EIGHTH YEAR OF SERVICE

RADIO ENGINEERING

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IN THIS ISSUE

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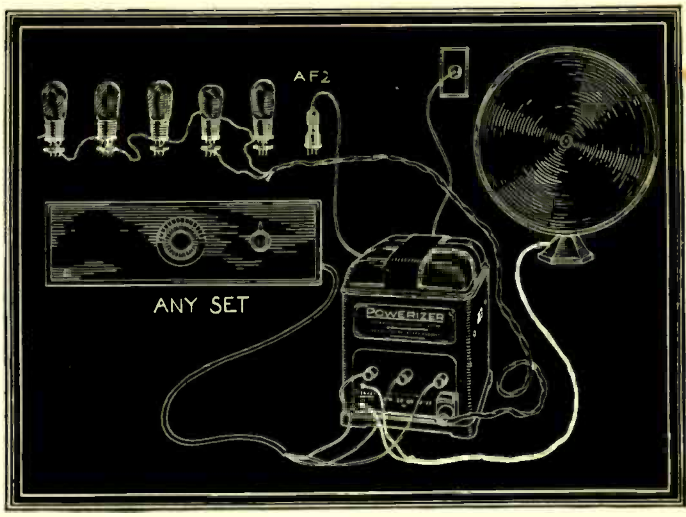
The TECHNICAL MAGAZINE of the RADIO INDUSTRY



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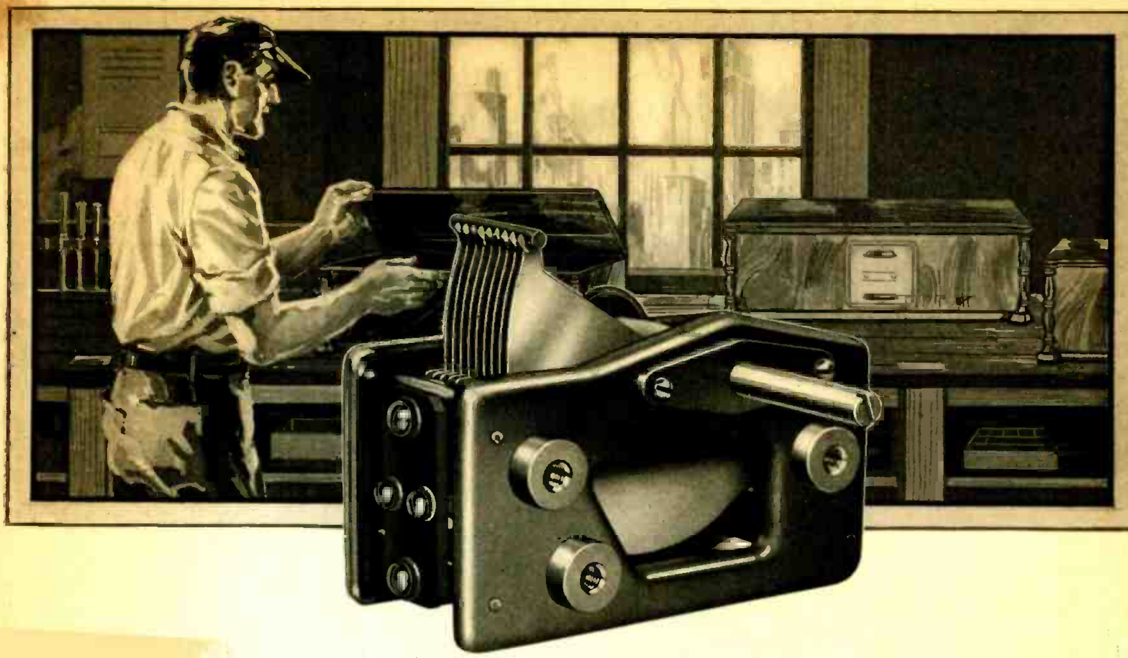

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52 Vanderbilt Avenue, New York, N. Y.

EDITED BY M. L. MUHLEMAN

Vol. VIII   FEBRUARY 1928   Number 2

EDITORIAL

ARTICLES have appeared in numerous periodicals purporting to provide the final analysis of the existing conditions in the radio field. No two analyzations have been alike. Each and every one of the authors has been influenced by his own pet theory and to such an extent that relative conditions have been lost sight of.

It is next to impossible for anyone to propound a true analysis of market conditions. One might as well attempt to prognosticate the future trend in political warfare.

We have it from an authority that it is disastrous for the radio set manufacturer to discontinue the merchandising of battery operated sets. If the manufacturer loses sight of the large volume of potential business in the farming districts and direct current territory he is very likely to find himself out of the picture. The reasons given are comparatively simple; farming districts are not supplied with alternating current and therefore battery operated sets must be used; direct current territory represents in practically every case a concentrated population, New York City as an example, where there are over 335,000 direct current consumers, and such territory represents enormous business opportunities to the manufacturer of battery operated sets.

These statements so obvious in their logic, are not quite as inspiring as they ought to be—possibly because the logic is applied. If the above facts are true why is there a drop-off in the sale of battery operated sets in practically every district of the United States? Why is it that the farmers and the direct current consumers are not buying battery operated receivers when they are in the highly advantageous position of being able to purchase them below the retail price?

Farmers are well known for their conservatism. The poor farmer, and there are numerous poor ones, must, by necessity invest his meagre earnings to give him the best possible returns. When he buys a milk churn he expects it to last a good many years. He is instinctly tight-fisted and views all articles from the standpoint of their utility value. He will make his three tube dry-cell set last as long as his milk churn.

The same psychology cannot be applied to the wealthy farmer but investigation shows that most rich farming districts are supplied with electric power. Since the current must be carried over considerable distances it is alternating of character and consequently A.C. receivers are applicable. The numerous farmers having 32 volt farm lighting plants represent a large percentage of the total number but the battery operated set is not as yet practically applicable to a 32 volt system.

Direct current consumers in the metropolitan areas are being supplied socket power receivers by local manufacturers. There are three comparatively large set manufacturers within a radius of fifty miles of New York City who supply 90% of the direct current set market. It will require time and concentrated effort for other manufacturers to break in on this business to any extent.

Unquestionably there is a market for battery operated sets but manufacturers should exercise caution and seek to strike the proper balance of production.

M. L. MUHLEMAN, *Editor.*

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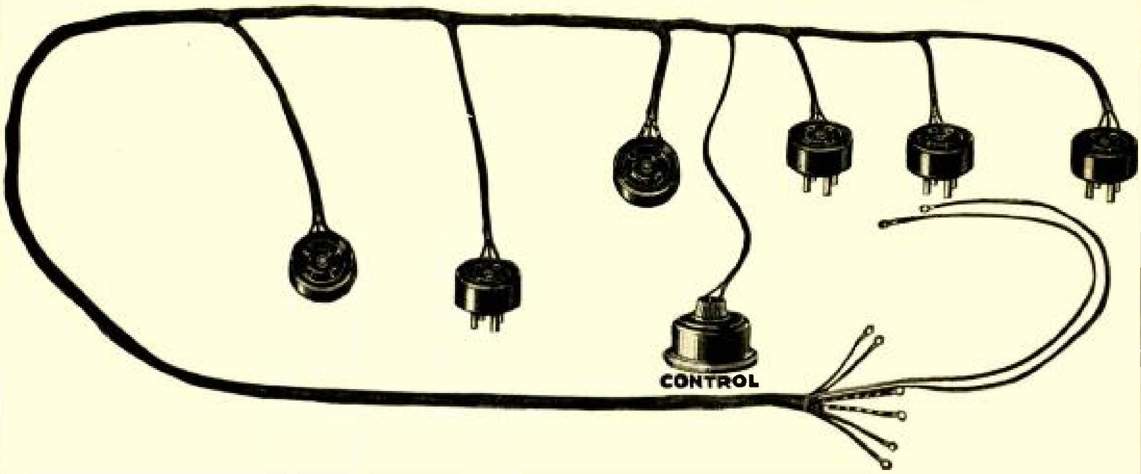

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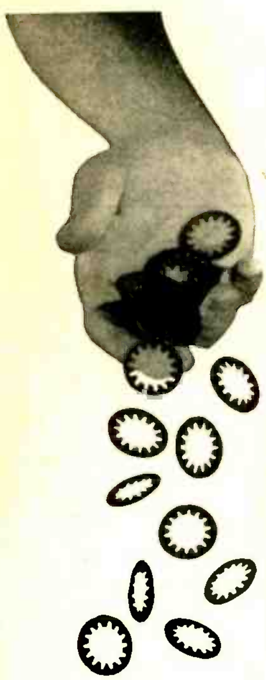

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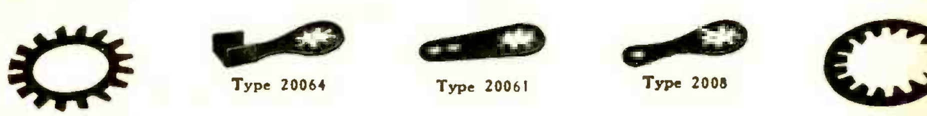

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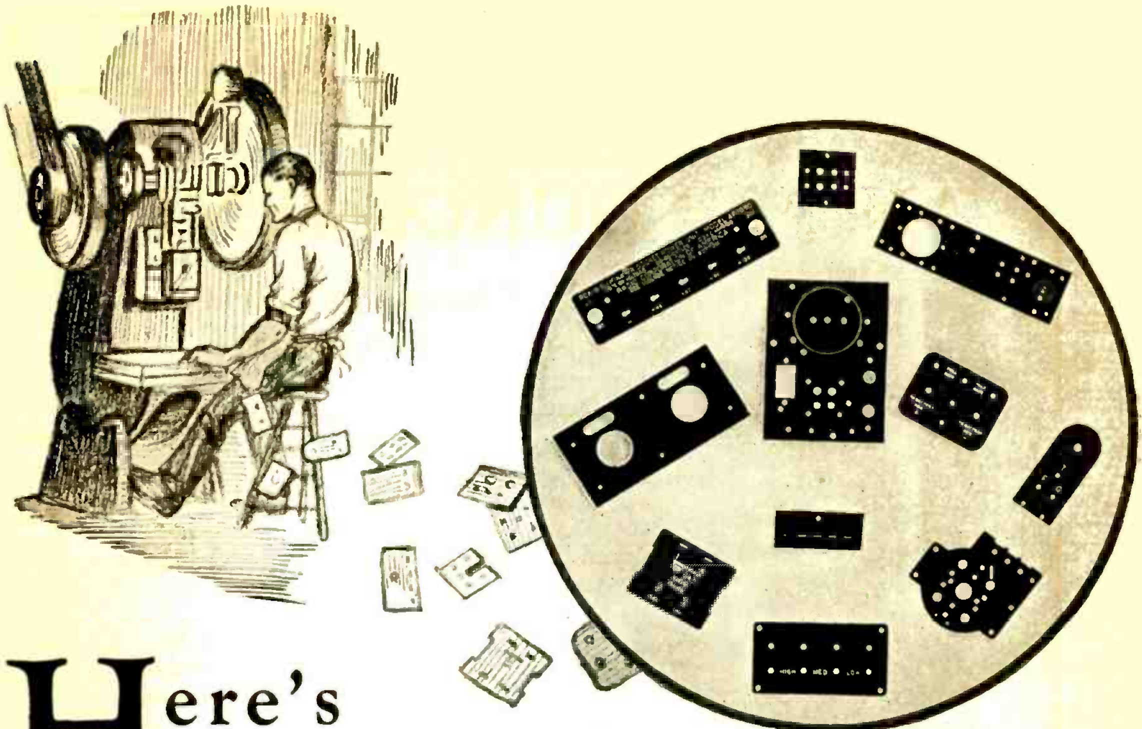

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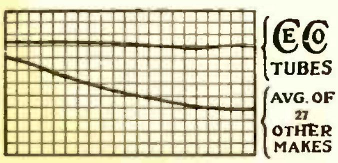
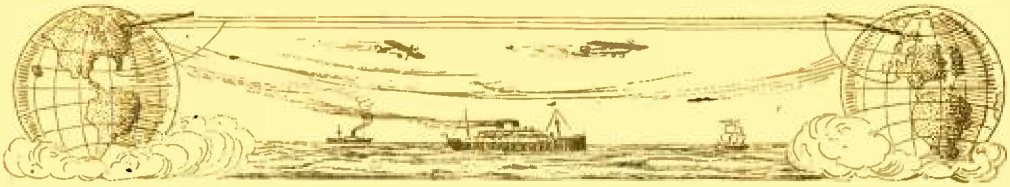


CeCo RADIO TUBES



The Problem of the Battery Set

Observations on Series and Parallel Filament Connections for the Operation of Receivers from A. C.

By Victor Greiff *

PART I

THE writer realizes that in addressing the readers of RADIO ENGINEERING, he faces a varied, highly informed circle of readers, and is subject to direct comparison with some of the foremost technical authorities and most scholarly analysts in the profession, but begs immunity from much possible criticism on the ground that he merely submits observations and experience, without any claim to fundamental scientific accomplishment, or novelty.

A Condition

No one will contradict me when I say that the whole radio industry today is confronted by an unprecedented condition of a radical change having come about almost instantaneously by the release of the new tubes and their almost universal adoption.

Close upon this, well known quantity producers have sprung the surprise of sets for these tubes at prices but little above the price of their battery models three months ago. As most of us know, the intrinsic values in a power plant are large compared to the set, perhaps greater if good audio transformers and a case are not included in the latter. So it seems that we face a real condition of trade disturbance—to put it mildly.

At the same time, the industry offers the consumer marvelous power amplifying sets, (I use this term for those having a 210 or equal in the last stage) at prices not so high compared to the values included, and the writer does not doubt for a moment that this de luxe business will go right on with the irresistible sweep of prosperity and progress.

Can our optimism, however, extend so far as to include the expectation that the millions of present owners of sets will straightway scrap them and buy the new electric sets?

Again the answer is probably to be found in psychology and sense rather than in engineering formulae:—the set owner, unless he is of the class that can afford to give away his old set—will usually spend more on auxiliaries and improvements than the set cost and many times more than its worth—just like the Ford owner and the multitude of attachments; an example of this is to be found in the immense sale of electrolytic and trickle devices sold at high prices as "Socket Powers," whatever that term may mean.

Summing up the situation, it seems to me that the important question for every man in the radio industry today is—"What shall I do?"—coming from the owner of every battery set.

Of course, the holders of battery sets in the trade are most interested, in order to move their merchandise.

The designer of new sets for production will find little new in what the writer has to say—he knows the facts and generally agrees with the conclusions, judging from the designs of sets being released on every side.

It may be possible to destroy all the value of existing battery sets—just discourage the owners to the point of junking them—or "trading them in" for a mythical "allowance" amounting to a price cut on the new set, but I can see here a marvelous opportunity for all the radio service organizations, "Community Set Builders"—"Radio Doctors," and all those who are depended upon by their friends for guidance.

It is up to every technically informed radio man to answer this SOS, which may well be interpreted "Save Our Sets," whence the importance of this discussion of ways and means.

Possible Methods of Conversion

The methods of converting a battery set to an "Electric All Electric" set (according to terminology approved by the "Better Business Bureau") are about parallel with the manufactured types of this class of set.

The writer was an early advocate of the rectified current series string set using 201-A's, and at that time the rectifying unit was the best of its kind.

Rectifying Filament Supply

Rectification was accomplished by two two-ampere tungars. As these were only called upon for a trifle over ¼ ampere—together—they were in no danger from overload. However, a little difficulty was sometimes experienced in getting them to operate at the high output voltage of 120 volts. A contributory cause of this is found in the fact that in these circuits the valve on the reverse half wave has the double peak voltage impressed across it, and some of these bulbs arced and flashed under this condition. Recently, an experienced service man showed me that such bulbs could be cured by "seasoning" a few minutes without plate voltage—perhaps some loose material in the wrong place is distilled off.

The filter required for this rectifier was very heavy—a choke weighing five or six pounds, and about sixty microfarads capacity.

While some systems claim to accomplish results with a fraction of this filtering, it is noted that systems filtering filament current almost all involve liquid condensers, sometimes frankly, or covertly as "colloid" or paste, or semi-dry "units." Sometimes these units have been found to operate the set tubes for some hours after being entirely disconnected from the line, the

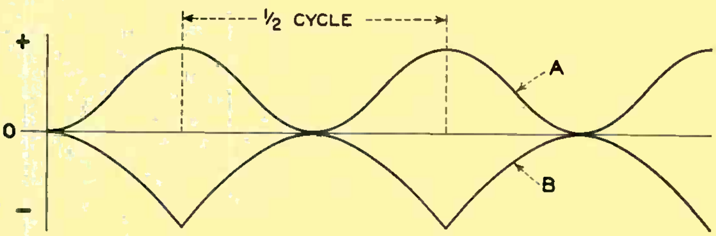


FIG. 1

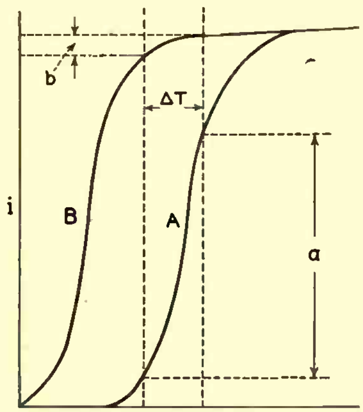
Disturbing effects in a 112 type tube, A.C. operated. A is the thermal effect and B the potential effect.

* Chief Engineer, Radio Receptor Co., Inc.

rectifier and the transformers, thus revealing their chemical nature.

Such flagrant offenses against engineering codes are cited merely as an indication of the difficulty of filtering filament current. Most of these devices intended for popular use as "A"-eliminators, attempted to furnish current for multiple operation of the tubes, but conservative engineering has generally avoided this method with great care.

It will be well at this stage to consider some of the fundamentals of filtering, so perhaps to gauge the problems involved.



-FIG. 2-

The effect of the emission characteristic upon fluctuation.

Roughly speaking—the condensers of a filter system must store up a charge at or near each "peak" of the A. C. which is given up during the time when the voltage applied through the rectifier is below a certain level.

This time of discharge does not vary widely—for full wave rectification, it is, of course, somewhat less than a half cycle.

It will appear from this that (since the time element is substantially fixed), the amount of current we can draw depends on the capacity, and the permissible fluctuation in volts. Of course, the latter is a matter of much discussion, but obviously the higher the filtering voltage, the higher the permissible fluctuation. If all other things are constant, and the same percentage of fluctuation held, it will require one thirtieth more of the capacity to filter at 180 volts than it does at 6 volts.

If now we top this by asking for two amperes instead of fifty mils, we again increase our problem forty times, or the problem of parallel "A" supply is perhaps 1200 times as difficult as the ordinary "B" eliminator.

Furthermore, we run into the interesting but expensive phenomena of choke core saturation, which end up in calculations of air gaps which are well known in other branches of applied electrics, and practically amount to the complete loss of the permeability of the iron—the choke must be designed with a certain volume of air gap, turns enough to energize it, and massive core to hold the winding, distribute the flux over the air gap, and itself remain a negligible factor, threatened by saturation, and working at low permeability.

Series filament circuits are more promising, filtering one-quarter ampere at say thirty volts is not impossible, the writer's experience was with filament plus plate current, about 300 mils, filtered at 120 volts, and the arrangement described gave excellent filtering. In series systems filtering must be unusually good—it must be remembered that any fluctuation is immediately imposed on all audio grids, including the detector, as there is more or less grid to filament potential, generated by filament drops, and, of course, fluctuating with them, and this is then given all the amplification of the set.

The outstanding successful rectifying job has been the Radiola 28, A.C. operated. This is a series string of 199's, and while a dozen microfarads are ample to give ordinary good filtration at 400 volts, yet it seemed necessary to the designers to use an additional condenser pack across the various filaments to hold down these grid fluctuations, which would be amplified into the output. This condenser pack which the writer advised continuing with the new power pack designed for this set, totals thirty-two mfds, in addition to the filter condensers.

This being the case for a string circuit drawing .060 amps, the writer admits cowardice in facing the commercial problems indicated by the above simple calculations, when the current is increased four or five times.

This leads to an investigation of the properties and operation of A.C. tubes, and of this many of my readers are at least as well informed as I.

A. C. Tubes

About two years ago, it was announced and demonstrated that by carefully controlling filament, plate and grid bias, the 112 tube could be satisfactorily operated on "raw" A.C. in all positions in a 5-tube neutrodyne, except the detector.

This tube was the 5-volt, 1/2 ampere type, and not previously considered suitable for A.C. operation.

While this practice is no longer followed, we are indebted to its sponsor (Miessner) for the first published analysis of the factors underlying A.C. tube operation.

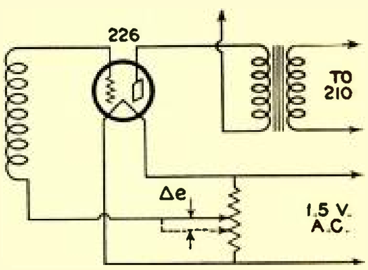
Briefly, there are two causes for disturbance when a tube is operated on alternating current. First the cyclic variation of plate current due to the fluctuation of filament temperature and therefore emission, and second, an electronic effect due to the difference of potential between the ends of the filament. Both these effects are of double frequency in effect, and it was shown that they tend to oppose each other, and by adjusting values properly, they were made to practically neutralize. As it developed in practice, a little "juggling" was required to keep these effects in equilibrium, and the obvious solution seemed to be to reduce both of them substantially, and make adjustments unnecessary.

A learned research expert present at the time said that since the heat effect was quadratic, and the other effect of the first power, theoretically they could never completely neutralize, but this is rather splitting hairs.

The shape of the curves is shown in Fig. 1. It seemed clear to the practical minded that if these effects were both reduced substantially, the A.C. tube would be with us.

Taking first the effect of rise and fall of potential across the ends of the filament—all other things equal—this can be reduced directly by operating the filament at the lowest possible voltage. A little reflection reminds us that all we are trying to accomplish is to heat a piece of metal and the lower the voltage and heavier the current, the simpler and more rugged can this be. The limit is theoretically to be found in the wiring losses, and would probably be troublesome if we attempted to draw many amperes at less than a volt. So one volt has been the low limit of A.C. filament potential in practice up to date, and the 226 is rated at 1.5 volts, drawing about 1 ampere.

Roughly, therefore, the possibility of disturbance from potential is reduced to about one quarter, in these new tubes, as compared to the 112. There are other conditions entering, which make this reduction still more marked, and in fact this tends to become a vanishing quantity.



-FIG. 3-

Grid return potentiometer may be used to give known disturbance.

Considering now the effect of filament temperature fluctuation, this is reduced by

(a) The cross section of the filament, i.e., its heat capacity, compared to its cooling surface.

(b) The emitting characteristic of the filament—if the variation of emission with temperature (filament current) is practically nil for a considerable percentage variation, (tested under continuous current condition, let us say) (See Fig. 2, B), then a given amount of cooling between cycles will have comparatively little effect upon the uniformity of the plate current.

(c) The actual temperature of the filament is not to be overlooked, as the rate of loss of heat is probably mostly by radiation, which follows a fourth power law, which like compound interest, runs up fast.

Summing up, we find that the thick coated filament of the 226 which develops almost full emission at two-thirds the rated voltage, and operates at the lowest temperature of any emitter yet produced, is admirably suited for A.C. operation.

The very minute filament fluctuations supposed to be present, probably are balanced by the potential effect, as in the case of the 112, above described but they are both so minute as to be difficult of demonstration in a two stage amplifier with a 210 in the output stage. If, however, the plate voltage and grid bias are varied over very wide limits, (far out of the useful operating range of the tube) a hum can be produced, indicating that under working conditions the same important phenomena noted by Miessner in the 112 are working in our favor here, to eliminate even the last theoretical traces of fluctuation in the output, in fact the components themselves are negligible.

The tolerance of the ear to 60 cycle hum, measured in volts on the grid of a tube, may be readily tested by means of a circuit containing potentiometers for grid returns. See Fig. 3.

In this way a displacement of 10% from the neutral i. e., 0.15 volt R.M.S., A.C. on the grid of the first audio stage, entirely destroys the quietness of an amplifier with a 210 last stage and a good responsive loudspeaker.

It is difficult to say exactly what this would represent calculated back to the detector grid, but with a four to one transformer ratio and the usual low detector plate current favoring low frequency amplification, it is likely that something at least of the order of 10 would be realized in voltage amplification, or we may roughly estimate .015 volt as the extreme tolerance limit for detector grid disturbance.

If we obtain anything like theoretical amplification from one transformer and tube, the voltage gain should be $7 \times 4 = 28$, which would give a still lower tolerance, about .006 volt.

Whichever of these values is the limit, the 226 is not recommended as a detector, though it has been found excellent as a first detector in superheterodyne circuits.

If, for example, a 199 were used as detector on rectified A.C. as mentioned above, at 3.3 volts filament, it may be considered that if the filament voltage fluctuates, half of this fluctuation takes place between the grid and the filament, as the grid returns to one end of it.

Using the largest tolerance, and comparing it with half the filament voltage ($.015 \div 1.66 = 1\%$ about) it is seen that a one per cent. voltage fluctuation would spoil results even though temperature, emission, etc., did not pulsate, which is far from the case, and the detector problem is by far the most difficult one in the field of filament energy supply.

The answer of course, has been to "unscramble" heater and emitter, in the so called heater type tubes, and while these were at first considered a great problem, improvements in ceramics for the insulator, metallurgy for the various parts, and emitting materials for the cathode coating, have made these tubes remarkable in performance. A glance at the low working heat of a coated filament, e.g., the 280 full wave rectifier, inclines one to believe that it should be no trick at all to heat a bit of foil to that temperature and so it seems to be, as these tubes are now produced in quantity with excellent results.

The heater type tube proves excellent as a detector, the others, using A.C. in the filaments are very similar to 201-A's, though of noticeably greater energy output, and operate excellently in all other positions of all sorts of circuits, and the basis seems to be laid for consistent and continuous progress in rendering almost all sets "electric all-electric" in this fashion, and with the experience of the set manufacturers to learn from, though powerizing units for existing sets were actually ready and offered before any of the corresponding crop of A.C. sets was announced.

These A.C. tubes are neither of them of the output capacity which we have learned to demand of the last tube of the set. In this position we choose to use the 210 whenever possible, as its low plate impedance makes it a great conserver of low frequencies. The 171 is almost universally used in the lower-priced outfits, due to the additional cost, principally of plate supply and filter and also of the larger tube.

Of course, the 210, with 1.25 amps in its heavy filament is eminently suited for A.C. operation, particularly in the last stage.

(The next instalment will tell of circuits, circuit changes, methods, and experience of applying A.C. tubes to existing sets.)

A New Development in Television

Simplified Equipment Adaptable to the Home

At three different points in the city of Schenectady groups of engineers, scientists and newspaper men standing before the first "home television sets" ever to be demonstrated, saw the moving images and heard the voices of a man and a woman transmitted from the research laboratories of the *General Electric Company* several miles away.

So lifelike were the lights and shadows reproduced from the research studios that the curl of smoke from a cigarette and the flash of an eye were transmitted by radio just as a picture unfolds on a screen.

The first home television set is of very simple construction, not unlike the familiar phonograph cabinet in size and exterior appearance. It was developed by Dr. E. F. W. Alexanderson, consulting engineer of the Radio Corporation of America and the General Electric Company and his assistants in the laboratory.

In this instance the transmission of the moving object was made on 37.8 meters wavelength while the voice was simultaneously sent through the air on 379.5 meters, the normal wavelength of WGY. The receiver which Dr. Alexanderson used differs from the ordinary short wave receiver in that it converts the electro-magnetic wave into light instead of sound and the light becomes an image corresponding in movement to the action of the artist at the transmitting end.

Elements of Television Receiver

The elements of the television home receiver are a light source, the scanning device and the synchronizing system. The signal, or electro-magnetic wave from the television transmitter, is received in equipment designed to receive modulations as high as 40,000 cycles. The amplifier is substantially the same as the usual form of A.F. power unit. The receiving system differs from a modern loud speaker system in that a neon gas filled lamp is substituted for the loudspeaker. The amplified current is delivered to this lamp, known as the Moore lamp, which responds to the intensities of the current and gives fluctuations of the light intensity.

The scanning disc is 24 inches in diameter with 48 small holes, each hole 35 mils in diameter and arranged in a spiral so that each of the 48 holes will pass each other and trace successive lines of the picture, completing or literally painting a picture in one revolution. In other words, if the disc

Dr. E. F. W. Alexanderson seated in front of his newly developed television receiver. The three-inch picture screen is seen near the top of the cabinet. Dr. Alexanderson is holding the push button which is used for maintaining the proper speed of the revolving "scanning disc."

were revolved very slowly a ray of light through successive holes would trace over the entire object. The disc is revolved by a standard motor, similar to those used in household devices such as the washing machine or vacuum cleaner. The revolutions occur at a speed of 18 per second, slightly faster than a film passes through a motion picture camera. An observer, looking at this revolving disc as the light from the Moore lamp shines through these small holes, would see the image being sent by radio but this picture would be but 1½ inches square.

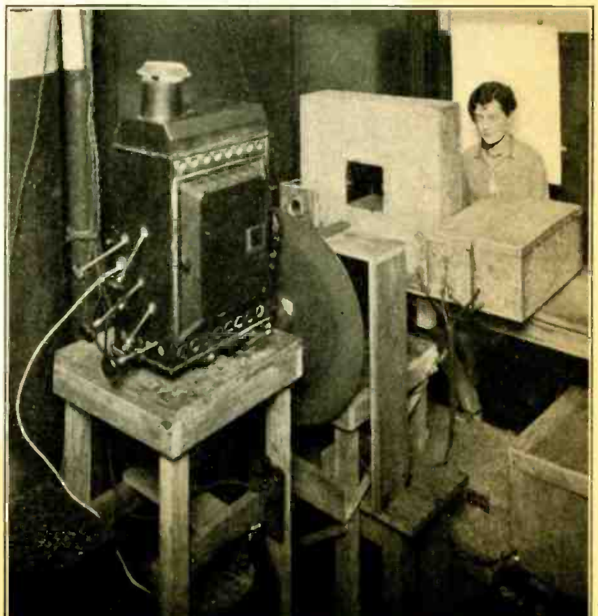
Magnifying lenses enlarge the picture twice so that it is 3 inches square in the aperature in the front of the receiver cabinet.

Synchronization of the scanning disc of the receiver with the scanning disc of the transmitter is obtained by a manually operated control, a push button held in the hand, which alters the speed of the motor revolving the scanning disc. By means of this button, of the bell ringing type, the picture may be held in the field of vision with a little practice, as naturally after a time as driving an automobile or steering a bicycle.

The reproduced picture or object has a pink color, which is characteristic of the neon gas used in the Moore lamp. D. McFarlan Moore, inventor of the lamp and an engineer at the Edison Lamp Works of the General Electric Company, found in early work that this gas was most efficient and most sensitive for reproducing a light which will go on and off in a millionth part of a second.

The Television Transmitter

The transmission system is of the type using a disc with spiral holes, a duplicate of the disc in the receiver. A spot of light is projected on the object through the moving disc and the reflection of this light is intercepted by photo-electric cells, which convert the light to electric waves, ready for the short wave transmitter.



A view of the television transmitter, showing the motion picture arc lamp, the revolving "scanning disc" and the attendent equipment. The photo-electric cells are open to view on the side of the metal box facing the young woman. The light rays pass through the square opening in the box.

Development of Transmitter and Receiver

Remarking on the television equipment developed by him, Dr. Alexanderson said, "television receivers may be worked out in a variety of ways according to well-known principles. The first choice to be made was to select the source of light. This choice was soon narrowed down to two alternatives. The light control developed by Professor Karolus of Leipsig and the Neon lamp developed by D. McFarlan Moore of the Edison Lamp Works of the General Electric Company. Tests of these two sources of light for television soon convinced us that each has its own distinct field of usefulness. When a large volume of light is needed for projection on a screen the Karolus system is preferable. The work on television which I described in a paper last year was built around the idea of using the Karolus light control for projecting television images on a large screen.

The other light source available for television was the lamp invented by Mr. Moore, who proposed this lamp for television in a paper as early as 1906 but it was not until 1913 that he received a quantity of neon from Sir William Ransey which enabled him to construct a practical lamp. While the Neon lamp does not compare with the Karolus light in brilliancy it is more sensitive and easier to operate. The distinct fields of usefulness of these two systems thus become evident,—The Karolus light for the large television projector and the Moore light for the home receiver.

Most experiments with television in Europe, as well as America, have used the Moore lamp. Mr. Moore has developed one television lamp which gives a uniform glow over a flat plate and another which gives a concentrated light in a cavity in the electrode. An enlarged and improved lamp of the first type was one of the important elements used in the demonstration of television by Dr. Ives of the Bell Laboratories last April. The tubular lamp with 2500 electrodes was also based on the Moore invention.

One of the features of the demonstration by the Bell Laboratories at that time appears to be a valuable contribution to the art of television,—the arrangement of large photo-electric cells for intercepting the reflection from a moving spot of light. This system saves the eyes of the subject from the glaring light to which he would otherwise be exposed. The Bell Laboratories photo-electric system has been adopted in our equipment for broadcasting television and will probably prove to be one of the factors in the development of practical television.

Returning to the design of the television receiver, we had the choice between three well known systems—the mirror drum, the disc with lenses and the disc with holes. Our conclusion was that, while the mirror drum and the lens disc may have certain advantages for television production on a larger scale, we decided that from the point of view of television in the home a hole is more economical than a lens and 48 holes are more so than 48 lenses.

Dr. Alexanderson and one of his assistants examining the interior of the television receiver. The amplifier is mounted on the base of the cabinet, the batteries on the first shelf, the motor, which revolves the "scanning disc," on the second shelf, and above is the Moore lamp.

Synchronization

Whenever television has been discussed in the past there has always been some pessimist who has wound up the discussion by asking how are you going to synchronize? The answer has always been that we will have a synchronous motor and transmit a special synchronizing wave or synchronize to the picture frequency or to a tuning fork. But all these devices mean higher cost, special amplifiers, and more things that may get out of order. We, therefore, simply decided to leave out all this complication. We took a standard electric motor made for household use and are manipulating its speed by an electric hand control. With a little practice and coordination between the eye and the hand it is possible to hold the picture in the field of vision. In special cases when the transmitting and receiving system are on the same power network the machines may be operated by 60 cycle synchronous motors, in which case the control button can be dispensed with.

Experiments Continued

Experimental television programs will be continued to be broadcast from a laboratory transmitter on a wavelength of 37.8 meters with the accompanying voice transmission on the regular 379.5 meters of WGY. As soon as it is found that the range can be extended the television transmitter will be transferred to the high power short wave experimental station at South Schenectady. A new transmitter is being built for this purpose so that the voice and the television can be radiated simultaneously by two transmitters.

The "Checkerboard" Antenna

We feel the inauguration of this new development will be the starting point of practical and popular television. The transmission is the expensive part of such an undertaking and we feel that it is our privilege to provide it. A new television transmitter is nearly completed at our South Schenectady plant. A part of this equipment is a new type of projector antenna which is now being tested with music and voice modulation and favorable results have already been observed in San Francisco and Europe. We have called this a projector antenna because it does not pretend to be a beam. The radiation that would be wasted backward and sidewise is saved and projected in the general direction where it is desired. After trying several types of projector systems we have arrived at a type which we call the checkerboard antenna. It is built in a checkerboard pattern; the sides of each square being a wire half a wave length long. All these half-wave antennas are connected in such a way that they oscillate in phase and require no tuning or adjustment.

A duplicate of this transmitter is being installed in the San Francisco broadcast station of the General Electric Company. This plan was decided on in order to provide means for systematically studying the physical phenomena of wave propagation over long distances. Television will here serve as a means to an end, but in the determination of wave phenomena one thing is certain, that the eye is infinitely superior to the ear for ascertaining facts and for a critical analysis and comparisons. This has already been proven by our television tests in Schenectady. Occasionally when we "look-in" on television at our homes uptown we observe a visual echo of the wave from the electronic layer on the upper atmosphere. The evidence of the echo is that two images appear side by side instead of one. The echo image is usually displaced a distance, corresponding to one fifteen hundredths of a second, showing thereby that the echo wave had traveled about 200 kilometers and yet the echo image is occasionally as strong as the direct image which traveled only a few kilometers. Such phenomena can obviously not be observed by the ear.

What we may learn about wave propagation by systematic study of television across the continent is something we can only vaguely imagine, but we do feel without any doubt that television is the new tool by which we are going to explore the secrets of space.

A New Band Selector

*"On the Distortionless Reception of a Modulated Wave and Its Relation to Selectivity"**

By Frederick K. Vreeland

THE ideal solution of the problem of distortionless reception of a modulated wave is a system which has a substantially rectangular frequency characteristic, that is, one which gives substantially uniform reception over a definite band of frequencies, including all the side band frequencies of the modulated wave, with a sharp cut-off for frequencies outside this band. Such a system in its ideal form would give distortionless reception, with a selectivity that is limited only by the overlapping of an interfering wave with the signal band. The closeness with which this ideal has been approximated will appear later.

The problem admits of two distinct solutions.

1—The use of one or more band selectors, each of which possesses a substantially rectangular frequency characteristic.

2—The use of two or more receiving elements whose individual frequency characteristics are not rectangular but which in combination have an overall characteristic that is substantially rectangular.

Again various combinations of these elements are possible. For example we may have—

a—A band selector with a flat amplifier

b—A band amplifier

c—Various combinations of band selector and band amplifier.

All of these solutions have been developed into practical working receivers.

The Band Selector

A band selector has been developed which meets the three stated conditions *i. e.*, fidelity, selectivity, and simplicity. It comprises in general a system of reactances so related to each other that they are mutually balanced, not merely at a single frequency as in the case of the ordinary tuned circuit, but also at any frequency within a given band. At any frequency outside of this band the reactances are not balanced and the unbalanced reactance is high. As a result of this property, the band selector unit responds with substantial equality to all frequencies within its characteristic band and is non-responsive to frequencies outside this band. When the system is suitably designed the cut-off at the limits of the band is very sharp. The electrical and mechanical construction is exceedingly simple, and frequency adjustment is obtained by means of only two variable elements operated by a single control.

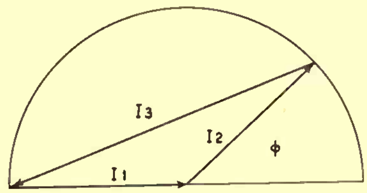


FIG. 2

Vector diagram showing the phase relations of the currents in the band selector. I_1, I_2 and I_3 represent the currents in the branches X_1, X_2 and X_3 respectively. (Fig. 1.)

The band selector is shown in generalized form in Fig. 1. It employs two reactive couples X_1 and X_2, preferably alike, each having a capacitance and an inductance that are balanced within themselves at the same frequency, together with a third reactance X_3 which is common to both. This third reactance is small in relation to the reactances of the two reactive couples and may be either inductive or capacitive.

An input electromotive force is impressed on the system in any suitable way as at E and the output is taken off in any suitable way as at S. At a particular frequency F_1, this being the frequency at which the reactances of the couples X_1 and X_2 are balanced within themselves, the overall reactance of the circuit including X_1 and X_2 will be zero, current at the frequency F_1 will circulate through the branches X_1 and X_2 without traversing X_3, and the system has zero reactance at this frequency.

At any other frequency the reactive couples X_1 and X_2 will not be balanced within themselves. The result will be a potential difference across points *a*, *b*, the terminals of the bridging reactance X_3. If the frequency is lower than F_1 the reactances of X_1 and X_2 will be capacitive. If now the reactance X_3 is inductive, it will tend to neutralize the unbalanced capacitance of branches X_1 and X_2, provided their combined reactance is no greater than X_3. In that case current will flow through X_3 of such amount that the reactive electromotive force across points *a*, *b*, due to the current in X_3, is equal to that due to the currents in X_1 and X_2. The phases of the currents in X_1 and X_2 will adjust themselves so that I_3 is equal to the vector sum of I_1 and I_2.

The operation of the band selector unit may be more readily understood by reference to the vector diagram Fig. 2. Let the currents set up by the impressed electromotive force E in the three branches X_1, X_2, and X_3 be I_1, I_2 and I_3 respectively. These three currents are considered positive when they flow in the direction from the common point *a* of the branches to the common point *b*. Since the total current flowing into or out of points *a* and *b* must be zero, the current I_3 in the common reactance X_3 must be equal and opposite to the vector sum of currents I_1 and I_2 in the other two branches. This relation is shown by the vector diagram Fig. 2, I_1 being regarded as fixed and I_2 rotating with relation to I_1, with the phase difference ϕ. For any value of ϕ the current indicated by the vector I_3 is the third side of the triangle formed by I_1 and I_2.

In the case of a symmetrical system where the branches X_1 and X_2 are

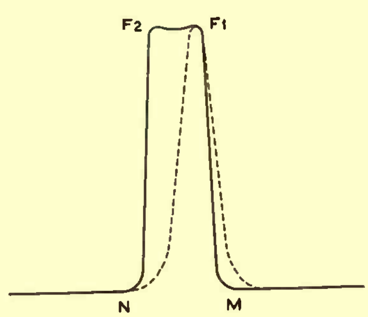


FIG. 3

Frequency characteristic (computed) of the band selector shown in Fig. 1. Note the steep gradient of the cut-off, F_1M and F_2N, and the sharpness of the band at the base compared with the resonance curve (dotted).

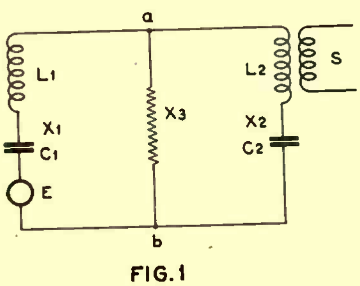


FIG. 1

Generalized schematic diagram of a band selector. X_1 and X_2 are two reactive couples. X_3 is the bridging or band-forming reactance.

* *Courtesy of Institute of Radio Engineers. Paper presented at Annual Convention of I. R. E., New York City.*

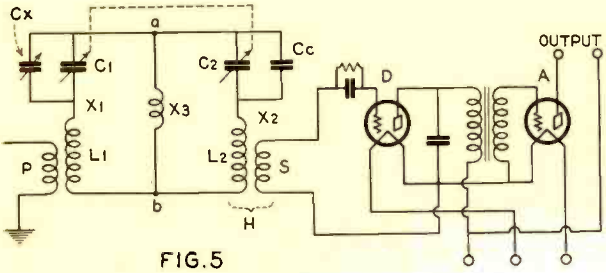


FIG.5

Schematic diagram of a broadcast receiver including a single band selector X_1, X_2 and X_3, feeding an aperiodic amplifying system D,A

alike, the currents I_1 and I_2 will be equal the current I_3 will have the value:

$$I_3 = -I_1 - I_2 = -2I_1 \cos\frac{\phi}{2}$$

It thus appears that the current in the common reactance I_3 varies between the limiting values $-2I_1$ and zero, as the phase difference ϕ between currents I_1 and I_2 varies from zero to 180°.

This phase relation depends upon the frequency of the impressed electromotive force in the following manner. Since the points a, b, are points of like potential difference in the three branches of the system, the current distribution in the system must be such that the reactive electromotive forces in the three branches are equal, that is

$$x_1 I_1 = x_2 I_2 = x_3 I_3$$

In the case of symmetry this becomes

$$x_1 I_1 = x_2 I_2 = -2x_3 I_1 \cos\frac{\phi}{2}$$

or

$$x_1 = x_2 = -2x_3 \cos\frac{\phi}{2}$$

For the other limit where ϕ equals zero this becomes

$$x_1 = x_2 = -2x_3$$

For the other limits where ϕ equals π of 180°,

$$x_1 = x_2 = 0.$$

In other words there is a limiting frequency F_2 at which the reactances are balanced when the phase difference between I_1 and I_2 is zero and the current in the common reactances X_3 becomes equal to twice I_1, and there is another limiting frequency F_1 at which the reactances are balanced when the currents I_1 and I_2 differ in phase by 180° and the current in X_3 becomes zero. This latter frequency is the one at which the reactances of the reactive couples X_1 and X_2 are balanced in themselves, and the current circulates wholly through the branches X_1 and X_2, no part of it traversing X_3. At the former frequency the reactances of the reactive couples X_1 and X_2 are not balanced in themselves, but they are completely balanced by the reactance X_3 when the entire current of both branches flows through X_3.

At any frequency between these limits, the phase difference between the currents I_1 and I_2 will have a value lying between zero and 180°, the resulting current I_3 will have a value intermediate between $-2\ I_1$ and zero, and the reactive electromotive force across X_3 will have a corresponding intermediate value equal to the reactive electromotive force in the branches X_1 and X_2.

The reactances of the system as a whole are thus completely balanced at any frequency between the limiting values F_1 and F_2, and the system will transmit freely any frequency in a band comprised between these limits. When X_3 is an inductance the frequency F_2 is lower than F_1. When X_3 is a capacitance F_2 is higher than F_1.

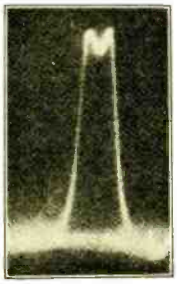


Fig. 4. Oscillogram showing the frequency characteristics of an actual band selector corresponding to Fig. 3. Carrier frequency, 635 kc. Effective band width, 18 kc

Since the phase difference between I_1 and I_2 cannot be less than zero or greater than 180°, if the impressed electromotive force has a frequency lower than the limiting frequency F_2 or higher than the limiting frequency F_1; (or vice versa when X_3 is capacitive) there is no possible phase adjustment which will cause the reactances to balance, hence there will be an unbalanced reactance in the system that will prevent the flow of current.

The above analysis neglects the resistance of the system. If the resistance and other losses are low, as they should be, the cut-off at the limiting frequencies is very sharp, and the frequency characteristic of the band selector unit has the form shown in Fig. 3.

The width of the band depends upon the relation of the reactance X_3 to the other reactances of the system. Thus if X_3 is an inductance, the band width depends upon the relation of this inductance to the inductances L_1 and L_2. If the reactance X_3 is a capacitance the band width is determined by the relation of the capacity reactance of X_3 to the capacity reactance of C_1 or C_2.

It is of interest to note the relation of the frequency characteristic of the band selector unit to the characteristic of a tuned resonant circuit. Thus if the common or bridging reactance X_3 is omitted the two branches X_1 and X_2 together constitute a resonant circuit tuned to a certain frequency F_1; this being one of the limiting frequencies of the band of the selector unit. The resonance curve of such a tuned circuit is shown by the dotted lines in Fig. 3 in its characteristic sharply peaked form.

When the common reactance X_3 is added to the system the curve takes the band form shown in full lines, the limiting frequency F_1 corresponding to the natural frequency of the tuned circuit and the limiting frequency F_2 being below or above this frequency, depending upon whether the reactance X_3 is inductive or capacitive.

When the reactance X_3 has a suitable small value in reference to the other reactances the widths of the two curves at the base are substantially the same, showing that the uniform band reception is achieved without any loss in selectivity, but rather with a noteworthy gain, as will now appear.

The frequency characteristic of an actual selector of this type is shown in the oscillograph record Fig. 4. It will be noted that the band is substantially rectangular, the sides being almost vertical. The gradient of the cut-off is very much sharper than that

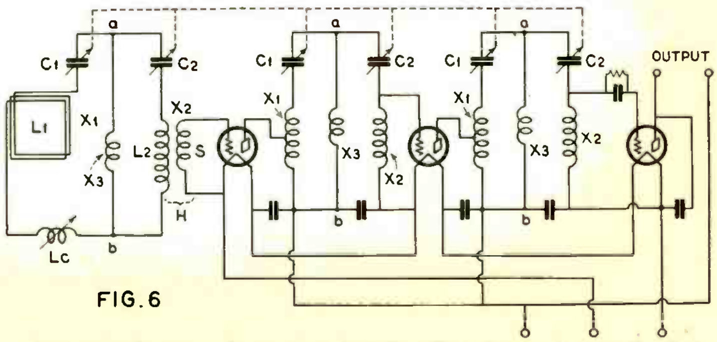


FIG. 6

Schematic diagram of a receiver including three band selectors, the first selector including a collecting loop L_1 and the second and third selectors being used as interstage couplings in a radio frequency amplifier.

of a resonant circuit made up of similar reactances.

With the band selector the characteristic is broadened, giving perfect (not approximate) side band reception, with no loss in sensitivity and with a great gain in selectivity.

Applications of the Band Selector

The generalized band selector Fig. 1 may be readily adapted to radio reception by antenna or loop. Such an arrangement using an antenna is shown in Fig. 5. The antenna coil

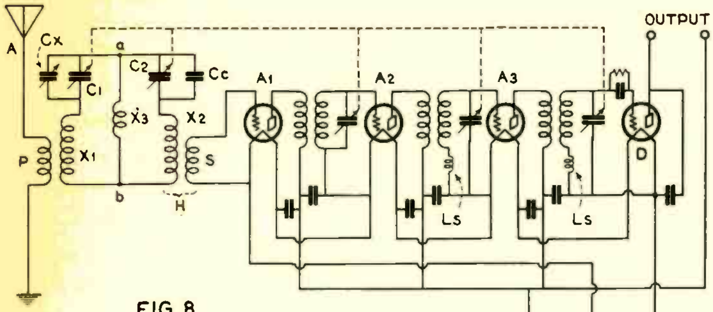


FIG. 8

Schematic diagram of a receiver including a single band selector coupled to a spaced band amplifier. Ls, Ls are the spacing inductances.

P, preferably with a step-up ratio. The capacity introduced into the branch X_1 by the antenna is compensated by a fixed capacity C_c in the branch X_2. In order to permit compensation for an antenna of any desired capacity without disturbing the frequency calibration of the system an additional variable condenser C_x is inserted, which makes up the difference between the capacity introduced by the antenna and the capacity C_c, so that the symmetry of the system is secured.

The adjustment of C_x is made arbitrarily until the signal strength becomes maximum, after which no further adjustment of C_x is required for a given antenna. The sole frequency adjustment is that of the two coupled condensers C_1 and C_2.

It is of interest to note that any lack of symmetry in the system that might result from careless or imperfect adjustment or the capacity C_x, within reasonable limits, does not materially alter the band form of the characteristic but merely reduces its amplitude.

The band selector may be used in a variety of ways. It may be employed as the sole selective element of a receiving system, feeding a flat amplifier, as shown in Fig. 5. This makes a system of great simplicity and high efficiency, and with sufficient sensitivity and selectivity for ordinary broadcast reception. It is particularly adapted to use in the metropolitan areas.

The band selector lends itself readily to use as an interstage coupling element of a radio frequency amplifier. Such an arrangement is shown in Fig. 6.

In this arrangement each of the selective elements has in itself a substantially rectangular band characteristic. With two or more such units combined in an amplifier the over-all frequency characteristic has a similar rectangular form with a sharper cut-off. Increased sensitivity and selectivity are thus secured with no diminution in the band width. This is in marked contrast with the tuned radio frequency amplifier, where an increase in the number of stages inevitably narrows the characteristic. When the various band selector units are made alike, as they may readily be, the whole system, including the compensated antenna selector, is symmetrical and all the variable elements may be operated by a single control, as shown.

The Spaced Band Amplifier

In the band amplifier of the second type the several stages have different frequency characteristics which are not rectangular in themselves, but in combination they produce an over-all band characteristic. This is done in the manner illustrated in Fig. 7 where 1, 2, 3 are of the individual characteristics of a three stage amplifier. These will have in general the characteristic form of a damped resonance curve, and they are made similar but differently spaced in the frequency scale. When the three stages are combined in an amplifier the over-all characteristic does not follow the geometric law, as in the case of synchronously tuned stages, but has a form totally different from that of the resonance curve. In general there is a certain spacing at which the over-all amplification becomes substantially constant over a considerable frequency band, and drops off abruptly with a sharp cut-off at the extremities of the band, as shown in curve 4, Fig. 7. The cut-off is very much sharper than that of the component characteristics; in fact is much sharper than the gradient for a three stage synchronously tuned system of the same damping. When the circuits are made with small damping and the correct spacing the characteristic is substantially rectangular. If the spacing is closer than the optimum value the over-all characteristic will have a bump in the middle. If the spacing is greater than the optimum there will be a double peak. The value of the optimum spacing depends upon the form of the individual characteristics.

The spacing may be secured in a variety of ways. Thus the coupling coils or transformers may be made with different inductances and the frequency adjusting capacities made alike, in which case the band width, measure as a fraction of the carrier frequency, will be uniform over the range of the frequency adjustment. Or the transformers or inductive elements may be made alike and the capacities different, or both inductances and capacities may be made alike and a small spacing inductance added to each of the lower frequency stages. From a practical standpoint it is usually desirable to make the coils and capacities alike and to add spacing inductances or spacing capacities to the lower frequency stages, as shown in Fig. 8.

An important feature of the spaced band amplifier is its inherent stability. Since the several circuits are not synchronized, the tendency to regeneration and oscillation is small. In addition to its inherent stability other features are employed which make the amplifier exceedingly stable. These features include an astatic winding of the coupling coils or transformers, which renders magnetic coupling between the stages negligible, and mutually reversed primary and secondary windings, which cause a phase-reversal of any external electrostatic couplings, putting the potentials of the several stages in such phase relation that they do not cause regeneration. The resultant of these three features is an amplifier of such stability that no capacity neutralization or balancing of any kind is required, and the coupling transformers may be placed closed together without shielding.

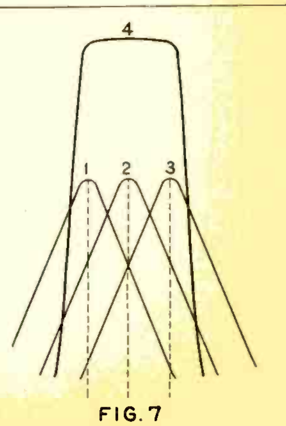


FIG. 7

Graphs illustrating the principle of the spaced band amplifier. Graph 4 shows the overall characteristic of an amplifier whose individual characteristics are 1, 2, 3

The Best Reproduction in Radio and Its Attainment[1]

Dealing With the Design and Frequency Characteristics of Radio and Audio Frequency Amplifiers, Detectors and Loudspeakers

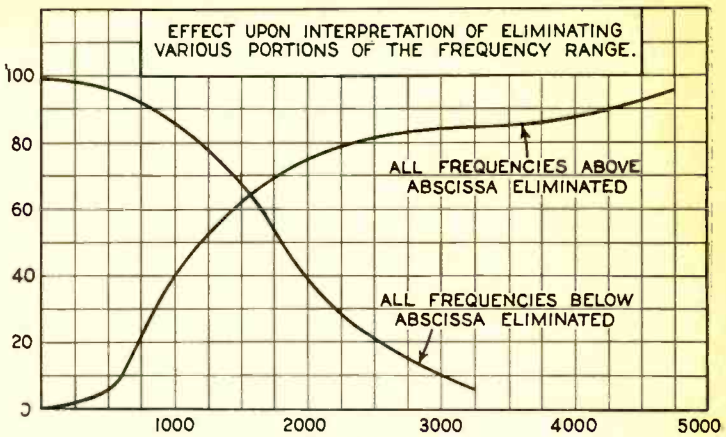
By Paul G. Andres*

TWO major problems in radio reception have engaged the attention of the scientist, engineer, designer and inventor. The first of these problems is the attainment of simplicity of installation, of operation and maintenance of the radio set. It is met by the completely self contained receiver utilizing a loop or short aerial, single control with attendant ease of operation and finally by the development of the socket power operated set which reduces the maintenance to a minimum.

The second problem in radio reception, with which this paper concerns itself primarily, is as vital as the first. It consists in the realization of a perfect amplifying radio and audio frequency band system, complete demodulation of the incoming carrier and the development of a reproducing device capable of recreating the sound energy as it exists before the microphone. Restated, the latter problem resolves itself into evolving a radio frequency system having frequency characteristic which passes or amplifies the carrier and side bands with no modification. The demodulating device or detector should separate the carrier from the side band in such a manner that the latter remains without distortion. The audio frequency system must be a perfect amplifying band pass filter covering the required frequency range. Last but not least, the reproducer or loudspeaker should create the sense of complete illusion by transforming the electrical energy received from the audio system into sound waves with perfect fidelity. Truly extraordinary results have been attained in the solution of this problem. It may be in order to review in a general way some of the factors which contribute toward the achievement of the goal of perfect reproduction and to consider briefly some of the factors which require further development before this end can be attained.

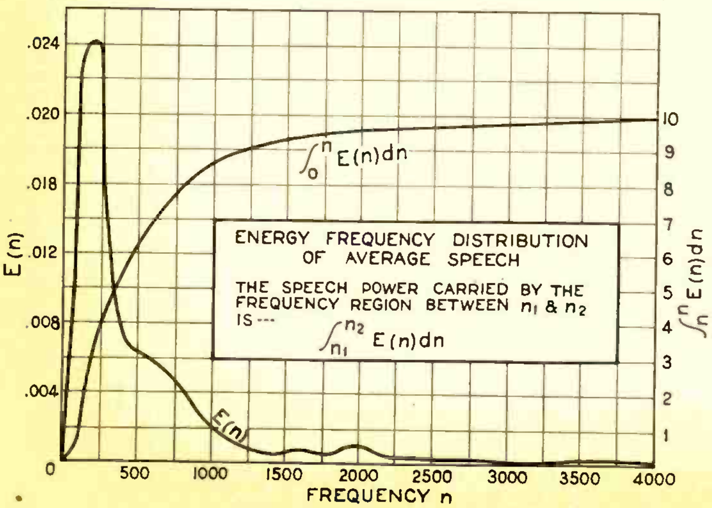
Before going into the matter of the mechanics of the receiver and loudspeaker, definite knowledge as to the frequency requirements in reproduction is necessary.

[1] Paper presented at meeting of R. M. A. in Chicago on Jan. 5.
* Chief Engineer, Temple, Inc.



-FIG. 2-

Delineation of the frequency characteristics of articulation. It will be seen that this depends primarily on the higher frequencies.



-FIG.1-

Characteristic of average speech energy. The major portion of it lies within the neighborhood of 250 cycles.

Speech and Music Frequencies as Applied to Broadcast Reception

The frequency range of speech and music covers the frequencies from approximately 30 or 40 cycles up to 8000 to 10,000 cycles per second. It has been found that the upper range may be reduced without greatly affecting the reproduction and present broadcasting is limited to the upper frequency of 5000 cycles per second. In the case of the low frequencies, a lower limit of approximately 70 or 80 cycles is obtained in broadcasting governed largely by the amplifying characteristics of the speech amplifier used at the broadcast station.

The proper evaluation of these frequencies throughout the speech and music band has received considerable investigation within recent years. Speech has been analyzed into its components by the technical staff of the Bell Laboratories and Fig. 1 gives the energy frequency distribution of average speech as determined by Dr. Harvey Fletcher of that laboratory. It will be noticed that the major proportion of speech energy lies in the neighborhood of 250 cycles per second with but very slight energy present in the frequencies above 2500 cycles. The articulation in speech, however, depends primarily on the higher frequencies and Fig. 2, determined by the same investigator, gives the relationship of the articulation with respect to frequency.

Music on the other hand has not been analyzed as completely as desired at the present time. Dr. Karl Willy Wagner of the Telegraph Bureau in Germany together with a number of other investigators has determined some of the main characteristics in music and finds that this particular analysis is extremely complex although subject to solution. The overtones of musical instruments largely determine the characteristics of these instruments. The complexity of the wave form found in musical reproduction can be appreciated when one of the modern electrically cut phonograph records is viewed under the microscope. With this in mind the matter of accentuation of certain frequencies in the audio frequency range may introduce distortion which is considerably more noticeable in one part of the frequency band than in another. The table in Fig. 3 gives an index of the per cent. of increase in intensity and frequency which is just perceptible to the average ear, which incidentally shows that in order to maintain the best possible reproduction and to create the illusion of perfect reproduction, that the recreation of sound should be at the same intensity as the original.

Numerous tests and investigations have been made on the response characteristic of the ear. Practically all of these tests were made in a room of perfect quiet. Radio reproduction on the other hand is generally obtained with a certain definite noise level present and in order to obtain some idea as to the frequency response characteristic of the ear with various noise levels present, a large number of tests were made under varying conditions. Fig. 4 shows a device designed and arranged so as to evaluate the response characteristic of the ear. Tests were made on over one thousand ears and a number of interesting results were obtained.

An average of all ears tested, as shown in Fig. 5, disclosed the fact that the average layman's ears respond closely to the results obtained by the Bell Laboratories in their investigations under quiet conditions.

In this connection it may be stated that of the many tests made on radio designers and engineers, imperfections were the common thing instead of the exception. It may be that listening tests or unusual conditions have gradually deadened the response instead of improving the keenness of hearing. From this it is apparent that listening tests by one or two individuals are not sufficient to determine the merit of the receiver and loudspeaker with respect to its reproduction. Reliable measurements are very much desired which give a relative or absolute index as to the performance against certain standards. On the other hand tests made in laboratories may show only mediocre results but if the product meets with unusual consumer acceptance it may well be possible that the measurements did not receive proper interpretation. Much remains to be done in developing suitable test methods which will predict performance in the field definitely.

MINIMUM PERCEPTIBLE INCREASE IN INTENSITY AND FREQUENCY

(Knudsen, Phys. Rev. 21, p. 84. Jan., 1923)

Sensation Level in Sensation Units or TU's	Per Cent Increase in Intensity to be Just Perceptible
10	23
20	14
30	12
40	11
50	10.6
60 to 100	10

Frequency	Per Cent Increase in Frequency to be Just Perceptible
64	.93
128	.59
256	.40
512	.32
768 to 4096	.30

Fig. 3

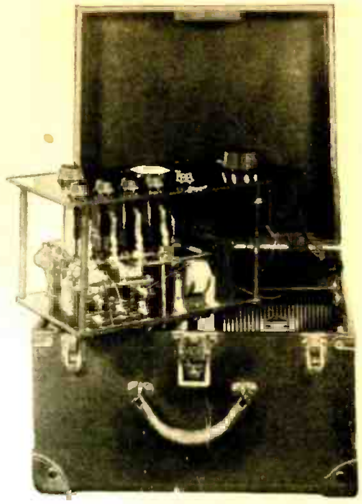


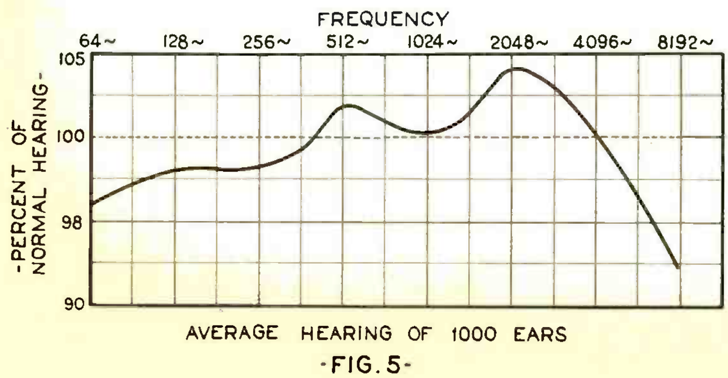
Fig. 4. The apparatus employed for determining the average frequency response of the ear.

With a definite picture of the requirements of a radio receiver and loudspeaker in reproducing all the frequencies from the very low to 5000 cycles, an analysis of the receiving set with respect to the behavior of its component parts toward frequency discrimination may be considered.

The Radio Frequency Amplifier

All radio frequency systems utilize resonant circuits, consisting of inductances and capacities, as coupling devices between the amplifying tubes. The frequency amplitude characteristic of such devices in the radio band can be made sufficiently broad to cover the modulated carrier fairly uniform. Regeneration when introduced either by design or inherently present, being caused by tube or stray capacities, requires most careful design in order that the response characteristic maintains a flat top as wide as double the audio frequency band to be transmitted. The selectivity and distance getting ability of a set are greatly increased by regeneration but the best reproduction cannot be obtained since the low audio frequencies are eliminated when excessive regeneration is present. The fact that in the mind of the layman local broadcast reception is generally synonymous with good quality reproduction has a bearing on this point since under controllable regeneration he has no occasion to use this method of obtaining sufficient signal intensity.

One of the milestones in preventing undesirable regeneration has been the development and application of proper shielding between stages. Proper shielding allows each stage to operate without inter-action from another stage and in this way permits the designer to treat each individual stage as a unit. Numerous circuits have been developed which prevent tube capacities from entering into factors



-FIG. 5-

A very interesting curve showing the average frequency response of the ear. Note the humps at 512 and 2048 cycles.

contributing toward regeneration or at least put as much regeneration as desired under control. The recently developed screen grid tube is intended to operate along the line of stabilizing the receiver and incidentally permits of greater amplification. The application of this idea to the radio frequency receiver and its performance in the field will undoubtedly be watched with considerable interest.

The desired amplifier would be one, of course, which passes the 10 kilocycle band uniformly. As shown in Fig. 6, curve A, which is a typical response curve obtained with a coupling circuit not sharply resonant, has a rather flat top and gives good quality. On the other hand interference comes into play due to its over-lapping on other wave channels. Curve B on the other hand is relatively free from interference but the quality of reception suffers because of incomplete reproduction of the frequencies required as shown by the darkened portion in the 10 kilocycle channel. Obviously some compromise must be made between selectivity and sensitivity against reproduction. The trend however has been toward better reproduction and some decrease in sensitivity. The mechanics and alignment of gang condensers is receiving much attention in order to insure proper tuning and reproduction in tuned radio frequency acts.

The ideal radio frequency amplifier is one in which the radio frequency stages are coupled by sufficiently broad tuning circuits and inter posed somewhere in that circuit a band pass filter which passes the 10 kilocycle band but which is variable to include the entire broadcast band, that is from 550 to 1500 kilocycles.*

The Detector

The vacuum tube detector in commercial receivers of today has assumed one of two general forms. The grid condenser-leak type and the C battery type. The former, because of its simplicity and ease of application, is the one most commonly used. An examination of this circuit utilizing the grid condenser and leak, shows that the time constant of the circuit, that is, the product of the capacity and resistance, should be smaller than one-five-thousandths of a second if the device is to allow satisfactory reception for audio frequencies. If any frequency discrimination exists the high frequencies are the ones that suffer. In practice the grid circuit of the detector includes the grid to filament A. C. resistance which has a value considerably less than 100,000 ohms for a 201-A tube when the grid is kept slightly positive. The time constant of the circuit, therefore, becomes the product of the capacity times the parallel resistance of the grid-leak and tube resistance. This value is sufficiently small to insure good detection for frequencies well above the audio frequency range.

It is vitally necessary that a receiver maintain the detector grid at this positive potential since a slightly negative one causes the A. C. resistance between the grid and filament to reach high value. In such cases the time constant of the circuit becomes sufficiently large to introduce a decided falling off in quality. The use of the low grid-leak resistance or an extremely small value of condenser to obviate this defect is generally insufficient.

With a slightly positive grid the tube input circuit has a broadened resonance curve which further aids in preventing frequency distortion by the circuit. In general it may be said that very satisfactory results are obtainable with grid detection under proper conditions of design. C battery detection, as mentioned above, has not been used extensively in commercial practice. The sensitivity of this arrangement is perhaps not as great as that obtained with the first method nor is its application as convenient, but the fact that the power capacity of the detector is greater should recommend itself for certain applications.

The detector circuit on A. C. operated sets requires much consideration to insure not only sufficient power capacity, but also freedom from frequency distortion and the introduction of hum. One of the major problems of a radio set designer centers around the detector and improved methods and circuits are highly desirable to remove its limitations.

* *In line with Frederick Vreeland's Band Selector described in this issue.*

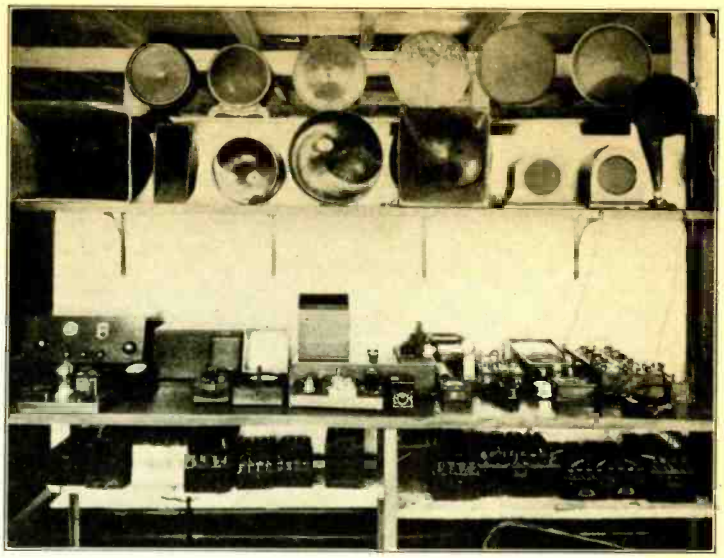
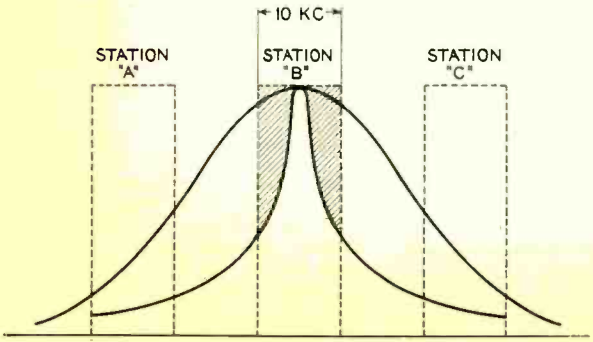


Fig. 7. Apparatus employed to determine the performance of loudspeakers at low frequencies and to indicate the amount of undistorted power output.

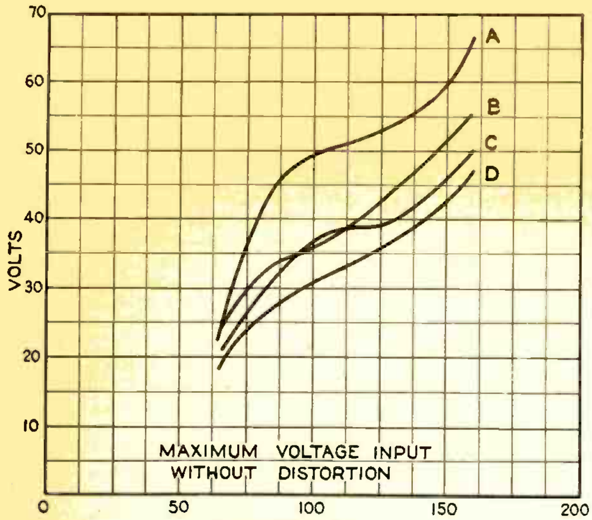


-FIG. 6-

Resonance curve illustrating broad and sharp tuning—and the consequent frequency cut-off in the latter case.

The Audio Frequency Amplifier

The audio frequency amplifier, because of its application not only in radio receivers, but also in telephone repeater circuits, phonograph reproduction, broadcasting and other uses, has received intensive study. The three forms of audio amplifiers, resistance, impedance and transformer coupling, together with modifications have vied with each other for supremacy with high quality reproduction as the primary goal. The consumer's demand for better and better quality have brought about the use of larger coupling transformers with



-FIG. 8-

Results obtained from four different loudspeaker motor drives. These curves indicate that the power capacity of the average loudspeaker is limited on low frequencies.

more perfect reproducing ability, particularly on the low end of the frequency spectrum. Tuned impedance coupling circuits have been developed which give the coupling device characteristic a decided gain on low frequencies and permit a gain on the high frequencies to obtain a more uniform sound output with a given speaker.

The causes of distortion in the audio frequency amplifier may be summarized as follows:—coupling circuits having more or less resonant characteristics; regeneration; operation too near either of the bends of the tube characteristic; overloading of tubes; frequency discrimination in the output filter or transformer.

Resonance effects in coupling devices are invariably present in audio frequency amplifiers due to self capacity of the windings. The tendency has been to minimize their effect by throwing them either below or above the audio frequency range.

Space requirements in the modern set have made close placement of equipment imperative which in many cases has resulted in regeneration, causing certain sections of the overall response characteristic to show decided gain. Regeneration in the audio system is one of the bugbears of the designer. It is caused primarily by coupling between stages and also by common impedance in the plate circuit. The use of B battery eliminators, unless properly designed aggravate this condition.

A common offender in audio circuits in preventing high quality reproduction consists in operating the tubes too near either of the bends in the grid voltage and plate current curve, that is, the C bias is incorrect. The proper value of bias is not a definite value for any given tube, but depends on the plate voltage. Current supply devices operated from socket power have aided materially in maintaining the plate potential at the proper and fixed value with a definite grid bias depending on that plate potential.

The development and application of power tubes within the last year or two have largely removed the limitations of over-shooting the straight part of the curve of the amplifier tube with a strong input signal. The gain produced by these tubes in improving quality of reproduction is primarily noticeable on low frequencies. In this connection it may be mentioned that the linear part of the tube characteristic is dependent on the output impedance and hence the output circuit should be designed to operate most efficiently in conjunction with the tubes.

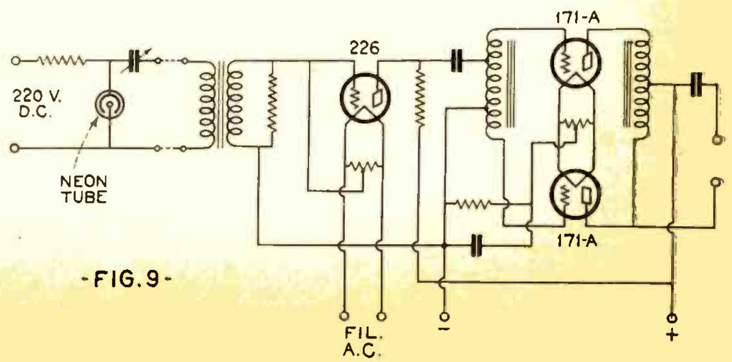
Push-pull amplification, previously used in a limited way, has been extensively revived recently; the advantages of this type of amplification for the last audio stage are numerous. It permits a greater input signal before overloading of the tubes occurs and in this way gives an undistorted output considerably in excess of twice that of the single tube. The impedance of the combination is low which has some advantages when operating into the present day loudspeaker. In addition to this, this type of amplification can be used to advantage on socket power operated sets and amplifiers since hum is reduced to a minimum.

The use of power tubes calls for a speaker filter or output transformer to keep the plate current from flowing through the loudspeaker winding, causing saturation effects and possible burn-outs of the speaker windings. The output transformer in this case closely approximates that of the conventional power transformer with the provision that it should pass the entire audible frequency band without modification. This condition has been achieved by the large output transformers now on the market. The complete isolation of secondary from primary is advantageous in preventing high voltages, which may reach values in the neighborhood of 400 to 500 volts, from being connected to the loudspeaker. The speaker filter consisting of a choke and a condenser offers another solution to the problem particularly in those cases where the plate potentials are low or where the speaker is located in proximity to the amplifier. It has an excellent frequency characteristic.

The Loudspeaker or Reproducer

The last link in our chain of radio receiving apparatus is the loudspeaker or reproducer. This piece of apparatus is perhaps the most defective of the entire chain. The conversion of electrical into acoustic energy can be considered as consisting of two parts. There is first, a conversion of elecrrical energy into mechanical energy which resolves itself into a motor drive and then the conversion of mechanical energy into acoustic energy. The latter transformation generally takes place by moving a small diaphragm connected to an air column or by means of a large open air radiator consisting of a large diaphragm generally conical in shape. Two types of motor drives have been extensively used in loudspeaker work, the electric-magnetic and the electro-dynamic types.

The design of such a motor is an



-FIG.9-

Circuit employed for the production of oscillating current having a steep wave-front.

extremely complex problem because it should be reasonably efficient and the moving parts should be as light as possible. Resonances invariably occur except in the most damped structures in which case the efficiency is low. The mechanical parts, their interlinkages and the structure of the magnetic circuit offer considerable experimentation in order to achieve a device which covers the entire audible range, and which does not lead to excessive resonances.

The air columns which couple a small diaphragm to the open air matches the high mechanical impedance of the diaphragm to the low impedance of the open air and in addition to this it propagates the energy across the varying sections of the horn, and with proper design results in a maximum energy transfer between the two mechanical impedances. In actual practice the shape of the horn has been practically standardized on the exponential form. but the fact that the horn is exponential does not insure that the impedance match is correct, since this depends in a large measure on the terminal openings and on the taper constant. Resonances are present in such a device but when the air column is coupled to a unit which in itself also has some resonances, the net overall effect will be a substantial flattening of the output characteristic.

In the case of the open radiator or cone type speaker, it has been found that the efficiency is lower than that of the air column type and the resonances are generally much sharper. The tendency has been toward larger radiators to insure the reproduction of low tones.

The main requirements of any loudspeaker are that it shall reproduce all frequencies throughout the audible frequency band with a uniform intensity of sound; it shall have no marked resonance points; it should reproduce a number or a combination of frequencies in their true proportion and introduce no distorting harmonics at any frequency.

In order to test the performance of a loudspeaker, numerous methods have been proposed from time to time, some of which yield excellent results by giving the true indication of the performance of the speaker under normal conditions of use. The apparatus shown in Fig. 7 is particularly of interest in this connection, inasmuch as this is used to determine the performance of the loudspeaker at low tones and gives an index as to the amount of undistorted power output any individual speaker may possess at those frequencies. In a general way, the beat oscillator produces the low frequencies which are amplified through a suitable amplifier and their wave form is checked on an oscillograph. These frequencies are then applied to the loudspeaker and careful note is made when distortion occurs due to the introduction of harmonics when the speech voltage is increased to a certain amount. Fig. 8 shows the result of four different loudspeaker motor drives connected to their respective air columns or cone structures, as the case may be. These tests indicate that the power capacity of the average loudspeaker is decidedly limited on low frequencies. This limitation is caused primarily by the movement of the armature out of the position of neutral flux with the result that third and fifth harmonics appear.

The ability to reproduce composite wave forms in their true proportion is extremely difficult of realization. Normally loudspeakers are tested on a sinusoidal wave form but when chopped direct current, which gives a square wave form or a steep wave front circuit such as the one shown in Fig. 9 is used to supply the energy, the deviation from the original wave form is quite noticeable. This is caused primarily by lags and mechanical hysteresis in the moving parts.

The electro-dynamic motor drive coupled to an open air radiator has found considerable application in practice, but the fact that external excitation is required limits the use of this speaker to certain applications.

Intensive development work is being brought to bear on the solution of the loudspeaker problem. Because of the impedance matching mentioned above, some manufacturers are incorporating part of or the complete audio frequency amplifier with the loudspeaker as a distinct unit which allows greater flexibility in design and incidentally permits the use of socket power for excitation in the loudspeaker.

One of the factors which should be considered in obtaining perfect and natural reproduction is the placement of the loudspeaker in the room and definite knowledge as to reverberation in that room so as to obtain the sense of perfect illusion. This requires that some compromise must be made in broadcasting so that the reproduction shall have a reverberation time equal to that given before the microphone. In other words, the reverberation time present in the reproduction should be equal to that obtained under conditions where the mechanism of broadcasting and reception is completely eliminated.

The problem of loudspeaker design is resolving itself gradually into a determination of the various losses encountered in the motor and in the radiator circuit so as to effect the greatest efficiency with a minimum of distortion.

Conclusion

There are so many factors contributing to distortion and mal-performance in the radio set and loud speaker that it is indeed a surprising fact that the sounds being emitted are not only recognizable but that they actually closely approximate the original. There is hardly a factor in the entire chain of the radio frequency amplifier, detector, audio frequency amplifier and loudspeaker which cannot be tremendously improved by design and the application of engineering skill coupled with correct interpretation of reliable measurements made in the laboratory. Undoubtedly many of these improvements tending toward better reproduction will be brought about by invention and design from time to time but the changes that will undoubtedly occur within the next five years will not be as great as the changes which have come about through the development of the last five years in radio reproduction.

RADIO LEADERS CONSIDER BROADCASTING AND PATENT PROBLEMS

RMA Membership, Engineering and Committee Meetings Discuss Industry Problems

TWO hundred leaders of the radio industry met recently at the Hotel Pennsylvania at the Annual Midwinter sessions of the Radio Manufacturers' Association, Inc., and discussed many important public and industry problems, including broadcasting, patents and technical engineering matters.

Mr. O. H. Caldwell, Commissioner of the Federal Radio Commission, at Washington, was the speaker at the monthly RMA luncheon, and outlined the Commission's progress in improvement of broadcasting and also the increasing markets for radio.

Prior to Commissioner Caldwell's address, a special RMA membership meeting, presided over by Mr. C. C. Colby, of Canton, Mass., President of the RMA, was held and received a report regarding the RMA movement to effect a plan for interchange of radio patents, to meet the important patent problems of the industry. Mr. A. J. Carter, of Chicago, Chairman of the RMA Patent Interchange Committee, submitted a report regarding the substantial progress made towards the interchange plan. It was discussed fully by members and, Chairman Carter announced, will be ready for formal presentation to the manufacturing industry, as represented by the RMA, at the Association's Annual Convention in Chicago next June.

Other RMA meetings were of the Engineering Division, of which Mr. H. B. Richmond, of Cambridge, Mass., is Chairman; the RMA Parts Committee, and the Engineering Division meetings together with a meeting of the RMA Merchandising Committee, of which Mr. L. E. Noble, of Buffalo, is Chairman.

The RMA Board of Directors held its monthly meeting and the RMA Legislative Committee also considered several radio legislative problems. Standardization problems in receiving set design were discussed at an Engineering Division meeting, presided over by Mr. L. F. Curtiss, of Springfield, Mass. The Engineering Division discussed "socket power" and the new electric sets, together with variable condensers, dials, etc.

The Problem of Radio Set Power Supply

Rectifiers for A and B Power Units

By George B. Crouse*

PART II

SINCE something over 90% of the connected lighting load in the United States is alternating current, one of the most important elements in any battery elimination apparatus is the rectifier. The function of the rectifier is to act as a sort of electrical check-valve, allowing the current to flow in one direction and not in the other. A suitable rectifier system inserted in an alternating current circuit will produce an output which is pulsating but always in the same direction. The properties of the rectifier which are of particular importance in determining the suitability of the device for a given Socket Power design are:

1. Useful life.
2. Uniformity of performance between individual samples, or, in other words, interchangeability.
3. Price.
4. The character of the failure at the end of the useful life.
5. Amount of radio frequency radiation.
6. Variation of output voltage with line voltage.

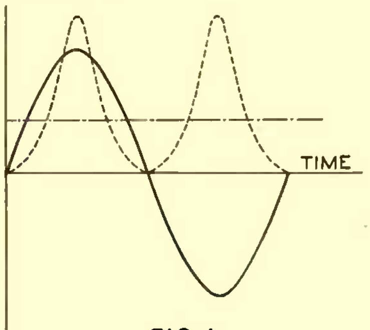


FIG. 1

Curves illustrating the momentary heavy load placed upon the filament of a hot cathode type full-wave rectifier tube.

In assigning limits to the above characteristics to give a satisfactory rectifier, we can only be guided by practical commercial experience; in other words, the customer sets the standard in the last analysis. The following discussion of the properties enumerated above is based upon the writer's wide experience with rectifiers in actual commercial service.

In regard to useful life, it has been pretty well established that any replaceable unit should have a life of at least one year in normal service. An analysis of statistical records drawn from a number of sources indicates that the normal use to which a radio set is put in one year is in the neighborhood of 800 hours, so that in setting the minimum number of hours of useful life which a rectifier must have, we shall not be far wrong if we place it at 1000 hours.

In determining this useful life certain precautions must be observed. In the first place, we should be sure that we are testing useful life and not total life. In other words, the characteristics of the device must remain substantially constant and as soon as marked changes in characteristics appear the test should be brought to an end. The author has seen life test records which on the face of them showed remarkably long performance, but when analyzed it was found that the device actually was only useful during the first few hundred hours of the test, the output having fallen off beyond that time to a point where the user would certainly have thrown the device away.

In practice it is best to test the rectifier under the actual conditions of use. They are particularly sensitive to overload, and in making life tests it is important to be sure that the tests are made under maximum load conditions. Also, if as is usually the case, the rectifier will be turned on and off many times during its life, the life tests should be made under intermittent conditions. This is particularly true where the rectifier employs a hot filament and in crystal and chemical rectifiers.

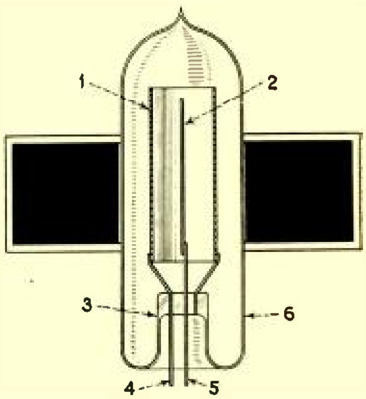
There is, unfortunately, no substitute for the life test. Accelerated tests of various kinds have never proven satisfactory, which is another way of saying that the rectifier is sensitive to its environment, and its performance in one environment is not a measure of its performance in another.

No very definite limits can be set as tolerances of interchangeability. The designer must decide for himself what limits may be accepted in the output voltage of his design. If the radio set is, for instance, extremely sensitive to over-voltage, tending to oscillate at either radio or audio frequencies, the limits must be very narrow. Ordinarily plus or minus 5% of the output voltage of different samples of rectifiers, for a given service under constant input voltage, will be satisfactory. The best method of testing is to measure the output voltage with the actual apparatus in which the tube is used.

It should be pointed out that even though satisfactory performance of the receiver may be secured with wide variations in rectifier characteristics, that the ultimate consumer is very likely to reject and return those rectifiers which give a low output, and it is difficult to persuade him that he has not been sold a poor unit.

The possible list price of any device is a controversial subject. The author's experience indicates that a rectifier should list at about $5.00. Of course logically the list price should bear some relation to the useful life, but it is generally difficult to sell the public on this idea. The possible list price also bears some relation to the total price of the apparatus in which the rectifier is used, and in high priced apparatus the above figure could probably be considerably increased without limiting the sale materially.

A very important feature in rectifiers is the character of the failure which may be expected. The most desirable type of failure is one in which the rectifier at the end of its life suddenly and completely opens circuit. Since it is generally impossible to secure this, a rapid falling off of output voltage is the next best thing.



- FIG. 2 -

Details of an early type gaseous conduction rectifier tube.

A rectifier which fails by short-circuiting is in no case satisfactory, since a short circuit passes alternating current through the rectifier and will ordinarily result in the destruction of the transformer. It may be urged that this may be very simply overcome by the use of a fuse in the primary or secondary line of the transformer, but experience indicates that once the original fuse has blown the user replaces it with a nail or other similarly highly conductive, but generally unsatisfactory substitute.

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

Radio frequency radiation is caused by sudden current peaks passing through the rectifier, setting into oscillation portions of the associated circuits at frequencies within the range which the radio set will take. In determining the characteristics of a new rectifier tests for this effect should always be made using the rectifier in

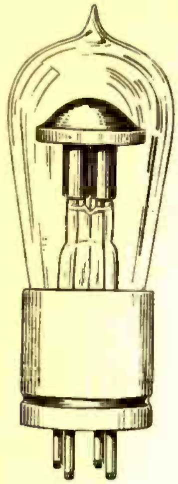


Fig. 4. Modern type of gaseous conduction full-wave rectifier, designed for use in B power units.

the actual apparatus in which it is proposed for use, and employing a radio receiver of high sensitivity with a good antenna. The rectifier manufacturer generally recommends some device for reducing this effect, such as the so-called buffer condensers connected across the primary or secondary winding of the transformer, and when the recommended device is used with the rectifier no radio frequency noise should be apparent with the best available receiver.

Since the internal impedance of many rectifiers is not a constant, but varies with the current variations, any alternating current input voltage would ordinarily result in a different percentage of direct current output voltage. This effect may to some extent be counteracted by suitable designs of the associated apparatus, as will be pointed out later, and is a defect in most rectifiers which must be endured.

Classes of Rectifiers

For the purpose of this article rectifiers are classed according to their use, as follows:

1. Rectifiers for B Socket Powers.
2. Rectifiers for parallel filament A Socket Powers.
3. Rectifiers for Series Set Socket Powers.

In the following where there is only one example of a given type of rectifier in the market, the manufacturer's trade name is used as the designation. Where more than one example of a given type is available a designation has been coined and defined.

Rectifiers for B Socket Power

Of the rectifiers commercially available for this class of service we may list the following:

1. The hot cathode, high vacuum type, typified by Radiotrons Nos. 280 and 281.
2. The cold cathode, gas-filled tube, typified by the Raytheon and the Q.R.S. type.

Hot Cathode Type

The first mentioned type is an enlarged edition of the ordinary audion, with the grid left out, and may be constructed to rectify either half or full wave. It depends for its rectifying properties on the fact that a heated filament emits negative carriers which, when the cold plate is positively electrified, are drawn to the plate, thus completing the electrical circuit. On the other hand, when this plate is negative, the negative charged carriers are returned to the filament as fast as they are given off and the circuit is thereby interrupted.

Tubes of this general type may be constructed to rectify extremely high voltages, but have a definite current limitation. This current limitation is due to the fact that all of the electrical carriers must be supplied by the filament which, if any large amount of current is to be rectified, becomes impracticably large and heavy. It should be pointed out in this connection that the rectifying capacity of a tube in terms of current cannot be determined by direct current tests. This will be made clear by reference to Fig. 1, in which is shown a sine wave of voltage in the full line, the resulting current wave in a full wave rectifier in dotted lines, and the resulting average direct current in the dot and dash line. It will be seen that the filament is called on to supply, momentarily, a current almost three times the average direct current.

There are two types of filament material suitable for this service, Thorium impregnated Tungsten, and various metals coated with oxides of the rare earths. From the standpoint of the user, we believe that there is little to choose between the two types.

The useful life of rectifiers of this type is probably in the neighborhood of 1200 hours average, although considerable variation in life between individual samples will be observed. Either type of filament is somewhat sensitive to voltage overload, and the transformer should be designed to keep the filament voltage down to the rated voltage, as stated by the manufacturer, at the maximum line voltage which may be encountered. This is perfectly practical inasmuch as it will ordinarily be found that sufficient emission will be obtained at 20 to 25% below the rated voltage, particularly if the maximum current demand does not reach the maximum rated output.

Other than the variation in life, the tubes should run very uniform in characteristics and are completely interchangeable, one sample with another. In selecting a given manufacturer's tubes, attention should be paid to this point. In order that the output may be uniform it is very essential that the highest degree of cleanliness be observed in the manufacture and that thorough cleaning of the elements of the tube of all residual gas be accomplished. This of course requires adequate manufacturing facilities and careful and painstaking supervision.

The list prices of good rectifiers of the hot cathode type remain somewhat above the $5 figure discussed earlier in this article, which is probably due to the difficulties of uniform manufacture and a rather high percentage of rejection of finished tubes.

The character of the failure at the end of the useful life is a very desirable one in that the output gradually decreases. This decrease of output is ordinarily due to the exhaustion of the electron emitting materials on the filament. The filament rarely burns out and this is sometimes a cause of dispute with the user who cannot understand why a tube which "lights up" is not still a good tube.

The amount of radio frequency radiation is generally small. Looking again at Fig. 1, it will be observed that the current in the rectified output rises gradually and therefore there is little tendency to set the associated circuits in oscillation.

The D.C. output voltage variation, with variation of line voltage, is very good. The tubes have no "arc characteristic" and in fact in one type of B Socket Power the tubes are worked so close to the saturation, or maximum emission point, that they act to a certain extent as voltage regulators. However, this is not good practice,

Circuit arrangement employed for determining the conducting and break-down voltages in a gaseous conduction rectifier tube.

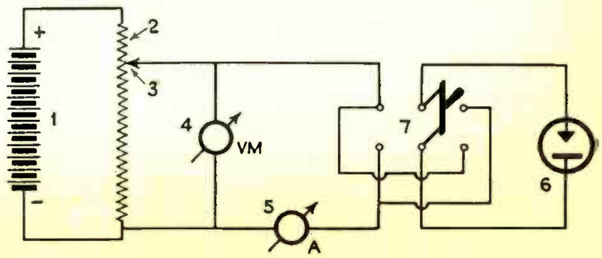


FIG. 3

and the designer should be content to get D.C. variations equal to the A.C. input varitions.

Cold Cathode Type

The rectifying action of this tube is somewhat involved and much more complicated than in the case of the hot cathode type just discussed. For purposes of explanation, there is shown in Fig. 2, in diagrammatic form, an early model. It comprises a metallic cylinder 1, and a metallic wire 2 located on the center line of the cylinder. These two elements are carried on suitable insulated supports in a glass stem 3, connection being made to the cylinder and wire by means of the terminals 4 and 5. The whole structure is mounted in a glass envelope 6. This envelope is thoroughly exhausted, all the metal parts being suitably bombarded to free them from occluded gases and the envelope then filled with an inert gas at a pressure of 10 to 14 m.m. of mercury. Helium is most used for this purpose, but argon or neon may be used or mixtures of any two or all three.

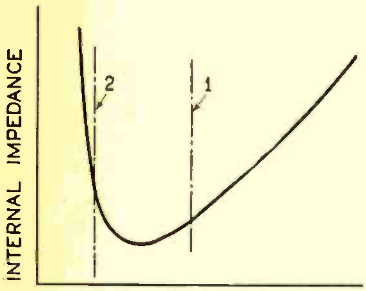


FIG. 5

Illustrating the relation between gas pressure and internal impedance in a gaseous conduction rectifier.

Consider now that the two terminals 4 and 5 are connected to a source of potential of such polarity that the center wire 2 will be positive. Under these circumstances there will be a strong electrostatic field set up between the cylinder and the wire which, by the geometry of the parts, will increase in intensity towards the center. There will be in such a gaseous atmosphere some free negative ions; any of these ions located near the inside surface of the cylinder will be attracted toward the wire with increasing acceleration, due to the increasing field strength. If the field strength is sufficiently great the velocity of this electron will reach the point where, if it should collide with a molecule of gas, it will knock off an electron from the molecule and thus create two new current carriers, one positive and the other negative. The new negative carrier may in turn pick up sufficient velocity to ionize another molecule, and thus very shortly the entire space between the wire and the cylinder will be filled with positive and negative carriers and the tube will be in a conducting condition.

If we now reverse the polarity of the potential applied to the electrodes, making the cylinder positive, it will be seen that negative carriers originating near the wire will move out into a field of continually decreasing potential, their acceleration will decrease and they will never reach sufficient velocity to enable them to separate other negative carriers from the gas molecule.

From the explanation just given we may theoretically deduce certain peculiarities of this tube, and these deductions are verified in practice. In the first place, note that the carriers are supplied almost entirely by the gas itself and not by the electrodes. This means that the action of the tube is much more dependent on the constitution and purity of the gas than on the electrode material. Second, a certain strength of field must exist between the electrodes before conduction can take place at all. Third, since there will always be some carriers present in the gas, there will be some current flowing on the nominally non-conducting half of the cycle.

These peculiarities make necessary certain precautions in testing a given manufacturer's tube to determine its suitability for a given job. Since, as pointed out above, there is a definite break-down voltage at which the tube begins to conduct, there will be a sudden rush of current through the tube when the voltage reaches this break-down point. It is important that this break-down voltage be as close to the conducting voltage as possible, in order to minimize this steep current wave and reduce radio frequency radiation. This break-down voltage and conducting voltage are ordinarily determined on direct current by means of the circuit shown in Fig. 3. In this figure, 1 is a source of direct current of say 300 volts. 2 is a potentiometer connected directly across this source and having the sliding arm 3. 4 is a voltmeter on which the break-down voltage is read, and 5 is an ammeter for indicating when the tube begins to conduct. The rectifier is shown at 6 connected into the circuit by means of the reversing switch 7. Several tests should be made, average values being taken. Between each test the reversing switch 7 should be thrown. This is important since the passage of direct current through the tube leaves the space between the electrodes swept clean of negative carriers, and succeeding tests for break-down voltage will show increasing values unless a reverse potential is applied to the tube between each test. This same set-up serves to determine the conducting voltage drop and the reverse current.

A good rectifier of the gas-filled type should have a running voltage of 90 to 100 volts, a break-down voltage not in excess of 130 volts, and a reverse current not in excess of 15 milliamperes at 300 volts applied.

Tubes are ordinarily constructed for full-wave rectification and are of the form shown in Fig. 4.

The useful life of the gas-filled tube should be over 1200 hours. In making life tests it is not necessary to make intermittent tests as the operation of the tube is in no way affected by starting and stopping. These tubes are even more subject to wide variations of life than are the hot cathode type, probably due to the difficulty of keeping the gas pure.

In the last two years much intensive development work has been done on the manufacture of this class of rectifiers, with the result that a high degree of uniformity, as regards performance characteristics, other than life, may be expected. But if any question as to the manufacturer's experience in this field exists careful checks for uniformity in the actual apparatus should be made.

These tubes are priced well under the $5 figure, and are probably inherently cheaper to manufacture than the hot cathode type.

For a given arrangement and size of parts the internal impedance of the rectifier depends upon pressure of the gas. Gas pressure and impedance are connected by a function which may be approximately represented by the curve of Fig. 5. During the life of the tube the gas slowly disappears, being probably driven into the material of the electrodes. The manufacturer usually fills the tube to a pressure corresponding to the line 1 in the figure. During the useful life of the tube pressure will gradually decrease, the impedance will first decrease and then increase rapidly and the tube's life will be ended when the pressure reaches the line 2. The character of the failure is therefore a gradual increase of impedance.

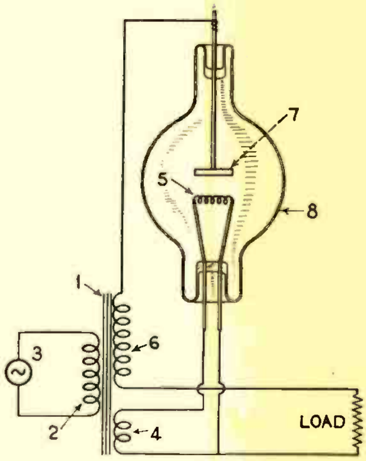


FIG. 6

A Tungar rectifying tube and its associated rectifying circuit.

Due to the fact that the tube passes a steep wave front of current on each half cycle, special precautions must be taken to prevent radio frequency variations. The use of buffer condensers connected either across the primary or secondary is too well known to need detailed explanation. In addition to this, it is desirable in designing the transformer for use with the cold cathode tube to introduce both electrostatic and electro-magnetic leakage in amounts considerably greater than employed in ordinary commercial transformers. This may be conveniently done by physically separating the primary and secondary windings by approximately 1/8 inch. This construction helps to isolate the supply line from the rest of the circuits and thus prevents it from acting as a radiating antenna.

Another characteristic of this rectifier which was not mentioned above is that the internal impedance is dependent upon the current flow. The larger the current, the greater the number of carriers in motion, and therefore the greater the formation of new carriers. In this respect the device behaves like an arc. In one way this is beneficial; as the current demand increases the impedance of the tube decreases and partially offsets the ohmic drop through other parts of the circuit. On the other hand, an increase in the supply voltage will cause a magnified increase in the output voltage. In B Socket Power devices this is not ordinarily a serious trouble.

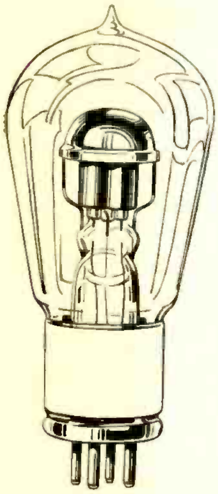


Fig. 8. A large capacity gaseous conduction, full-wave rectifier of modern form. This tube will supply from 300 to 350 mils. and can be used to supply filament current for a series string of 201-A tubes and the B power as well.

Comparison of Hot Cathode and Cold Cathode Types

In regard to useful life, there is very little to choose between the two types, the average life of the cold cathode type being apparently somewhat longer.

Both types by suitable care in manufacture may be built to have a high degree of uniformity and interchangeability.

The cold cathode type are at the present time priced somewhat lower and probably are inherently cheaper to build, as pointed out above.

Both types fail by gradual increase in internal impedance.

It is more difficult to eliminate radio frequency oscillation in the cold cathode type.

The cold cathode type has a magnified output voltage variation with changes in input voltage.

The efficiency of the two types is not particularly important in this class of service, but the cold cathode type is certainly more efficient and can withstand much greater overload without damage. Another advantage of the cold cathode type is that it requires no additional winding for energizing the filaments.

Rectifiers for Parallel Filament A Socket Power

Rectifiers for this class of service must be capable of delivering at their D.C. terminals a potential of approximately 12 volts at 3 amperes. There are at present only two types available which meet these requirements.

1. The Tungar tube.
2. The Crystal type.

The Tungar Tube

This rectifier which has been on the market since 1916 may be described as a combination of a hot cathode and gas-filled tube, and it may be said to combine some of the merits and some of the defects of both types.

In Fig. 6 is shown diagrammatically a half-wave Tungar with its associated rectifying circuit. In this figure, 1 is the core of a transformer having a primary 2, energized by the A.C. source 3. 4 is a secondary for energizing the filament 5 of the rectifier. 6 is the plate secondary, one end of which connects to the anode 7, the load being connected between the other end of this secondary and the filament 5. The glass envelope 8, after exhaustion is filled with an inert gas, generally argon, to a pressure of 10 millimeters of mercury or more.

The mode of operation is as follows: The filament 5, being heated to incandescence, will give off negative carriers as in the case of the hot cathode, high vacuum tube. These carriers, however, are not directly relied upon for conduction. Suppose that at a given instant the electrode 7 is positive. The negative carriers will then be drawn from the filament at high velocity, will collide with the molecules of the gas and form new pairs of positive and negative carriers in the same manner as explained above in connection with the cold cathode B Socket Power tube. Under these conditions the tube will become highly conductive. On the next half cycle of the alternating current supplied by the secondary 6, the electrode 7 will become negative, the negative carriers will be repelled and thrown back on the filament and the tube will be non-conductive.

From this explanation it will be seen that broadly speaking that during the conducting half cycle the tube will behave like a cold cathode gas-filled tube, and during the non-conducting half cycle will behave like a hot cathode high vacuum tube. For instance, this type of tube has a definite break-down voltage at around 15 volts, and unless this potential is reached the tube will fail to conduct. Its internal impedance is dependent upon the current flow. In other words it has an arc characteristic. During the non-conducting half cycle it shows practically complete shut-off, no back current being measurable.

These tubes may be constructed for either half-wave or full-wave rectification, and a wide variety of characteristics may be imparted to them by proper selection of the gas pressure and the design and spacing of the electrodes.

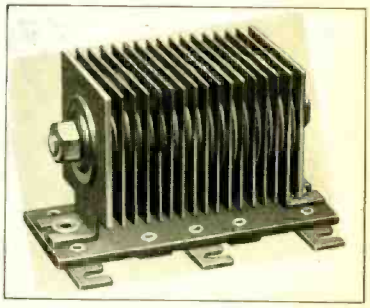


Fig. 7. A modern crystal type rectifier. These are particularly adaptable to A-eliminators and A battery chargers.

The useful life of the Tungar tube when properly used is extremely long, the average being probably well over 2000 hours. Certain precautions, however, must be taken in applying the rectifier to a given service. In the first place the filament voltage must be kept as low as possible during normal operation but in starting, filament voltage should be high. If the tube operates for the first few cycles at a sub-normal filament temperature the thorium will be stripped from the surface of the filament and the break-down voltage and internal impedance will become abnormally high. For this reason it is a good plan to design the filament secondary 4 to have a large magnetic leakage, thus applying the high voltage to the filament until the direct current load comes on. Obviously, intermittent life tests of the tube under the actual conditions of use are very important.

Due to the dependence of the tube characteristics on the spacing and design of the electrodes, an extreme degree of uniformity is somewhat difficult to obtain, but the ordinary commercial run of tubes will be found sufficiently close for most applications.

The tubes are priced from $4 to $7.50, depending on size, and therefore fall within the commercial range set forth in the beginning of this article.

These rectifiers generally fail by gradual exhaustion of the thorium in the filaments, their internal impedance slowly increasing to the point where the tube is no longer satisfactory. An occasional filament burnout is noted, but this is unusual within the useful life period.

The Tungar tube, like the cold cathode gas-filled tube, delivers a steep wave front of current at the break-down voltage and for this reason precautions must be taken to prevent radio frequency radiation. The same recommendations given above in connection with the cold cathode gas-filled tube apply here.

The arc characteristic of this tube means that the D.C. output variation for A.C. input variation is magnified. Ordinarily the magnitude of this effect will be approximately two to one. In other words, if the A.C. input rises 10% above a given value, this will cause a 20% variation in the D.C. output voltage.

Crystal Rectifiers

This designation is used to cover rectifiers employing a metal electrode and a co-operating electrode of an oxide or a sulphide of the metal. These couples will rectify up to about 2 1/2 volts and are usually employed stacked up in series as shown in Fig. 7.

Very little is known concerning their theory of operation. Apparently they have a definite break-down voltage which is very low, and in other respects behave like the Tungar tube discussed above.

These units also fail by a gradual increase of internal impedance, but if improperly constructed flash-over may occur at anytime during the life of the unit.

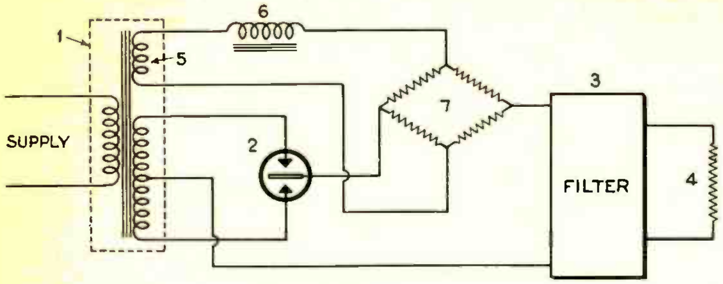
Radio frequency radiation is comparatively small, due to the very low break-down voltage of this type of unit.

The crystal rectifier has a distinct arc characteristic and is substantially identical in regard to the D.C. voltage output vs. A.C. voltage input, with the Tungar tube.

Rectifiers for Series Set Socket Powers

Due to many causes, not the least of which is the probable introduction of the four-element audion or screen grid tube, the Series Set Socket Power is almost certain to increase in popularity and importance. Sets wired in this way can be made interchangeable, for use on either batteries or Socket Power excitation, and at the present time at least may be made to have much higher audio quality than the A.C tube set.

There is only one type of rectifier available for this service which is substantially an enlarged version of the cold cathode gas-filled B Socket Power tube discussed above. A drawing of one form of commercially available rectifier for this service is shown in Fig. 8.



- FIG. 9 -

Schematic diagram of a resistance type voltage regulator for B power units.

Voltage Regulators

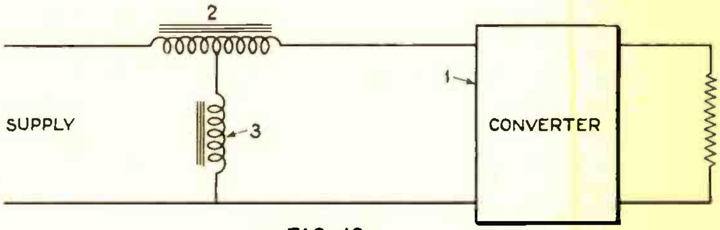
Because of the importance of voltage regulation in connection with rectifiers for all classes of service, with the exception of the B Socket Power, it has been thought proper to introduce a description of two such regulators into this article. One type is shown in Fig. 9. In this figure, 1 is a transformer, 2 is a rectifier, 3 the filter and 4 the load. The voltage regulator comprises three elements; an additional secondary winding 5 on the transformer, an iron core inductance 6, whose core is magnetically saturated, and a temperature variant resistance 7, arranged in the form of a bridge inserted in one of the leads connecting the rectifier to the filter.

The operation of the device may be briefly described as follows: Suppose the voltage of the supply to rise above some normal minimum value. This will cause an increase in voltage across the terminals of the secondary 5, and because of the presence of the saturated core inductance 6 in this circuit, a considerably increased alternating current will be caused to flow from the secondary 5 through the bridge resistance 7. Because of the positive temperature coefficient of this resistance its value will be much increased and will thereby absorb the additional potential across the rectifier output caused by the increased supply voltage. Because of the balanced bridge arrangement of the resistance 7 the direct current to the filter is electrically isolated from the alternating regulating current supplied by the secondary 5, so that no direct current will be wasted in the regulating circuit and no alternating components will be introduced by the regulating circuit into the direct current circuit.

This device is, of course, not instantaneous in action, but by proper mechanical design of the resistance 7 may be made to operate in a few seconds.

Turning to the device shown in Fig. 10, this operates entirely in the primary side of the alternating current circuit and the transformer, rectifier and filter are all included in the block 1 marked "Converter." The regulator comprises a series inductive element 2 so designed that its iron core never becomes saturated throughout the normal working range of the device, and a shunt inductive element 3 whose iron core is normally saturated. The exact theory of operation of the device is somewhat involved, but it may be roughly stated that an increased supply voltage causes a magnified increase of current through the saturated element 3. This magnified current flowing through a portion of the inductance 2 causes an increased potential drop across that element to affect regulation and this increase of potential drop is multiplied by the ratio of total turns to the turns included between the supply and the connection of the coil 3.

This device is instantaneous in operation and, as will have been noted, requires no temperature variant resistance.



- FIG. 10 -

Schematic diagram of a magnetic type voltage regulator. This device is instantaneous in action.

Better Radio Reception†

Methods of Eliminating Home-Made Static

*By Robert J. Casey**

PART II

Miscellaneous Causes of Interference

1—X-Ray Machines—It was found that when such apparatus is properly installed and carefully shielded the range of interference is not great.

2—Storage Battery Chargers—This subject is treated under three heads: A—Vibratory or mechanical rectifiers; B—Thermionic or ionized gas rectifiers; C—Chemical rectifiers.

The noisiest are of course the vibrators on account of arcing at the contacts. A small condenser across the vibrator element ends the disturbance. Tube rectifiers sometimes sputter, but may be silenced by use of condensers and chokes on the line side. Electrolytic rectifiers are not noise producers unless the genius of the user contrives some method for making them arc across the top. The engineers in their report stated that the chief cause of interference lies in close coupling between the set and the light line that supply the chargers.

3—Annunciator Systems—See door-bells.

4—Stock Tickers—Trouble, if any, results from coupling of apparatus with line of communication.

5—Ignition Systems—Some radio frequency energy is put out by normal activities of spark plugs and distributors. It can be corrected by moving the automobile. In effect it is not serious.

Similar causes produce similar results in the case of stationary gas engines. Here the shielding of ignition leads is advocated.

6—Electric Elevators—The National Electric Light Association engineers leave the problem of the electric elevator to be dealt with in a later survey. They point out two kinds of interference—a click heard in the loud speaker when contactors are engaged or disengaged—(a sound like the turning on and off of the light switch), and a steady hum due to the motor. As a matter of fact the motor problem is merely another of those things. The clicking of contacts in an elevator control seems eliminable by the same methods used to cope with other make and break disturbances.

The chief cause of interference in electric elevators is not that they are electrically operated, but that the motive apparatus is old and poorly cared for.

7—Electric Furnaces—These things do create some disturbance. As an active agency in the great national cacophony they are about as important as the blowing of tin whistles in Mesopotamia.

Let's forget this one.

8—Moving Picture Equipment—With moving picture theatres now more numerous than radio stores it is time somebody gave some attention to their power for interference. Apparently they haven't much. Motor equipment for projecting and re-winding of films is subject to the usual ills of motors. Projecting arcs may develop some radio frequency energies. However, it was found that with such apparatus in good condition the R. F. currents were pretty well choked out of the feeder lines and there were no other important nuisances in the theatre aside from the pictures and ushers.

9—High Voltage Testing Equipment—Ho hum! Who thought of that one?

MORE ON "BETTER RADIO RECEPTION"

The article appearing on this page is an extract from the R. M. A. Manual On Interference. The Manual contains a great deal of valuable data which RADIO ENGINEERING is unable to print due to space limitations.

We sincerely hope that the material presented will prove of value to our readers.

If you wish to procure the additional data and at the same time have the subject in complete form you can obtain a copy of the Manual from the Radio Manufacturers' Association, Inc., 32 West Randolph Street, Chicago, Ill. The price is 25 cents.

Sparks, Accidental or Otherwise

This ends the summarization of the report turned in by the Electric Light Association's engineers.

By this time any reader who has not yet fallen asleep probably knows that sparks caused accidentally or on purpose are the principal factor in the general jamboree. He does not know yet—but he soon will—that it takes no search warrant to discover these vagrant crackles and little or no time to end them.

An important noise manufacturer in cities is the printing press and this because of a characteristic that has nothing at all to do with the motors and switches which operate it. For many months during the early days of radio, radio editors of metropolitan newspapers producing from three to ten editions a day were at a loss to discover why static overcame them whenever the presses were running.

The interference, it was discovered, was quite what it appeared to be—static—and produced as static.

The friction of paper running between the cylinders of the press produces a charge like that obtained in physics experiments by similar processes. It is possible to get a sizable spark out of a freshly printed paper merely by holding one's hand near it and the smell of ozone is sometimes so strong in a big press room that it predominates over the tang of the ink.

Fortunately, these static factories generally can be rendered inoperative by grounding the frame of the press or if that fails by hanging short lengths of grounded chain where they will just touch the revolving cylinders. Flat bedpresses such as are used in job printing shops will occasionally produce static, but their field of interference is limited. In any case the treatment is the same.

The Elimination Process

Getting down to cases in the matter of stifling interference, one discovers that the whole process is merely an application of filters.

Two years ago one might have hesitated to mention the word "filter" before a large and varied audience. At that time a filter was supposed to be a little sack of carbon that clamped over the drinking water faucet. The true inwardness of the electrical sieve was known only to initiates, most of whom were too busy in the telephone service to worry about radio.

However, the popularity of battery eliminator devices and the need for loud speaker protection, resulting from the use of high plate voltages with the new power tubes has done much to spread the light among the radio enthusiasts. It is no longer a secret that a filter is a condenser or condenser-choke combination designed to keep unwanted currents where they belong.

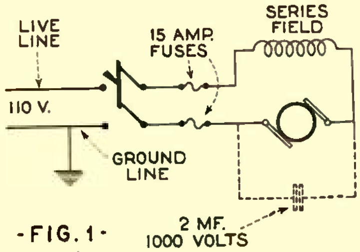
The trouble of interference in electrical devices as we have seen is due to the generation of radio frequency currents at spots where there should be no radio frequency currents and the broadcasting of these volunteer energies with the power lines acting as antennae.

What more natural then, than to seize upon these emanations at their source and block them from the lines? There are various ways of doing it. In some instances they are allowed to wander into a condenser which acts as a sort of sump tank and loses them until their ambition is all gone. In others they are actually choked out of the line. Occasionally they are grounded.

† *Courtesy of Radio Manufacturers' Association.*

* *Staff-writer, Chicago Daily News.*

It has been found by some genius who apparently does not have to worry about his light bill, that if one hooks a condenser of sufficient size across the feeders of his service line at the point where it enters his house, he need worry no longer about interference from devices within his own walls. An ingenious plan, earnestly recommended to those who have plenty of money. It has only one drawback, which, of course, need not be considered: If the condenser is large enough to function properly it is large enough to by pass a considerable quantity of alternating current, generally peddled at a price per kilowatt hour. The power company might object, therefore, to the installation of such a super filter ahead of the meter. And at a point immediately after the meter, but close enough to the point of entry to do any good it would remain in operation day and night from now till bankruptcy whether or not the house light might be turned on or the suspected devices in use.



- FIG. 1 -

Filter arrangement for small motor, using a single 2 Mfd. fixed condenser.

For those who do not feel like making such a grand gesture, individual filters are recommended—one for each trouble maker. If properly connected, they cease to function when the device to which they are attached is shut off—and even when operating, their size need not be large enough to pay any extra dividends on power company stock.

The Cure for Noise Makers

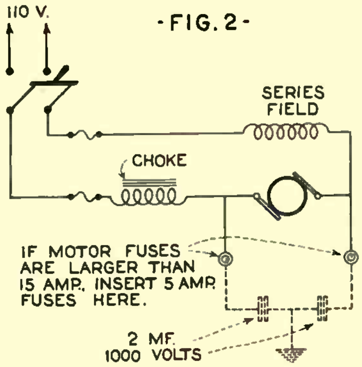
We shall take up the care and cure of noise makers according to their classification at the beginning of this report and so arrive at the long-deferred discussion of

1. *Motors.* The motor noise is a contact noise—a spark emanation more obnoxious than most spark emanations, because continuous. Its generation may be understood by anyone who understands the working principle of the device. A motor consists of an armature revolving in a magnetic field. The driving current passes first through the armature whence it is used to excite the field magnets, the technique of which need not be gone into here. The point of the matter is that the current has to be conveyed to the windings of a revolving spool and this can be done only by sliding contacts called brushes. The brushes press down against a drum of copper and when both are clean, function without interruption, sparking or noise.

Dirt and corrosion change the whole performance. The contact becomes erratic and is accompanied by sparking, which pits the metal and produces more sources of bad contact.

The first treatment of a noisy motor is to clean it—not a bad idea whether it is noisy or not. Cleanliness saves cost of upkeep and service and is an economical procedure well spoken of even in districts where radio does not amount to much.

Even a sparking commutator might not cause a great deal of trouble if the iron shell of the motor were grounded, but surveys have shown that old motor installations frequently were made on wooden supports and virtually insulated from the ground. Grounding may therefore be listed as a second step. With these two maneuvers completed, one may choke off the last of the interference by connecting a 2 Mfd. condenser—tested to stand 1,000 volts D. C.—across the brushes. Fig. 1 shows the method of connection.



Filter arrangement for motor working on ungrounded line of less than 600 volts.

As in all cases where filters are used, the condenser should be placed as near as possible to the point where noise originates. This precaution will prevent the broadcasting of interference with condenser leads as antennae.

The design of the filter varies somewhat if the line is less than 600 volts and ungrounded. In that event two condensers grounded at their common lead may be used as shown in Fig. 2.

For very small motors such as those used in soda-mixers, fans, hair driers, vacuum cleaners and the usual portable appliances found in the home, it will generally be found that the connection of a high test condenser of about ¼ Mfd. across the commutator will end the noise. With such devices the use of a middle-tapped condenser with a ground connection is not practicable.

An efficient motor filter is shown in sketch C of Fig. 3 of the National Electric Light Association group. Two chokes of the type outlined in Fig. 4 are connected into the A. C. line, confining the radio frequency currents to the point of their origin.

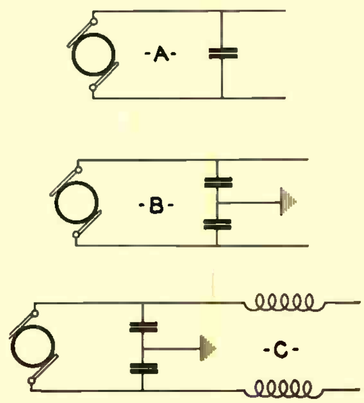
Condensers specially made for filter purposes are now available in the radio market as are condenser choke combinations mounted and ready to connect. It should be borne in mind when installing any of these devices that large capacity condensers contain wax and therefore should be placed where heat generated by the motor will not affect them.

The rules seem simple—and they are. One reading them for the first time may be excused for skepticism, for the noises emanating from commutators and such things seem as invincible as they are mysterious. As a matter of fact it is only the very old motor, long a stranger to care, that will not respond immediately to shielding and filtering.

2. *Thermostatic Controls.* Something of the treatment indicated in cases of electric pads, humidors, furnace controls, refrigerator controls, etc., has already been mentioned.

These sources of trouble are more difficult to eliminate only because they are more difficult to reach. Fortunately their operation is in most cases of short duration and at periods widely separated. In the event that exceptional circumstances make them exceptionally obnoxious, much of the radio frequency current may be short circuited before it gets out into the lines, by hooking a high test condenser of ¼ Mfd., more or less, across the input.

Such an arrangement has the disadvantage of being somewhat removed from the actual seat of the trouble, but test has proved it effective in a large number of cases. The contact points of the thermostat may be reached for filtering in nearly all devices, save the electric heating pad and the usual difficulty with heating pads lies in the fact that the user is generally ignorant of the fact that he is causing interference. Education in this respect will probably do more to end the interference than a filter.

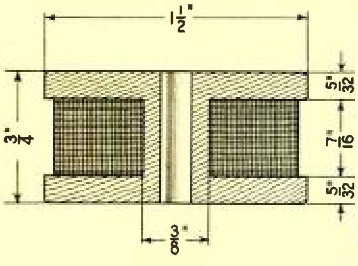


- FIG. 3 -

Three filter arrangements advised by the N. E. L. A. engineers.

3. *Bad Contacts.* The best cure for a bad contact, of course, is to fix it. Loose fuses, loose connections, wobbly light sockets and all of that are a menace to many things aside from radio. They constitute a fire hazard for one thing (or rather the last two items do) and once located they should not be left unattended, even if the annoyance they cause is only sporadic.

Other contact noises, however, may well be considered here, for while they are produced with malice aforethought, their effect on radio reception is quite



-FIG.4-

Choke coil advocated by N. E. L. A. for use as motor filter. It is made from a spool of maple finished with clear shellac, wound with 530 turns of .012" D. S. C. wire

the same as if they were purely accidental.

Under this head might be considered flasher signs, elevator contactors, vibratory rectifiers, violet-ray machines, X-ray machines, bell ringers and the like. . . . Simple cases, all of them and simply treated.

Sign flashers are of two types, one operated by a rotating element, actuating a series of make and break devices, the other turned on and off by a thermostatic element. The second properly falls under the classification just discussed and falls into the same group for treatment as the other thermostats. The first may have two sources of disturbance, the actuating motor and the contacts.

Contact noises are easily quelled by the connection of a 1 Mfd. condenser across the terminals. The filtering of motor noises, if any, is the same as for other motors.

Sign flashers have been causing trouble since the inception of radio, and formerly were considered a necessary nuisance. Householders in neighborhoods affected by them were so loudly unanimous in their complaints that an effort was made to study the situation, but for a long time the only remedy suggested was the shielding of the control device. This remedy was no remedy at all.

The condenser, however, is in most cases a cure, installed in five minutes and effective at once. Here, as in all cases so far discussed, ignorance has been the principal source of interference. Sign flashers are generally used for advertising purposes and no advertiser cares to antagonize an entire neighborhood.

Elevator contactors in some localities have been so persistently active that engineers have abandoned hope of doing anything with them except leaving them to run elevators. However, they may be silenced, no matter how refractory, if properly approached.

The method is the same as for the sign flasher, but owing to the larger currents involved is considerably more expensive. No one can hope to stifle a good honest elevator contactor by hooking a 1 Mfd. condenser across it. The proper treatment is a big condenser—twenty microfarads or more—and of a type tested to stand the D. C. voltages to which it may be subjected.

The condenser is connected across the contact points and if properly sized will put the device on its electrical rubber heels. Twenty microfarads of condenser represent a considerable outlay of money especially where it must be repeated for several contactors, but no more than the building owner stands to lose if it becomes noised about that radio is a mere rumor in the vicinity of his shafts.

The Refractory Vibratory Rectifier

The most amazing experiment of this group is the throttling of our old and very oral friend, the vibratory rectifier. Once it seemed impossible that this device could ever become housebroken and so strong is that belief to this day, that many communities like Van Wert, Ohio, have passed legislation against it.

However, it takes its medicine without protest and thereafter is no more noticeable in the loudspeaker than the time signals from Timbuctoo.

The usual stuff—a one-mike condenser connected across the vibratory element.

All such rectifiers consist of a vibrating reed, making and breaking contact with a fixed terminal. One end of the condenser goes to the reed, the other to the fixed terminal. And that's all there is to it other than accepting the thanks of the neighbors.

The violet-ray machine has come in for much comment before this. If a one-mike condenser is connected across its vibrator it may possibly operate without causing riot, mayhem and murder. However, the best eliminator for such device is the electric light switch. Caution dictates that they should not be used while radio listeners are straining their ears for the surf on a distant coast.

X-ray machines, according to the best authority, are quiet only when they are used in rooms shielded with metal mesh or lead foil. At any rate they are quite beyond the ministrations of the average broadcast listener.

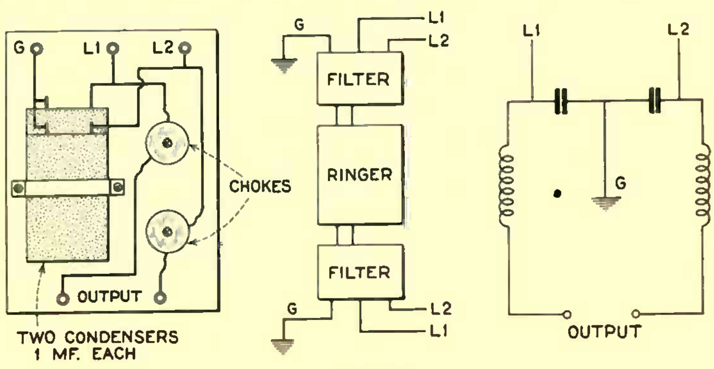
Recent experiment with X-ray installation tends to show that standard filter equipment probably will be the solution of the interference problem even here. Shielding of rooms in which such apparatus is used is becoming more and more general for reasons that have nothing at all to do with radio and in numerous instances it has been found that air core chokes—made of a few turns of heavy gauge wire, placed in the feeders near the X-ray machine—and a fairly large condenser across the line as described in the paragraph on motor interference generally will restore the peace and quiet of the community.

The filter circuit for the gagging of bell ringers is shown graphically in Fig. 5. It looks fairly complicated but the analysis shows it to be merely an old friend, two condensers in series with a ground mid-point and two chokes.

It consists of a middle tapped condenser—or two condensers connected in series and grounded where connected, and two chokes of the type already described. Two such filters are connected into the system. One at the input and one at the output. They are not difficult to make nor to install.

Two such filters are used, one at the input and one at the output of the ringer. Radio men who installed the broadcasting apparatus at the Scopes trial in Dayton, Tenn., reported the successful use of such silencers in a district where telephone exchange activities had made radio reception impossible.

Of similar nature and calling for similar treatment is the telephone ring-



-FIG.5-

Compound filter suggested by N. E. L. A. for use with ringers and similar devices.

ing magneto, which is still to be found in rural America. Sparking of brush contacts is the cause of rumbling interference which may be stopped by the connection of a filter across the brushes much as in the case of noisy motors.

4. *Leaks.* In this classification the worries are altogether the property of power companies. Condenser-choke arrangements will not help any if insulators are bad or high tension wires are allowed to scrape against trees.

However, the power companies are always willing to buy new insulators or repair defective apparatus when needed. Power tossed off into the air—to fall, of course, one knows not where—pays no dividends on the common stock.

It may be repeated here that the engineers of such companies are not only willing to end such interference, but grateful for information concerning it.

Manufactured Static

We might consider a fifth classification—the static engendered by belts and printing presses, although such interference is highly local and of little or no importance save where receiving sets are operated in industrial districts.

Condensers and chokes are of no use in the solution of such problems, but the actual remedy is even less complicated.

Grounding the frames of machinery is the first step. The second, is to provide some form of brush collector that will remove the static charge from belt or paper without sparking. A lead from the collector to the ground is the only requirement.

Some interference in rural districts is beyond classification under any of these subheads, particularly where farm lighting plants are employed.

Investigation has shown that a large portion of this interference arises from poor grounds. In sandy districts, such as those of Northern Michigan, this problem is serious, as the soil is a pretty good insulator. Moistening the earth about the ground stake has little effect, inasmuch as the wet spot is surrounded by non-conducting silicates.

It is recommended for such localities, that the ground be attached to a pipe, driven down into the soil at the bottom of a well.

Interference from farm lighting equipment is sometimes difficult to trace because of the multiplicity of spark producers that may be found in such an installation.

All of these plants consist of some driving mechanism, a dynamo and storage battery bank, active or floating in the system. The driving mechanism usually is a gasoline motor with spark plugs and a magneto. It probably will have an automatic starting arrangement, subject to the same troubles as an automobile starting device.

Hence the elimination of noise in districts where there are such systems will require a varied course of treatment.

A small condenser—about ¼ Mfd., connected across sparking contacts in the ignition system will end trouble from that source. It may also be found necessary to shield the magneto—a process which sounds complicated but really consists of placing a large can about the magneto and grounding the can. Commutator troubles in starting motor and in the dynamo are the usual commutator troubles and may be corrected by the means outlined under the heading "Motors." If there is a make-and-break contact device in the plant, it, too, will have to be shunted by a condenser of the same size as that prescribed for the ignition system.

Diagnosis of Ills Really Simple

And that about ends the lesson. We have come a long distance to analyze an irritating situation and to discover that diagnosis of the trouble and the prescribing of a cure might well be condensed in a page or two. The space has not been wasted if it enables the reader to seek intelligently for the things that have ruined his radio reception and to institute needed reforms.

Receiving sets have become more sensitive since the early days of radio and with their increasing sensitivity, they have become more and more prone to pick up noises that passed unnoticed in the period of the headphones and crystal detector. There is vital need for some concerted effort to rid the air of needless racket.

Condenser sizes given in this illuminating treatise have been based on the requirements for sixty-cycle power lines. Most of the power systems in the United States are this type, but not all. In Buffalo, a twenty-five-cycle current is used, in Grand Rapids, thirty cycles, in California, from thirty-three to fifty.

Changes in filters due to differences in current frequency will be slight, if any.

It has been found that a quarter microfarad condenser is almost standard for all filters affecting small motors—of the soda mixer, or electric vibrator, or hair dryer type—as well as for automobile ignition noises and similar disturbance, arising from thermostatic controls and make-and-break contact gadgets.

For larger motors a condenser of from two to eight microfarads may be necessary, but such exceptions are mentioned specifically elsewhere in the text.

As a general rule, for the benefit of persons who live in districts where some odd frequency is used in power lines, it should be remembered that the lower the frequency the larger the condenser required. In the case of chokes, low impedance coils are used in filtering high frequencies and high impedance coils for low frequencies.

Bell Telephone Labs Enter Research on Airway Communication Systems

During 1927, the American Telephone and Telegraph Company conducted a comprehensive survey of commercial aviation in its present economic, commercial and technical aspects with the conclusion that it could serve the industry by a further development of equipment and methods for communication along airways and to airships. It is evident that the country is now in the midst of a vigorous development in this new field of transportation. So far as the engine and the airplane are concerned, a commercial degree of safety and reliability is attainable in the present state of the art and, while further improvements in design are certain, no fundamental invention in the airplane itself is required for its utilization for air transport services.

The greatest need is to increase the reliability of transportation and safety of passengers. Such safety can be increased by means of minimizing the hazards of weather, aids to navigation to minimize the risk of losing the true course along the airway and finally means to minimize the risk of collision by the use of a despatching system analogous to modern railway practice but certainly very different. For all of these purposes, electrical communication system will be required using both wire and radio.

The Bell System provides a nation-wide communication service, and is working on the new apparatus and equipment necessary to extend communication service to airways and aviators as and when required. The problem is at first one of research and development, and the Bell Telephone Laboratories have, therefore, included in their 1928 programs a substantial amount to be devoted to the advancement of safety in aviation by the application of electrical communications.

The Mathematics of Radio

Calculation of Resistances in Parallel Circuits and Determination of Wattage

By John F. Rider, Associate Editor

PART III

THE advent of individual C batteries for audio amplifying tubes, particularily the 40.5 volt C bias required for the 171 output tube has often caused the necessity of placing opposing voltages in series circuits in order to obtain the desired voltage. That is to say, two sets of batteries are arranged in a manner which permits the reduction of the maximum potential of one battery, by virtue of the opposing action of another battery whose polarity is reversed with respect to the first battery. This is shown schematically in Fig. 10. Here we see a battery supplying 6 volts and another battery supplying 1.5 volts. We note that the minus of the 6 volt battery is connected to the minus of the 1.5 volt battery and that the total voltage of the combination is only 4.5 volts. The action of the 1.5 volt battery is connected to oppose or "buck" the voltage of the 6 volt battery to the extent of 1.5 volts Expressed differently 1.5 volts of the 6 volt battery is balanced out by the 1.5 volt battery, the resultant voltage being 4.5 volts. This state is found only when the batteries are connected so that their polarities buck each other, as for example the minus of the 6 volt battery being connected to the minus of the 1.5 volt battery.

The final 4.5 volts available from the combination has the same polarity as the main 6 volt battery; that is to say, the positive of the 6 volt battery is still the positive terminal of the final 4.5 volt output, and the positive terminal of the 1.5 volt battery is the negative terminal for the 4.5 volt output. The action of the 1.5 volt battery connected as shown, is to counteract or counterbalance, whichever term you wish to use, 1.5 volt of the 6 volt battery. Such connections are often utilized to reduce the voltage of a 45 volt B battery when the unit is utilized as the C battery for a 171 tube, which requires a grid bias of 40.5 volts with 180 volts on the plate. To reduce the voltage to the proper value, a 4.5 volt battery is arranged to buck the 45 volt battery to the extent of 4.5 volts, thus reducing the available voltage to 40.5 volts.

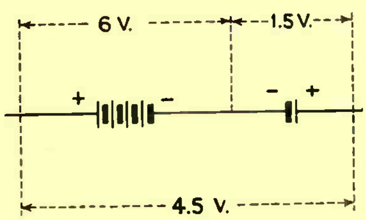


FIG. 10

Illustrating the result of bucking one battery against another, thus creating a counter—E. M. F.

The action of opposing voltage in series circuits is vividly illustrated in battery charging combinations. A storage battery, an ammeter and a charging source are illustrated in Fig. 11 and the explanation of the operation of the system will be understood after a study of the system depicted in Fig. 12. Without a doubt most of the readers of this article are aware of the "tapering charge" system employed in the majority of charging combinations. The charging rate is high at the start and gradually tapers until when the battery is fully charged, the charging current has been reduced to a very small value. Let us picture battery B to be the charging source; the battery B1 to be the battery being charged and the galvanometer G to be the ammeter in the circuit. The resistance R-R1 permits a variable charging voltage. Referring for a moment to Fig. 11, let us consider the battery to be charged as being a 6 volt storage battery. The charging source is of such nature that it supplies 2.4 volts per cell in the battery. Since the voltage of the charging source is greater than that of the battery a certain charging current will flow. As the state of charge increases the voltage of the battery under charge will increase, thus automatically decreasing the charging current.

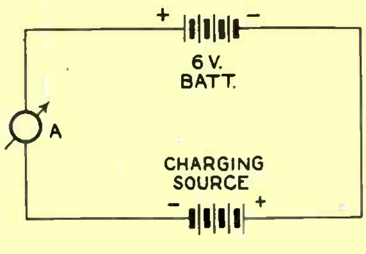


FIG. 11

A series circuit containing two opposing voltage supplies.

In Fig. 12, the battery B causes a voltage drop across the resistance R-R1. Battery B on the other hand causes a voltage drop across the resistance R. Thus two voltages are across the resistance R. When the voltage drop due to battery B is equal to the voltage drop due to B1, the galvanometer will read zero. This is equivalent to the rise of the battery being charged to a potential equal to the charging potential, at which time the charging current will fall to zero. By varying the slider on the resistance it is possible to produce a preponderance of voltage drop due to battery B1 or to battery B. If battery B1 is the one being charged, it is always necessary to maintain the charging voltage at a value at least equal to that of the battery, otherwise the current indicated on the meter would be the discharging current of the battery, discharging back into the line.

Resistances in Parallel Circuits

Now we enter upon the subject of resistances in parallel circuits. At first glance one is apt to wonder where such circuits find use in everyday radio practice. It is true that their use is not as frequent as that of regular series circuits, but they have their place. An idea of two resistances placed in parallel is shown in Fig. 13-A and one use of this combination is shown in Fig. 13-B. The latter illustration depicts two resistances in parallel, located in the output circuit of a B battery eliminator. R is the resistance located within the eliminator and R1 is the variable resistance located externally and connected in parallel with the fixed resistance within the unit. The function of the resistance R1 located outside of the eliminator is to permit the reduction of the resistance R within the eliminator to the value required to permit the flow of the necessary amount of plate current required. The occasion often arises when the plate current and voltage available from a certain tap on the eliminator is insufficient to fill the requirements. The only means of in-

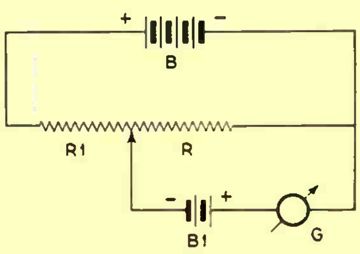


FIG. 12

Circuit arrangement illustrating the action of a taper charge.

creasing the available plate current and plate voltage, is to reduce the value of the resistance within the unit. This can be accomplished with the greatest ease by connecting a variable resistance across the fixed resistance. The selection of this resistance and the method of calculating the

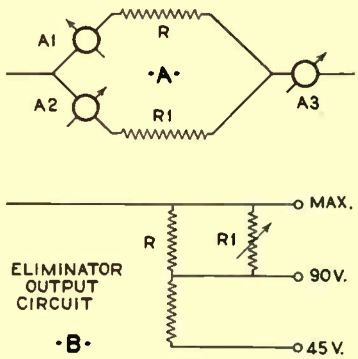


FIG. 13
Two circuits having resistances connected in parallel.

resultant resistances, when two such resistors are in parallel will be discussed in subsequent paragraphs. The selection of the correct resistance in order to obtain the required plate current and plate voltage was described in Part II of this series.

First, let us define the parallel circuit. A parallel circuit is one in which two or more parts are connected between the same two points of a circuit. In Fig. 13-A, we see the two resistances R and R1 connected between the same two points of the circuit. In such parallel circuits we have two considerations. First is the resultant resistance of the combination. Second is the current flowing in each branch circuit. Assuming a certain current flow indication on ammeter A3, we note that the sum of the current flow indications on ammeters A1 and A2 is equal to that on A3. To determine the current in the branches of the circuit we must adhere to a certain law, viz.: the current flow in any branch of a parallel circuit is equal to the voltage across its terminal divided by the resistance. In other words, if we know the voltage across the two branches of the circuit, the current indicated on ammeter 1 will be equal to

$$I = \frac{E}{R}$$

If the voltage is 50 volts and the resistance of R is 5 ohms, the ammeter A1 will indicate

$$I = \frac{50}{5}$$

or I=10 amperes

By the same method of reasoning if the resistance of R1 is 50 ohms the current indication on ammeter A2 will be

$$I = \frac{50}{50}$$

or I=1 ampere

Now if we wish to express the total current flowing in the circuit as indicated on A3 it would be

I3=I1 plus I2 since

the total current flowing through any parallel combination inserted between two points of a circuit is equal to the sum of the currents in the branches.

We note that the current indicated on ammeter A3 is 6 amperes, and further that the sum total of the current in the two branches is equal to the total current. Supplementing this fact, we further note that the current in each branch is less than the total and since the sum of the branches is equal to the total, the resultant resistance of the two resistors in parallel is less than that of either one of the resistances.

Now we arrive at the calculation of the resultant resistance of two resistances in parallel. The voltage is constant across the combination, and the current in each branch is equal to the voltage across the combination divided by the resistance of each branch; and the currents are additive, the voltage divided by the resultant resistance is equal to the voltage divided by R plus the voltage divided by R1 or

$$\frac{E}{R2} = \frac{E}{R} \text{ plus } \frac{E}{R1}$$

therefore the resistance of the combination is equal

$$\text{to } \frac{1}{R2} = \frac{1}{R} \text{ plus } \frac{1}{R1}$$

which is expressed as

$$\frac{1}{R2} = \frac{1}{5} \text{ plus } \frac{1}{50} \text{ or } \frac{1}{R2} = \frac{1}{.22} \text{ or } \frac{1}{R2} = 4.54 \text{ ohms}$$

Expressed differently we can solve for the joint resistance by using the following formula:

$$R2 = \frac{E \times R1}{R \text{ plus } R1}$$

$$R2 = \frac{5 \times 50}{55}$$

R2=4.54

The explanation for the above formula is that the joint resistance of two resistances in parallel is equal to their product divided by their sum.

If by chance the resistance values of the resistors are equal, the resultant resistance of a number of parallel resistances of equal resistance, is equal to the resistance value of one resistance divided by the number of resistances or

$$R2 = \frac{R}{n}$$

From the preceding formula we see that in order to halve a resistance, we must place in parallel with it, another resistance of like value. In other words, the joint resistance of a number of equal resistances in parallel varies inversely with the number of resistances used, viz; three like resistances in parallel will provide a resultant resistance equal to one-third the resistance of one; four such resistances, one-fourth, etc.

Let us see how we can apply the above data to the eliminator circuit shown in Fig. 13-B. Suppose we have a fixed resistance R of 5000 ohms which cannot be tapped so as to reduce its resistance and permit greater current and voltage at the 90 volt tap. By connecting the resistance R1 between the maximum output voltage tap and the 90 volt tap, we have the resistance R1 in parallel with the resistance R and the total resistance is less than that of the smaller of the two. If the maximum resistance of R1 is equal to the total resistance of R, the maximum resistance of the combination R-R1 will be

$$\frac{R}{2}$$

or 2500 ohms.

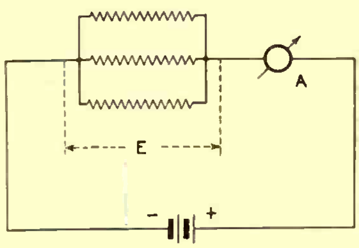


FIG. 14
A series circuit including three resistances connected in parallel.

A resistance R1 equal to twice that of R will give a maximum resistance equal to

$$\frac{5000 \times 10{,}000}{15{,}000}$$

or 3333 ohms.

Let us now consider three resistances in parallel as in Fig. 14. If we were to place an ammeter into each branch circuit the total current would equal that indicated by the ammeter in the main line. The joint resistance of the three resistances in parallel is again equal to

$$\frac{1}{R} = \frac{1}{R1} \text{ plus } \frac{1}{R2} \text{ plus } \frac{1}{R3} \text{ and if R1 equals 5 ohms}$$

and R2 equals 10 ohms and R3 equals 40 ohms

$$\frac{1}{5} \text{ plus } \frac{1}{10} \text{ plus } \frac{1}{40} = \frac{13}{40} \text{ or}$$

$$R = \frac{40}{13} \text{ or } 3.07 \text{ ohms}$$

Expressed differently we can resolve as follows

$$\frac{1}{R} = \frac{1}{5} \text{ plus } \frac{1}{10} \text{ plus } \frac{1}{40} \text{ or}$$

$$R = \frac{1}{3.25} \text{ or } 3.07 \text{ ohms}$$

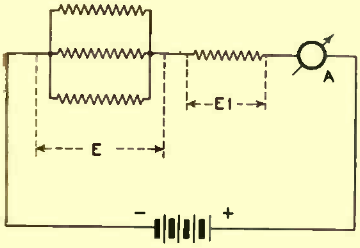


FIG. 15

A series circuit including three resistances connected in parallel and a fourth resistance in series with the group.

Series-Parallel Arrangements

Now suppose we have a combination of resistances in parallel and in series as for example in Fig. 15. Here we see three resistances in parallel and one in series with the parallel combination. The ammeter A indicates the current flow in the circuit. Since we have two sets of resistances, the voltage drop E across the individual resistance will be equal to the current in the circuit times the resistance, which is the joint resistance of the three in parallel. The solution of this value was just concluded. The voltage drop E1 is then equal to the current in the circuit times the resistance of the resistor associated with it. The voltage drop E plus E1 is equal to the current as indicated on the meter, times the figure representing the resistance of the parallel resistances plus the series resistance.

If we were to express the above combination we would have the following: R2=RR plus R1, where R is the individual series resistance and R1 is the joint resistance of the three parallel resistances.

In the entire discussion of parallel resistances, we neglected to mention that the joint resistance of the parallel combination can be in the form of a single resistance unit of the proper resistance value. That is to say, if the resultant resistance of two resistances in parallel is 15 ohms, the two resistances can be replaced by a single resistance of 15 ohms, providing that the resistance is capable of carrying the total amount of current flowing in the circuit. The total amount of current in the circuit is the prime consideration when several parallel resistances are replaced by a single unit. The reason for this is easy to comprehend. Glance at Fig. 13-A once again. A certain amount of current flows through the branch circuit A1 and a different amount of current flows through the branch circuit A2. The combination of the resistance and the current flow in that branch results in the dissipation of a certain amount of power equal to I^2R or to the current squared times the resistance.

Wattage Rating of Resistors

This power is dissipated in the form of heat generated in the resistance. When the joint resistance of the two resistances in parallel is obtained in the form of a single resistance, this resistor must pass or carry the current equal to the sum of the currents present in each leg when the two resistances in parallel were used. Therefore, the current carrying capacity of this resistance must be greater than that of either one of the two resistances which comprised the branch circuit. The rating of the current capacity of the resistance is made by quoting the wattage capacity, since this is the I^2R which is equivalent to E x I, viz: We have a circuit containing a resistance. The voltage across the resistance is 3 volts and the current flow is 2 amperes. The number of watts being dissipated across that resistance is equal to

$$W = E \times I$$

$$W = 3 \times 2$$

$$W = 6$$

The resistance used in the circuit is equal to

$$R = \frac{E}{I}$$

$$R = \frac{3}{2}$$

$R = 1.5$ ohms.

The power in watts being dissipated by the resistance is equal to

$W = 2^2 \times 1.5$

W=6 watts

The wattage rating of resistances is of the greatest import where B battery eliminators are concerned. We have illustrated the method of determining the correct value of voltage reducing resistances required for use in B battery eliminators and the foregoing illustrates the method of determining the wattage rating of the resistances. In order to be in a position to select the correct wattage rating, it is evident that the current flow must be known. The accompanying table gives the relation between current, voltage, watts and resistance, showing the current carrying capacity and allowable voltages that can be applied to resistances of 3, 10, 25 and 50 watts capacity:

(To be Continued)

WATTS →	3	3	10	10	25	25	50	50
Resistance	Amperes	Volts	Amperes	Volts	Amperes	Volts	Amperes	Volts
1	1.730	1.73	3.163	3.163	5.000	5.000	7.070	7.070
1.5	1.410	2.115	2.572	3.858	4.083	6.124	5.773	8.659
2	1.224	2.448	2.235	4.470	3.420	6.840	5.000	10.000
2.5	1.097	2.742	2.000	5.100	3.154	7.885	4.474	11.185
3	1.000	3.000	1.835	5.505	2.939	8.817	4.083	12.249
3.5	.970	3.395	1.689	5.911	2.672	9.342	3.778	13.223
4	.866	3.44	1.579	6.316	2.500	10.000	3.420	13.680
5	.774	3.87	1.414	7.070	2.236	11.160	3.154	15.770
7.5	.632	4.74	1.154	8.655	1.826	13.695	2.581	19.357
10	.547	5.470	1.000	10.000	1.598	15.980	2.236	22.360
15	.447	6.705	.816	12.240	1.298	19.470	1.829	27.435
20	.389	7.78	.708	14.160	1.119	22.380	1.598	31.960
25	.346	8.65	.632	15.800	1.000	25.000	1.414	35.350
30	.316	9.48	.577	17.310	.912	27.360	1.298	38.940
35	.292	10.220	.534	18.690	.844	29.540	1.197	41.895
40	.274	10.960	.500	20.000	.791	31.640	1.119	44.760
50	.245	12.250	.447	22.350	.700	35.000	1.000	50.000
75	.200	15.000	.365	27.375	.574	43.050	.818	61.350
100	.173	17.300	.316	31.600	.500	50.000	.700	70.000
150	.141	21.150	.258	38.700	.432	64.800	.577	86.550
200	.122	24.400	.223	44.600	.353	70.600	.500	100.000
250	.109	27.250	.200	50.000	.316	79.000	.447	111.750
300	.100	30.000	.182	54.600	.294	87.800	.432	129.600
350	.097	33.950	.169	59.150	.269	94.150	.378	132.300
400	.086	34.400	.158	63.200	.250	100.000	.353	141.200
500	.077	38.500	.141	70.500	.224	112.000	.316	158.000
750	.063	46.650	.115	86.250	.186	139.500	.257	192.650
1000	.054	54.000	.100	100.000	.158	158.000	.220	220.000
1500	.044	66.000	.081	121.500	.129	193.500	.182	273.000
2000	.038	76.000	.070	140.000	.112	224.000	.159	318.000
2500	.034	85.500	.063	157.000	.100	250.000	.141	352.500
3000	.031	93.000	.057	171.000	.091	273.000	.129	387.000
3500	.030	105.000	.053	185.500	.085	297.500	.119	416.500
4000	.027	108.000	.050	200.000	.079	316.000	.111	444.000
5000	.024	120.000	.044	220.000	.071	355.000	.100	500.000
7500	.020	150.000	.036	270.000	.058	445.000	.081	607.500
10000	.017	170.000	.031	310.000	.050	500.000	.070	700.000
15000	.014	210.000	.025	375.000	.043	645.000	.057	855.000
20000	.012	240.000	.022	440.000	.035	700.000	.050	1000.000
25000	.011	265.000	.020	500.000	.031	775.000	.044	1100.000
30000	.010	300.000	.017	510.000	.029	870.000	.043	1290.000
35000	.009	315.000	.015	525.000	.026	910.000	.037	1290.500
40000	.008	320.000	.014	560.000	.025	1000.000	.035	1400.000
50000	.007	350.000	.013	650.000	.022	1100.000	.031	1550.000
75000	.006	450.000	.011	825.000	.018	1350.000	.025	1875.000
100000	.005	540.000	.010	1000.000	.015	1500.000	.022	2200.000

Courtesy of Electrad, Inc.

Service is Keynote of Radio Set and Accessory Merchandising

Electrical Instruments Make Laboratory Set Inspection Possible in the Home

By Lewis B. Hagerman*

SERVICE has become a predominant factor in every branch of modern industry. The success of any product and its acceptance by the public is in direct proportion to the degree of service that is rendered in conjunction with its sale.

This word has been greatly abused, and up to a short time ago, the offer of service in the sale of a radio set or instrument was considered of little or no value. This situation, fortunately, has been rapidly changing. The radio dealer who fails to give intelligent service to his customers is seeing his sales drop, while those who specialize in this feature are increasing their business by benefiting from the word of mouth advertising that results from a completely satisfied customer, and are cutting down overhead created by returned sets and instruments and wasted time in trying to satisfy a disgruntled customer, without an intelligent knowledge of just what his trouble may be.

The question arises as to what is the best method of servicing a radio installation in the most efficient and expeditious manner, so that any trouble that may be had with a receiver or its accessories can be accurately located and corrected.

Sources of Trouble

There are four places in which trouble may originate: in the set itself, the accessories, the tubes, or the installation, such as the antenna and ground.

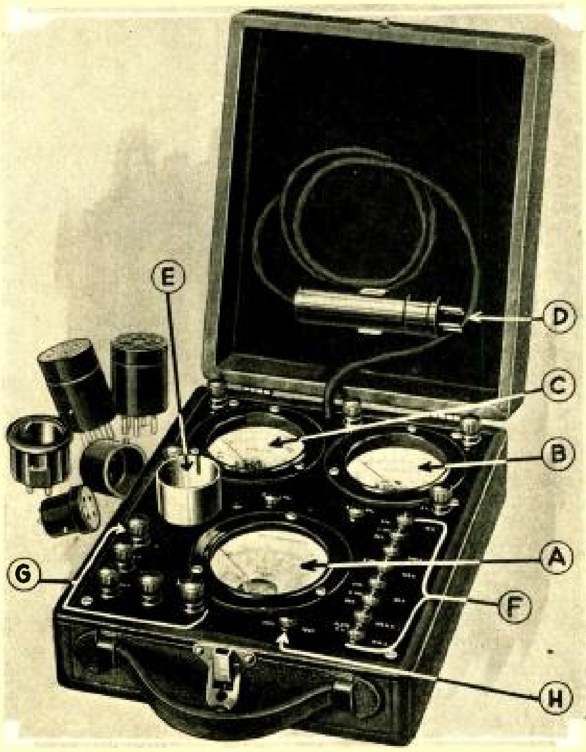
It has been truly said that the tubes are not an accessory to the set, but rather is the set an accessory to the tubes. The function of a receiver is merely as a coupling and selecting device to pass the correct frequencies and amount of current from one tube to another so as to enable them to perform their function of amplification or rectification.

This being true, it can be seen therefore that the proper place from which to check a radio set is the tube sockets, as at this point every source of power as well as every circuit in the set itself terminates. The actual voltage delivered by the power units is secondary to the question of whether it is delivered to the tubes. Determining this ascertains that the power units are O. K. or otherwise, and also that the current arrives at its destination and is of the correct value at that point, which is of prime importance.

To make this test requires an adapter to bring the connections from the tube sockets so that they will be accessible to electrical measuring meters which will determine the respective voltage impressed on the tube and check the circuits conducting them to this point.

Radio Set Analyzer

There are Radio Set Analyzers on the market that will completely check every power supply unit, "B" eliminator, "A" eliminator, storage battery, "B" battery, "C" bias or battery and power amplifier with voltages up to 500 volts D.C., as well as all intermediate voltages down to a fraction of one volt. They will also check the efficiency of the tube by showing the output in milliamperes, both with and without a grid bias by pushing a button, "H," and in so doing will prove that every circuit in the set is complete, or detect any open circuits that might exist. One of these instruments is shown in the accompanying illustration.



A special set analyzer that will check A and B eliminators, power units up to 500 volts, and all tubes including A. C. tubes and 210 type power amplifiers.

The operation of this part of the tester is almost entirely automatic. The tube is removed from the set and an adapter "D" inserted that extends the leads to the tester. The tube is then inserted in the tester socket "E," and all measurements made without additional wiring changes of any kind. The meters are arranged so that they can be connected for measurement by means of small push buttons "F," that can be pushed down for a momentary reading or fastened permanently for a prolonged test.

There are three meters on the tester panel, but they are so constructed that they give the readings of equivalent to nine individual meters, which would be sufficient to equip a fairly efficient laboratory.

Meter "A" gives D.C. voltage readings of 0-500; 0-100; 0-50; and 0-10 volts; also milliampere readings of 0-10 and 0-100. This will test the output of any "B" eliminator, "A" eliminator, power pack or amplifier, and test any type tube, including the largest power tubes, such as the 210 type. It will also give the exact "C" or grid bias voltage.

Meter "B" is a double reading, alternating current meter, with a range of 0-3 and 0-12 volts. This will test the A.C. filament voltages on any of the new A.C. tubes, for which a special adapter is furnished so that they also can be tested in the analyzer.

Meter "C" is an 0-150 volt A.C. meter for testing line voltages.

* *Jewell Electrical Instrument Co.*

A Good "B"-Power Unit

By James Millen

THIS power unit is strictly a heavy duty type capable of supplying the "B"-power to even the largest of sets.

The voltage regulator tube employed, not only prevents any tendency toward motor-boating when used with sets employing resistance coupled or other such forms of high quality audio channels, but also maintains the voltages at the various taps at constant values, regardless of the load or type of sets with which the power unit is employed. The filamentless full-wave rectifier tube, the wire wound resistors, the high voltage short path condensers contribute to long life and freedom from trouble.

Transformer Unit

In general, "B"-power circuits may conveniently be divided into three parts: first, the transformer-rectifier unit; second, the filter unit and third, the voltage divider unit. Under the first classifications comes the transformer which steps up the house current to a usable value and the rectifier element, commonly a tube, which alters the form of the stepped-up current from that of an alternating nature to one of a pulsating uni-directional form. The transformer which is selected for the purpose must be so designed that when it is in operation its core laminations will not produce a 60 cycle hum, usually the result of loose assembly. The better types of transformers now available overcome this difficulty not only by substantially clamping the core-pieces together but by imbedding the entire transformer assembly in a wax compound. Of necessity the transformer should be enclosed in a metal can which acts as a shield to prevent the electromagnetic lines of force set up by the transformer from intercoupling with other nearby pieces of apparatus. Of late there has been manifest a trend toward the combining of the audio channel of a radio receiver with the "B"-power supply device. Where such a construction is attempted this last-named consideration attains considerable importance as there is the possibility of the audio amplifying units picking up the 60 cycle disturbance where the transformer is not enclosed in an iron can. The grounding, not only of the center-taps of the several transformer windings but of the transformer can itself, is highly desirable and constitutes an additional safeguard against an unstable "B"-power supply unit.

Rectifier Unit

As to the rectifier element, there are several types which may be employed but special attention is directed to the new Raytheon R-9 tube which will very satisfactorily handle currents up to and including 125 milliamperes. This is an important item because the use of this tube in "B"-power supply devices enables the owner of the "multiest" of multi-tube receivers to power it from the lamp socket without the probability of operating the power unit at its limit of handling capacity. In other words, the use of this new rectifier tube insures a current output which is highly in excess of what will be required by receivers employing a maximum number of tubes as we understand that term today. The new Raytheon tube is rated at 125 milliamperes, which is 40 milliamperes in excess of the rating of the older previous BH tube, rated at 85 milliamperes. In the usual five and six tube receivers this reserve which constitutes a very large margin of safety makes for an unusually stable receiver with little chance for overtaxing the output limitations of the "B"-power supply device. So much for the transformer-rectifier section.

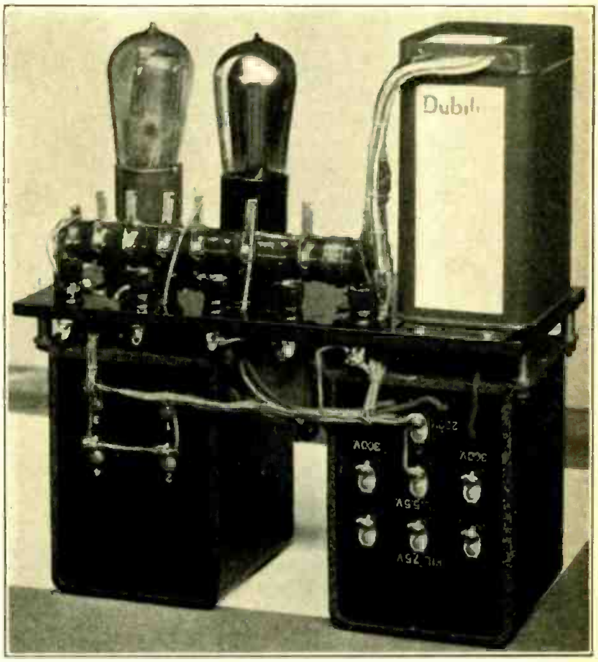


Fig. 1. The completed B-eliminator. This uses the new Raytheon R-9 rectifier tube which does away with the buffer condensers. The voltage regulator tube is optional.

The Filter

The filter section, that part of the "B"-power supply device which directly follows the transformer-rectifier section, has as its main function the smoothing out of the many pulsations or ripples which exist in the output as it comes from the rectifier tube. The filter consists of a combination of choke coils and condensers, the chokes acting as a smoothing agent and the condensers functioning in the dual capacity of smoother and storage tank. It is the business of the chokes to retard or impede the flow of any alternating current which would manifest itself in a series of pulsations at the rectifier output. Yet at the same time the chokes must not have a high direct current resistance, otherwise there would be too great a reduction in the voltage available for use at the power supply output. Now the use of a rectifier tube such as the 125 mil. R-9 tube imposes certain restrictions upon apparatus which may qualify for use in the filter circuit. First, the chokes must contain plenty of iron in the core —that is, the core must be quite husky. Secondly, the coils must be wound with heavy wire so as not to set up too great a D. C. resistance. The air gap of the core must be such that the chokes will satisfactorily pass 100 milliamperes of current without saturating the cores. The chokes (two are employed) may be assembled to be contained together but they too should be enclosed in a metal can for the same reasons as given for the transformer.

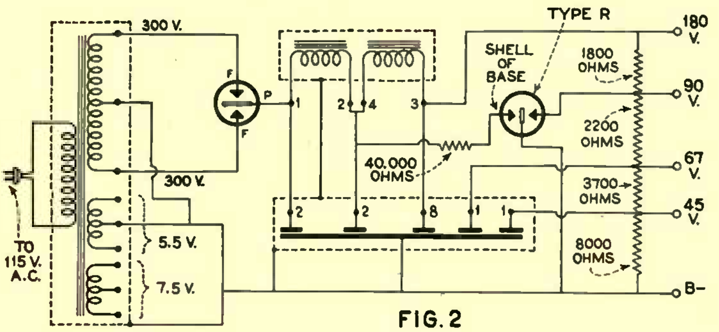


FIG. 2

Schematic diagram of the B-eliminator which uses the new Raytheon R-9 rectifier tube. Note the absence of buffer condensers.

The condensers comprising the storage tank of the filter circuit must meet certain requirements which fix their overall worth. First, they must be of the proper capacity, that is, the several condensers contained in the block must not be lower in capacity rating than the label on its front indicates. The only way to be sure that the condensers finally selected are satisfactory in this respect is to purchase units which have made a reputation for themselves and which are in every way entirely reliable. Secondly, these condensers should be of a voltage rating which makes them satisfactory for the particular type of "B"-power supply in which they are to be employed. This factor depends largely upon the transformer which is selected to work with the type of rectifier tube employed. For instance, in some filament types of rectifier tubes there is only need for a 300 or 400 volt secondary winding on the transformer because the rectifier system is of the single or half wave type. However, when the R-9 Raytheon tube is employed as the rectifier in a full or double wave rectifier circuit then the transformer chosen must necessarily have a higher secondary voltage output, usually on the order of 500 or 600 volts with mid-tap. Since the voltage drop across the rectifier tube is only slight, a mere fraction of the output voltage of the transformer secondary, it is well to choose filter condensers which are rated at a working voltage either equal to or in excess of the transformer secondary voltage from the mid-tap to either outside terminal. This is a particularly important point because if a poor make is selected it is quite probable that such a filter unit will be short lived, one or more of the sections breaking down, making useless those sections and jeopardizing the others. As pointed out previously, the use of the new 125 mil. R-9 Raytheon tube in the rectifier circuit minimizes the possibilities of broken down condensers because the new tube has a lower peak voltage and thus exerts less strain on the condenser bank than with the older type of rectifier tube.

Together with the filter section of a "B"-power supply may very well be considered the use of the Raytheon voltage regulator or R tube. The inclusion of such a tube in a "B"-supply circuit presents several advantages. First, because the tube has the property to function similar to part of the condenser bank in smoothing out any slight ripples which may have been incompletely filtered by the chokes and condensers, it makes possible the selection of a condenser bank with less capacity in microfarads than was formerly possible. In the older types of "B"-power supply units it was customary to have a condenser bank consisting of a total of 14 microfarads, as follows: 2, 2, 8, 1, 1. With the use of the R tube, which by the way is employed for an entirely different purpose, it is only necessary to use a condenser bank totaling 12 microfarads, surely an economical procedure. The main use of the R tube is to maintain at a steady figure the output voltage from an intermediate tap at the output of the complete "B"-power supply unit, regardless of the total current drain which might fluctuate under varying conditions of load. The prevention of "motor-boating," that troublesome noise which bothers satisfactory reception of radio signals where the receiver is powered from a dubious make of power supply, is attributed to the inclusion of a regulator tube to maintain the intermediate voltage at a steady value. Probably one of the most serious objections to former types of regulator or "glow" tubes as they were called, was the tendency to oscillate and thereby introduce noises and other disturbances into the output of the power supply, often of such a disagreeable nature as to make reception virtually impossible. Besides the usual two elements which have heretofore been found in such tubes there is now incorporated in them a third or "keep-a-live" element and its associated circuit. The complete keep alive circuit is a most unique one in that it consists of a tube within a tube where the inner one is operated from a point of high voltage off the filter circuit at no load and keeps the gas within the tube in an ionized state. If, for any reason the voltage across the operating electrodes should fall below a value required to maintain the gas in an ionized state, the potential of the third element will be sufficient to maintain ionization. A forty thousand ohm resistor is employed in the filter connection circuit to minimize the additional drain on the rectifier and filter and limits this parasitic current to approximately three milliamperes. Unlike former types of regulator tubes the inclusion of the third element and its associated circuit in the new type of tube makes unnecessary the high starting voltage formerly required.

The Resistors

Like everything else which may be classed as radio apparatus, resistors suitable for use in "B"-power supply devices have not been left to remain unchanged.

By the use of the voltage regulator tube, the necessity for variable resistors has disappeared. A long lived, noiseless and trouble-free wire wound resistor, with several taps, taking their place.

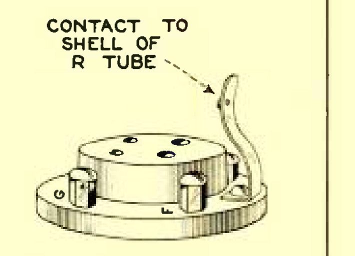


FIG. 3

Special connection for voltage regulator tube.

With the new arrangement, there is no "guessing" as to what voltage is being delivered at any one tap; the careless operator can no longer apply excessive voltage to his R. F. or detector tubes; in fact, the power unit becomes a true "B battery Eliminator."

Constructing the "B"-Power Supply

The arrangement of the parts as shown in Fig. 1 was selected for two reasons—to simplify construction and to obtain compactness. As a result of this compactness, the complete power unit takes up but little more space than a standard 45 volt heavy duty "B" battery and far less than 180 volts of heavy duty dry "B."

The "chassis" consists of 5"x10" bakelite ¼ inch in thickness.

Mounted underneath, but held away from the bakelite plate by ½ inch collars or spacers are the power transformer and the filter chokes. Between these two units is mounted the 40,000 ohm resistor for the regular tube.

On top, the space is taken up by the filter condenser, the tube socket, the resistor and the binding posts.

As the R tube requires a contact to the brass shell in addition to the base prongs, either a spring contact, which presses on the side of the shell when the tube is inserted (See Fig. 3) must be added to the R tube socket or else a clip or strap must be fastened around the tube base after it is inserted in the socket.

The several different leads from the condenser block are of well insulated rubber covered wire and may be bound together into a cable, as shown in the illustration, in order to enhance the appearance of the completed power pack.

LIST OF PARTS REQUIRED

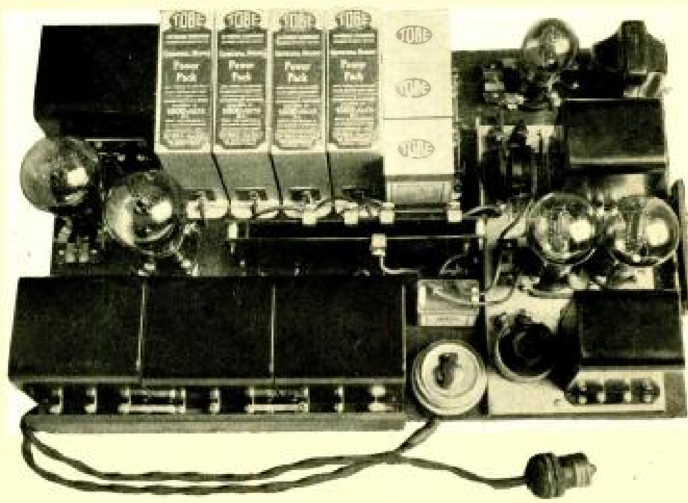
1—National Power Transformer, Type R
1—National Filter Choke, Type 80
1—Dubilier B Block Condenser
2—General Radio Sockets
1—Arthur H. Lynch Tapped Resistor, Type R
1—Arthur H. Lynch 2,000 Ohm Resistor, Type P
1—Raytheon R-9 Tube, 125 mils.
1—Raytheon R Tube
5—Binding Posts
1—5"x10"x¼" Bakelite Panel
25 Feet Corwico Braidite
R.H.B. Machine Screws with hex nuts, solder, etc.

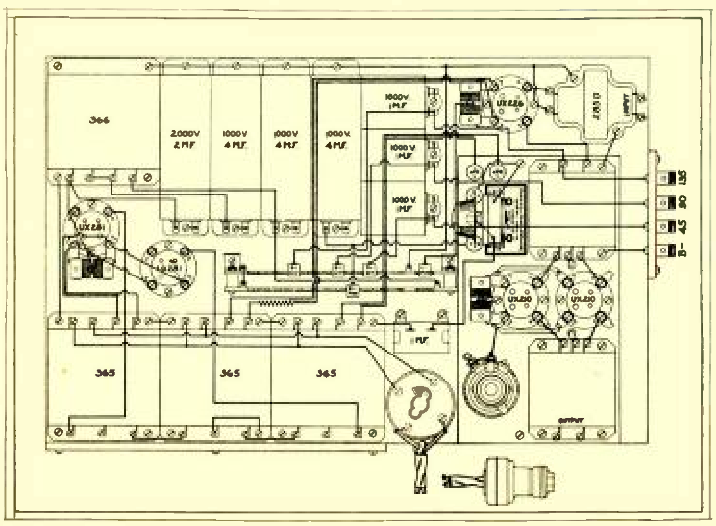
An A. C. Operated Push-Pull Amplifier

By A. R. Wilson

THE General Radio Power Pack is a complete two stage A. C. operated amplifier, adaptable for use after the output of the detector tube or with a phonograph magnetic pick-up, utilizing transformers with a 226 type tube in the first stage and two 210 tubes in the last stage. The rectifier system has been designed to furnish approximately 750 volts D. C. when two 281 rectifying tubes are employed.

The voltages placed on the plates of the two 210 tubes have been made adjustable over a wide range as it was felt that the common practice of connecting the plate of the last stage tube directly to the high voltage side of the rectifying system was not in keeping with the maximum efficiency. In similar devices the grid voltage for the last tube is usually obtained by the voltage drop through a resistance placed in the grid return. This resistance is usually variable and any adjustment of it affects the plate voltage, consequently the final adjustment is more or less an arbitrary value for both grid and plate voltages. By making the plate voltage variable over a wide range, it permits the tubes to be operated at their maximum efficiency regardless of the load.





Above: The completed A.C. Operated Push-Pull Amplifier. Left: The layout and wiring of the amplifier.

The direct current available from the rectifying system is approximately 200 milliamperes. A high current output makes for better voltage regulation and will easily supply sufficient current to operate a multi-tube set with a great reserve of power.

The construction and placement of parts in the General Radio Power Pack is evident from Fig. 1.

The wiring is all straightforward and simple. The only precaution needed is to place some sort of guard over the high voltage side of the power transformer and to use rubber covered wire for all connections. Under no circumstances should anyone attempt to make any adjustments without first turning off the electric current.

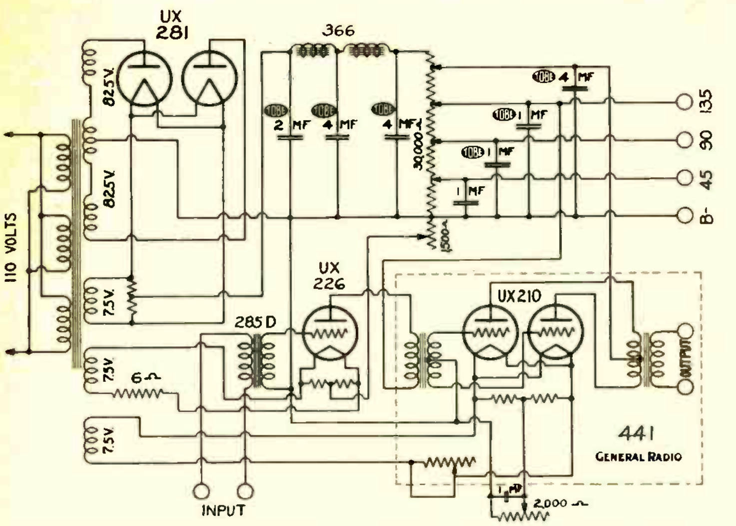
For convenience the 2000 ohm variable resistor is mounted by means of a metal bracket directly to the B— binding post of the push-pull amplifier. When AC is used to light the filaments of the tubes used in this amplifier it is a simple matter to utilize part of their plate current to obtain a grid bias voltage. This is accomplished by connecting the C— binding post directly to B— and inserting a resistance, which in this case is a variable 2000 ohm resistor between the C— and the B— binding posts. By-passing this resistance by a condenser is sometimes helpful in reducing hum.

The filaments of the rectifier tubes together with those of the amplifier tubes are lighted from the low voltage secondaries of the power transformers. In the case of the 226 tube a fixed resistance of 6 ohms, capable of carrying at least 1 ampere, is inserted in one of the filament leads underneath the baseboard.

To operate this device it is simply necessary to connect the output of the detector tube or a phonograph magnetic pick-up to the primary of the input audio transformer. The reproducer is connected to the terminals marked output on the push-pull amplifier. If it is desired, the push-pull stage alone may be used by connecting the output of another amplifier directly to the input terminals of the push-pull amplifier.

Under normal operating conditions the tubes, especially the two 281 rectifying tubes and the two 210 tubes together with the resistance unit, should get decidedly warm. If the plates of the two 210 amplifying tubes should get red after a period of use it is an indication that the grid bias voltage used is improper and the biasing resistance should be adjusted until this condition disappears. It is almost a positive indication that one or more filter condensers are defective if the plate of the rectifier tube turns red.

Under operating conditions, with the primary of the input transformer open, a hum should be heard in the reproducer. This, however, should almost disappear when the two input terminals are shorted or a reasonable load placed on them. In an AC operated device of this sort it is extremely important that the plate and grid voltages of the amplifying tubes be adjusted properly as this helps materially in reducing hum: also the cases of the various parts should be grounded to B—. When using a phonograph magnetic pick-up with this device it is sometimes helpful in removing needle scratch to shunt the input terminals by a fixed condenser. The proper value can only be determined after experimentation, but will usually be around .01 mfd.



The schematic diagram of the A.C. Operated Push-Pull Amplifier. Note that the maximum obtainable B voltage is not placed on the plates of the 210 tubes.

LIST OR PARTS REQUIRED

3—General Radio Type 365 Transformers.
1—General Radio Type 366 Choke.
1—General Radio Type 441 Push-Pull Amplifier.
2—General Radio Type 446 Resistance Units.
1—General Radio Type 285 D Transformer.
3—General Radio Type 349 Sockets.
2—General Radio Type 439 Center Tapped Resistance Units.
1—General Radio 6 Ohm Resistance Strip capable of carrying one ampere.
1—2000-volt, 2 Mfd. Condenser.
3—1000-volt, 4 Mfd. Condensers.
3—500-volt, 1 Mfd. Condensers.
1—1 Mfd. Condenser.
1—Variable Resistance, 2000 ohms.
1—Baseboard, 12″ x 20″.
Misc. wire, screws, bolts, etc.

The Vitrohm D. C. Unit with Power Amplifier

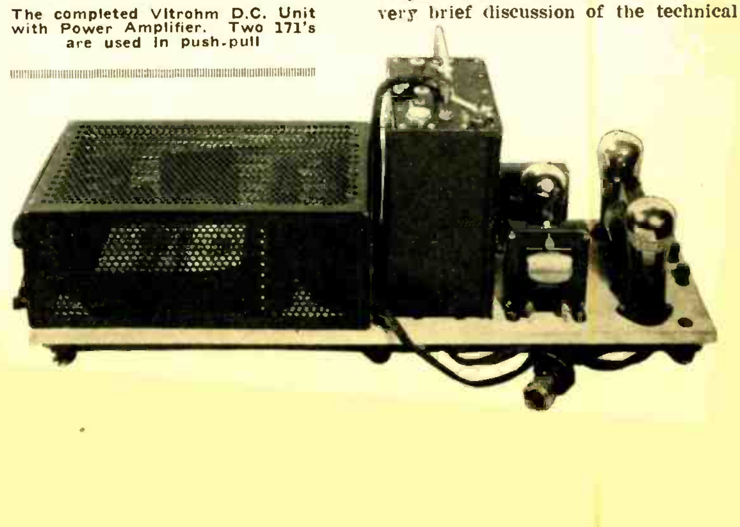
THE Vitrohm D. C. eliminator, described in the last issue of RADIO ENGINEERING, has been combined with an exceptional two-stage amplifier with power characteristics. The first stage of the amplifier is transformer coupled, while the second is push-pull, operating at 90 volts on the plates, with 9 volts grid bias.

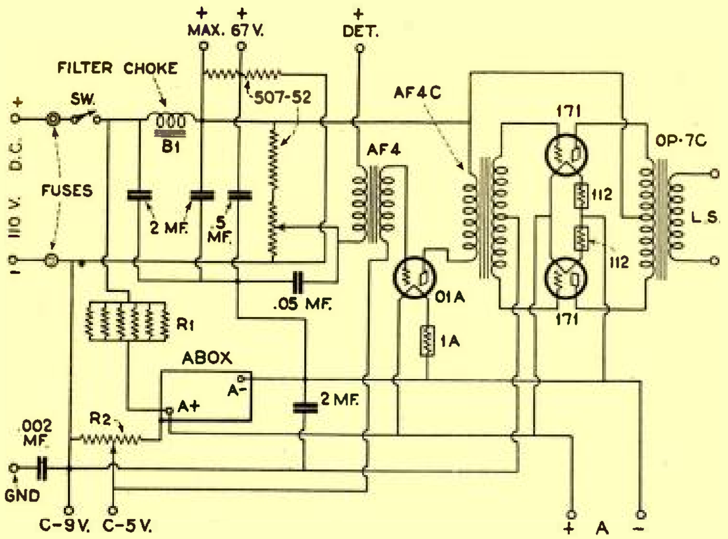
The combined eliminator amplifier operates entirely without batteries of any kind from the 110-volt direct current light socket. All voltages, A, B and C, are supplied through the eliminator to the receiving equipment for use with the amplifier.

Using the combined unit is no more difficult than hooking up any eliminator to a standard receiver. The eliminator-power amplifier is so connected that leads need be run only to the receiver and the amplifier is automatically connecred and ready to perform.

To those who have not had an opportunity to hear an amplifier of this type working on 90 volts from direct current sources a certain degree of skepticism and doubt is natural. A very brief discussion of the technical

The completed Vitrohm D.C. Unit with Power Amplifier. Two 171's are used in push-pull





Schematic diagram of the Vitrohm D.C. Unit and Power Amplifier.

side of the question may help to clear up skepticism. Let us compare this new amplifier with a standard high quality amplifier with 180 volts on the plate of a 171 in the second stage. The transformers are 3.5 to 1 ratio.

Here is what we have for comparative voltage amplification:

First Stage	Two Transformers.	Output Tube.	Total.
O1A tube	3.5 to 1	171	...
8	3.5 squared or 12.25	3	294
8	3.5x3.5x1 or 12.25	3+	294+

The conclusion is obvious. Look at it any way you will, the second amplifier (with 90-volt push-pull) has a voltage amplification at least equal to the regular amplifier with a 171 at 180 volts. The milliwatts output is somewhat less, granted, but in practical use quality or volume from the speaker is little affected. And incidentally the 90-volt D. C. amplifier will handle a signal input up to 18 volts. So rather than losing with the push-pull system we are more apt to gain amplification and handling capacity.

There is another advantage in the push-pull system which has a decided appeal. Tube distortion and wave form distortion are practically done away with, due to the neutralizing effect of the two opposed tubes in the system.

In actual practice this push-pull amplifier gives results and tone quality which are most pleasing. Reproduction is clean and clear cut. There is plenty of volume. On any appreciable incoming signal the tendency will be to cut down volume for regular home use. Distortion is absent. And the final point is simply that the amplifier handles a heavy load admirably.

The eliminator section of the combined unit is fundamentally the same as the Vitrohm D. C. eliminator discussed last month. The wiring of the eliminator itself remains the same, the amplifier being wired in at the proper points to bring voltage to the three tubes.

The front panel of the eliminator stays unchanged. The parts under the perforated metal case are distributed in the same manner, using the heat baffle plate and the metal end piece to throw heat upwards from the other parts.

The two line fuses and their clip holders are mounted under the baseboard in the combined eliminator-amplifier. This allows the Abox filter to go closer to the metal case with a resultant saving in space.

Also under the baseboard are mounted three Amperites controlling the filament current on the amplifier tubes.

A baseboard of treated transite (hydraulic asbestos) 7¼x24x½ inch is used to hold the complete unit. Six mounting feet provide strong support for the entire assembly.

The amplifier layout and mounting is extremely simple, as shown in an accompanying photograph. The Ferranti push-pull output transformer mounts near the back center, with a socket on both sides. The third socket mounts in front of this transformer, up near the Abox. Looking at the assembly from the rear the AF4 transformer goes at the left and the push-pull input at the right. Two output binding posts go at the back edge of the baseboard.

The schematic drawing shown here gives the complete hookup for the eliminator-power amplifier. If this is followed no input posts or special connections to the amplifier from the set will be needed.

In wiring endeavor to keep amplifier grid and plate leads well apart with grid leads as short and direct as possible. Rubber-covered wire will be best for the whole job, with the exception of the leads to the top of the Abox unit, which should be of duplex power cable.

LIST OF PARTS REQUIRED

1—Ferranti Type AF-4C Push-Pull Transformer.
1—Ferranti Type OP-7C Push-Pull Transformer.
1—Ferranti Type AF4 Audio Frequency Transformer.
3—Sockets.
2—Binding Posts marked "Output."
1—Abox Filter (6 volts).
1—Amperite, Type 1A.
2—Amperites, Type 112.
6—Ward-Leonard Vitrohm Resistors, B300. With Mounting Bolts.
1—Ward-Leonard Vitrohm Resistor, No. 507-52. With Mounting Bolt.
1—Ward-Leonard Vitrohm Resistor, Type A5CT. With Mounting Bolt.
1—Ward-Leonard Vitrohm Adjustat, 10,000 Ohms.
1—Ferranti B1 Audio Choke.
2—5 Ampere Fuses and Four Clips.
1—Cord and Plug.
1—Parvolt Condenser, Block 2, 2, 2, .5, .5 Mfds.
1—Sangamo Mica Condenser, .002 Mfd.
8—Binding Posts, marked Power B plus, 67 volts, B Det. plus, A Bat. plus, A Bat. minus, Gnd, 4 Volts C minus, 9 Volts C minus.
1—Heat Baffle Plate Transite 4⅝ x 6⅞ x ¼ inch.
1—Baseboard, Transite, 7¼x24x½ inch.
1—Bakelite Front Panel 4 7-16x⅛x7 inches.
1—110-volt Toggle "on-off" Switch.
1—Polarity Indicator (Charge-O-Discharge).
1—Stamped Metal Case.
(Incidental hardware, including tapped rods, six mounting feet and mounting brackets for metal case.)

Converting the D. C. Receiver to A. C.

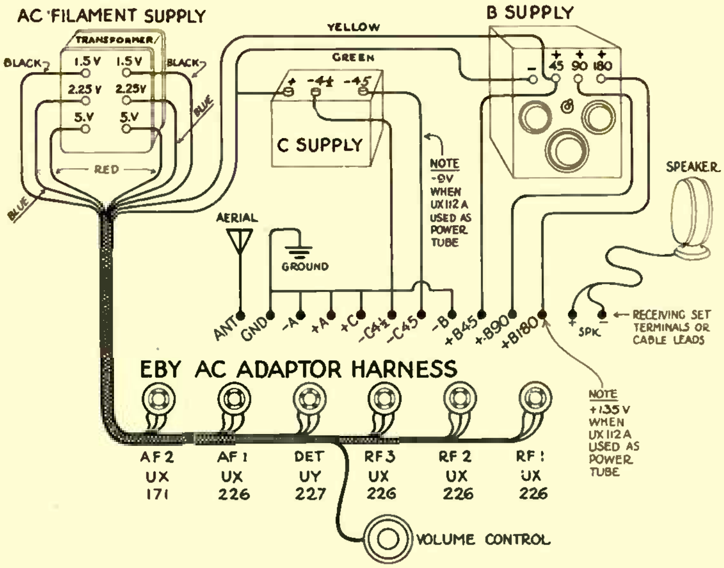
Convenience has been a prime mover in life since days primeval.

At the advent of the first receiver designed for broadcast reception, convenience of operation was not accorded any thought or consideration. The paramount item was reception. With the gradual progress in design, the ultimate receiver owner—operator was taken into account and items which would tend to make operation simpler and more convenient, were given detailed thought. The first step was the development of the low current consumption (filament) tube, thus increasing the periods between A battery recharging. Then arrived the B-eliminator, which was soon followed by the A. C. receiver.

"Converting the D. C. receiver to A. C." is the title of a story by *John F. Rider*, in which he describes the conversion of an Atwater Kent 6-tube D. C. receiver into an A. C. operated unit by means of an A. C. filament adaptor harness. While this one particular receiver is used as a concrete illustration, the harness is adaptable with equal facility to practically any standard five or six tube D. C. receiver.

The story continues as follows:

I know that many fans are interested in the conversion of their receivers from D. C. to A. C. filament supply, particularly when alterations in the receiver wiring are unnecessary.



Complete connections to the A.C. Adapter Harness and to the binding posts of a 6-tube receiver.

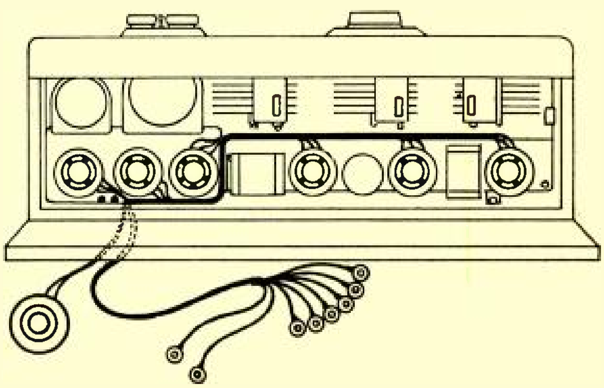
The person knows very little about receiver wiring and the ultimate gain is convenience. Therefore, I am going to briefly describe the transition.

I have mentioned the receiver in use. It is a six tube affair utilizing three stages of radio frequency amplification, detector and two of transformer coupling. The harness used consists of six adaptor sockets wired for three stages of radio frequency amplification, detector and two stages of audio frequency amplification. These sockets are wired to a cable which contains the necessary filament midtap resistances for all types of 226 and 227 A. C. tubes, and 112 and 171 tubes, or other tubes whose filament characteristics are similar.

The cable consists of nine leads. Six leads supply the filament potential for the various tubes in the receiver; two supply the bias required for the 227 type detector tube, and one is connected to the new receiver volume control, which is in the form of a rheostat controlling the filaments of the radio frequency tubes, an ideal form of volume control. The filament leads comprising the harness are pairs of black, blue and red wires. The black leads are the 1.5 volt leads for the 226 tubes; the blue leads are the 2.25 volt leads for the 227 detector tube and the red leads are the 5 volt leads for the 112 or the 171. The yellow lead is the B plus 45 for the detector tube and the green lead is the B minus and C plus.

The actual conversion process is simple, and the position of the adaptor harness as applied to this receiver is shown in Fig. 1. The regular D. C. tubes are removed from the receiver, and the harness adaptor sockets placed into the receiver sockets as shown in Fig. 2. The loose end of the cable is passed through the wiring hole in the rear of the receiver cabinet. The two wires from the harness volume control rheostat are disconnected, passed through the rear hole in the cabinet and again fastened to the rheostat. If the original receiver wiring is equipped with filament rheostats, these are permanently fixed at "full on" position and are not manipulated thereafter.

The control of receiver volume is effected with the harness volume control. The harness leads are then connected to the proper terminals on the filament heating transformer required with the harness. The yellow and green leads are attached to the B-eliminator plus 45 and minus B respectively, or to the plus 45 and minus B of the B battery, if battery source of B potential is employed. The original A minus, A plus, C plus and B minus posts in the receiver terminal board are connected together. The A. C. tubes are now inserted and the receiver is ready for operation.



Showing the A.C. Adapter Harness installed in the Atwater Kent 6-tube battery operated type receiver.

The exact equipment used to convert this receiver into an A. C. unit is as follows:

1—Eby Six Tube A. C. Adapter Harness.
1—Silver-Marshall 247 Filament Transformer.
1—227 Detector Tube.
4—226 Amplifier Tubes.
1—171 Power Amplifier Tube (this tube was also used when the filament supply was D. C.).

Fans who have five tube receivers, consisting of two stages of radio frequency amplification, detector and two stages of audio should use a five tube harness in place of the six tube affair used in this receiver. The adaption of this harness does not require any changes in either B or C potential, since this harness effects only the filament circuit, which voltage is supplied by the power transformer from the house supply. The control of the complete filament circuit is simple. In our case, the B supply and the A. C. filament supply are connected to a double plug which is located in a lamp socket. The switch controlling the lamp socket controls the filament and B supply for the receiver. If the B supply is a B eliminator with a built-in flush receptacle and a switch, plug the filament transformer lead into the receptacle and use the B eliminator switch to turn them both on and off.

These harnesses are adaptable to many other five and six tube receivers. It is essential, however, that the correct filament heating transformer be used, since the correct filament potentials and current values are essential. The transformers suitable with this harness are: Karas AC Former; Dongan No. 6515; Acme AC2; Jefferson No. 464-131 and Silver-Marshall No. 247.

NEWS OF THE INDUSTRY

Herbert H. Frost Leaves Cunningham—M. F. Burns Newly Appointed Sales Manager

Herbert H. Frost, General Sales Manager of E. T. Cunningham, Inc., has tendered his resignation, effective February 29, 1928.

Effective March 1, 1928, Mr. M. F. Burns, who has been New York District Sales Manager for Cunningham, becomes Sales Manager.

Herbert H. Frost Joins Federal-Brandes

At a meeting of the Board of Directors of Federal-Brandes, Inc., manufacturers of Kolster Radio, held on January 23rd, Herbert H. Frost was elected a Vice-president of the Corporation, in charge of Merchandising.

Melhuish Becomes Director of Radio Division, N. E. M. A.

H. T. Melhuish, formerly manager of sales administration of the Radio Corporation of America, has joined the staff of the National Electrical Manufacturers Association as Director of the Radio Division, according to announcement by Alfred E. Waller, Managing Director of NEMA.

For the past five years Mr. Melhuish has been one of the principal executives of the Sales Department of the R. C. A. representing that corporation in the various trade associations and other outside affiliations as well as coordinating the work of the several divisions of the Sales Department.

Ernest Kauer Elected to R. P. A. Directorate

Mr. Ernest Kauer of the C. E. Mfg. Co., Providence, R. I., has just been elected to the Board of Directors of the Radio Protective Association.

Pamphlet on Aquadag

To break up graphite—a comparatively inert, non-fusible solid, insoluble in all known solvents—into particles sufficiently fine to pass through the pores of a filter paper is quite a feat. Dr. E. G. Acheson, the father of carborundum, not only succeeded in accomplishing this but did it on such a large scale as to make the resulting product an article of commerce.

"Deflocculated Graphite," as Dr. Acheson calls it, is obtainable as a colloidel solution in either oil or water and is marketed as Oildag and Aquadag, respectively. The merits of the former as a lubricant have frequently been cited in the scientific press. Aquadag is not only indispensable in the drawing of tungsten wire but enjoys at the same time, numerous special applications in the radio field, including its use as a raw material in the manufacture of grid leaks, resistances, etc.

An interesting folder on these products has just been issued by the Acheson Products Sales Company, Inc., of Newark, New Jersey. A copy can be had upon request.

Rochester Radio Show Set for September

The dates of the Fourth Annual Rochester Radio Show, sponsored and managed by Rochester Radio Trades, Inc., have been set for September 17 to 22, inclusive, 1928, at Convention Hall, Rochester, N. Y.

Arborphone Appoints New Detroit Distributor

General Sales Company, 124 Woodward Avenue, Detroit, Michigan, has recently been appointed distributor for Arborphone Radio and Power Speakers in Detroit and vicinity, says an announcement from the Arborphone factory.

According to Louis Ingram, Sales Manager of the General Sales Company, the new Arborphone A. C. operated models are moving rapidly, and, with the reopening of the Ford Motor plants and the prospects of a banner year in other motor car factories, a gratifying increase in radio sales is expected.

C. C. Henry Joins Majestic

Charles C. Henry, for the past four years with the Sonora Phonograph and Radio Company of New York, has joined the Grigsby-Grunow-Hinds Company, of Chicago, manufacturers of Majestic Electric Radio Power Units, and has already entered upon his duties in his new location. Mr. Henry occupied the post of Radio Sales Engineer with the Sonora Company and will continue as Sales Engineer for Grigsby-Grunow-Hinds Company.

Radio Aeronautic Report

In connection with the assistance offered by the Radio Manufacturers Association to the aeronautical industry, to develop radio aids for air navigation, the RMA has been advised by Mr. George K. Burgess, Director of the Bureau of Standards, Department of Commerce, that the Bureau is preparing a comprehensive report covering the work done by Government scientists in the Bureau in developing apparatus for aeronautics. This is to be furnished the RMA Engineering Division for its studies and laboratory experiments in development of radio apparatus for use in connection with aerial commerce. RMA engineers are engaged in studies looking to the development of fixed aerials for airplanes, for the use of short wave transmissions in aerial navigation, and other radio aids in aeronautics.

Roy Dunn Joins Splitdorf

Roy S. Dunn has joined the staff of Splitdorf Radio Corporation as western radio sales manager.

The announcement of Mr. Dunn's appointment has just been made by Hal P. Shearer, general manager of Splitdorf. Mr. Dunn will handle all radio sales for the Splitdorf organization in the North Central States.

J. W. Jenkins Sales Representative for Arborphone

J. W. Jenkins has joined the national sales organization of the Arborphone Division, Consolidated Radio Corporation, Ann Arbor, Michigan, as special Sales Representative.

Mr. Jenkins will work intensively with a selected list of Arborphone distributors, helping them apply to their own territories the Arborphone plan of merchandising. His long experience in selling and his intimate technical knowledge of radio should prove very valuable to those distributors with whom he will work.

Naylor Joins Arcturus

L. P. Naylor is the latest addition to the corps of radio pioneers headed by George Lewis, added to the executive staff of the Arcturus Radio Company, A. C. tube manufacturers of Newark, New Jersey.

Mr. Naylor, Sales Manager of the organization, is a graduate E.E. (Columbia University) and made his radio debut in the rather distant days when crystals were used as detectors.

L. A. Chambers Co. Open New Offices

A successful sales year has made it possible for the L. A. Chambers Company to establish new and larger headquarters in the Machinery Hall Building at 549 West Washington Street, Chicago. The L. A. Chambers Company is the sole representative in Chicago and the outlying districts of Tobe-Deutschmann Company and Silver-Marshall, Inc.

Chas. Himmel Appointed Chairman of the Mayor's Radio Committee

Mayor Wm. Hale Thompson of Chicago, has appointed Mr. Chas. S. Himmel, 116 South Wells Street, chairman of the Mayor's Radio Committee.

Mr. Himmel, who is well known in the Radio Trade, is manager of the Hudson-Ross Company, Inc., Radio Distributors, is now planning his committee, which will be composed of the leading Radio men of this section, and directors of many of the Broadcasting Stations.

The names of the members of this committee will be announced later.

Co-operative Research by Radio Protective Association

Plans for co-operative research by the independent manufacturers in the radio industry were made at the first meeting of the new Committee on Patents and Engineering of the Radio Protective Association, recently held at the Palmer House in Chicago.

The committee decided to invite the assistance of the independent engineers and inventors of the industry, whether they are connected with manufacturers who are members of the association or not. A number of offers of new circuits and new radio devices had already been received at the Chicago headquarters of the association, and were referred to members of the committee for further investigation.

Aerovox Installs 4,000-Watt Testing Plant

A veritable power house has been installed by the Aerovox Wireless Corporation for the testing of their power condensers and resistances.

The gradual trend towards high-voltage "B" eliminators and amplifiers necessitates the testing of the fixed condensers and resistances designed for use in these units at not only the rated voltages, but at much higher voltages to study overload characteristics. In addition, in the endeavor to produce a meritorious product it is essential that the fixed condenser and resistance manufacturer be in a position to carry out extensive research work on the power-handling ability of these units so as to incorporate satisfactory safety factors in the design. This calls for high voltages and high values of power. Realizing these needs, this company has recently installed a new 4,000-watt testing unit in addition to the old one. This testing unit provides D. C. voltages from a fraction of a volt up to 4,000 volts and A. C. voltages of the same value.

All of the equipment is controlled from a single panel board, and is equipped with ultra-modern safety devices.

E. T. Angell Joins Polymet

Mr. E. T. Angell, formerly with the Daven Radio Corp., has joined the Polymet Mfg. Corp., 599 Broadway, New York, as Assistant Sales Manager. Mr. Angell comes to the Polymet organization with a wide acquaintance among the jobbers and manufacturers of the radio industry.

Peter Podell Resumes Radio Activities

Peter Podell, president of the Peter Podell Company, Inc., announces his resumption of radio activities after an absence of six years from the field, during which time he was in the automotive selling field and sales manager for Dodge Brothers.

Mr. Podell is at the present time, a factory representative for several automotive lines, and is manufacturing cone speaker and "A" eliminator kits.

His company is located in the Fisk Building at 250 West 57th Street, New York City.

Zenith Uses Hiler-Tuned Double Impedance

Announcement is made by the Hiler Audio Corporation that the Zenith Radio Corporation of Chicago, manufacturers of the Zenith line of radio receivers, are using tuned double impedance coupled audio frequency amplification in their 8-tube receiver. This type of audio amplification is the invention of E. E. Hiler, an American engineer, and is covered by U. S. patent numbers 1589692 and 1615224.

Other licensees operating under Hiler patents are Ford Mica & Radio Co., Leslie F. Muter, American Specialty Company, Paragon and Kenneth Harkness Laboratories.

Federal Appoints New Representatives in Michigan and California

The Federal Radio Corporation announces the appointment of W. F. Kroenig as territorial representative in Michigan to replace H. H. Wilkin, who has been transferred to California. Although a new member of the Federal sales organization, Mr. Kroenig has had several years of selling experience in radio, and is expected to continue the good record in Michigan. He will work in conjunction with the Grier-Sutherland Company, Detroit, wholesalers for Federal Ortho-sonic radio in that territory.

Mr. Wilkin's assignment to California fills the post left vacant by P. J. Rundle, who was recently made special representative.

Radio Railroad Rates

A movement to reduce the delivery cost of radio products was initiated recently at New York by the Radio Manufacturers Association through its Traffic Committee of which Captain William Sparks, of Jackson, Michigan, is chairman. After conferences in New York with RMA directors and officers and also traffic experts of RMA members, Captain Sparks headed a delegation which appeared January 12th before the Consolidated Classification Committee and inaugurated the effort to secure fair and lower railroad rates for radio receiving sets, accessories and parts.

The Classification Committee indicated its agreement with the RMA delegation on the latter's plea to reduce the minimum carload weight required under the tariff for radio cabinets and receiving sets. The present carload minimum of 20,000 pounds cannot be loaded by radio manufacturers except in rare instances. The average carload is from 12,000 to 18,000 pounds, and the RMA delegation's request for a minimum of 16,000 pounds appeared to be favorably received. The rates on radio accessories and parts, with additional information on cabinets and receiving sets, will be discussed further before the Classification Committee at Chicago.

Federal Issues New Service Manual

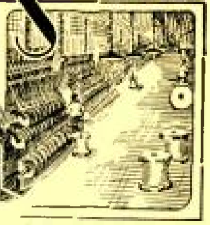
A very effective and adaptable type of service manual has recently been issued by the Federal Radio Corporation for the use of Federal Ortho-sonic wholesalers and retailers. This is a looseleaf book, printed on a distinctive buff paper, and completely furnished with index tabs for easy reference. Standard supplements, 8½ by 11 inches, can readily be inserted when necessary. Wherever possible, notes and sketches pertaining to the general text have been placed in the margin to eliminate needless turning of pages.

Directory of R. M. A. Personnel Available

The Radio Manufacturers' Association have just completed, for mailing to all members, a complete directory showing the officers and directors of the association and also a complete list of all committees, and committee personnel.

In addition there has been prepared an organization chart which is printed in conjunction with the above list.

NEW DEVELOPMENTS OF THE MONTH



Daven A. C. Tube Ballasts

The Daven Radio Corporation, of Newark, N. J., has developed two A.C. tube ballasts, the Daven AC-26 Ballast and Daven AC-27 Ballast.

It is stated that these ballasts are so designed that they compensate for any voltage or current fluctuations, due to inaccuracy in transformer windings, line surge, or overload, that is likely to prove ruinous to alternating current filaments.

Whereas, ordinary D.C. ballasts have become universally adopted because of their convenience in eliminating rheostats, the A.C. ballast is required more as an actual protective device.

The manufacturer states that used with any standard filament transformer, normally delivering 3.5 volts for type 227 A.C. tubes, the Daven AC-27 Ballast, operating with a 20 volt line variation, gives a total variation of .17 (17/100) of a volt. The minimum is 2.225 volts, and the maximum 2.4 volts—the best operating range of 227 type tubes, according to RCA specifications.

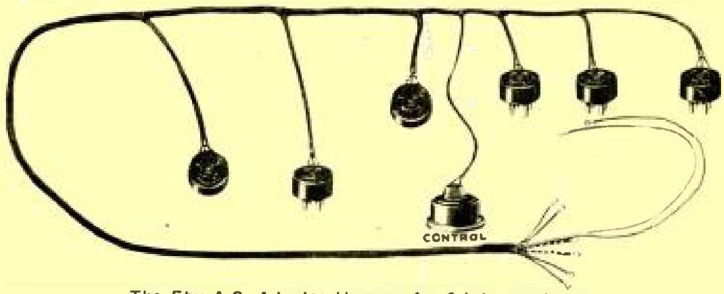
The Daven AC-26 Ballast, operating from a transformer normally delivering 2 volts, and with a 20 volt line overload, gives a total variation of .16 (16/100) of a volt on type 226 tubes. The minimum is 1.3, and the maximum 1.46 volts.— the best operating point for minimum hum.

Carter A. C. Tube Adapter Harness

The new Carter Adapter Harness manufactured by the Carter Radio Co., Chicago, Ill., makes it possible to convert practically any battery operated set to AC tube operation. When making this conversion, it is not necessary to do any wiring or make changes in the set. The entire operation takes but a few minutes.

Simply remove the present tubes, disconnect the "A" and "C" batteries, insert the adapters which are part of the Carter Adapter Harness, into the tube sockets, insert the AC tubes, and attach the end of the Harness to the binding posts on the filament transformer. The terminals and wires are clearly marked.

Since the "A" and "C" batteries were disconnected, the "A" battery terminals, or leads, remain unused. The "C-" terminals or binding posts, should be connected to the "C-" binding posts with a short piece of wire. The receiver is then ready to operate.



The Eby A.C. Adapter Harness for 6-tube receivers.

After the set is converted the old volume control usually becomes inoperative. The most effective volume control for AC operated sets is a variable resistance connected across the aerial and ground terminals. The Carter No. 100 Auxiliary Volume Control consists of a suitable variable resistance on a 10 foot cord. The other end of this cord may be connected across the aerial and ground binding posts of a radio set. This permits adding a volume control to any converted set without changing the wiring.

Standard harnesses are available for 5, 6 and 7 tube sets, both with or without power tube.

New Eby A. C. Adaptor Harness

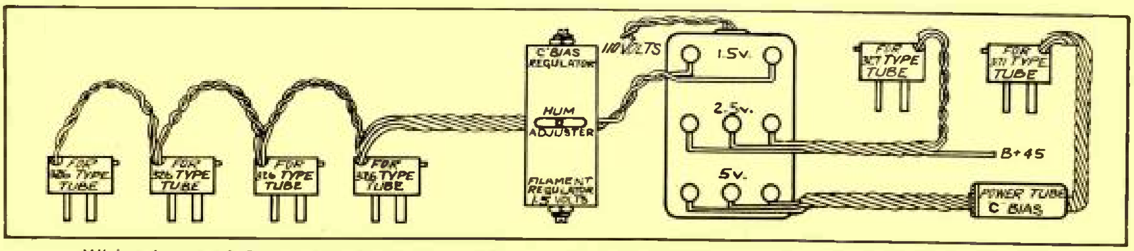
Accessory manufacturers have accorded serious thought to the problem of converting battery operated sets over to A. C. operation and solved it by the development of an A. C. adaptor harness whereby practically any standard five or six tube D. C. filament radio receiver, can be converted into an A. C. filament operated installation, without molesting any of the wiring within the receiver cabinet.

After a survey of the majority of popular receivers manufactured since the advent of radio broadcasting, the engineers of the H. H. Eby Mfg. Company, announce the development of an A. C. harness adaptor suitable for use with practically every standard five or six tube D. C. filament receiver. The only other things which are necessary to buy with this harness are the A. C. tubes and a filament supply transformer of standard make.

Lignole Adapts New Style Inlay for Kit Panels

The Lignole Corporation, manufacturers of Lignole Radio Panels, has recently adopted a new style of inlay in conjunction with their kit panels.

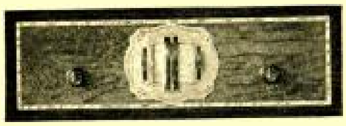
This inlay consists of a narrow strip of imported tulip wood bordered on each side by a narrow line of white holly and the whole, bordered by a narrow line of black ebony. This marqueterie, as it is called, is inlaid into the panel and serves to separate



Wiring layout of Carter A.C. Tube Adapter Harness, including A.C. tube transformer, for 6-tube receivers.

the body of the panel from the darker shaded margin or border which comes in contact with the cabinet.

This two-tone effect.as they term it, permits a panel to be placed in any style or make of cabinet irrespective of the shade of stain used in finishing the cabinet. Lignole panels are also made in the above two-tone effect



New Lignole panel with attractive inlay.

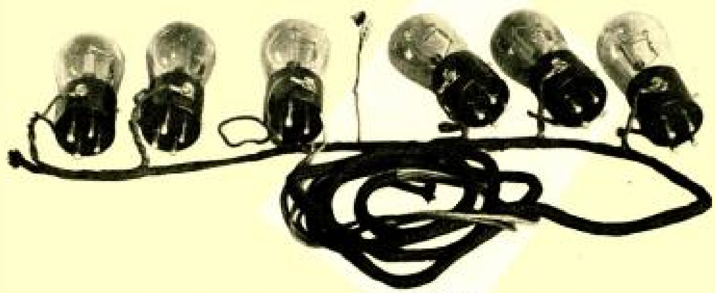
but instead of using the inlay have substituted in its place a narrow vein which in the same way serves to separate the two shades of the panel.

While these panels lack the extreme beauty and attractiveness contributed by the inlay, they are, nevertheless, a very attractive panel and represent a material saving in cost.

Arcturus "A-C Cable"

By means of a simple and flexible device, known as the "A-C Cable," it is possible to adapt many battery receivers to the use of alternating current tubes.

The "A-C Cable" is manufactured by the Arcturus Radio Company and is designed to adapt their A-C tubes



Arcturus A.C. Cable and special Arcturus Tubes.

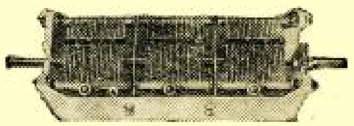
to a number of different and popular receivers.

The "A-C Cable" takes the form of the conventional battery cable. In the majority of cases it consists of three colored leads in a braided covering, having paired outlets spaced according to the tube arrangement in the receiver. It is only necessary to connect the A-C tubes to the cable by means of two small screws provided on the base of tubes, insert them in the socket and make the transformer connection to convert the average receiver to A-C operation. According to the manufacturer, the operation requires a screw driver and ten minutes. No changes whatever are made in the wiring of the receiver, all battery and eliminator connections being effected through the "A-C Cable" and the original set cable. With the exception of the transformer the power leads are usually identical with the D-C connections. As the Arcturus tubes are all of the four prong base heater type, no change in the detector socket is necessitated.

It has been necessary to design a special tube, providing the A-C Cable connection screws, for this purpose. The Cable tubes are manufactured with the same characteristics as the standard Arcturus A-C tubes, i.e., amplifier, detector, high-mu and power types, respectively the 28C, 26C 32C and the 30C.

Amsco Duo-Space Condenser

Amsco Products, Inc., of New York, specialists in tandem tuning apparatus, have brought out a line of extra-space condensers, having a spacing between rotor and stator plates of 32 thous-



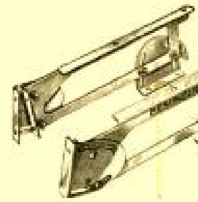
Amsco Duo-Space Gang Condenser.

andths of an inch, ten thousandths greater than standard types. These condensers, known as the Duo-Space, are made in single, double and triple units. The large spacing, in addition to contributing an accuracy essential to single dial arrangements, recommends their use in power oscillators and five watt transmitters.

Condensers built up in three or more gangs are often thrown out of alignment by different forms of mounting which place varying stresses on the frame. Condensers that match perfectly in the laboratory will often be found considerably out, and to different degrees depending on whether they are mounted with two or three screws, or base mounted. The possibility of discrepancies arising from this cause is also eliminated in the Duo-Space Precision three gang condenser by casting the frame in aluminum. A factor of safety characterizing the casting eliminates the possibilities of warp.

Benjamin Sub-Panel Support

With the increasing use of wider sub-panels, it is frequently advisable to use some auxiliary support in addition to the self-supporting brackets. The Benjamin Electric Manufacturing Company, of 128 So. Sangamon Street, Chicago, Ill., have devised a



Benjamin Sub-panel Supports.

very clever arrangement of this sort, using the four heel plates furnished with their adjustable bracket set No. 9029.

The supports thus made are adjustable to sub-panel heights of 1⅞" to 2⅞". The two brackets proper are used in the same manner as the ordinary rigid type bracket.

Muter Audiochoke

The Leslie F. Muter Company, 76th Street and Greenwood Avenue, Chicago, Ill., have placed on the market an audio choke designed to be used in the plate circuit of the detector tube and the plate circuit of the first audio frequency tube to prevent audio frequency regeneration. Since audio frequency regeneration tends to alter the frequency characteristics of a good audio amplifier and inject undesirable humps in the characteristic curve, it is desirable to use some form of choke, together with a by-pass condenser to prevent this reaction.

The Muter Audiochoke has been designed to have an inductance equal to that obtained by transformer secondaries, but has a D.C. resistance of only 445 ohms. The drop in B voltage across the choke is negligible thereby in no way reducing the efficiency of the power supply.

The effective inductance of the choke is 100 henrys when used with a 201-A type tube and may be used with tubes drawing plate current up to 15 milliamperes without becoming ineffective at any frequency.

New Muter Audiochoke.

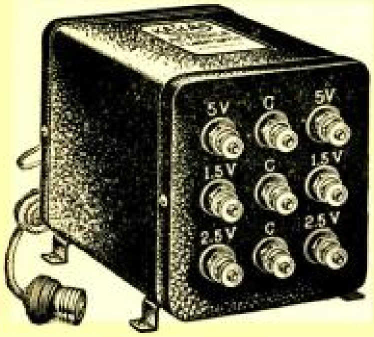
Since a by-pass condenser is essential, the Muter Company have included it in the case with the choke. This condenser has a capacity of 1 Mfd. and is tested at high voltage.

The Muter Audiochoke can also be used to advantage in the first and second stages of either a resistance or impedance coupled audio amplifier.

Karas A.C. Former

The Karas Electric Company, of 4040 No. Rockwell Street, Chicago, Ill., announce their new A.C. Former designed for supplying raw alternating current to the filaments of A.C. tubes.

The Karas A.C. Former has removable stand feet and long threaded binding posts so that it may be mounted on the sub-panel of the radio receiver, or used externally as desired. Together with the cord and plug for connecting the A.C. Former to the light socket, there are two wires protruding from the rear of the case which connect directly to the filament switch on the radio receiver. This saves having to tap or splice the light socket cable or the trouble of removing the plug from the light socket when the set is not in use.



Karas A.C. Former.

By providing a center tap on each of the low voltage windings at the electrical center, the proper "C" bias is supplied without the use of additional equipment.

There is a universal plug-in socket on the back of the A.C. Former where the "B" eliminator cord can be plugged in. In this way, the filament switch on the receiver turns on and off, both the "B" eliminator and the A.C. Former.

The A.C. Former is made in two types. Type 12 supplies filament potential for 12 tubes as follows: Eight 1½ volt type 226 tubes, two 2½ volt type 227 tubes and two 5 volt type 171 tubes.

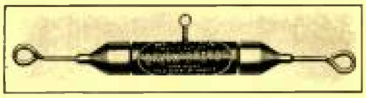
Type 13 supplies filament potential for 10 tubes as follows: Eight type 227 tubes and two type 171 or two type 210 tubes.

The Karas A.C. Former can be used in conjunction with any of the available Cable Adapter Harnesses on the market.

Daven Center Tap Resistors

To minimize the hum in electrified receiving sets, many manufacturers incorporate center tap A.C. filament resistors. The value of these resistors ranges from 2 to 60 ohms, depending upon the number of tubes and the current supply.

Efficiency of these center tap resistors depends upon how closely the tap approaches a true electrical center for grid return connections. To this end, the Daven Radio Corporation has developed a wire wound center tap A.C. resistor, that is wound from each end inward, with the two matched windings connected at the



Daven Center Tap Resistor.

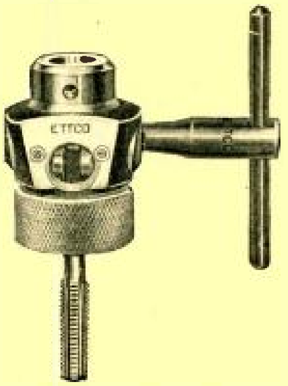
mid-point. It is claimed that this is the best known practice for arriving at a true node point.

Resistors of this type are now available to set constructors for application in any circuit calling for 10, 25, and 60 ohm sizes.

Ettco Tap Holding Chuck

A new line of Tap Holding Chucks have been added to the tools manufactured by the Eastern Tube & Tool Co., 594 Johnson Avenue, Brooklyn, N. Y.

This new Tap Chuck has some very new and novel features. The operator can see the two floating jaws actually gripping the square. The grip is positive as the square of the tap is held by the two floating jaws which are



Ettco Tap Holding Chuck.

tightened with a key. The jaws operate by means of a right and left hand thread. The two jaws are free to float transversely as their only function is to grip the square and prevent the tap from rotating. The tap is centered by three jaws which are closed in by the knurled collar, centering the tap dead true. The two gripping jaws for the square of the tap are made of a high carbon alloy tool steel properly heat-treated and ground to an accurate fit in the body. The lower centering jaws are also made out of an alloy steel properly heat-treated and ground.

The Chucks are furnished in three sizes. No. 1 size; capacity of round shank 1/4," capacity of taps 3/8". No. 2 size; capacity of round shank 3/8", capacity of taps 1/2". No. 3 size; capacity of round shank 1/2", capacity of taps 5/8". Two larger sizes are being designed.

The Tap Chucks can be furnished with backs threaded, tapered backs or with Morse taper shanks in same. Provision is made for pinning the threaded shanks securely in place. The Chucks are also manufactured with the back extended 1" so they can be used in tap holders of screw machines. The Tap Chuck fits directly into the tap holder and is held by a set screw. This takes the place of many tap bushings and if a change is necessary, can be made much quicker than replacing a tap in a bushing. The Tap Chuck drives taps more accurately than a bushing especially if the bushings are worn.

Drills, reamers, counterbores and other tools, can be used to advantage in the Tap Chuck by simply grinding any kind of a flat on the round shank of the tool. The Tap Chuck will drive them positive and true. It can also be used for multiple spindle operations, both drilling and tapping.

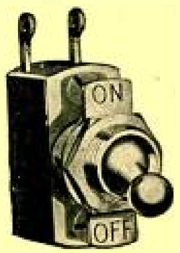
Bremer-Tully "B" Power Unit

The Bremer-Tully Manufacturing Company, of 520 So. Canal Street, Chicago, Ill. have introduced a new "B" power unit, which will supply a maximum of 150 volts and 125 milliamperes which is sufficient for all power tubes up to and including the 171 type. There is a variable voltage tap for the detector tube and two intermediate taps at 45 and 90 volts for the R.F. tubes and the first stage A.F. tube.

Saturn Power Toggle Switch

The Saturn Mfg. & Sales Co., Inc., 50 Beekman St., New York City, have introduced a new Power Toggle Switch for use in connection with socket power-operated sets.

This switch will handle six amperes at 125 volts or 3 amperes at 250 volts. The case is made of solid bakelite and the unit is of the single hole mounting type, designed to fit both thick and thin panels.



Saturn Power Toggle Switch.

The switch shown is of the single pole, single throw type, opening one circuit, and can be used with Power Sets, A-and B-Eliminators and Chargers.

The Saturn Power Toggle Switch is also made in O. P. D. T. type.

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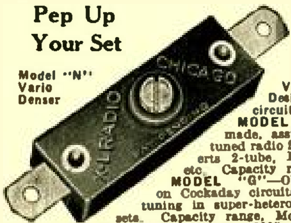

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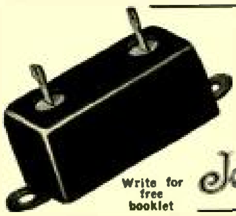
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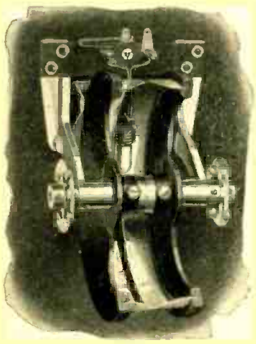

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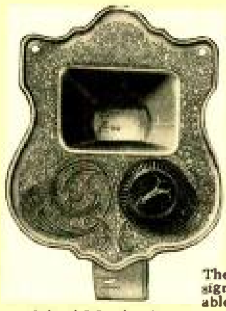

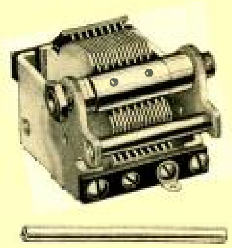

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Karas Electric Co.

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Cardwell, Allen D. Mfg. Co.
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Central Radio Laboratories.
Electrad, Inc.
United Scientific Laboratories.
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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.
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Yaxley Mfg. Co.

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Central Radio Laboratories.
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Electrad. Inc.
Hardwick, Field, Inc.
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Ward Leonard Electric Co.
Wireless Radio Corp.

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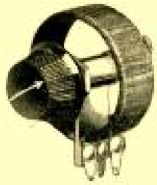

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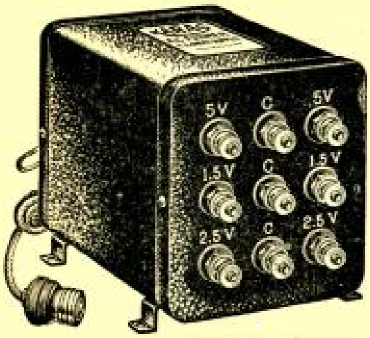

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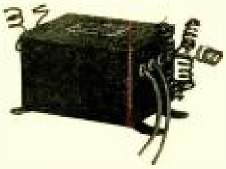

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