RADIO

Volume X — NOVEMBER, 1928 — No. 11

Radiotorial Comment

POLITICAL speeches may simultaneously be either the most or the least obnoxious kind of radio advertising—depending upon the political beliefs of the listener.

When a man ceases to criticize the radio conditions in his locality, he has lost his interest in radio. Then there is really something the matter with it.

Radio applause cards, once as numberless as the buffalos of the great plains, are now as nearly extinct. Advertising is killing them.

Good radio humor is the best of the twice-told tales. For if it "gets over" from a radio studio it will register where the teller is present. And it is always clean.

Television will soon add "synchronize" to the slang dictionary. Its meaning requires no definition, as applied to an individual, for anyone who has watched or manipulated a receiver screen.

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A RADIO operator has always been judged largely upon his proficiency in sending and receiving code. Wire telegraph operators were once valued likewise. So also was a bookkeeper gauged on his ability to add, and a typesetter by his speed and accuracy as a hand compositor. But nowadays type is set on a linotype machine, adding is done with an adding machine, and telegraph messages are sent and received by means of machine printers. Eventually, also, the great bulk of radio traffic will be sent by photoradio.

In each of these cases the operator has graduated to higher duties which require more technical knowledge and which command higher pay. The world is rapidly approaching the point where it will be difficult to find men to cope with the modern machines which are being created. Radio, in particular, is a new field and is destined to great progress. The radio operator who keeps in step with this progress is also destined to a great future.

* * *

AN SOS is a signal for a broadcast station to cease transmitting. No matter how trivial or how important its program, whether a jazz request number or an address by the President of the United States, it must give way to the distress call. This was absolutely necessary to prevent interference in the old days of spark transmitters. But with the use of continuous waves from vacuum tube transmitters it is as needless as a hitching post for automobiles. No broadcast station on 545 meters or under need cause any interference on 600 meters. The portion of this law which requires a broadcast station to maintain continuous watch on 600 meters is virtually a dead letter. In view of the progress which has been made since the law was passed, it should now be wiped off the statute books. Aside from the unnecessary annoyance that it may cause broadcast listeners it may cause a direct financial loss to a station which is broadcasting a sponsored program.

* * *

THE subject uppermost in broadcast discussion today is the probable effect of the Federal Radio Commission's order that nine-tenths of the stations change their wavelengths on Armistice Day. At first glance it might appear that in this new deal just as much satisfaction would have been created by dealing five hands, one to each zone, from a well-shuffled deck of cards.

Yet a little analysis shows that the deck has been carefully stacked in an endeavor to improve reception conditions for the listener. So, aside from the temporary inconvenience of changing the logs or dial markings of most of the stations ordinarily heard, the average listener will probably hear his favorite stations to better advantage than he did last winter.

To understand the plan upon which the new allocations are based, it is necessary to know that there are ninety-six channels or highways in the broadcast spectrum between 550 and 1500 kilocycles. Each of these channels is ten kilocycles wide, the modulating or sound frequencies extending for five kilocycles on both sides of the station's carrier frequency. Incidentally, since the station frequencies are designated in multiples of ten so as to give this ten kilocycle separation, it is more convenient and less confusing to omit the final cipher and to designate the channels by numbers from 55 to 150, corresponding to 550 to 1500 kilocycles.

Naturally a collision occurs whenever two or more stations are radiating energy into the same channel at the same time. If the stations are very powerful and are not given sufficient geographical separation, these collisions or heterodynes will be heard as a high-pitched singing note, especially where the receiver is located between the interfering stations.

Of the ninety-six channels, six are assigned exclusively to Canada, leaving ninety channels for the use of six hundred and twenty-four stations in the United States and Alaska, an average of nearly seven stations per channel.

Heretofore, no station has occupied a clear channel unless the other stations assigned to its wavelength were not broadcasting. For instance, due to the difference in time, some Pacific Coast stations could be heard without heterodyning only after their Eastern channel-sharers had shut down. But as a general rule no station was free from a heterodyne whistle during some period of its operation. What could the Commission do to remedy the trouble?

* * *

There were two answers to the problem of preventing collisions on the radio highways: one to reduce the number of stations which employ them, and the other to reduce the time that some of the stations operate, thus allowing two or more stations to use the same channel during different periods, much as a thrifty landlord used one set of beds to accommodate three shifts of miners in the early days of the gold rushes. The Radio Commission adopted the latter plan.

Forty channels were cleared, eight in each zone. One-fourth of these were assigned exclusively for the use of single stations. On the other three-fourths, two or more stations are limited in time so that they do not operate simultaneously. Most of them are high-power stations. Consequently, during the night hours, there should be little or no interference on nearly one-half the dial. According to the Commission's original order the clear channels are Nos. 64 to 87 inclusive (excepting 78) and channels 97 to 119 inclusive (excepting 101 and 112). Subsequent allocations may slightly change these figures. This should revive interest in long distance reception on these channels.

Of the remaining fifty channels, four are assigned for simultaneous use in not less than two zones, thirty-five for not more than three zones, five for all zones for stations whose power does not exceed 1000 watts, and six for all zones for power not over 100 watts. The last two classifications cover 317 stations. Thus more than half the number of stations are accommodated on eleven channels and nearly a fourth of them are found on three local service channels, number 120 with 52, 121 with 45, and 131 with 51 stations.

These allocations, as well as this interpretation thereof, are somewhat tentative and many of them will be changed, if the number of protests is any criterion. But zone assignments of power and particular frequencies cannot be greatly altered because of the interdependence of the entire set-up.

* * *

Another revolutionary order which will be bitterly opposed by the stations, and as heartily approved by the majority of listeners, is that prohibiting the broadcasting of chain programs from more than one station for more than one hour a day where the chain stations are within three hundred miles of each other.

So the eleventh of November will probably mark the beginning of the end of much of the interference that the listener has endured for many months. But in the meantime active hostilities are in progress between station and station and between stations and the Commission. Many stations and communities are up in arms against what they consider unjust discrimination. Consequently, even if Armistice Day brings an armistice in this radio warfare, it will leave many hard feelings to be softened by subsequent peace negotiations.

The Short-Wave Trans-Atlantic Radiophone

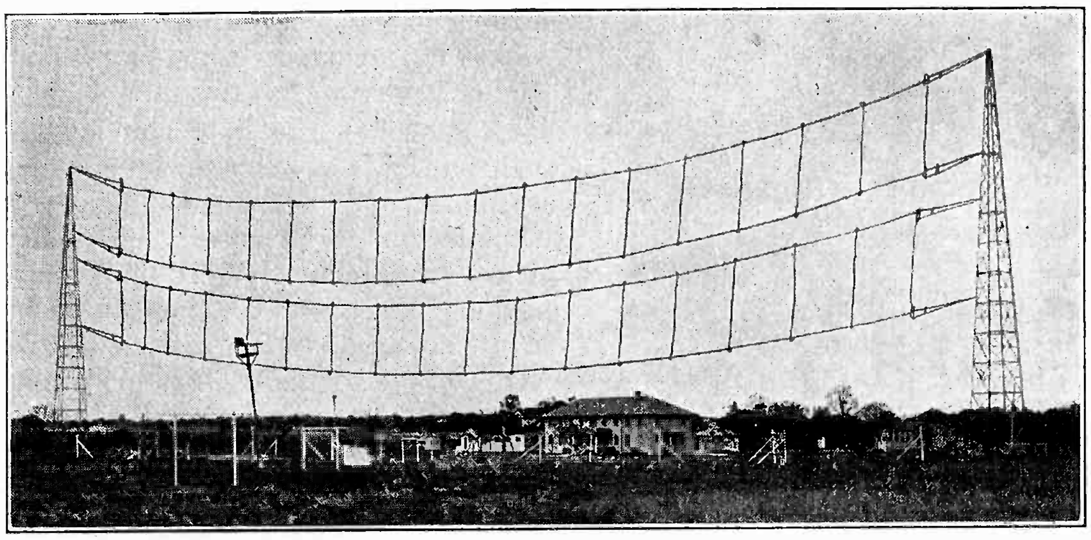
By S. R. Winters

A regular radiotelephone service on short waves between the United States and England is soon to be in effect. This is a departure in that two-way communication is to be attempted on short waves, instead of the long waves by means of which the service was introduced. The Bell Telephone Laboratories, Inc., recently erected buildings and installed short-wave receiving equipment at Netcong, New Jersey, and the British Postoffice has completed a short-wave transmitting station in Scotland.

The radiotelephone calls between this country and Great Britain now average 30 a day, and occasionally the number of international radio conversations may reach 60 within twenty-four hours. To accommodate this increasing traffic as well as to determine the suitability of short waves for regular, dependable long-distance communication, the duplex, two-way system has been constructed in the two respective countries. Until quite recently England had no short-wave transmitting station for communication with the United States. The new short-wave receiving station at Netcong, New Jersey, is a mate for the recently built English high-frequency transmitting station.

The use of a radiotelephone for dependable communication over a distance exceeding 3000 miles requires the application of three pairs of short wavelengths. The vagaries of short waves are such as to require different frequencies for effective operation at varying periods of the day and night. For example, in the two-way trans-Atlantic radiotelephone service one wavelength will be used during daylight hours, a different wavelength will be employed for night service, and still a third wave channel of a frequency at variance with the other two will be necessary for effective communication when a portion of the signal path is shrouded in darkness and the other part illuminated by daylight.

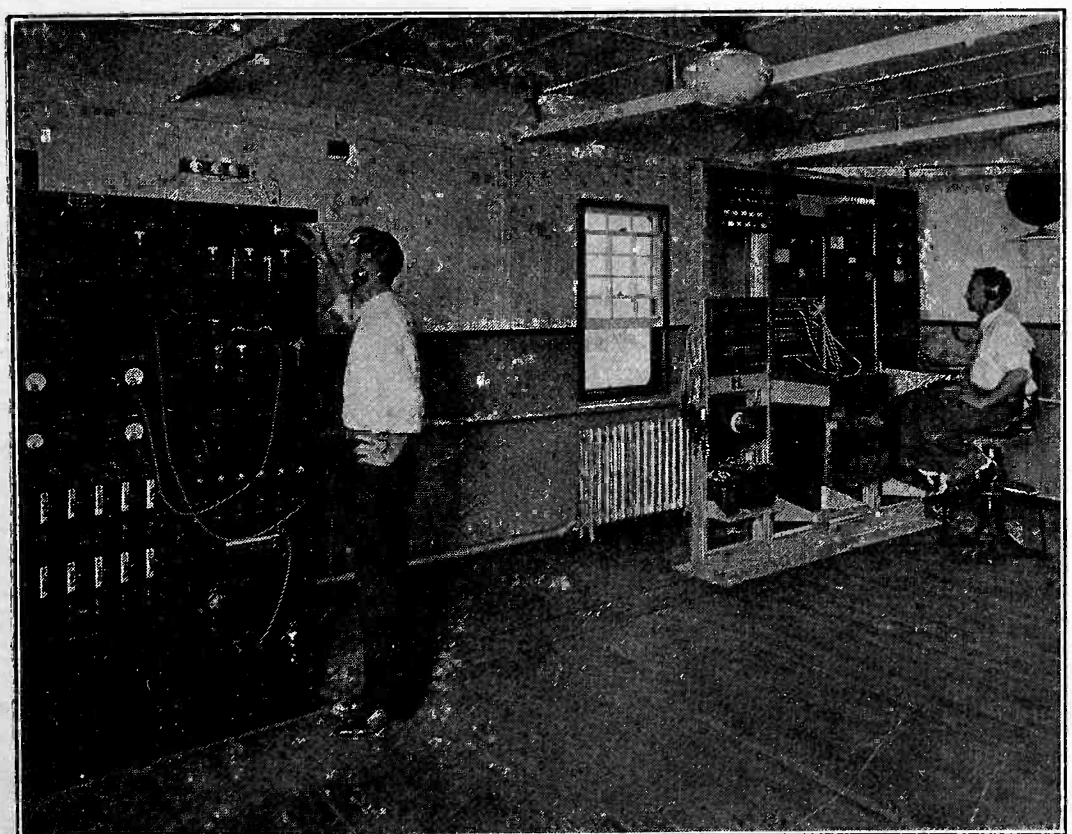
In this particular, the short-wave service differs essentially from that of long-wave trans-Atlantic radiotelephone communication. At present, in the use of long wavelengths, two-way operation is effected on a single wavelength by means of the single-sideband method of transmission and voice-operated relays. This arrangement permits of telephone currents traveling in but one direction on the circuit at any given moment. Single-sideband transmission and working both ways on one wavelength are not now practicable commercially on short waves, contend engineers of the Bell System. The voice-operated devices, however, are employed in connection with two slightly different wavelengths, one of which is used for eastbound speech and the other for westbound conversation.



Short-Wave Telephone Transmitting Station at Deal, N. J.

The short-wave transmitting station of the Bell Telephone Laboratories is located at Deal, New Jersey—occupying the grounds and housed in the building originally dedicated to the innovation of exchanging radiotelephone communications between shore and ship stations, about ten years ago. This is fitting that the same location should mark the inauguration of two such signal achievements in the art of radiotelephony. The ship-to-shore experiments were conducted from 1919 to 1922. Quite recently, a marine-service company in California inaugurated a regular radiotelephone service hourly between the Los Angeles harbor and a fleet of steamers and tugboats operating in the southern California waters.

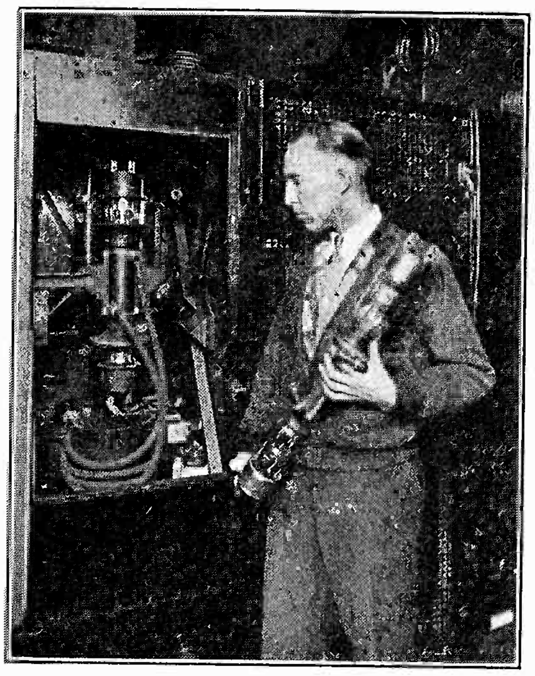
The New Jersey short-wave transmitter for trans-Atlantic communication is subject to quartz-crystal control, a thin slab of this mineral—encased in a constant temperature cabinet—governs the transmitting frequency or wavelength with remarkable precision. The shifting from one wavelength to another in the variable frequency operating schedule is effected in less than ten minutes. This change in operating wavelengths merely requires the substitution of one slab of quartz crystal for another of different thickness and the insertion of different inductance units in the output circuits of the high-frequency amplifier. These changes in operating conditions are not only dictated by variations in day and night periods but by seasonal de-



Short-Wave Receiving Station at Netcong, N. J.

mands—the change from summer to winter or vice versa, for example.

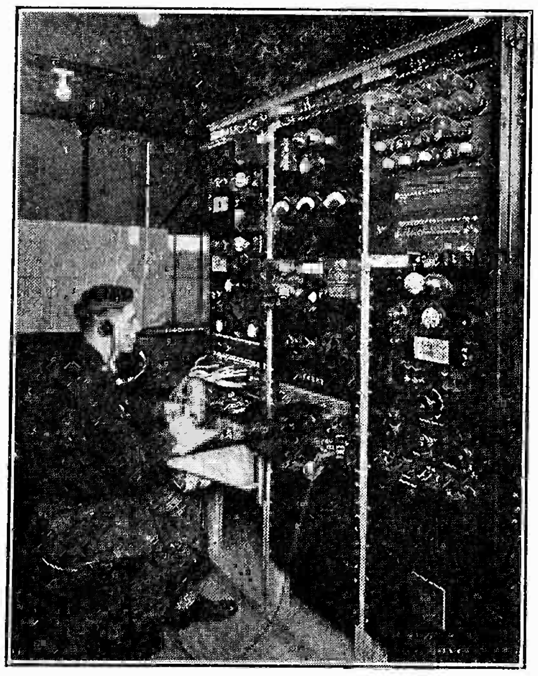
The short-wave receiving station at Netcong, New Jersey, is an absolutely new link in the radio and telephone communication chains of the Bell System—the buildings having been recently erected and the equipment newly installed. Both stations are linked by land wires with communication headquarters



Transmitting Equipment

of the Bell Telephone Laboratories at 24 Walker Street, New York City. At this point, the two one-way circuits converge and are thus transformed into a two-way circuit for connection through the long-distance switchboard to the lines of the Bell System.

This new undertaking of establishing two-way radio communication between America and England on short-waves



Speech-Input Monitoring Panel at Transmitting Station

should further contribute to our knowledge of a band of frequencies which radio amateurs discovered as having great intrinsic value. Already, the one-way trans-Atlantic communication has disclosed that static or atmospheric disturbances discriminate against long waves in favor of short waves for such long-distance service. Short waves, it has also been found, do not travel so nearly in a bee-line to their destination as do the long wavelengths. The exact path of short waves, however, remains to be defined and charted. Our knowledge of the skip effect and the fading of signals when employing short waves should be contributed to measurably by this regular radio service for spanning the Atlantic Ocean.

SIMPLIFIED FORMULAS FOR REACTANCE

By Arthur Hobart

A delightful simplification can be made in radio's most fundamental equation, which says that the total reactance of a series circuit is equal to the difference between the inductive reactance and the capacitive reactance.

It is ordinarily expressed as $X = \omega L - 1/\omega C$, where X is the reactance in ohms, ω is $2\pi f$, f being the frequency in cycles per second, L is the inductance of the coil and C the capacity of the condenser. The circuit is resonant when $\omega L = 1/\omega C$, the reactance then being zero and the impedance to the flow of an alternating current being equal solely to the resistance of the circuit.

But the prodigious labor involved in calculating a resonance curve with this formula may be greatly lessened by simplifying it to meet the conditions found in practice. As the circuit conditions are constant when it has been tuned to resonance for a given frequency, the only variable is the non-resonant frequency, for which the impedance is to be found.

Thus it is common practice to use a 170 microhenry coil with a .0005 microfarad condenser to cover the broadcast band from 550 to 1500 kilocycles. A frequent problem is to determine the proportionate interference that may be caused by a carrier wave in a channel close to that to which the circuit is tuned. The reactance to the tuned frequency is zero and that to the interfering frequency is approximately $X = 4\pi L d$ when d is the difference in *megacycles* between the two frequencies and L is expressed in microhenries.

The value of this approximation can best be illustrated by a typical problem. Assume that a circuit consisting of a 170 microhenry coil and a .0005 mfd. condenser is tuned to 1000 k.c., i.e. $X=0$ at 1000 k.c. What is its reactance to 990 k.c.?

By the standard formula it is first necessary to find the $L\,C$ value of the circuit, either from a published table or from the formula $L\,C = 1/(2\pi f)^2$, which in this case is .02532. From this find C as $.02532 \div 170 = .000149$ mfd. Then $X = 6.28 \times .990 \times 170 - 1 \div (6.28 \times .990 \times .000149) = 1057.4 - 1079.0 = 21.6$ ohms.

By the approximate formula $X = 4\pi \times 170 \times .01 = 21.4$ ohms, and how much easier it is to check the correctness of your work!

For a 5-ohm circuit tuned to 1000 k.c., the impedance is 5 ohms to 1000 k.c., and $\sqrt{5^2 + 21.4^2} = 22$ ohms to 990 k.c., or 4.4 times greater. So, for equal signal input, the 1000 k.c. signal is 4.4 stronger than the 990 k.c. signal at the circuit output, or the 990 k.c. signal is less than one-fourth as strong as the 1000 k.c. signal.

The method whereby this approximation, and also a very simple exact equation for reactance, may be derived is an interesting exercise. At the resonant frequency f_R, the inductive reactance is equal to the capacitive reactance,—$2\pi f_R L = 1/2\pi f_R C$, whence $L\,C = 1/(2\pi f_R)^2$ and $2\pi L = 1/(2\pi f_R{}^2 C)$. At any frequency f, $X = 2\pi f L - 1/2\pi f C =$

$$\frac{(2\pi f)^2 L\,C - 1}{2\pi f C} = \frac{\dfrac{(2\pi f)^2}{(2\pi f_R)^2} - 1}{2\pi f C}$$

$$= \frac{f^2 - f_R^2}{2\pi f_R{}^2 C f} = \frac{2\pi L (f^2 - f_R^2)}{f}$$

Let $f = f_R \pm d$, $f^2 = f_R^2 \pm 2 f_R d + d^2$, $f^2 - f_R^2 = \pm 2 f_R d + d^2 = d(\pm 2 f_R + d)$

So $X = 2\pi L d \left(\dfrac{\pm 2 f_R + d}{f_R \pm d}\right)$ and if d/f_R is small, $X = 4\pi L d$.

As an example of the use of the exact formula, consider a circuit tuned to 1500 k.c., using a 170 microhenry coil. What is the reactance to 1510 and 1490 k.c.?

$2\pi L = 6.2832 \times 170 = 1068.124$, $d = \pm .01$, $f_R = 1.5$.

$$X = 1068.124 \times .01 \left(\frac{\pm 3 + .01}{1.5 \pm .01}\right)$$

$$= 10.68 \times 1.993 \text{ or } -10.68 \times 2.0066$$

So the reactance to 1510 k.c. is 21.28 ohms and to 1490 k.c. is 21.43 ohms. By the approximate method, $X = 21.4$ ohms for either case. The magnitude of the error introduced by this approximation is about $\pm d/2f_R$, which is negligible in most practical cases.

An equation of almost equal simplicity can be developed for a parallel or non-resonant circuit. Assuming that the losses due to resistance are small, and consequently neglecting R, the reactance X of a parallel circuit is $\omega L/(1 - \omega^2 LC)$. Adopting the same method and notation as in the case of series reactance, this can be successively reduced to

$$\frac{-2\pi L f_R^2}{d}\;\frac{1 \pm d/f_R}{(\pm 2 + d/f_R)} \text{ or}$$

approximately $X = \dfrac{\mp \pi L f_R^2}{d}$

This method is much simpler and easier than the usual method of finding susceptances and reactances and is just as accurate.

What Is an Underground Antenna?

By G. M. Best

Each radio season sees the advent of a crop of devices commonly advertised under the name of "underground antennas." To read the claims for such devices, as set forth in their published advertising and mail circulars, creates an expectation that they will give absolute freedom from static, power line interference, and other annoying noises usually present when a conventional type of antenna is used, and at the same time with no sacrifice of distance, selectivity or other impairment of operation of the receiving set.

As this seemed too good to be true, an investigation of the various devices of this type was made, with a view to determining their merits, if any, and also to obtain an accurate definition of an underground antenna as conceived by its inventors.

The principal patents covering underground antennas were granted to James Harris Rogers of Hyattsville, Md., in 1919 and 1920, and we understand that these patents have been sold by Mr. Rogers to other interests. A study of the patent papers discloses some very interesting data, and in Fig. 1, a reproduction of one of the many types of antenna systems covered by Mr. Roger's patents is shown, as a typical example.

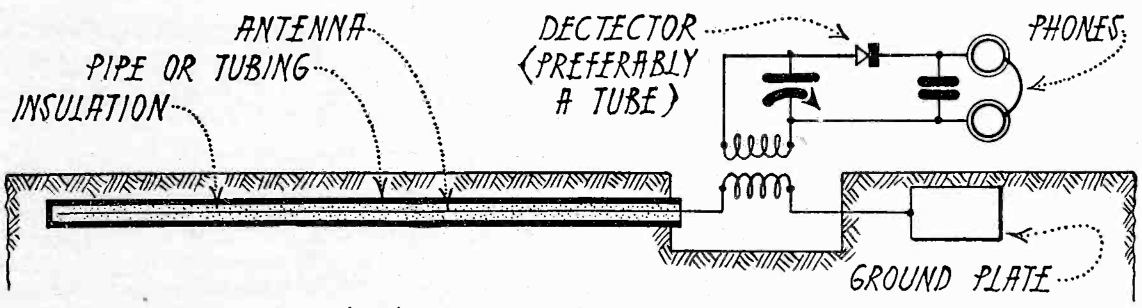


Fig. 1. Rogers Underground Antenna

The principal claim covering this type of antenna defines the antenna as "A radio signaling system comprising an antenna extending horizontally substantially parallel to the surface of the earth and insulated therefrom, a metallic covering inclosing said antenna but insulated therefrom and in intimate contact with the earth substantially throughout its length, signal instruments associated with said antenna, and a balancing connection on the opposite side of said instruments."

Referring to Fig. 1 it is obvious that the underground antenna consists of an indeterminate length of insulated wire enclosed in a metal sheath such as a lead cable, buried sufficiently so that the sheath is in good electrical contact with the earth, and parallel to its surface, the lead-in being brought to one side of the coupling inductance of the receiver, the opposite end of which is grounded. Many variations of this method are covered by the patents, including such an arrangement as is shown in Fig. 2, in which equal lengths of buried, shielded wire are placed on each side of the coupling inductance, and no ground connection whatsoever is used.

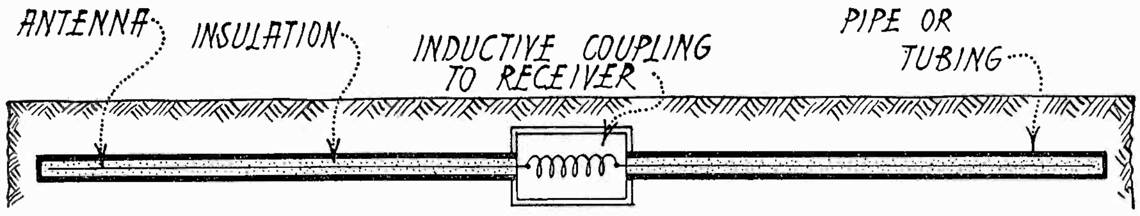


Fig. 2. Underground Antenna of Equal Sections

Other variations place the shielded cable on top of the ground but in contact therewith; place the cable on supports so that it is elevated a few inches above the earth; and several of the arrangements include grounding of the far end of the buried cable instead of insulating it as is done in Figs. 1 and 2.

Dr. Rogers developed his various underground systems before and during the World War, his first application for patents being made on May 2, 1917, and to him should go the credit for the remarkable work which he did at a time when radio was in its infancy and the apparatus with which he had to work was necessarily of crude form. Being interested in knowing just what Mr. Rogers thought of the various so-called underground antennas being sold to the general public, a letter was addressed him on the subject, and the reply thereto is reproduced below:

Rogers Radio Research Laboratory
Hyattsville, Maryland

August 22, 1928.

Editor, Radio

Sir: My brother Dr. J. Harris Rogers, who is unwell, begs me to acknowledge receipt of your kind letter of August 10, and to thank you for the credit you propose to give him for his pioneer work in underground and underwater radio, in your valuable publication.

His attention has been called to various publications and advertisements of devices utilizing the underground principle and making exaggerated claims, for which he is in no way responsible, and which are misleading and unwarranted, and likewise unjust to himself and to the public.

Referring to the class of devices referred to in your letter, he is frank to say that in his opinion they are not comparable in efficiency with the elevated antenna or the underground antenna when buried substantially parallel with the surface of the earth.

Again thanking you for your esteemed letter, I beg to remain,

Very truly yours,

(Signed) Jas. C. Rogers.

Having thus received confirmation of our opinion from the man best informed on the subject, a further investigation was made as to the nature of the various devices being sold, and the results obtained with them when used with an average broadcast receiver.

Practically all of them consist of a metal container, usually sealed and made of brass or copper, to which is connected a length of lead-in wire. In one or two specimens, the container was filled with a mixture of charcoal and common salt, the assumption apparently being that after the device had been buried for some time, the moisture in the soil would penetrate the container and make a better contact between the lead-in and ground. Some of the patent grounds which do not claim to be underground antennas have various combinations of chemicals, chiefly copper sulphate, which when combined with moist soil is supposed to provide an exceptionally good ground. This phase of ground connections is covered in detail in an article by Heckert Parker in August, 1928 Radio.

All of these devices have ordinary rubber and cotton covered lead-in wire, and the accompanying instructions direct the buyer to install it directly outside the wall of the house, under the window through which the lead-in wire is to be brought. From our own experience, when used with a broadcast receiver having an average degree of sensitivity, the results were so poor as to make the set useless except for local stations.

Experiments with a real Rogers antenna, similar to Fig. 1, using a sensitive superheterodyne, showed that a range of 500 miles at night, in the winter, might be expected, with loud speaker volume, from stations having a power of at least 1000 watts. The static level was very much lower than when using an elevated antenna, 40 ft. above the ground, and 80 ft, long. Although the volume on distant stations was much less with the underground antenna, a well-defined reduction of static to signal ratio was noted, and except for stations at distances of over 500 miles, the Rogers antenna was preferable.

However, when using the underground antenna with a 7-tube tuned r.f. set of well-known make, the results were much poorer than those obtained with the superheterodyne, due of course, to the lower degree of sensitivity in the tuned r.f. set. Stations 500 miles away which came in with good volume with the elevated antenna, could not be heard with the underground antenna, and this performance was made with the underground antenna arranged in such a manner as to receive the signals of the distant station to the best advantage. On local stations, however, the performance of the set was very satisfactory, and while the static level on the elevated antenna was so far down as to be barely noticeable, a difference could be detected when the underground antenna was used.

So much for the conventional buried wire in metal conduit. Several of the buried container antennas were then connected to the superheterodyne, and the results compared with those obtained with the Rogers system. Distant stations could not be heard, and only those locals which were within 6 or 7 miles of the receiver could be picked up with sufficient volume to give a satisfactory performance. In fact, with the superheterodyne, better results were obtained when a good water-pipe ground connection was used, with no antenna, than with the buried antenna. Hence, the conclusion was reached that if the lead-in from the buried antenna was cut off close to the ground, and only the lead-in used, better results would be had, and this proved to be the case. How much better it would be, then, for one to dig a small trench, say six inches deep, out through the back yard for a distance of fifty feet or more, and bury therein a length of lead covered wire, rather than to spend more money, and install what actually is nothing but a high resistance ground, with a small effective capacity thrown in.

It is necessary to give the devil his due, however, for one device proved to be quite satisfactory with sets such as the superheterodyne, and was the nearest to being an underground antenna of any of them. This device consisted of a sealed metal container, in which was coiled a roll of lead covered wire perhaps 60 ft. long. The wire passed through a hole in the container, and a 15 ft. piece was provided for the lead-in. Directions for installation called for burying the device in a vertical position, directly under the window through which the lead-in would pass, and did not call for any section of buried wire like the Rogers system.

The station log obtained with this antenna, using a superheterodyne, proved that a considerable amount of energy was being collected by the antenna, and that as compared with an elevated antenna, it was preferable except for the reception of extreme distance, in which case the elevated antenna was by far the best of the two. But the strangest part of the whole thing was that when the coil of wire was removed from the can, and laid out flat on the ground, the results were much better than when the coil was wound up and sealed within the buried container. "Why not eliminate the metal container then, dig a trench for the cable the same as for the Rogers system, and do a real job of it?" you might ask, but this would never do, for who would dare ask ten bucks for 75 ft. of lead covered wire? A copper-plated can filled with mystery looks ever so much more worth while to the average uninformed radio fan. Of course, digging the trench is a lot of bother, and conditions may be such that there is no room for a real Rogers antenna, which is the best argument the patent ground makers can bring forth.

A fair idea of how much money must be made on such devices can be gained by the writer's experience in answering a number of advertisements concerning them, for where the first quotation was list price, as advertised, subsequent follow-up letters gradually brought the price down until in one case the reduction amounted to nearly 70 per cent. It would be foolish to assume that they were not making a profit even at 70 per cent discount, so the reader can draw his own conclusions.

The moral of all this is that if you are satisfied with local reception, a short elevated antenna will give you the results you want with practically no static, except in the summer months, and unless the elevated antenna is impractical due to the location, the expense of a factory made underground antenna is not warranted. If you expect to receive distant stations, however, do not be disappointed if you meet with failure, for while you may find the static level very much lower than before, you will probably find the signal level has gone down in much the same proportion. So if you buy one, patronize the firm with the money-back guarantee and here's hoping you get your money back.

NEW SYSTEM FOR DETERMINING SHIP'S POSITION

A radio acoustic system for determining the position of a survey ship when it is beyond the visibility of shore objects has been developed by the U. S. Coast and Geodetic Survey. As described in the Survey's special publication No. 146, it consists essentially of a radio transmitter at each of two widely separated shore stations and a radio receiver on the ship.

Each transmitter automatically radiates a characteristic signal whenever a submerged microphone is disturbed by the explosion of a bomb close to the ship. This disturbance or noise is also instantaneously transmitted by a submerged microphone at the ship. At varying periods of time, depending upon the distance from the two shore stations, their radio signals are also received. As the speed of sound in water is definitely known, as are also the station locations, the ship's position may be quickly plotted on the survey map.

When the position of the ship is wanted, a small bomb is fired in the water alongside. The instant of the explosion is automatically recorded on a chronograph aboard the ship. The sound of the explosion disturbs the submerged microphones at the shore stations and their resulting characteristic radio signals are received and recorded on the ship's chronograph. The ship thus obtains the time of travel of sound in sea-water from her position to each of the known positions of the shore station microphones, and therefrom is figured the distances. This method has successfully been used with a ship 75 miles away from the shore stations.

RADIO SIGNAL TRANSMISSIONS OF STANDARD FREQUENCY, OCTOBER TO MARCH

The Bureau of Standards announces a new schedule of radio signals of standard frequencies, for use by the public in calibrating frequency standards and transmitting and receiving apparatus. This schedule includes many of the border frequencies between services as set forth in the allocation of the International Radio Convention of Washington which goes into effect January 1, 1929. The signals are transmitted from the Bureau's station WWV, Washington, D. C. They can be heard and utilized by stations equipped for continuous-wave reception at distances up to about 500 to 1000 miles from the transmitting station.

The transmissions are by continuous-wave radiotelegraphy. The signals have a slight modulation of high pitch which aids in their identification.

Information on how to receive and utilize the signals is given in Bureau of Standards Letter Circular No. 171, which may be obtained by applying to the Bureau of Standards, Washington, D. C. Even though only a few frequency points are received, persons can obtain as complete a frequency meter calibration as desired by the method of generator harmonics, information on which is given in the letter circular. The schedule of standard frequency signals is as follows:

RADIO SIGNAL TRANSMISSIONS OF STANDARD FREQUENCY

Schedule of Frequencies in Kilocycles

Eastern Standard Time	Oct. 22	Nov. 20	Dec. 20	Jan. 21	Feb. 20	Mar. 20
10:00—10:08 P. M.	550	1500	4000	125	550	1500
10:12—10:20	600	1700	4200	150	600	1700
10:24—10:32	650	2250	4400	200	650	2250
10:36—10:44	800	2750	4700	250	800	2750
10:48—10:56	1000	2850	5000	300	1000	2850
11:00—11:08	1200	3200	5500	375	1200	3200
11:12—11:20	1400	3500	5700	450	1400	3500
11:24—11:32	1500	4000	6000	550	1500	4000

Electric Phonograph Pick-up Units

A Description of Their Methods of Operation and Suggestions for Improvement of Tone Quality

By FRANCIS CHURCHILL

WHILE many different phonograph pick-up units are available, but little information is given as to their proper use. An electric pick-up unit usually consists of a permanent magnet, a field coil and a moving armature. The armature is actuated either directly or through a link coupling, by the phonograph needle. The magnetic type is the most popular and seems to have the best frequency characteristic.

The frequency at which the needle moves across the groove of the record determines the pitch of the sound produced. The needle moves an armature, which in turn generates a voltage in the field coil, since it is cutting lines of force produced by the permanent magnet. This voltage is then applied to an audio frequency amplifier and loud speaker and is reproduced as sound.

As the design of the pick-up unit cannot be easily changed by the experimenter, the output frequency characteristics are not variable for a particular unit. That unit may not be very good on the low frequencies, or perhaps on the high frequencies, but by proper use it may be made to give satisfaction.

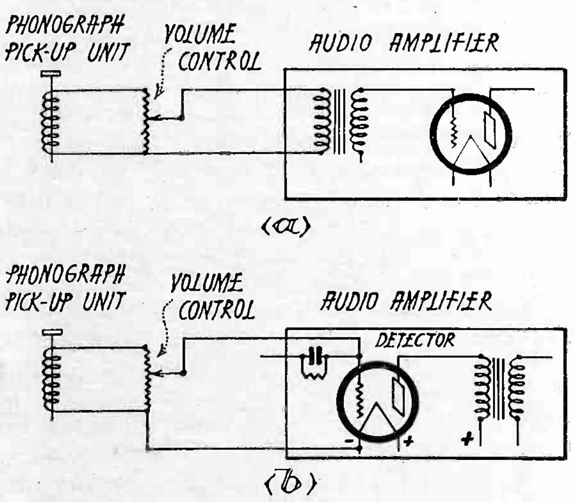


Fig. 1. Usual Methods of Connecting Pick-up Unit

Fig. 1 (a) and (b) show the usual methods of connecting a unit into the audio amplifier of a radio set. The ordinary pick-up unit has an impedance of about 1000 ohms at the low frequencies and may rise as high as 20,000 ohms at 5000 cycles, as shown in Fig. 2, whose curves were made with a standard impedance bridge and are typical.

When such a unit is connected as shown in Fig. 1 (a), the high frequencies may be lost if the volume control is of too low a value, since the load would then be equal to the pick-up or generator impedance at the lower frequencies. If the resistance is made high enough so that the pick-up unit works into, in effect, an infinite impedance, then a more uniform voltage output would be obtained for all frequencies. However, in such a case the primary of the first audio transformer would be across a variable impedance, depending upon the volume control setting, and so would not amplify uniformly.

Considering only the first transformer in the usual two-stage audio amplifier, the impedance across its primary should not be over 10,000 to 20,000 ohms. With impedances higher than this the low frequencies are lost, as also are generally the high frequencies. This means a peaked amplifier and poor tone quality. This is likely to happen at certain volume control settings if the resistance happens to be greater than 50,000 ohms. With this same arrangement at very low volume settings or at the highest settings, the primary of the audio transformer will be connected across a low impedance, which will improve the low frequency response and also the high end. This is undesirable, since changing the volume causes a change in quality.

A good way to get around this trouble is to connect the volume control as an ordinary variable resistance in shunt to the pick-up unit. With such a connection, the maximum impedance across the transformer will be somewhat less than that of the pick-up unit, which means a fairly low impedance at any volume control setting. This is desirable because the characteristic of the first audio transformer stays the same, as does the complete amplifier.

Let's see what happens when such a low impedance is connected across the amplifier. Curve A in Fig. 3 is that of a popular type of audio transformer when connected across a detector tube having about 20,000 ohms plate impedance. Curve B shows the same transformer with a pick-up unit across it. Due to the lower impedance, the low frequency response is much better and the transformer is nearly perfect on the lower end. However, the upper end has an enormous peak. Tests on a number of makes of transformers showed the same effect with the peak ranging from 4,000 to 7,000 cycles. Such a peak would cause over-amplification of the higher frequencies and needle scratch.

All audio transformers have a certain amount of leakage reactance and the secondaries have distributed capacity and capacity to ground, as well as the input capacity of the vacuum tube across it. All of these capacities resonate with the leakage reactance in such a way as to

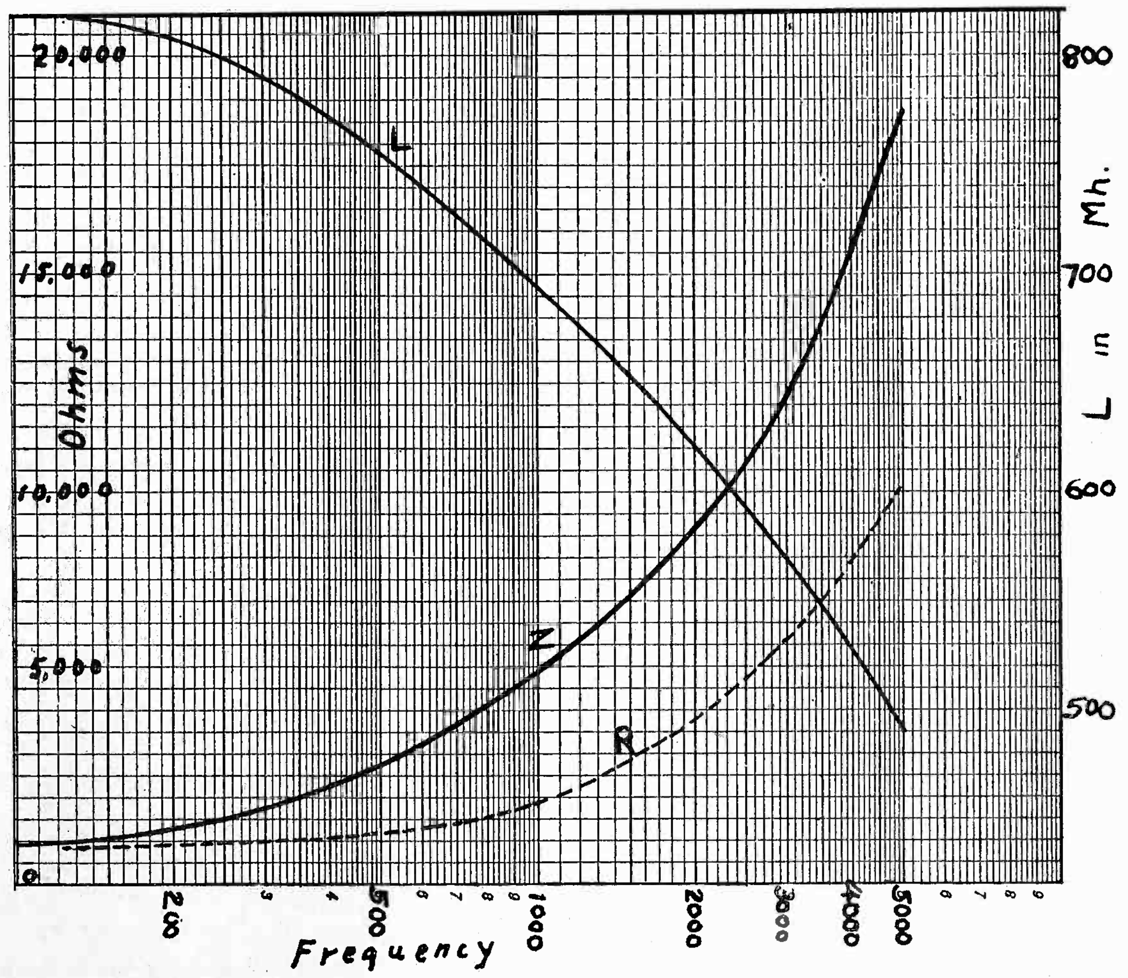


Fig. 2. Resistance, Inductance and Impedance Curves of Typical Pick-up Unit

cause a peak in the high frequency range. This leakage reactance can be increased by adding an external inductance in the primary circuit, which is exactly what we have done when connecting the pick-up unit across the primary. Naturally the lower the resistance in series with this resonant circuit effect, the higher will be the resultant peak. The pick-up unit has a fairly low resistance and so the curve B of Fig. 3 is obtained. There are two ways of overcoming this peak but first let us see whether it is desirable to eliminate it.

If the rest of the audio amplifier is not peaked on the high frequencies, such a peak in the first transformer can be put to good use. When the volume control resistance has a maximum value of say 10,000 ohms, the pick-up unit will not give a good high frequency response and the lower this value of resistance the poorer the response. Then the peak in the amplifier practically offsets the droop in output of the pick-up unit and so an excellent sound output is obtained over the whole range of frequencies.

Suppose that the amplifier has too high a peak or that the pick-up unit has naturally a greater output at high frequencies, then it would be desirable to eliminate this peak. This can be easily done in two ways; by inserting a 10,000 or 20,000 ohm resistance directly in series with the transformer primary, or by inserting a higher resistance in the grid return of the secondary.

The first scheme has the objection of causing a drop in the low frequencies as well as the highs, since the curve A will generally be obtained, but it has the advantage of being very simple to install, since it can be external to the radio receiver. The middle frequencies are not diminished, since even 20,000 ohms is only a very small portion of the transformer primary impedance at these middle frequencies.

The second scheme has the advantage of not affecting the low frequencies but does drop the higher ones. It has the disadvantage of having to be inserted in the audio amplifier and should not be used with a detector tube input, since the high frequencies would be practically lost.

Fig. 4 (a) and 4 (b) show the connections for these two schemes. In the latter,

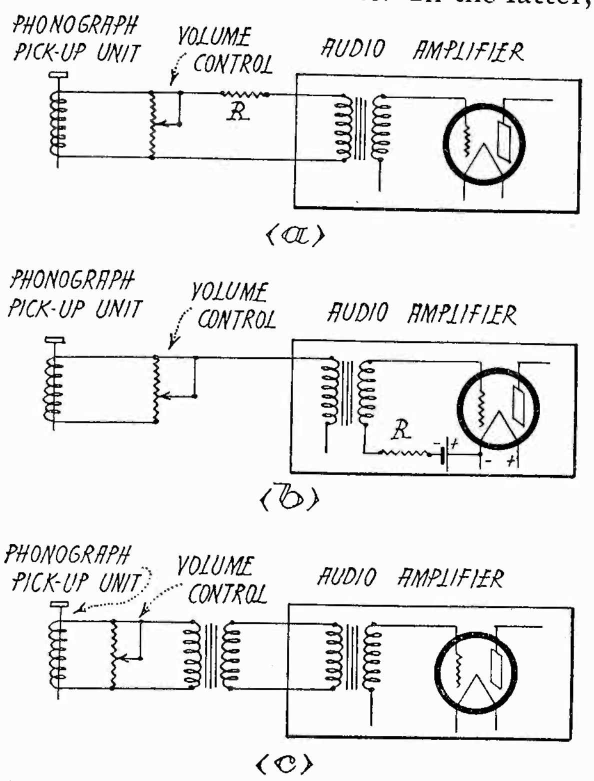


Fig. 4. Suggested Connections for Pick-up Unit. (In 4b the volume control resistance should be connected to ground.)

the resistance *R* will vary between 50,000 ohms and 250,000 for different types of pick-up units and audio transformers. Its action is as follows: There is a capacity between the two windings of the transformer which is charged by the secondary induced voltage. The charging current flows to ground through this resistance *R*, causing an emf opposite to that of the secondary induced emf in its effect on the grid of the tube. Thus one voltage counteracts the other and so the hump on the high frequencies is reduced. At lower frequencies the charging current is less, due to the higher reactance and so the very low frequencies are unaffected.

Often the pick-up unit does not deliver enough voltage to properly operate the audio amplifier and loud speaker. When this occurs an intermediate impedance matching transformer may be used as shown in Fig. 4 (c) or the unit may be connected across the grid of the detector tube.

Curve C, Fig. 3 was obtained when such a transformer was used in conjunction with the first audio transformer. The rising low frequency response was obtained evidently from the effect of impedance matching at the very low frequencies, with a corresponding drop for all higher frequencies. Curve C does not show the voltage gain when using this step-up transformer but merely shows the frequency response with 1000 cycles per second as a reference.

Fig. 1b shows the method of connecting the pick-up unit and volume control into the grid of a detector tube. This can be most conveniently done by means of a flat adapter which will slip over the grid and negative filament prongs or cathode of an a.c. tube, after which the detector tube can be inserted in its socket. The volume control should be connected to ground and should be at least 50,000 ohms. A 500,000 ohm potentiometer would be more suitable and a more uniform frequency response would be obtained.

As stated before, the low frequency response with this last arrangement will not be as good as when the unit is connected directly across the audio transformer, but more gain will be obtained since the detector tube is used as an amplifier. There will be no high frequency peak, at least no more than when used for radio reception, but the pick-up unit will give more output at the high frequencies. Scratch filters may be used if the needle scratch is objectionable, though if the pick-up unit is used properly, such a filter is unnecessary.

Phonograph records are cut laterally. To prevent the cuts from cutting through to the next groove, the very low notes are undercut or in effect, attenuated. With a good dynamic speaker mounted in a large cabinet or baffleboard, the audio amplifier may be made to have a

(Continued on Page 47)

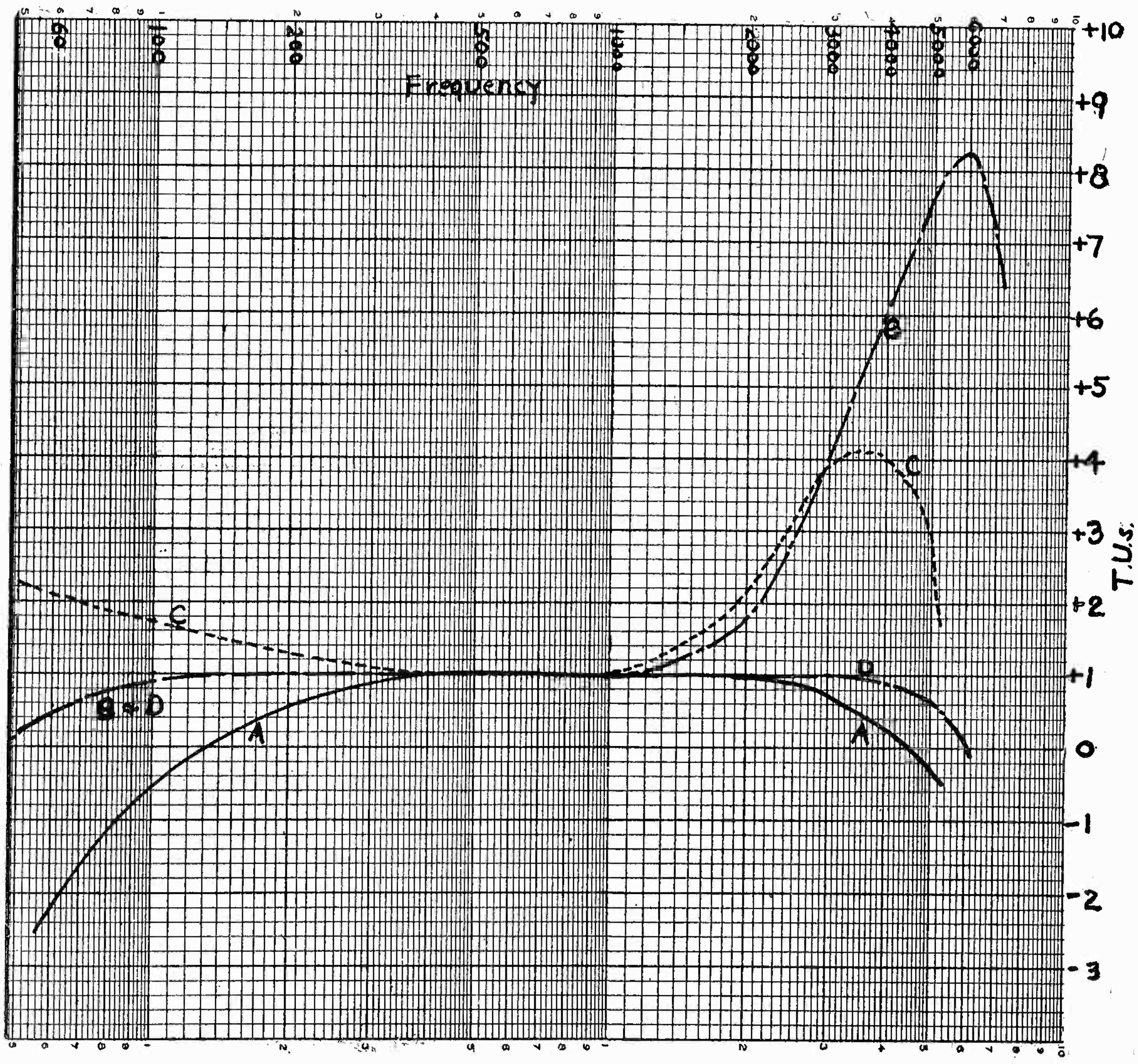


Fig. 3. Effect of Different Impedances on Audio Frequencies

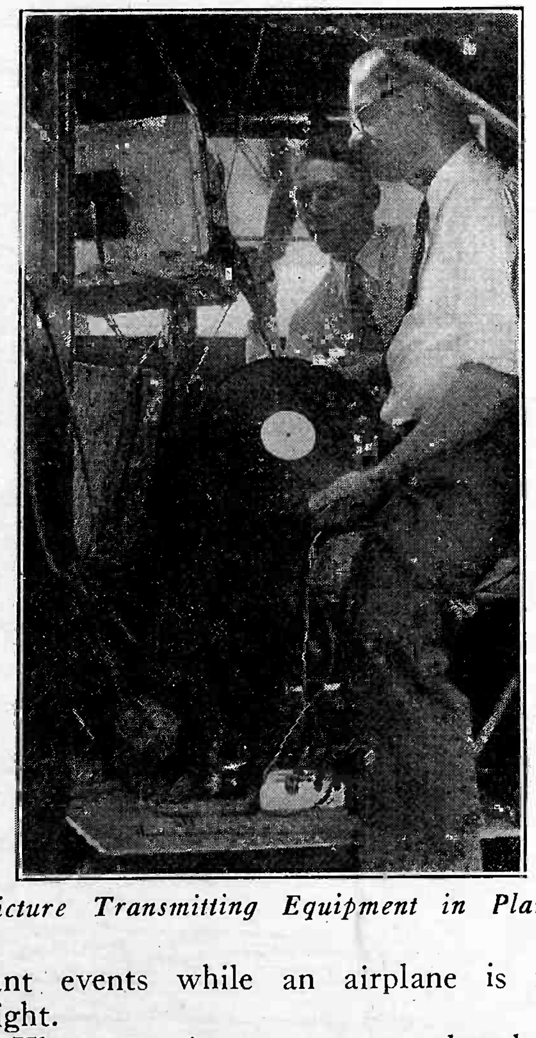
Radio Picture Transmission and Reception

Photoelectric Equipment and Methods for Visual Communication

By JOHN P. ARNOLD, *Departmental Editor*

SOME of the future possibilities of the electrical transmission of photographs were strikingly demonstrated when signals, emanating from radiophone apparatus installed in the cabin of an airplane, flying a mile above the city of Philadelphia on the afternoon of August 14, were picked up by Station WFI in that city and rebroadcast for radio listeners who were equipped with picture receiving apparatus.

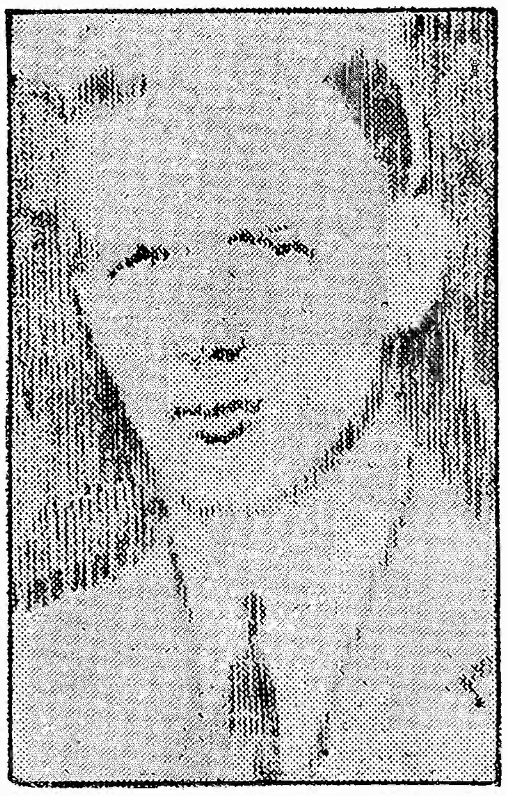
Due to the vibration of a wind-driven generator which supplied the power for the radio transmitter, the results were not highly satisfactory as far as the quality of the received pictures was concerned. But the demonstration itself, probably the first in the history of phototelegraphy, marked an epoch in the application of still picture transmission to modern problems such as the dissemination of military information to numerous points along a battle front, the location of forest fires by aerial patrols, and the transmission of photographs of important events while an airplane is in flight.



Picture Transmitting Equipment in Plane

The experiment was undertaken jointly by the Philadelphia airport, Ludington Philadelphia Flying Service, Inc., Station WFI of the Strawbride & Clothier Store and the Radiovision Corp. of New York. A Cooley "rayfoto" transmitter was installed in the cabin of a Fairchild monoplane. The short-wave radiotelephone equipment, having a maximum input of 75 watts, was mounted in the cockpit. A 65-ft. "fish line" antenna was used.

The flight over the central section of the city required more than an hour.



Reproduction of Received Radio Picture of Colonel Lindbergh

Half an hour was needed for the plane to gain the high altitude necessary to throttle down the engine so that it would not interfere with radio transmission. Photographs of Col. Lindbergh and Graham MacNamee, which had previously been converted to a "sound record" on a phonograph disc in accordance with the usual method employed in the Cooley system, were transmitted. Although this demonstration did not include the actual photographic operations of taking, developing and preparing the pictures for transmission aboard the plane, there would be no difficulties in carrying out these steps on an airplane especially equipped for this work.

The airplane was piloted by Robert P. Hewitt, assisted by John Busher, and the broadcasting apparatus was operated by John J. Leitch, Federal Radio Inspector of the Third District.

The picture signals were received on a short-wave receiving set on the roof of Station WFI and rebroadcast on that station's regular wavelength.

Essentially the system of transmission consists in converting the light and shade of a photograph into audio-frequency impulses which are received on a conventional radio receiver and converted to light impulses by a three-tube amplifier-oscillator circuit. This apparatus converts the audio-frequencies, which would ordinarily be fed into a loudspeaker in speech reception, into ultra-violet light variations radiated from a needle-point stylus. The light impressions are recorded on sensitive photographic paper, producing a positive reproduction of the transmitted pictures. It requires but three minutes to make a 4 x 5 picture consisting of 100,000 image impressions.

A REVOLUTIONARY LIGHT-SENSITIVE CELL

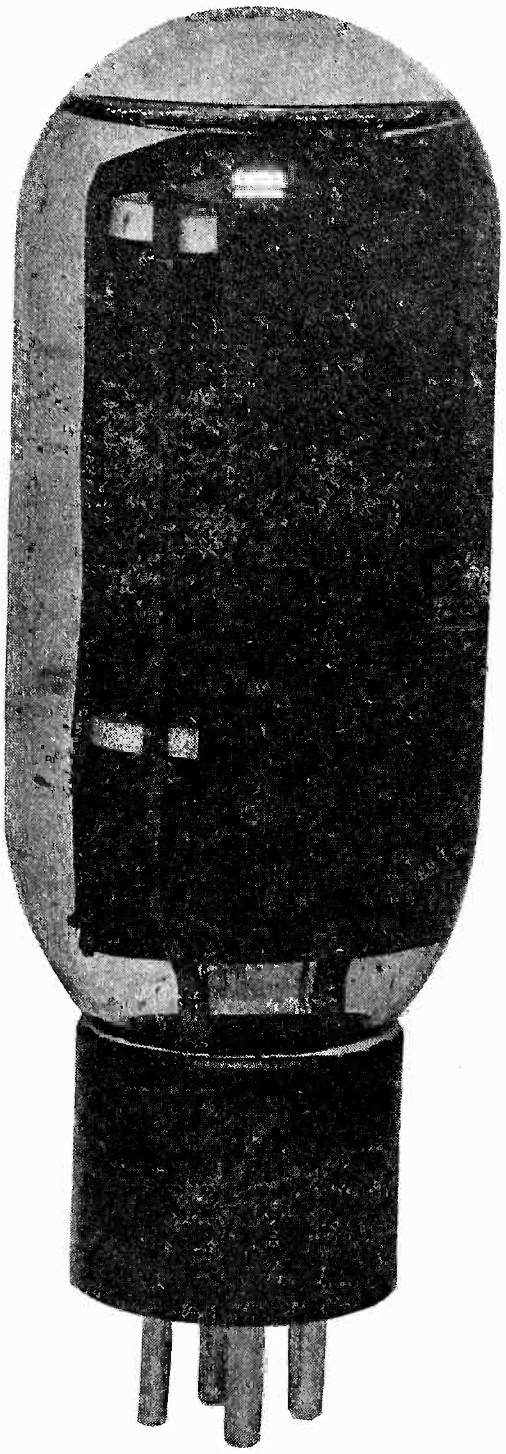
READERS of these columns have already been introduced to the well-known types of photoelectric cells; that is, those which employ the alkali metals or selenium as the light-sensitive material. Still another type is the photovoltaic cell which is an important development in photoelectric cell construction. It is quite likely that the recent perfection of this cell will solve some very troublesome problems in the field of visual communication and in the improvement of various sound recording and reproducing devices for which light-sensitive cells are commonly employed.

To go back a bit to the early period of photoelectric history. In 1873 Willoughby Smith observed a phenomenon which is now designated as the *photo-resistive* effect. In this case the substance changes (usually lowers) its electrical resistance when light falls upon its surface. The effect is observable in selenium, molybdenite, the metallic sulphides, oxides and various other crystalline forms. Selenium cells were the first to be used for practical engineering work; but their response is very slow.

The so-called true *photoelectric* effect, first noted by Hertz in 1887 and later more fully investigated by Hallwachs, refers to the emission of electrons *from* a metal or compound when illuminated. Stated in other words, a photoelectric body loses a negative charge due to the action of light. Potassium or the other alkali metals are usually employed for the construction of such cells.

The photovoltaic effect is a case where an electromotive force is generated between two metals in an electrolyte as the result of the action of light on one of the metals. The discovery of this effect extends back many years, probably before either the photo-resistive or photoelectric phenomena were observed. In any event, in 1878, Sabine designed the first practical photovoltaic cell, employing selenium deposited on an aluminum plate for this purpose. Cells of this type consist of two electrodes immersed in a liquid or electrolyte and, in operation, do not require the use of an external battery as is necessary in using selenium or potassium cells.

Although this particular effect was discovered many years ago and although various combinations of electrodes and electrolytes have been tried, satisfactory results were rarely achieved. It would be tedious to describe the reasons why the development of this type of cell was neglected all of these years; it will suffice to mention that the general belief is that fatigue precludes any successful results with them. As we learn more about the matter of fatigue, in regard to the photo-electric cell, it is conceded that the emission of electrons is an intrinsic property of the light-sensitive material, and that strong fatigue characteristics are often due to secondary causes which improved design is constantly eliminating.



Photovoltaic Cell. (Radiovision Corp.)

Although it is too early to say that this is also true in the case of photovoltaic cells, nevertheless, careful laboratory tests, which would detect a delay in response of the order of hundredths of a second, have failed to reveal any fatigue. Moreover, there are additional reasons for believing that these cells may be used for practically all applications which require a high frequency of response. The credit for the perfection of the photovoltaic cell is due to Samuel Wein, of the Radiovision Corporation, New York, who has also made other valuable contributions to the science of photoelectricity.

The construction of this cell may be studied by referring to the accompanying picture. Two metallic plates, rigidly supported and separated about ½ in. from each other, are immersed in an electrolyte contained in a cylindrical glass bulb, 1½ in. in diameter and about 4½ in. long. The cell is fitted with a radio base and the electrodes are connected by wires to the prongs which correspond to the plate and grid of a radio tube.

By connecting a very sensitive meter in series with the electrodes, a large deflection will be noticed when one of the plates is illuminated. In direct sunlight, the writer has obtained deflections of ½ milliampere when the cell is exposed. When an opaque screen is interposed between the cell and light, the pointer of the meter immediately falls to zero. While such relatively small deflections may seem insignificant to the lay reader, it is enough to make the informed experimenter sit up and take notice, since such results are unusual in this type of cell.

This cell may be temporarily sensitized in the following manner. When the terminals of the cell are connected to a 45-volt battery for about 10 seconds, the battery then removed and a meter substituted, deflections of several milliamperes—in fact, three or four times the value before sensitizing—have been observed. The effect of this charging gradually diminishes and disappears in about an hour, but the charge can be renewed as often as desired. The makers of the cell are planning to insert an auxiliary electrode between the two metal plates, serving a purpose similar to that of the grid in a radio tube, by means of which a constant charge may be maintained indefinitely. However, it is not necessary for the cell to be charged, since its output is sufficient to operate sensitive relays directly.

Further characteristics of these cells may be gathered from the curves illustrating this article, and from the following facts which were taken from laboratory tests:

Current Output: In very feeble light the cells furnish a current of the order of 10^{-6} amperes.

Internal Resistance: The internal resistance of five cells measured at 1000 cycles in the conventional manner ranged from 15 to 52 ohms, with an average of 32 ohms.

Photovoltaic Potential: The voltage illumination curves (Fig. 1) indicate that the potentials are proportional to the incident illumination; the apparent deviations from this generalization are doubtless due mainly to the difficulty of measuring closely the distance of the illuminated plate from the source at high light values. At low intensities, between 10 and 20-foot candles, there is apparently a critical phenomenon, for nearly every plate exhibits a peculiar reaction as evidenced by change of curvature in the characteristic curve.

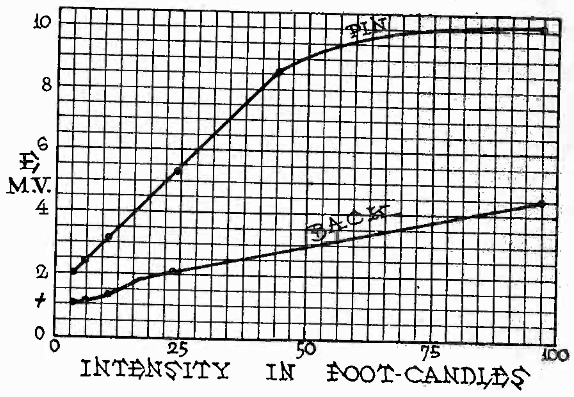


Fig. 1. Voltage-Illumination Curves for Photovoltaic Cell Whose Plates Are Designated as "Pin" and "Back"

Spectral Sensitivity: A measure of the sensitivity of this type of cell to different spectral colors (Fig. 2) was obtained by means of Wratten light filters. The light source was a tungsten filament lamp with a concentrated filament supplied by a storage battery. The curve shown is purely qualitative as is any obtained by filters which pass a relatively wide band of frequencies. The cell shows a rather marked selective effect in the yellow. This rapidly decreases in the green and changes sign (positive to negative) in the blue. In the blue-violet the potential has reached an appreciable value of the opposite sign. The various spectral colors, red, orange, yellow, green, blue and violet are denoted by *R, O,* etc., in Fig. 2.

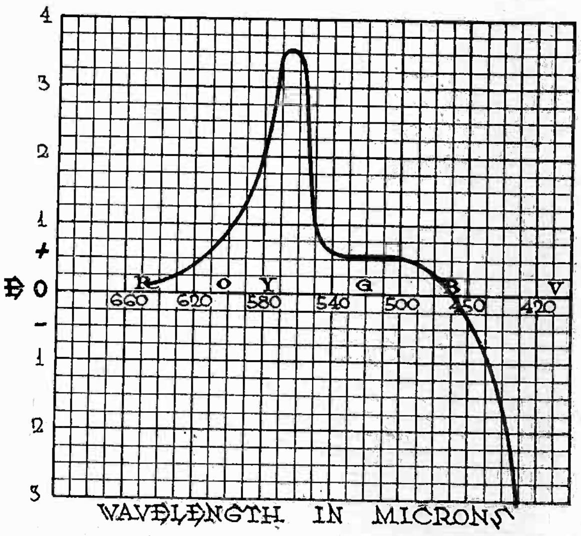


Fig. 2. Wavelength Sensitivity Curve

As has been previously noted the new photovoltaic cell may be employed for all the ordinary applications for which the other types of light-sensitive cells are used, with the additional advantage of not requiring external batteries.

A PHOTOELECTRIC AMPLIFIER

The practical employment of photoelectric cells involves as a rule the amplification of the extremely minute photoelectric current. To accomplish this purpose the cell is connected to the input of a vacuum tube amplifier.

For delicate measuring work or for amplifiers designed for "still" picture transmission or television, steady sources of potential are required; the usual *A, B,* and *C* batteries and, in addition, a fourth or *D* battery, as it is sometimes called, may be used to charge the photoelectric cell. The use of a power tube in conjunction with the cell requires batteries of several hundred volts, depending on the types of cell and tube.

Where photoelectric cells are used to control power circuits through a relay or for other similar purposes, variations in the supply source are not particularly harmful and it is possible therefore to design amplifiers which have the advantages of greater convenience and lower cost. Circuits have been devised to operate directly from a.c. or d.c. power circuits, although these are not as satisfactory as the "eliminator" described here.

The circuits differ merely in the placing of the photoelectric cell and were described in a paper by Fox, Rood and Marburger in the *Journal of the Optical Society of America* for December, 1927. The specific purpose for which this apparatus was designed was to control a laboratory clock by photoelectric signals; but the amplifier itself is suitable for many other useful applications of photoelectric cells.

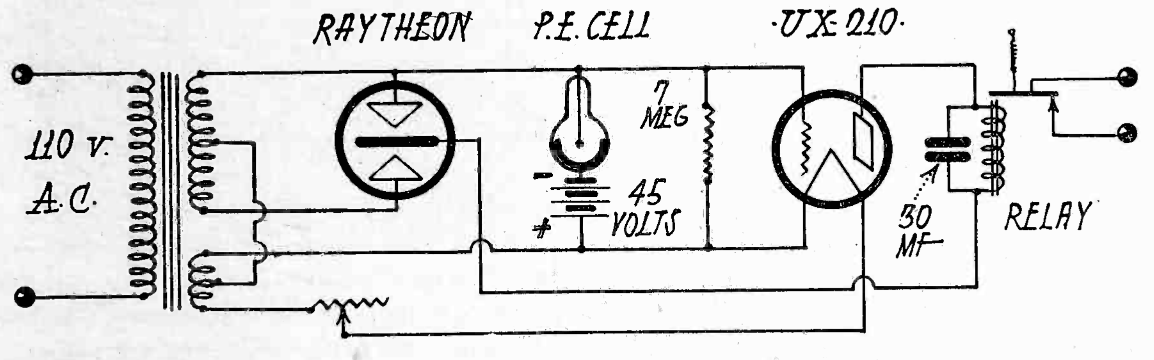
The circuit diagrams require no particular explanation since they are not unusual in any way. It is necessary, however, to mention that the photoelectric cell should be inclosed in a light-tight box, preferably fitted with an iris diaphram to control the beam of light

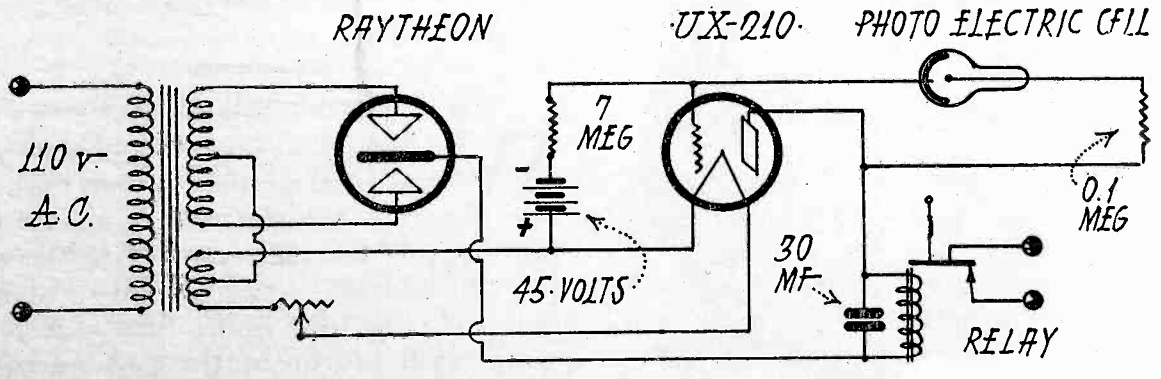
The parts which are suggested for the construction of this power amplifier are the following.

1 Photoelectric cell, gas or vacuum type.
1 UX-210 Power Tube.
1 Type 365 General Radio transformer.
1 Raytheon BH tube.
1 Mershon 30 MF electrolytic condenser.
1250 ohm Ghegan relay.
2 Daven grid leaks, 7 meg and 0.1 meg.
1 Bradleystat.

which falls within. The source of light may be an ordinary incandescent filament lamp. The photoelectric cell used by the authors of the above-mentioned paper was a potassium hydride, gas-filled cell.

In operation, when light falls upon the sensitive cathode of the cell, the "light signal" charges the grid of the vacuum tube and actuates the relay in its plate circuit. The relay can be made to operate any apparatus that is designed.





Circuit Diagrams for a Photoelectric Power Amplifier

A NEW TYPE OF SELENIUM CELL

An extremely simple process of making selenium cells was recently described by R. E. Martin in the April, 1928 *Journal of the Optical Society of America.* This simplicity of construction should appeal to experimenters who are interested in making light-sensitive cells and especially those who must work with limited resources.

Powdered vitreous selenium is placed in a pyrex test tube and heated to slightly above its melting point (217 deg. C.) in an electric furnace or over a Bunsen flame. The selenium is then allowed to cool slowly and, as the temperature decreases, it becomes more plastic. By turning the tube nearly upside down, the viscous selenium can be poured from the edge of the tube in long cylindrical threads, the diameters of which depend upon the temperature. The size of the threads which were found to be most suitable for making up into cell form were about 2 cm. long and 0.1 cm. (79 x .039 in.) in diameter.

The annealing or rendering the selenium light-sensitive is the next step to be undertaken. A thread of selenium is placed on a piece of glass or mica which rests on a copper plate. This is heated from below by an open flame or, preferably, by an electric heater, the latter permitting better temperature regulation. As the temperature is gradually raised to about 130 deg. C. (266 deg. F.), the selenium changes from a shiny black material to the familiar dull grey of the light-sensitive crystalline variety. After the thread is entirely crystallized, the temperature is slowly raised toward the melting point and the thread is observed through a small magnifying glass. When the first signs of melting are noticed (that is, as soon as the crystalline structure shows signs of disappearing), the temperature is immediately lowered 6 or 7 degrees and held constant for about 30 minutes. Again the temperature is gradually lowered to about 180 deg. C. (357 deg. F.), held there for several hours, and finally reduced slowly to room temperature.

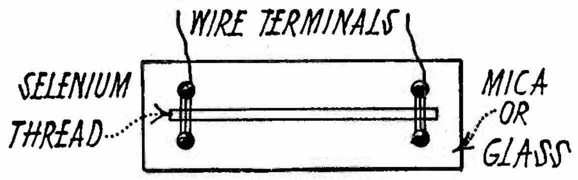


Fig. 1. Construction of Selenium Cell

The electrodes or terminals of the cell are now attached. These may be fine wires of platinum, nickel or copper which are passed through the holes previously drilled in the glass or mica insulating base and bind the selenium tightly to it. The advantage of this form of construction is that the electrodes may be attached after the cell has been annealed, since the metal of the electrodes combines with the selenium to produce metallic selenides, a combination which is thought to be detrimental to the action of the cell.

When this cell is connected in series with a battery and a current measuring instrument (0 to 15 scale milliammeter), a current flows through the cell even in the dark. Exposure to light lowers the electrical resistance of the selenium and the pointer of the milliammeter will indicate this by moving to a higher value according to the intensity of the light. These cells have a resistance of about ½ megohm.

Selenium fumes are poisonous, especially affecting the delicate membranes of the throat. Therefore, the experimenter should work either in the open air or carry out the heating under a hood as used in chemical laboratories.

SYNCHRONOUS MOTORS FOR VISUAL COMMUNICATION

In a recent paper T. Thorne Baker observes that the attainment of absolute synchronism between transmitting and receiving equipment is one of the chief reasons for the success of modern phototelegraphic systems, as the greatest failures in the early days of this means of communication were largely due to the lack of perfect timing between the apparatus of the two stations.

The earlier methods of obtaining synchronism included the use of electrically controlled clocks, pendulums, etc. The so-called "stop-start" system was also in vogue. By this method the receiving cylinder was turned over at a rate slightly in excess of that of the transmitting cylinder and was stopped at the completion of each revolution by some mechanical means until a signal from the sending station released it as the transmitting cylinder began the next revolution. This system, while simple and economical, is not very effective in the transmission of photographs in which a high grade of reproduction is demanded.

Synchronism for television is only another name for trouble raised to the nth power. When it is seen that the sending of a single picture in about four minutes involves difficulties, the synchronizing of apparatus which must deal with about sixteen pictures per second, might seem to come under the head of impossibilities, although someone has said that the word should be banished from the dictionary.

At any rate, modern television experimenters, with very few exceptions, employ synchronous motors. Motors of this type are controlled by the application of a pulsating current. They are used, of course, to rotate the conventional Nipkow disc or some similar device which scans the scene or object before the transmitter, and recomposes the image at the receiving station.

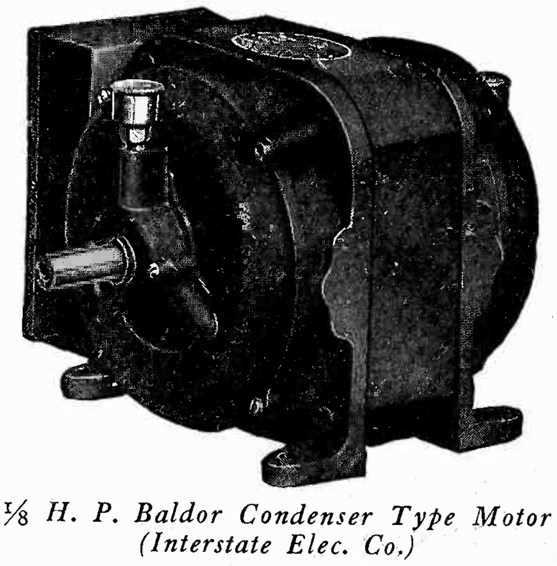
Alternating current motors for this work must be built in accordance with rigid specifications to obtain satisfactory results. The motor should be of the induction type, which does not rely upon a commutator either for starting or running. Since this motor must be placed rather close to the amplifying apparatus, a sparking commutator would create electrical disturbances which seriously distort the pictures. The ideal motor should be silent in operation and free from hum. Moreover, the motor at the receiving station must be so designed that, by inserting a suitable control mechanism in the form of a switch, and a variable resistance, reactance, or a combination of the two, its speed may be changed to and kept constant with the speed of the motor at the transmitting end of the system.

As some of the problems of photo-electricity and electrical image transmission are highly technical, and consequently not of general interest to the average reader, such problems are often not fully treated in these columns. But in order that we may be of service to the more advanced experimenter, we will gladly answer specific questions of this nature by mail. There is no other obligation than that the correspondent accompany such requests for information with a self-addressed, stamped envelope. Address the communication to John P. Arnold, 541 S. Yewdell Street, Philadelphia, Penn.

A recent engineering test of the requirements of motors employed for driving television scanning discs has revealed some interesting facts. The scanning disc as used for television reception is usually anywhere from 9 to 24 in. in diameter, 1/16 to ⅛ in. thick, and is often made of aluminum, although other metals and some materials like bakelite are used. Such discs can be driven by 1/15 h. p., 110-volt, 60-cycle, single-phase motors. With a perfectly true 15-in. disc, such a motor runs within 50 or 75 revolutions of the synchronous speed.

In order to reduce the speed to that required for the particular television system, it is only necessary to place a series resistance in the circuit with a means of short-circuiting about 15 per cent of the resistance. For example, a 15-in. disc, ⅛-in. thick, with a required speed of 1080 revolutions, needs a fixed resistance of 160 ohms, with a switch shunted across 25 or 30 ohms for the purpose of control.

Although this method has proved fairly successful, there is another way of obtaining more stable operation. As a flat disc is practically a frictionless load upon a motor, it is an advantage to load it in some way. For instance, if six small blades, 1 by 2 in. are placed around the circumference of the scanning disc, a slight load is placed on the motor, enabling the receiving operator to hold the speed of the disc more constant because the motor then responds to changes in speed much more readily. The motor will require only 30 ohms fixed resistance, with approximately 5 ohms to be short-circuited for adjustment, assuming the use of a 15-in. disc turning at a speed of 1080 r.p.m.



⅛ H. P. Baldor Condenser Type Motor (Interstate Elec. Co.)

With a load of this kind, it is possible to produce any speed from about 1700 r.p.m. down to 300 and maintain it very easily by the selection of the proper amount of resistance placed in the supply lead. A mechanical resistance, such as fins or blades attached to the scanning disc, helps to stabilize and enables the operation to more rapidly synchronize the receiving motor with the transmitter.

Although the 1/15 h. p. motor is quite

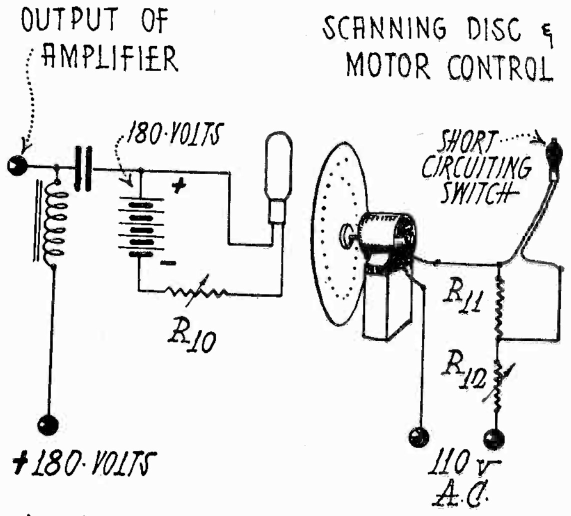


Fig. 1. Circuit Diagram of Television Receiving Equipment

satisfactory in the case of scanning discs of from 9 to 15 inches, when larger sizes are used or heavier loads are involved the ⅛ h. p. Baldor condenser type motor will be more suitable for the work. A motor of this type is shown in the accompanying illustration and is employed in both transmitting and receiving stations. Such motors can also be used for synchronizing in "still" picture systems.

The circuit diagram (Fig. 1) shows the use of such a motor with the usual television receiving equipment. The operator views the illuminated plate of the neon tube, the brightness of which varies in accordance with the television signals, through the scanning disc. When the motor gets slightly out of step with the transmitter, which will be noted when the image appears to be "out of frame," the short-circuiting switch may be closed, speeding up the disc slightly or, when open, the speed is somewhat decreased. In this way, synchronism is maintained between the transmitting and receiving discs.

The Unholy Writ

We make no bones about defying the lexicographer when it suits our fancy to torment the language of our fathers; yet the recent verbal atrocity, "to televise," causes a rill of shudders to course our spine. We look forward with horror to the possibility of the report that some operatic tenor was "highly *enthused* to have been *televised* and *broadcasted* to an admiring world."

PICTURES TRANSMITTED IN ONE MINUTE AT RADIO SHOW

A RADIOPHOTO apparatus capable of picking electrical impulses out of the air and converting them in less than one minute into a complete 5x7 photograph was demonstrated at the New York Radio World's Fair. This apparatus, developed in the research laboratories of the Westinghouse Electric and Manufacturing Company, has been used in experimental transmissions over short waves from Station KDKA at East Pittsburgh, Pa.

Because of the difficulty in securing radio wave channel assignment, the demonstrations at Madison Square Garden used wires, rather than air channels, for the transmission of the pictures. Westinghouse engineers state, however, that the equipment functions equally as well by radio as by wire within the limits of fading and static.

The Westinghouse apparatus employs standard photographic processes for making pictures. Its pictures are made by the exposure of sensitized paper to light, in exactly the same way pictures are customarily made in photographic studios.

Dr. Vladimir K. Zworykin, Westinghouse Research Engineer, Inserting One of His Photoelectric Cells Into the Radiophoto Transmitter

In addition to ordinary short wave transmitting apparatus, the system uses three principal pieces of equipment: a sending set, a receiving set, and a "synchronizer."

In the sending set, an ordinary photograph or manuscript is placed on a cylinder which rotates slowly and at the same time moves forward longitudinally. In this way, every point on the picture comes within the range of a tiny beam of light. By a system of mirrors, the beam of light is reflected at an angle from the photograph to a photoelectric cell, which gives out an electrical impulse corresponding in intensity to the degree of light or shadow of the particular pin-head of space on the photograph covered by the beam of light at that particular moment. This procedure, in other equipments, generally requires that a transparency be prepared.

Westinghouse Radiophoto Receiving Set

For radio transmission, the feeble currents given out by the photoelectric cell pass through three stages of amplification and then go by wire to the radio broadcasting station, which may be located a short or long distance from the radiophoto sending set. There the light waves, already converted into electricity, go out into the ether in the form of radio waves. At KDKA, the short-wave 63-meter channel was used.

At the receiving end, which could be situated anywhere within the effective range of short waves, a standard short wave receiving set is used to pick the impulses out of the air. The impulses are carried to a special lamp, which flickers according to the fluctuations in intensity of the current. The light from this lamp is focussed into a tiny beam which plays on a cylinder moving in the same ways and at the same speed as the cylinder at the sending end. This cylinder is covered with sensitized paper, and as the light falls on it with varying brightness, a series of impressions of varying degree are made on the paper, which, when "developed," present a facsimile of the picture placed on the sending cylinder.

An essential feature of this system is that the cylinders at the sending set and at the receiving set rotate and move forward at exactly the same speed. To accomplish this very difficult feat is the duty of the "synchronizer." Synchronization is accomplished by the transmission, over the same wavelength used for the radiophoto transmission, of a constant frequency note which regulates the speed of identical synchronous motors driving the two cylinders.

The finished photographs, after passing through the "dark-room" processes of developing and drying, correspond in practically every detail with the originals. If the pictures are held two feet away, it is impossible to tell the original from the copy which has been sent through the air.

SCANNING FOIBLES

Aristarchus, a Greek and astronomer of classical times, noted that the moon has always providentially avoided collisions with our earthly planet. Feeling called upon to exploit away this perverse circumstance, he did so by recourse to the principle which Huygens, later, denominated *vis centrifuga,* a phrase which seems to denote, being translated, the centrifugal force of the physics textbooks. To bring this paragraph up to the very minute, we may point out that the conventional scanning disc for television is an excellent example of the tendency of parts of rotating systems to move away from their center of circumvolution. We mention this because it has been brought to our attention by experimenters who have been treated to impromptu demonstrations of the phenomenon that a disc, insecurely attached to a motor shaft, may depart from thence on a tangential and destructive journey and end up abruptly and partially buried in a wall or ceiling or, mayhap, in some other semi-inert body which stands in its path. Thus, by the operation of the very principle which Aristarchus believed governed the movements of the heavenly orb, a scanning disc will perform certain parabolic peregrinations which may reduce a parlour laboratory to debris and an ardent experimenter to sampling the contents of the arnica bottle. Such happenings are to be deplored; yet to suggest the remedy partakes of the obvious.

Satisfactory radio reception for all tenants in an apartment house may be secured from an untuned antenna and a centrally located r.f. amplifier having a flat characteristic for all broadcast wavelengths. The amplified r.f. current corresponding to each channel may then be separated by a system of filters or fixed tuners. The amplified detector output from each channel can be conducted to a terminal board in each apartment. This board may be equipped with a number of jacks into any one of which the listeners can plug a loudspeaker cord. By providing each jack circuit with a resistance unit having the same impedance as the speaker, a listener may change from one channel to another without affecting the volume of reception in other apartments.

Radio Aids Air Races

By WALLACE S. WIGGINS

Of the 350,000 people who watched the 1928 National Air Races from the grandstands at Mines Field, Los Angeles, from September 8 to 16, not to mention other thousands who failed to get closer than the gates, it is probable that only a few hundred were aware of the important part played by amateur radio in contributing to the success of this great event. The contribution was not "spectacular" in the common meaning of the word in comparison to the hair-raising aerobatics of the contestants, but in the minds of the officials it exceeded all expectations for its utility. The Amateur Radio Research Club of Los Angeles, affiliated with the American Radio Relay League, saw their opportunity to render a service. With the assistance of radio friends, they rendered this service to their credit.

In addition to the transcontinental and international races which finished at the field, several races were scheduled daily over distances of 25 to 120 miles around courses of five and ten miles each. The courses were marked by "pylons"—steel towers flying the "wind sock" at the top and having black and red checkered sides for greater visibility. As the planes circled the pylons, observers checked them according to their lap numbers and closely watched for fouling or cutting pylons, forced landings, plane trouble of any kind, crashes, etc., which made it necessary to have speedy and reliable communication from pylon to pylon and with the judges' stand at the field. Many minor needs for fast communication developed as the races progressed.

Signals by flags or semaphore between pylons were obviously impractical because of distances. Telegraph and telephone were too expensive and the time was too short for such installations. As a last resort, radio seemed to be the only practical solution to the problem, but the expense likely to be incurred might amount to more than the cost of either telephone or telegraph. The air meet was not intended to be a financial profiteering stunt, but rather as a means of contributing to the "air-mindedness" of southern California, in which endeavor it certainly succeeded.

M. E. McCreery, 6LJ, was a member of the committee on communications as sponsored by the Los Angeles Junior Chamber of Commerce. He saw the need of the race officials and put up the proposition to Robert Parrish, 6QF, president of the A. R. R. C. Parrish took the proposition to the members of the club who gave their hearty approval of the stunt and conferred upon their president full authority to supervise the job—and a generous share of the work.

Bert Fox at 6EMI, Transmitter Constructed by Don Champion, 6FA

Licenses were obtained from the Commission for five stations: one for each of three pylons, one for the judges' stand, and one for an aeronautical exhibit booth in the exposition. "Bob" Parrish, manager of the Pacific Engineering Laboratory Co., supplied the main transmitters and a few receivers. Other transmitters and receivers were supplied by members of the club.

The pylons were not supplied with power, so portable power was necessary. The final decision was for batteries, but how could they pay for them? The average radio club never gets endowments. At least 350 volts were necessary at each pylon to supply plate current to the 7½-watt transmitting tubes in tuned-plate tuned-grid circuits. Storage batteries were needed for all filament supply, but there was no means for recharging them. What to do? The answers to these questions came in the form of friendly cooperation of the French Battery Co., the Durkee Thomas Corp., and the Western Auto Supply who furnished all the batteries and tubes without charge.

From an inclosed box at the top of the crowded grandstand, a splendid view of the field was had by the operator at "6EMF." Directly in front of the stand was Pylon Number 1. Off to the right and to the west could be seen Pylon Number 2, at a distance of a mile. Here was located station 6EMH. On a line south of the grandstand and about two miles away was Pylon Number 3, with station 6EMI. Pylon Number 4, two and a half miles farther on and in line with Pylons 2 and 3, was designated as station 6EME. It was five miles around Pylons 1, 2 and 3, and ten miles around all four pylons.

Let's watch a race! Here are six planes at the starting line ready for the 720 cu. in. event. The planes are "at rest," waiting for the starter's flag, with motors turning over slowly. Dots and dashes from 6 EMF in the grandstand are flashed to all pylons and they form the following words: "QST QST DE 6EMF RACE ABOUT TO START QRX (Stand by) FOR QST TON (Take-off numbers)."

The operators at the pylons inform the observers and everyone is in readiness. The starter walks out to the first plane and suddenly dips his flag. The motor roars, the plane moves, rapidly gains speed, and soars into the air toward Pylon Number 2. 6EMF flashes: "THEY'RE OFF!" The remaining planes are started at thirty second intervals and are flown against time. To start all the planes at once would invite needless dangers. Take-off numbers are broadcast to the pylons, and as the last plane leaves the field, the first one may be seen on the home stretch of the first lap. When the "QST TON" has been completed, all pylons answer: "QST OK 6EMH," etc.

Watch these three planes in a bunch as they go around Pylon Number 1! Look at that little monoplane. See how it flits past the others like a little sparrow! Zoom! Zoom! Zoom! The three planes dart off toward Pylon Number 2 again on their second lap as the observers call off the numbers and check. The operator at 6EMF is constantly moving the dial on his receiver between two points. Operating on the 80-meter band, he finds the pylon stations only a few kilocycles apart. 6EMH is at 54, 6EMI at 49.5, and 6EME at 45.5. Not so bad.

Several laps have been completed now. Here comes a plane that seems to be having trouble. The motor sputters, indicating a broken pipe or valve, perhaps. Awful strain, these races on planes and pilots. The plane makes a graceful landing and taxis out of the way. The number is immediately flashed to all pylons. Why? Inside of three minutes would come as many inquiries about the plane and its failure to appear.

Now let's go out to 6EMI, at Pylon Number 3. We are out of sight of the grandstand, but we could reach it by auto in ten minutes through traffic. By airplane, we could get there in one minute! The surrounding country is practically level, but between us and Pylon Number 2 is a small ravine and some trees. We can see the planes coming straight toward us, flying dangerously low, barely clearing the tree tops, and now skimming along the ground to the pylon. They bank sharply, usually gaining a little altitude, circle the marker, and fly off toward the field. This is a five mile race, so they are not using Pylon Number 4.

(Continued on Page 46)

Battery Charging with a Synchronous Rectifier

Complete Details Regarding the Construction and Operation of a Synchronous Rectifier

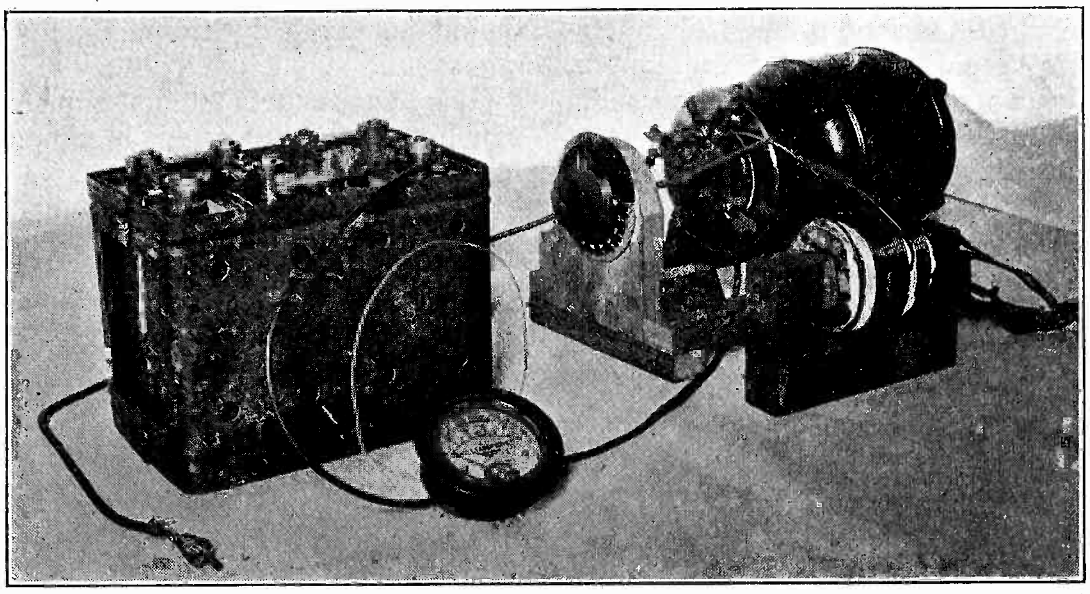
By G. F. LAMPKIN

A SYNCHRONOUS rectifier is an excellent source of high potential d.c. for transmitting, as testified by the many "syncs" owned by amateur operators. Such a rectifier, as may be known, utilizes a synchronous motor, a commutator disc, and a brush rigging. The commutator is rotated in step with the alternating current, and functions as a switch, reversing at the correct instant so as to bring the output voltage right side up. In its use for high-voltage, full-wave rectified supply it is eminently satisfactory. With a small amount of care it will function just as satisfactorily to deliver several amperes at comparatively low voltages.

The chief advantage of a sync lies in the range of currents and voltages over which it can be used. In the role of battery charging 20 amperes is by no means the limit of current obtainable; while for a transmitter the output voltage can be run upwards of 3000 volts. The metal to metal contact assures a high rectification efficiency. A disadvantage is that the rectifier works best into a resistance load. If an attempt is made to work into a condenser or inductance, as in a filter system, trouble immediately develops through sparking at the brushes. Only by special means can a filter be used on a sync.

A description of a synchronous rectifier will serve the dual purpose of illustrating the processes involved in its operation, and of affording a basis for constructional work. The heart of the rectifier is of course the synchronous motor. The usual nameplate data for a sync-rectifier motor are ¼ h.p., 1800 r.p.m., single-phase, 60-cycle, 110-volt. An 1800 r.p.m. motor allows the simplest sort of commutator construction with only two segments.

The brush rigging uses two brushes into which a.c. is fed, and two from which full-wave d.c. emerges—a total of four brushes equi-spaced around the commutator periphery. Fig. 1 shows the commutator position and current



Complete Charging Outfit

flow at the beginning of a positive half cycle, and at the start of the succeeding negative half cycle. The disc, turning 1800 r.p.m., advances one-quarter of a revolution in a half cycle, 1-120 of a second. Thus the conditions of the sketches hold true—though the direction of current in the a.c. source reverses, the commutator maintaining unidirectional flow in the output.

A ¼ h.p., single-phase induction motor can be made into a synchronous motor of only slightly less capacity by facing off four flats on the rotor, approximately 1/16-in. deep, as indicated in Fig. 2. It is a simple machining operation, which, with the turning of the commutator disc, is the total of machine work necessary. The flats on the rotor of an induction motor form air gaps across which the flux is reluctant to slip, and the rotor holds in step with the impressed frequency. The induction motor must of course have four poles, so that its name-plate speed would be around 1740 or 1760 r.p.m.

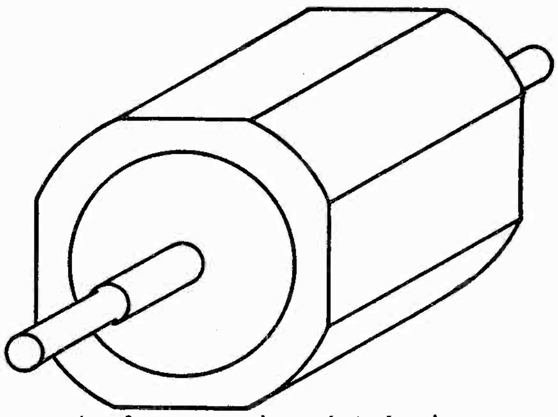


Fig. 2. Conversion of Induction to Synchronous Motor

The commutator disc in Fig. 3 was designed as small as was consistent for operation at 3000 volts. The larger the wheel, the greater is the space available

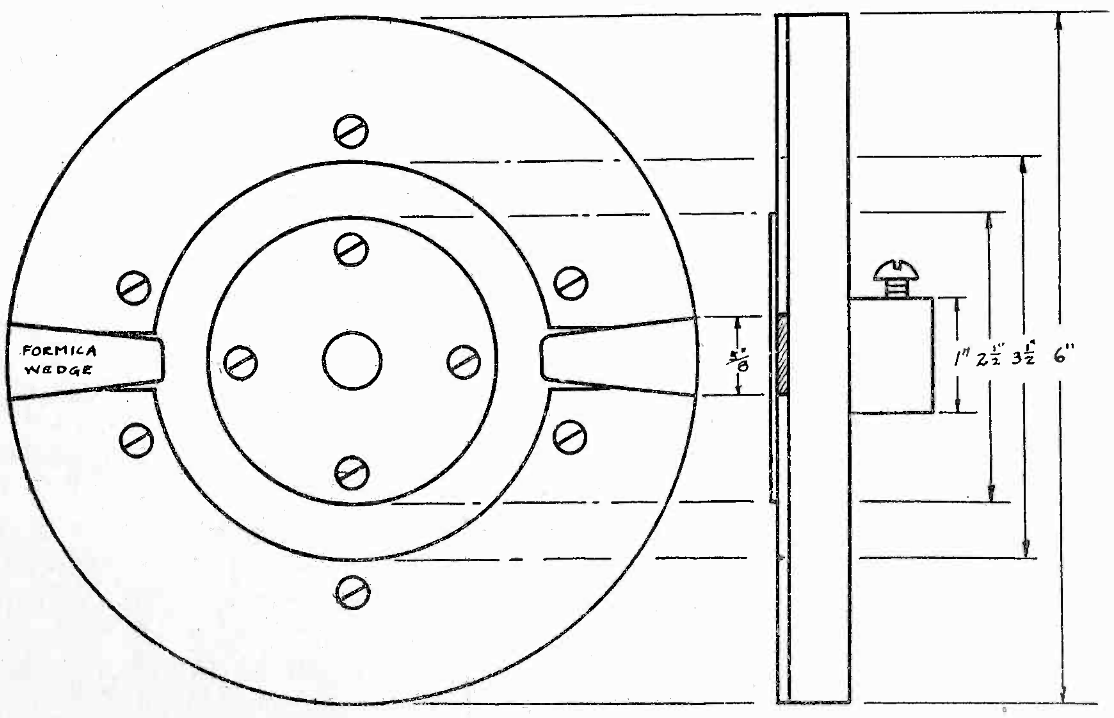


Fig. 3. Commutator Disc

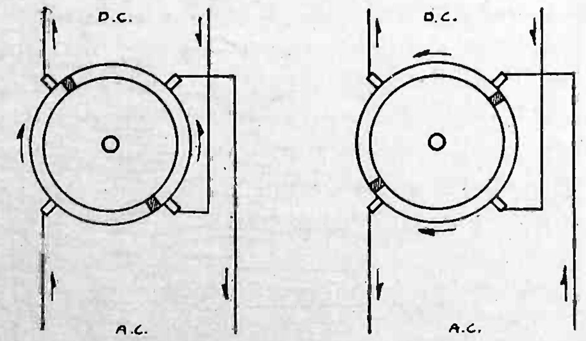


Fig. 1. Commutator Positions

for insulation. But also greater is the power necessary to turn the disc, for the friction and windage losses are increased. The disc proper, shown in the sketch, was cut from ½-in. micarta. The bushing for the shaft was turned from 2½-in. round brass bar; and the commutator was made from 3/32-in. brass. The latter was fastened to the disc by screws inside the brush path. Both this, and the filling of the slots between segments with drive-fit formica plugs, afforded a smooth brush path. Such a path not only reduces brush friction, but aids materially in keeping sparking at a minimum. In turning the disc a final smoothing cut should be taken over both segments and insulating sectors.

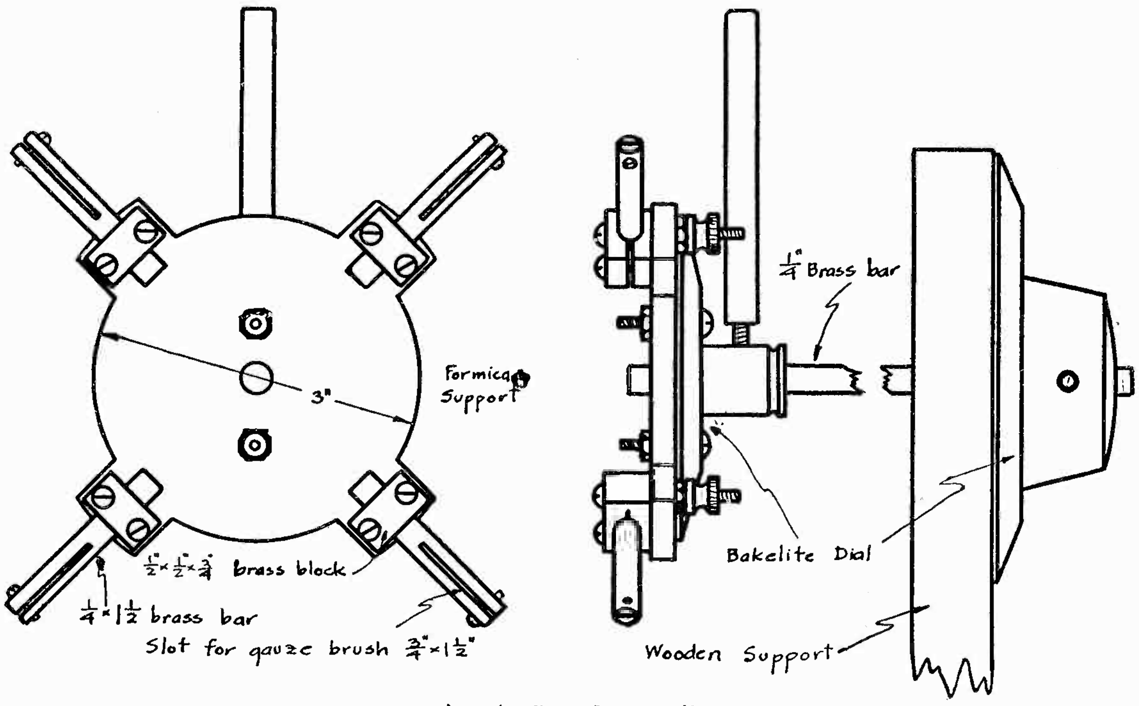


Fig. 4. Brush Details

Two bakelite dials were made to the foundation of the brush rigging. Copper gauze brushes and brass fittings completed the assembly, of which Fig. 4 gives details. The set-screw in one dial was removed and replaced by a threaded insert in an insulating rod. The latter was to afford a means of brush adjustment. Four thicknesses of medium copper gauze were used in each brush.

In the adjustment of the brushes lies the secret of sparkless commutation. When motor, commutator disc, and brush rigging have been assembled, the brushes should be carefully adjusted to bear equally on the commutator; the ends of the brushes should be parallel to a radius of the disc; the brushes should be exactly 90° apart; and two diametrically opposite brushes should make and break contact with the segments at the same instant. It is essential that severe sparking be eliminated, otherwise the brush and commutator life will be short. Elimination of sparking on a transmitter sync spells the difference between hash, and the distinctive, musical sync note.

Before using the sync under load the disc should be thoroughly cleaned, especially around the insulating sectors, of all metallic dust. Then place 110 a.c. on two brushes, 180° apart, and connect a lamp to the other two. Determine and fix the position of the brushes for maximum brilliancy of the lamp. The rectifier is then ready to feed 20 amperes to a battery, or 3000 volts to a transmitter.

For ordinary battery-charging, a 50 or 75-watt toy transformer is ideal. It is cheap, convenient, and usually with adjustable secondary voltage so that the charging rate can be varied. For each charging rate it is necessary to adjust the position of the brushes slightly. Both angular position and pressure on the disc should be changed till sparking is at a minimum.

The design data for a transformer which has been in this use by the author for over a year are as follows:

Core cross section .... 1½" x 1½"
Core window .... 1¼" x 4"
Primary winding 330 turns No. 20 SCE on long leg.
Secondary winding 45 turns No. 12 PE over primary.
Voltage primary 110, secondary 16.3, 60 cycles.

The layout was used to charge an 8-cell, 20-ampere-hour Edison battery at around 20 amperes. Such a charge filled the battery up in short order. More conservative rates should be used, of course, when charging lead cells. The secondary voltage of the transformer may be cut as desired by reducing the secondary turns proportionally. That is, for a secondary voltage of E, the new number of secondary turns is $E \div 16.3 \times 45$. The charging rate may be varied by using variable resistors of appropriate rating in the transformer primary or secondary. The best method is to use a tapped transformer.

A battery may be charged at around 5 amperes by connecting it to the rectifier output, and placing an electric iron in series with the 110-volt lines on the input—though such is hardly economical, because the iron gets most of the watt hours. The service man, however, may have enough batteries to connect in series and charge directly from the 110 supply.

The polarity of the output must be checked each time the rectifier is started up. The reason is that the rotor of the motor does not always pull into step with the a.c. in the same relative position. A reversing switch should be put in some portion of the circuit, for in-

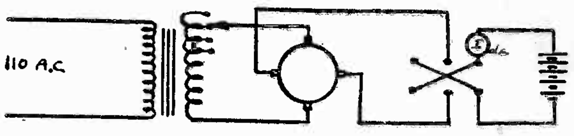


Fig. 5. Circuit Diagram with Reversing Switch

stance as drawn in Fig. 5. With a d.c. voltmeter the polarity of the rectifier can easily be determined, and correction made if necessary, before closing the charging switch. An a.c. voltmeter can be used by closing one side only of the charging switch. The voltage of both battery and rectifier in series is then read across the other open side of the switch, and that polarity of the rectifier which gives the smaller reading is correct for charging.

It is a simple matter to make a shunt for a milliammeter so that it will read the d.c. charging current, and by doing so it will aid materially in the operation of the sync. The meter in the picture was a Jewell, pattern 54, 0-100 d.c. milliammeter. A shunt of 17⅜" of No. 14 tinned bus wire converted it into a 20-ampere meter. If a standard ammeter is temporarily available it is only a matter of minutes to find the size and length of wire necessary to give any desired ammeter scale on a milliammeter.

The overall efficiency of any a.c. to d.c. unit is something that is seldom mentioned. Figures for such range from 50 to 5 per cent. With this outfit the input to the motor on the sync was 220 watts. If no resistances are used for charging-rate regulation, that figure may be taken as representative of practically the total power loss of the system. The more power put through the rectifier into the output circuit, the less is the cost per unit of output.

As stated before, the rectifier may be used for a 3000-volt transmitter supply. Actually it has been used to rectify 3300 r.m.s. or 4650 peak volts, when supplying 150 milliamperes to a c.w. transmitter.

Any a.c. hum from a filter circuit may best be reduced by increasing the capacities of the second and third condenser so as to by-pass the a.c. component of the rectified current. Humless operation requires that this component be less than 0.1 per cent. With a load of 75 milliamperes, 4 mfd. each in the second and third condensers give 0.07 per cent of hum, whereas 2 mfd. condensers give 0.3 per cent. When an eliminator is intended to supply more than 85 milliamperes a condenser block of 2-6-6 mfd. is desirable as such a great current drain increases the tendency to hum.

A Complete Tube Testing Set

By CLINTON OSBORNE

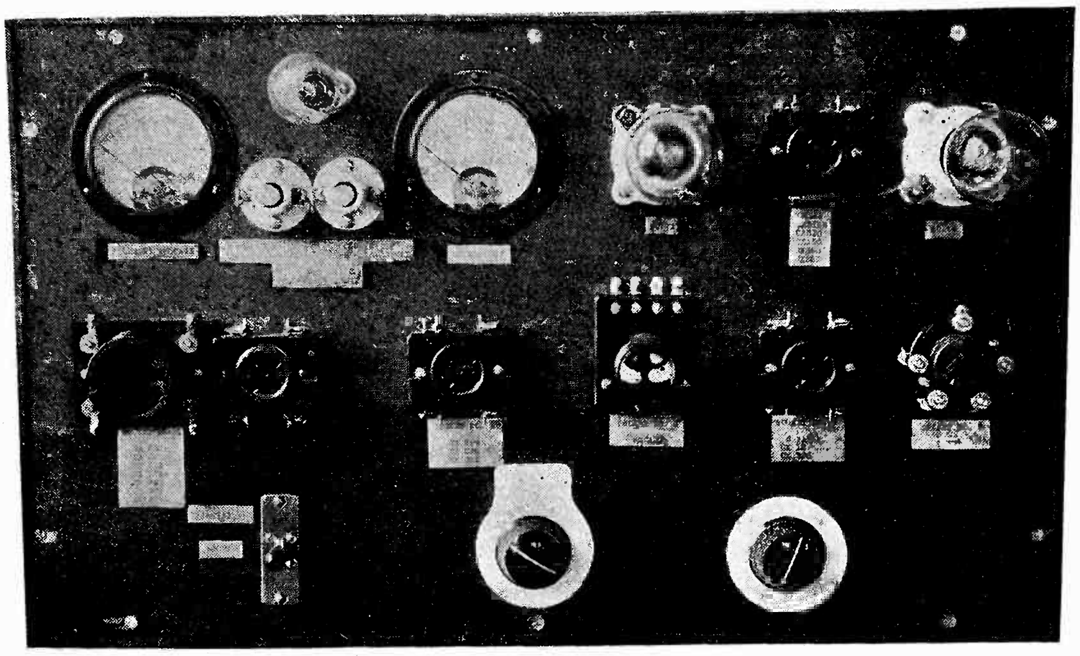
WHILE a number of tube testers have been described in past issues of RADIO, there have been none so complete in the number of possible tests which can be made, as the one described herewith. This tester was made up from suggestions contained in a tube data book recently published by E. T. Cunningham, Inc., and with it, the service man, experimenter or tube salesman can tell practically everything necessary about the condition of any of the standard tubes.

The tester is shown in the picture, and the circuit is shown in Fig. 1. The set has been designed to test all types of tubes, both a.c. and d.c. with the exception of the 374 glow tube, the 376 resistance lamp and the 300-A detector. It will give an accurate indication of the condition of the elements and, if the tube is operative, will also indicate the efficiency of the filament. Above all, it is inexpensive to construct.

The necessary materials for construction are given in the list of parts. The work is simple inasmuch as there are no complicated circuit arrangements; the meters, sockets, rheostats, etc., may be conveniently mounted on a bakelite or wooden panel, with a cabinet to conceal the wiring, or can be laid out on a baseboard. The actual layout and constructional details are left to the judgment of the builder, as it is thought that the circuit diagram and picture will furnish sufficient data for all practical purposes.

In building the test set, the variable rheostat should be of the 10-ohm size, capable of carrying 1½ amperes under continuous load. The fixed resistance *R* should be exactly 6 ohms, and is placed in the negative *A* lead from the No. 2 and 3 sockets to the 4-volt line of the battery. The switchboard key must be connected so that in its normal position it will indicate short circuits. If this connection is reversed so that the emission reading is taken first, the meters or the tube may be damaged, if the tube elements are shorted together.

To place the set in operation, turn the rheostat on slightly and set the switch *A* to the point indicating the corresponding socket number or numbers, these figures indicating which tubes may be tested in the correspondingly numbered socket. For example if switch is on contact *2-3,* type '99s, 220s, or 322s in socket No. 2 may be tested, and '99s in socket No. 3 may be tested. If switch is on contact *4,* C-11s, 12s and 326s may be tested



Panel View, showing Arrangement of Sockets and Meters

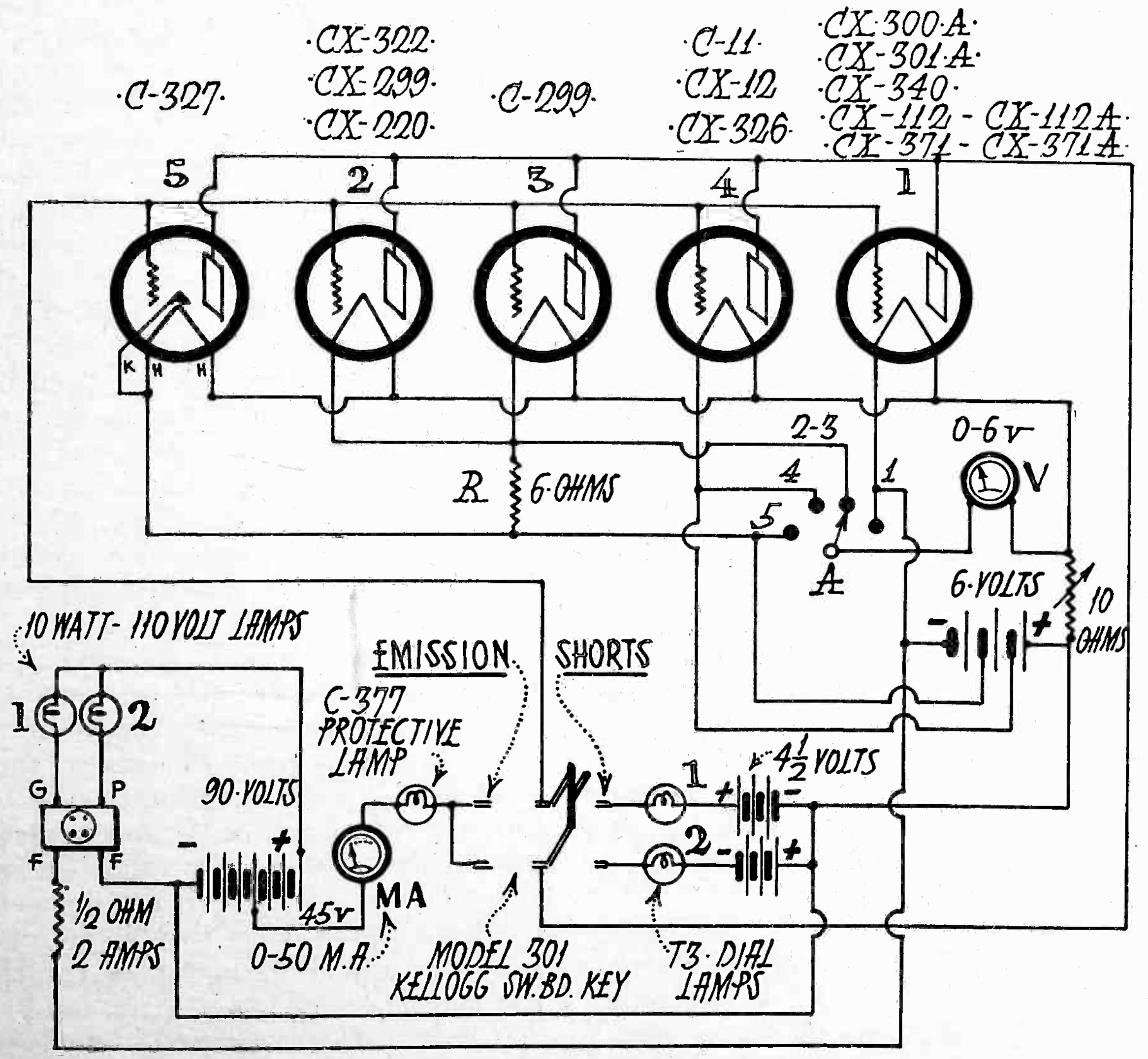


Fig. 1. Circuit Diagram of Complete Tube Tester

in socket No. 4 and so on: the tube to be tested is then inserted into its proper socket.

Note very carefully whether the dial lamps Nos. 1 and 2 are lighted, or even very faintly glowing. If they are, it is an indication that two or more elements within the tube are shorted, or that the filament is open and resting against the grid. To determine if the latter is the case, turn the rheostat up and if no regulation of voltage is possible, an open filament is indicated. If lamp No. 1 lights, a short between filament and grid is indicated; if No. 2 lights, it indicates a short between filament and plate; if Nos. 1 and 2 light, it indicates a short between grid and plate.

If neither lamp lights, then the elements are free from short circuits and the rheostat should be turned up until the voltmeter shows that exactly the proper voltage, as given in the accompanying chart on voltage and emission limits, is being applied to the filament. If the rheostat has no effect on the filament voltage it indicates an open filament, either broken or burned out. When the voltage is correct, *momentarily* press the switch indicating the emission current.

(Continued on Page 50)

The Marshall Short-Wave Receiver

A New Short-Wave Circuit Developed for the Navy and Using Screen-Grid Tubes

By S. R. WINTERS

A NEW high-frequency receiving set designed and built at the Bellevue Naval Research Laboratory incorporates the screened-grid or four-element electron tube. This receiver, intended for use on battleships and other floating units as well as at shore stations of the United States Navy, marks the introduction of a push-pull, screened-grid type of receiving set in the Government service—a type of amplifier already popularized by broadcast listeners and radio amateurs. However, this novel circuit is said to be the most sensitive yet developed by the Navy for high frequencies.

This high-frequency receiver is described as a single-stage tuned radio-frequency amplifier, preceding an autodyne detector and two stages of audio-frequency amplification. It is a six-tube unit, including two four-element tubes, connected for push-pull operation, as well as two detector tubes. A frequency range from 4,000 to 25,000 kilocycles is embraced—this extensive wavelength range requiring the use of five inductance coils of varying sizes. Thomas A. Marshall—then a student and research worker in electron tubes at the Bellevue Naval Research Laboratory—designed this receiver.

The so-called "Marshall Receiver" employs two tubes of the '22 type in the radio-frequency circuit—each of these tubes having two grid elements and being wired for push-pull operation. These two four-element tubes operate on 3.3 volts for the filaments, 120 volts for the plates, and 60 volts for the plate screens.

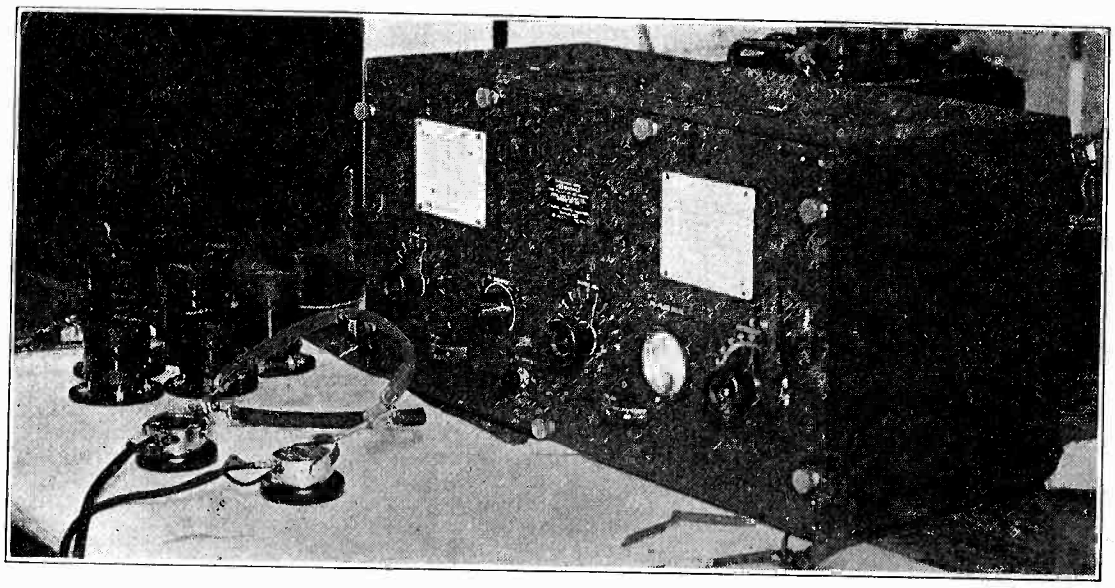
The two detector and two audio-frequency tubes are the '01A type and require 5 volts on the filaments. Forty-five volts are impressed on the plates of the detector tubes but this potential may be varied by use of a potentiometer. The two audio-frequency tubes use only 60 volts on their plates as the sole negative bias available for the grid elements is a one-volt drop in the filament rheostat. The batteries necessary for the entire power supply are a 6-volt, 100-ampere-hour storage battery for the *A* supply, and a 120-volt *B* battery with 45- and 60-volt taps.

The antenna circuit of this novel short-wave Naval receiver consists of a small antenna coupling condenser, connected through a series inductance to the ground. This series inductance coil is coupled to the tuned input-inductance of the amplifier. These two inductance units are wound on a plug-in coil system. When the latter is plugged into the receiver, the tuned-input inductance is connected across the tuning condenser or series inductance. A compensating condenser is employed across the tuning condenser to compensate the extra residual capacity which is present in the tuned detector circuit. This effects a dial alignment of the two circuits, thus insuring a similarity of dial readings for both the radio-frequency and detector variable condensers. The tuned circuit of the radio-frequency amplifier tuning condenser and the radio-frequency amplifier grid-circuit inductance feeds to the grids of the two push-pull tubes through two grid-coupling condensers.

The tuning condenser comprises two series halves with a rotor member common to both. The rotor is connected to the filaments and virtually is at ground potential. This is intended to eliminate hand or body capacity effect. Likewise, this series connection affords a relatively low capacity value—a minimum of approximately 8 mmfd. and a maximum of 57 mmfd. This gives a ratio of about 7.1 to 1, and yet the maximum capacity is quite small—resulting in a relatively high ratio of inductance to capacity. This is essential to effective amplification. The radio-frequency amplifier grids obtain their direct-current bias through 1-megohm grid leaks, which are connected to the junction between two filament-control resistances, thus affording a negative bias of 1.7 volts. The plate screens are maintained at plus 60 volts with respect to the filaments.

"In all amplifier work," emphasizes the Bellevue Naval Research Laboratory, "it is essential for greatest amplification that the external plate circuit impedance be kept relatively higher than that of the internal tube output impedance. This could, in a receiver of limited tuning range, be accomplished by adding a plate-circuit tuning control. But as simplicity of control, and a minimum of parts and space, is a general and important requirement in Naval service receivers, attempt has been made to employ fixed chokes for this purpose."

Therefore, in the "Marshall Receiver," two high-inductance, low-capacity chokes are employed throughout the frequency range of 4,000 to 25,000 kilocycles. A third and similar choke has been positioned at the junction of the two plate chokes and in series with the *B* battery lead-wire. The latter choke coil serves the function of barring radio-frequency currents from the *B*-battery circuit. This additional or third choke likewise serves the purpose of isolating the junction of the two plate chokes from the ground potential. This permits of the chokes finding their own electrical center, which may be different from that of the apparent center, due to electrical irregularities in the two tube and choke circuits. This arrangement is an aid in the preservation of symmetry, which is essential to efficient and stable operation of the receiver at the ultra-high frequencies.

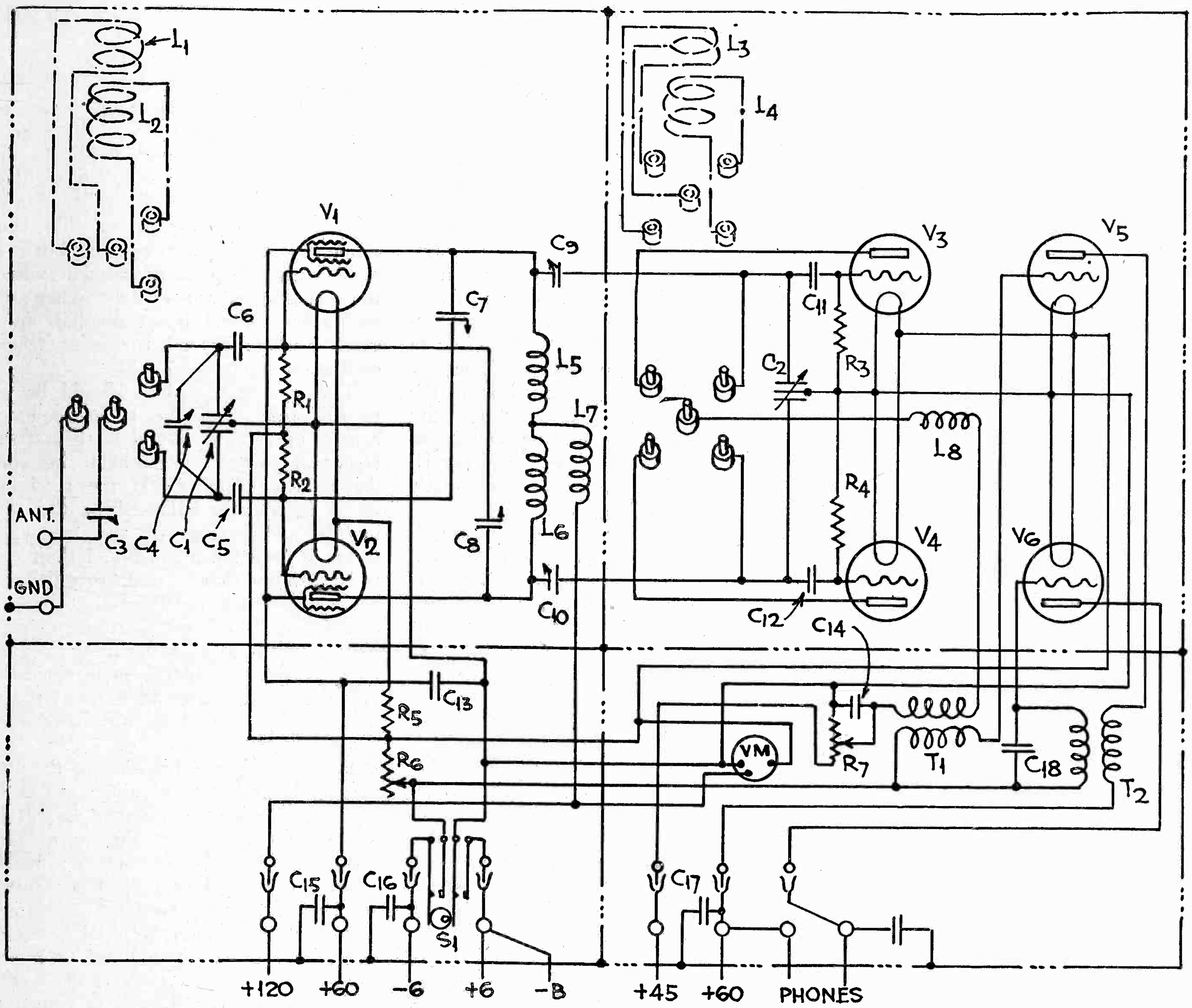


Marshall Short-Wave Receiver, as Used by Navy

The detector circuit and the radio-frequency amplifier are in individual shielded compartments. The two are coupled by two fixed condensers, small enough to prevent reaction of the amplifying circuit on the oscillating detector circuit. The capacity values of these two condensers, however, are not detrimentally low—that is, they do not cause a loss of signal in so far as ear tests can determine.

The tuned detector circuit employs a "plug-in" inductance system similar to that used in the antenna circuit. This, labelled "Detector Coil," includes the grid inductance and the tickler feed-back inductance. The tuning condenser in the detector circuit is similar to that employed in the amplifier circuit. The push-pull performance of the two detector tubes again gives practical application to the sound engineering principle of a large inductance in relation to capacity. This insures a greater amount of inductance with which to couple the inductive tickler feed-back than any single-tube circuit. Furthermore, we are assured by the Navy Department, this combination gives a circuit that oscillates with ease throughout the entire frequency range from 4,000 to 25,000 kilocycles.

The tickler feed-back inductance coil is tapped in the center—the two ends being associated with their respective plates and the center to the plus-*B* battery through a radio-frequency choke and the primary winding of the first audio-frequency transformer to the regenerative-control potentiometer slider. This, in turn, is connected across 45 volts. Regeneration or oscillation control is effected by varying the direct-current voltage on the plate elements of the two detector tubes, using the potentiometer for varying the potential. The potentiometer slides, operated by manipulation of a knob on front of the radio-receiver panel labelled "Regeneration Control," is by-passed to shield or ground through a 2-microfarad condenser.



Circuit Diagram of Marshall Short-Wave Set

V_1 V_2—Radio-frequency amplifier tubes, type UX-222.

V_3 V_4—Detector tubes, type UX-201-A.

V_5 V_6—Audio Amplifier tubes, type UX-201-A

L_1—Antenna Coupling Inductance.

L_2—Radio-frequency amplifier grid circuit inductance (Both L_1 and L_2 wound on r.f. amplifier coil form).

L_3—Tickler feed-back inductance. (Wound on "DET" coil form).

L_4—Detector grid circuit inductance. (Wound on "DET" coil form).

L_5 L_6—Low distributed capacity 250 m.h. plate chokes in r.f. plate circuits.

L_7 L_8—Low distributed capacity 250 m.h. plate chokes in battery leads.

C_1—R.F. amplifier tuning condenser.

C_2—Detector circuit tuning condenser.

C_3—Antenna coupling condenser.

C_4—Compensating condenser to assist in dial alignment of r.f. and "DET" tuning condenser.

C_5 C_6—Grid coupling condensers from tuned r.f. circuit.

C_7 C_8—Balancing condensers to balance out reaction of amplifier on autodyne circuit.

C_9 C_{10}—Coupling condenser from r.f. stage to autodyne circuit.

C_{11} C_{12}—Detector grid condensers.

C_{13}—Bypass condenser on plate screen voltage lead.

C_{14}—Bypass condenser on oscillation control resistance.

C_{15} C_{16} C_{17}—Bypass condenser on battery leads.

C_{18}—Tuning condensers on second audio transformer to cut out audio oscillation.

R_1 R_2—Grid closure resistances to establish proper bias on amplifier tubes.

R_3 R_4—Grid leak resistances for detector tubes.

R_5—Fixed resistance in series with R_6 giving 3.3 volts on amplifier tube filaments.

R_6—Variable filament control resistance.

R_7—Potentiometer 100,000 ohms on 45-volt detector plate battery for oscillation control.

S_1—Filament switch that also disconnects R_7 from circuit.

T_1 T_2—Audio-frequency transformer type CAY 4342.

The first audio-frequency tube is fed from the secondary winding of a transformer — type CAY4342 — while this tube's plate circuit feeds into the primary winding of another transformer, of the same type as the first. The primary winding of the second transformer is slightly tuned with a .0001-microfarad by-pass condenser on the oscillation-control resistance. This, in effect, cuts down the amplification of the higher audio-frequencies, above 1,500 cycles, and correspondingly reinforces the lower frequencies. The secondary winding of this transformer feeds the second audio-frequency tube, while the plate circuit of the latter extends to the telephone connection and through the head telephones to the 60-volt *B*-battery terminal.

The controls on the front of the receiver panel, reading from left to right, are the radio-frequency tuning condenser for bringing into resonance the radio-frequency amplifying stage, the autodyne-detector-circuit tuning condenser, and the regeneration control. An "on" and "off" filament switch is located centrally and near the bottom of the front panel. This switch opens both sides of the filament battery and at the same time opens the potentiometer across the 45-volt supply, thus preventing the *B*-battery from discharging when the receiving set is not in operation.

A voltmeter gives indication of the filament voltage on the '01A type tubes. When the voltmeter-push-button switch is pressed the maximum *B* voltage as applied to the two screened-grid tubes is indicated. These four-element tubes require a filament voltage of 3.3 volts and this current is supplied when the voltmeter reads 5 for the 'A tubes. A single filament rheostat is supplied for the *A* battery control. The screened-grid tubes are fed with energy through the latter resistance unit and through an additional series resistance. The latter should afford a drop of 1.7 volts as required for the efficient operation of the receiver.

The receiver is 22¼ in. long, 10¾ in. high, and 9¼ in. deep. The parts, including diaphragm shielding and wiring, are made secure to the front panel. Withdrawal of the latter displaces completely the receiving set from the box and at the same time automatically disconnects battery, telephone, antenna, and ground leads. These leads, entering the box or receiver container, are permanently fixed to the box fittings. The external connections are made to the receiver circuits through sliding contacts, which close when the panel is secured in place.

The outstanding feature of this new short-wave circuit—its extreme sensitivity—is also its serious limitation. "This receiver has much greater sensitivity at the higher frequencies than any previously supplied to the service," is the unqualified statement of the Navy Department. For this same reason, the set must be mounted on a shock-absorbing pad and the detector tubes inserted in jackets of sponge rubber; otherwise, microphonic noises are so disturbing as to practically defeat the otherwise superior merit of this receiver, namely, ultra-sensitivity.

"The high-frequency receivers as developed in the past," points out the Bellevue Naval Research Laboratory in discussing the theory and operation of this new circuit, "using the customary three-element tubes, have been incapable of giving much amplification over the higher-frequency end of their range and in some cases give a loss above 8,000 kilocycles. With the development of the new four-element tube, which may be called the shielded-plate tube, together with a new circuit arrangement, it is possible to get an appreciable amount of amplification over the entire high-frequency band as now employed.

"The two factors which have previously prevented radio-frequency amplification at the higher frequencies have been the relatively low input impedance of the tube and the low ratio of inductance to capacity, which has existed when using the three-element tube. The low input impedance has resulted from the relatively high grid filament capacity which has under operating conditions been in effect several times the geometrical capacity—being controlled principally by the grid-plate capacity.

"The new circuit employs a push-pull type of radio-frequency amplification, where each of the tube-grid-filament circuits are across but half of the tuned circuit input voltage. This decreases the grid-filament conductance to half for each tube and as the two reactances are in series the total conductance across the tuned circuit is one quarter what it would be for a single-tube-amplifier stage. When the effect of the grid-plate capacity of the three-element tube is considered it is apparent that the push-pull combination with four-element tubes will increase the tube input impedance many times. This improved condition makes it possible to maintain a much higher potential across the tuning-condenser terminals, or the two input grids, than by previous methods. The use of the symmetrical push-pull circuit, which permits a larger ratio of inductance to capacity to prevail, together with the adoption of the four-element tube, has been highly responsible for the improved results at the higher frequencies."

The two screen-grid tubes are equipped with balancing condensers to avoid interplay or disturbing reaction between the stages of radio-frequency amplification and detector. These condensers are located beneath the two holes in the cover which have been blanketed with a butterfly-spring arrangement. Reaction between the different stages in the circuit may be overcome by shifting the vacuum tubes in different sockets. If, however, the trouble persists, the Navy Department indicates that the balancing condensers will accomplish the desired result if this procedure is followed:

The receiver—which may be operated on an antenna only a few feet in length or one several wave-lengths long—is connected to the pickup system and No. 1 inductance coil brought into use. The cover over the adjusting holes in the main cover is removed or loosened and turned 90 degrees, in order to render accessible the condensers with the main cover closed. The lock-screws on these units are loosened.

The receiver circuits are brought in resonance with the detector oscillating. An unbalanced condition is evidenced when the tuning of the radio-frequency circuit through resonance with the detector circuit, when it is barely oscillating, produces a squeal in the head telephones or stops oscillation. This condition is well-nigh ever present, but it is possible to obtain an adjustment where the reaction is not evident when the oscillation control is set one-half of a small division beyond the point where oscillation starts.

The oscillating circuit should be set to this point and the radio-frequency control operated back and forth past the resonance point until the balancing condensers are adjusted. If the receiving set is apparently balanced at the top, middle and bottom of the frequency range of inductance coil No. 1 then it is to be assumed that a satisfactory balance has been assured for the four other inductance coils. For the balancing condenser adjustments a bakelite, fiber or hardwood screwdriver is used, since the presence of metal would defeat any attempts to adjust these balancing condensers.

While the Radio Division of the Bureau of Engineering is prone to classify this new short-wave receiver as still in an experimental stage—due to its tendency to set up microphonic noises when not situated in a shock-absorbing, steadfast position—twelve or fifteen units have been manufactured. Several of these have been introduced to Naval service—both on surface and subsea craft—and when subjected to comparative tests with a standard short-wave set of Navy design the results have been gratifying, in some particulars at least.

For example, while in service on the *Eagle,* a patrol boat for conducting sound and radio experiments, the strength of the signals received by the "Marshall receiver" were stronger than those tuned by the standard Navy short-wave set—though the signals of the latter were more readily tuned and the distant stations more easily located. The selectivity of the "Marshall receiver" was marked and once the stations were logged the dial could be consulted time

(Continued on Page 49)

TECHNICAL BRIEFS

TRANSATLANTIC radiotelephone service between the United States and Great Britain as well as various cities of Continental Europe, Canada, and Cuba is normally available from 5:30 a. m. to 8:00 p. m., eastern standard time. The British receiving station is at Cupar, Scotland, as far north as conveniently possible so as to reduce interference caused by atmospheric disturbances.

THE R. C. A. projector system used in long distance radio communication includes both directive transmission and directive reception on short waves. Several receiving antennas, directive in themselves, are spaced so as to eliminate the momentary fading which originally limited the use of short waves.

RAILWAY radiotelephone equipment has been developed for front-to rear communication on long freight trains. A four-months test of the equipment by the Chesapeake & Ohio Railroad showed that telephonic communication could be maintained between the locomotive and caboose whether the train was standing or in motion and even when the train was broken if the separation did not exceed five miles. A signal system of lower power has been developed for service between the front and rear of long freight trains. One-way telephonic communication with low power equipment may also be maintained between the yardmaster's office and any locomotive in the yards.

THE demand for quartz crystals for controlling the frequency of radio transmitters is supplied mostly from Brazil. The present price is about $3.00 per lb. To be acceptable to the Naval Research Laboratory at Anacostia, D. C. they must be single crystals weighing at least two pounds and must show growth lines on at least two faces. They must be free from imperfections such as internal fractures and inclusions of foreign matter. They must be absolutely clear when viewed by transmitted light.

THE radio experimenter may find much interest in utilizing the radiated output of a short-wave oscillator to produce luminous discharges through rarefied gases in tubes such as the neon tubes which are now used in electric signs. Whereas a high voltage is necessary to produce a glow when low frequency alternating current is used, relatively low voltages are needed at high frequency.

Thus James and Wilfred Taylor, in a recent issue of *The Wireless Engineer*, London, describe some experiments with a 35,000 k.c. (8.57 meters) oscillator whereby beautiful discharges were produced at 15 volts. In the circuit diagram of Fig. 1 the plate *B* and the grid *D* are connected to two parallel copper wires about 50 in. long and 3 in. apart. A

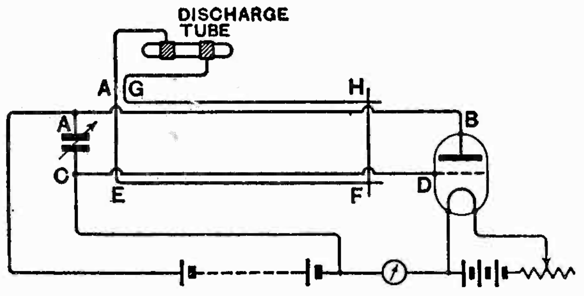


Fig. 1. Circuit Diagram for High Frequency Generator and Discharge Tube

.001 mfd. variable condenser is shunted across the ends of these wires at *A C, A* being connected to the positive terminal of a 220-volt d.c. source and *C* to the negative terminal. *E, F, G, H* is a tuned system coupled to *A B D C* by the Lecher wire method. Two annular rings of copper foil are wrapped around the outside of the glass tube to serve as electrodes.

Different colors and forms of discharge occur as the gas pressure or gas composition is varied. The experiments were made with air, neon, helium and mercury vapor. The discharges are caused by the motion of the electrons between the electrodes; light is emitted as an electron jumps from an outer to an inner orbit as it collides with a gas molecule.

THE economically-minded person sometimes objects to the thought of using an apparently wasteful voltage divider to supply 45 and 90 volts to a radio set from a rectifier-filter system which also supplies 180 volts or more for a power tube. But when it is realized that the waste current through the divider not only may improve the voltage regulation or stability of voltage output, but also reduce the strain on the filter condensers, its use is well justified.

A rectifier-filter system is a constant wattage device. The voltage drops as the load or current drain increases, increasing the load resistance decreases the load current. When the current drain is increased from any tap, the voltage output and current supplied from the other taps is correspondingly decreased. Part of the increased load current comes from the rectifier-filter system and part from the voltage divider system, both at the expense of decreased voltages.

These facts are used by the Aerovox Wireless Corporation to explain the advantage of a low resistance voltage divider over a high resistance device, i. e. the advantage of a voltage divider having a relatively high waste current. Tests were made with eliminators having a wide range of regulation curves and with voltage dividers having waste currents of 5, 10, 20 and 30 milliamperes. In all cases the calculated load was assumed to be 20 m.a. at 180 volts, 12 m.a. at 90 volts, and 2 m.a. at 45 volts. The results are tabulated herewith to show the voltage change produced at any tap by increasing or decreasing the load by 1 m.a.

I. 5 MIL VOLTAGE DIVIDER

Tap	45V.	90V.	180V.
45V.	4.25	1.85	negligible
90V.	2.20	3.98	1.88
180V.	0.53	1.40	1.25

II. 10 MIL VOLTAGE DIVIDER

Tap	45V.	90V.	180V.
45V.	3.02	1.37	negligible
90V.	1.53	2.95	1.30
180V.	.38	1.05	.87

III. 20 MIL VOLTAGE DIVIDER

Tap	45V.	90V.	180V.
45V.	2.05	.96	negligible
90V.	1.12	2.03	.93
180V.	.25	.73	.63

IV. 30 MIL VOLTAGE DIVIDER

Tap	45V.	90V.	180V.
45V.	1.75	0.56	negligible
90V.	.92	1.17	0.77
180V.	.21	.50	.50

Thus it is shown that an increase in the load resistance at the 45-volt tap of a 5 m.a. divider so as to produce a decrease of 1 m.a. at that tap, will cause increases of 4.25 volts at the 45-volt tap, 2.2 volts at the 90-volt tap, and 0.53 volts at the 180-volt tap, as compared to 1.75, .92 and .21 volts respectively when using a 30 m.a. divider. A decrease in the load resistance to produce a 1 m.a. increase in current causes voltage drops of corresponding values. The 90-volt tap is evidently the most easily and greatly disturbed, and the 180-volt tap, which feeds without passing through the divider, the least disturbed by any change in the load. As the 45-volt tap is very sensitive to changes of load at 45 volts, many eliminators do not work satisfactorily when feeding a set which has a large 45-volt load, like a superheterodyne.

It is evident that voltage variations due to variable loads may be minimized by using as heavy a waste current as possible. Furthermore the rise in voltage due to removing the load is thus minimized.

THE general theory of sound picture reproduction which was recently explained in these columns, was based upon the Vitaphone and Movietone systems, which record the sound waves on phonograph records, or film respectively, in the form of parallel lines. A third system was inadvertently omitted, this being known to the trade as the Photophone system. The latter is similar to the Movietone in that the sound waves are recorded photographically on the same film with the picture, but these waves are in the form of a single, jagged heavy line that looks like a cross-section of a mountain range. Its width varies in accordance with the frequencies recorded. A photoelectric cell and aperture somewhat like the Movietone system converts this solid black strip into sound, to be amplified and projected into the theatre by means of loud speakers.

Many of the latest types of motion picture projectors are equipped with special fittings so that any of the three systems of sound reproduction can be used by changing the aperture plates, projection lenses, and making minor adjustments requiring only a few minutes. The size of the picture on the Photophone film is somewhat smaller than for ordinary silent pictures, so as to allow a greater width for sound recording, but the picture is rectangular in shape instead of square as for the Movietone system shown in the September issue. This requires a different set of lenses, and a smaller aperture for the picture, but the change is quickly made, and hence no inconvenience is caused by the different systems. Probably the first radio movies which will eventually be made available to the general public will use this system.

AN exhaustive series of measurements of the amplification and selectivity of sixteen different types of r.f. coils, by Alfred J. Daniels of Aero Products, Inc., shows that in the conventional r.f. circuit the most efficient practical type of those coils tested has its primary wound to occupy ½ in. inside and opposite the low potential end of the secondary. But by means of a special circuit, herein described as the "Chronophase," still better results with screen-grid tubes were secured from an autotransformer whose primary is a portion of the secondary, the low potential ends being common.

All of the coils were of the type shown in Fig. 1, being air-spaced wound to approximately the ideal shape-factor

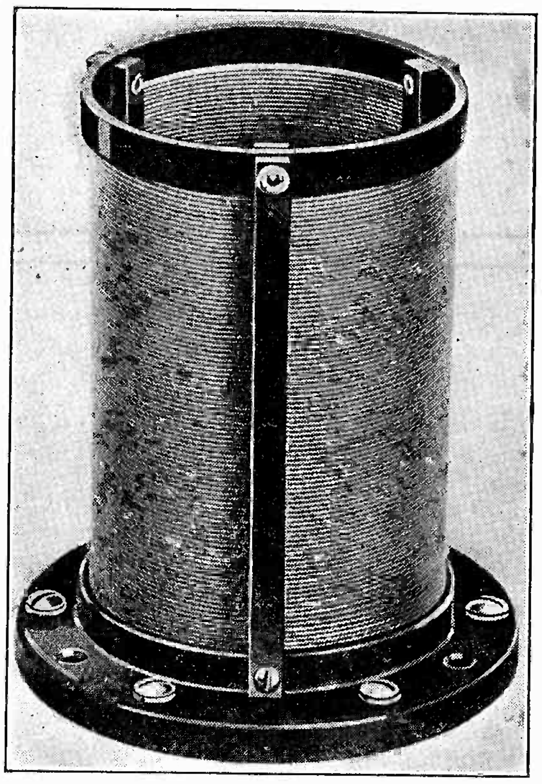


Fig. 1. Type of Coils Tested

and supported by a skeleton bakelite frame to minimize insulation losses. Each type had various numbers of primary turns and, where possible, was tested with variable coupling. The secondaries, measured independent of the primaries, had an inductance of 167.4 microhenries and an r.f. resistance of from 3.85 ohms at 550 meters to 9.6 ohms at 200 meters. These figures are changed by the presence of a primary.

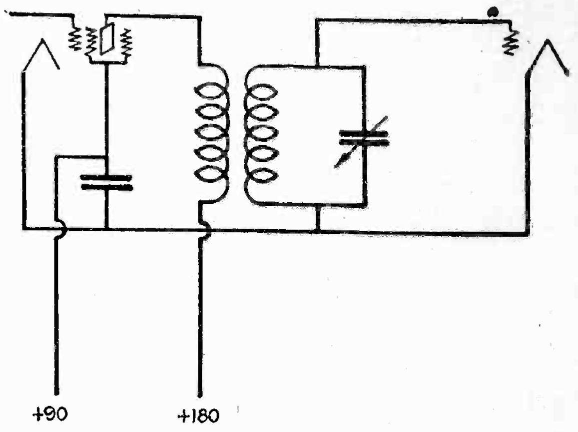


Fig. 3. a. R. F. Circuit Connections for Screen-Grid Tube with Conventional Transformers

The coils under test were supplied with a constant input signal at various frequencies in the broadcast spectrum, and the output was measured with a

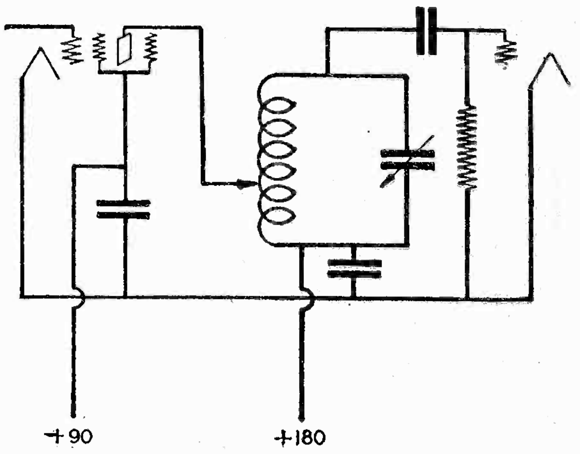


Fig. 3. b. R. F. Circuit Connections for Screen-Grid Tube with Autoformer

vacuum tube voltmeter. The test conditions were nearly identical with those surrounding a coil in an actual receiver.

Fig. 2 shows the amplification curves obtained with the autotransformer and

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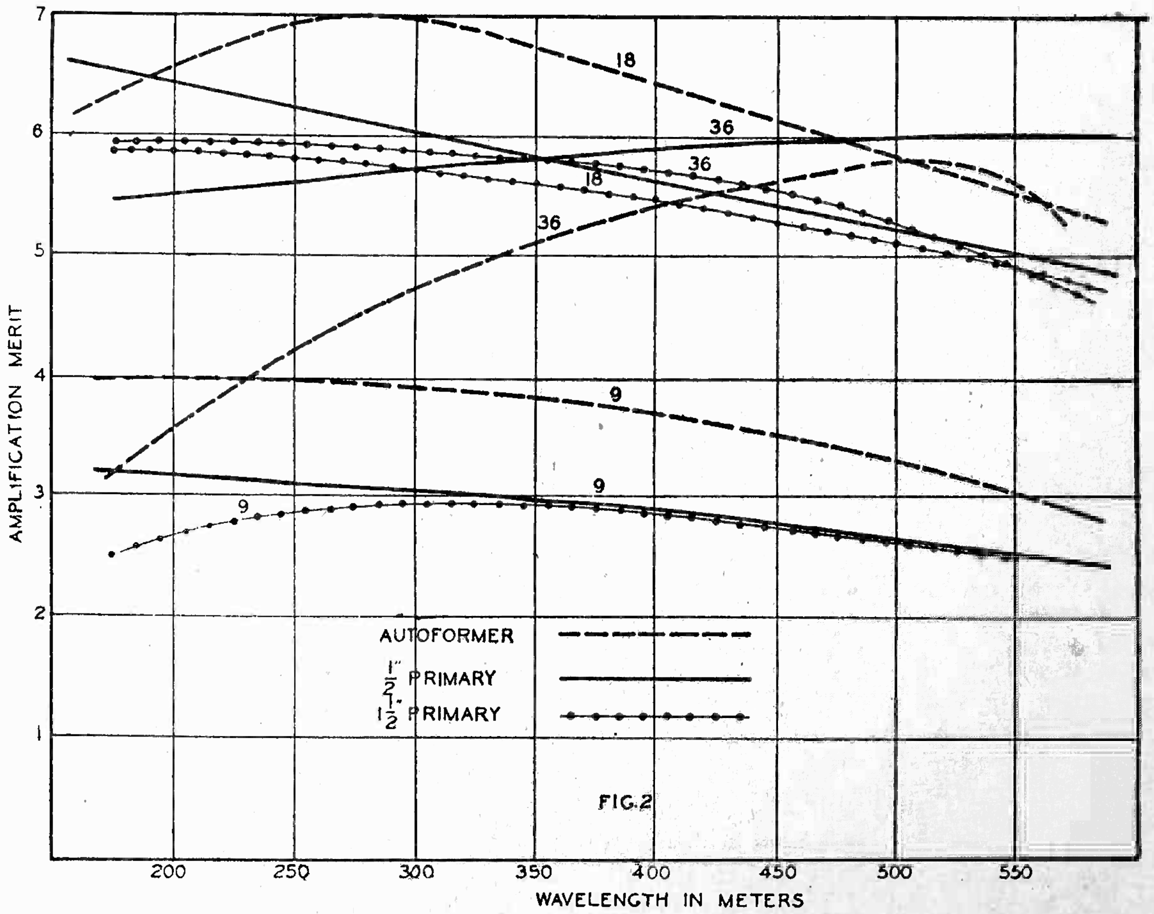
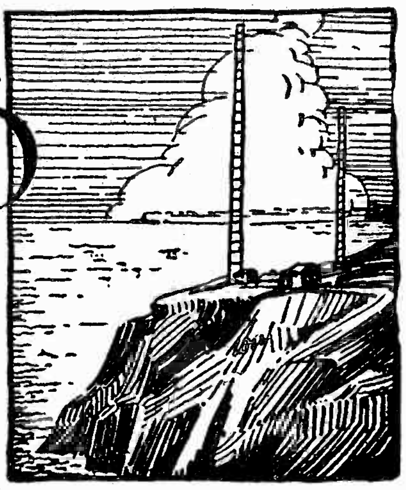


Fig. 2.. Amplification Curves for Three Types of Coils with Varied Number of Turns

The COMMERCIAL BRASSPOUNDER

A Department for the Operator at Sea and Ashore



Edited by P. S. LUCAS
R. O. COOK, *Assistant*

A LETTER from Fred M. Winckel comments upon L. W. Gillis' article in June RADIO. Mr. Gillis, you remember, pointed out several reasons why radio operating conditions seem to be going from bad to worse, and made a few suggestions which might help remedy the situation.

Mr. Winckel believes that the only way to improve matters is to go right down to the bottom of things and attack the existing radio laws. No doubt he is right; but, as he goes on to say, the radio operator alone is not in a position to approach the radio commission or the senate committee on such a subject. He feels that the idea of an association of sea-going operators is still good, even if it has failed on several attempts. That is a subject that is always open for debate.

Even if we had an association of radio operators; even if we were solidly organized; where would it get us? Our strength would serve as a threat, but would the threat scare anyone into improving conditions for us? It would certainly antagonize the steamship companies, the radio companies and even the ill-informed public. "Radio operators imperil many lives." We can see the newspaper headlines—and the general public thinks we are having a lovely time of it.

No, radio operating is a profession, and strikes always belittle a profession. The world as a whole is drifting away from such methods of improving conditions; conditions are improving themselves. Employers are acquiring educations; they are learning, through the advancement of psychology, that it is to their advantage to show a little consideration to their employees.

We'll agree with you that our theorizing sounds very nice, but that it does *not* apply to our situation. Why? Are we so different from all other professions?

Well, here's our theory; and this is open to argument. We may be on the wrong track entirely. Anyway, it is our humble opinion that the great majority of operators take life too easily. It is difficult for a man to go onto a job, boss of his own time and unwatched by any authority, without falling into easy going habits. It is extremely difficult when the operator knows full well that he can do all that is required of him in three or four hours a day. If he can handle his job in four hours of concentrated effort, why shouldn't he do so? That's reasonable logic. But here's the reason why he shouldn't; the reason why he should *find* enough work to keep him busy for at least eight hours a day as regularly as any man on the crew.

The general impression is abroad that the wireless operator has an easy time of it. This starts with the other officers immediately associated with the op. It spreads to the crew, to the marine offices, to the higher officials. Not one man in a thousand gives the radio operator credit for doing a good day's work in all his existence. And here we have it. The officials require very little from an operator; and pay him what the fulfillment of those requirements are worth to them. The operator works about as hard as he is paid for; the report gets out that the operator has an easy life; the officials—etc., etc. It goes around in circles.

Now what can we suggest as a remedy for this peculiar condition? In the first place the operator, every operator, must make up his mind to putting in a good, full eight-hour day. He should make out a schedule for himself and, figuratively speaking, "punch the clock." He should win the captain and the mates to his side by voluntarily giving them every available aid to navigation. He should insist that that is a part of his work and he is paid for doing it. (Fingers crossed). If the engineers ask for any aid on their generators he should jump at this opportunity of winning their friendship. While listening in for "roll-calls" and other signals he should not only keep his log up to date, but file away in his head, every bit of information possible so that if anyone asks him any questions he might be able to give the impression that he is well informed. In brief, he must consider his job more important than his officials consider it, and organize it accordingly. How long, under such conditions, would it take for a vastly different sort of "underground telegraph" message to be buzzing in the ears of the officials?

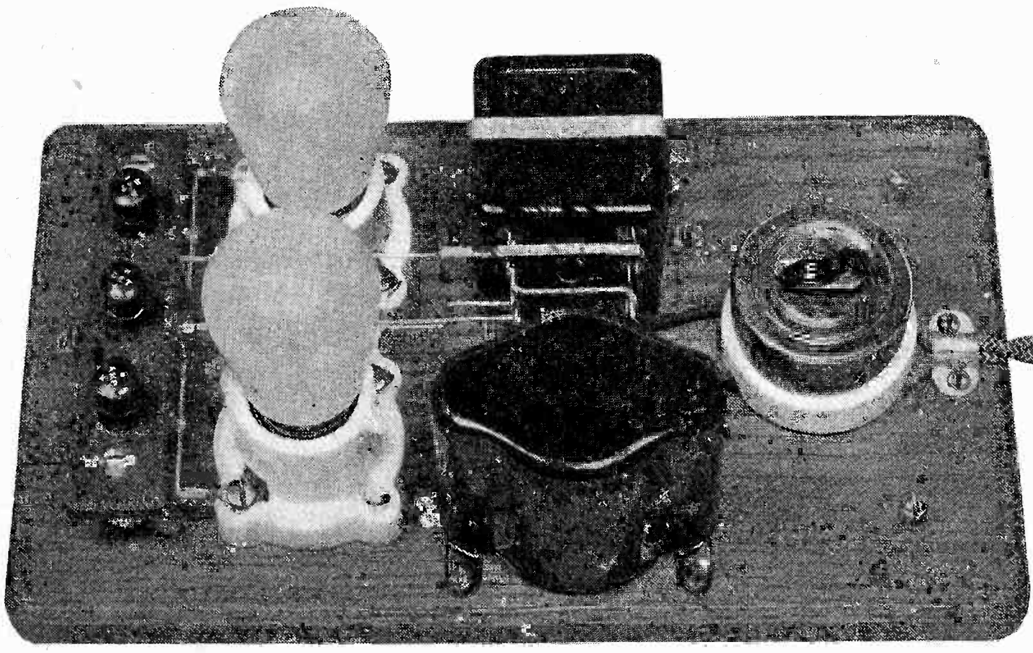
This should be the one great object of an organization: to so enthuse the mass of operators with the possibilities of improving conditions ashore and afloat that they will carry out the suggestions just made. Let the organization be formed to promote the member's interest in his work. Every operator must feel his responsibility in this matter or the situation will be worse twenty years from now than it is today.

And one parting shot to the man who intends to take one trip or spend one year, then quit. You will get a whole lot more out of your trip or your year, you will have more to look back upon, and you will equip yourself for a more successful future if you will play the game as if it were to be your life's work. While you are in it feel yourself a part of our development program. Men, it's up to you.

A PRACTICAL "B" ELIMINATOR FOR SHIP USE

By R. M. HUGHES

Many sea captains, as well as mates, engineers and radio operators, have their own broadcast receivers aboard ship. Yet few of them use a *B* eliminator, although there is no place where local conditions are better suited for its use. The ship dynamo supplies direct current at about 110 volts. This contains a commutator ripple which must be filtered out before it is suitable for use as the plate supply for a radio set.

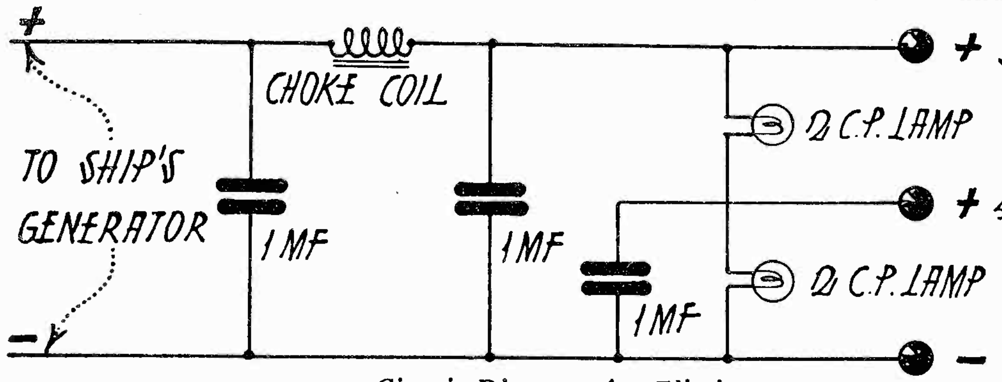


"B" Eliminator for D.C. Supply

All that is needed to make the satisfactory battery eliminator shown in the picture and circuit diagram herewith, can be bought at a chain store for less than four dollars, or for slightly more if purchased from a regular dealer in radio parts. This equipment can be quickly and easily assembled on a baseboard and will furnish hum-free current at 45 and 90 volts.

An ordinary snap-switch is used to turn the current on and off. The choke coil has an inductance of about 20 henries. Each of the three condensers has a capacity of 1 mfd. and should withstand 200 volts. The voltage dividing circuit consists of two 2 c.p. lamps connected in series, one being connected directly to the negative side of the ship's generator and other through the choke coil to the positive side of the line. The center tap gives 45 volts.

As a ship's power system is not grounded, a necessary precaution requires a 2 mfd. condenser in the ground-lead of the receiver. This does not interfere with the receiver's r.f. ground, but does prevent shorting the ship generator.



Circuit Diagram for Eliminator

All of the parts can be assembled on a baseboard 6 by 10 by ⅝ in. The condensers can be stacked on top of one another and held in place by a small strip of brass. This device has proven to be satisfactory with many different receivers in many locations.

TRANSLATION OF ESSENTIAL WORDS USED IN XDA WEATHER

By Paul Otto

Several operators have asked me where I got the impression that XDA weather is easy to translate! Here is a list of twenty words that chiefly constitute the construction of these weather reports. Of the twenty, there are only eight whose meaning in English is not self-evident. Judge them for yourself.

From experience I have found that the weather contained in the number groups, from coast towns, is the most desired.

In the first group the first three figures are the barometer in centimeters. The fourth is the wind direction, and the fifth the wind force. In the second group the first figure is the state of the weather, and the third is the sky report. These figures can be very easily decoded by referring to a copy of "Radio Aids to Navigation," which can be purchased for seventy-five cents at any store that carries hydrographic publications.

Here are the words:

ENGLISH	SPANISH
Somewhat	Algo
Lower	Baja
Cape	Cabo
Coast	Costa
Of	De
Light	Debil
Of the	Del
The	El, or La
East	Este
Strong	Fuerte
Gulf	Golfo
As far as, or to	Hasta
Moderate	Moderado
Very	Muy
North	Norte
West	Occidental, or Occ.
East	Oeste
Shifting, or changing	Rolando
South	Sur
Winds	Vientos
Northeast	Noreste
Northwest	Noroeste
Southeast	Sureste
Southwest	Suroeste

CCA, ANTOFAGASTA, CHILI

By Charles F. Stewart

Having read pleas for South American material in the Commercial Brasspounder, I decided to take advantage of a stop-over in Antofagasta last May to check up on Station CCA.

CCA is a naval station and handles Government business only, on 1800 and 2800 meters. It is intended, however, to install a 600-meter spark, with which to handle commercial ship to shore traffic. Perhaps this service has already been inaugurated.

I was cordially met by the chief operator of CCA, Mr. Stienbacher, who kindly showed me the installation and later introduced me about the town, even throwing a party for me. He told me that I was the first American operator he had met and asked that I extend the invitation to any other operators who might come to Antofagasta, which I hereby do. Take him up if you ever drop your hook in Antofagasta; you will not be sorry.

Now for the station: CCA is housed in a three-story building. Mr. Stienbacher and family live on the first floor where the power supply is also located. On the second floor are the living quarters of the three assistant operators, while on the third floor are the receiving apparatus, control room and land line.

There are two receivers, one Marconi, the other made by Telefunken. The transmitter is on the ground floor near the generators, and is a 10 kw Marconi outfit, with 10 1 kw tubes. The transmitter occupies a room to itself and is surrounded by a brass rail, only the tubes and rheostats being mounted on a panel.

Although the soil is extremely dry a ground is used for transmission and reception. I asked Mr. Stienbacher about the possibilities of a counterpoise, but he had never heard of one and was quite interested when I explained it to him. A Marconi engineer made the installation and I cannot understand why he didn't install a counterpoise.

The Chilean Navy was experimenting with short waves at that time, and was sending its operators small booklets on that subject. It might be well to mention that all stations in Chili are under the control of either the Chilean Army or Navy. The Navy maintains a school in Valparaiso, where its operators are trained. English equipment predominates, although a few Telefunken tubes and receivers are used.

To listen to a Chilean coast station handling commercial traffic you would think the operators and equipment very poor, but the stations handling government traffic have first-class equipment and operators. Only men with a high rating are used for this type of service. It is easier to understand this when it is known that the Chileans believe the Army and Navy to be the most important elements of their country's organization.

Mr. Stienbacher speaks excellent English and is very anxious to get acquainted with American operators. As we said before, if you want to be well received, drop in on CCA.

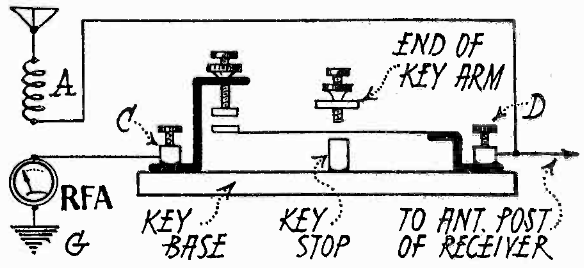
AN EASILY CONSTRUCTED BREAK-IN

By J. A. Bender, *S. S. West Cactus*

A lot of fine machine work can be put in on a break-in, but when the all-important consideration is cash there is just one item, outside of efficiency, to be discussed, and that is simplicity. Therefore, if you are interested, read about the one you can make out of parts retrieved from your junk-box.

Delve into the aforementioned curio shop and bring out the following trinkets:

1 piece of bakelite panel 5"x3".
1 piece of bakelite strip 3"x½".
1 piece of heavy brass strip 3"x½".
1 piece of heavy brass strip 1½"x½".
1 piece of spring brass strip 2"x½".
2 binding posts.
1 8/32 screw about 2" long with nut.
1 brass bushing about ½" long, tapped on one end to an 8/32 thread and on the other end to same thread as on the key contacts named below.
1 piece of brass bushing about ¼" long tapped 8/32 thread for key stop.
2 key contacts.



View of the After End of the Key Base

First, mount the key on the piece of panel so that about 3 in. of the base extends out in back of the key proper.

Second, drill three holes in the panel about ¼ in. from the end; the two outer holes being about ⅛ in. from the edges of the panel and the center hole in line with the adjusting screw of the key proper. All the holes must be in line.

Third, take the brass ¼ in. bushing and screw it into the center hole.

Fourth, take the piece of strip bakelite and drill a hole in each end, tapping one hole with the same thread as the adjusting screw on the key. Remove the back adjusting screw from the key arm and bolt the bakelite strip to the arm, using the hole from which the screw was taken. Now screw the adjustment screw into the tapped hole of the bakelite strip.

Fifth, drill and tap one hole on the long strip of brass and bend the strip to right-angles about ¾ in. from the end, using an 8/32 tap to tap the hole.

Sixth, drill a hole in the other end and bend in the opposite way about ¼ in. from the end. Screw the long 8/32 in. screw into the tapped hole, leaving the nut on the screw, and screw the key contact to it, using the ½ in. bushing. Now take the finished piece and bolt to one side of the panel, using a binding post.

Seventh, take the brass spring, drill a hole in each end and screw the other key contact to it. Take the short brass strip and drill a hole in each end, then bend it at right-angles about ½ in. back from each end, reversing directions. Bolt the spring to the strip and bolt the whole thing to the panel.

Eighth, replace the arm of the key and you have the break-in completed. Not much to look at, but it surely does the work.

In hooking up the break-in, disconnect the transmitter from the r.f. ammeter, at *A*. Run a lead from the ammeter to the binding post *C* on the break-in. Run a lead from the binding post *D* to the antenna binding post on the receiver, also to the transmitter at *A*.

(Continued on Page 48)

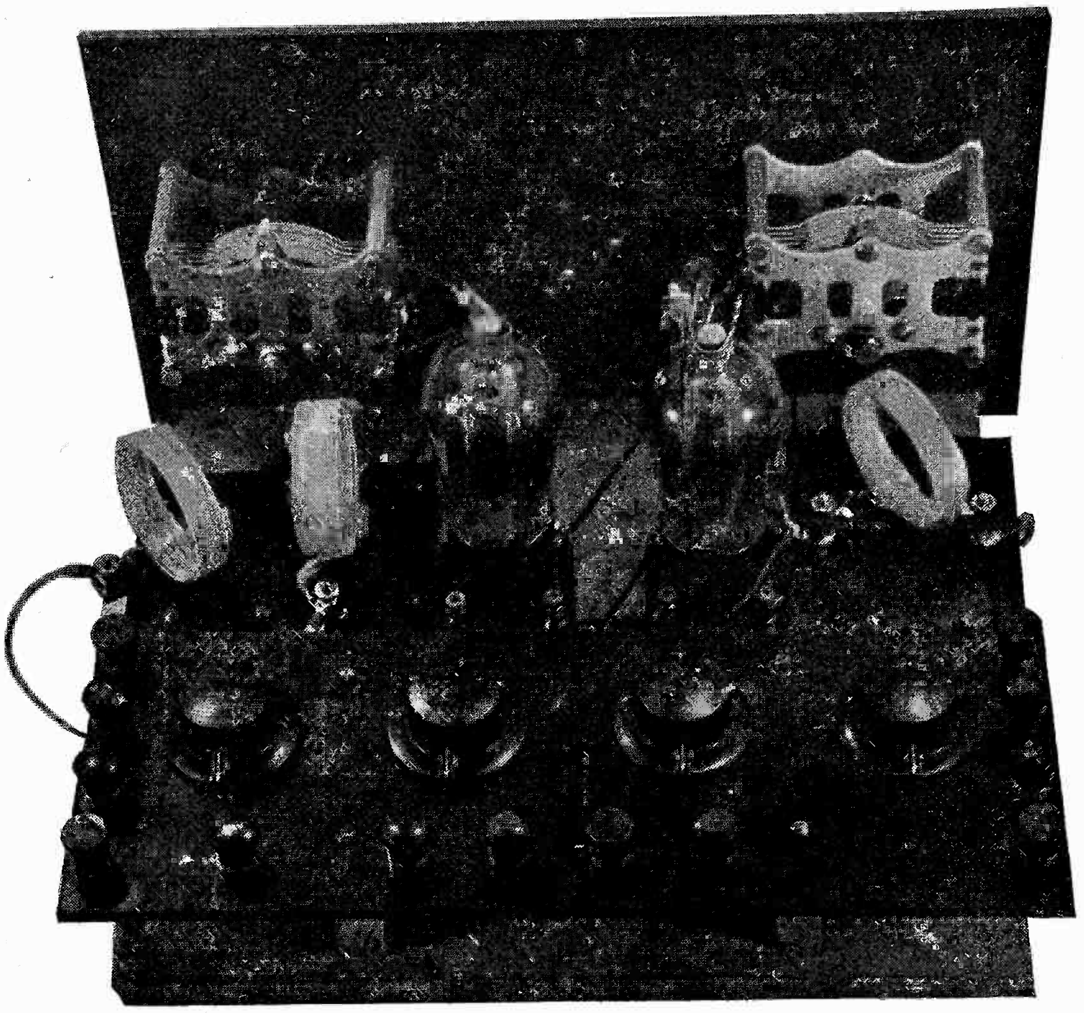
With the Amateur Operators

AN ALL-SHORT-WAVE RECEIVER

By A. BINNEWEG, JR.

UNLESS particular attention is given to station design for 1929 conditions, amateurs may have difficulty in working at the higher frequencies. The experimenter will use the 10-meter and 5-meter bands with reflectors. Those who will use the 20 and 40-meter bands must use special care and apparatus.

The usual 40 and 20-meter receiver will not also operate at 5 and 10 meters, as the parts are too large. To satisfy 1929 requirements, the set must tune sharply over a narrow band, which means that midget condensers will be used. Many amateurs will leave the narrow bands and experiment with the much wider 10-meter one which has exceptional possibilities. The writer has developed a receiver which covers efficiently the 5 and 10-meter bands and meets the 1929 requirements for the 20 and 40-meter ones.



Short-Wave R.F. Amplifier with Screen-Grid Tubes

The receiver is constructed in two sections: a two-stage screen grid amplifier in one and a regenerative detector and two-stage audio amplifier in the other. The r.f. amplifier section is especially useful for the higher frequencies as the amplification falls off. It may be added to any short-wave receiver. By proper circuit design and parts placement, it is possible to operate the amplifier without any great amount of skidding, a grounded copper sheet between the two tubes usually being sufficient to prevent oscillation at 5 and 10 meters. Fig. 1 shows the complete circuit diagram.

The r.f. amplifier coils must be of small diameter to limit the field and minimize inductive feed-back. For 40 meters, 2-in. coils with 12 turns are about right, and at 20 meters 4 turns will do, the exact size depending upon the range of the tuning condensers. The antenna coil and its associated secondary are mounted on a 3 by 4-in. piece of bakelite placed directly below the condenser so that the wiring is short and direct. The plate coil of the first stage is mounted in a similar manner. A 10 by 11-in. baseboard provides ample space between the parts.

Separate batteries can be used for each stage. Separate binding posts are provided for each *A* and *B* battery supply and two posts are left free for the leads of the output coupling coil.

Filament current for each r.f. amplifier stage is supplied through two rheostats connected in series. One is variable for filament regulation. The other is fixed as regards filament voltage, but is adjustable so as to give the best grid-bias. This bias adjustment is secured through a lead from the movable arm to a separate post. The four rheostats and binding posts are mounted on a 4 by 11-in. piece of bakelite, which is separated above the baseboard by two wooden uprights.

The second r.f. stage requires a .0002 mfd. grid condenser and 1 or 2 meg. leak. This amplifier will operate well at 40 meters without by-pass condensers. For shorter wave work .002 or .003 mfd. will serve.

The clips for the control grids consist of trimmed fahnestock clips to which the leads are soldered.

The main panel measures 7 by 12 in. and shows two 100-degree dials and a filament switch between. The ground post is mounted on the small panel, with the antenna coil, which is fitted with a strip of bakelite and a G. R. plug; this rotates in a jack which can change the coupling. A flexible lead to the antenna coil connects to the antenna post at the rear of the set. The small panels supporting the plug-in coils are fastened to wooden supports and clear the baseboard about ½ in.

The tuning of the amplifier is not sharp at any frequency so that one can tune somewhere near the band, and the receiver is then the usual two-control affair. The input tuned-circuit to the amplifier has the most effect on the overall amplification.

The construction of the regenerative detector and audio section is almost self-evident from the circuit diagram and picture.

For reception at 5 meters, both 100 pfd. midget shunt condensers are set at minimum, the 2-turn secondary is used, and tuning is as easy as usual. The shunt condensers are adjusted for a certain minimum capacity which is desirable in the secondary circuit,

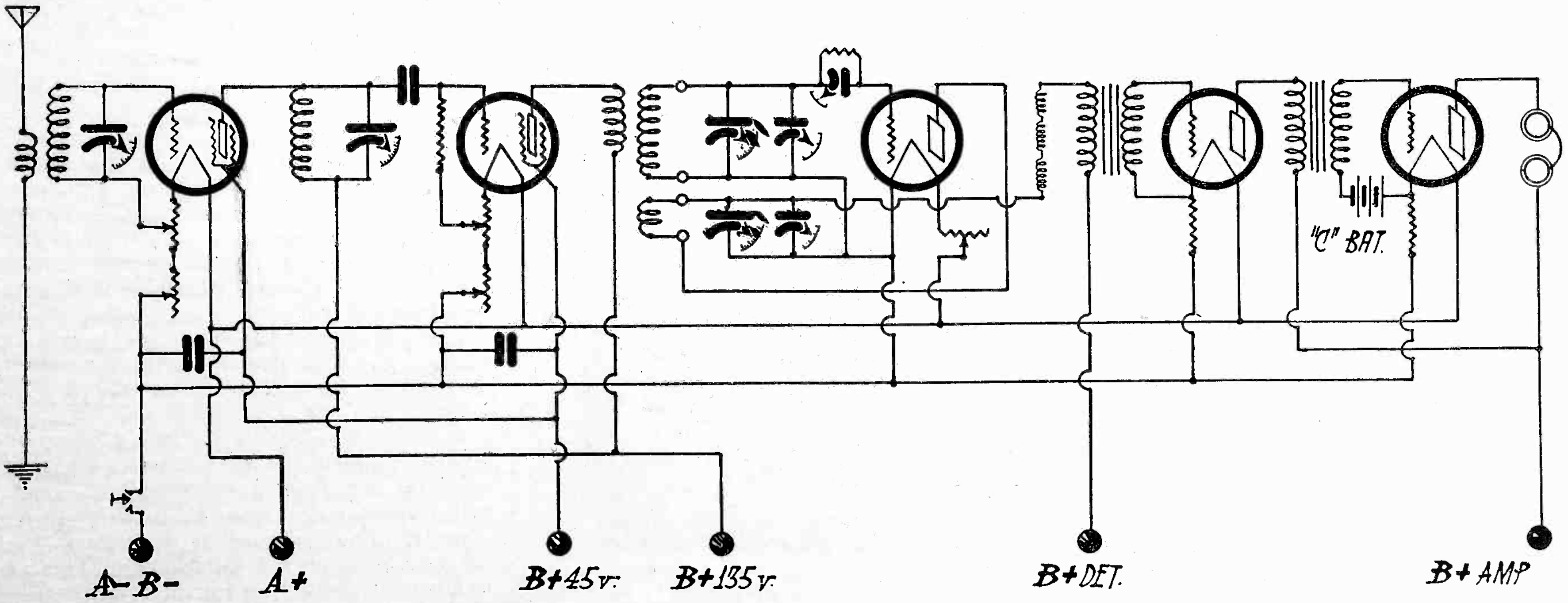


Fig. 1. Circuit Diagram for All-Short-Wave Receiver with Screen-Grid R.F. Amplifier

for the throttle-control has a large detuning effect when the total secondary capacity is near that of the tube capacities.

To operate at 10 meters, simply plug in the next coil and listen anywhere between 5 and 10 meters. The secondary shunt condenser is used to shift to a new band.

To operate at 20 or 40 meters, a large inductance can be used, or else the shunt condenser can be set somewhere near maximum and a smaller coil employed.

It is interesting to compare receiving conditions with the different *LC* ratios possible. Any size of inductance, within reason, is all right, as adjustment is made with the shunt condenser. When the proper position is once located, the knob-setting is noted, and rapid wave-changing is then possible. It certainly is a relief to have a receiver which will operate efficiently at the lower wavelengths also.

For 5 and 10 meters, the plug-in coils are self-supporting and are mounted in '99 bases; for 20 and 40 meters, the larger bases may be used with the coils wound directly on them.

If desired, celluloid-supported coils may be mounted horizontally on these bases. A good tube socket should be used for the plug-in coils; by a simple test, at even 10 meters, the capacity between the socket terminals (and what little wiring there is) alone, is sufficient so that the operation of one condenser has some effect on the other. The socket is mounted on a block between the condensers and the leads are thus short.

The throttle-control is a 100 pfd. midget which is sufficient for the shorter wave-bands. For the higher wave-bands, the other 100 pfd. midget, shunt condenser, is utilized and the receiver can thus cover a very large range without changing coils. It is important to adjust the tickler so that good regeneration-control is secured with the condenser near a maximum setting, so that detuning of the secondary circuit will be negligible.

The midgets are mounted on small brass angles; some midgets already have these. Extension handles are used, which allows efficient reception at the highest frequencies without any body effects. A half-inch wooden panel, screwed to two uprights, to which the sub-panel is screwed, makes a sturdy set. To properly center the extension handles, the condensers are first mounted in place and the handles extended to the panel, which is then marked and drilled. Large holes are drilled half way through the panel for the vernier-dial screws, and smaller ones the rest of the way. Often the advantage of a good vernier dial is lost by motion at the bottom; if two brass wood screws fitted with washers are used to hold it here, no trouble will be had. A small dial or knob is used on the regeneration control.

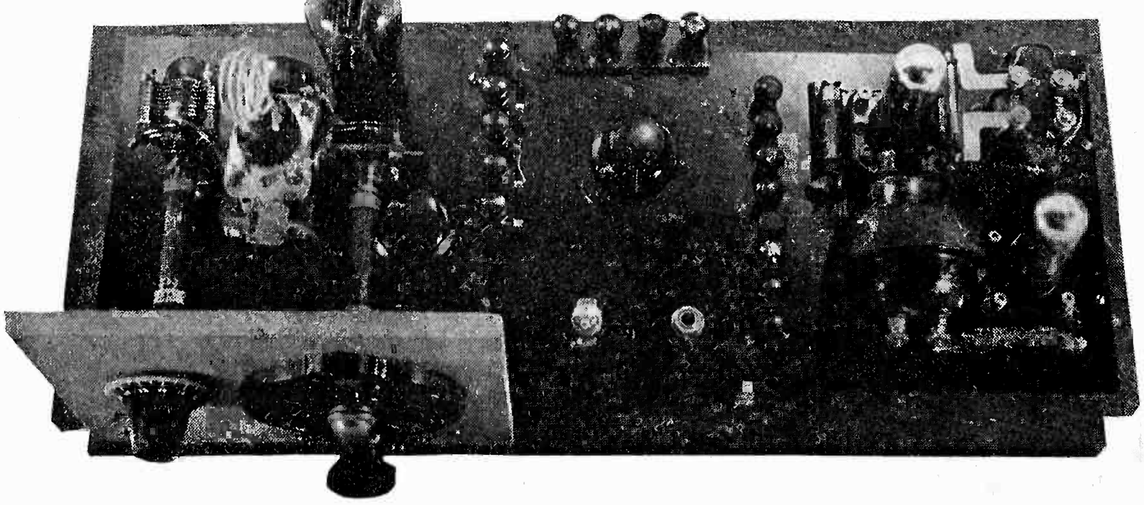
A good choke, which will cover the 5 and 10-meter bands also, consists of several small windings in series on a ¼-in. dowel; these windings consist of 20, 40, 60, 80 and 100 turns, bunch-wound, and are spaced about ¼-in. apart. Basket-weave coils may be used if desired.

LIST OF PARTS FOR ALL SHORT-WAVE RECEIVER

4 100-mmfd. Midget variable condensers
1 15-mmfd. Midget variable condenser
Tube bases for coils
2 sockets for amplifier tubes.
5-meg. grid leak
1 filament switch
1 detector rheostat
112 detector tube
2 amplifying tubes
2 peaked audio amplifying transformers
2 fixed filament resistors
2 extension handles
Wire for coils (No. 12 and No. 20); wire for chokes (No. 36), bakelite (7 by 12 and 7 by 7 suggested); baseboard and uprights, screws for same, etc.

The capacity of the grid condenser has considerable effect on the operation of a receiver of this type. If too large, considerable effect of one control on the other occurs through the tube capacities. For "all-wave" use, it is preferable to use a variable condenser so that best values may be selected in different bands. A midget having a maximum of 100 pfd. gives good results. At 5 and 10 meters, this condenser is turned down

(Continued on Page 52)



All-Short-Wave Receiver

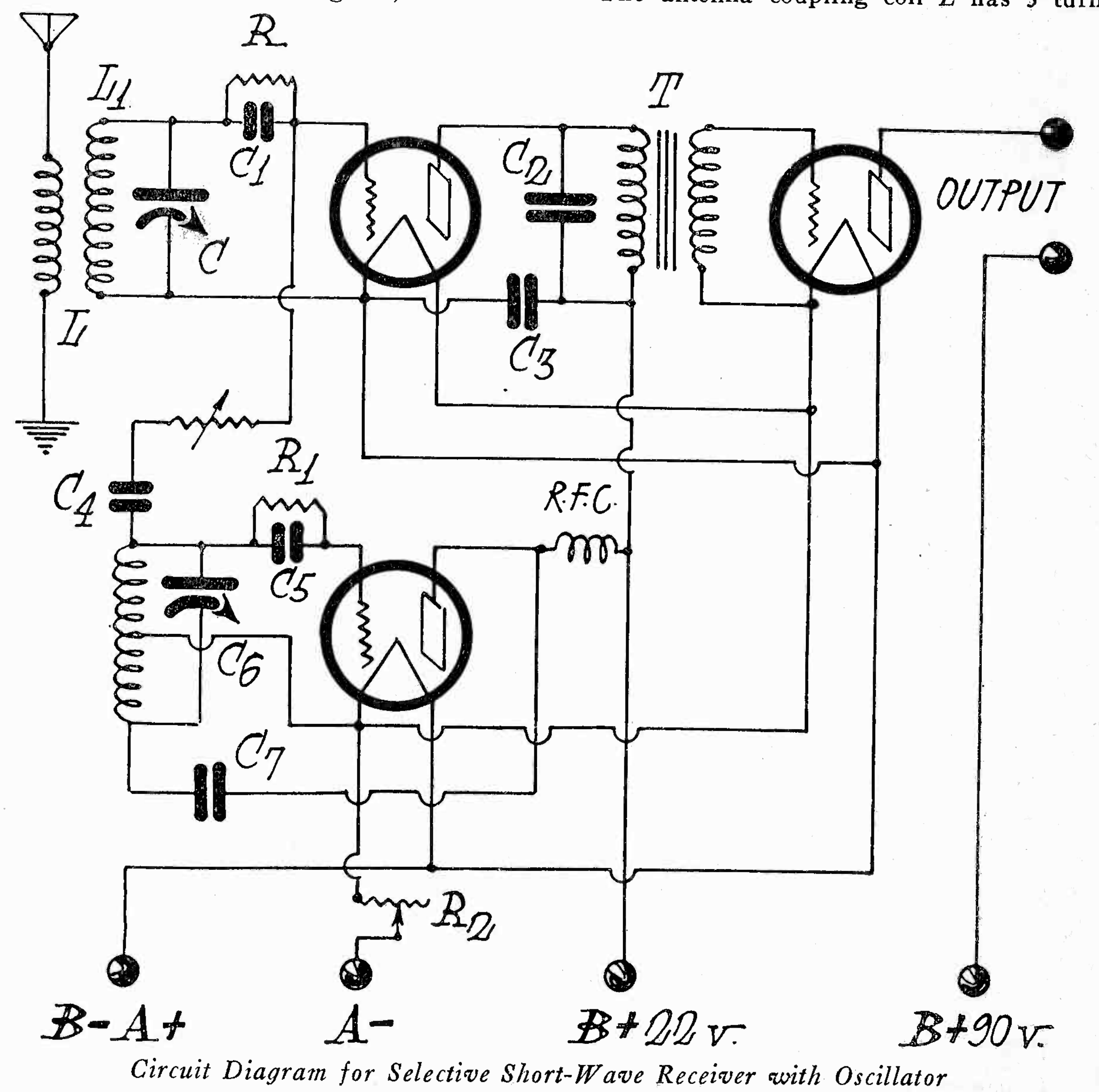
A SELECTIVE SHORT-WAVE RECEIVER

By R. Wm. Tanner

The selectivity of the usual regenerative short-wave receiver can be greatly improved by adding a Hartley oscillator and removing the tickler coil as shown in the accompanying circuit diagram. The oscillator control has no tuning effect on the detector. The pitch of the signal is not changed when the secondary condenser is varied after a signal is tuned in. This is in marked contrast to the detuning of the grid or secondary circuit which occurs when the tickler is varied in the usual form of regenerative receiver. If the tickler coil is retained when the oscillator is added, greater sensitivity is possible, but another control is added thereby.

While complete shielding is desirable, it is not necessary if the oscillator harmonics are used to produce beats. A slight rushing noise is heard when one of the harmonics crosses the wave of the detector. Although this set is a little harder to tune than a straight regenerative receiver, the results are more than worth it. R_1 is a 1 megohm clarostat used in place of a pick-up coil.

The antenna coupling coil *L* has 5 turns



Circuit Diagram for Selective Short-Wave Receiver with Oscillator

of No. 18 enamel wire and may well be variable so that close coupling can be used on weak signals and loose coupling on strong signals. The secondary plug-in coils L_1, are space-wound with No. 18 enamel wire on a 3-in. form. They have 19, 8 and 3 turns respectively for the 80, 40 and 20-meter bands, being tuned by a .00014 mfd. condenser *C*. The detector grid condenser C_1 is .00015 mfd. and the grid leak *R* 6 megohms.

The oscillator coil L_2 has a wavelength range of about 180 to 400 meters when tuned with a .00025 mfd. condenser C_6. A high ratio vernier dial must be used on this condenser. The coil consists of 50 turns of No. 26 d.c.c. wire on a 3½-in. bakelite form, with a filament connection tap at the 25th turn.

(Continued on Page 54)

Inside Stories of Factory Built Receivers

III. Freshman Model Q-15

THIS is the first factory-built a.c. receiver to use a screen-grid tube as an r.f. amplifier. The other tubes in this four-tube set are a '27 tube as a detector, a '26 tube as a first audio amplifier, and a '71 tube in the second audio stage. Filament current at 3.1, 2.25, 1.4, and 4.8 volts, respectively, is supplied through a stepdown multiple-tapped transformer from a 110-volt a.c. source. Plate voltages are supplied through a full-wave rectifier-filter system using an '80 tube. The entire receiver, including the power supply equipment, is compactly assembled on a steel chassis.

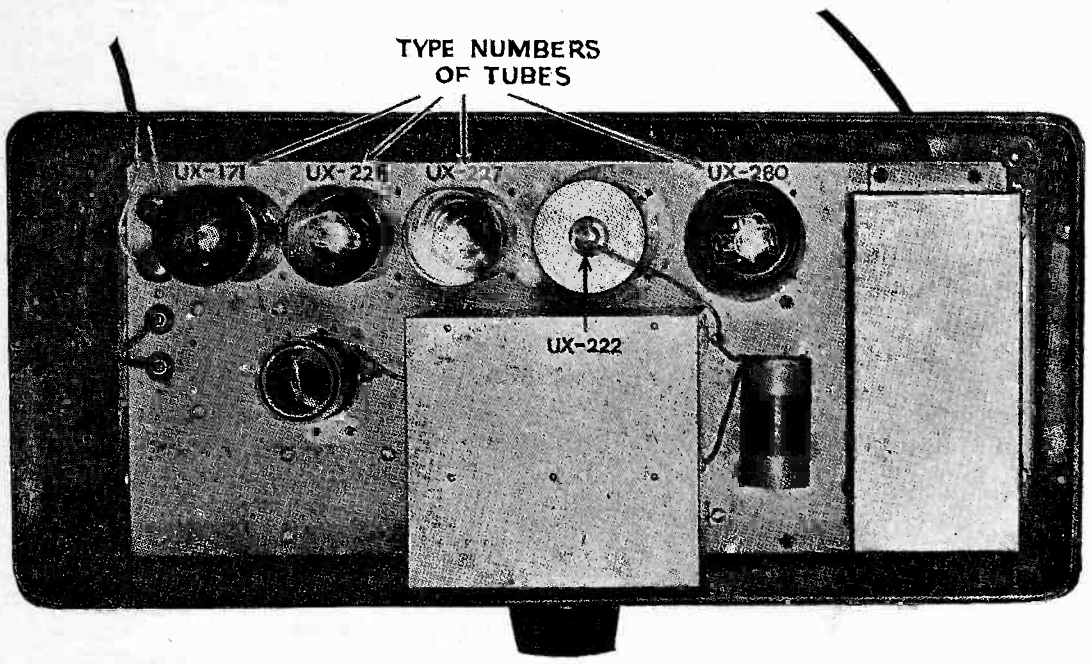
The set has four controls: a 190 to 570 meter tuning dial which operates a two-gang .00036 mfd. condenser, a vernier .00004 mfd. condenser which adjusts for fine selectivity and sensitivity, a volume control, wherein a rheostat varies the antenna current, and an "on-and-off" switch. It uses an outside antenna and ground.

The tuning condenser and power plant are in separately shielded compartments. The screen-grid tube is also shielded.

The r.f. amplification from the screen-grid tube and its associated transformer is claimed to be from 25 to 40, despite the limitations imposed by operating the filament on raw a.c. Such amplification is as good or better than is secured with the usual two stages of r.f. amplification. One of the secrets of its performance is the use of a high grid bias to prevent a.c. modulation.

A small amount of regeneration is ingeniously introduced into the detector circuit to more than compensate for the slight reduction in shield-grid tube gain. This is automatically maintained well below the oscillating point so as to avoid distortion.

Most of the circuit constants for the receiver and power plant are shown in the accompanying circuit diagram. The general construction and arrangement of the chassis may be seen in the picture thereof.



Freshman Model Q-15 Chassis

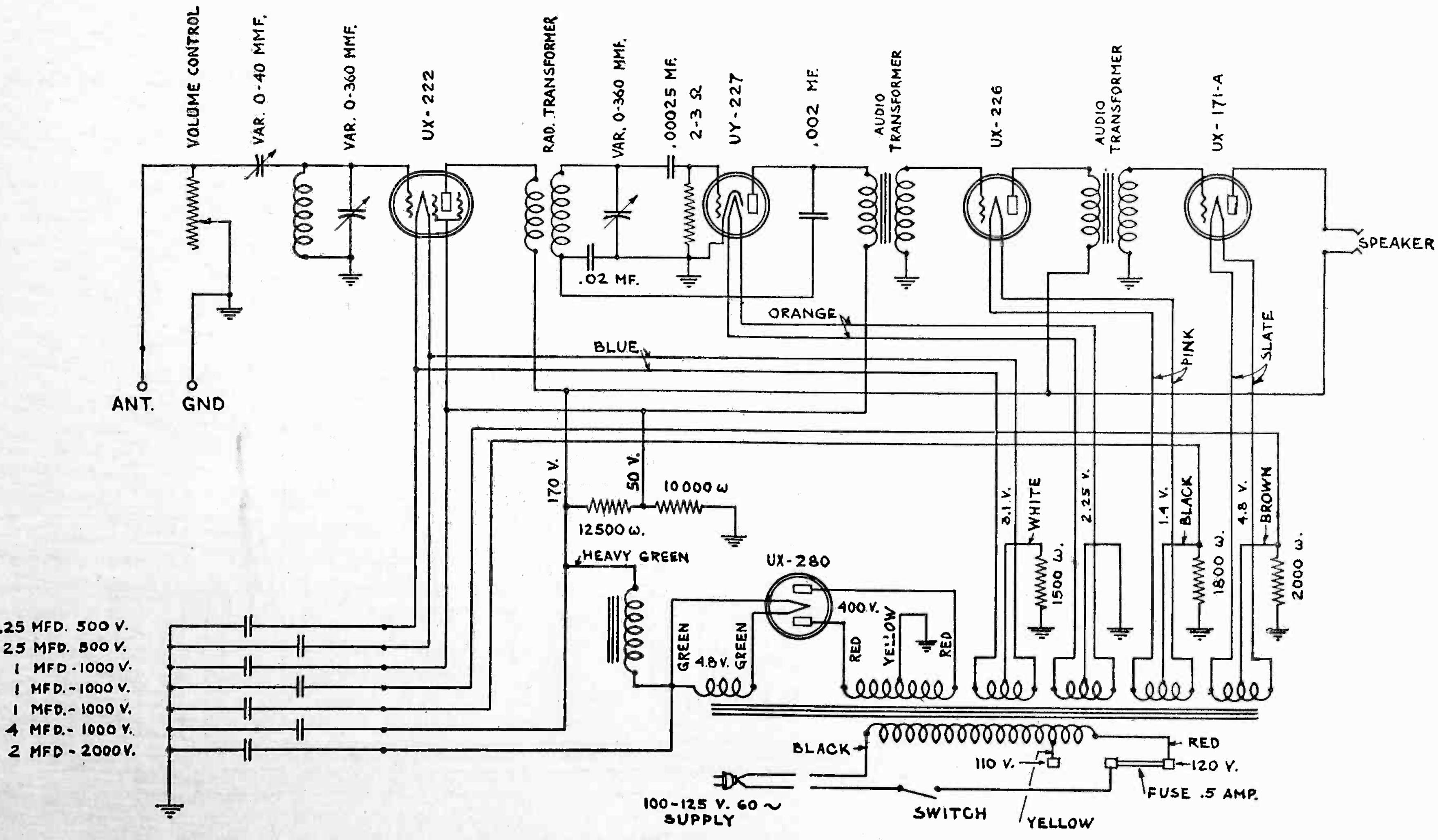
NEW RADIO CATALOGS

Radio Insulators of all types are illustrated and described in a pamphlet from Knox Porcelain Corp., Knoxville, Tenn., which also shows such antenna accessories as wire, lead-ins, and lightning arresters.

A new bulletin on socket power condensers from the Dubilier Condenser Corporation of New York City shows a complete line of paper dielectric condenser blocks as designed for use with various standard transformers. Dry "A" 2000 mfd. condensers are also listed and described.

Publication No. 84 from the U. S. Bureau of Standards is a Standard Time Conversion Chart which gives a direct reading for the standard time at any desired longitude corresponding to the time at a given place. The chart is printed on heavy Bristol board and consists of two concentric circles, one of which can be revolved. This can be secured from the U. S. Government Printing Office for ten cents.

Scientific Paper No. 568 from the U. S. Bureau of Standards contains "Methods, Formulas and Tables for the Calculation of Antenna Capacity," by Frederick W. Grover. This information is of value to an amateur transmitter who is designing an antenna system whose fundamental wavelength he desires to know.

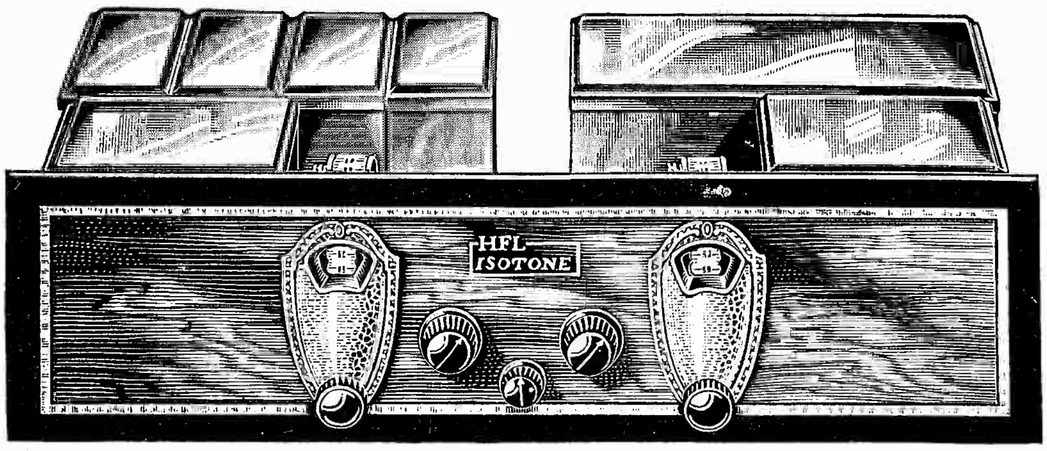


Circuit Diagram of Freshman Model Q-15 Receiver

Radio Kit Reviews

HFL MODEL 10 ISOTONE

THE HFL Model 10 Isotone is a standard screen-grid superheterodyne, utilizing nine d.c. tubes as a radio receiver, with a tenth tube available as an extra stage of audio amplification for phonograph reproduction. It incorporates several new features, including a radiophone control switch on the panel. When this switch is turned to the phonograph side the oscillator, detectors and i.f. amplifiers are completely disconnected from the circuit, leaving three stages of a.f. amplification with '12A tubes for the first two stages and two '71As in push-pull for the third. This a.f. amplifier may be used in connection with any external detector, short wave or broadcast, by plugging the latter into the tip jacks designed for the phonograph pickup. When the switch is turned to "radio" one stage of audio is disconnected, and the other tubes thrown back into the circuit.



HFL Model 10 Isotone

Either a loop or an outside antenna may be used. In the case of the latter, the phone tips hanging from the antenna coupler are plugged into the tip jacks marked for the loop. The oscillator and first detector use '01A tubes, the three i.f. stages use '22 type, the second detector and first two stages of a.f. use '12A type, and the last stage of push-pull audio '71A tubes.

The i.f. transformers are peaked at 450 k.c. so as to give one-spot tuning. It will be noticed that a 25 mmf variable condenser is shunted across each of the larger .0001 secondary condensers, allowing each i.f. circuit to be separately tuned. This compensates for variations in the internal capacities of the tubes, making it possible to maintain the utmost selectivity of the amplifier at all times. The sensitivity of the i.f. amplifier is controlled by variation of the voltage applied to the screen grid. Each stage is said to have a radio-frequency gain of 65.

In the tuning unit a small trimmer condenser, shunted across the oscillator coils, makes it possible to adjust the oscillator and antenna tuning dials so that they read alike. In balancing the instrument for best results it is necessary to leave all the shield cans covered with the exception of the one to be balanced. Once the intermediate amplifier is balanced it should be left that way until such time as any of the screen grid tubes have to be replaced. The only remaining variable control is the small trimmer condenser in the antenna tuning stage. This is non-critical in adjustment and does not usually have to be touched. It is possible, however, to make the receiver oscillate by tightening this condenser. All units are thoroughly shielded.

The kit comes in four parts; namely the base pan, the front control unit, the i.f. amplifier unit and the a.f. unit. All are fastened to a metal sub-base drilled for speedy mounting. Six bakelite strips protrude through the bottom of the base pan and the terminals thereon are easily hooked up with nickel-plated connecting strips. The whole job of assembly can be done in less than an hour; each unit fitted into place and made fast, bottom connecting strips screwed on, panel and knobs mounted on front, tubes put into their sockets and covered with the individual shield cans. The panel is 7 x 26 in. in size, of walnut grained Micarta.

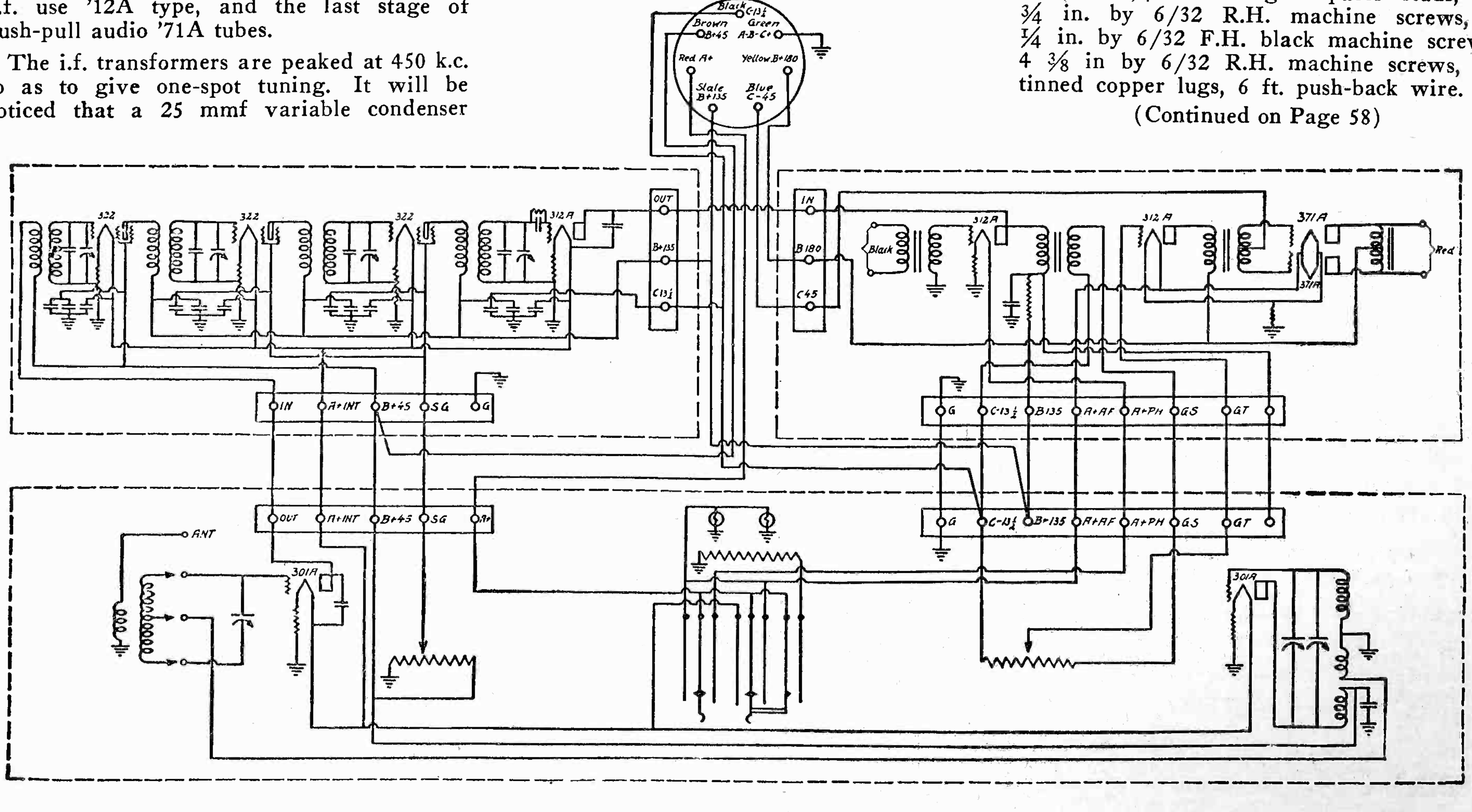
The manufacturers of the HFL Isotone have also designed a power pack which furnishes all of the required voltages to the receiver. This is sold completely assembled and wired and provides the following currents and voltages: *A* current, 2½ amperes at 6 volts; *C* voltages variable 0-15 and fixed 45 volts; *B* voltages 45 (variable 0-90), 135 and 180 volts. There is a variable resistor in the *A* supply circuit which allows the filament voltage to be increased or decreased. Oversize condenser sections and heavy chokes eliminate all tendency toward motor boating and voltage fluctuation. The instrument uses dry rectifiers and condensers throughout and the plate current is furnished by means of a 280 rectifier tube.

When using the power pack on the a.f. amplifier alone, i.e., on phonograph reproduction, with the filaments of the six unused tubes turned off, it was found necessary to use a compensating resistance. This is incorporated in the set.

The parts in the kit are:

1 HFL Isotone assembled and wired tuning unit, 1 HFL Isotone assembled and wired screened grid amplifier, 1 HFL Isotone assembled and wired audio amplifier, 8 HFL Isotone shield cans with tops, 1 base assembly plate, 1 drilled and engraved front panel, 1 seven-wire cable and plug, 2 gold escutcheons with knobs (attached), 2 dial lights (inside of drums), 2 large walnut control knobs, 1 small walnut switch knob, 2 steel panel supporting brackets, 12 plate connecting strips, 55 6/32 hexagon brass nuts, 14 ¾ in. hexagon spacer studs, 14 ¾ in. by 6/32 R.H. machine screws, 6 ¼ in. by 6/32 F.H. black machine screws, 4 ⅜ in by 6/32 R.H. machine screws, 11 tinned copper lugs, 6 ft. push-back wire.

(Continued on Page 58)



Circuit Diagram of HFL Model 10 Isotone

RADIO AIDS AIR RACES

(Continued from Page 30)

Here they come! There they go! Zoom! Zoom! That was a close one. He didn't miss the pylon very far that time! And we're inside, too. Here comes one that whines like a siren. After it passes, an observer calls:

"Operator! Plane number 159 fouled pylon! Sixth lap."

The operator grabs the key.

"6EMF 6EMF 6——"

He doesn't complete the third set of call letters before headquarters station, 6EMF, answers, using the "break-in" system.

"6EMI DE 6EMF GA (Go ahead)," says 6EMF.

6EMI: "QFP (Foul pylon) NR 159 SIXTH LAP K."

6EMF answers: "OK QRX." (O. K., stand by.)

In a few seconds come the signals from 6EMF again: "6EMI DE 6EMF NR 159 DISQUALIFIED AND SIGNALLED QSU (Will call you later.)"

The whole operation hardly took over thirty seconds! Before the plane could reach the field, flying well over 100 miles an hour, the judges knew what had happened at Pylon Number 3. Plane Number 159 is flagged out and is saved from going around several useless laps.

Even more important than "QFP" was QRR. This signal in amateur radio corresponds to the "SOS" of commercial radio. At the air races it was used as the signal for a crash, and we are glad to say that its use was seldom required.

One day, a plane failed to appear at Pylon Number 3 after three laps. 6EMI advised 6EMF, and the latter made an immediate investigation. It was found that the plane had completed three laps at Pylons 1 and 3, and had passed Pylon Number 2 on its fourth lap. The plane was therefore between 2 and 3. A search was made by a scout plane and it was found only a few minutes after it had made a forced landing because of minor trouble.

On another occasion one of the pylons reported a grass fire in the vicinity. A scouting plane was dispatched to the scene and an accurate report of the blaze was made to firemen within a very short time, thus aiding them materially in handling the situation.

It was one thing to tap out a few orders and acknowledgements at the key from time to time, but it was another thing to continue this work from hour to hour and from day to day. It was also quite a job to make five complete installations and then remove them after the races. Sometimes during the day there was considerable time between races. The most you had and tne least you wanted was dust and heat! Ice cream sodas at a dollar each would be cheap! But the boys stuck it out to the last day with perfect scores.

As a reward for their services they received the sincere thanks and appreciation of the race officials and the satisfaction that they had contributed, in no small way, to a good cause. They had saved the management some thousands of dollars. They had eliminated a large amount of worry for the officials. They received not a cent of money, as this is against the amateur's code of ethics and the rules of his license.

The boys operating the stations during the races were: Bert Fox (6DY), Charles A. Hill (6BRO-6DRO), Charles Lundblad (6CYX), William Breuer (6BZR), Charles A. Nichols (6ASM), Donald Champion (6FA), and Bob Parrish (6QF-6PS-6XC).

PHONOGRAPH PICK-UP UNITS

(Continued from Page 24)

rise on the low frequencies to compensate for the drop in the phonograph records. This may be accomplished by using an audio transformer in the first stage which has the primary circuit resonated at a low frequency, somewhere between 40 and 80 cycles per second. There are available on the market at least three varieties of transformers which have a resonant primary, generally with the condenser and *B* battery feed resistance, mounted inside of the transformer case. Such a transformer will give a decided peak on the very low notes when the unit is connected across it and the volume control is simply a variable resistance in shunt. With this arrangement much better music is available from phonographs than is available from most broadcast stations.

BOOK REVIEW

"Practical Radio," by James A. Moyer and John F. Wostrel, third edition, 378 pages, 5 by 7½ in. Published by McGraw-Hill Book Co., New York City. Price, $2.50.

This text provides a simple answer to the question of what is radio and how is it transmitted and received. In an elementary manner it describes the circuits and parts ordinarily used in radio telephony and telegraphy. Its discussion of vacuum tubes is especially helpful to the novice. As part of a section devoted to the testing of sets is printed a trouble chart which shows at a glance the probable cause and remedy for the common troubles to which a set is liable. It also includes a somewhat sketchy treatment of a.c. filament tubes, rectifiers and loudspeakers. As a whole, it provides a good introduction to the serious study of the subject of radio stripped from its mathematical technicalities.

A low voltage filament is used in the '26 type of a.c. tube because thereby the a.c. hum is reduced. The lower voltage allows the use of a heavier filament and greater current with consequent smaller change in filament temperature and emission. The lower voltage also causes a smaller electro-static field and consequent tendency to hum.

CONSTRUCTED BREAK-IN

(Continued from Page 40)

When the key is up you are receiving through the secondary of the transmitter's oscillation transformer. When the key is pressed the receiver is grounded out and the ground circuit of the transmitter is closed.

Be sure to adjust the contacts of the break-in so that they close just a fraction of a second before the main power contacts of the key close. In other words, the receiver must be grounded *before* the power goes into the transmitter for full protection. It is advisable to put a safety gap across the antenna and ground posts of the receiver as an added precaution; that is, if the receiver is not already so equipped.

AMATEUR RADIO RESEARCH CLUB BANQUET

By Wallace S. Wiggins

The largest amateur radio banquet in two years for Southern California took place in the Chamber of Commerce Building, September 12, 1928, sponsored by the Amateur Radio Research Club of Los Angeles. Over 115 enthusiasts of "brass pounding" were present in the banquet hall, which echoed and re-echoed with shrill whistles in true "ham" style.

A. H. Babcock, A. R. R. L. director, described the situation at Washington with regard to the status of the amateur, and stressed the importance of keeping up with the times in the design of transmitters and receivers for efficient operation in the new kilocycle bands. He also spoke of operation in channels other than the amateur bands, explaining the "American Eagle Channel," for the Army and Naval Reserve Units.

"Bob" Parrish, 6QF, president of the A. R. R. C., and chairman of the banquet committee, introduced the speakers. "Jimmie" Warner of KHAB, the "Southern Cross," first plane to fly from Oakland to Australia, modestly described part of the flight in a short speech, saying that the trip was "uneventful," but that he appreciated the co-operation of the amateur operators. Bob Hutchings, 6AKF, related a most interesting story of a trip to Siberia and China on which they took portable receiving and transmitting equipment. The big "kick" of the evening came when Hutchings said that although reception was none too good, the strongest signals from the United States came from 6CUT. As the owner and operator of that station was present, he was called upon to describe his supposedly super-high powered transmitter for the benefit of those unfortunates who lacked the cash to purchase high-powered stuff. He was introduced as Homer F. Beal, Jr., of Riverside, Calif. The surprise and wonder of the assembly can well be imagined when Beal said he was using a 7½-watt tube with 1000 volts on the plate through a 30-henry choke. He explained further, however, that a zeppelin antenna, constructed with the greatest care, was being used. This probably accounted for a large share of the success of his strong signals in Siberia.

"Wally" Wiggins, 6CHZ, explained the operations at the National Air Races in connection with the club's activities in providing communication. Bert Fox, 6DY, supplemented this with an explanation of the details of installation and operation. It was announced that over 2400 messages had been handled, free of charge, for patrons of the recent radio show in Los Angeles.

MARSHALL SHORT-WAVE RECEIVER

(Continued from Page 36)

after time without any variation in the dial readings or numbers. Reception on 8000, 12,000 and 16,000 kilocycles was effected without interference. A temporary removal of one of the shielded-grid tubes, however, cut down the signal strength appreciably.

Using this receiver, the *Eagle* picked up signals in the daytime with regularity from Washington, D. C.; Key West, Fla.; New Orleans, La.; and Guantanamo, Cuba, while cruising in the Panama Canal Zone. However, the signals from stations northward from Louisiana to the Great Lakes were intercepted with the greatest clarity while the *Eagle* was located in the Panama Canal waters. Amateur stations on the Atlantic seaboard were also heard satisfactorily. The comparative tests between this receiver and a standard navy outfit were conducted with both receivers connected to the same antenna—using the so-called "coupled tube" arrangement of the Bellevue Naval Research Laboratory.

Tests on a submarine were restricted by the usual limiting factor of submerging radio in salt water, namely, at a depth of 20 feet there is a sudden and complete extinction of the received radio signal. However, this receiving set oscillated and was as easily controlled while submerged as when on the surface of the water. Furthermore, when using a loop or coil of wire as pick-up system on this submarine the distant signals—from Rocky Point and other transmitting stations—were nearly as loud as when employing the conventional high-frequency antenna on the *Eagle*. The use of one-half of the loop antenna on the submarine caused a material sacrifice in signal strength. When the submarine was resting on the surface of the water, this new receiver appeared to function most advantageously when receiving signals from distant stations on a frequency of 18,000 kilocycles.

IMPROVEMENTS IN CRYSTAL CONTROL

AMATEURS should take particular note of the improvements which are being incorporated into many of the broadcasting stations, in the form of crystal control. Several of the stations have two crystals, either of which may be used as the main control, and these crystals are cut so accurately as to be within 100 cycles of each other. To maintain accurateness of frequency, each crystal is heated electrically to a certain fixed temperature, at which it is calibrated.

With the coming limitations of the amateur bands, there will undoubtedly be an increased use of crystal control on the short waves. By the installation of a simple heating system and ther-

(Continued on Page 51)

TUBE TESTING SET

(Continued from Page 33)

The reading should then be compared with the nominal limits as indicated on the accompanying table. If the emission

POWER AND RECTIFIER TUBE TESTS

		Indication for Good Tube
CX 310	No. 1	Dull red
	No. 2	Dull orange
CX 313	No. 1 } No. 2 }	Dull orange
CX 316B	No. 1	Dark
	No. 2	Dull orange
CX 350	No. 1	Dull red
	No. 2	Dull orange
CX 380	No. 1 } No. 2 }	Dull orange
CX 381	No. 1	Dark
	No. 2	Dull orange

reading is below these figures it indicates, as a rule, that the tube has been overloaded due to excessive filament or plate voltage, or both, or that there has not been sufficient *C* battery voltage provided.

To take an emission reading on a 322, the screened grid amplifier, it is necessary to connect the two grids together; this may be easily done by arranging an X base socket on an X tube base, connecting a flexible wire with a clip on it to the grid terminal of the socket, inserting the 322 into this adapter, placing the whole assembly into the proper socket in the test set. If no short circuits are shown on the lamps, connect the clip to the top contact on the 322 and then press the emission key momentarily. To test the C-11 it will be necessary to use an adapter to accommodate the special arrangement of contact pins to the C-12 socket.

Type 300-A gas filled detector tubes require a special test for sensitivity, and can only be tested for short circuits and filament emission in this test set.

The testing of 310, 313, 316-B, 350 and 381 tubes is extremely simple, it being only necessary to place the tube in the socket with the switch in position No. 1, the condition of the tube being indicated by the glowing of the lamps. Make certain before placing the tube in the socket that there is no short circuit between the elements. A low emission tube usually indicates abuse resulting from too high filament voltage, too high plate voltage, or insufficient grid voltage. A gassy tube may cause the lamps to glow as if O. K., but of course, is de-

	C 11 CX12'	C-CX' 299	CX 220	CX 301A	CX 300A	CX 340	CX 112	CX 112A	CX 371	CX 371A	CX 326	C 327'
Filament Voltage	1.1	3.3	3.3	5.0	5.0	5.0	5.0	5.0	5.0	5.0	1.5	2.5
(Min. MA)' Emission	6.0	5.5	13.0'	20.0'	14.0'	14.0'	45.0'	45.0'	40.0'	40.0'	35.0'	35.0

fective. Make certain that there is no decided blue glow surrounding the filament. A faint glow on the 380s, 381s and 350s is the normal condition and does not indicate a defect.

LIST OF PARTS FOR TEST SET
1 Panel 12 x 20 in.
4 X base sockets
1 Navy type socket
2 Dial lamp sockets (Edison Min. base)
2 110-volt lamp sockets, Standard type
1 Socket for 327 a.c. tubes
1 Socket for old style 99 tubes
1 Socket for 377 protective lamp, Bayonet type
2 10-watt, 110-volt Mazda lamps
1 6-ohm, ¼-amp. fixed resistor
1 7-wire cable, 5 ft. long
1 Kellogg Model 301 Key
1 10-ohm rheostat, 1½ amps. load
1 0-6 V. voltmeter
1 0-50 M. A. milliammeter
1 4-contact switch
1 ½-ohm 2-amp. resistor (6 in. No. 22 Nichrome wire)
2 Dial lamps, 6 volts

The thoriated tungsten filament tubes may be reactivated if the overload has not been too severe. The coated type of filament cannot be reactivated due to its design, and any attempt will result in its immediate burnout. The tubes which may be reactivated are as follows: 99, 220, 322, 300-A, 301-A, 340, 371, 310, 313 and 316-B.

In reading the tables accompanying this description, it is well to keep in mind the following notes:

If the dial lamps light, it indicates a short circuit; do not then attempt to take an emission reading or you will damage the meters.

Lighting of lamp No. 1 indicates a grid to filament short; lamp No. 2 indicates a plate to filament short; both lamps indicate grid to plate short.

An open or burned out filament may fall against the grid or plate, causing the lamps to light. This may be determined by turning the rheostat up and if voltage regulation is impossible, the filament is open; such tubes are called open filaments, either broken or burned out, according to the results of the inspection at the service station.

IMPROVEMENTS IN CRYSTAL CONTROL

(Continued from Page 49)

mometer as an indicator, the amateur can maintain an absolutely dependable constant frequency of transmission. By placing the crystal with its associated tube, inductance and condenser in a closed box or compartment, together with a 25 or 40-watt mazda lamp controlled by a rheostat, a control of the temperature can easily be had, at little or no additional expense.

The broadcast stations are commencing to use an enclosed automatic heating unit and crystal which is supplied by the Western Electric Co. But an amateur does not need the automatic feature if he watches the thermometer.

ALL-SHORT-WAVE RECEIVER

(Continued from Page 42)

to a low value and the setting noted. A pair of grid-leak clips are mounted on it and a variable grid leak is best, although 5 megohms is the usual value.

A 112 used as detector oscillates easily at the highest frequencies. No tube-socket is used, since different tubes change things so much. The set ought to be built around the particular type of tube employed. Holes are drilled through the bakelite and the leads are soldered in place. Should another tube be necessary, the 112 is easily removed as it is at the rear of the set.

No short-wave receiver should be without a filament switch, as best oscillation is always secured at some particular filament-setting. These tubes usually work best with very low filament and about 67½ volts on the plate; other tubes will sometimes require comparatively large values of tickler turns and often higher plate voltages. The correct adjustment of the set, for the higher frequencies, is important and will require some experimentation for values giving best results.

The arrangement of apparatus is convenient for the experimenter as the filament rheostat and switch, phone jack and audio amplifier are mounted on a separate panel. All parts are arranged so that they can be used separately.

The whole set is mounted on a heavy baseboard and is supported above it. The 4½-volt *C* battery is mounted underneath. Dry cell tubes can be used and the set made semi-portable; it is a simple matter to mount the layout on the seat of the car and study the 5 or 10-meter signals at a distance from the station.

The audio transformers peak at 1000 cycles and the set therefore gives best response at this audio frequency. There are still AC signals on the air so that a very selective audio amplifier would hardly be desirable yet, especially for all-wave use. In this amplifier, the better signals are received with excellent results and extraneous noises are greatly reduced. Often one can "tune" an audio transformer to about the correct value by using condensers across the windings; some transformers are designed for peaks in the audio range.

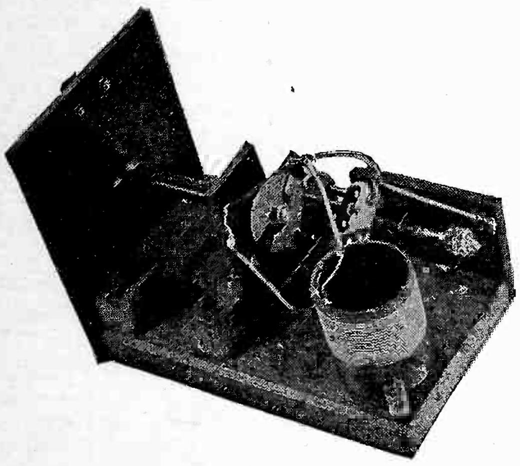
The selection of proper midget condensers is important, as many types are not so good. If these are of the one-bearing type, this bearing should be well-constructed and about this the amateur knows. These condensers will eventually replace the larger sizes for most short-wave uses. Almost a whole set of these may be obtained for the price of the usual large instrument. They are as good electrically, if not better, than the larger sizes, especially at the higher frequencies as shown by repeated tests at 5 and 10 meters.

The coils can be celluloid-supported and No. 20 wire is about right for the well-spaced turns. The 5-meter coil consists of about 2 heavy turns on a 1-in. diameter, and the 10-meter one is about double that; at 40 meters, 18 or 20 spaced turns is about right, but the values are not critical because the shunt condenser will compensate. Large coil diameters for 5 and 10 meters should be avoided as movement of the body then has considerable effect on regeneration.

Fixed filament resistors are used in the audio amplifier. To use the set without r.f. amplifier, the antenna is connected directly to a lug on the secondary condenser through a small midget. The output of the r.f. amplifier may be similarly connected; it is perhaps better to use separate batteries for the r.f. amplifier but one will work all right with the same batteries for the whole layout. Often the tube will oscillate much better if the filament leads to the detector are reversed.

The actual wave-change caused by supposedly small effects is too large. In the usual amateur wavemeter employing a flashlamp indicator, the wave may be changed as much as ½ meter at 40 meters by simply changing lamps or shorting a given lamp in or out. Such changes are too large for 1929 conditions. There are perhaps only two arrangements which are practical for average amateur use.

One of these consists of the tuned circuit described above to which is coupled a 2-turn loop (at 40 meters) including a flashlamp in series. Some flashlamps give very broad tuning, but tests show that the 1.25-volt type ("S" filament) is about the best to use, as the filament cools rapidly and gives a sensitive indication. If the main inductance consists of about 18 turns on a 2-in. tube, this 2-turn loop should be set at about ¾ in. from it. Indications will be quite sharp, and with loose coupling, the effect of the lamp circuit causes very little tuning effect. The lamp when turned into, or out of, the socket will have a small effect on the wave, but if left in place, will give good results and tuning will be sharp.



Wavemeter with Neon Tube Indicator

An accurate wavemeter is necessary for calibrating the set. The picture and circuit diagram in Fig. 2 show one using a neon lamp as a resonance indicator. It uses a 15 mmfd. midget tuning condenser cut down to three plates and a 20-turn coil, which is wound on a threaded length of 2 in. bakelite tubing. A 50 mmfd. midget condenser is shunted across the tuned circuit.

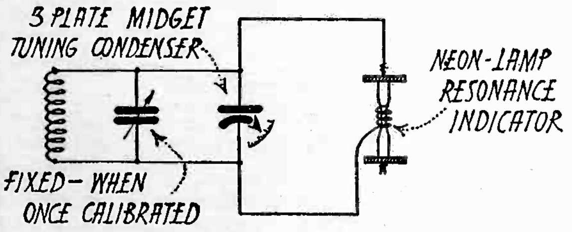


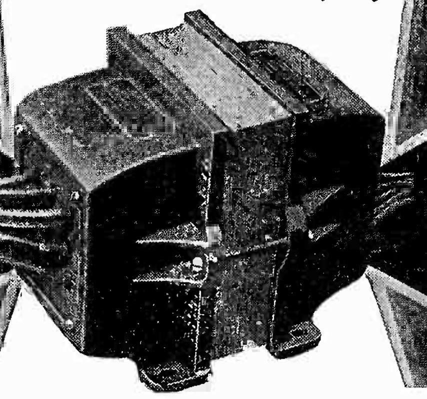
Fig. 2. Wavemeter Circuit Diagram

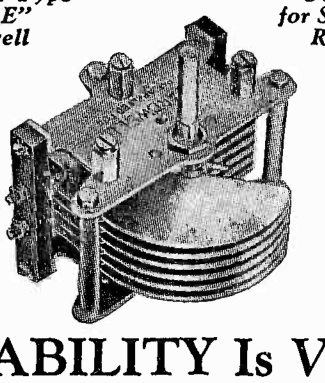
The condensers are mounted on a hard rubber strip which, together with the panel supporting the vernier dial, is securely fastened to heavy baseboard blocks. A small extension handle eliminates the necessity of shielding. The threaded tubing is secured to the baseboard by small metal angles at the base. Heavy copper wire is used for connections.

The neon lamp should be of 5-watt size or larger. It is somewhat more sensitive if one terminal is left open and a length of copper wire, wound around the middle, is used as the other. The lamp is securely fastened to a bakelite piece and is held by a piece of wire passed around the lamp and through holes.

For accuracy, it is best to have a separate instrument for the 40-meter band. The small condensers are economical and at small expense accurate instruments can be constructed for 20 and 40 meters. The 10-meter band is wide and accuracy is not as important.

To calibrate the wavemeter accurately, the transmitter can be operated without an





antenna with a very small input, and so a harmonic falls exactly on the wave of a broadcast station which has been carefully tuned in with any ordinary nearby regenerative, broadcast receiver. By using different stations, various points on the wavemeter calibration-curve are easily obtained. The wavemeter in each case is checked with the wave of the transmitter, the wavelength of which is calculated from the broadcast frequency by dividing by the proper whole number.

Operation is simplified by using a sensitive grid d.c. milliammeter in the transmitter in series with the grid leak. For a 210 tube, this meter ought to be about a 0/25 size. Resonance is denoted by the dip of the grid meter. Several check points should be used and the average curve taken.

The transmitter must also receive special attention for 1929 conditions. It should be sharply tuned and not "modulated" by a poor plate supply, giving the usual broad wave. Good d.c. plate supply will help considerably. Many amateurs may desire to operate with small "99" transmitters. These are quite cheaply constructed and give exceptional results in these days of sensitive, screen-grid r.f. receiving systems, like the one described.

The average amateur transmitter is too closely coupled to the antenna. A broad interfering wave is caused and operation in two frequencies, close together. With loose coupling, the wave is sharpened, transmission is on only one frequency, the note is improved, and the antenna system has less effect on the oscillating circuit, reducing considerably, any "wobbling" effects. One should use a large capacity in the oscillating circuit, which usually eliminates "creeping." If the tubes are run cool, this effect is greatly reduced. Any circuit, when properly adjusted, gives a good constant oscillating frequency.

Since bringing up a tuned antenna circuit to the primary changes the plate current and therefore the tube temperature, the value of coupling will have some effect on the frequency of the transmitter. The coupling depends on so many factors that a general rule cannot be given; if one adjusts the coupling so that 85 or 90 per cent of the antenna current is obtained with close coupling, good results will be secured. The note should be studied near the set and is affected to some extent by antenna tuning. In general, any change in the transmitter which changes the plate current value will have an effect on the frequency and any such will have less chance, if a low L C ratio is used.

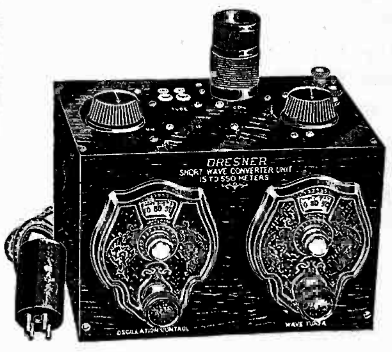
If all amateurs in the 40-meter band would use direct current plate supply, operation would be improved because of the sharp waves. The high-pitched notes would encourage the use of peaked audio amplifier systems, thus reducing other interference and amplifying, to a maximum degree, the proper signal. A surprising number of such stations could operate without interference if both the transmitting and receiving systems were sharply tuned. The all-short-wave receiver here described is a step in that direction.

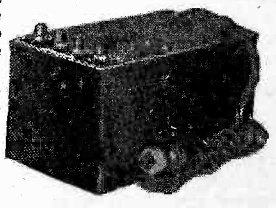
SELECTIVE SHORT-WAVE RECEIVER

(Continued from Page 42)

The r.f. choke consists of 300 turns of No. 36 wire, scramble-wound on a 1-in. core. A .00025 mfd. oscillator grid condenser C_5 and 1 megohm grid leak R_1 lowers the plate current somewhat. The condenser C_7 is of .002 mfd. capacity, C_2 .0005 mfd., C_3 1 mfd. and C_4 .0005 mfd.

The filaments are all controlled by one 6 ohm rheostat R_2. Sockets are mounted on sponge rubber cushions to prevent microphonic noises. All parts are mounted on a 7 by 18-in. panel.





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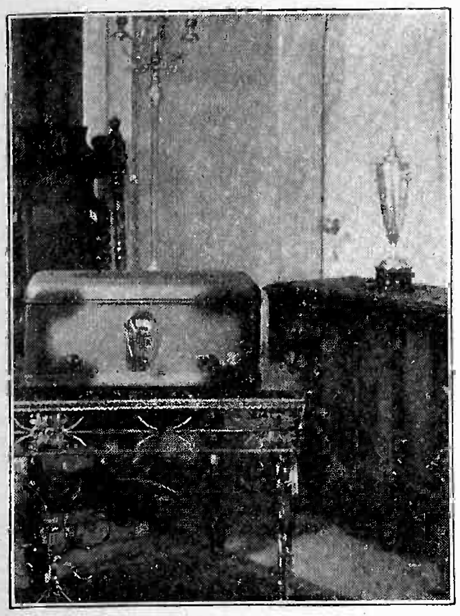

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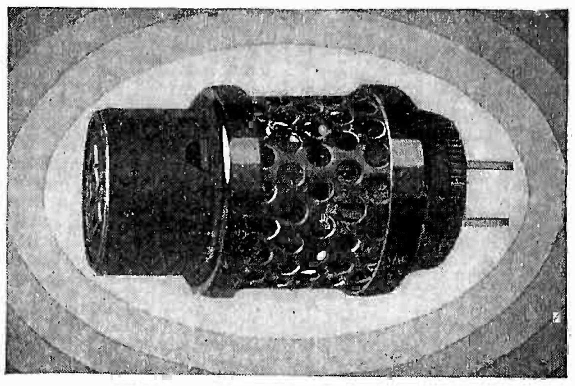

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TECHNICAL BRIEFS

(Continued from Page 38)

with transformers having ½-in. and 1½-in. primaries, for 9, 18 and 36 turns each. The screen-grid tube circuit connections for each type are shown in Fig. 3, *a* showing the transformers and *b* the autoformer.

The 1½-in. primary type is that generally advocated for use with a shield-grid tube when a tuned impedance is not employed. It will be noticed that there is little gain in amplification when more than 18 turns are used, thus impairing its possibilities for selectivity.

With the ½-in. primary a variation in the number of turns changes the point where maximum amplification is secured. Hence with a multi-stage cascade amplifier uniform amplification can be secured over the whole band by adjusting the number of turns in the primary of each transformer, although this may result in sacrificing the selectivity of one or two stages.

As the inductive coupling is much greater with an autotransformer, a few turns will give a high primary impedance and a consequently greater overall amplification. As the number of turns is increased in the portion of the secondary which acts as a primary, the amplification on the higher frequencies is reduced because the two currents in this portion of the coil are in quadrature, and the voltage in the grid of the next tube is consequently lower. This can also be used in a multi-stage amplifier to secure uniform amplification over the entire spectrum without so greatly impairing the selectivity.

The selectivity curves for these three types of transformers, are shown in Fig. 4. The figure of merit considers the inverse ratio of amplification obtained at the mean of frequencies 50 k.c. distant from the oscillator frequency, plotted against a percentage cutoff at seven-tenths of the maximum. A selectivity factor of 50 is fair, 55 is good, and 60 gives an extremely desirable point. It will be noticed that at 350 meters, for example, this selectivity figure can be obtained with the autoformer circuit with an amplification figure of 5.7, whereas the corresponding ½-in. primary is secured with an amplification

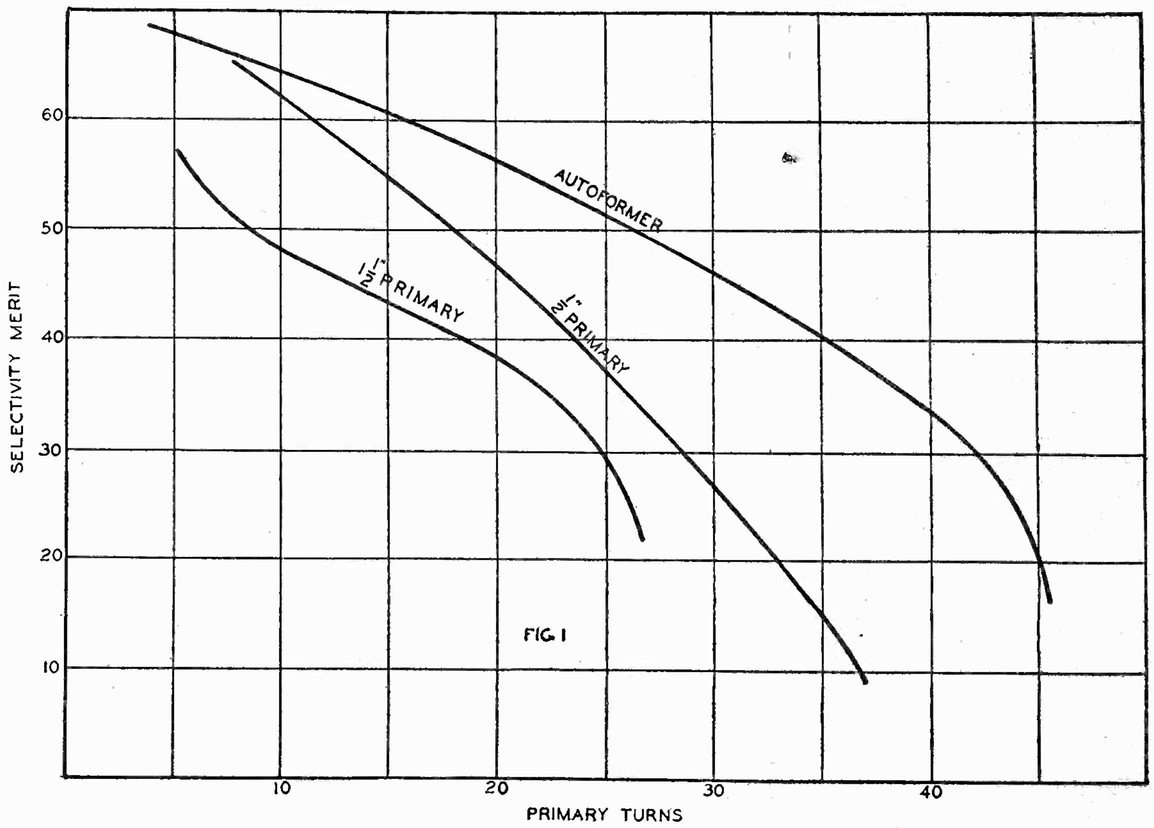


Fig. 4. Selectivity Curves for Three Types of Transformers

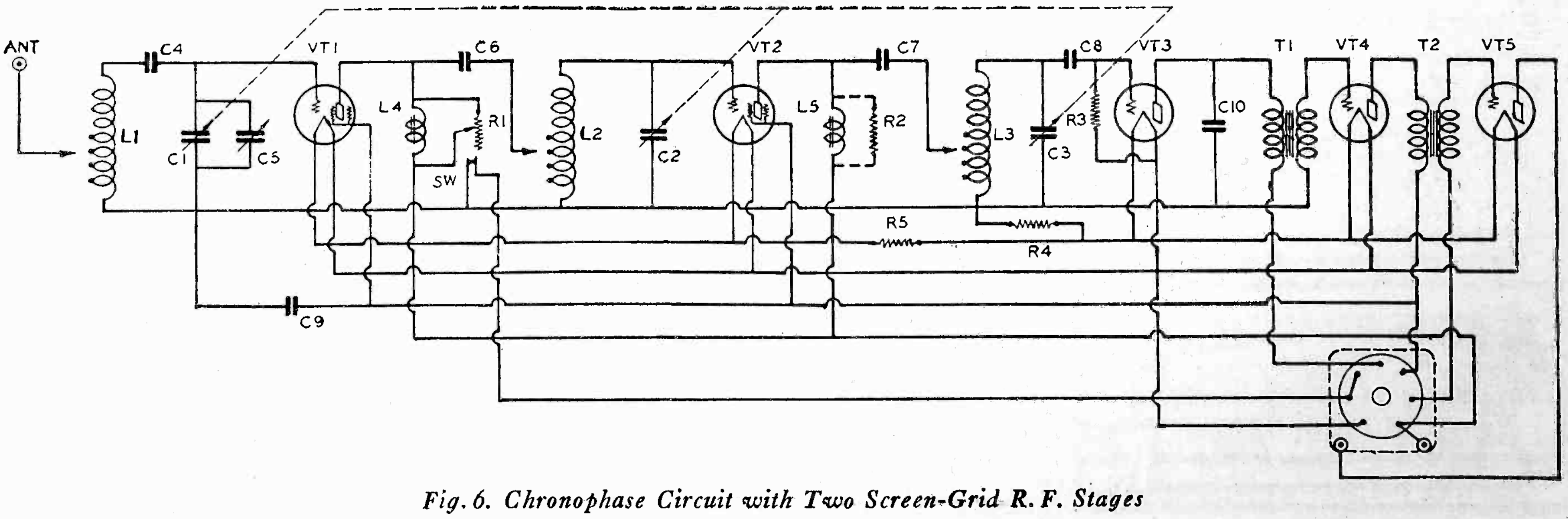


Fig. 6. Chronophase Circuit with Two Screen-Grid R. F. Stages

of only 3.6, or about 65 %. In this particuler instance the superiority of the autoformer type is outstanding.

Oscillation was frequently encountered, even in connection with the supposedly non-oscillating shield-grid tube, unless some means were taken to prevent it. The best results were obtained by shifting the phase angle of the currents in various stages by the method illustrated in Fig. 5.

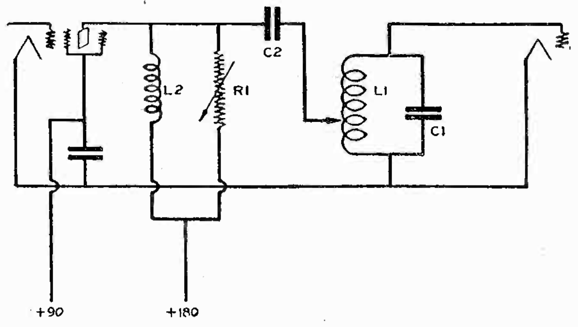


Fig. 5. Chronophase Circuit

An inductance L_2 of comparatively low d.c. resistance was shunted around the resistance R_1, maintaining a maximum static value of plate voltage at the tube, while offering a very high impedance to r.f. currents. The resistance R_1 can be varied without affecting the static value of the plate voltage and will be found to serve as an oscillation control. If provision is made so that it can be reduced to a low value, so as to effectively short-circuit C_2, it can also be employed as a volume control.

In a circuit containing two stages of radio-frequency amplification, it will rarely be found necessary to employ more than one such resistance, as sufficient adjustment of the time relation can be obtained to avoid oscillation while still maintaining the satisfactory value of overall amplification. Maximum results, regardless of the type of tube used, can be obtained by varying the proportion of L_1 which is used in the plate circuit of the preceding tube. Little trouble was experienced from inductive coupling between coils.

Shielding always introduces certain losses in the coil, due to linking a portion of the coil's field, and also complicates the mechanical construction of the receiver. It will be seen from the curve that the necessity of shielding is mitigated as far as interstage coupling effects go, while the diameter of the coil is so small that direct pick-up from local stations is reduced to a minimum, as has been demonstrated in practice.

One such receiver using two stages of tuned radio-frequency amplification with shield-grid tubes, employing the "Chronophase" system, has been given an exceedingly thorough tryout. On a 25-ft. aerial located on the shore of Lake Michigan, in the heart of the most congested mass of broadcasting stations in the world, it has been possible to cut through locals and secure good loud speaker reception of stations a thousand miles distant.

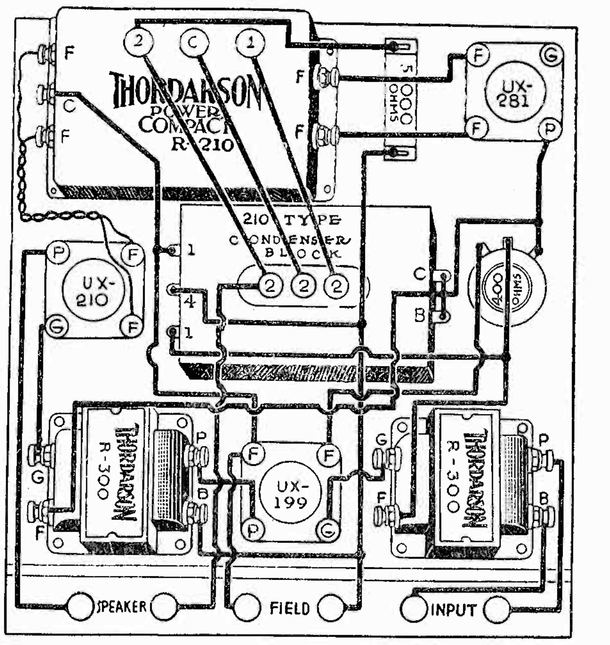
RADIO KIT REVIEWS

(Continued from Page 44)

THORDARSON PHONOGRAPH AMPLIFIER

This two-stage all-electric amplifier using a 210 power tube, converts an old style mechanical phonograph into a modern high quality electrical reproducing machine. In addition to the revolving turntable and electrically recorded records, it requires only a good pick-up unit and the easily assembled equipment listed in this kit to get faithful reproduction of audio frequencies from any good radio speaker.

The amplifier is operated completely from alternating current and is so constructed that it is readily portable. It is exceedingly compact, being 10x10-in. and may be placed in one of the compartments or in the tone chamber of the phonograph so that no unsightly or difficult connections to the radio receiver are necessary.



Pictorial Wiring Diagram of Thordarson Phonograph Amplifier

The power transformers and filter chokes are completely housed in the Thordarson R-210 Power Compact. This unit furnishes power for the high voltage supply to the plate of the 281 rectifier tube, power for the filament of the same tube, as well as power for the filament of the 210 power tube. The rectifier and filter circuits are conventional, and furnish to the voltage divider, direct current free from hum.

Filament current for the first audio-frequency tube is supplied by the current flowing through the voltage divider. When the 100-volt field of the dynamic speaker is connected to the terminals marked "Field," about 60 milliamperes will flow through the field windings of the dynamic speaker and will be available for heating the filament of the 199 tube.

The plate voltage applied to the plate of the 210 power tube is 385 volts, secured through the voltage drop of the 5000-ohm resistor and the field of the dynamic speaker.

LIST OF PARTS

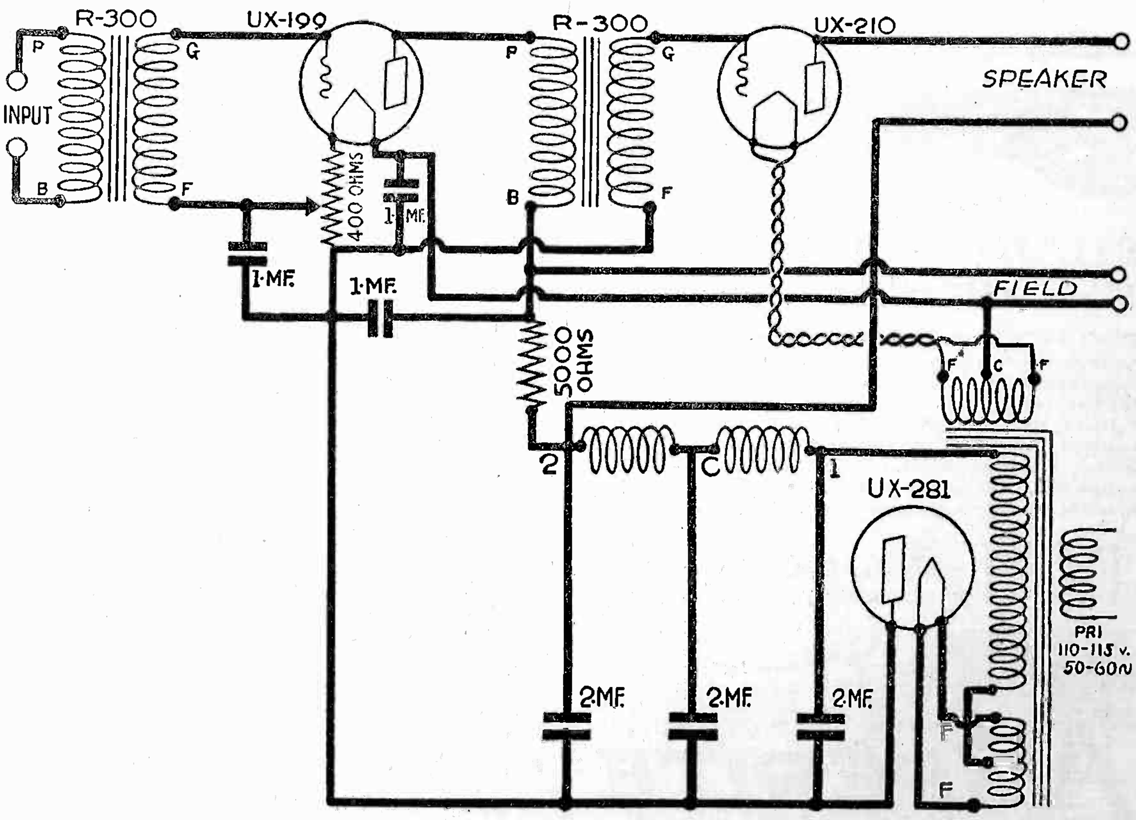
1 Thordarson R-210 Power Compact
2 Thordarson R-300 Audio Transformers.
1 210 Condenser Block (Dubilier, Tobe, Potter, Acme, Aerovox, Fast, Splitdorf).
1 Electrad Fixed Resistor, 5000 ohms, Type B.
1 Yaxley 400-ohm Potentiometer.
3 Benjamin Sockets (Sub-panel).
6 Binding Posts, 2 Input, 2 Speaker, 1 Pos., 1 Neg.
3 Benjamin Sub-panel Brackets.
1 Pc. Bakelite 10" x 10" x 1/4".
1 Pc. Bakelite 10" x 2" x 3/16".

TUBES

1 UX-281 Rectifier.
1 UX-210 Power Amplifier.
1 UX-199 Amplifier.

The grid bias of 25 volts is secured through the voltage drop through the filament of the 199 tube and the 400-ohm potentiometer. The plate potential for the 199 tube is taken from the high voltage side of the power field of the dynamic speaker, about 125 volts. The grid bias for the 199 tube is obtained from the voltage drop between the filament side of the 400-ohm potentiometer and the movable arm. The arm should be adjusted for best results. The undistorted output of the 210 power tube operating under the above conditions is about 1200 milliwatts.

In view of the fact that dynamic speakers have incorporated in their assembly an output transformer, none is needed in the amplifier itself. It is to be noted at this point



Circuit Diagram of Thordarson Phonograph Amplifier