REQUIRED

1—7"x21"x3/16" Black Westinghouse Micarta Panel.
2—DeJur No. 180-B .00035 Mfd. Variable Condensers.
6—Eby Sockets.
1—Electrad Phasatrol.
2—1st Stage Tuned Double Impedance. (Harkness, Ford Mica, Kelford, Mutter Paragon).
1—Type Y Samson Push-Pull Audio Transformer.
1—Type Z Samson Push-Pull Output Impedance.
1—Aerovox No. 1450 .00025 Mfd. Condenser (C).
2—Aerovox No. 250 1. Mfd. Fixed Condensers (C1, C2).
1—Aerovox No. 250 .5 Mfd. By-pass Condenser (C5).
1—Aerovox No. 1450 .001 Mfd. Fixed Condenser (C6).
2—Aerovox No. 400 4 Mfd. 400 Volt Filter Condensers (C3 C4).
1—DeJur 7 Ohm Rheostat (to carry one ampere) (R).
1—DeJur 400 Ohm Potentiometer (R2).
1—DeJur 200 Ohm Potentiometer (R4).
1—0 to 50 Jewell D. C. Milliameter.
1—Electrad Type E, 0 to 500,000 Ohm Royalty Resistance (R3).
1—Electrad Type 0 to 25,000 Ohm Variable Resistance (R1).
1—Silver Marshall No. 115A Coil (L2).
1—Silver Marshall No. 515 Coil Socket.
1—Ellis D Coil (L).
3—Arcturus Amplifier Tubes.
1—Arcturus Detector Tube.
2—171 Amplifying Tubes.
9—Eby Binding Posts as follows: 1-Aerial, 1-Ground, 1-67.5 v, 1-90 v, 1-45 v, 1-180 v, 1-6-40 v, 2-Output.
1—Small Choke (40 turns of No. 30 DSC wire on a 1" spool).
1—2 Meg. Grid Leak and Mounting (GL)

The "C" batteries supplying the radio frequency, detector and first two audio tubes are connected directly to the grid return terminals. The "C" bias for the push-pull tubes can be obtained from the "B" eliminator. The filament voltage for the 171 tubes is obtained from the transformer supplying the A. C. tubes, and is reduced by means of the 7 ohm rheostat, R. The mid-tap, for this circuit is obtained by means of the 200 ohm potentiometer, R4.

The Arcturus A. C. tubes do not require a mid-tap, the "C" plus terminals of the various grid voltage batteries being connected to the cathode of the tube. The "B" minus terminal of the "B" battery is also connected to the cathode of the detector tube. It is recommendation that a 45 volt "C" battery be used as the source of grid bias for the push-pull output tubes. The transformer supplying the 15 volts for the tubes is a Lionel 25 volt, 100 watt unit. It is tapped for various voltages between 7 and 25 volts.

The New Browning-Drake Receiver

By Glenn H. Browning

WITH the normal progress of radio the question of refinement has become paramount. Simplicity of control and beauty of appearance are now demanded of apparatus which a year or two ago merely needed to be efficient to be acceptable.

A new Browning-Drake tuning kit makes its bow with this issue of RADIO ENGINEERING, featuring a positively driven drum dial single control tuner, with coils of two inches in diameter, the whole unit mounted on an aluminum chassis.

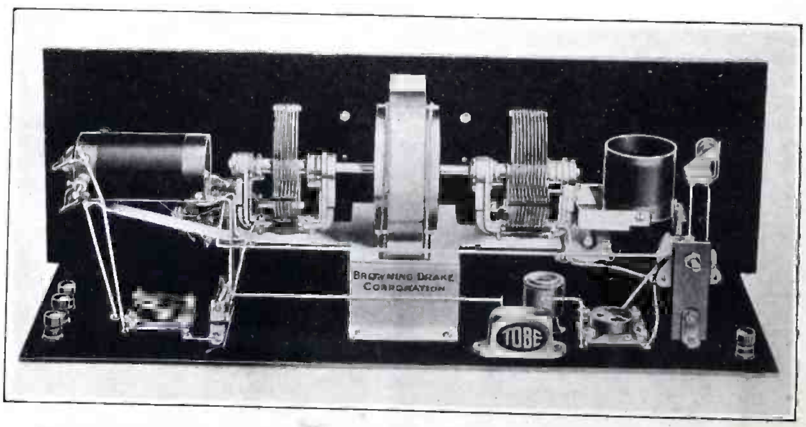
Reduction in the dial ratio is achieved by a new mechanical action which absolutely prevents any backlash taking place. This was designed by Mr. Harold Benner at Cruft Laboratory, Harvard University. Smooth action with none of the usual dragging feeling of the ordinary vernier dial is a feature of this device. It is illuminated from behind the drum, the figures showing through a window in the front panel plate.

Realization that the audio end of a receiver need not be built in with the R. F. end of a set is slowly dawning on the minds of the radio public. There are so many obvious advantages in having a separate amplifier that one wonders that it had not been done before.

The development of a tuned radio frequency transformer by Dr. Drake and the writer in the fall of 1923, which was later incorporated in a tuning device consisting of one stage of tuned R. F. amplification, neutralized and combined with a regenerative detector, makes a very satisfactory two-tube kit-set to go with any form of audio amplifier system.

The type of R. F. amplifier above described has proved itself to be a great deal more efficient than one stage of neutralized R. F. amplification with a non-regenerative detector. This is undoubtedly due to the fact that when regeneration is applied to the detector circuit you also get some regeneration on the antenna tuning system, which increases the amplification of both circuits in the same operation.

The antenna circuit employed in the Browning-Drake receiver is a conductively coupled one, that is the antenna comes in directly to a tap on the antenna coil through a .0001 mfd. condenser. This system has proven to be very efficient inasmuch as it gives a much more even response over the whole broadcast band than any other circuit tested. There is also the advantage that good signal strength may be obtained even from an extremely short antenna, although one



Rear view of the new Browning-Drake Receiver. The tuning equipment is made into a single unit and is single control.

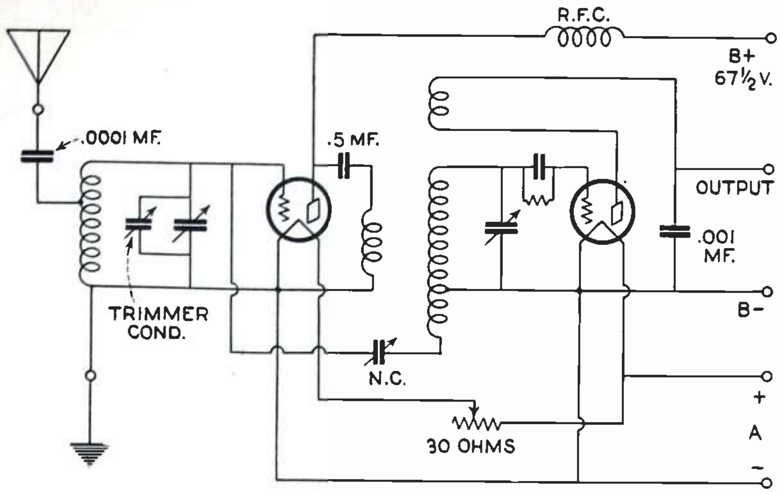


FIG. 1

The new Browning-Drake circuit designed for battery operation. Volume is controlled by the 30 ohm rheostat.

disadvantage is that it is rather hard to make the two condensers on the receiver run together when long and short antennas are being used alternately.

Dr. Drake and the writer, however, have during the past season been working on what is called a "single control" for this circuit and have so designed the set that the tuning condensers used may be put on one shaft controlled with a single drum type illuminated dial, without any adjustments for certain types of antennas. The receiver described herewith, however, incorporates what might be termed a "trimmer condenser" in parallel with the first tuning condenser and the operator will find that in most cases it will be necessary to make slight adjustments on this for various stations.

A change has also been made in the neutralization. A system has been developed so that a large tube may be employed as an R. F. amplifier. The 199 type tubes are so short lived that it seemed advisable to utilize the storage battery type, or A. C. tubes, throughout, if possible.

As will be noted from the wiring diagrams, the neutralization system consists of an extra winding added on the secondary of the R. F. transformer and its end connected to the rotor plates of the neutralizing condenser, the stator plates then being connected to the grid of the first tube.

It was also deemed advisable, even employing this system of neutralization, to keep all R. F. current out of the "B" supply. Consequently, a .5 mfd. condenser is placed in the line which runs to the primary of the R. F. transformer. A parallel feed is put in which incorporates an R. F. choke, connected directly to the plate of the tube, the other end going to the "B" supply.

Many readers may wonder why a .5 mfd. condenser was employed in this parallel feed system, as it would seem that radio frequency currents could pass readily through as small a condenser as a .006 mfd. condenser. It is correct that radio frequency currents can pass through a .006 mfd. condenser, but this value has a large impedance to all audio frequencies. In the paper by Dr. Chaffee and the writer, in *Proceedings of the I. R. E.* it is shown that if an audio plate impedance is added in an R. F. amplifier tube, detection of signals occurs in this tube. With this in mind, therefore, sizes of condensers were experimented with and it was found that the .5 mfd. condenser was about as small as could be used in the position above mentioned without seriously impairing the operation of the first tube as an R. F. amplifier.

Shielding is now recommended for the first time for the Browning-Drake Receiver. The last Official Kit-Set was made as sharp as possible, but, when the receiver was located within a radius of a few miles from broadcasting stations, it was found that a large amount of signal was picked up on the coils and wiring of the set, which made it extremely difficult to receive distant stations while the locals were on. When four or five miles away from broadcasting stations, the receiver operated very satisfactorily.

The set builder may now choose whether or not to completely shield the receiver. He should be governed in his choice, however, by his local broadcasting conditions, that is, if he is situated in an extremely congested region, he should, by all means, completely shield the Kit-Set. If he is in the country, this would be an added and entirely unnecessary expense.

The average set builder will need very little constructional data on this Two-Tube Tuner inasmuch as schematic wiring diagrams are given, both for A. C. and D. C. operation. The set builder will note that no "A" battery binding posts are mounted on the Foundation Unit. This is because of the set being universal, that is for A. C. or D. C. operation, and if A. C. supply is being used on the filaments of the tubes a twisted pair must be run from the transformer to the tube sockets in as direct a manner as possible. When using the 127 type A. C. tube detector, it is advisible to experiment somewhat with the voltage on the plate, as the writer has found as low as 16 volts to operate the receiver somewhat more satisfactorily than a plate voltage of 45. If a storage battery is used to supply the filaments of the tubes, no "C" voltage is necessary, consequently no "C" battery binding posts are put on. However, when A. C. tubes are used, it is advisable to put in a 3½ to 4½ volt "C" battery as shown in the diagram. The home constructor will find it very convenient to bring out a pair of wires to the "C" battery in this case.

With D. C. operation, it is advisable to use a rheostat on the first tube as a volume control rather than the resistance in series with the "B" supply which the use of A. C. tubes necessitates.

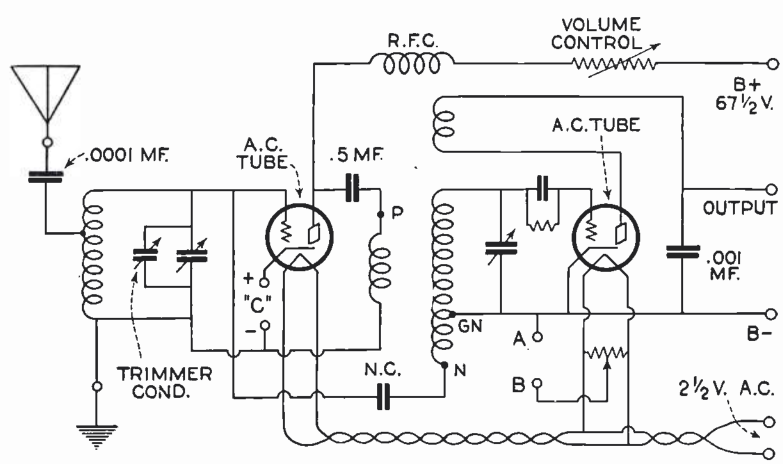


FIG. 2

The new Browning-Drake circuit designed for A. C. operation, using A. C. tubes. Note that the volume control is in the form of a variable resistance in the plate circuit of the R. F. tube.

If the constructor has chosen to use D. C. tubes with a storage battery and 30 ohm rheostat, the balancing is the same as in all previous Browning-Drake Kit-Sets.

In case the set builder chooses the A. C. tubes the balancing or neutralizing of the set should be as follows:

The Clarostat, which is a volume control, should be turned clockwise as far as it will easily go. Set the condensers at a low value, say 20, on the scale. Turn the tickler coil down until the second circuit is oscillating. This may be determined by touching the finger to the stator plates of the second tuning condenser (the one to the right as one faces the set). The tickler coil should then be set back so that this circuit just goes out of oscillation. Adjusting the trimmer condenser will, if the set is not neutralized, throw this circuit into oscillation, which may be determined as mentioned above. Set the neutralizing condenser so that turning the trimmer condenser has no effect on the oscillation produced in the second circuit.

LIST OF PARTS REQUIRED

1 Single Control Drum Type Official Browning-Drake Kit
1 Type A Official Browning-Drake Foundation Unit consisting of Westinghouse Micarta drilled and engraved front panel and subpanel, with mounting hardware, machine screws, nuts and wire.
1 Browning-Drake 135 MMF. Condenser
1 Yaxley Filament Switch
1 Browning-Drake Radio Frequency Choke Coil
1 Tobe Moulded Condenser .5 Mfd.
1 Official Browning-Drake Neutralizing Condenser
2 Tinytobe Condensers (.00007 and .001 Mfd.)
1 .0001 Mfd. series antenna mica condenser
1 Tobe Veritas Leak 6-8 Megohms
1 Set of Shields (Browning-Drake Corp.) Optional
5 Eby Binding Posts (Ant., Gnd., B—, Output, B—)

If the A. C. Model is used, the following parts are to be added:

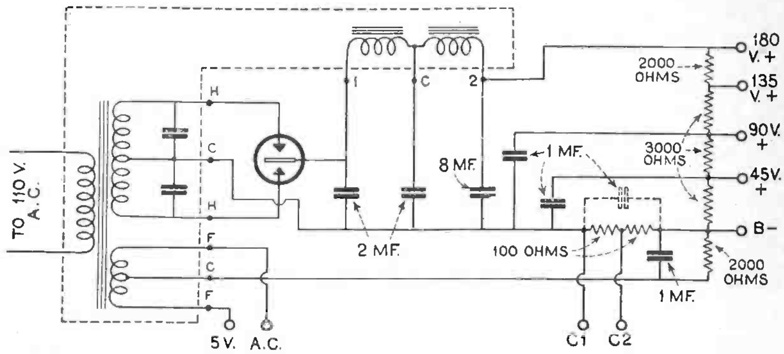
1 Clarostat
2 Benjamin Y Type 5 Contact Sockets
1 Center tapped Resistor—20 to 50 ohms
5 Eby Binding Posts (Ant., Gnd., B+, Output, B—)

If the D. C. Model is constructed, the following parts instead of the A. C. parts are to be added:

1 Yaxley 30 Ohm Rheostat
1 Amperite Type 2-A
2 Standard Benjamin UX Type Spring Sockets

The "Alpha Six" Power Supply

THE power supply portion of the "Alpha Six," described in the last issue of RADIO ENGINEERING, is remotely controlled by a switch located on the receiver panel. Turning the switch in an "on" position will make the set ready for reception, while turning it off will automatically turn off the "B" eliminator and will connect the trickle charger into the circuit. This is made possible by the use of the control relay placed in the battery circuit.



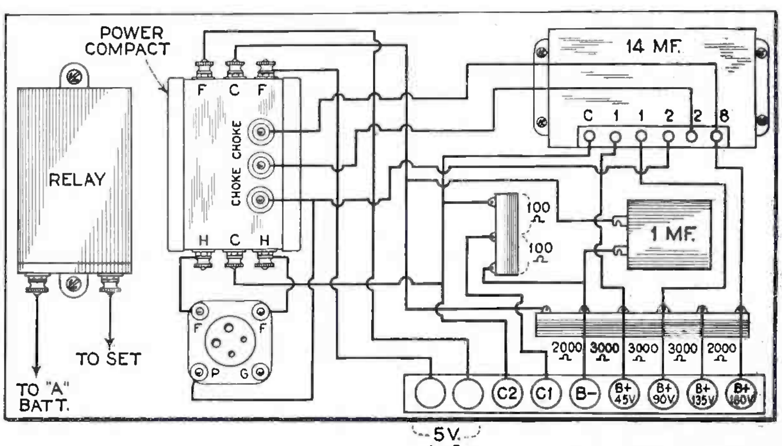
Schematic diagram of the power supply unit designed for the "Alpha Six" receiver. This unit supplies two values of "C" bias aside from the "B" voltages.

The unit consists of the control relay, and parts for the "B" eliminator circuit. These are all mounted on a wooden baseboard. Due to the fact that the parts are made up into unit form, the fan will find it comparatively easy to assemble and wire the complete unit. The two filter chokes and the power transformer are mounted in one unit; this is called the power compact. All the condensers except one 1. Mfd. are also mounted in the container. The voltage divider resistance takes care of the "B" voltage and the grid bias voltage for the power tube. The other tapped 200 ohm resistance gives two bias voltages, 4½ and 9. The rectifier tube is the 85 mil. B. H. type.

Before going further the writer wishes to stress the importance of careful selection of parts for any portion of the set. In the event that the parts mentioned cannot be obtained, he may substitute those of a reliable manufacturer and should be discreet in so doing. However, he will note that the parts mentioned are all of the most well known manufacturers and he should not have any trouble in obtaining them.

LIST OF PARTS REQUIRED

1—Polymet, Type F 1,000 Condenser Block (14 Mfd.)
1—Polymet, Type A, 1 Mfd. Condenser
1—Thordarson R 171 Power Compact
1—Ward Leonard, 508-1 Resistance (R)
1—Ward Leonard 200 Ohm Resistance Tapped at 100 (R)
1—Brach Controlit Relay
1—Raytheon B. H. Tube
1—Sterling 0-300 Type R. Voltmeter (R-415)
1—Roll Corwico "Braidite" Wire
9—Eby Binding Posts (with markings as indicated)
1—Tungar Trickle Charger.

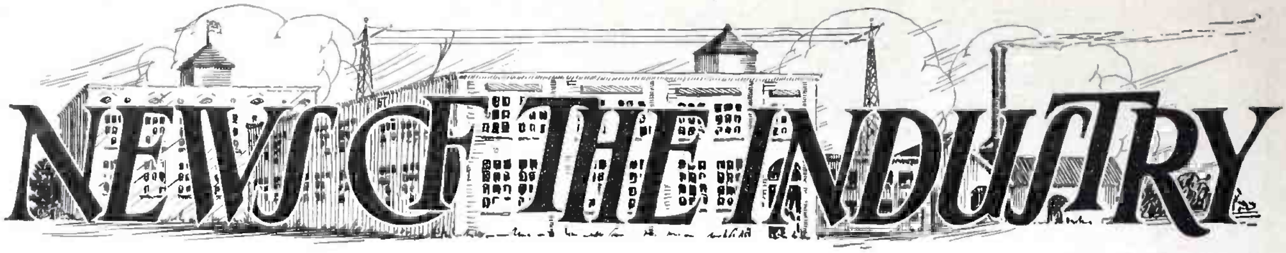


Layout of parts in the "Alpha Six" Power Supply. The relay mounted on the left side of the sub-base is used for automatically controlling the sources of "A" and "B" supply.

NEXT MONTH

The Constructional Development Section for the February Issue of RADIO ENGINEERING will carry two excellent articles worthy of special mention. The first, "A Good 'B' Power Unit" by James Millen, covers in detail the design and construction of a power supply unit incorporating a number of new features. The unit is compact, comparatively inexpensive and is adaptable to general purpose use.

The second article, "An A. C. Operated Push-Pull Amplifier" by A. R. Wilson, of the General Radio Company, also contains a number of new features which manifest in improved operation. This unit is designed to supply "B" power to the receiver as well.



R. P. A. Laboratory for Cooperative Research

Plans for financing a joint laboratory for cooperative research were completed at the Convention of the Radio Protective Association held recently.

The new laboratory will be established under the name of "R. P. A. Laboratories, Inc."

Valuable radio patents will be held by the laboratory for the benefit of the membership.

The need for such a laboratory for cooperative development of the radio art was emphasized as necessary, by some of the leaders in the movement, to counteract the tendency in certain sections of the industry to perpetuate the present status of the art instead of exploring new fields and creating radically new radio inventions.

The exact location of the new laboratory, probably at some point in the East, will be determined at a meeting of the Board of Directors to be held in New York City.

Channel Number Plan Not Approved by RMA

The Federal Radio Commission has been advised by the Radio Manufacturers Association, Engineering Division, that, to avoid confusing the radio public, it is not ready to approve a proposal for identification of broadcast channels by numbers, necessitating radical changes in the dials of receiving sets. The Federal Commission has been advised by Mr. H. B. Richmond, Director of the RMA Engineering Division, that the engineers of the RMA for the past three months have been studying the channel-numbering proposal and are giving it further careful consideration but so far are unwilling to endorse the plan.

New Zenith Sales Manager

Paul B. Klugh, Vice President and General Manager of the Zenith Radio Corporation, Chicago, announces the appointment of Thomas H. Endicott as sales manager. This executive position was made vacant in August when the former sales manager, N. A. Fegen, resigned in order to become a wholesale distributor of Zenith in Cleveland and northeastern Ohio.

Mr. Endicott, the new sales manager, brings to Zenith a wide and varied experience in sales management of electrical and related lines of equipment. Mr. Endicott is a member of the American Institute of Electrical Engineers and Association of Iron and Steel Engineers.

R. E. Thompson Company Reorganized

The former Thompson Radio Company, one of the oldest radio firms in the country, with a factory at 66 York Street, Jersey City, was recently reorganized and has announced production of 5-tube Neutrodyne sets.

By a recent sale, the present owners have bought out the R. E. Thompson Company, the R. E. Thompson Radio Corporation, and the Wireless Improvement Company.

In charge of the new organization are Mr. Alfred Zipser, and Mr. Otto A. Martini. Mr. Zipser was formerly General Manager of the Freed-Eisemann Radio Corporation and at one time was also associated with the Sperry Gyroscope Company.

Mr. Otto A. Martini, who will be General Manager of the new company, was formerly associated with the Wireless Improvement Company.

Grisby-Grunow-Hinds to Build New Plant

The Grisby-Grunow-Hinds Company, of Chicago, Ill., manufacturers of the Majestic line of "A" and "B" power units, announce that a large addition is to be made to their present plant.

Work has already commenced on the new factory and when completed, it will more than double their present floor space.

Cortlandt Panel Engraving Co. Moves

After five years of steady and conservative growth, the Cortlandt Panel Engraving Co. has found it necessary to move to larger quarters, and are now located at 165 Greenwich Street, New York City.

Their plant, fully equipped for the production of every type of radio panel, is now twice as large as formerly.

Celoron Co. Appoints New Executives

The personnel of the Purchasing Department of the Diamond State Fibre Company and The Celoron Company, a division of the Diamond State Fibre Company, has recently undergone a change.

Mr. W. A. Knerr, formerly Purchasing Agent for both companies, is now Secretary of the Norristown Branch of The Pennsylvania Manufacturers Association.

Mr. Lawrence T. Kratz is buyer for the Celoron Company, and Mr. Wallace McCarter is buyer for the Diamond State Fibre Company. Both Mr. Kratz and Mr. McCarter have been active in the Purchasing Department for several years.

Freed-Eisemann Appoints New Executive

Arthur A. Trostler, pioneer in the merchandising of musical merchandise and well known throughout the radio trade in the United States, has been designated as assistant to the Chairman of Freed-Eisemann Radio Corporation. Mr. Trostler thus becomes the executive aid to Alex Eisemann.

Mr. Trostler until recently was western sales representative of the Freed-Eisemann Company.

Wheeler Insulated Wire Company Elect Oswald Dale as Vice-President

The Wheeler Insulated Wire Company, of Bridgeport, Conn. announce the election of Oswald Dale as the Vice-President of the Company.

Mr. Dale for the past six years has had charge of the development, engineering and sales of varnished insulations and radio products for the Acme Wire Company, of New Haven, Conn.

B. H. Clark Appointed Chicago District Manager for Arborphone

Bayard H. Clark has joined the national sales organization of the Arborphone Division, Consolidated Radio Corporation, Ann Arbor, Michigan, taking charge of the Chicago territory comprising the states of Indiana, Illinois, Wisconsin, Minnesota, North and South Dakota, Iowa, Nebraska, Kansas and Missouri. His headquarters will be at the offices of the Arborphone National Representatives, Sanford Bros., at 30 W. Walton Place, Chicago.

Improve Your Reception!

Your receiver will give you quality reception if equipped with the General Radio Type 285 Audio Frequency Transformers. They are so designed as to sustain both the upper and lower ends of the amplification curve and are capable of truthful reproduction. Available in either 1 to 6 or 1 to 3 ratios.

Price — $6.00 Each

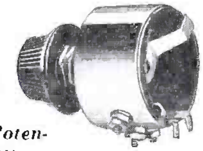
General Radio

Write for our bulletin No. 929 if your dealer has not the necessary information in regard to our products.

GENERAL RADIO CO., Cambridge, Mass.

Improved, Positive Voltage Control for "B" Eliminators

HEAVY DUTY Centralab PotentiometeR



The new *Centralab Heavy Duty Potentiometer* is all wire wound and will carry the entire output of any "B" power device with an unusually high margin of safety. Resistance remains constant at any knob setting so that panel or knob can be marked in volts. A single turn of the knob will give full variation.

Has sufficient current capacity to permit shunting a low resistance value across the "B" power unit to obtain constant voltage regulation. A sufficient current load is maintained through the resistances to reduce the rectifier voltage to workable pressure even though set is not connected — an insurance against filter condenser breakdown.

Resistances 2,000, 3,000, 5,000, 8,000, 10,000, 15,000, 20,000, 50,000, price $2.00; at your dealer's or C. O. D.

Write for folder giving details of this circuit.

CENTRAL RADIO LABORATORIES
25 Keefe Ave. Milwaukee, Wis.

Centralab

NEW AERO CHOKE COILS

The Aero Choke 60

Modern circuits of high sensitivity demand the use of radio frequency chokes in certain parts of the circuit. The Aero Choke-60 is designed to have a uniform choking action over a wide range of wave lengths, including Broadcast bands and Amateur Short Wave bands as well. Many chokes employed on short waves have an unpleasant characteristic of showing so-called "holes" in the tuning range, which is present also on the broadcast band but in a minor degree. These faults are corrected in the Aero Choke 60. Price, $1.50.

The New Aero Choke 248

The Aero Choke 248 is especially designed for operation in Aero Transmitter kits 2040K, 4080K, and 9018K, and other circuits. Aero Choke 248 presents a high impedance or choking action over the usual amateur wave lengths. It is wound with a conductor sufficiently liberal to handle transmitters up to 100 Watts. Price, $1.50.

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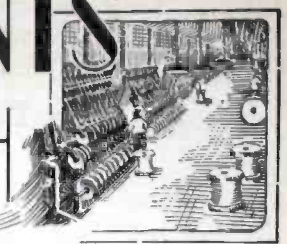
R. E. 1

NEW DEVELOPMENTS OF THE MONTH



Durham Resistor for Manufacturing Trade

The International Resistance Company announce a new type of fixed resistor which is made expressly for the manufacturing trade. This type of

New Durham Resistor

unit is identical electrically to Durham Metallized Standard Resisters, the difference being that it is made with metal insert ends and in a manner which effects some economy in price.

Magnavox Electro-Dynamic Cone Speakers

The Magnavox Company, of Oakland, Cal. have introduced their new electro-dynamic power speakers. All of these models employ the moving coil principle, the coil being attached to the cone.

The R-4 cone speaker is designed for use in connection with a 6-volt storage battery or any 6-volt supply such as an "A" power unit, "A" eliminator or trickle charger. The field of this unit has a resistance of 12 ohms and draws ½ ampere. The unit is provided with an input transformer and filter so that the impedance of the speaker, which is very low, will match the output impedance of the audio amplifier to which it is connected.

Magnavox Electro-Dynamic Speaker

The R-5 unit has an excitation field having a resistance of 2,500 ohms and draws from 40 to 80 milliamperes at 100 to 120 volts D.C. This power can be obtained from any direct current house lighting outlet or from rectified and filtered A.C. current. The power consumption is approximately 5 watts.

The field of this unit is so designed that it can replace one choke of the rectifier and filter system of a "B" power unit since it has an inductance of 40 henrys which is satisfactory for filter purposes. Both types of speakers are provided with two 10 ft. cords, one to connect to the output of the audio amplifier and the other to the source of power to excite the field winding of the speaker.

The shipping weight of the R-4 unit is 32 lbs; and the R-5 unit 30 lbs.

The Magnavox Company are also manufacturing a type R-500 unit which uses the R-5 speaker in conjunction with a "B" power unit, and a power amplifier employing a 210 type power tube. This unit is designed to operate from the usual 105 to 125 volt, 50 to 60 cycle A.C. lighting current.

General Radio Plate Supply Unit

The General Radio Type 445 Plate Supply has been designed to meet the demand for a thoroughly dependable light socket "B" Power Unit that is readily adaptable to the tube requirements of any standard type of radio receiver.

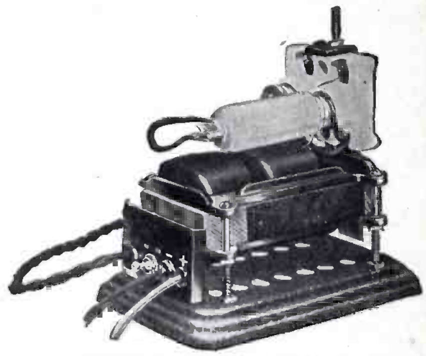
General Radio "B" Power Unit

Voltages are varied by moving adjustable clamps with thumb screws along a wire-wound resistance. Through this method of voltage control any combination of voltages from 0-180 may be taken from the four positive "B" terminals. An adjustable grid bias voltage from 0-50 is also available for use on the power tube of an amplifier.

The Type 445 Plate Supply is designed for use on 105 to 125 volt A. C. lines (50-60 cycles) and uses the UX 280 or CX 380 rectifier tube. To make this unit safe even in the hands of persons not familiar with electrical devices an automatic cutout switch is provided which breaks the 110 volt A. C. circuit when the cover is removed.

Interstate Metallic Rectifier Tube

The Interstate Electric Company, of 4339 Duncan Avenue, St. Louis, Mo. has placed on the market a new type



Interstate Metallic Rectifier

of metallic rectifier which is capable of supplying from 2 to 2½ amperes of rectified current.

This rectifier is composed of a number of metallic discs under pressure. The characteristics of the metal form the rectifying action. The unit is contained in heavy nickel tube with a standard Edison base, which will fit any standard receptacle.

New Eby Five-Prong Socket

The H. H. Eby Manufacturing Company, 4710 Stenton Ave., Philadelphia, announces the development of a new five-prong socket for use with the new

Eby Five Prong Socket

five-prong tubes. This socket possesses some exclusive features.

In the first place it has a guide groove, by means of which the inser-

See Page 56 for Radio Engineering's Special Offer

tion of the tube into the socket is greatly facilitated, particularly so, when the tube socket is located within a shield or can devoid of sufficient light. This groove guides the tube until the proper alignment of holes and prongs is found, when the prongs slide into place.

The socket is universal, in so far as use is concerned. It is adaptable with equal facility for baseboard or subpanel mounting, regardless of the subpanel or baseboard material. When used for subpanel mounting, it is unnecessary to resort to the use of a fly-cutter. The socket contacts slide through small holes drilled into the subpanel.

Ettco High Speed Tapping Attachment

The Eastern Tube & Tool Company, 594 Johnson Avenue, Brooklyn, N. Y., are now making deliveries on their new size No. 3 Ettco High Speed Sensitive Tapping Attachment. The range of this tool is from 0 to 5/8". This Tapping Attachment is designed for high speed sensitive tapping. There is no friction for the operator to set. It eliminates tap breakage, whatever the cause. In fact, a green operator can hit the bottom of a tapped hole without breaking the tap, it is stated. The leather-lined cone clutch and cast iron driving cone have a smoothness of action and a slipping point which prevent tap breakage. The operator

Ettco High Speed Tapping Attachment

can enter or stop a tap at whatever speed is desired, regardless of the speed of the drill press, by the simple regulation of the press lever. If a tap sticks or hits the bottom of a hole, the clutch slips; if it sticks backing out, the reverse cone slips. The reverse is twice as fast as the forward speed. By locking the threaded Morse shank in the tapper, left hand threads can be tapped as readily as right hand. Material such as Bakelite can be tapped successfully with this tool. An aluminum case and light alloy steel parts greatly reduce weight. This tapper can be applied to light drill presses. It is claimed, by the manufacturer, that on some work this Tapping Attachment will increase production from one hundred to five hundred per cent. The manufacturer states they will be very pleased to put them out on a ten day trial basis.

New Modern A.F. Transformer

The Modern Electric Manufacturing Company, of Toledo, Ohio have introduced a new audio frequency transformer, known as Type M, with a very large core and high impedance primary winding. The transformers

Modern Type M Audio Transformer

are enclosed and sealed in a metallic case which is an effective shield. This Type M transformer can be used with plate potentials as high as 500 volts without danger of damage to the windings.

The new Type M transformer is made for straight amplification circuits as well as push-pull amplifiers. The output transformers are designed to match the new type low impedance speakers with the low impedance power amplifier tubes.

Elkay Suppressors

The Langbein-Kaufman Radio Company, of 62 Franklin Street, New Haven, Conn. are now manufacturing Suppressors which can be employed in practically any form of radio frequency circuit for the purpose of suppressing oscillation.

These Suppressors are wound with a double strand; one wire counteracting the inductance of the other, and it is stated that the use of a Suppressor in the grid circuit of a tube will not change the resonance or tuning point of the circuit in which it is used.

Elkay Suppressor

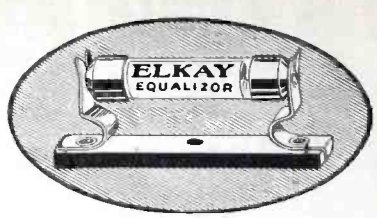
Elkay Suppressors have a resistance of approximately 700 ohms and will carry 35 milliamperes.

Other types of Elkay Suppressors can be obtained in resistance values ranging from 100 to 1,800 ohms.

Elkay Equalizers

The Langbein-Kaufman Radio Company, of 62 Franklin Street, New Haven, Conn. announce a complete line of Elkay Equalizers for controling the filament current for all of the various types of tubes now marketed.

An Equalizer connected in either the positive or negative lead of the tube



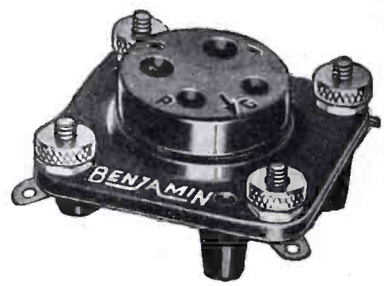
Elkay Equalizer

filament circuit will automatically regulate the current through the tube to the rated amount.

Benjamin Red Top Socket

The Benjamin Electric Manufacturing Company, of 120 So. Sangamon Street, Chicago, Ill. have introduced a new socket with a red top which, aside from being attractive in appearance makes it much easier to see the socket holes and the indicating arrow.

These sockets, like the original type, are full floating and have suffi-



Benjamin Red Top Tube Socket

cient resiliency to absorb shocks and thus eliminate tube noises. The special side wiping contacts insure perfect electrical connection to the tube prongs.

Electrad Resistance for A. C. Tubes

The wide and growing use of A. C. Tubes has prompted Electrad, Inc., 175 Varick St., New York City, to bring out a resistance for A. C. Tube operation.

This resistance which is now on the market is designated as the Electrad Type V Center Tap Resistance. It is particularly designed for use across the filaments of A. C. Tubes, the center tap providing the electrical center for grid return leads.

Values of stock types given by the manufacturers are as follows:

Types	*Total Resistance*	*Working Maximum Voltage*
V10	10 ohms	3.5
V20	20 ohms	5.5
V30	30 ohms	6.5
V50	50 ohms	8.5
V80	80 ohms	11.0
V100	100 ohms	12.0
V150	150 ohms	15.0
V200	200 ohms	17.0

PROFESSIONAL DIRECTORY

Buyers Directory of Equipment and Apparatus

Readers interested in products not listed in these columns are invited to tell us of their wants, and we will inform the proper manufacturers. Address Readers' Information Bureau.

Addresses of companies listed below, can be found in their advertisements—see index on page 54.

ADAPTERS:
Bakelite Corp.
Carter Radio Co.

AMMETERS
Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co.

AMPLIFIERS, RESISTANCE:
De Jur Products Co.
Polymet Mfg. Co.

ANTENNAE, LAMP SOCKET
Electrad, Inc.

ARRESTERS, LIGHTNING:
Bakelite Corp.
De Jur Products Co.
Electrad, Inc.,
Jewell Elec. Inst. Co.

BASES, VACUUM TUBE:
Bakelite Corp.
Zierick Machine Wks.

BATTERIES, DRY:
National Carbon Co., Inc.

BINDING POSTS:
Bakelite Corp.
X-L Radio Labs.

BOXES, PACKING:
Tifft Bros.

BRACKETS, ANGLE:
Zierick Machine Wks.

BRASS:
Copper and Brass Research Ass'n.

CABINETS, METAL:
Van Doorn Co.

CELLS, PHOTOELECTRIC:
Burt, Robert C.

CHASSIS:
Algonquin Elec. Co., Inc.
United Scientific Laboratories, Inc.

CHOKES, AUDIO FREQUENCY:
Samson Electric Co.

CHOKES, RADIO FREQUENCY:
Cardwell, Allen D., Mfg. Co.
General Radio Co.
Samson Electric Co.

CHOKES, B ELIMINATOR:
Dongan Elec. Mfg. Co.
General Radio Co.
Samson Electric Co.

CLAMPS, GROUND:
Aurora Electric Co.

CLIPS, SPRINGS:
Aurora Electric Co.

COILS, CHOKE:
Dudlo Mfg. Co.

COILS, IMPEDANCE:
Dudlo Mfg. Co.

COILS, INDUCTANCE:
Aero Products, Inc.
Dresner Radio Corp.
Hammarlund Mfg. Co.
National Co.
Samson Electric Co.
Precision Coil Co., Inc.

COILS, MAGNET:
Dudlo Mfg. Co.

COILS, RETARD:
Aero Products Co.
Hammarlund Mfg. Co.

COILS, SHORT WAVE:
Aero Products Co.
Hammarlund Mfg. Co.
Precision Coil Co., Inc.

COILS, TRANSFORMER:
Dudlo Mfg. Co.

CONDENSERS, BY-PASS:
Concourse Elec. Co.
Electrad, Inc.,
Fast, John E. & Co.
Polymet Mfg. Corp.

CONDENSERS, FILTER:
Aerovox Wireless Corpn.
Concourse Elec. Co.
Fast, John E. & Co.
Polymet Mfg. Co.

CONDENSERS, FIXED:
Aerovox Wireless Corpn.
Cardwell, Allen D., Mfg. Co.
Concourse Elec. Co.
Electrad, Inc.
Fast, John E., & Co.
Flochtheim, An., & Co.
Polymet Mfg. Corp.

CONDENSERS, MIDGET:
Cardwell, Allen D. Mfg. Co.
Hammarlund Mfg. Co.

CONDENSERS, MULTIPLE:
Cardwell, Allen D. Mfg. Co.
Hammarlund Mfg. Co.
United Scientific Laboratories.

CONDENSERS, VARIABLE TRANSMITTING:
Cardwell, Allen D. Mfg. Co.
Hammarlund Mfg. Co.

CONDENSERS, VARIABLE:
Benjamin Elec. Mfg. Co., Inc.
Cardwell, Allen D. Mfg. Co.
General Radio Co.
Hammarlund Mfg. Co.
Samson Electric Co.
United Scientific Laboratories
Wireless Radio Corp.
X-L Radio Laboratories.

CONNECTORS:
Saturn Mfg. & Sales Co.

CONTROLS, ILLUMINATED:
National Co.

CONTROLS, REMOTE:
Algonquin Elec. Co., Inc.

COPPER:
Copper & Brass Research Ass'n.

CURRENT CONTROLS, AUTOMATIC:
Radiall Co.

DIALS:
Bakelite Corp.
General Plastics, Inc.
National Co.

DIALS, DRUM
Hammarlund Mfg. Co.
United Scientific Laboratories

DIALS, VERNIER:
National Co.

ELIMINATORS, B BATTERY:
Dongan Elec. Mfg. Co.
General Radio Co.
National Co.
Radio Receptor Co.
Samson Electric Co.

ELIMINATORS, UNITS FOR:
Dongan Elec. Mfg. Co.
General Radio Co.
Radio Receptor Co.
Samson Electric Co.

FILAMENT, OXIDE COATED:
Independent Laboratories, Inc.

EXPORT:
Ad. Auriena, Inc.

FILAMENT CONTROLS, AUTOMATIC:
Radiall Co.

FOIL:
U. S. Foil Co.

GALVANOMETERS:
Jewell Elec. Inst. Co.

GETTER MATERIAL
Independent Laboratories, Inc.

GRAPHITE:
Acheson Products Sales Co., Inc.

GRID LEAKS:
Aerovox Wireless Corpn.
De Jur Products Co.
Electrad, Inc.
Hardwick, Field, Inc.
Lynch, Arthur H. Co.
Polymet Mfg. Corp.

HEAD SETS:
Bakelite Corp.

HORNS, MOLDED:
Bakelite Corp.
Racon Elec. Co., Inc.
Temple, Inc.

IMPEDANCE UNITS, TUNED DOUBLE:
K. H. Radio Laboratories.

INDUCTANCES, TRANSMITTING:
Aero Products, Inc.

INSTRUMENTS, ELECTRICAL:
Jewell Elec. Inst. Co.

INSULATION, MOULDED:
Bakelite Corp.
General Plastics, Inc.
Westinghouse Elec. Mfg. Co.

JACKS:
Aurora Elec. Co.
Carter Radio Co.
Electrad, Inc.
Union Radio Co.
Yaxley Mfg. Co.

JACKS, TIP:
Carter Radio Co.
Union Radio Co.

KITS, LOUDSPEAKER:
Engineers Service Co.

KITS, RECEIVER:
Algonquin Elec. Co., Inc. (Super Hilodyne)
Lynch, Arthur H., Inc. (Aristocrat)
Tyrman Radio Co.
United Scientific Laboratories. (Pierce-Aero)

KITS, SHORT WAVE:
Aero Products, Inc.

KITS, TESTING:
Jewell Elec. Inst. Co.

KITS, TRANSMITTING:
Aero Products, Inc.

KNOBS:
Bakelite Corp.

LACQUER:
Egyptian Lacquer Co.
Zapon Co., The

LABORATORIES:
Electrical Testing Labs.

LEAD-INS:
Aurora Electric Co.
Electrad, Inc.,

LOCK WASHERS:
Shakeproof Lock Washer Co.

LUGS:
Aurora Electric Co.

METERS:
Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co.

MOUNTINGS, RESISTANCE:
Aurora Electric Co.
Electrad, Inc.,

NUTS:
Shakeproof Lock Washer Co.

PACKING:
Tifft Bros.

PANELS, COMPOSITION:
Bakelite Corp.
Lignole Corp.
Van Doorn Co.
Westinghouse Elec. & Mfg. Co
Wireless Radio Corp.

PANELS, METAL:
Crowe Nameplate Co.

PAPER, CONE SPEAKER:
Seymour Co.

PLUGS:
Bakelite Corp.
Carter Radio Co.
De Jur Products Co.
Polymet Mfg. Co.
Yaxley Mfg. Co.

POTENTIOMETERS:
Carter Radio Co.
Central Radio Laboratories.
Electrad, Inc.
United Scientific Laboratories.
Ward Leonard Electric Co.
Yaxley Mfg. Co.

RESISTANCES, FIXED:
Aerovox Wireless Corp.
Carter Radio Co.
Central Radio Laboratories.
Daven Radio Corp.
De Jur Products Co.
Electrad, Inc.
Hardwick, Field, Inc.
Lynch, Arthur H. Co.
Polymet Mfg. Corp.
Ward Leonard Electric Co.
Yaxley Mfg. Co.

RESISTANCES, VARIABLE:
American Mechanical Labs.
Carter Radio Co.
Central Radio Laboratories.
Daven Radio Corp.
De Jur Products Co.
Electrad, Inc.
Hardwick, Field, Inc.
Polymet Mfg. Corp.
Ward Leonard Electric Co.
Wireless Radio Corp.

RHEOSTATS:
Carter Radio Co.
Central Radio Laboratories.
De Jur Products Co.
Electrad, Inc.
Polymet Mfg. Corp.
United Scientific Laboratories.
Yaxley Mfg. Co.

SCHOOLS, RADIO:
National Radio Institute.

SHIELDING, METAL:
Copper and Brass Research Assn.
Crowe Nameplate Co.
Van Doorn Co.
Zierick Machine Wks.

SOCKETS, TUBE:
Bakelite Corp.
Benjamin Electric Mfg. Co.
General Radio Co.

SOLDER:
Chicago Solder Co. (Kester).
Westinghouse Elec. & Mfg. Co.

SOUND CHAMBERS:
Racon Elec. Co., Inc.
Temple, Inc.

SPEAKERS:
Amplion Corp. of America.
Temple, Inc.

STAMPINGS, METAL:
Zierick Machine Wks.

STRIPS, BINDING POST:
X-L Radio Laboratories.

SUBPANELS:
Bakelite Co.
Lignole Corp.
Westinghouse Elec. & Mfg. Co.

SWITCHES
Aurora Electric Co.
Carter Radio Co.
Electrad, Inc.
Yaxley Mfg. Co.

TAPPERS
Eastern Tube and Tool Co.

TESTERS, B-ELIMINATOR:
Jewell Electrical Inst. Co.

TESTERS, TUBE:
Jewell Elec. Inst. Co.

TESTING INSTRUMENTS:
Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co.

TESTING KITS:
Jewell Elec. Inst. Co.

TESTING LABORATORIES:
Electrical Testing Labs.

TOOLS
Eastern Tube and Tool Co.

TRANSFORMERS, AUDIO:
Dongan Elec. Mfg. Co.
Ferranti, Ltd.
General Radio Co.
K. H. Radio Laboratories.
Radiart Laboratories Co.
Samson Electric Co.
Wireless Radio Corp.

TRANSFORMERS, B-ELIMINATOR:
Dongan Elec. Mfg. Co.
General Radio Co.
K. H. Radio Laboratories.
Samson Electric Co.

TRANSFORMERS, FILAMENT HEATING:
Dongan Elec. Mfg. Co.
General Radio Co.
Samson Electric Co.

TRANSFORMERS, OUTPUT:
Dongan Elec. Mfg. Co.
General Radio Co.

TRANSFORMERS, POWER:
Dongan Elec. Mfg. Co.
Ferranti, Ltd.
General Radio Co.
National Co.
Samson Electric Co.

TRANSFORMERS, R. F., TUNED:
Cardwell, Allen D. Mfg. Co.

TUBES, A. C.:
Arcturus Co.
C. E. Mfg. Co.
Daven Radio Corp.

TUBES, RECTIFIER:
Arcturus Co.
C. E. Mfg. Co.
Eureka T. and M. Co.
Q. R. S. Company, The.

TUBES, VACUUM:
Arcturus Co.
C. E. Mfg. Co.
Eureka T. and M. Co.
Q. R. S. Company, The.
Shieldplate Tube Corp.

UNITS, SPEAKER:
Amplion Corp. of America.

VOLTMETERS, A. C.:
Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co.

VOLTMETER, D. C.:
Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co.

WASHERS:
Shakeproof Lock Washer Co.

WIRE, ANTENNA:
Cornish Wire Co.
Dudlo Mfg. Corp.
Roebling, J. A., Sons, Co.

WIRE, BARE COPPER:
Cornish Wire Co.
Dudlo Mfg. Corp.
Roebling, J. A., Sons, Co.

WIRE, COTTON COVERED:
Cornish Wire Co.
Dudlo Mfg. Corp.
Roebling, J. A., Sons Co.

WIRE, ENAMELED COPPER:
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Dudlo Mfg. Corp.
Roebling, J. A., Sons Co.

WIRE, LITZENDRAHT:
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Dudlo Mfg. Corp.
Roebling, J. A., Sons Co.

WIRE, PIGTAIL:
Cornish Wire Co.
Dudlo Mfg. Corp.
Roebling, J. A., Sons Co.

WIRE, SILK COVERED:
Cornish Wire Co.
Dudlo Mfg. Corp.
Roebling, J. A., Sons Co.

WIRE, TINNED COPPER:
Cornish Wire Co.
Dudlo Mfg. Corp.
Roebling, J. A., Sons, Co.

INDEX OF ADVERTISERS

JEWELL

Pattern No. 41

A Favorite with Engineers

The Jewell Pattern No. 41 pocket portable is a favorite with engineers because of its small size, its sturdy construction and its built-in accuracy. Radio engineers are finding this instrument very useful in the solution of their testing problems where the use of a larger instrument is undesirable.

An oustanding feature of this instrument is the scale which is 30% longer than on any competitive instrument of the same size, and with a correspondingly enlarged scale opening allows closer determination of indicated values.

The movement is a D'Arsonval moving coil precision type and is completely shielded, thus eliminating errors from magnetic influences. The case is of moulded black bakelite of a size easily carried in a coat pocket.

This instrument is available in a handy combination of triple range voltammeters ranging as low as 1 milliampere full scale and to as high as 150 volts with self-contained resistance.

It has long since been proven substantial by widespread use in railroad signal and in industrial use. Its combination of ranges with prices are given in special circular No. 1121 which is available on request.

"28 Years Making Good Instruments"

Jewell Electrical Instrument Co.
1650 Walnut St., Chicago

The right flux for radio can *make* a manufacturer The wrong flux can quickly *break* him

After costly experiments scores of radio manufacturers have found there is but *one* safe flux for radio soldering—rosin.

Rosin, an organic mixture, is a *non-conductor* and *non-corrosive.* The glass-like surface of this material does not readily lend itself to the collection of dust (carbon particles) as will the sticky organic greases of paste. Nor will rosin attract moisture from the atmosphere; the chlorides of pastes and fluids will. *Moisture plus carbon particles defeat the best insulations produced. Moisture plus chlorides direct a slow but determined corrosive attack upon supporting metals.* Such slow corrosion in wiring causes a steadily increasing resistance to the flow of electrical energy.

Kester Rosin-Core Radio Solder scientifically combines radio's premier flux, rosin, with a solder alloy of unvarying quality. The use of Kester Radio Solder furnishes the user with a means of accomplishing *safer, faster and cleaner* set wiring.

Manufacturers using Kester Rosin-Core Solder are assured that no part of their production will ever be returned or fall into discard through the corrosive and conductive action of a chloride flux.

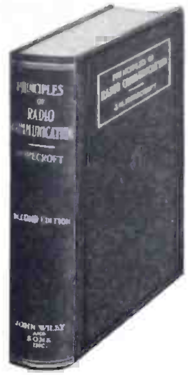
Our experimental and research laboratory has assisted many manufacturers in the solving of their soldering problems. A post card will bring you further information without obligation.

KESTER SOLDER

Rosin-Core

CHICAGO SOLDER COMPANY
4224 Wrightwood Avenue, Chicago, U. S. A.

Originators and World's Largest Manufacturers of Self-fluxing Solder



PRINCIPLES of RADIO COMMUNICATION

(Second Edition)

Completely Revised and Up to Date by

JOHN H. MORECROFT

Professor of Electrical Engineering, Columbia University
Past President Institute of Radio Engineers

assisted by

A. PINTO

Electrical Engineer, Otis Elevator Co.

and

W. A. CURRY

Assistant Professor of Electrical Engineering, Columbia University

Practically a New Book—including all new developments but retaining the good features of the old.

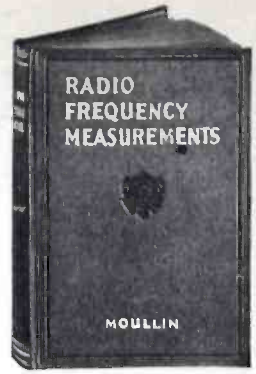
Saves Hours of Calculation

RADIO FREQUENCY MEASUREMENTS

by

E. B. MOULLIN, M. A., A. M. I. E. E.

It contains formulae for measurements that the experimentor in the past had to derive for himself. Theories are made practical by examples. Practically every measurement is illustrated by an example. There are copious instructions about the manipulation of apparatus. The use of the vacuum tube voltmeter is described.



For use while measurements are in progress. This book shows how the latest discoveries in R.F. measurements are practically applied.

Let Radio Engineering Assist When You Are Adding to Your Technical Library

See offer at foot of this advertisement

ENGINEERING WORKS

Radio Frequency Measurements	by *E. B. Moullin, M.A., A.M.I.E.E.*	$10.00
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Wireless Pictures and Television	by *T. Thorne Baker*	2.50

* Robison's Manual is the standard radio text book of the U. S. Navy.

Note.—Radio Engineering will be glad to give information concerning the above works and other radio and engineering books, in which subscribers may be interested.

Note: Your subscription, or the renewal or extension of your subscription saves $1.00 toward the purchase price of any of the above publications.

Just add $1.00 to the price listed opposite the book desired. Send check or Money Order to Radio Engineering, 52 Vanderbilt Ave., New York City, and you will receive a full year's subscription to Radio Engineering and the book (postpaid) by return mail.

Williams Press, Inc., New York—Albany

QUALITY DONGAN PRODUCTS

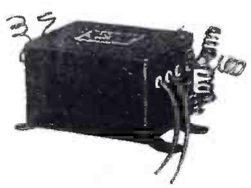
14

Types of A C Transformers and A B C Units

for use with

All Authentic Makes of Power Tubes

Ranging in price from $4.25 to $22 for the precision-built No. 5553 complete A B C Units, Dongan A C Transformers and A B C Units are designed for electrical operation of all sets using any of the approved new tubes. You can change over your present set to an electric power set in a few minutes. From then on, you will enjoy radio as never before.



If your dealer cannot supply you at once, send check or money order. to factory. Immediate delivery.

TWO POPULAR TYPES

No. 4586—Illustrated here, AC Transformer for 1 to 8 UX 226, 2 UY 227 and 2 UX 171 tubes; eliminates need of A battery and charger.

$8 list

No. 6515—AC Transformer, for sets using 4 or less UX 226 tubes, 1 UY 227 tube, and 1 UX 171 tube.

Only $4.75 list

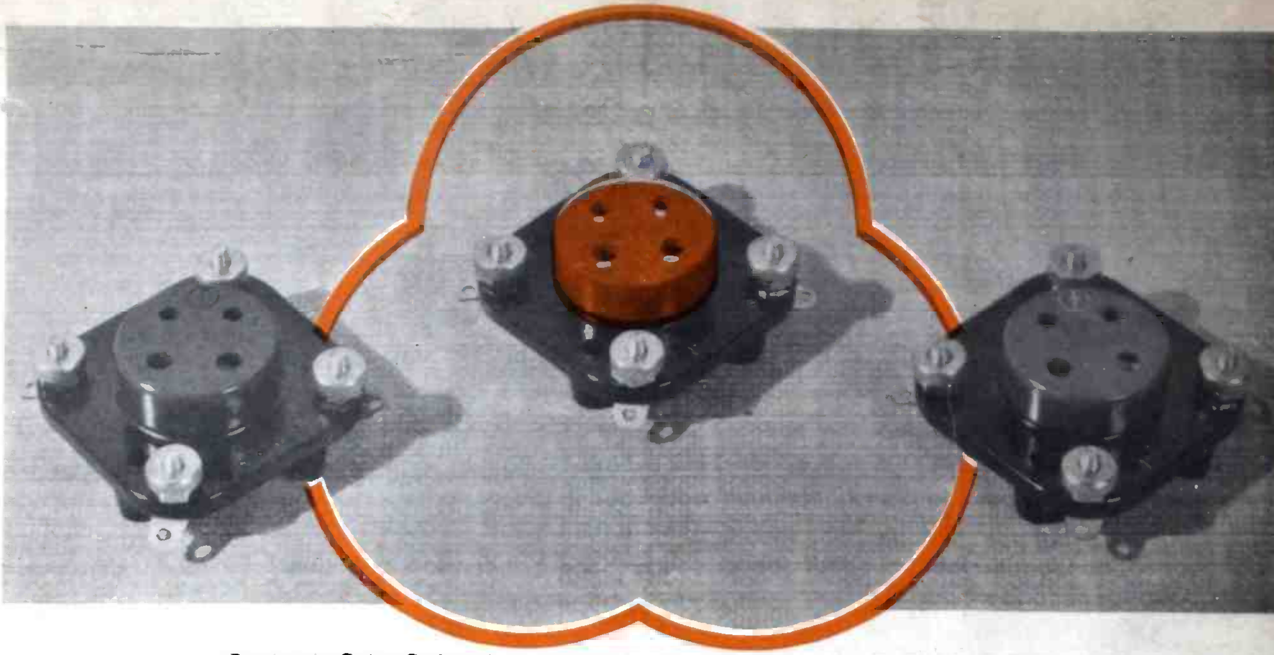
MANUFACTURERS

Of these 14 types—you can secure several in unmounted style, in production now exclusively for set manufacturers. You are assured promised deliveries. For special information and prices, write or wire at once.

DONGAN LABORATORIES—**Authentic Source for Engineering Data on A B C Operation**

Dongan Electric Manufacturing Company
2995-3001 Franklin St., Detroit, Michigan

TRANSFORMERS of MERIT for FIFTEEN YEARS



Benjamin Color-Code tube sockets of Bakelite Molded in green, orange and maroon. Made by Benjamin Elec. Mfg. Co., Chicago.

Bakelite Molded in Colors
to meet the new Color-Code System

COLOR indexing to avoid confusion and errors is an excellent practice. In radio it has long been used for battery leads, later for binding posts, and now Bakelite Molded in colors has made it practical for tube sockets.

Green Bakelite Molded for detector tube socket, orange for power tube and maroon for amplifier tubes is the code approved by the Radio Manufacturers' Association and the Radio Division of the Nat'l Electrical Manufacturers' Ass'n.

Bakelite Cooperation

Since the earliest days of Radio, the Bakelite Corporation has kept pace with the development of Broadcast Receivers, and its engineers and research laboratories have cooperated with manufacturers in adapting Bakelite Materials to each exacting need. The wealth of knowledge acquired during these years of experience is offered to the radio industry through our Service Engineers located in important industrial centers.

BAKELITE CORPORATION

247 Park Avenue, New York, N. Y. Chicago Office: 635 W. 22nd Street

BAKELITE CORPORATION OF CANADA, LTD., 163 Dufferin St., Toronto, Ont.

BAKELITE

REGISTERED U. S. PAT. OFF.

THE MATERIAL OF A THOUSAND USES

"The registered Trade Mark and Symbol shown above may be used only on products made from materials manufactured by Bakelite Corporation. Under the capital "B" is the numerical sign for infinity, or unlimited quantity. It symbolizes the infinite number of present and future uses of Bakelite Corporation's products."