1940
RADIO
and
TELEVISION
Data Book

Published by
ZIFF-DAVIS PUBLISHING COMPANY
608 South Dearborn Street, Chicago, Illinois
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A STUDY of occupational possibilities in the field of television before that interesting art has made its commercial debut is possibly premature and certainly hazardous. It savors slightly of planning the Panama Canal shortly before the discovery of America. At best, any vocational analysis of the television of the future must be read with several provisos in mind. In the first place, a normal engineering development of television is assumed. That is, it is taken for granted that technical knowledge of television will increase apace, enabling the practical solution of the remaining engineering problems of television within a reasonable time.

In the second place, a normal economic development of television must be regarded as probable in any analysis of its occupational possibilities. Television transmitting and receiving equipment is elaborate and relatively costly. Television program construction will be more complex and expensive than radio program construction of today. The television art is a comparatively luxurious one. Manifestly, such an art can hardly be introduced rapidly on a large scale in times of marked economic depression nor can it be expected to win public favor under such circumstances. The television programs will be paid for, under our present system of broadcasting operation, by advertising sponsors in the main. The sponsors will in this way purchase a portion of the purchasing power and general good will of the looking and listening public. But the size of the audience, its purchasing power, and its mood will all influence the extent to which the advertiser can justifiably support television broadcasting. Accordingly, there is an action and reaction between economic conditions and television success. If times are bad, the programs must be restricted which, in turn, affects the public response that justifies the broadcasting of the programs. Only in reasonably good times can this circle of effects be broken advantageously. Accordingly, those contemplating television as a career will watch closely for times of general economic recovery since it is in such times that arts like television can be expected to flourish and to afford opportunities for a multitude of new workers.

Opportunities in Manufacturing
Let us start at the factory where the necessary equipment for television transmission and reception originates. Here are needed apparatus engineers who are capable of doing research, development, and design work in that complicated field. These men must be technically trained and well-qualified along conventional radio lines in order to meet the more difficult problems of television. These radio engineers are, in fact, electrical engineers with specialized training in the particular field of communications. In the factory there are also needed tube engineers who will handle the similar problems of vacuum-tube and cathoderay-tube production which are an integral part of the television transmitters and receivers. Some of these men may be university-trained physicists who are prepared to enter the equally complex but more commercial fields of tube research and design. The usual factory personnel will be required for television equipment construction, including test men, supervisors, production and manufacturing engineers, and the like.

Transmitting Station Jobs
Once the television transmitter has been built and shipped, it must be installed in the television transmitting station and thereafter maintained. At this point, an entirely new series of openings will exist. Television station engineers will include field-survey engineers who will determine the best location for the station and its antenna system and who will study the strength and acceptability of the signals throughout the service range of the station. These men will also furnish the data which will satisfy the governmental authorities that the station is covering its territory with an adequate service in the physical sense. The equipment must be maintained in good condition at all times, and emergencies must be met, and this is the job of the maintenance staff of the station.

The television-station studios will require a staff of their own of considerable size and of wide diversity of tasks. Considering the technical men only for the moment, there will be lighting experts who will arrange and control the powerful illumination which
floods the sets (scenery) in the studio and the actors. These men must be skilled electricians capable of handling, shifting, and controlling illumination in any desired fashion. There will be the microphone or sound men in the studio who will place and control the microphone supports or booms which hold the microphone close enough to the actors to pick up speech or music, while still keeping the microphone outside of the field of view of the camera. Here men with steady hands, quick responses, and a cool way of working effectively will be required (particularly in the stress of high-speed operations during the studio performance).

In the control rooms of the studio, there will be sound-control men and picture-control men who will handle respectively the quality of the sound and the picture which is being transmitted.

Sometimes, the television transmissions will be from sound-motion-picture film which has been previously made. For example, a film newsreel may be transmitted. This requires that there shall be projectionists who will handle and project the film on the television picture-by-picture or where it is sent to the audience. Here too there will be necessary film-sound control men and film-picture control men who will carefully monitor the transmissions.

Camera Men

The television-camera men will constitute a new profession as well. These men handle the television pick-up or "camera" which is trained on the action and carefully and continuously focused. The reactions of these camera men must be instantaneous, they must work with perfect coordination in groups where several angle-shots of the same scene are to be transmitted, and they must be resourceful and artistic in their pictorial sense.

The television-camera men in the studio will be a part of a larger group, for it is clear that the outdoor television pick-ups will require the services of men of similar qualifications and perhaps as great resourcefulness to meet the multitude of complicated, partly unforeseeable, and sometimes uncontrollable conditions to be encountered in outdoor jobs. The outdoor camera man will necessarily be of somewhat the same type as the present successful newsreel camera man who can meet an emergency promptly and effectively.

Since a fair portion of television programs may be, as stated above, from film, it will be necessary to film program material, recording both picture and sound in the same way as now done by the motion-picture studios and newsreel companies. This will lead to a demand for film camera men, sound recordists, editors, cutters, and other men of the types found in the motion-picture studios of today. The demand in these fields may develop fairly rapidly as the program "hunger" of television broadcasting rapidly increases after its commercial inception.

Television Service Men

Still considering work of primary technical nature in the television field, it is clear that the television接收ers of today must be installed correctly and kept in good operating condition. This requires the existence of a good-sized group of television service men. Such men must be familiar with the circuits of television receivers, their operation, the testing of the receivers for faults, the location of the faults and their correction, and the best method of installing and maintaining the receiver in the home. The public response to television will depend in some measure on the skill, honesty, and diplomacy of these service men, particularly during what may be the more or less difficult early days of commercial exploitation of television.

Caution!

One final word may be in order in the form of advice to the person who is thinking of entering the field of television. Don't push and run—walk; and watch where you are going. Speed in rushing into the field will not be nearly so helpful as first knowing where your abilities lie, cultivating those abilities by training in fields similar to television, and then everlastingly sticking to the job of perfecting your talents and their application once you have entered the television field. Remember that television success will come rather as the result of a prolonged marathon of effort than from a brief gold-rush of enthusiasm.

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ICW for 5 Meters

In the old days of "Rock Crushers" and "Squeak Boxes" (spark transmitters to you youngsters), a ham was known by his signal, as well as his call. In many cases if he should have forgotten to sign, it would have made little difference anyway as by listening to the particular note, you could identify the man behind the gun. The distinctive signal of the particular individual was just as much of a label, as his voice would be in a conversation.

No wonder "wireless" in those days had the glamour and fascination to attract a following. Those old time signals had a punch that somehow seems to be lacking today with the pure flutelike CW notes. Even though the CW note of today is better in cases of interference, it seems to become more monotonous to listen to for any length of time, as compared to the old type note that was composed of several patches and was full of overtones.

Inasmuch as ICW is still a regular form of communication on the five meter band, why not rig up a trick oscillator that gives a combination of tones, which when blended would give an imitation of the old spark-type transmitter already discussed. Such an arrangement can easily be constructed using a pair of quarter-watt argon tubes, used with a pair of triodes as a mixing device to prevent reaction between the two argon audio oscillators.

Referring to the diagram you will note that one argon oscillator is used for low tones while the other is used for higher tones. Each of these oscillators being resistance coupled to the grids of their respective triodes (type 30's in this case for portability) for mixing, and also to get some gain. It is then only necessary to blend the two tones until the desired note is obtained. The pitch of either oscillator can be varied over quite a range by means of the series resistors so marked in the diagram, and the two tones blended by means of the volume control on the input to the low tone amplifier, marked "Blender Control." With the saw tooth waveform produced by the argon oscillator it is quite easy to adjust the rig to give quite a good imitation of an old fashioned spark transmitter, or in fact an imitation of almost any type of note ever used in "wireless" or "radio" telegraphic communication.


**TELEVISION FUNDAMENTALS**

Diagram showing the various stages of the television and audio broadcast.

You gentlemen with more than the average broadcast listener’s interest in radio, who intend getting acquainted with Miss Television during her “coming out” parties of the next few months, will find this fascinating newcomer speaks a new and strange language. Her sense of time is not that of seconds, minutes and hours, but is in terms of “H” and “V”—3H, 0.15H, 0.10V and 0.07V—in which “H” is 1/1320th-second and “V” is 220/5 H’s.

There is much of merit in the developments of Marconi, Telefunken, Farnsworth, Mihaly-Traub, Scophony, Dumont, Parnsworth and many others. While it appears that American practice will be developed around electronic optical scanning systems, on the cathode ray tube, equally good results have been achieved with mechanical optical systems. Research into the work done both here and abroad during the past ten years, brings to light an almost unbelievable number of combinations of lenses, apertures, prisms and mirrors mounted on drums, spirals and discs. As this is being written, a novel method has been issued by Scophony, Ltd. (British) that a $10,000,000 American affiliate will be formed to market receivers utilizing mechanical optical designs.

Allen Dumont has an excellent system of television which involves no synchronizing signals, has 4-to-1 instead of 2-to-1 interface, and utilizes two carriers. Over in England they use “negative” modulation which means that highest amplitude is white rather than the synchronizing pulse level in blackest black, and the sync pulse level is zero radiated power where our standards of “positive” modulation result in white. Should one care to make a careful study of the work of many very brilliant minds and form his own opinion of the relative merits of each one’s methods, it will be interesting, and definitely instructive; the fact will remain, however, that the electron optical systems are going to dominate commercial television just as gasoline motors outnumber diesels, there will be synchronizing signals transmitted, 441 will be the generally-used line frequency, and sync signals will be above blackest black.

First of all, television broadcasting is to be done in the ultra high frequency spectrum, and, to start, seven channels have been assigned for this service between 44 and 108 megacycles, and another twelve between 156 and 294 megacycles (see Figure 1). This is necessary as it was only in this division of the useful frequencies that enough frequencies were available to permit a few channels with the relatively wide sidebands required (a television channel is six megacycles in width). Here also, reflections from the “heavens” layer occur but seldom. Reflections would be disastrous, as the difference in time between the arrival of the ground wave and that of the reflected wave would produce images in offset pairs or “ghosts.”

![Figure 1](image1)

Each channel is complete in itself, that is, it includes both the video (picture) and the audio (sound) transmission, and these will, in every channel, be a definite distance apart. Thus they can be tuned-in simultaneously, heterodyned by one oscillator, and each diverted into its own intermediate amplifiers. How this works out is illustrated in Figure 2. For this example, the channel in use at the Empire State Building (N.B.C.) transmitter is chosen—the channel from 44 to 50 megacycles (mc.).

It has been found that the wider the video sidebands, the better the detail and entertainment value, so, rather than transmit both sidebands (video) and have each be 2.5 mc. deep, it will be the practice to utilize but one sideband and have it, roughly, 40 mc. deep. The other will be suppressed. In Figure 2, the video carrier is shown as 45.25 mc. and placed 1.25 mc. from the 44 mc. (lower frequency) edge of the channel. Its sideband is about 4.0 mc. deep. The sound carrier is at 49.75 mc., placing it at 4.5 megacycles above the video carrier and 0.25 mc. from the 50 mc. (higher frequency) edge of the band. This 4.5 mc. separation, and the 0.25 mc. placing of the sound carrier, are in the recommended standards.

If, at the receiver, we tune an oscillator to 78 mc., and have it heterodyne the 45.25 and 49.75 mc. carriers, we automatically secure the RMA standard sound intermediate frequency of 8.25 mc. and the video intermediate frequency of 50.25 mc. Whether one tunes to the 44-50, the 50-56 or the 78-84 mc. channel, the two carriers will tune correctly and heterodyne to their proper I.F. passbands.

Probably the easiest way to visualize the pickup and retransmission of television transmission is to imagine that you have before you, as a photoprint, the scene to be transmitted, as it would be at any given 1/30-second. You have a current-generating pencil, from which a wire leads to the transmitter—you draw a straight line across the top edge of the picture, and, as you go over a black spot the current generated increases, while a gray spot produces less current, and a white area would result in no current flowing. Obviously, using a photograph, the current would constantly be changing.

Now you draw another line as close to the first as possible, so that a total of 441 lines will cover the picture completely. When you have finished, of say 24, one of the picture will have been represented by a current, either strong or medium or weak, flowing from your pencil. In television, a tiny stream (or beam) of electrons is caused to travel, just as you did it, over the image picked up by a lens and a complex variety of cathode-ray tube called an Iconoscope. This is called “scanning” and it results in a constantly-varying current, modulated onto a high frequency carrier, which, when received, can be re-created into an identical picture by another beam on the end of another type of cathode-ray tube termed a Kinescope.

While cathode-ray tubes, as used in television, will be analyzed and explained in detail in the next article, I present in Figure 3 a simplification of the Iconoscope and Kinescope, to make the current discussion more readily understandable. The pickup of a scene is, in principle, not difficult to understand when an illustration is available. The left wall of the Iconoscope, as shown in Figure 3, is of exceptionally clear, highly-polished glass, with a lens of the order of f2.8 or f3.5 mounted at correct focal distance so the scene to be transmitted is reduced to proper size on the Signal Plate within the tube. As the electron beam systemically covers the image on the Signal Plate, a constantly-varying current is caused to flow to amplifiers and the transmitter.

At the receiving end, this varying current which is stronger as the picture is darker and weaker as the picture tends to be lighter.
60 is beam

To see how they are used, I now refer to Figure 5. The upper half illustrates the television signal covering the bottom edge of the picture in one scanning field ("A") and the top edge of the following field ("B"); the lower half of Figure 5 portrays the signal during transmission of the bottom edge of the second field ("B") and the top edge of the third field ("C"). This is necessary to show the differences in pulse arrangement, which explain how interlacing is accomplished.

As in voice transmission, the carrier provided for video transmission has a definite amplitude (voltage maximum) which it maintains even until modulated. Whereupon the voltage rise in each sideband varies with the impressed signals. In the television set itself, what is represented is that a complete cycle of variations of maximum amplitude, 525/60ths of a second, is maintained.

Since we have full black at 75% amplitude, anything that may be done with the other 25% would not be visible on our Kinescope, and it is here that we put the synchronizing pulses. At the left end of the upper half of Figure 5 we come into the middle of the fifth line from the bottom of the picture of one field. As illustrated, it is going from dark to light (slopping down). The narrow upright pedestal shown represents the last 15% of this line, at the right edge of our transmitted picture. What is called a "blanking pulse" is injected which immediately jumps the carrier to zero volts. In other words, we do not "see" the last 0.10H on each swing of the Kinescope beam.

The narrower extension on the top of the pedestal is the "horizontal synchronizing pulse," whose job it is to swing the traveling Kinescope beam back to the left for the start of the next line (4th from bottom) while a condition of full black exists. This horizontal synchronizing pulse starts 0.01H after the front edge of the blanking (full black) pedestal pulse. It lasts but 0.08H in time, then the voltage drops back to the blanking pulse level for 0.06H more, and, at its end, we are starting the 4th from the bottom line of the picture. This cycle continues through the last line of picture.

You will note a vertical broken line identified as "Bottom of Picture—Field A." This is the bottom edge of the tube which is visible; our electron beam will continue swinging but the final 15 to 22 lines of the field will be blanked out or black. The recommended standards say this period, known as "vertical blanking" shall be 0.07 to 0.10 of the time of one field (1/60th second) which is roughly 15 to 22 lines of our 220H/2 per field.

With the Kinescope held black, six narrow pulses termed "equalizing pulses" are introduced. They are 0.04H wide and spaced at 0.5H intervals, beginning 0.01H after vertical blanking began. Three of these are, in effect, horizontal synchronizing impulses to keep the beam horizontally synchronized; the three marked "M" are necessary to assure proper interface in the receiver, and their action will be described in article three.

The vertical synchronizing pulse, which comes next, requires the time 3H. It is composed, as shown, of six 0.46H pulses and six serrations or slots which are 0.04H each. It should be noted that the front edge of the vertical synchronizing pulse and two of these serrations (0) correspond in their timing with the horizontal synchronizing pulses. The other three (N) are necessary to make identical the vertical synchronizing pulses of odd and even fields (see the vertical synchronizing pulse directly below in the following field).

While these slots are shown with vertical sides, because they are so small in the illustration, the sides are really sloping, so there is a slanting fall on one side of each slot equal to 0.005H in time, and a slanting rise on the other side of 0.005H in time.
That is only 5/1000th of 1/13230th of a second, but these slopes are necessary that a wave of the proper form be supplied to the deflecting circuits of the receiver's Kinescope.

While the vertical synchronizing pulse has now thrown the Kinescope beam back to the top of the picture for the start of another field, there remain six more equalizing pulses, which must be present for the same reason as was the first group. A series of horizontal pulses then follows before the vertical blanking is removed, and the picture is resumed. The number of such pulses at this point may vary from approximately six to thirteen and this will not affect reception, except that it shortens the height of the picture by an infinitesimal amount if more are used. At the point marked "Top of Picture—Field B" the vertical blanking ends and slightly over four lines of the next field are shown.

The lower half of Figure 5 is similar in its cycle of pulses to that of the previous field, but certain features should be stressed. Note that the last line of Field B (odd field) is not complete when the vertical blanking begins at the bottom of Field B's picture. These are (presuming 30 lines of blanking per frame) lines 407, 409 and 411, and their timing must be 1/3H "off" in relation to those above in Field A (even field) which are 406, 408 and 410. At the right end of the lower illustration, a half video line is indicated following the finish of vertical blanking, whereas above it, a full video line is shown. In the upper drawing, these top-of-field (B) video lines are 1, 3, 5, 7, etc., while below, these first lines are 2, 4, 6, 8, etc., of an even field (C).

When the fact that "an aspect ratio of 4:3 is recommended to conform with existing motion picture practice" is added, we have concluded our review of the more important introductory features of television. This quoted sentence simply means that the height of the picture shall be 3/4 width, regardless of size Kinescope used.

**BUILDING A TELEVISION RECEIVER**

With television looming on the horizon an attitude of watchful waiting is being assumed by the radio public in general. But neither the ham nor general radio experimenter is the type to sit and wait for someone else to do things for him. Not so many years ago when there began to be some thought given to the possible practical value of short waves for communication and broadcasting these men didn't wait for someone else to point the way. They dug in and pioneered development. There is every chance that they are likewise going to play a big part in evolution of television. Even the Radio Corporation of America recognized this possibility when over a year ago it made both information and special television tubes available to experimenters, and particularly to hams.

In this video set, which is based on the Garod Model 100, certain refinements have been avoided—refinements whose complications do not justify their advantages. It is believed by the designers, for instance, that to build the sound and video receivers in one unit would add complications not warranted by the saving in space and a few tubes that might result. Moreover, a separate receiver can be more readily used for other ranges such as the 5- and 10-meter ham bands, the u.h.f., high-fidelity broadcast stations, etc., than can one whose circuits are interwoven with those of the video receiver.

The complete circuit diagram for the video receiver and power supply is shown in the figure. These are two separate units as shown and are interconnected by means of cable and plug.

The first six tubes constitute the superheterodyne receiver and include one r.f. stage, combined oscillator-mixer, 3 i.f. stages and diode detector. This differs in a number of respects from conventional broadcast superhets. First of all, every i.f. and r.f. circuit must be capable of passing a tremendously wide band of frequencies which constitutes the video signal. Even where only a single side-band is transmitted the receiver circuits are called upon to pass a band approximately 2000 kilocycles wide or more. This is accomplished by heavily loading the tuned circuits of both r.f. and i.f. with resistors as shown at R1, R6, R10, etc. The r.f. and i.f. tubes are all of the new ultra-high frequency type developed especially for television use. These tubes provide high gain at these frequencies—gain comparable with that obtained at lower

![Circuit diagram of a home-built television receiver.](image)
frequencies from the 6K7, and the like.

The tuning range is approximately 39 to 63 megacycles, and the intermediate frequency 12 megacycles. The receiver is designed to suit pictures from stations using the R. M. A. standards of 441 lines, 30 pictures per second with interleaved scanning. It can be adapted to other standards by alteration of the sweep constants.

The first and second video amplifiers (1852 and 6V6G) function like the audio amplifier in a sound superhet except that they must be capable of passing a wider frequency range. There is also the difference that the signal as amplified by these tubes contains not only the picture modulation, but the synchronizing impulses, as means of which the viewing process at the receiving end is kept in exact step with the scanning operation at the transmitter. There are two groups of impulses, one controlling the horizontal sweep and operating at 13,230 cycles per second, the other the vertical sweep, at 60 cycles per second.

The scanning impulses are of greater voltage amplitude than the picture signal and are separated from the latter by means of the 6H6 diode just to the right of the 6V6G video amplifier. This diode is replaced by means of the potentiometer R36 so that it passes current only at voltages above a predetermined level appearing in the output of the 6V6G. Thus by adjusting this level (by means of R36) to a point somewhat higher than the picture signal output the synchronizing impulses are separated from the picture signal and cause current to flow through the 6H6 corresponding to the synchronizing impulses. Then by means of properly proportioned circuits, the high-frequency and low-frequency synchronizing impulses are separated, the former being fed to the control grid of the high-frequency sweep oscillator and the other component to the low-frequency oscillator.

Separation of the synchronizing signals after rectification in the 6H6 is accomplished through selection of the proper resistance-capacity filter values. C32, having a value of only 0.0001 mfd. will not pass the low-frequency signal but will pass the high-frequency, impulses to the grid of the high-frequency oscillator. The low-frequency impulses are readily passed by C31 to the grid of the low-frequency oscillator but the high-frequency impulses are blocked out of this circuit by the high resistance of R34. Thus complete separation is effectively obtained.

The cathode-ray tube employed is one of the 5-inch type in which the image has a greenish tint. Tubes which provide black and white image can be used but have the objection that for given anode voltages the images are less brilliant, which is another way of saying that for equally brilliant pictures the "green" tube is less expensive.

All voltages for the cathode-ray tubes are provided by the 879, high-voltage supply. The 523 supply takes care of all other tubes.

Construction Hints and Data

The antenna primary L16 is connected to the Dipole (or other type) antenna through a twisted pair. The secondary is tuned to the carrier frequency by the first section of the three gang condenser, and is fed into the grid of the 1852 r.f. amplifier. The plate circuit feeds through inductor L2 as a plate load into the control grid of the 6K8 converter (through the 00001 mfd. coupling condenser). The oscillator is of the Hartley type, although the elements have been used in a somewhat unconventional manner. Note that the oscillator plate (No. 6 pin) is not used. It was found that better stability was obtained with the circuit as shown, than with the conventional arrangement. The converter is followed by three i.f. stages operating at 12 M.C. The 6H6 is used as a diode detector in the usual way. The two chokes L1-L8 together with the 00003 mfd. condenser serve as a filter to remove the i.f. component from the video channel. The 1852 and 6V6 act as 1st and 2nd video amplifiers respectively for the picture signal. A single 1½ volt cell such as is used for Pen-Lite flashlights supplies the "C" bias for the 1852 first video stage. This cell will last for a considerable period, since no current is drawn. The output of the 6H6 is connected to the control grid of the cathode ray tube as well as the sync. separator.

The sweep circuit oscillators are of the multi-vibrator type, are very stable in operation, and can be readily controlled by the sync. pulses, which are introduced into the 6K7 and 6V6. Both sweep circuits utilize the same circuit arrangement, except of course, that different constants are used for the horizontal (high) and vertical (low) sweep frequencies. The saw-tooth waves generated in such a multi-vibrator are, if no compensating means is used, logarithmic in form. Chokes L12 and L13 are therefore inserted to correct this deficiency and produce a saw-tooth, substantially linear, so that the electron beam is carried across the tube at a uniform rate.

The synchronized saw-tooth pulses are then fed to the two sets of deflecting plates to scan the face of the picture tube by means of the electron beam emitted by the electron gun in the neck of the tube. This beam is in turn modulated (through the control grid) by the synchronizing pulses obtained from the output of the 6V6.

Means are provided for centering the picture by varying the fixed positive potential on the two sets of deflecting plates. Other controls focus the beam and adjust the potential on the focusing electrode (R39) and adjust the bias on the cathode ray tube (R36) to set the average brightness (contrast).

Assembly and Wiring

The assembly of the component parts may be seen from the photographs and diagrams. All parts should be assembled as shown and checked against the circuit diagram to prevent any possibility of error.

Note that the end of the shield on the underside of the chassis is soldered to a lug fastened under one of the screws on the gang condenser.

Coils L1, L2, L3, and L16 are wound with No. 16 bare wire. A ¾" diameter former is used and resistors, mica and tubular condensers. All wiring should be as short and direct as possible. Particular care should be taken in the video amplifier to avoid high grid or anode capacities to ground, since this will result in a loss of high frequencies with consequent poor detail. This applies especially to leads from the Diode detector to the 1852 and coupling condenser from 1852 to 6V6 as well as wiring from L11. These should be lifted away from the chassis ¼ to ½ inch. Do not fasten the grid lead from the picture tube to the chassis or wrap it around the other leads in the cable.

CAUTION

Approximately 1400 volts is supplied to the high voltage supply. This voltage should be treated with great respect, since under certain conditions it may be DANGEROUS. Be sure that the power switch is OFF or better still, remove the line cord from the outlet, when making any changes, or touching any parts, other than the control knobs.

With a high resistance (1000 ohms per
Automatic Background Control: Aperture developed by the multi-vibrators age two factors, namely: the sweep entire range. If neither all and use ascertain the tubes. If there voltmeter, 10 volt) voltmeter, 10

Composite Signal: ode-ray and synch. pulses

By the intermediate frequency is 12 mc. The i.f. transformers are now adjusted for maximum output in the conventional way.

Now introduce a signal, whose frequency is approximately that of the principal station to be received, into the antenna circuit. Tune this signal by rotating the dial, then align the antenna and r.f. circuits for maximum output by means of the trimmers on the variable condenser. After this has been done, the receiver is ready for a test on the air. It is best to make adjustments on the fixed pattern transmitted by television stations during test periods preceding the regular scheduled programs. The i.f. system should now be re-adjusted by staggering the peaks to accept a wide band of frequencies (5 megacycles). This will result in considerable improvement in picture detail, with relatively slight loss in gain.

The i.f. transformers are heavily loaded (with 1900 ohms across each secondary). It is possible to overload these, with an increase in gain if they are carefully realigned so as to stagger the peaks, with a resultant "square top" resonance curve over the band.

The r.f. circuits should now be re-aligned for best tracking. It may be necessary to adjust the r.f. coil inductions slightly to obtain the proper range and tracking. If necessary the end plates of the variable condenser may be bent to accomplish this.

About 20 volts at the control grid of the cathode ray tube is necessary in order to obtain a good picture. If everything is functioning properly this should be easily obtained from stations within range. This can be checked with a vacuum tube voltmeter or calibrated oscilloscope.

A little experience will enable the user to tell in a station quickly and clearly. Proper manipulation of the controls is important.

TELEVISION WORDS & TERMS

FIELD FREQUENCY SYNCHRONIZING IMPULSE: In order to keep the vertical scanning of the generator at the receiver in step with the transmitter, it is necessary to impose a square topped impulse at the end of each vertical scanning of the picture field.

FRAME FREQUENCY: Refers to the number of times per second the frame area is completely scanned.

FRAME: The frame is a complete picture.

HORIZONTAL BLANKING IMPULSE: Is a synonym for "Line Frequency Blanking Impulse."

HORIZONTAL SCANNING FREQUENCY: Is the synonym for "Line Frequency."

GHOST IMAGE: If the signals generated during the retrace time of the television camera scanning produce a ghost image signal, it is known as the "Ghost Image." This is subsequently erased by the blanking signal.

ICONOSCOPE: Is the television eye and is a cathode-ray type tube which has a mosaic plate and is so arranged that the positive charges thereon are neutralized so that the discharge currents constitute a video signal.
Image Dissector:
A television cathode-ray camera type tube is one in which the electron image which corresponds to the optical image of the scene being televised is made to move in such a way that the electrons so collected constitute a video signal current.

Interlaced Scanning Field:
It is a rectangular field within which the field frequency is a part of the frame frequency and in which the lines traced on each action being scanned on the picture area are made to fall evenly between those of each previous fraction of one scanned line in order that they scan each picture frame.

Interlace Ratio:
Is the numerical ratio of the field frequency to the frame frequency.

Keystone Distortion:
When the picture field assumes a trapezoidal rather than a rectangular shape it results in an optical or electrical distortion which is referred to as a "Keystone Distortion."

Kinescope:
This is the cathode-ray tube used in television which relies on an electronically focused cathode.

Line Frequency:
A saw tooth wave is used for scanning in a horizontal direction and is the line frequency that is equal to the number of lines per second scanned.

Line Frequency Synchronizing Impulse:
Is the same as the frequency of the saw tooth waves, which is used for scanning in the horizontal direction.

Line Frequency Synchronizing Impulse:
Is the frequency at the end of each scanning line to keep the horizontal generator at the receiver end in step with the horizontal generator at the transmitter end.

Line Frequency Blanking Impulse:
Is a square topped impulse transmitted at the end of each scanning line to erase the return trace of the cathode-ray spot on a television receiver tube.

Master Pulse Generator:
This generator is used at the studio end to provide all blanking and synchronizing signals for both the receiver and the transmitter.

Magnetic Deflection:
Refers to the directing of a lateral or vertical motion to the cathode-ray spot by passing it through a field produced by a coil through which the saw tooth scanning current is flowing.

Magnetic Focus Coil:
Is a solenoid which directs the stream of electrons emitted by the cathode-ray gun into a very fine spot on the cathode-ray screen.

Negative Transmission Polarity:
When a decrease in the light intensity results in an increase in the radiated R. F. power of the transmitter it is known as "Negative Polarity."

Negative Picture:
When the polarity of a video signal is reversed at the grid of the cathode-ray receiving tube it is called a negative picture.

Odd-Line Interface:
When the number of lines which are being scanned within each picture frame become an odd number they are known as "Odd-Line Interface."

Optical Focus:
"This refers to the focusing of the image optically on the light sensitive cathode of the dissector tube and should be distinguished from the electrical focusing of the electron image produced within the tube.

Oscillophone:
Is a cathode-ray television reproducer tube which is of the magnetically focused type.

Positive Polarity of Transmission:
When in initial light increases the radiated power of the transmitter the polarity of the transmission is said to be positive.

Picture Element:
The smallest subdivision of the picture area defined in the process of scanning.

"Rain":
If a poor signal-to-noise ratio exists on the television image it is commonly referred to as "rain."

Retrace Time:
The time which elapses between the end of one vertical scan of the picture field and the start of the next vertical scan. Or else, it might be the time which elapses between the beginning of scanning line and the starting of the next consecutive line.

R. F. Television Signal:
The signal caused by the modulation of the R. F. picture carrier by the composite television signal.

Scanning:
When the dimensions, including the height and width together with the intensity of the picture, are being scanned by means of a predetermined manner and from an electrical amplitude-time function representing an integral summation intensity of each elementary area of the original image, the amplitude-time function thus obtained becomes a video signal.

Scanning Interference:
When there is cross-talk between the video and scanning circuits and it is produced on the television image, it is known as scanning interference.

Scanning Field:
Is the area covered by the scanning spot either in displaying or reproducing the television images.

Synchronization:
When the generators at the receiver are in step with the scanning generators feeding the television camera, both the transmitter and receiver are said to be in "synchronization."

Scanning Generator:
Is used to generate the saw tooth waves which are used for the electrical scanning of the television scanning tube or the cathode-ray type of reproducer.

Telecine Transmission:
Refers to the process of televising and transmitting motion picture film subjects.

Vertical Blanking Impulse:
Commonly referred to as "the field frequency synchronizing impulse."

Vertical Synchronizing Impulse:
Refers to the field frequency synchronizing impulse.

Vertical Scanning Generator:
Refers to the field frequency scanning generator.

Video Signal:
When the cathode-ray tube in the television camera is used to scan an image, the signal resulting from the scanning which is being transmitted is called the "Video Signal."

XTAL DOPE
QUARTZ CRYSTALS USED IN HARMONIC TYPE OSCILLATOR CIRCUITS

Many amateur operators are disappointed in attempting to oscillate so-called 10 and 20 meter crystals in the harmonic type of oscillator circuits. It is well to point out that 10 and 20 meter crystals are essentially to 60 meter fundamental and therefore operate on their odd harmonics rather than the even harmonics. For example, a circuit which attempted to use a so-called 20 meter crystal would actually put out a harmonic on 15 meters, which would fall out of the amateur bands.

It is therefore apparent that in order to get good efficient performance from either 10 or 20 meter crystals that they be used as a straight crystal controlled oscillator and never to use them as a generator of harmonic frequency.

Never attempt to use a crystal itself as a power device. It is far better to use an oscillator which is idling than one which has a high plate voltage supplied. It is always good practice to incorporate some sort of a fuse in the crystal circuit and this fuse will be one of the popular type of pilot lamps, possibly of the brown bead variety. This particular bulb will pass 125 ma of current at full brilliancy. Most crystals are designed to operate up to that value but never exceeding that value, so that if this bulb were used in the crystal return circuit of the oscillator, any current in excess of 125 ma would blow the bulb, thereby protecting the crystal. It should not be assumed that the crystal should be operated to light the bulb to full brilliancy as such is not the case and the crystal current should be kept well below those limits.

Cystals suitable for frequency multiplying are either the 160, 80 or 40 meter type and may be of any of the standard cuts.

Crystal cleaning: The quartz used for crystals must be handled very carefully. When cleaning and the best solution to use is either alcohol or carbon tetrachloride, which is available in the drug store in the form of "Carbona." The face of the crystal must never be handled by the hand and a clean soft cloth or paper should be used when replacing the crystal to its holder.

WIRE TABLE
Winding Turns Per Inch

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<tr>
<th>Gauge</th>
<th>Diameter</th>
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D.C. C.C.  B.C. C.C.  Enamel  D.C. C.C.  B.C. C.C.  Enamel

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AN AMATEUR’S TELEVISION TRANSMITTER

The system of transmission of a negative is quite unique in that it incorporates the cathode ray tube as the heart. The difference between our system and the Iconoscope was that while the Iconoscope scans an image inside of the tube, we were able to scan an image outside of the cathode ray screen. This was done by placing a negative flat against the end of the cathode ray tube and transmitting the ray through the glass and the film, collecting it in an Eby cell upon which it had been focused by means of a series of lenses. This then would be our “Iconoscope.” The lens we used was an ordinary photographic convex type which can be purchased in any supply store. Our system had one drawback. There was not enough light hitting the Eby cell to operate the modulator for the ordinary speech input.

Our second big problem, therefore, was to design an amplifier which would amplify the very small amount of energy obtained from the Eby cell sufficient to modulate a small transmitter.

A lot of different things had to be taken into consideration. Firstly, the amplifier had to pass a very wide range of frequencies, from 20 to 1,500,000 cycles with a constant output over the entire frequency rate. We determined we had to have at least a 60-volt output from the amplifier in order to adequately excite the drivers and the modulators of the transmitter.

In order to avoid distortion, the capacity of all of the parts had to be very small. The amplifier had to be hum-free, and each stage would have to be shielded so that there would be no interaction between them.

Forgetting for the moment the video or transmission of television signals, we concentrated on the design of an amplifier suitable for our purpose. Before going into the actual construction itself, it might be well to state a few axioms of television. The simple basis of comparison with television is the ordinary broadcast transmission and reception. An ideal broadcast or phone transmitter is one which can follow transmitted variations in one ten-thousandth part of a second. This will not do for television. In picture transmission it is necessary that the transmitter follow a variation from light to dark in almost a millionth part of a second.

In our transmitter the total numbers of lines in the complete picture was 240 scanned sequentially, and horizontally 24 picture transversals per second or 24 complete frames per second. The line frequency of our transmitter then was 5,760 cycles horizontal deflection, and frame frequency of 24 pictures per second. Later we were able to push out scanning lines up to 300 with some distortion and our horizontal deflection ran 7,200 cycles. This distortion was noticeable and not pleasing to the eye.

Before commencing the construction of the amplifier it would be better to construct the oscilloscope and its associated circuits. If two 908 oscilloscope tubes are available, one may be used with which to transmit, and the other one to check the entire system by receiving the image. They may be hooked in parallel insofar as the power circuits go. High voltage power supply for the cathode tube can be seen directly behind the amplifier in the picture at the top of the page. It uses a single 866 rectifier and operates on the half-wave rectification system. The current drain from this power supply is one milliampere and it will not cause any voltage fluctuation in the power supply when this is used. A full-wave system could be used, but the cost would be exorbitant. The diagram fully explains the component parts and their hook-up. It also gives the necessary voltages for checking.

After the high voltage supply has been completed, the sweep circuits should next be commenced. The cathode ray sweep circuit and its associated power supply is shown. The controls in the front of the panel are from left to right the horizontal amplitude control, the horizontal frequency control, blocking control, frequency control and the vertical amplitude control. This sweep circuit operates the horizontal and vertical amplifiers of the cathode ray oscilloscope. It utilizes two 887 discharge tubes.
and two 56 tubes. The associated power supply to which it is connected by means of a compartment contains a power transformer a type 5Z3 choke and the condensers in filter arrangement. Two power supplies are mounted on this chassis, one for the sweep circuits and the other for the amplifier. The transformers are mounted along the outside edge of the sweep circuit chassis and 2½ volt filament transformers are used to light all of the heaters in the transmitter.

After the oscilloscope power supply and sweep circuits have been completed it will be well to test them with an oscilloscope. In the event the beam of wave input is not available for test purposes, 60 cycle current may be put upon horizontal or vertical plate through a .002 mfd. mica condenser. If everything is in order, the oscilloscope should operate as is customary.

The amateur is now ready for the construction of the difficult part, the amplifier. Component parts are all listed in the diagram itself. Procure a chassis 35 inches long, 10 inches wide and 6 inches high. Divide this into six compartments, each of approximately 6 x 10 inches in size. The tubes should be mounted in each compartment as is shown in the photograph, making certain that all wiring is as short as possible. Do not purchase anything but the very best parts. Check each resistor at the time of the purchase, and be sure that the values are exact and use the ohmmeter as a reference rather than the printed label upon the part. A few ohms difference in the various resistors might imbalance the amplifier and will make a great deal of difference in the performance of the finished product.

Mount the Eby cell on the outside of the chassis to the extreme left and proceed with the wiring and construction as is indicated by the diagram and the photograph.

After the amplifier has been completed tubes should be inserted and it should be checked for him by turning on all of the filaments and the voltage to each tube. If any hum is present, it will show on the cathode ray tube in the receiving position. Hum may be checked before the amplifier can be put into television operation.

By means of the lenses, focus the beam of the transmitting cathode ray tube upon the Eby cell. If everything is in order, a square frame of light should appear on the receiving tube at the other end of the amplifier. Both cathode ray tubes are connected in parallel as is indicated in the diagram. If the diagrams, pictures and hints herein contained have been followed, and the apparatus tests ok, a picture can now be televised. Place a sharp contrast negative up against the end of the cathode ray in the transmitting position. Turn on all filaments and tubes. If everything is working right, a positive reproduction should appear on the receiving C. R. tube screen. You are now ready to put the television transmitter on the air.

Because of the wide frequency range of video signals, it is impossible through a transformer plate to modulate any transmitter. Grid modulation therefore will have to be resorted to. The modulator and driver should now be constructed. We used a pair of 10's as modulators and a pair of 10's as RF final amplifiers.

Feeding the output of the amplifier at points x-x into a pair of 45's in push-pull as is indicated in the diagram, we fed that to 210's operating in Class A. Here again the diagram is self-explanatory. The output of the 41 drivers is fed through a low impedance network to the modulators. These, in turn, grid modulate another pair of 10's acting as final RF amplifiers. The crystal and exciter circuit in the RF section has not been drawn since it is well-known to give almost every amateur.

In order that amateurs who have different types of receiving sets, as well as any short wave listeners who might be equipped to give you a report, can tune you in, the following procedure is one we adopted with considerable success.

Fire up your regular transmitter, call "CQ Television," or "CQ Video." Do not turn on the video transmitter. When you make a contact, inform the person receiving, that you wish to transmit a video signal. The person receiving will need the following information. First, the wavelength in KC upon which you expect to transmit your video signal; second, the horizontal scanning frequency; and third, the vertical frequency of the image.

Actually in practice, it works out something like this. W9... calls CQ on 59.9 MC. Receiving a reply, he advised the recipient to watch for the video signal on 58 MC and gives him the horizontal scanning frequency of 5760 cycles and the vertical frequency of 24 cycles. The recipient then tunes his television receiver to 58 MC and sets his cathode ray sweep circuit to the horizontal frequency of 5760 cycles and the vertical frequency of 24 cycles. By doing this, the transmitter and the receiver were in synchronisation. Transmitted signal and picture came through with considerable clarity. Audio or voice transmission must be at least 1.5 MC removed from the video signal.

The transmitter we described does not transmit any signal of a synchronizing nature, but it does enable the amateur to start on his way with television. As we see it, in the future amateurs will call "CQ Video" and receiving an answer, will transmit their video signals. The receiving amateur will set up the necessary components in his receiving oscilloscope to synchronize with the transmission. Wide variation from 60 cycles on the A.C. line will prevent the picture from being received properly.

At the present writing, the television bands have been put down to 2.5 meters insofar as the amateur operator is concerned. This means that extraordinary care will have to be used to prevent feedback. Any such manifestation will spoil the picture transmission, and may even make it unintelligible. Great care should be taken to avoid r.f. feedback.

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**LEARNING THE CODE**

THE Ham Maker consists of groups of letters, numbers, and abbreviations arranged in groups of five; in other words, code words.

There are fourteen horizontal rows of code words, each containing fourteen groups. They are arranged in rows vertically and horizontally so that they can be read down or across.

This sheet was evolved after a long search for some economical, sure-fire way of giving code practice to aspiring hams. I have tried sending from newspapers but the fault there is only that common letters appear while x, j, q, and numbers seldom appear. Also there is no way of estimating your speed when sending this way.

All these faults are done away with in the Ham Maker. Every letter and number is included at least once in each line. Abbreviations commonly in use appear often. Furthermore the sender, by glancing along the top of the page as he sends and keeping his eye on the watch, can keep a very accurate check on his speed. Suppose he finishes group two at the end of 15 seconds, his speed is 8 words per minute.

Some hams and would-be hams have attempted to solve the problem by making up sentences containing all the letters. Obviously this is a difficult task in the first place, and in the second place the code student unconsciously memorizes the sentences.
THE JONES 8-TUBE SPECIAL SUPERHET

COMMERCIALLY built communication receivers are being used by a great many amateurs. However, experimenters still like to build their own. Some of the experimental receivers have circuit improvements which can be added to existing receivers without too much effort, thus bringing the nearly obsolete receiver up to date in performance. For these reasons, magazine articles on both simple and complicated receivers are of interest to nearly all readers. The receiver illustrated here has a number of good circuit improvements such as high C oscillator, low C r.f. and detector tuned circuits; modern tuned plate hexode mixer system; simple variable selectivity crystal filter circuit; high IF amplifier frequency with high image rejection; simple second detector, AF and BFO circuit with a 6N7G tube; and a fine new noise limiting circuit.

The receiver was primarily designed for code reception with a view to obtaining a high signal to noise ratio. It is quite satisfactory for phone reception though no AVC or R meter circuits were included. It would be possible to use AVC on the two IF stages with a separate amplified AVC circuit with a 6B8 tube without disturbing the present circuit layout. Plug-in coils, inside of removable shield cans provide good efficiency and short r.f. leads with less difficulty in construction than in the case of a band-switching system.

Band spread over each amateur band is accomplished by tapping the ganged midget tuning condensers across the proper amount of coil turns in each case. This tuning condenser is connected across the whole 80 and 160 meter coils but is tapped part way down for the other bands. The coil table gives the turns and dimensions for all bands from 10 to 160 meters.

Low C to L ratio is extremely desirable for the signal frequency tuned circuits for weak signal reception. A low C oscillator circuit is unstable and tends to drift badly while the receiver is reaching its normal operating temperature. These effects can be nearly eliminated by using a high C to L ratio in the oscillator circuit. It was found that very good tracking of the tuned r.f., detector and oscillator circuits was possible with a high C oscillator over the relatively narrow amateur bands. The trick is to calculate the values of inductance and capacitance which will cause the oscillator to tune to about 1600 KC (1560 KC in this re-
The first detector-oscillator is a 6J8G hexode which is much more effective than any of the older combination mixer tubes. It is fairly similar to the 6K8. A tuned plate oscillator circuit provides better frequency stability and less detector reaction than the conventional oscillator tuned grid circuits.

A high intermediate frequency was chosen in order to minimize image response in the high frequency amateur bands and to improve the sensitivity for 10 meter band reception. The usual 465 KC IF causes the oscillator to be tuned to more nearly the same frequency as the detector grid and space charge effects tend to decrease the signal to noise ratio in the 10 meter band region. This degenerative effect is reduced when the oscillator frequency is far enough away from the signal frequency so the ratio of frequencies is more like that obtained in the 80 meter band with a 465 KC IF. The 1600 or 1560 KC IF is very desirable in a receiver designed for 10 and 20 and even 40 meter band reception. The gain is less with a 1560 KC IF and so two stages are needed, though in this case each stage is overbiased enough to reduce the gain to a value about equal to a single 465 KC high gain IF stage. The additional tuned IF stages aid in selectivity.

The crystal filter circuit includes a 1560 KC crystal shunted by a vari-
resistor connected in series with the normal 350 or 400 ohm cathode resistor in the 41 power amplifier tube. This delay voltage is adjustable in order to set the noise suppressor starting action at any desired level.

With no delay bias the noise reducing action takes place on all audio signals and distorts voice reception. A delay voltage of 1/2 to 5 volts eliminates this distortion and allows that amount of audio signal to pass through without distortion.

Component Parts List

- C1: 20 mmfd var. Bud 322
- C2: 33 mmfd var. Bud 322
- C3: 15 mmfd. var. Hammarlund HF15
- C4: 3-30 mmfd. trimmer Hammarlund
- C5: 100 mmfd. max. paddar Bud 321
- C6: 0.1 mfd. 600 v. paper C-D
- C7: 1 mfd. 600 v. paper C-D
- C8: 0001 mfd. mica Mallory
- C9: 001 mfd. mica Mallory
- C10: 25 mmfd var. Hammarlund H
- C11: 00005 mfd. mica Mallory
- C12: 002 mfd. mica C-D
- C13: 1/2 mfd. paper 400 v. C-D
- C14: 1/2 mfd. paper 400 v. C-D
- C15: 20 mfd. electrolytic 50 v. C-D
- C16: 16 mfd. electrolytic 450 v. C-D
- T1: Center tapped audio choke—primary of PP in leads to speaker transformer—secondary of PP
- T2: 3-1 interstage AF trans.
- Ch1: 15 heavy 85 ma. Slow choke
- LC2: 2nd detector cathode coil—30 turns No. 28-170D random wound on a 3/4" diameter porcelain rod insulator
- R1: 300 ohms 1/4 w. Centralab
- R2: 50,000 po. (RF regeneration) Centralab
- R3: 50,000 1/4 w. Acorvox
- R4: 50,000 1 w. Acorvox
- R5: 5,000 1/4 w. Acorvox
- R6: 10,000 1/4 w. Acorvox
- R7: 5 megohms (bias control) Centralab
- R8: 1,000 ohms 1/4 w. Centralab
- R9: 100,000 1 w. Acorvox
- R10: 50,000 pot. (1F control) Centralab
- R11: 22,000 1 w. Acorvox
- R12: 220 ohms 10 w. Ohmite
- R13: 70 ohm rheostat (mica, silence bias) Frost
- R14: 25,000 10 w. Ohmite

### 8 Tube Communication Receiver

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<thead>
<tr>
<th>COIL BAND</th>
<th>R. F.</th>
<th>DETECTOR</th>
<th>OSCILLATOR</th>
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<tbody>
<tr>
<td>45 turns No. 20 DCC 1/2&quot; long Cond. tap at 4 turns Cath. tap at 3/4 turn</td>
<td>45 turns No. 20 DCC 1/2&quot; long Cond. tap at 4 turns</td>
<td>1/2 turns No. 20 DCC 1/2&quot; long—1/4&quot; diam. No cond. tap</td>
<td></td>
</tr>
<tr>
<td>12 turns No. 22 DCC 1/4&quot; long Cond. tap at 5 turns Cath. tap at 1/2 turn</td>
<td>12 turns No. 22 DCC 1/4&quot; long Cond. tap at 5 turns</td>
<td>1/2 turns No. 20 DCC 1/2&quot; long Cond. tap at 3/4 turn</td>
<td></td>
</tr>
<tr>
<td>24 turns No. 22 DCC 1/4&quot; long Cond. tap at 12 turns Cath. tap at 3/4 turn</td>
<td>24 turns No. 22 DCC 1/4&quot; long Cond. tap at 12 turns</td>
<td>1/2 turns No. 20 DCC 1/2&quot; long Cond. tap at 5 turns</td>
<td></td>
</tr>
<tr>
<td>49 turns No. 24 DCC 1/4&quot; long No cond. tap Cathode tap at 3/4 turn</td>
<td>49 turns No. 24 DCC 1/4&quot; long No cond. tap</td>
<td>15/16 turns No. 20 DCC 1/4&quot; long No cond. tap</td>
<td></td>
</tr>
<tr>
<td>80 turns No. 26 E 1/4&quot; long No cond. tap Cathode tap at 3/4 turn</td>
<td>80 turns No. 26 E 1/4&quot; long No cond. tap</td>
<td>24 turns No. 22 DCC 1/4&quot; long No cond. tap</td>
<td></td>
</tr>
</tbody>
</table>

### RADIO TUNER FOR P. A. SYSTEMS

Simplicity of control, including a phone jack, make this P.A. tuner the ideal for use by the serviceman. Receptacles are grouped around that socket to give the best possible output—something which a very simple set-up employing few parts can be made to do.

Physically, the tuner is quite compact and certainly portable—cabinet dimensions being 8 1/2"x3 1/2"x13". In non-portable layouts, by the way, and particularly in assemblies of dual-channel design, two of these units may be mounted side-by-side to form a compact 15-inch relay panel and operated simultaneously without interference one with the other. TRF design of course precludes the necessity for local oscillator circuits, which in contingent superhet, tuners might cause considerable trouble.

The coverage is limited to the standard broadcast band—the actual frequency range being from 530 kc. to 1600 kc. Tuning and tracking is very precise—and related to a calibrated four-inch dial scale.

**The Circuit**

Four tuned stages are employed—antenna, two r.f. and detector—variable condensers in gang for single-dial control. The detector—a diode—provides both an A.V.C. and an a.f. voltage related to signal. The two-section a.f. tube, with its two output terminals...
The 6F8G plates, unlike the grids, are not paralleled but work into separate output circuits—one for headphone monitoring, one for tuner feed to the amplifier. Monitoring does not affect the output in any way; neither the quality nor the level of the signal supplied the amplifier is changed by headphone plug-in.

Terminals 1 and 3 provide a 10,000 ohm match to the amplifier input, terminals 2 and 3 a 2,500 ohm match. Terminals 4 and 5 parallel the monitor circuit. Connections to 200 or 500 ohm lines may be successfully made to terminals 2 and 3—but advisable practice (this really goes without saying) would of course be to provide a more accurate line match by means of a suitable transformer, its high impedance primary tied to 1 and 3.

Layout

The four-gang condenser centers along the chassis, with the transformers (r.f.) to the right and the associated tubes to the left of it. The 6H6 is forward in tube line-up, the 6K7 in the first tuned circuit toward the rear and nearest the glass 6F8G. Power components—rectifier, power transformer, and filter condenser are at the back.

The potentiometers for volume and tone control are assembled on the front chassis drop, the one to the left and the other to the right of the tuning dial. The phone jack is on the front panel, which is extended forward from the chassis sufficiently far to provide for ample dial-face clearance.

Wiring and Construction

Matters of assembly are, for the most part, fairly obvious to the reader who has studied the circuit and under-chassis diagrams; and those of wiring are made clear with similar study. However, a few pointers might facilitate exact reproduction and provide for proper tuner performance on "first test," so perhaps we had best present these pointers or suggestions here—with apologies to the more advanced and practiced builder to whom they may seem unnecessary—but with our advice to the general reader that they be borne carefully in mind.

Mount the small parts—sockets, terminal strips, and the like—first. Solder each socket-saddle to the chassis at some convenient point.

Remove the flat strips between mounting bolts on the power transformer (these strips afford a tight press on the laminations), mount the transformer as indicated, then replace the strips below chassis.

Install the grommets for the gang condenser stator or grid leads (lower). Bend the lower stator lugs until they clear the chassis, solder 2½ inch long pieces of green braid covered stranded wire to the upper stator lugs, then install the condenser shield on the tuning unit, bringing the grid leads through the shield openings provided and terminating these leads with grid-cap clips.

Mount the condenser on the chassis, after connecting the lower lugs to the green leads (short direct tied) from associated r.f. transformers.

Remove the plate leads from the r.f. transformers and replace with pieces of braided wire, stripping the braid back an inch or so at each end of the wires. Connect these new leads in circuit properly. See to it that the shield material makes no other than chassis contact, and solder the shield material to chassis at both socket and each of the transformer points.

The chassis serves as one common lead for the filament circuit; connect the No. 2 lug of all but the 5Z4 socket to it. Connect the 6F8G grids together by means of an appropriate length of green-braid covered stranded wire—from the number 1 terminal of this tube's socket up through chassis to the grid cap.

Mount the tuning dial last—fastening it to the chassis by means of a single mounting screw. With the dial pointer set in line with the horizontal markers and with the variable condenser plate at full mesh, tighten the hub-screws on the shaft. Check and re-check for proper wiring continuity.

Alignment and Operation

Close the line input (on the tone control) and check for these voltages (to chassis):

A. Common screen supply bus—75 volts.
B. R.F. plate—240 volts.
C. 6F8G plates—120 volts.

The total "B" drain will measure 27 ma. if the receiver is grounded and all tubes are drawing correct power at these potentials.

Tuned circuit alignment is made at one point—at about 1400 kc. If an accurate adjustment is effected at this one frequency, the tracking will hold true across the band. No bending of outside condenser plates should be necessary.

As we have advised before, the .0001 mfd. mica condensers from plate to ground in the first two 6K7 circuits should not be removed unless maximum sensitivity is required of the tuner, the general tuner adjustment being so made that the sensitivity and gain will be entirely sufficient with the condensers in place.

To operate the unit, connect to your amplifier, matching the two assemblies properly at the screw terminals.
When radio reception was confined to the broadcast band, the aerial did not present much of a problem. Any length of wire from 50 to 150 feet in length and attached to a convenient spotting place—hill, tree or barn would suffice. Now, however, with short wave reception very much in the picture, the call is for all-wave doublet, double-doublet, spiderwebs, and other complicated forms of antennas, all laid out to the most precise specifications. It is much more difficult to find supports just the right height and just the right distance apart, and it is usually necessary to erect a special support for at least one end of the antenna.

Attempts to put up thirty or forty foot wooden or metal masts or towers have often proved to be guilty of failures for the inexperienced, but it is really no trick if you know how. This article will describe a 38-foot mast which is simple to construct, easy to erect, and which is inexpensive—the whole job can be done for about seven dollars, and will literally “last a lifetime.”

This mast is constructed, fundamentally, of two lengths of galvanized iron pipe, one of somewhat smaller diameter than the other, so that it will telescope within the larger section at the joint between the two. A galvanized iron cap and pulley are provided at the top of the mast and a galvanized mounting flange at the bottom—these together with suitable guy wires, are all that are necessary to provide a strong, sturdy and professional-looking antenna support.

A complete list of materials, with approximate costs, follows:

<table>
<thead>
<tr>
<th>Material</th>
<th>Approximate Cost</th>
</tr>
</thead>
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<tr>
<td>Total</td>
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</tr>
<tr>
<td>1 20 foot section 1 1/2 iron pipe</td>
<td>$2.10</td>
</tr>
<tr>
<td>2 12 foot sections 1 1/2 iron pipe</td>
<td>$.50</td>
</tr>
<tr>
<td>2 pipe cap</td>
<td>$1.00</td>
</tr>
<tr>
<td>1 2 1/2 x 4 1/2 x 12 iron pipe</td>
<td>$.10</td>
</tr>
<tr>
<td>12 5/16 x 3/4 machine bolts and nuts</td>
<td>$.10</td>
</tr>
<tr>
<td>1 pulley cap</td>
<td>$.60</td>
</tr>
<tr>
<td>100 feet No. 10 galvanized iron wire</td>
<td>$1.00</td>
</tr>
<tr>
<td>50 feet No. 8 galvanized iron wire</td>
<td>$.50</td>
</tr>
<tr>
<td>200 feet No. 6 galvanized iron wire</td>
<td>$.05</td>
</tr>
<tr>
<td>Total</td>
<td>$7.00</td>
</tr>
</tbody>
</table>

The actual costs of these materials will vary somewhat in different localities, but the prices given are about average, and the actual total cost should not vary by more than half a dollar from the estimated cost as shown. The two sections of pipe, the pipe cap and the flange can all be obtained from any good plumbing shop, the machine bolts, pulley and galvanized iron wire from any hardware store, and the strain insulators from any radio shop. Iron pipe such as this is always referred to by inside diameter, so the two lengths of pipe may be larger than you would expect. The actual outside diameters of those two sections are approximately 2" and 1 5/8" respectively, but the plumber won’t know what you are talking about if you order them this way.

The general appearance of the completed mast is shown by the sketch. Allowing for a two-foot overlap, and with 20-foot sections of pipe, the height of the completed mast will be 38 feet, as shown. Similar masts of lesser height can easily be constructed, of course, by using shorter lengths of pipe—two 16-foot lengths will make a mast 30 feet high, allowing the same overlap, and two 12-foot lengths will make a mast 22 feet high. The constructional details given here can easily be modified if masts of lesser heights are desired.

A 3/8" hole should be drilled through the smaller pipe about two feet from one end, and one of the machine bolts put through it and tightened securely. This bolt prevents the smaller pipe from slipping down within the larger one further than desired, and also provides a convenient spot to attach the lower guy wires, as shown.

Another 3/8" hole should be drilled in the smaller piece about two inches from this end, and the other machine bolt secured in this. This bolt serves as an anchor for the top guy wires, as well as for the wire by which the pulley is attached, and prevents any of them from slipping down. This end of the smaller pipe should be threaded when you buy it, to take the cap as shown. This cap is not absolutely necessary, but it does keep rain and snow out of the upper section, and gives it a finished appearance.

The end of the larger pipe should also be threaded, to take the floor flange, which in turn may be bolted or screwed down to a block of metal or hard wood set into the ground, to give the mast a firm footing.

Masts of this type not more than twenty feet high may be guyed with a single set of guy wires radiating from the top of the mast only, but taller masts should have two sets of guy wires as shown. One set is attached to the top of the mast, and one set at or just above the center. These should be arranged in triangular fashion, as shown. One wire forward, in the same direction as the antenna, and two toward the rear, all equally spaced around the circumference of an imaginary circle. All three are necessary at the middle of the mast, but only the two back guys are needed at the top—the antenna itself will serve as the front guy at this point.

Both top and middle guy wires may be brought down to the same point, which should be a stake or pipe driven into the ground at a distance from the mast of not less than half the total height. This stake or pipe should be two or three feet long, and should be driven into the ground at an angle, to provide the maximum resistance to strain. All guy wires should be made fast to the mast before raising, and after the mast has been raised the lower set should be drawn up to the stakes loosely as first, and then gradually tightening first one and then another until the mast is absolutely vertical and all wires are taut. The two guy wires from the top may then be drawn up, but these cannot be finally adjusted until after the antenna is erected and has put its strain on the mast.

The approximate length of each guy wire can be calculated in advance, by considering it as the hypotenuse of a right triangle, with the mast as one other side and the distance from the foot of the mast to the stake as the third side. Then (height)^2 plus (distance to stake)^2 equals (hypotenuse)^2. In the case of a 38-foot mast, with the stakes twenty feet from the base, this would give

\[ V(38^2) + (20)^2 = V(1444 + 400) = V1844 = 43' \]

as the length of each of the two top guy wires. Add about five feet to this, for easy handling and fastening, and cut it off later. The approximate lengths of the lower guy wires, to the same stakes, would figure out about 28-29 feet each.

For maximum efficiency, particularly if the antenna is to be used for transmitting, strain insulators should be inserted in each guy wire at ten-foot intervals. Such insulators will break up these wires into short, electrically isolated sections of a length that will not absorb energy from the antenna if it is used for transmitting, or cause any “shielding” effects if it is used for receiving.

A metal mast such as this does not need any annual painting or, in fact, any attention at all, once it has been erected in a workmanlike manner. If a good grade of galvanized iron was used, to prevent rust, a mast of this type will give many years of faithful service, with no other attention than an annual inspection to detect cracked insulators or guy wire stakes which may be loosening. And it will be far more satisfactory and pleasing in appearance than any of the usual haywire antenna hung on tree limbs, bent and rotting 2x4 beams or crumbling chimneys, such as are seen so plentifully on every hand.

For those amateurs desiring a vertical radiator the mast will more than fill the bill. It may be used insulated from the ground, or not, depending on the type of feed. 33' is the usual amateur length. This can be made of two pieces 16' in length securely threaded together by means of a reducing joint. A bolted antenna should not be used for transmission because of loss at the bolted stages.
Rapid Breakin' with the VOX System

The VOX System is simplicity itself. While the laboratory model is mounted on a separate chassis, there is no reason why this unit cannot be built into the transmitter.

With the advent of more QRM in the ham bands plus the skip and fading that has been more than usually present these last few months, quick "breakin'" for 'phone or even CW use has become almost a necessity. Many ham installations are so equipped, but then there has always been a mess of switches to throw and the ability of getting at them quickly. In a rapid breakin' QSO the switches "smoked" with their continuous "on-and-off," and the average ham soon got to the point that he did not care to use that type of contact. I became determined to find a way out of the difficulties of throwing switches and evolve—if I could—a system that would permit "lazy-man" operation and yet be fool proof and sure-acting.

The unit employs a 37 tube as an amplifier and isolator, coupled to an 885 gas discharge tube which, in turn, controls the bias on the 37 tube to operate the relay. Approximately 1/2 volt of energy is required across the input terminals. The unit may be coupled with a condenser to one of the speech amplifier tubes.

If 37 tubes are not available, 76's or even 56's may be used without much change in the circuit, excepting that the 76's will require 2.5 volts a.c. for the filaments. I found that the 37 tubes had just the right amount of gain and stability to operate perfectly and hence my choice of them as amplifiers.

The circuit is a simple one and the input may be connected across the 500 ohm output line of the speech amplifier where it goes to the modulators, or else the input may be connected in series with the plates of any one of the speech tubes. Of course, for operation it will be necessary for the speech always to be on with means to remove the power from the modulators and r.f. section of the transmitter. Most hams
prefer to cut the power in the a.c. primary circuit, although it can be done in the B—
side of the power supply. In this latter case it would be well to use a separate relay
to prevent the high voltage, which might be lethal, from being present in the VOX
System housing. I am sure that there must be as many ways of connecting this little
system as there are different types of rigs.

Lay out a bent chassis similar to the one used in the model I built, or a standard
chassis 5" x 10" x 3" may be purchased. In experimentation, it was found advisable to
isolate the power 80 tube and its associated circuits from the rest of the VOX System
in order not to pick up too much hum which itself might throw the transmitter on. This
was done by locating that tube and its power transformer to the extreme right of the
chassis while the other three tubes are located on the left-hand side.

Once the holes are drilled and punched out, the filament leads should be wired in,
being sure to use or make twisted wires so as to have the hum cancel out. After
the filament leads are wired in, the power circuit should be wired in complete. It should
then be tested and if the voltage rises above 300 volts d.c., provision for a bleeder (R14)
and tapping of that bleeder should be ar-

ranged for. The VOX System operates on
exactly 210 v. d.c. under full load, and more
than that will make for unstable operation
of the 585 gaseous discharge tube.

After completing the placement of the
transformers, the audio circuit should be
wired in.

Care should be taken to see that the
respective input and output circuits of the
audio end be kept carefully separated in
order to reduce feedback.

If the circuit has been carefully wired in,
the VOX System is now ready for a test.
Do not connect into the transmitter-receiver
circuit yet. Connect power input to electric
light lines, and replace the relay with a 0-100
ma. meter in series with a 10,000 ohm re-
sistor. Turn on unit. The meter should read
between 20 and 25 ma. with the input to
the first 37 set for the minimum gain or
"ground" setting.

**VISUAL DEVIATION FREQ. METER**

One of the oldest phenomena known
to the radio amateur is the effect,
termed "zero beat." This occurs
when two carriers of identical frequency are
superimposed one on the other. The result-
ing frequency, numerically, will be of zero
audio amplitude and if either of the two fre-
quencies are changed they will produce a
beat note, the frequency of which is the
difference, numerically, between the two car-
riers.

It was this condition of which advantage
was taken and the frequency monitor was
developed so as to have this beat note be-
come visual rather than aural.

To do this an oscillating detector was
built with an amplifier, and in the output
of the amplifier a simple a.c. voltmeter was
placed.

Since this a.c. voltmeter will read any
amplitude of alternating current, and since
a beat note is of that character, little or no
difficulty was experienced in having the
meter register the beat note which was im-
posed upon it. Fortunately for the author,
the average a.c. voltmeter is not linear. By
this it is meant that the higher the audio
(a.c.) frequency, the less the response of
the voltmeter to this frequency as long as the
voltage is varied with the a.c. component.
The curve of the response of the meter rises
to a certain frequency per second in cycles
and then drops off rapidly again to zero.
This may be checked very easily by any
amateur if he will put an audio oscillator
across an a.c. voltmeter and see that, rising
from zero beat to say about five thousand
cycles the meter gradually rises in the indi-
cation of the amount of a.c. voltage. From
1000 cycles to 10,000 cycles it drops off very
rapidly and beyond 10,000 cycles it fails,
or refusas, to register any voltage whatsoever.
The frequency has passed beyond the scope
of a normal 60 cps. meter. It was this addi-
tional phenomenon of which advantage was
taken in building the visual frequency
monitor.

The action of this visual frequency monitor
is as follows: Supposing that the transmitter
is operating on a frequency of 3800 kcs.
The meter was warmed up to operating tem-
perature and set for a frequency of 3800
kcs. This resulted in a zero beat signal or
an a.c. (audio) component in the output of
the audio amplifier of zero volts. Now if the
transmitter frequency were to shift by
one thousand cycles, the 3801 kc. frequency
of the transmitter and the 3800 kc. oscil-
lating frequency of the detector would be
one against the other resulting in a beat
note of 1000 cycles, which, if a pair of phones
were placed in the output of the monitor,
would be distinctly heard as a high pitched
whistle. In addition to this, this 1000 cycle
note has a definite a.c. component and is
registrable in voltage on the meter.

In using this theory in the construction
of the visual monitor it was found in actual
operating that this was not practical. This
was so because on zero beat the meter did
not register anything, and it took a consider-
able "off-frequency" shift to make the meter
show an appreciable amount of increase of
voltage. Or the monitor may be loosely
coupled to any one of the modulated buffer
stages; the higher the frequency the better

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Circuit diagram of the Visual Monitor.
since the transmitter oscillator frequency is multiplied by the buffers. In order to check whether the transmitter frequency has shifted beyond the range of the meter, a phone jack is inserted in the circuit as shown. This, of course, would be more annoying when tuned to receive a signal. Therefore, the monitor frequency is detuned to produce a note of—say—500 cycles, and thereafter this setting and frequency of the monitor is used as a reference point.

Thus it can be seen that the visual monitor does not give the actual frequency during operation but rather shows any deviation whether plus or minus from the fixed frequency transmission. Summing up, then, with the oscillating detector set at 500 cycles off the transmitter, any change in frequency of the transmitters will manifest itself as change in a.c. voltage or audio on the output meter, whether this change be up or down. In other words, the note will become 500 cycles plus or minus whatever the frequency to which the transmitter is set and it is this particular change which is looked for on the meter and which indicates that the transmitter is not operating on its proper frequency.

**Construction**

The metal chassis is 9"×7×2" and is 2" deep. This size is convenient for the amount of parts which are to be mounted, but any handy size may be used, if the various parts are not crowded. It was first intended that a standard full-wave rectifier be used with a power transformer but after making tests on the stability of the detector it was felt that a half-wave rectifier furnishing a lower plate voltage to the tube would greatly add to the stability.

A combination rectifier and output pentode tube is used which receives its filament voltage through a resistor cord the same as is used in the a.c.-d.c. receivers. This tube is wired in series with the combined detector and first audio tube. Filtering of the rectifier output is done with a 200 ohm resistor in series with a 12 ohm coil. The output is metered by a 1500-volt class C meter and a 1000-ohm class A meter. The meter is O-1500 v.a.c. @ 100 ohms per volt resistance.

The controls on the front panel are arranged so that short and direct leads may be made to the tuned circuits. The upper right-hand knob is the trimmer condenser which sets the frequency of the regenerative detector to a point within a few cycles of the incoming signal from the transmitter. The bandwidth of the condenser mounted along the inch of the chassis in order that may be varied to set the limit switch control as well as being readily accessible to tune from the side when the bands are being set.

Directly under the trimmer condenser is the special shorting type switch. This switch is furnished with isolating insulation to further reduce the said over-all efficiency. To the left of the switch control knob is mounted the regeneration control. This condenser controls the amount of feedback in the detector circuit and is used to adjust the regeneration to a maximum indication of the needle on the indicating meter after the trimmer condenser has been properly set.

A phone jack is provided so that the signal appearing in the output may be monitored. By so doing, the operator may instantly tell the approximate change in frequency required to change the reading on the output meter and by becoming familiar with this change he can estimate how many kilocycles the transmitter frequency has shifted, assuming that the detector is operating day and night or at least long enough to have reached a proper operating temperature.

The wiring of the various parts is simplicity itself and the only precaution needed is to keep the wires short and direct. It is important that the temperature in the metal box be kept as constant as possible. It would be even more satisfactory to line the insides of the box with a layer of Celotex or some other form of insulating material. The use of heater-type tubes adds to the operating stability as a change of line voltage does not affect the operating temperature of the tubes as much as would a drop in filament voltage on a filament type tube.

Remember that in order to maintain an even temperature in the monitor cabinet certain requirements must be met. It is not necessary that plate voltage be applied when the monitor is not in service, but the filament should be left on at all times if the rig is used every day.

While the construction of the monitor may be applied to various types of relay racks, etc., it is best that it be built in compact form so as to have it as close to the operating position as possible or at least near enough to be clearly read.

**Adjustment**

When the monitor has been finished and tested it should be allowed to run for an hour or so to reach a fixed temperature. The unit operates in much the same manner as a regenerative receiver. The amateur bands are first located by means of a signal generator on the signal line from the transmitter. In the 50 meter position the trimmer condenser only is used to cover the band. Set the selector switch to the off position which will disconnect the padders and tune the trimmer to a 10 meter signal. Advance the regeneration control to the point where the tube breaks into oscillation.

Tune for a whistle which will give a reading on the output meter and then readjust the trimmer for maximum indication on the meter. Now any variation in the signal will change this beat note or whistle and will likewise change the reading on the output meter. Remove phones.

The above procedure is followed for the other bands and the initial adjustments are made by adding additional capacity to the selector switch and its associated padding condensers. A shorting type switch must be used so that as the switch is rotated, the condensers will add to each other in capacity.

A total of five positions cover the 5-10-20-40-80 meter bands with the capacities shown on the schematic diagram. Each variable condenser has a capacity range of from 10 to 70 mfd. The 40 and 80 meter bands are tuned with a higher capacity than would be reached with the trimmer alone so additional capacity is furnished by the fixed mica condensers as shown. The high C greatly adds to the stability of the monitor.

In actual use with a low power oscillator it was found that a short piece of wire about one foot in length offered sufficient pickup to the monitor even though located some 10 feet away. Do not use this pickup as to do so will block the monitor signal.

The extreme sensitivity of the monitor makes it important that the case be grounded to reduce body-capacity effects. A vernier dial in place of the knob shown will further add to the operating ease and precision adjustment.

In conclusion it is well to repeat that the monitor reads changes in frequency in cycles and is therefore fast reading if this condition takes place. A frequency change of but a fraction of one kilocycle will cause the needle on the output meter to drop to zero if care is taken in properly setting the regeneration and trimmer controls.

The users of this instrument will be amazed at the drift in their transmitters, but it can safely be said that if the monitoring signal stays on the meter in any position above 0 reading, that no change will be recorded at the receiving position. [Grand Island Station is the exception, hi, Ed.] The meter should not be relied on for exact edge-of-the-band transmissions.

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### TABLES

#### CONVERSION TABLE

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<thead>
<tr>
<th>Multiplier</th>
<th>Conversion Factor</th>
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<tbody>
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<td>1,000,000</td>
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</tr>
<tr>
<td>1,000</td>
<td>1 milliampere</td>
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<tr>
<td>.001</td>
<td>1 microcoulomb</td>
</tr>
<tr>
<td>.000,000,000</td>
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#### FRACTIONAL-DEcimal EQUIVALENTS

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RADIO NEWS 1940 RADIO & TELEVISION DATA BOOK
20-W Bandswitch Transmitter

The result is a complete phone and C.W. transmitter, including its a.e. power supply, in a cabinet measuring 19" x 13" x 8½" overall, and capable of operation on any frequency from 1.6 to 60 mc. with crystal control. Frequency change can be accomplished in 30 seconds or less by means of two plug-in coils and a plug-in crystal; and the rated input at all frequencies is 20 watts. The modulator delivers 10 watts of audio power which is capable of modulating the amplifier one hundred percent. The input can be increased to 30 watts if desired with one hundred percent modulation possible at voice frequencies on peaks.

The radio frequency section utilizes a type 6F6G tube as a crystal controlled oscillator, driving a type 807 or RK39 final amplifier. Split stator condensers are used both in the oscillator and final circuits so that the proper L/C ratio is obtained for all frequencies; and the sections of both condensers are automatically switched when the plug-in coils are inserted. A 2 v. 60 ma. pilot light bulb is connected in series with the crystal to act as an indicator of the crystal current and also as a fuse. Proper shielding in the amplifier stage is incorporated for increased stability and eliminates neutralization even at the higher frequencies. The antenna is coupled to the amplifier stage by means of a link or by capacity coupling to the amplifier tank circuit.

The speech amplifier and modulator tube used is as follows: 6J7 input, 6C5 voltage amplifier, 6N7 Class "A" driver, and 6N7 Class "B" modulator. Sufficient gain for any crystal microphone or similar high impedance input is provided; and different load impedances are available at the modulator transformer by tapping the secondary at the number of suitable points.

The power supply uses a type 5Z3 full-wave rectifier and delivers approximately 400 volts D.C. out of the filter, which uses a condenser input. An additional filter section is inserted to the supply power circuit to the three speaker amplifier stages to insure humfree operation; and a tapped voltage divider R 17 is used to obtain the proper voltage for the speech amplifier (300 v. D.C.) and the oscillator screen grid (175 v. D.C.), while the screen voltage of the 807 (or RK39) is supplied through dropping resistor R4.

All controls are mounted on the front panel, including the microphone and keying jacks and a built-in meter switch permits the reading of oscillator, amplifier, and modulator plate currents with a single meter and no plugs or jacks.

The chassis parts layout is as follows, along the panel from left to right: amplifier tank coil, amplifier tank condenser 807 (or RK39), amplifier tube, oscillator tank coil, and oscillator tank condenser.

The ordinary four metal tubes at the right end of the chassis are those of the oscillator and modulator stage. Along the rear of the chassis (foreground in the picture) from left to right: the power transformer 5Z3 rectifier tube, filter power condensers; and the tapped modulation transformer. The crystal is to the left of the oscillator coil, and the pilot crystal fuse is between it and the tube.

The filaments should be wired first, along with the primary circuit of the power transformer and tested right away. Then the plate supply connections can be made and the complete power supply tested. Next comes the R.F. Crystal oscillator circuit followed by the 807 amplifier stage. It now becomes necessary to wind a pair of coils so that the R.F. section can be tested. All the coils consist of a single winding and it should not take long to make up the first pair. All data for number of turns, wire size, base connections, etc., can be found in the coil table. If the data is followed carefully, little or no trouble should be experienced in getting the tank circuits to resonate properly.

A reliable 80 or 40 meter crystal is usually a great help in getting started on the "right foot"; so, with the proper coil plugged in the oscillator plate circuit, the oscillator can be tuned up. The meter switch should be in the "Oscillator" position and the meter should read anywhere from 20 to 40 ma., minimum dip, depending on the frequency, crystal, tube, voltage, etc. When tuning the oscillator for the first time, it is advisable to leave the amplifier coil and tube out of their sockets. If the 807 is left in the socket and the amplifier coil removed, the full voltage is left on the tube's screen. This will short life the amplifier tube considerably and might even cause its complete destruction. After the oscillator is resonated, the amplifier coil and tube can be inserted and also be tuned to resonance. With the meter switch in the "Amplifier" position the current should dip to a value ranging from 3 to 15 ma. at resonance. When loaded the amplifier plate current should be from 50 to 75 ma., depending upon the input desired.

Frequency doubling or quadrupling can be employed in both stages of this transmitter, which makes it possible to cover all bands with 160, 80 and 40 meter crystals.

The value of condenser in the oscillator circuit is fairly critical and can be varied either way to obtain the greatest harmonic output.

The 2 v. 60 ma. pilot light bulb in series with the crystal indicates the crystal current, which should be kept to the lowest value consistent with good output.
FEDERAL COMMUNICATIONS COMMISSION
Washington, D. C.

In a regular meeting of the Federal Communications Commission held at its offices in Washington, D. C., on October 3, 1938.

The Commission having considered a request on the part of the amateur service regarding the term "amateur" service to become effective on December 1, 1938.

IT IS ORDERED, That the following rules, regulations, and orders are hereby amended as of December 1, 1938.

152.50 Additional conditions to be observed by an amateur operator licensees.

152.51 Quiet hours.

152.52 Prohibition of prohibited broadcasts.

152.53 Notice of same violation.

152.54 Operation in emergency.

152.55 Additional conditions to be observed by an amateur operator licensees.

Sec. 152.50 Amateur service. The term "amateur service" means a radio service carried on by "amateur stations" only. It shall be the duty of the Commission to authorize the use of amateur service for the operation of amateur stations only.

Sec. 152.51 Quiet hours. The term "quiet hour" means a time period when the operation of amateur stations is prohibited by the Commission.

Sec. 152.52 Prohibition of prohibited broadcasts. The term "prohibited broadcast" means a broadcast that is prohibited by the Commission.

Sec. 152.53 Notice of same violation. The term "notice of same violation" means a notice that is sent to an amateur operator licensee by the Commission.

Sec. 152.54 Operation in emergency. The term "operation in emergency" means the operation of an amateur station in an emergency.

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152.40 Additional conditions to be observed by an amateur operator licensees.

Sec. 152.50 Amateur service. The term "amateur service" means a radio service carried on by "amateur stations" only. It shall be the duty of the Commission to authorize the use of amateur service for the operation of amateur stations only.

Sec. 152.51 Quiet hours. The term "quiet hour" means a time period when the operation of amateur stations is prohibited by the Commission.

Sec. 152.52 Prohibition of prohibited broadcasts. The term "prohibited broadcast" means a broadcast that is prohibited by the Commission.

Sec. 152.53 Notice of same violation. The term "notice of same violation" means a notice that is sent to an amateur operator licensee by the Commission.

Sec. 152.54 Operation in emergency. The term "operation in emergency" means the operation of an amateur station in an emergency.

Oct. 4, 1938.

Chief, Radio Bureau.
In addition, an amateur station may be kept in reserve by an amateur operator who holds an amateur operator’s license in the United States Government, and the control point thereof when remote control will not be issued to a school, company, corporation, association, or other organization; nor for their use; provided, however, that in the case of a bona fide amateur radio society a station license may be issued in accordance with Section 152.20 to a licensed amateur operator as trustee for such society.

Sec. 152.02. 

Eligibility of corporations or organizations.

No amateur station license will be issued to a school, company, corporation, association, or other organization; nor for their use; provided, however, that in the case of a bona fide amateur radio society a station license may be issued in accordance with Section 152.20 to a licensed amateur operator as trustee for such society.

Sec. 152.03. 

Radio station, and the control point thereof when remote control is authorized, shall not be located on premises controlled by an authorized public radio station, and the control point thereof when remote control is authorized, shall not be located on premises controlled by an authorized public radio station.

Sec. 152.04. 

License period. 

License for an amateur station shall be valid for three years from the date of issuance of a new, renewed, or transferred license.

Sec. 152.05. 

Authorized operation. 

An amateur station license authorizes the operation of all transmitters which are authorized to be used under the license specified in the station license and in addition there shall be included by an amateur operator at any time and at other locations under the same instrument.

Sec. 152.06. 

Renewal of amateur station license. 

An amateur station license may be renewed upon presentation of the duly executed renewal application, the completed months of receipt of the application by the Commission, the payment of the fees specified in the regulations promulgated by the Commission, except that in the case of the holder of an amateur station license issued for an amateur society or radio club, an application for renewal of such amateur station license shall be made by an amateur operator. Failure to comply with the provisions of this section will result in the license not being granted until two months after expiration of the old license.

Sec. 152.07. 

Posting of station license. 

The original of each station license or a facsimile thereof shall be posted in a public place in the room in which the transmitter is located or in a location where it is accessible to the public, except when such license has been filed with the Commission and such copy is furnished to the Commission or the holder of such license on request in writing.

Sec. 152.08. 

Assignment of call letters. 

No amateur station license shall be assigned or transferred except by authority of the Commission, and in such case the assignment or transfer shall be made under the same instrument.

Sec. 152.09. 

No renewal of amateur station license. 

An amateur station license will not be renewed if the holder of such license has failed to comply with the provisions of Sec. 152.07 or Sec. 152.08, as the case may be.

Sec. 152.10. 

Call sign for use of member of U.S.N.R. 

In the case of an amateur license whose station is located in a state regularly commissioned member of the United States Naval Reserve, the Commandant of the naval district in which such station is located shall be notified in his discretion of the use of the call letter prefix W in lieu of the prefix WW in accordance with the regulations of the Commission. The use of such a prefix shall be limited to the holder’s station only and the holder’s family during his absence from the station. It is the responsibility of the holder to provide the holder of the station with all instructions to be issued by the United States Government.

Sec. 152.11. 

Types of call signs.

A call sign shall consist of one or more groups of letters, the first and last of which shall be a letter assigned by the Commission, and each intermediate group of letters shall consist of three or more letters. The call sign shall be used by each holder of an amateur station license issued for an amateur society or radio club, and the holder of such license shall be the only holder permitted to use such call sign.

Sec. 152.12. 

Use of call signs.

An amateur station license shall be used only for the operation of amateur stations, and no other call sign shall be used by the holder of such license.

Sec. 152.13. 

Transmission of call signals.

An operator shall not transmit call signals, identification, or name of radio station, and the control point thereof when remote control is authorized, shall not be located on premises controlled by an authorized public radio station.

Sec. 152.14. 

Points of communication.

An amateur station shall not be used for the transmission of any form of entertainment, or for the transmission of any program of signals or programs emanating from any class of station other than amateur.

Sec. 152.15. 

Radiotelephone tests.

The transmission of radiotelephone tests is permitted only without disturbance to any operator who has not authorized the use of such tests, and only during times when the operator is not required to make any other transmission.

Sec. 152.16. 

Broadcasting prohibited.

An amateur station shall not be used for broadcasting any form of entertainment, or for the transmission of any program of signals or programs emanating from any class of station other than amateur.

Sec. 152.17. 

Radio telephone tests.

The transmission of radiotelephone tests is permitted only without disturbance to any operator who has not authorized the use of such tests, and only during times when the operator is not required to make any other transmission.

Sec. 152.18. 

Frequencies for amateur use.

A band of frequencies shall be assigned for the use of amateur stations, and such bands shall be used only for the purpose of communication.

Sec. 152.19. 

Frequencies for emergency communication.

If the call sign of the station shall be followed by an announcement of the amateur call sign or the type of station calling, the transmission of any program of signals or programs emanating from any class of station other than amateur shall be prohibited.

Sec. 152.20. 

Frequencies for amateur use.

A band of frequencies shall be available for the use of amateur stations, and such bands shall be used only for the purpose of communication.

Sec. 152.21. 

Frequencies for emergency communication.

If the call sign of the station shall be followed by an announcement of the amateur call sign or the type of station calling, the transmission of any program of signals or programs emanating from any class of station other than amateur shall be prohibited.

Sec. 152.22. 

Frequencies for emergency communication.

If the call sign of the station shall be followed by an announcement of the amateur call sign or the type of station calling, the transmission of any program of signals or programs emanating from any class of station other than amateur shall be prohibited.

Sec. 152.23. 

Frequencies for emergency communication.

If the call sign of the station shall be followed by an announcement of the amateur call sign or the type of station calling, the transmission of any program of signals or programs emanating from any class of station other than amateur shall be prohibited.

Sec. 152.24. 

Frequencies for emergency communication.

If the call sign of the station shall be followed by an announcement of the amateur call sign or the type of station calling, the transmission of any program of signals or programs emanating from any class of station other than amateur shall be prohibited.

Sec. 152.25. 

Frequencies for emergency communication.

If the call sign of the station shall be followed by an announcement of the amateur call sign or the type of station calling, the transmission of any program of signals or programs emanating from any class of station other than amateur shall be prohibited.

Sec. 152.26. 

Frequencies for emergency communication.

If the call sign of the station shall be followed by an announcement of the amateur call sign or the type of station calling, the transmission of any program of signals or programs emanating from any class of station other than amateur shall be prohibited.

Sec. 152.27. 

Frequencies for emergency communication.

If the call sign of the station shall be followed by an announcement of the amateur call sign or the type of station calling, the transmission of any program of signals or programs emanating from any class of station other than amateur shall be prohibited.

Sec. 152.28. 

Frequencies for emergency communication.

If the call sign of the station shall be followed by an announcement of the amateur call sign or the type of station calling, the transmission of any program of signals or programs emanating from any class of station other than amateur shall be prohibited.

Sec. 152.29. 

Frequencies for emergency communication.

If the call sign of the station shall be followed by an announcement of the amateur call sign or the type of station calling, the transmission of any program of signals or programs emanating from any class of station other than amateur shall be prohibited.

Sec. 152.30. 

Frequencies for emergency communication.

If the call sign of the station shall be followed by an announcement of the amateur call sign or the type of station calling, the transmission of any program of signals or programs emanating from any class of station other than amateur shall be prohibited.

Sec. 152.31. 

Frequencies for emergency communication.

If the call sign of the station shall be followed by an announcement of the amateur call sign or the type of station calling, the transmission of any program of signals or programs emanating from any class of station other than amateur shall be prohibited.

Sec. 152.32. 

Frequencies for emergency communication.

If the call sign of the station shall be followed by an announcement of the amateur call sign or the type of station calling, the transmission of any program of signals or programs emanating from any class of station other than amateur shall be prohibited.

Sec. 152.33. 

Frequencies for emergency communication.

If the call sign of the station shall be followed by an announcement of the amateur call sign or the type of station calling, the transmission of any program of signals or programs emanating from any class of station other than amateur shall be prohibited.

Sec. 152.34. 

Frequencies for emergency communication.

If the call sign of the station shall be followed by an announcement of the amateur call sign or the type of station calling, the transmission of any program of signals or programs emanating from any class of station other than amateur shall be prohibited.

Sec. 152.35. 

Frequencies for emergency communication.

If the call sign of the station shall be followed by an announcement of the amateur call sign or the type of station calling, the transmission of any program of signals or programs emanating from any class of station other than amateur shall be prohibited.

Sec. 152.36. 

Frequencies for emergency communication.

If the call sign of the station shall be followed by an announcement of the amateur call sign or the type of station calling, the transmission of any program of signals or programs emanating from any class of station other than amateur shall be prohibited.

Sec. 152.37. 

Frequencies for emergency communication.

If the call sign of the station shall be followed by an announcement of the amateur call sign or the type of station calling, the transmission of any program of signals or programs emanating from any class of station other than amateur shall be prohibited.

Sec. 152.38. 

Frequencies for emergency communication.

If the call sign of the station shall be followed by an announcement of the amateur call sign or the type of station calling, the transmission of any program of signals or programs emanating from any class of station other than amateur shall be prohibited.
RADIO NEWS 1940 RADIO & TELEVISION DATA BOOK

**COMMON WORD ABBREVIATIONS**

- **ABT** ahead
- **AHD** ahead
- **AHN** ahead
- **AK** any
- **BK** bad
- **BUG** speed key
- **BN** be
- **BD** before
- **BRI** DIZ because
- **BTW** business
- **CN** can
- **CU** see
- **CW** continuous wave
- **D** distance
- **DH** dead-head
- **DS** distance
- **E** es
- **EB** from
- **F** fr
- **FM** finish
- **G** go ahead
- **GM** good morning
- **GR** get
- **GT** get
- **HR** here
- **H** how
- **I** including
- **ID** independent
- **IC** I see
- **IOM** old man
- **IP** independent
- **IR** inspector
- **IY** in
- **J** join
- **K** key
- **LL** little
- **LST** last
- **LW** listen
- **MD** make
- **MDR** mile
- **MT** million
- **M** make
- **MN** many
- **MIL** military
- **MV** million volt
- **MX** many
- **MY** my
- **ND** nothing doing
- **NE** nothing
- **NL** neutral
- **NM** number
- **NO** nothing
- **NP** no power
- **NR** near
- **NS** nowhere
- **O** old
- **OBS** observed
- **OK** okay
- **OLD** old
- **OM** old man
- **OMG** old man
- **OS** outside
- **OUT** outside
- **PLS** please
- **PST** press
- **PR** press
- **PS** please
- **QP** quite
- **QTH** quiet
- **RSS** radiotelephone
- **SKED** schedule
- **T** talk
- **TH** think
- **TNK** think
- **TP** talk
- **TR** there
- **UL** understand
- **W** will
- **WX** weather
- **X** exchange
- **Y** yes
- **Z** zero

**READABILITY**
1. **UNREADABLE**
2. **BARELY READABLE**
3. **READABLE WITH CONSIDERABLE DIFFICULTY**

**SIGNAL STRENGTH**
1. **FAINT**
2. **BARELY PERCEPTIBLE**
3. **WEAK**

**R-S-T REPORTING SYSTEM**

1. **WEAK SIGNALS**
2. **FAIR SIGNALS**
3. **GOOD SIGNALS**
4. **MODERATELY STRONG SIGNALS**
5. **STRONG SIGNALS**
6. **EXTREMELY STRONG SIGNALS**

**TOKE**
1. **EXTREMELY ROUGH, HISSING NOTE**
2. **VERY ROUGH A.C. NOTE—NO TRACE OF MUSICALITY**
3. **ROUGH, LATCHED A.C. NOTE—SLIGHTLY TONE**
4. **ROUGH A.C. NOTE—MODERATELY TONE**
5. **MUSICALLY MODULATED NOTE**
6. **MODULATED NOTE—SLIGHT TRACE OF WHISTLE**
7. **NEAR D.C. NOTE—SMOOTH RIPPLE**
8. **GOOD D.C. NOTE—JUST TRACE OF RIPPLE**
9. **PUREST D.C. NOTE**
WITH DX bands becoming more crowded, and the hunting of DX a national sport, a well calibrated receiver is almost a necessity. There are many calibrated receivers on the market, but few of them, unfortunately, are accurate. The RCA Piezo-Electric Calibrator is a distinct asset toward calibration.

If you figure its cost in dollars per ounce, or dollars per cubic inch, it comes pretty high! Actually, its cost is about half that of a good all-wave oscillator, and in value per dollar it is, in the estimation of the writer, the best buy in radio test equipment today. It consists of a 955 acorn tube, a special circuit, and a crystal with two frequency nodes. This provides a wealth of harmonics with an accuracy as high as two parts in one million. The instrument is of equal value to the serviceman, the short-wave fan and the amateur.

The crystal’s fundamentals are 100 and 1000 kilocycles. A toggle switch selects either frequency. Operated from 115 volts 60-cycle a. c., raw a. c. is applied to the plate of the 955 providing a 60-cycle modulated output. With the removal of a jumper across two posts and the substitution of 90 volts of “B” battery, a pure d. c. output is obtained. The 1000 kc. harmonics are readily detectable as high as 30 megacycles—the thirtieth harmonic—and the 100 kilocycle harmonic at 15 megacycles—the 150th harmonic! Ordinarily the device is merely placed near the receiver—no input necessary. With closer coupling one can go even higher.

This instrument will fit readily even into a small service kit, and therefore provides the quickest and most simple check on a receiver’s calibration in the home as well as in the shop. Plugged in on any a. c. line, 11 frequency checks are supplied on the standard broadcast band employing the 100 kc. fundamental, plus one check right in the center of the band, at 1000 kc. on the 1000 kc. fundamental.

On the higher frequencies there are many more checks per band—every 100 kc. and every 1000 kc.—up to the limits of the harmonics which are above the range of the average set. Naturally every 1000 kc. harmonic coincides with a corresponding 100 kc. harmonic. For instance, if 9 megacycles, on the high position, the 9th harmonic of the 1000 kc. fundamental will be heard. On flipping the toggle switch to the low position the 90th harmonic of the 100 kc. fundamental will be received—“right on the nose!”

The 1000 kc. steps are used for spotting rather than calibration. It might often be impossible to identify a 100 kc. harmonic. For example, several 100 kc. harmonics will be located close to 9 megacycles, but only that one coinciding with the 9th harmonic of the 1000 kc. fundamental locates 9 mc. It is then possible to count in either direction in 100 kc. steps, and calibrate the receiver or oscillator in a series of 9.1 mc., 9.2 mc., 9.3 mc., etc. Care, however, should be taken to observe and reject image frequencies on the wavelengths below 25 meters.

While the all-wave oscillator is one of the serviceman’s most useful tools, its utility is considerably lessened when it gets out of calibration. Such oscillators are readily calibrated with the aid of the Piezo-Electric Calibrator. The setup is shown in the figure—a Hickok oscillator in the background, an all-wave receiver to the left, and the calibrator in the center. The frequencies to be checked are located on the receiver, and the oscillator tuned to zero beat. Needless to say, the all-wave oscillator should be given ample time to warm up. The same holds for the crystal oscillator—but to a much less degree.

To the serious short-wave experimenter, the crystal calibrator affords accurate calibration of vernier dials, greatly facilitating the identification of stations by their known frequencies. Start counting in 100 kc. steps from a positively identified 1000 kc. harmonic. These steps will be consistent—evenly spaced—and relatively weak signals between these steps are spurious and should be disregarded.

A similar curve on an amateur receiver provides an immediate answer to a request for a frequency check. Explanation of the use of the calibrator will furnish the answer to the inevitable government license examination question, “Explain how you would determine whether the frequency of your transmitter was within the amateur band?”

The quartz crystal and plates should be cleaned frequently. As soon as the harmonic output of the 100 kc. fundamental begins to weaken around 20 meters, or when a tap against the side of the instrument is required to obtain a vigorous response, the crystal holder should be dismantled and the plates and crystal cleaned with carbon tetrachloride or alcohol. Do not disturb the 1000 kc. trimmer. After cleaning do not touch the plates or crystal with the hands. Use a clean soft handkerchief to prevent grease from the skin from filmming the cleaned parts.

The crystal is then replaced and the plates evenly tightened until the crystal will not oscillate. Letting up equally on the three nuts thus loosening the plates until the 100 kc. harmonic on a high frequency coincides with the 1000 kc. harmonic.

Occasionally the oscillator should be checked against a reliable broadcasting station, or better yet, WWV’s standard frequency transmissions. These occur daily at 9000 kc., the 9th harmonic of the “high” top or 90th harmonic of the “low.” Beat the oscillator against the signal. If a zero beat results the instrument is OK, if not determine by heterodyne beat method the amount it is off and mark this up for reference.

A chart should then be made for all frequencies to maintain accuracy.
A HOME-BUILT AUDIO OSCILLATOR

With high fidelity audio amplifiers and audio by-pass filtered circuits becoming more and more commonplace, the laboratory of the advanced amateur and servicer is not complete without an audio oscillator, sometimes termed "Beat Frequency Oscillator." Unfortunately this apparatus is expensive when purchased complete and, therefore, many experimenters and engineers have preferred to work without it.

The working circuit of the Beat Frequency Oscillator is difficult to obtain because it is rarely published and the one herein described resulted from an enthusiastic session with a slide rule and a soldering iron.

It includes a vacuum tube voltmeter brought to its own separate terminal, an innovation which greatly increases the flexibility of making measurements. With a comparatively high output, the unit proved such a good performer that it has busily been going the rounds on loan to other laboratories.

The very use to which a beat frequency oscillator is put, make a vacuum tube voltmeter a necessity. In this unit the meter is brought out to a separate terminal; the customary practice is to bridge it directly to the output terminal within the instrument. Calibrated readings in both the input and output circuits of amplifiers are therefore possible.

A separate voltage divider is provided for the vacuum tube voltmeter. This improves power supply regulation (the current for the meter does not pass through the chokes) and thereby eliminates frequency flutter in the output when the volume control is suddenly turned full on with the meter connected.

The layout is compact. The component parts are so placed that the path of the signal is progressive and long leads are eliminated. The front panel is simple and businesslike. The power supply is grouped in one corner with the power output tube adjacent to it. The most sensitive circuits, those of the oscillators, are placed well away at the other end of the chassis. The variable condenser is mounted on rubber grommets to eliminate microphonic effects which could otherwise become annoying. (Only one section of the standard two section broadcast variable condenser is used.)

The oscillator inductances and the tuned tank are made from ordinary single tuned intermediate frequency (IF) transformers. The rated frequency is not important, but the three should be identical. Mica dielectric trimmers were used in the unit being described, but air trimmed transformers are preferable.

The transformers are carefully removed from their cans and the following changes are made. As soon as each has been reconnected, it should be returned to its can and marked to eliminate the possibility of error in placement.

For the variable oscillator inductance: The trimmer is disconnected. The primary and secondary of the transformer are connected in series so that both windings run continuously in the same direction. The trimmer is connected to one end of the primary and one end of the secondary. Three leads are brought out, two from the trimmer and one from the junction of primary and secondary. When the windings have been replaced in...
the can, a zero adjuster is made from a small right angle bracket, a piece of fiber rod filed to a screwdriver shape on one end, and a knob. This is clearly shown in the illustration.

For the fixed oscillator inductance: The primary and the secondary are connected in series so that both windings run in the same direction. The trimmer is connected to the two open ends left. Three leads are brought out, two from the trimmer and one from the junction.

For the tuned tank: The primary and the secondary are again connected in series and the trimmer is connected across the two outside ends. Only two leads are brought out, however, one from each side of the trimmer.

The front panel is of aluminum and measures seven inches high by fourteen inches wide. The chassis is of plated steel seven inches deep, thirteen inches wide and two and a half inches high.

The output control (marked A in the diagram) is an ordinary 5,000 ohm wound potentiometer. It would be well worth the slight additional expense, however, to substitute an L pad at this point. Such a pad would keep the output impedance of the oscillator constant regardless of the output level. In the described unit, this output impedance changes with each change in tuning.

Degenerative coupling is used in the output for the sake of its response-improving and flattening effect. The 10,000 ohm wire wound potentiometer (marked B in the diagram) serves both as a cathode bias resistor and a means of tuning the half-cycle signal voltage. It should be noted that the 5 mfd. low voltage electrolytic at this point is connected from the cathode to the potentiometer arm and not to the ground.

Both sides of the primary of the power transformer are connected to the chassis through 0.1 mfd. fixed condensers. If a transformer with an electrostatic shield between primary and secondary can be had, so much the better. These precautions will be appreciated when the beat frequency oscillator is used in connection with sensitive receivers or to modulate the output of a signal generator.

The wiring diagram should prove self-explanatory as far as connections go. The RF chokes are the standard broadcast type wound in pi form; the values are not critical. The trimmer marked C is a pad for the variable condenser; it enables the full audio scale to be spread over the entire dial.

Putting this beat frequency oscillator into operation is easy. Turn the unit on, adjust the range, and touch the grids of the oscillators with the prong of a high resistance voltmeter. If they are oscillating properly the grids will show negative.

Next connect a pair of phones or a small loudspeaker to the output terminal and advance the volume control slightly (the knob under the meter). Tune the tank to the fundamental frequency of the fixed oscillator. This can be done in various ways as, for instance, by watching a meter in the plate circuit. The dial is then set to zero and the zero adjuster on the can of the inductance is turned cautiously until zero beat is heard. (Later zero beat adjustments are made much more accurately with the vacuum tube voltmeter.)

The padding trimmer C is then manipulated until the highest audibility frequency comes at the high end of the tuning dial. The coupling trimmers D and E are turned to the positions (usually around their lowest capacities) which will give the purest notes. The degeneration control B is also set at the best point. An oscillograph is a great help at this point in inspecting the waveform, which should be pure.

When everything is running smoothly, a calibration chart of the beat frequency oscillator is prepared. The easiest method, of course, is to compare it to a standard.

**CONSTRUCTING A POLARIZED RELAY**

**THEORY**

There is always considerable use for relays in the equipment of experimenters, especially in photo-electric cell applications. Relays are not hard to build, but the average home-constructed relay is very insensitive to feeble currents of a milliamperes or less.

The relay to be described is very sensitive, the one constructed operating well on currents as low as 10 microamperes. In this experiment, it operated on 50 microamperes, although the reliability was poor for this sensitivity. The current controlling capacity however is quite low, when operating at such low currents, due to the small separation of the contacts, so an auxiliary relay drawing an energizing power of not over 1/4 watt should be used.

Auxiliary relays should always be used when the sensitive relay is operating on currents of a milliamperes or under. Those working on up to two watts are satisfactory. This relay is polarized so as to operate on currents of a certain direction. Single pole, double throw, it can be adjusted to stay closed in one position until direct current flows through the relay, the other being cut off entirely, the output of the audio set when the signal input reaches a certain predetermined minimum value.

With no current flowing in the coils the armature is attracted equally to either pole. If a current is passed through the coil in the direction shown, the polarity of N1 will be strengthened, and the polarity of N2 weakened or even changed to the opposite. This, of course, tends to move the armature toward N1. The action is reversed by changing the direction of the current. The parts needed are very easy to obtain. The magnets can be obtained from an old magneto. The cores of laminated iron of good permeability. The coils are made of audio transformers are used in the two pi section filter and a dual dry electrolytic is used across the taps of the main voltage divider. A millimeter of 0-50 range is incorporated in the circuit. An oscillograph is a great help at this point in inspecting the waveform, which should be pure.


the completed polarized relay. Simple, compact and efficient, it will give excellent service.

The drawing is more or less self-explanatory. The dimensions, of course, have followed exactly, but could be unhappy.
changed to fit the material available. If L shaped laminations of the dimensions shown are not available, the laminated spacers between the two permanent magnets can be varied to obtain the same air gap between the pole pieces.

The armature is held to the pole piece at the bottom by a piece of light spring brass. This acts as a hinge. The laminations of the lower pole piece are cut to form the small recess shown so as to obtain more flexibility in the brass spring and still allow the armature to come close to the pole piece and form a good magnetic connection. A strip of brass with contacts attached is clamped between the laminations of the armature. This should be very stiff and have no appreciable bend as the relay operates. The upper pole pieces are held to the magnets by the U-shaped clamps. The lower one is held by the piece of 1/8" sheet steel cut and bent as shown in the drawing.

The adjustable contacts are shown in Fig. 2. A piece of nonmagnetic angle such as brass or aluminum is used for the double purpose of a mounting for the contact panel, and to hold the pole pieces in their proper position.

The angle is slotted to allow the armature to move from side to side. The screws used to hold the panel and the ground binding post are countersunk in the angle so as not to interfere with the pole pieces. The mountings for the adjustable contacts are made from binding posts, the horizontal holes being tapped out the size of the contact screw. It is advisable to slot these lengthwise for a short distance and bend slightly together to make the contact screw self locking.

A small panel can be fastened to the permanent magnets to provide connections for the coils. It is advisable to use four binding posts so as to provide series or parallel connections for the coils. This will furnish one-half or double the resistance of each coil, as a total resistance.

In use, the armature will be attracted to one pole piece or the other, depending upon which side of center it is released. The contacts, however, hold it in the position desired. The relay will be most sensitive when the armature is nearest a central position.

To adjust as a sensitive simple relay, one contact is screwed to just past center so that the armature when pressed to this contact, with no current flowing in the coils, will just fall back to the other position. Then with the current desired to close the relay, flowing in the coils (in the proper direction), the other contact is moved up until the relay trips.

This last mentioned contact controls the closing sensitivity, and the former contact the release sensitivity.

A VACUUM TUBE VOLTMETER

ALTHOUGH cathode ray oscillographs, signal generators, b.f. oscillators, and a.c. and d.c. meters of every description, make, range, and style abound in the modern experimenter's shack and the up-and-coming service shop, one instrument which is not found in many labs as often as its usefulness warrants is the vacuum tube voltmeter. High cost, low sensitivity and complicated, battery operated designs have been some of the reasons. Eliminating many former defects this v.t. voltmeter is completely a.c. operated, of reasonable high sensitivity and accuracy, and at the same time stable and rugged in operation. The 2-5 so called because of its two stage circuit and five self contained ranges in either circuit employs two type 53 tubes in bridge circuits, one as the voltmeter, the other as a direct coupled d.c. amplifier. By this means, the sensitivity has been boosted to less than 1/2 volt. Throwing a single switch and readjusting the milliammeter to zero, takes the amplifier out of the circuit and connects one section of the 53 as a conventional plate circuit v.t. voltmeter, giving less sensitivity and higher accuracy on high frequency measurements.

Construction of the 2-5 is quite simple.

A few points concerning the input circuit will be explained. The parts specified are not critical and good components of the same values can be substituted. Wire wound resistors and paper condensers must be used where specified. The sub-panel brackets were revamped from one standard 3/4" by 6" aluminum bracket by cutting it in two lengthwise and filing the two halves where required. The angle bracket for the four plate resistors and the bias resistor was bent up from a piece of scrap metal.

The socket for the voltmeter tube is mounted directly on the range switch in order to obtain the shortest possible leads. This keeps down stray input capacities. The wafer socket is easily mounted by removing the two screws which hold the switch contact plate to the indexing plate. Two 1" bolts, of the same size, with two nuts on each will mount the socket and also hold the switch plate solidly in place. Mount the socket as close to the switch plate as possible without shorting the contacts. It may be necessary to file the holes in the socket ear slightly oblong, as their center distance is slightly different from that of the switch plate.

Mount resistors, switch contacts. Note that metallized resistors were used in the
The mounting of component parts.

The circuit of the 2-5 Vacuum Tube Voltmeter.

Under chassis view, showing resistor bank.

All connections should first be carefully checked with an ohmmeter. Do this with the amplifier switch on both the off and on positions to make sure that the switch has been properly connected. Tap T4 should be set at about the center of the bleeder, its actual position not being very critical. Place t2 near the high voltage end of the resistor, temporarily. The connection between t2 and the cathode of the voltmeter tube must be broken at some point and the milliammeter connected in series so as to measure the total cathode current of the voltmeter tube. Now, with the amplifier

original 2-5. Substitution of precision, wire wound resistors is a worth while investment, since the accuracy of the instrument will be much greater. Also, a calibration made on any range will then hold for all the other ranges. However, it is now possible to obtain metalized resistors on special order in high accuracy units, around 2%. If either of the above methods cannot be used, it is possible to use the standard commercial metalized units, and either select them from a large number so that values sufficiently close to the correct ones can be found, or else to make a separate calibration curve for each range. For service work, the commercial units will probably be sufficiently accurate without selection or separate curves.

After mounting the range resistors, wire the socket to the switch, connecting the switch arm to the grid terminal nearest it. The socket should be mounted so that the filament terminals are at the bottom. Plate cathode and filament leads about 10" long should be soldered to the socket with two shorter leads for connecting the input terminals to the switch unit. Now mount the entire socket unit on the panel and proceed to wire according to the diagram. The filament center tap for the 53's must not be grounded unless a transformer with separate filament windings for each tube is used. In this case the center taps should be connected to their respective cathodes. Mount the milliammeter last, and leave the leads temporarily disconnected. If a separate 1000 ohm per volt meter is not available for the final adjustment of the v.t. voltmeter, it will be necessary to connect the milliammeter of the 2-5 in series with one watt metalized resistors to make a temporary voltmeter.

The circuit adjustments are made by changing the positions of taps on R1, R2 and R6. These adjustments are important and must be carried out carefully if the meter is to operate at its best and give the sensitivity of which it is capable.

The power supply of the 2-5.

R1—200,000 ohms, ½ w. metalised
R2—100,000 ohms, ½ w. metalised
R3—100,000 ohms, ½ w. metalised
R4—100,000 ohms, ½ w. metalised
Rs—600,000 ohms, ½ w. metalised

For DC calibration, substitute a 2-6 volt battery for the transformer and use a DC meter. Connect + side of meter to center terminal of the 2-5, and the — to bottom terminal. Calibration made as above will be accurate on any frequency, including RF.

For AC calibration, substitute a 2-6 volt battery for the transformer and use an AC meter. Connect + side of meter to center terminal of the 2-5, and the — to bottom terminal. Calibration made as above will be accurate on any frequency, including RF.

Switch—Single gang, shorting type selector switch. Single circuit, six pole, Yaxley 1216L.
Sw2—SPST toggle switch.
Sw3—Six pole, double throw switch Yaxley No. 1263, non shorting type. Set adjustable stop for two position operation.
R1—1,000 ohms, 10 w. adjustable wire wound, Electro Travel.
R2—90,000 ohm wire wound, 20 w.
R3—100,000 ohm wire wound, 20 w.
R4—10,000 ohms. Yaxley universal wire wound volume control. Linear taper.
R5—10,000 ohms, 10 w. wire wound
R6—10,000 ohms, 10 w. wire wound
R16—2 megohms, ½ w. metalised
R20—1 megohm, ½ w. metalised
R21—2 megohms, ½ w. metalised
R22—2 megohms, ½ w. metalised
R23—1 megohm, ½ w. metalised
R24—600,000 ohms, ½ w. metalised

SW1

AC 110V

C1, C2

TO*

X

DD NOT GND

X

The circuit of the 2-5 Vacuum Tube Voltmeter.
switch on off and the amplifier tube out of its socket, short the input circuit (range switch on 0), apply the power and allow ten or fifteen minutes for the voltmeter tube to become thoroughly heated.

Next, carefully adjust the cathode tap, t2, until the milliammeter reads 55 ma. total cathode current. Slightly higher values will give a better accuracy, but less sensitivity. Higher values only cut down the sensitivity. Replace the milliammeter in its regular position, apply an ac input to the meter and check the voltage necessary for full scale. This should be about 4 volts on range 1. The meter is adjusted to zero before applying the input by turning R5. If the zero adjustment of R5 is too critical for easy operation, connect a 1000 ohm, wire wound resistor in series with one of the leads going from the single cell flashlight battery. Attempting to use a tap on the bleeder resistor to supply the bucking-out current for zero adjustment, in place of the battery, will result in greatly decreased accuracy and sensitivity. The life of the battery is practically its shelf life.

Next step is adjustment of the voltmeter with the amplifier in the circuit. Disconnect the milliammeter. Turn the amplifier switch off, the range switch on 0, and plug in the amplifier tube. Connect the ammeter with a range of 0-2 ma. or higher in series with the cathode lead of the voltmeter tube (the lead going to t1, with the amplifier on). The milliammeter E or the V may be used by connecting a temporary shunt directly across its terminals. Set tap t3 as close to t4 as possible, t1 about in the center of R1. Allow tubes to become thoroughly heated. Now adjust t1 until the cathode meter reads 0.5 ma. total current for the voltmeter tube.

A 1000 ohm per volt meter with a range of 270 volts should then be placed across R4. The reading should be about 45-50 volts. Connect a voltmeter with a range of 100 volts across R7. Then carefully adjust the cathode tap, t3, of the amplifier tube until the meter reads 25 volts. This adjustment is very critical and varies as R5 is turned. Set R3 at about the center of its range whole making the adjustment. Then adjust the end clip on R6 until the milliammeter in its regular position reads zero. This adjustment will also vary with the position of R5, which should again be in about the center of its range.

Tighten all taps thoroughly so that pulling them slightly in any direction will not change the meter reading. This is important, since a loose clip will ruin the calibration curve. The sensitivity with the amplifier on may now be checked by applying an ac input. Full scale should be reached at 1/2 volt or less. With the amplifier off, if the milliammeter reads backward with a.c. input, reverse the meter connections. Then, if the knob of R5 turns in the opposite direction to the meter needle, change the wire leading to the outside terminal of R5 to the outside lug on the other end of the potentiometer winding. Now, if the meter reads backwards with the amplifier on, reverse the leads going to the grids of the amplifier tube. When adjusting R6 for a zero meter reading with the amplifier on if sufficient resistance cannot be obtained, reverse the two plate leads from the amplifier tube to the plate resistors.

The meter is calibrated by using an a.c. voltmeter and the filament winding of a power transformer to supply the input voltage, according to the diagram.
RECENT developments in the broadcasting art, such as the new single tower vertical aerials and automatic volume control devices installed in the audio system of the transmitter have so increased the efficiency of many stations that they have an effective range of from two to four times that previously obtained. This results in much stronger signals in the vicinity of the stations and relatively less interference from two to four times.

Recent trends in receiver design must be given their full share of responsibility for the serviceman's woes. It is the purpose of this article to help the serviceman solve some of the problems caused by the above changes.

Cross Modulation

Although the term "cross modulation" is by definition "a type of intermodulation due to the modulation of the carrier of the desired signal in a radio apparatus by an undesired signal," it has come to be necessary to divide the trouble into two distinct types to be known as "External Cross Modulation" and "Internal Cross Modulation." The internal type will be discussed first.

Internal cross modulation then, will be assumed, is due to something about the design of the set, the way it is connected to its aerial and ground system, the location it is being used in or perhaps the present condition of the tubes or adjustments of the set. Likewise, external modulation is due to external causes, such as defects of the aerial and ground system or of the wiring and piping in or near the location of the radio.

Of course, both types of cross may be present at the same time along with several other troubles.

A—Internal Cross Modulation and Distortion

When there is internal cross modulation, usually there is distortion along with it, although it is possible to have either without the other; however, inasmuch as the cure for one is frequently the cure for the other, it will be assumed that the troubles are interchangeable.

The cause of this trouble is always the overload of some tube to such an extent that signal present from the interfering station is large enough to cancel out the bias on this tube, thus causing the tube to act as a detector.

The causes of this overload may be:

1. Lack of preselection (two gang condensers). There are probably some sets having three gang tuning condensers in which this is still the real cause of the trouble, especially when shielding and design are bad.

2. Lack of a good ground. For years engineers have stressed the value of a good ground connection, but the lack of one is still a major cause of poor operation of modern radios. Why does a good ground help? Simply because radios are usually built with the idea of having the aerial wire pick up the desired signals rather than the power line; and, unless a ground is connected, the power line may be putting more signal energy into the radio than the aerial, and the line may be introducing the signal directly to the first detector while signals from the aerial must travel through the tuned circuits of the detector and r.f. stages, if any.

3. Several cases of cross modulation recently occurred in which the trouble was due to a very short aerial (10 ft.). Even though a ground was being used, apparently more energy was still being introduced by the power line than by the aerial, because increasing the aerial length immediately cured it.

4. Lack of line filter. Next in importance as a cause of overload and distortion is the case of the power line acting as an aerial. The presence of a good aerial and ground does not help much unless the power line is further prevented from acting as an aerial. Seemingly miraculous is the cure of some old and some new sets when 0.1 mfd. condensers are connected from the line to ground. This also helps to control volume on local stations.
make a simple continuity test of the transmission line. If open, there is no transformer at the top. There is at least one exception to this in the case of a popular all-wave aerial shipped with each set from the factory. Small mica condensers were placed in series with the line just inside the transformer housing.

If the set is overloaded due to excessive aerial, it is either due to too much top or the combination of top and lead-in being too much, matters not. If you cannot sell the customer a modern noise reducing aerial, there is an easier and better way to cure the trouble than by going up on the roof and cutting off the aerial. In the first place, you cannot be sure just how much aerial to cut off, and no aerial is ever too long. The reason for this is that long aerials always give better reception on distant stations both in signal strength and noise ratio.

A. But to get back to curing the overload.

The easiest way to reduce signal strength is simply to connect a small mica condenser in series with the lead-in at the aerial terminals. If an L aerial, only one is needed; if a twisted pair lead in, two of equal size are required. The size will depend on the amount of signal reduction needed to cure the cross talk. Usually the size will vary between 50 and 100 mmfd.; but less than 50 mmfd. will almost always cause excessive hiss on distant stations. Check this with a weak station at the low frequency end of the dial. The exact size can be quickly determined without making several trips to the roof; and there is no loss of the noise reducing effect of the long aerial.

A word about local-distance switches. What serviceman has not made fool trips to someone's home to find the antenna switch open? Secondly, any radio is subject to any one of a dozen troubles if operated without an aerial even if it be only on local stations. To enumerate only a few of them, they are: fading or sudden change in volume when light switches are thrown, noise, hum on carrier, and cross talk.

B. Next comes the old faithful wave trap. If one station is the cause of all the trouble, the very best solution is a wave trap, as this affects only the interfering station. However, with modern types of aerials involving transmission lines, the problem becomes very complicated. In some cases, two traps may be necessary, one in each side of the line. There are a great many types of wave traps appearing on the market, but usually only one will do the job. The problem is to know which type to use. Two basic types are available; one in series, the other parallel tuned. This difference is very important.

Type A is a new article commercially and works by allowing only the undesired signal to pass through it, rejecting all others. It must, therefore, be connected in parallel with either the antenna coil, if an L aerial, or in the transmission line of most modern types. As such, it is very effective provided the transmission line is acting as a true line. If not a true line, the effect will be nil and the only solution is a type B trap in each wire of the so-called line. Type B is an old friend that you have used for years; its action is one of absorption. The undesired signal is absorbed within the tuned circuit and the trap must, therefore, be connected in series with the circuit for best results. This is ideal for L type aerials and may be used with some success, if connected as shown in Fig. 2, on transmission line couples.

C. There is another gadget available which does a good job of removing cross talk, at the expense of the weaker stations, however. It frequently reduces their level down to noticeable hiss. It is a cross talk eliminator, whose action is that of a selective shunt, and it is merely a small r.f. choke of low resistance which is connected across the transmission line. Its impedance is sufficient to prevent short wave signals from being by-passed.

D. It is obvious that there is very little hope of removing cross talk unless all coils, tubes and long grid leads are shielded.

E. Much cross talk and distortion would not occur if there were sufficient automatic volume control action to properly bias the tubes. This whole problem is a very complicated one of the vicious circle type; for as soon as the r.f. voltage is available and the gain decreases, the available voltage also decreases with which to cut down the gain. The real problem arises from the fact that it is a characteristic of most automatic volume control systems to work inefficiently on strong signals. The problem is to increase and conserve all the available voltage. Increasing the voltage is best done by making sure the alignment of all trimmers is absolutely perfect. Frequently the distortion and cross talk disappear at the same time. In rare cases the trouble is too much AVC voltage, although this usually is only indirectly the cause of the trouble. Sometimes placing new tubes in a set or balancing up the set will cause distortion to appear that previously was not present. This would seem to indicate too good a job had been done, and the temptation is to throw the set slightly out of balance again or perhaps put back one of the old, weak tubes. The real trouble is the outdated design of the set or else some trouble we have missed. Suggestion: Check all the bypass condensers in the AVC feed line. Replace all those that show any leakage whatever. Leakages of 10 or 20 megohms will cause trouble. Make sure none of the tubes have any cathode leakage. This applies especially to the tubes used in early AVC circuits. Occasionally, the tubes being controlled by AVC voltages develop defects which cause them to draw grid current. Most tube testers are incapable of detecting this defect. When in doubt, try new tubes.

It may be helpful in some modern sets to separate the detection and AVC actions. This is easily possible if a duplex-diode triode is used. The reason for the improvement is that for detection purposes one cannot make the detector load resistor more than .5 megohms; 35 megohms, or even 1 megohm, would give better audio quality, but if the same resistor is used to develop AVC voltage, obviously more could be developed across a larger resistor. The change is illustrated in the circuit below:

F. So much for the newer sets. There are many older sets that can be much improved by some modernization. If the changes are made at the same time as repairs, the cost will be very little more than the repairs alone, and the result will be a job that you will get paid for. The customer seldom questions a bill if the set performs better than ever; whereas, if merely routine repairs are made, the general pepping up of the set often results in distortion or lack of control of volume on locals which the customer says he did not have before. So, rightly or not, he questions your bill and probably refuses to pay at all. The solution is simple. Sometimes, this means a change in the volume control circuit. Most likely the set needs a new volume control anyway, so change it over to an antenna-bias circuit and you will have a much better performing set. Again the trouble may be only the volume control circuit. Much improvement will frequently be had if the control circuit is merely changed a bit. The '24 tubes and old control, if not noisy, may be left right in. Such a circuit change is shown on the next page (Figs. 5 and 6). Only a few connections have to be changed.
The value must be determined by experiment. Site is correct when you can cut down the locals to zero volume and just a little to spare. Resistance will vary between a few thousand ohms and 3/4 megohm.

Cross modulation, if that term control happens to be a dual. The only change desirable would be to shield the antenna lead from the volume control to the primary coil.

**External Cross Modulations**

For some years, servicemen have noted certain peculiarities caused by distortion or cross modulation on local stations cleared up when lead in strips were wiggled. The answer is what some servicemen have long suspected. In the presence of strong signals from locals, poor contact between portions of the aerial and ground or of other metal objects such as pipe, BX or house wiring acts as a rectifier or detector of the strong radio signals flowing in them. Unfortunately, detector action is such that if signals from two or more strong stations are present, their combined carriers and modulation are re Radiated into the air on frequencies other than those desired. This is similar to the action of the first detector of any superheterodyne. Thus, we will be able to tune in these composite locals in numerous places on the dial. If we assign frequencies to imaginary Stations A and B, we should be able to hear them as shown in addition to their regular frequencies:

- A = 600 kc. 2A+B=1900 kc.
- B = 700 kc. 2A = 500 kc.
- A= 100 kc. 2B=A=800 kc.
- 2A=1200 kc. A=1800 kc.

If this is the result of a "cross" between only two locals, think of the confusion if three or four strong carriers are present.

Such a cross may occur in any conductor. It is only necessary to have two alternating currents present such as 60 cycle a.c. on one wire and 60 cycle hum modulation on the carrier of your locals—one or more. This type of hum-on-carrier does not respond to the usual cures because it enters the set through the aerial as a regular carrier. Distant stations are, of course, O.K. with you in this with a similar hum due to lack of line bypass condenser.

As to cures—that old nemesis of the radio man, the lead-in strip, is the most frequent cause of trouble. As we all know, copper oxides make fine rectifiers; and wherever we have copper exposed to the weather, this oxide develops and sooner or later starts its dirty work. The best way is to remove the strip altogether and bring a new lead wire direct from the antenna to the set.

Poor ground clamps, loose connections, or bad earth connections may be the cause of hum-on-carrier and cross talk. Leakage between the terminals of the lightning arrester has been a frequent cause of cross modulation and hum-on-carrier too, if the set and arrester grounds are of the same wire.

One of the most annoying cases of cross talk observed is that caused by a break in one or both wires of the transmission line. This usually occurs under the insulation and cannot be seen. Worst of all, one popular type of all-wave aerial, as previously mentioned, has a wire which normally shows open circuit. Although a screw eye is usually not furnished with all-wave aerial kits, it is absolutely essential that one be used for the first place of attachment or trouble will always result. Impossible as it is to understand, one may throw the lead-in from the offending aerial onto the window glass and then, using another aerial, the noise will be just as bad as with the defective one.

If the trouble is not due to the aerial in use, it has definitely been proven that adjacent aerials will produce the same result; in fact, it is the offending servant man who goes to the roof to inspect his customer's aerial to also inspect all other aerials on that roof, eliminating all shots between them or possibly cases of loose connection. Quite an undertaking, but absolutely necessary if you wish to be successful.

Intermittent connections between metal objects of any sort, especially pipes and electrical conduit in cellars or walls of the building or even adjacent buildings, are frequently the cause of noise or cross modulation. The cure may be effected by either separating the objects by an insulator or by connecting them together.

If, as occasionally happens, the cause cannot be located or is inaccessible, the installation of one of the best types of shielded lead-in aerial systems will materially reduce this trouble. Transmission line types of aerials will be needed if the line acts as a true line and better if the set coupler has an electrostatic shield.

**C-Monkey Chatter**

With the advent of superpower stations operating on adjacent channels (the classic example is WOR, Newark, and WLW, Cincinnati), another form of cross modulation has become a parent. Many have heard the unintelligible jibber-jabber in the background when tuned to one of these stations. This trouble can occur on any two stations operating on adjacent channels provided they are fairly strong and their carriers are not greatly different in strength. For lack of a better name, the effect has been called "monkey chatter." The trouble is commonly thought to be due to lack of selectivity in the set, but actually this is only partly true because, theoretically at least, the effect would be impossible if stations stopped all audio modulation above 5000 cycles, and the audio system of all receivers cut off abruptly at the same place.

This is not being done, nor is it likely to be done in the future; the tendency is to let the higher frequencies modulate the transmitter and builder and receivers that reproduce these high frequencies. There are a few sets that have a trap in the speaker that limits reproduction to those frequencies below 5000 cycles, but this does not eliminate monkey chatter from stations. The reason for this is: The overall selectivity of most sets is sufficient to adequately separate the carriers of the adjacent stations. Most of this selectivity is in the 1. A. amplifier, but the selectivity of the preselection circuits is inadequate to prevent both signals from arriving at the first detector.

The result is that the sidebands of the interfering station heterodyne with the carrier of the desired station and said detector does a fine job of extracting the beats. This beat varies with the modulation of the interfering station, but is not understandable because it is an inversion of the original. For example, suppose a station on 700 kc. is modulated with a constant pitch of 6000 cycles. This will produce sidebands or virtual carrier frequencies of 706,000 cycles and 694,000 cycles. If there is another station situated approximately 1/4 mile on 710 kc., that we wish to receive, we shall hear an interfering tone on the desired station of 4000 cycles. Whereas, if the modulation of the interfering station had been 4000 cycles, the tone on the desired station will be 6000 cycles. Obviously, in the first case, limiting the peak modulation frequencies to 5000 cycles would produce a 5000 cycle or higher beat on the desired station, and if the receiver audio system cut off abruptly at 5000 cycles, no interfering signal would be heard.

But if the peak modulation of the transmitter is not limited to 5000 cycles, beats of less than 5000 cycles will be produced on the desired station and will be heard in the receiver. There is no solution to this problem but to limit transmitter modulation to 5000 cycles so long as channels are only 10,000 cycles apart. The table below:

<table>
<thead>
<tr>
<th>Carrier</th>
<th>Interfering Station</th>
</tr>
</thead>
<tbody>
<tr>
<td>710 kc.</td>
<td>710 kc.</td>
</tr>
<tr>
<td>7100 cycles (1710 kc.)</td>
<td>7000 cycles (700 kc.)</td>
</tr>
</tbody>
</table>

**Modulation Carriers**

- 7100 cycle Modulation
- 4000 cycle Modulation
- 6000 cycle Modulation

It is apparent that 4000 cycle modulation on 710 kc. produces a sideband which is identical with a 6000 cycle sideband on 700 kc.

There is no cure for monkey chatter except as outlined. A high frequency tone control or trap in detector or speaker circuit will reduce it somewhat, as will additional tuned circuits ahead of the first detector, but no permanent cure can be effected as long as the broadcasting stations modulate above 5000 cycles with only 12 kc. separating their carriers. May there somehow be 20 or at least 15 kc. channels soon.

**Test Leads for the Experimenter**

Split two 6-inch penny wires in half, the long ends, and remove the lead. Cut out the groove a little as shown in the drawing. This groove prevents the wire from pulling loose. Dig down in the old box and get some number 12, hard copper wire. Cut two 3/4-inch lengths, sharpen points on one end, and solder four feet of flexible wire to the flattened ends. Place into the pencil as shown, and cement it together. Fix carton phone tips or spade tips to the end of the flexible wire and you have a good pair of test leads.

**For Better Reception**

There are many sections of the country where the soil contains very little moisture with the result that the ground circuit for a radio set is not very good. It can be greatly improved by making up a salt and water solution and using this to saturate the earth around the ground pipe. One part salt to three parts of water will do the trick.
How to Advertise Your SERVICE SHOP

Dealer's Choice

The pluggers I described have not revolutionized our business, nor have they led us to the end of the rainbow. They have, however, helped appreciably in forming a background of much-needed customer contact. Some of the card-calls are slow in getting to the shop, but they're worth waiting for. Get enough cards out, and it's just like money in a trust fund—you'll get it, providing you don't change your address too often.

We have, during the past three years, distributed 90,000 cards. That's a lot of cards, but they have been looked upon only as an adjunct activity to service work; we are considering advertising expenses. The data we have collected as we gave out the cards should be of interest to others in the same profession. Perhaps, with modifications befitting your location, budget, and customers, you can evolve a card that is best for your business.

Specifications are as follows:

Size: 1 3/4 x 4 inches. The width was decided upon because it is the greatest which permits entrance into mailbox slots. (If your postmaster objects, slip 'em under doors. You know your postmaster better than I do; if you don't, you had better.) The length forms a good proportion with the width when lines run across the shorter dimension.

Stock: White, weight that of a good calling-card; heavy enough so the prospect's instinct prompts him to leave it flat instead of folding it. A good stock helps to distinguish your advertising from that of the local fish market.

Type: 6 or 7-point, light-face, Vogue. Allow 90 or 100 words of copy without squeezing. Only one line should be in heavy face; the words in the heavy line need not be pertinent to your business. Simply make them conspicuous without disclosing the gist of the card to the person who gives it a quick glance.

A person who comes across the card is more likely to drop it if he can understand it immediately. If one line piques his curiosity, and if the remaining text is too small to read at the time, chances are about 4 out of 5 he will pocket it. Hence the small type.

Of course, what you wish, but not too simple and innocuous. Business name, address, and phone number are the essentials. Change the wording every month or so—helps you later, when you become curious concerning the most effective means of distribution, and wish to co-ordinate results with time of year or format.

In our organization, the repairmen pass out the cards; they carry them at all times, afoot or awheel. They are left in mailboxes; in cigar stores; in back of, and on top of, consoles; with persons we know and heaven forgive them—even in beer gardens. When business is slack, they are distributed systematically during spare-time intervals; during our occasional rushes, of course, they attend to pick-ups, repairs, and deliveries.

Here is some incidental information which might provide you with a short cut or two:

- In apartment house mailboxes, 70% of the cards are wasted—thrown on the lobby floor immediately; the remaining 30% are pocketed. (Seems wasteful, but the average for other business cards is even higher than 7 in 10. They would pay, I believe, if 9 in 10 were thrown away.)
- Two distinct responses follow their distribution. First, the immediate one, following a coincidental card and set failure; the customer calls the number on the card because he is too lazy to open a phone book. There is an average of one call per thousand cards that comes in immediately.

Ours is a radio repair shop fitted exclusively for maintenance. No frills—

**NO DRAFIERIES**

—everything in the shop is there for the single purpose of conditioning all radios quickly, properly, and at moderate cost.

Often it is some minor fault which keeps a set from playing—in that case, a repair is made immediately, in your home.

If a major repair is necessary, we have the largest stock of tubes and replacement parts in the county.

call Lincoln 4321
Open until 10 p.m.
SMITH RADIO
1234 N. 56 St.
Bellwood

customer in this class is like the man who gets a wife by writing to a matrimonial agency—any matrimonial agency. He is good picking, though, for, despite his conviction that all service men are alike he resigns himself to set breakdown as a trick of fate, and rarely questions price. His money is paid in the spirit of a man giving out alimony or taxes; he is reconciled to the fact there is no appeal. He seldom, because of this cynical attitude, becomes a staunch supporter of your shop.

The delayed response is more difficult to check. Some customers dislike being asked how they learned of you, or why they called your particular store. There will be, over long periods, enough calls from sections which have been carded to assure you it is worth while, whether or not you manage to trace the media. Getting the work is the important thing. How to the repair job—let the quantitative data fall where they may!

There is often a considerable period between a customer's receipt of a card and his 'phone call. Naturally a man's radio does not blow up just because he put your name on file. We are getting calls from persons who got some of our first copy; and some of those set owners have not had a repairman in the house for three or four years. These tardy customers are among our best; their lives are well-settled, they usually own their homes, and their receivers, although older, are higher-priced than those of the semi-transient kitchenettes.

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What's the Line Voltage?

More Power to You

H

AS the line voltage in your area been changed? If it hasn't, it will be; there is a general trend under way from 115 to 120 volts. The New York area has been using 120 for some time; Chicago finished the first step of its 5%/10% boost last December. Nearly half of the country is yet to be moved upward. While I, as a repairman, do not hope for an increased number of set failures as a result, I am keeping myself apprized concerning conditions in my territory, and am standing by to handle any work which might be necessary.

The method of change varies little between palaces. In order to get a true picture of the voltages at various points in, say, an area of ten square miles, a recording voltmeter would have to be run continuously in perhaps ten or more locations for long enough in each location to get an average typical curve. This would be a burden on the instrument. The instrument would have to be accurate, and have little operating inertia to record sharp rises or drops. When the observations were completed, the results would not have justified the bother and expense.

The top daily voltages encountered are the important ones for the repairman to know. First, call your local power company, and ask what the line voltage is supposed to be. (If you think this is a waste of time, ask any five servicemen, in an area which has been raised, what line voltages he comes across during a routine day. Few know for sure. In my case, the rise had been made two months before I learned of it. So check on it—a new level may have sneaked in without your knowing it.)

After you know your rated voltage, make checks in customer's homes for comparison with the voltage of its own house. This can be done with little or no bother during your usual daily travel, and a few weeks' systematic data will soon show you if any of your service sections are lower or higher than those in your shop.

Watch out especially for sections which are higher than the reading in your store location. Most of us have had the embarrassing experience of making a replacement, testing in the shop, and delivering the chassis, only to have the set fail as soon as it was installed. The cause can usually be traced to the presence of a lower voltage on the repair bench outlet.

If you are in a 5%/4% area that has been changed, remember that the 115-volt equipment, when being operated on 120 volts, can be subjected to an allowable maximum of 126. This is equivalent to a 15% overload, and, although it be the operating policy of your power company to keep well within the 9% margin of 120 volts, you should know how wide this margin actually is. The minimum 4% below 120 volts is at 115—exactly the rating of the old equipment. In other words, no matter what range the power company allows, it is always above the rating of a 115-volt set.

This is a condition worthy of note, especially when repairing a cheap receiver. Some repairmen, because of the carelessness in choice or assembly of parts, contain power transformers which, even at the 115-volt level, operate at a temperature just below the point of conflagration.

In the better sets, where power transformers have a more generous tolerance, failures might occur in the remaining apparatus on account of increased voltages from the secondary windings. One distributor, handling a very good line, reports that, while there has been no increase in the number of power transformer replacements following the use of 120 volts, there has been an increase in the number of filter condenser replacements. Another large sales-service company, after replacing more than the usual number of burned-out tubes in its "guaranteed" sets, now installs voltage reducers.

Although factual data is difficult to obtain, it is certain that more heat and voltage failures will occur in a given number of sets, running hotter than before. There is no number of preamplifiers or amplifiers.

Possibly the greatest utility of this idea, however, is found in fastening small pads, one or two inches square, on the bottoms of oscillators, meters, oscillographs and other instruments to keep them from scratching receiver cabinets, table tops or other surfaces upon which they may be placed. Quite frequently desks with polished tops are used as "operating tables" in ham shacks. If equipment which normally belongs on the operating table is so protected, much time and grief will be saved.

A good plan is to cut small squares from a kneeling pad and attach them to the corners of the bottoms of small instruments. Dope or DuPont's cement will fasten them securely. Neat squares are cut by using a safety razor blade with a steel-edge rule to guide it.

Homemade Banana Plugs

Cut a suitably square size of tin spring brass. The distance from the center to each corner should be slightly greater than the length of the intended plug. Spot the center and draw a line to each corner. Then draw in the legs approximately the shape suggested. Cut out the cross with a pair of tin shears.
ONE of the difficult problems involved in the design of audio frequency amplifiers is that of preventing oscillation. An amplifier which seems to be perfectly well designed will be found, when constructed, to oscillate or "motor-boat" so severely that the amplifier is of no use.

Oscillation in an amplifier is almost invariably the result of some kind of coupling between input and output circuits termed feedback. To prevent instability, therefore, it is necessary to determine the possible sources of this feedback, and to correct them. Feedback can occur by: coupling through the power supply, capacitative coupling between the elements of the amplifier, or inductive coupling between the elements. Each of these will be discussed in turn. The effect of radio frequency currents which may be present in the audio amplifier, when it is connected to a radio tuner, due to insufficient filtering or shielding, is not considered here.

The most common cause of instability is due to coupling through the power supply. Most amplifiers, with a voltage amplification greater than 500, will oscillate, if no precautions are taken to prevent coupling through the power supply. Feedback through the power supply is caused as follows:

**PREVENTION OF OSCILLATION IN PUBLIC ADDRESS SYSTEMS**

Consider the skeleton diagram of Fig. 1, in which several tubes of an audio amplifier are connected to the same power pack. The power supply has a certain amount of internal impedance, determined by its design. Variations in the instantaneous plate current of any of the tubes will cause a variation in the plate voltage of the power supply. Hence, the plate voltage of the first tube of the amplifier will be found to vary, exactly as the plate currents of the last tube. The variation in plate voltage of the early tubes will be amplified, just as if it were a signal, and, if of sufficient amplitude and of correct phase, a self-sustained oscillation will result.

If the phase relations are opposed, then "degeneration" occurs, and the amplification over a certain frequency range is reduced. While oscillation does not take place, the effect is undesirable, and should be eliminated.

It will be noted that it is the first and last tubes of the amplifier that are principally concerned with the problem of stability due to power supply coupling.

There are two methods by which coupling through the power supply may be minimized. The first is to employ a separate power supply for the last stages of the amplifier, generally for the power output stage alone. A second method is to reduce the effective resistance of the power supply, by alterations in its design. One such alteration is the substitution of a mercury vapor rectifier tube for a vacuum rectifier, if one has been used. This improves the regulation of the power supply considerably, and tends to improve the stability of the amplifier. Another improvement that can be made in the power supply is effected by increasing the size of the output filter condenser. In the mild cases of oscillation, doubling the size of the output condenser will cause some improvement, but this method is seldom the most economical one.

The application of resistance-capacity filters in the plate circuits of the amplifier tubes, is the simplest and most practical method of preventing oscillation as shown in Fig. 2. These filters are inserted in the plate supply lead to each amplifier tube, and effectively prevent alternating power supply voltage variations from reaching the vacuum tubes.

The size of the condenser and resistance that may be needed in any case may be determined mathematically. Results must always be checked experimentally in order to evaluate factors that cannot be found analytically. To make the information available, computations and experimental work have been performed for a number of typical amplifier circuits, and the results are presented here. While the tabulations given in this article are not exhaustive by any means, they are sufficiently complete to be of considerable assistance in the design of amplifiers.

Table 1 lists various circuit combinations, and gives the "type number" of the filter to be used in each plate circuit. The "type numbers" are given in Table 2, where several equivalent combinations of resistance and capacity are listed for each filter type. The particular choice which is to be made between filters of the same type is determined by the direct-current plate voltage drop which can be permitted in the filter resistor, and by the allowable cost of condensers. In Table 1, two choices of filter types are given, one for a power supply of high resistance, and the other for one of low resistance.

A low resistance power pack is one employing a mercury vapor rectifier, with low resistance chokes, and a transformer with excellent regulation. If the power pack employs a mercury vapor tube, but the chokes have higher resistance and the transformer poorer regulation, it should be classified as a
high resistance supply. A power pack utilizing a vacuum rectifier is always classed as one of high resistance, insofar as the selection of filters is concerned.

If there is any doubt in a particular case, into which class the power supply falls, the columns given for a high resistance pack may be employed most safely. Numerically, the dividing point between high and low resistance has been taken at 300 ohms, as determined by calculation and from the slope of the regulation curve of the power supply at its normal operating point. Allowance has also been made for the shunting impedance of the output condenser.

The second cause of instability in an audio frequency amplifier is capacitative coupling between the input and output circuits of tubes in the amplifier.

Capacitative coupling may be inter-electrode, that is, within one of the tubes of the amplifier, or it may occur between the components of the amplifier external to the tubes. Ordinarily, inter-electrode effects are small enough at audio frequencies to be negligible, although occasionally these are troublesome. Only one case in this category is reported, that of a 79 twin triode.

To prevent coupling between the components of the amplifier, they should be so laid out that input and output circuits are as widely separated as possible. Arrange the amplifier "in line," one stage after another, rather than to fold it back upon itself.

When the gain required is large, 50,000 or more, shielding is employed to minimize capacitative coupling. As the desired gain is increased, the better must be the shielding. For voltage gains up to 100,000, it may be sufficient to isolate the input and output circuits, and to shield the tubes in the amplifier, but when greater amplification is desired, each stage should be isolated in an individual metal box. In a special amplifier that has been constructed, with a gain of 5,000,000, it was found necessary to employ separate batteries for each stage, and to use multiple shielding, to the extent of shielding the batteries from each other and from the tubes. In practice, such elaborate designs are rarely met, however.

The last cause of amplifier instability is that due to inductive coupling between circuit elements. Leakage flux outside the magnetic path of a transformer, or of an iron core choke, induces a voltage in other similar parts of the amplifier. If the induced voltages are of sufficient magnitude, and of correct phase, instability results. This magnetic coupling can distort the frequency characteristics of the amplifier, and, if severe, cause oscillation.

Inductive coupling may be minimized by employing magnetic shielding, or the transformer may be re-oriented so that the induced voltage will be of smaller magnitude. Many types of transformers are assembled in iron boxes, make excellent magnetic shields. Additional shielding may be employed about entire amplifier stages, if needed. An iron or steel box surrounding a stage, making good electrical and magnetic coupling at all its edges, and connected to the common return of the amplifier, serves a threefold purpose. It eliminates electrostatic and magnetic coupling between stages, and it prevents pick-up to the amplifier due to external magnetic fields, which might result in noise in the amplifier output.

### TABLE 1

#### Amplifier Description.

3-Stage Amplifiers (including detector, if used.)

<table>
<thead>
<tr>
<th>1st Stage</th>
<th>2nd Stage</th>
<th>Input</th>
<th>3rd Stage</th>
<th>Input</th>
<th>High</th>
<th>Low</th>
<th>High</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>57</td>
<td>56</td>
<td>Res.</td>
<td>45</td>
<td>Res.</td>
<td>III</td>
<td>I</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>57</td>
<td>56</td>
<td>2-4S</td>
<td>pp Trans.</td>
<td>III</td>
<td>I</td>
<td>I</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>57</td>
<td>56</td>
<td>2-2A3</td>
<td>pp Trans.</td>
<td>III</td>
<td>I</td>
<td>I</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>57</td>
<td>56</td>
<td>2-2A5</td>
<td>pp Trans.</td>
<td>III</td>
<td>I</td>
<td>I</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>58</td>
<td>56</td>
<td>Res.</td>
<td>45</td>
<td>Res.</td>
<td>III</td>
<td>I</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>59</td>
<td>56</td>
<td>Res.</td>
<td>2-59</td>
<td>Class B</td>
<td>IV</td>
<td>I</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>57</td>
<td>56</td>
<td>Trans.</td>
<td>45</td>
<td>Trans.</td>
<td>IV</td>
<td>II</td>
<td>I</td>
<td>none</td>
</tr>
<tr>
<td>57</td>
<td>56</td>
<td>2-2A5</td>
<td>pp Trans.</td>
<td>III</td>
<td>II</td>
<td>I</td>
<td>none</td>
<td>none</td>
</tr>
<tr>
<td>57</td>
<td>56</td>
<td>2-2A5</td>
<td>pp Trans.</td>
<td>III</td>
<td>II</td>
<td>I</td>
<td>none</td>
<td>none</td>
</tr>
</tbody>
</table>

#### Amplifier Description.

4-Stage Amplifiers (including detector)

<table>
<thead>
<tr>
<th>2nd Stage</th>
<th>3rd Stage</th>
<th>Input</th>
<th>4th Stage</th>
<th>Input</th>
<th>High</th>
<th>Low</th>
<th>High</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>56</td>
<td>56</td>
<td>Res.</td>
<td>56</td>
<td>Res.</td>
<td>2-2A3</td>
<td>pp Trans.</td>
<td>III</td>
<td>I</td>
</tr>
<tr>
<td>57</td>
<td>56</td>
<td>Res.</td>
<td>2-4S</td>
<td>pp Trans.</td>
<td>III</td>
<td>I</td>
<td>II</td>
<td>II</td>
</tr>
<tr>
<td>57</td>
<td>56</td>
<td>47</td>
<td>Trans.</td>
<td>V</td>
<td>IV</td>
<td>I</td>
<td>III</td>
<td></td>
</tr>
<tr>
<td>57</td>
<td>56</td>
<td>Trans.</td>
<td>2-42</td>
<td>pp Trans.</td>
<td>V</td>
<td>IV</td>
<td>III</td>
<td>III</td>
</tr>
</tbody>
</table>

| Tubes with similar characteristics to those in the above table may be substituted directly. For example, the type 76 may be substituted for the 56. |

### TABLE 2

#### Filter Required

(as given in Table 1)

<table>
<thead>
<tr>
<th>Filter Number (Refer to Table 1)</th>
<th>C in mfd.</th>
<th>R in ohms</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>2</td>
<td>10000</td>
</tr>
<tr>
<td>II</td>
<td>4</td>
<td>10000</td>
</tr>
<tr>
<td>III</td>
<td>8</td>
<td>10000</td>
</tr>
<tr>
<td>IV</td>
<td>16</td>
<td>10000</td>
</tr>
</tbody>
</table>

The filter associated with any of the five numbers may be made up of any of the various combinations of R and C given above.

---

**A SCOTCHMAN'S SPECIAL**

An economical, fool-proof amplifier which is capable of practically distortionless reproduction that can be built by any one is this "Scotchman's Special.

The advent of television has brought this particular circuit back into popularity as frequencies above 30,000 cycles per second are common in such applications. The power output of this particular circuit is 9.5 watts, absolutely undistorted and the latest report shows that tubes which have up to 40 watts output per pair are in the last stages of experimentation. The new 6A5GS has all of the advantages and none of the disadvantages of the older types, and the simple construction which can be followed in making amplifiers with it, plus the excellent results obtained, are certain to bring it into widespread popularity.

The type 6F8 dual triode was used as a driver and also supplies bias for the 6AS7 push-pull output tubes. This tube was originally designed for use with the 76 as a driver, but the 6F8 has the same characteristics as the 76, only an added advantage is gained in having both the tubes in the same envelope.

The grids of the 6F8 have to be fed with an out-of-phase signal for correct push-pull operation so the simplest method was chosen—a push-pull inter-stage transformer. For phonograph operation or from a radio tuner output, a 6G5 as shown in the diagram is plenty to overdrive the amplifier. But if microphone operation is desired, the 6F5 will provide better gain when used with the types of microphones that have an output of minus 50 decibels or so.

The type of power supply isn't very critical, no voltage divider is necessary and only a double eight microfarad filter condenser is needed due to the inherent characteristics of triodes and their low power sensitivity. Placement of the parts isn't critical as prac-
tically all of the connections between tubes are merely wires. The power supply should be able to deliver a maximum of 90 milliamperes at 250 volts as the 6AC7's draw 32 milliamperes each and the 6F8 draws a total of 18 milliamperes, the 6CS draws 8 milliamperes.

The filament supply should be able to deliver 2.0 amperes maximum.

No shielding is required on any of the tubes.

All in all, the "Scottishman's Special" will provide the home constructor with an amplifier that is capable of reproducing faithfully the whole audio frequency spectrum at the minimum of cost for parts. It can be built in the minimum construction time. It is trouble-free from the standpoint of replacement of parts, such as resistors and condensers, and is ideally suited for work with the experimenter in trying out new microphone circuits, mixers, tone compensators, etc., where it is necessary to know that the output stage is positively high-fidelity.

**AN A.C.-D.C. 4-WATT AMPLIFIER**

RECENTLY, when a d.c. amplifier was needed by a ham in a location with only that type of power available from the mains, none was found to be readily usable which would at once fill the bill with compactness and speech frequency requirements. After the present one was designed it was thought to continue the development and make a first-class a.c.-d.c. job of it as well, so that should the ham change location, the speech amplifier would not be outmoded.

Four watts of undistorted output were provided, together with the usual rugged construction required by the average ham installation. The output was more than sufficient to drive a pair of class B tubes such as the 801 or T20. For that matter the amplifier made an excellent small p.a. system and also a driver for higher powered drivers should they be used.

The tube line-up consists of a 6J7 input stage resistance coupled to a 6CS which was in turn transformer coupled to a power of 25L6's. The rectifiers were two 25Z7's. In adding all of the filament voltages together, a total voltage of 112.6 volts was required to operate the filaments in series. Since the line voltage available was 115 volts, and because tubes today are manufactured to withstand a 10% variation in filament voltage without shortening their life, no line cord resistor was used. The additional 25Z5 tube inserted mainly to eliminate the aforementioned resistor may also be used to supply field exciting current for a speaker. However, in the present circuit this was not done because a magnetic speaker, or the 500 ohm line to the modulators, was used.

Sufficient gain was obtained from the 6J7 to permit operation directly from a crystal microphone, and the overall gain of the entire amplifier was conservatively found to be 89 db. Provision is also made for a high impedance phonograph unit which works directly into the 6CS. Fixed bias is supplied by a Mallory bias cell and the 6J7, pentode connected, capacity coupled to the gain control in the 6CS serves the purpose of mixing volume from the phonograph as well as the gain from the crystal microphone input. A tone control consisting of a one-half megohm rheostat in series with a .01 mfd. condenser serves to control the high frequency output of the amplifier and to produce the effect of a greater low frequency response at lower volume levels. Most important of all is the fact that this tone control acts as an impedance shunted across the output transformer, a condition necessary in pentode as well as beam type tubes. The 6J7 input is decoupled by use of a resistor and condenser to avoid oscillation and feed-back. Because it is quite customary to ground one side of the a.c. line, and because this amplifier was to be an a.c.-d.c. unit, it was necessary to "float" the chassis. This term is used in the industry to indicate that the "B" negative of the power supply does not return to the chassis itself, which is grounded to the circuit through a .1 mfd. condenser.

Actually, this last condenser acts as a direct ground in a.c. application. By "floating" the chassis it was possible to insulate the amplifier in such a manner that the possibility of a shock to any person touching a radiator or grounded object, and at the same time touching the chassis, was eliminated.

The chassis is a standard one, measuring 5"x10"x3", finished in black crackle.
MAKING YOUR OWN RECORDS

THERE are many times when the serviceman will be asked "Can you make a record?" Invariably the answer will be, "No, I'm sorry." There is not any reason why this situation should exist in the shop of any well equipped service center. Especially, if he has an amplifier, a few odds and ends lying around, and if he will purchase a recorder.

Briefly, a recorder is simply a loud speaker from which audio signals have been made into a record instead of giving aural response. The output of the amplifier is hooked to the recording head, which in turn places the audio response on a composition or acetate record. This is not to be confused, of course, with the commercial wax recording outfits, which are far too involved for any serviceman to attempt. This article will confine itself solely to a simplified method of recording which may be installed by any serviceman so as to realize on a market he has heretofore been turning away from his door.

Amplifier operates from 110 volts a.c. or d.c. and has two input channels, one for a phonograph pickup (playback) and the other for a high gain microphone such as crystal high impedance dynamic or high impedance velocity types. The tube lineup consists of one 6C8G double triode, two 25L6's and one 2576G rectifier. Resistance or transformer coupling may be used between stages, although some weight and space can be saved with the former. The output of the amplifier is coupled to a DB meter, the use of which will later be explained, and through that to a double pole double throw switch; then to a matching transformer which accurately matches the impedance of the recording head to the output of the amplifier. The output transformer of the average amplifier system has output of 4, 8, 16 and 200 ohms, and the average recording head is 500 ohms. Some, however, have impedances of 5 ohms. In the particular amplifier used there was not a 500 ohm output tap and so the matching transformer operating from 5 ohms input to 500 ohms output was used to match the output of the amplifier system to the recording head.

In order to play back the record after it has been made, a second switch is used. This throws the microphone out of the circuit and throws in the play-back head. The first switch of which mention was made, is used to throw in the speaker in place of the recording head. By throwing these switches first in the "up" position, a record is made, and by reversing the switch position and putting the play-back head on the recording head, the groove will be too deep and sometimes even scratch into the aluminum disk beneath the acetate. This will cause distortion and other undesirable features in the record and at times even make it unintelligible. The average groove, if correctly cut, will not exceed two thousandths of an inch in thickness. If too much audio is impressed on the cutting head, the groove will be too deep and sometimes even scratch into the aluminum disk beneath the acetate. This may cause distortion and other undesirable features in the record and at times even make it unintelligible. The average groove, if correctly cut, will not exceed two thousandths of an inch in depth. The easiest way to judge whether or not you have too much audio (without playing the record back) is to test the thickness of the "scratch" which will unfuel as the record is cut. This scratch should not be thicker than 3 human hairs intertwined. Unfortunately the average serviceman, with his desire to get the maximum recordings, will find that his scrap is of the thickness of a horse's hair, which is far too deep and the recording will be entirely unsatisfactory. For those who are more accurate-minded, the scrap should be approximately the same size as No. 36 bare copper wire; and it is a good point to have a piece of that size wire on hand together with a pair of cheap microscopes to measure whether or not there is any great difference between the scrap and the sample wire. Dispose of all scrap carefully as it is inflammable.

An indispensable addition to the serviceman's recording outfit is a cheap microscope such as can be purchased for approximately $1.00 in any novelty store. Dismount the microscope from the stand and mount it upon the recording head, placing a 6 volt pilot light so that it will throw its rays directly upon that part of the record being inspected. Inspection is made continuously during a recording. In looking through the microscope the depth and width of the groove both can be observed and the recording head jumping the groove in any overload peak can be avoided. The recording machine can also be used without the amplifier to make records from the "air." This is a profitable source of income for servicemen living in small towns and communities, which support a local broadcast station. There are any number of artists both amateur and professional who would value a record of their broadcast performance.

The method of procedure is exactly like making a record from the microphone, excepting that the recording head transformer is matched to the output transformer of the radio receiver. It is well to make several tests before going ahead with the recording. This can be done by starting in a good half hour before the appointed time and obtaining a "level" and making a number of test records. Once the level has been obtained through the same means used before, the record may proceed as if the recording artist were in the studio or store of the serviceman. One thing is sure, in recorded radio programs be sure to include the announcement of your customer's name as made by the station announcer on the record; since without it will not have nearly the value as it would have with this little touch.

There are some recorders which use 33/4 RPM and some which use 78 RPM and there are still others which use both speeds. It will be found that the average 12" record will "take" a full fifteen minute program on the 33/4 RPM speed. Whereas at the 78 speed the record will take approximately 7 minutes. The slower speed is very much more difficult to record and a higher powered motor must be used to turn the turntable.

Also, the acetate must be very smoothly put on the record and free of impurities. These types of records are slightly more expensive than the other types. With the slower speed it is extremely important to watch the groove and the depth of the cut since with the record turning so slowly any faults are greatly magnified.

In closing, it might not be amiss to state that all business is best run with a "line" front. If the serviceman will take the trouble to fit up a room with Celotex or other sound deadening material on the walls, rent a piano and set up a professional looking recording studio, he will find himself handsomely repaid in dividends.

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**Diagram:**

```
\begin{array}{c}
  \text{MIKE} \\
  \text{DPDT SWITCH} \\
  \text{AMPLIFIER SYSTEM (5WATTS)} \\
  \text{SWITCHES UP-'RECORD' SWITCHES DOWN-'PLAYBACK'} \\
  \text{DB METER} \\
  \text{RECORDING HEAD} \\
  \text{PLAYBACK} \\
  \text{MATCHING RXMR} \\
  \text{PHONES JACKS} \\
  \text{SPEAKER} \\
  \text{DPDT SWITCH} \\
  \text{How to hook up the home-recorder.}
\end{array}
```
Plates 15 & 16--

The Treasure-Hunter, or M-Scope, is light in weight and can be easily carried about. (This special plate is issued for the benefit of other's who want the benefit of others without violating the Fisher patents.)

The principles of the M-Scope is that of the Radio Balance, which requires a radio transmitter tuned to any frequency between 50 and 5,000 kc.; with wavelengths between 5,996 and 59.96 meters; and a modulation of 1,000 cycles. The transmitter output is coupled to a balance loop antenna.

The receiver has an impedance coupled radio amplifier, audio-amplifier, detector, and a sensitive tube voltmeter. Like the transmitter, the receiver is also coupled to a balanced loop antenna.

If the set is in balance, and there is no metal present, there will be no sound in the phones, but if there is any metal present it will disturb the balance, there will be a 1,000 cycle modulation note heard in the phones, and the tube voltmeter will register the strength of the disturbance caused by the metal.

If your transmitter and receiver are far apart you can increase the power in the transmitter very greatly, and locate large objects at great depths. On the other hand, if you want to find small objects, you must bring your transmitter and receiver close together, and this requires a reduction in power if you want your set to balance accurately.

The Fisher sets are a compromise between the extremes of theory. The Metallascope here described uses a frequency of 175 kc., and is especially adapted to finding small objects relatively close to the surface, but a higher frequency can be used by changing the inductance and capacity values and the impedance of the choke coils, and this will enable the builder to detect large objects such as gold deposits at great depths, if he is careful to keep down the amount of metal he puts into the equipment.

In looking at the diagram, you will see that we have indicated conventional type-30 tubes for the receiver, and type-61 tubes for the transmitter. These were less than shielded grid or pentode tubes which some experimenters prefer, require less plate voltages, and are less noisy in operation than the heavier tubes.

Construction of Apparatus

You can duplicate the M-Scope, the largest of the Fisher sets, for your own use, but not for sale, or for use by you as an employee of another person, since sale or rental of the device, or using it for hire would subject you to prosecution for violation of the patent.

Perhaps the best things to make first are the handles. These are of oak. There are two, each 34" long, 1/2" wide, and 3/4" thick. These should be planed and sand-papered and the holes should be drilled in accordance with the drawing. Use no paint or varnish; a simple stain is sufficient to protect them from the elements.

Next, you will want the r.f. Chokes, each with 1,500 turns, of No. 34 copper wire, enamelled. Be sure to get No. 34, enamelled, for another gauge or different covering may throw out the balance of the design. The windings can be either "Random" or "Duo-lateral"; this makes no difference in the result. The Chokes are labelled "2" in the drawings.

Now we jump down to the loop frames which are wound with 80 turns of No. 35 D.C.C. copper wire, center-tapped, and here again we must caution against using anything outside of the specifications if you want to have a perfect balance on the completion of your set.

In the diagram, R-1 is a 10 ohm filament resistor; R-2 is a 5 ohm for 1 tube, and 2.5 ohms for 4 tubes, and R-6 is 2 ohms. You can make up these resistors yourself with 30 Nichrome wire, which you wind on a fibre strip. In figuring resistance, allow 1 ohm resistance for each 1.6 inches of width of wire. At this rate, R-1 will have 16 inches; R-2 will have 8 inches for the one type-31 tube; 4 inches for four type-30 tube, and 3/4 inches of wire for five type-30 tube.

If you have assembled your equipment correctly, you now stand between the handles, with the receiver in front of you in a horizontal position, and the transmitter in a vertical plane, behind you, and the phones on your head. Turn on the power. If the apparatus is in balance there should be no sound in the phones, and no dial indication unless you are standing over buried metal. However, failure to follow the specifications we have given you may mean that your set...
is in balance when the transmittter is inclined at a slight angle from the vertical. Try it in different localities free from electrical disturbances and buried metal until you have located your neutral position of the transmittter, and then mark this with a line scratched on the box for future use.

With your equipment assembled and adjusted, you are now ready to prepare for field work. The simplest way to gain experience in operating the set is to follow a buried pipe line. Strangely enough, a pipe line lying on the surface of the ground, or one that has been laid very recently will not suit your purpose. The reason is that the ground itself is a conductor. A pipeline which has been buried for some time will enable the transmittter to set up eddy currents which radiate and create disturbance in the matrix around the pipe. A newly laid surrounded by loosely packed earth, or a pipe lying on the ground gives little disturbance and you will have trouble following it with your set.

To test yourself, follow the estimated course of the pipe line you have chosen, such as a city water line, and plot it on a rough map. When you have followed this for several hundred feet, take your map to the office of the water company and compare it with their actual surveys of their pipe system for that neighborhood. This will serve as a check on your readings for direction.

Next, make your frames. These are of oak, too, but you must not use any nails, bolts, or screws of iron or steel. Use wooden dowels and glue as much as possible, and when you do find it necessary to use metal, select brass bolts and nuts. Where you employ glue and dowels, reinforcing blocks can be placed inside the corners. These are not essential, and they are not shown in the drawing, but they do add strength to your frames. Plywood is used for the side panels.

Having made the frame and frames, we are ready for the actual radio equipment. If you do not have one already, buy a milliammeter (d.c.) with enough shunt resistance to permit about 3/4 full scale deflection with the receiver switch ON, and the transmittter switch OFF. The case of the meter should be of bakelite.

To search for buried treasure, oil, or minerals, first go over the suspected ground, plotting accurately on a map of the area the points where you get maximum meter readings, as well as the spots where you get low readings, recording in each case the exact reading of your meter. When you have a large number of readings, connect those of the same degree and you will have located the outlines and center of your metallic substance.

Depth of the object can not be accurately estimated, but you can obtain good approximate estimates by noting the angle of the transmittter at which you get maximum readings on your meter. By taking several readings for these angles, at different points, and plotting them on paper you can then figure the depth by either simple proportion or trigonometry.

The equipment which we have described is the M-Scope, which sells for about two hundred dollars. The simpler set, which is sold for ninety-five dollars, is the MT-Scope, which is also covered by a patent, but can be copied by readers of this magazine by permission of the patent-owner.

Internal parts of MT-Scope are fewer in number, and better adapted to the beginner who is content with a set of medium...
Most fading is due to the arrival of a single desired signal over not one atmospheric path, but its simultaneous arrival over two or more paths due to absorption and reflection of the signal by the Heaviside layer of the atmosphere. As a rule, transmitted signals are radiated over a general direction in a circle around a transmitting antenna, or in a beam. Either way, some of the signal travels up towards the Heaviside layer, while the other bounces along the ground. There may be several signals propagated sky-wise. Thus two or more — instead of only one — identical signals reach the receiving antenna, because the unequal path lengths cause the signal to arrive before, with and after itself.

This phase shift, or lag and lead, causes what was originally one signal to appear at the receiver as two or more identical signals of slight time difference. These signals are identical as to audio modulation, but lead and lag each other as to carrier frequency. When all arrive exactly simultaneously, they add, and this is the "top" of a fading cycle. When they lag or lead one another, they are out of phase and tend to cancel out. The extreme "bottom" of a cycle, corresponding to a completely faded out signal, is when the phase difference is such as to result in cancellation.

The means of eliminating fading lies in the fact that it does not occur for a given signal simultaneously in direction in two different antennae. Thus, two antennae may be set up like a see-saw, for when the signal has faded down in one, it has faded up in the other. Obviously, the answer is to combine the same signal as received in two different antennae so as always to listen to the strong signal. This cannot be done by simple interconnection of the two antennae, because the phase shift which causes the fading prevents the additive combination of the signals at radio-frequency. Thus a dual-diversity receiver must be very complicated in that it must be a two-receiver amplifier system. A common audio amplifier only. A common a.v.c. system must be used to squelch the weak signal receiver so that it may not contribute noise when its signal fades.

The new system devised by the author instead of requiring two receivers, can be added to the existing set to accomplish the same results. In this new diversity coupling system no attempt is made to combine the same out-of-phase signal from two different antennae, since the weak one will be of no practical value anyhow, but rather to cause the fading signal automatically to select for the receiver that one of two antennae in which a desired signal is fading upward at any given instant. The addition to any good receiver to obtain dual diversity reception needs only an antenna selector switch operated by the fading signal. As the signal in one antenna fades down to what may be considered one-half its maximum volume, the decreasing a.v.c. voltage generated in the receiver by the signal is caused to operate the antenna switch to shift over to the second antenna in which the signal will be rising.

A casual reading of the above will suggest that this coupling system provides only one-half average signal volume. The reverse is true, for it provides a constant signal volume equal to the maximum volume obtained on the same receiver without it. This is because the full cycle of fading is not actually heard on any receiver equipped with a good a.v.c. system — only the downward fade is actually heard. When the signal fades up, the a.v.c. levels it off to average volume, but when it fades down, the a.v.c. cannot release enough receiver sensitivity to bring in a signal which has faded out.

The new Diversity Coupling System operates to erase the downward fade by replacing it with an upward fading signal, and so hold volume consistently strong enough to be leveled down to desired volume by the receiver's a.v.c. system.

This not only increases average signal volume through eliminating the volume decrease on the downward fade, but erases all the noise which affects the weak signal in its downward fade. Given a signal the maximum volume of which on a good receiver provides relatively or completely noise-free reception, the Diversity Coupler eliminates the noise which invariably accompanies fading by replacing the downward fade with a strong signal.

A practical operating form of the Diversity Coupler is illustrated and diagrammed herewith. It is contained in a grey enameled steel case 6" x 4" x 1 1/2". Operating-wise, it has two binding post strips, one for a connection to the receiver's antenna binding post and two for connection, one to the existing antenna and the second for connection to a second antenna anywhere from 20' to 50' long. The only requirement for this second antenna is that it be at right angles, or as close to this as possible, to the existing antenna. If the existing antenna is horizontal, the second or new antenna should preferably be vertical, or at least at right angles to it. The second binding-post strip has two terminals for connection to the two ends of the receiver's a.v.c. load resistor. The one knob on the front panel turns on a.c. power and then regulates the volume level at which automatic selection between the two antennae occurs. Backing this knob "off" mutes the Diversity Coupler, but keeps it ready to be cut into circuit whenever a signal starts to fade by simple advancement of the knob. If it is turned up too far, the automatic switch will "chatter," for it is essential that the antenna be switched out as its signal begins to fade; down should at the instant of switching, be a little weaker than the second antenna signal, in order that the signal in the second antenna may be just enough stronger and hold the switch closed after the shift is automatically made. This difference, a matter of 1 to 5 microvolts, is controlled by single knob.

The circuit diagram shows that the Diversity Coupler is an extremely sensitive voltage-operated S.P.D.T. switch used to select either one of two antennae. Its sensitivity and adjustability to different strengths of signals is what allows it to be operated by a receiver's a.v.c. voltage, which varies in accordance with antenna strength, and is the "power" used to switch from the weak signal to the strong signal antenna automatically. In the illustration are seen the three contacts making up the S.P.D.T. switch, together with the circuits and components which cause a fading signal to operate it.
Although simple in the extreme in principle and in operation, the delicacy of the operation to be performed, involving the translating of a volt or less into a current in which to operate the switch, involved extensive research and experiment over a long period.

Examining the illustration, and neglecting the switch contacts marked for antenna connections the left hand pair of binding posts are for connecting across the receiver plate circuit to provide signal controlled actuating voltage. In effect, the signal generated a.v.c. voltage is used to add to the negative grid bias for the 2A4G gas triode Thyatron control tube provided by the 25 volt filament supply (for 252Z6 dual rectifier tube) of transformer MC81.

This negative grid bias is obtained by using one diode of the 2Z6Z rectifier, a 12 mfd. dry electrolytic condenser, a 3000 ohm, 1/2 watt resistor and a 2000 ohm potentiometer. These provide about 12 volts d.c. across the 2000 ohm potentiometer, which is applied to the 2A4G grid in amount just insufficient to prevent this tube igniting, or provide a high-current path from cathode to plate.

In this way, any a.v.c. signal voltage added to the prevent ignition, but when the signal fades downward, the grid bias drops, the Thyatron ignites or conducts, and pulls the switch over from antenna No. 1 to antenna No. 2. Transformer MC81 also lights the 2A4G filament, and could not be combined with plate transformer MC80 because of regulation problems—when the 2A4G ignites suddenly, not zero plate current, but about 85 ma., which drops the plate voltage from MC80 and, were MC80 and MC81 combined, could drop the bias voltage for an instant so that the switch would “chatter” instead of going cleanly from position No. 1 to No. 2. Hence, separate, though small and inexpensive, transformers are essential for grid-filament and plate voltage.

Once the fading signal has caused the bias on the 2A4G to fall below ignition potential, the tube passes a high plate current, and the grid loses control until the plate circuit is broken. So a second switch is mechanically built into the Guardian D100 magnetic switch so that when it operates, the plate circuit is broken for an instant necessary to cut off plate current, to be reclosed as soon as antennae have been changed to provide a more negative a.v.c. voltage so that the circuit will be ready to operate again when the signal in the selected antenna has begun to fade.

MC80 provides 190 volts a.c. for 2A4G plate power, through the second diode of the 2Z6Z rectifier and a 12 mfd. 250 volt dry electrolytic condenser. It will be noted that both grid and plate rectifiers have no filter chokes, for they are not needed, since a.c. hum is not a problem at all, these circuits having nothing directly to do with the receiver, and so being incapable of causing hum in its output.

The internal assembly of the Diversity Coupler is clearly illustrated. On the panel at the right is mounted the 2000 ohm grid, or “sensitivity,” potentiometer with its a.c. on-off switch. Directly below it, mounted on tie-lug strips, are the grid and plate filter condensers with the 3000 ohm grid voltage dropping resistor on its leads about them. To their left is the 2Z6Z, with behind it the 2A4G, tube. Still further to the left is a vertical partition, on the right of which are mounted the MC81 transformer at bottom and the MC80 at top.

Before turning to the illustration showing this partition assembly, the Guardian D100 magnetic switch may be profitably studied with a magnifying glass. At its left can be seen a black rectangle, which is the magnet operating bar, which, when the magnet pulls, breaks the contact between the two extreme left contact blades (silver studded) and so breaks the 2A4G plate circuit. To their right are a group of four blades. The extreme right one is the antenna switch actuating blade, raised and lowered by the clover-leaf cam seen at the top right of the switch.

Turning to the other illustration the ratchet and pawl operating this cam from the switch magnet can be clearly seen, together with the auxiliary pawl which locks the switch in correct position, preventing over or under travel.

The only trick about this switch is to make sure its contact blades are so bent that before the arm, or center blade, of the antenna switch has left one contact, it has closed the other. It is essential that this switch “make before break.” Likewise, it is essential that the plate circuit breaking switch should not open its contacts until the movement of the magnet arm has almost fully completed its downward stroke or application of current.

Interior illustration shows clearly the three antenna binding posts, the 400 ohm rheostat and 150 ohm, 1/2 watt resistor, and the 12 mfd. and 12 mfd. condensers across the plate switch contacts and switch coil. The 12 mfd. condenser and 150 ohm resistor prevent sparking at the plate circuit switch contacts, while the 400 ohm rheostat and 12 mfd. condenser across the coil serve two purposes. The condenser stores energy from the short duration pulse due to instantaneous plate circuit make and break so as to cause the switch arm to complete its stroke, and also to filter the current so as to prevent noise introduction through d.c. circuit make and break so physically close to the antenna.

In operation, no consciousness of the operation of the Diversity Coupler is had except a “click” every time the signal fades down. This is due to the antenna circuit switching, and is a very small price to pay for the elimination of fading and its steadiness, long duration noise on downward fades. It can be eliminated completely by a simple noise silencer consisting of a 6H6 double diode with its diodes connected in parallel across the receiver’s second detector, plate to cathode and cathode to plate. A biasing battery and potentiometer are the only other accessories needed for this noise squelcher, to adjust bias so the added diode cannot conduct, and so shut the signal temporarily until a noise voltage louder than the signal appears.

For code reception, where a continuous carrier is not present to hold the Diversity Coupler to antenna No. 1 or No. 2, and it would tend to switch antennae in following code carriers, the remedy is a delay circuit. Put a 1/2 megohm, 1/2 watt resistor in series with the 2A4G grid lead, and a 1/2 mfd. condenser from its grid to filament.
Homemade Pilot Light Socket

The accompanying drawing shows how a socket for the radio pilot light or a flashlight bulb may be made easily from an ordinary screen-grid tube clip, a few pieces of insulated wire and a couple of coupling washers. A drop of solder on the end of the feeder makes a good contact for the positive terminal of the bulb. The socket can be mounted by soldering directly to the chassis or by means of a soldering lug as shown in the drawing.

Antenna Impedance Matching Simplified

The ham is often faced with a difficult problem when it comes to matching the feeders to an antenna. Normally the antenna is operated in an elevated position where it is not accessible, so the matching is done on the ground, with a prayer that when raised to position the match will still be satisfactory. Where the feeders are of the tuned variety this course does not apply. It is in the case of non-resonant feeder so commonly employed on the five-and-ten-meter bands that it does apply, and is one of the reasons that standing waves are so often present on such systems.

When the antenna is a type that employs a matching section such as the "J", the "half-waves in phase" and various other array this problem can sometimes be overcome by making the matching section more than one half wave or quarter wave long.

Under conditions where a half-wave matching section is specified, it can just as well be two or more half waves long and can thus be extended down to a point within reach of a ladder or the roof, and the proper point for attaching the feeders determined with the antenna in its normal elevated position. Once a quarter-wave matching section is specified, it can be lengthened to any odd number of quarter waves.

Suppose the problem involves a 5-meter vertical "J" antenna with spaced feeders, the "J" to be mounted on a mast with its bottom 30 feet above the roof. Normally a quarter-wave matching section would be employed and the point where the feeders connect to it would be about 27 feet above the roof, with the shorting bar a foot or so below that. If the mast is husky enough to support a long ladder, all well and good. It is more simple, however, to make the matching section five quarter waves long, thus bringing its lower end down to about 10 feet off the roof where it can be reached comfortably from an ordinary step ladder.

The proper point for connecting the feeders then end can then be determined in exactly the same way as with a quarter-wave section, and the correct connection point for the feeders also. The only difference would be that the match would be a permanent one because the antenna would be in its normal position during the adjustment and therefore not subject to changes encountered when an antenna is matched on the ground.

only to have its characteristics altered due to surrounding objects when raised into position.

Chart of Tap and Clearance Drills

In radio construction work experimenters are often confronted with the problem of selecting the correct size drill for tapping, or for drilling a clearance hole to take a certain size machine screw. This chart gives the drill sizes required for average use. If the machine screw must pass readily through the hole, then the size drill is selected under the column headed "Clearance."

<table>
<thead>
<tr>
<th>Screw Number</th>
<th>Threads Per Inch</th>
<th>Drill Per Tap</th>
<th>Number Clearance</th>
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<tbody>
<tr>
<td>2</td>
<td>48</td>
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To measure resistance use your more sensitive voltmeter in the substitution method with a 100,000 ohm calibrated adjustable resistor. The range can be extended by connecting known values in series and adding so much to the reading. This method avoids meter error and voltage drop. Simply adjust to the same voltmeter readings whatever it may be and the resistance is the same as the unknown resistor which produced that same deflection. No ohms scale is required on the voltmeter.

For the voltmeter, an instrument of 1000 ohms per volt is good, one of 2000 ohms per volt very good and 5000 per volt excellent. Three d.c. voltage ranges of 30, 300, and 600 volts should meet all requirements. Connect as shown in Figure 2. In calculating multiplier resistances, you must know maximum meter current and the meter resistance; then add resistance in series until the sum (multiplier plus meter resistance) equals the desired voltage range divided by decimal fraction of an amperes. As shown in Figure 2 the meter is always set for the highest voltage—protected against mistakes. Lower voltages are read by holding down the proper key, temporarily shutting out part of the multiplier resistance. A chart of multipliers may be extended in the same manner with a top range of 700 or 800 volts.

Handy Continuity Tester

This pencil-tester should find a wide variety of applications in every experimenter's and serviceman's workshop in tracing continuity and shorts. It is especially useful in checking from point to point, testing coils, switch contacts, and other applications where very low resistance is found.

The sensitivity of the indicator can be controlled by substituting lamps of different current drain. A dial lamp of high current consumption is useful where it is desired to limit the resistance indication to a few ohms such as in coils and switches, while the special low current dial-lamps used in battery operated receivers can be used to indicate continuity in circuits up to approximately 70 ohms. Another useful application of this unit is its employment as a small torch for working in dark corners of receivers, etc. For use in this capacity it is only necessary to fasten the alligator clip to the test prod.

Fuses Save Dollars

A good guess is that burned out transformers represent one of the largest single items of replacement cost in the radio game. Yet we radio experimenters go right on building receivers, transmitters and other equipment without fuses, or with inadequate equipment to protect the relatively expensive power supply parts when, at a cost of only a few cents, we could gain such protection.

An automobile fuse rated at 1 ampere, connected between the line and the power transformer primary, will do the trick for medium and small receivers. For larger receivers and small transmitters the same kind of fuses but rated at 2 amperes will do the trick and for larger transmitters the fuses should be proportionately larger in current rating. These fuses cost five cents each and few presentations of 100 amount to much. Certainly safety is cheap at these prices.

The proper place for the fuse is in the line input as mentioned. Then if a short circuit occurs anywhere in the filament or
plate circuits of the receiver the fuse will go before the transformer can be damaged.
In equipment which employs more than one power supply, as in transmitters where the exciter, modulator and final stage may each have its own power supply, the line supply to each power transformer should be separately fused. Not only does this provide protection but when a fuse goes it will show the portion of the rig in which the trouble exists.

The best plan in selecting fuses for a given job is to figure the actual power drawn from the transformer, including all filaments, plates, pilot lights, etc. under conditions of maximum operating load. The power on the primary side will be somewhat higher than this, due to transformer losses. You will be safe to double this figure, convert it into terms of primary current by dividing this value (in watts) into the line voltage. Then use a fuse having a current rating nearest to this value. Doubling the power value as suggested avoids blowing the fuse as a result of normal surges that may occur.

**Increasing Voltmeter Utility**

Everyone who experiments with radio or electricity is equipped with a voltmeter of some type but many are not fortunate enough to own milliammeters—or at least the line so they believe. If you are one of this latter class you are due for a surprise because your voltmeter is a milliammeter as well. If you open it up and look inside you will find the meter mechanism and a resistor. Short circuit this resistor and the instrument becomes a straight milliammeter. Its range will be 0 to 1 milliammeter if the voltmeter is one with a 1000 ohms-per-volt rating. If a 100 ohms-per-volt rating the current range will be 0 to 10 ma., etc. Instead of short-circuiting the resistor, you can bring out a lead from between one side of the mechanism and a mounting case and another binding post on the meter case to which to connect this third lead. Then you can use the instrument either as a current meter or a voltmeter, depending on which of its terminals you employ. All of this is illustrated in Figure 1. (A) and (B) are the original positions while (C) is the added one. Terminals (A) and (B) are used for voltage measurements; terminals (A) and (C) for current. The range of either meter may be increased in the usual manner. Shunting suitable resistors across (A) and (B) will increase the current range. Inserting suitable resistors between (B) and the voltage to be measured will increase the voltage range.

**Fish Pole Antenna**

The manufacturers, quick to take advantage of the increasing interest in automobile radios, have introduced several new types of aerials for roof, door and bumper mounting. One of the simpler types that the experimenter can make for himself is the bumper rod antenna. Purchase a cheap one piece metal fishing rod, one that has a wooden or some kind of an insulated handle. You are not interested in its properties as a fishing pole and therefore a cheap rod will answer the purpose. Solder a lead-in to the bottom end of the metal rod and then fasten the pole to the rear bumper by means of an improvised iron strap and two long stove bolts. For this job it will be necessary to prepare two holes in the handle to take the bolts.

Several ways will present themselves for supporting the antenna. On some cars it can be fastened on the bumper rod, on others it can be mounted on the bumper support. It is suggested that the rod be given a coat of aluminum paint to prevent rust.

**Variable Tone Modulator**

The majority of manufactured or homemade 5 meter transceivers are not equipped with tone modulation for c.w. work. It is a simple matter to add this feature without molesting the transceivers in any way. Assemble a 1/4 to 1/2 watt neon bulb, a .001 mfd. variable condenser, a 100,000 ohm variable resistor and a key as shown. A 1/2 mfd. condenser should also be connected across the key. All this material can be taken from the junk drawer and assembled on a small board alongside or attached to a B eliminator of reasonable power.

Connect the output to an old magnetic speaker, turn on the power and press the key. The neon bulb will oscillate and produce a tone in the speaker. Its strength can be controlled by the variable resistance while the pitch can be varied from a low note of only a few cycles to one of the highest audible frequency by means of the tuning condenser. The note can be transferred to the transceiver by placing the tone close to the speaker and will not interfere with voice unless the key is depressed.

**Plug-In Resistors**

For experimental purposes where resistors have to be changed often as in biasing various types of tubes, control networks, etc. a plug-in arrangement is very desirable. The following idea has worked out very successfully.

The shells of several old tube bases were sawed off close to the bottom with two of the prongs left intact, except for cleaning out the wire and solder. Next the resistor was mounted as shown in the drawing with the leads crimped so that when said leads were pressed into the prong they made a good connection and support for the resistor. Sockets were then fitted to the receiver or were then fitted to the receiver or bread-board layout and wired into the resistance circuit.

It is a simple matter to pull out these plug-in resistors from the socket to substitute a resistance of a different value. For permanent use the resistor leads should be soldered into the tube base prongs and the latter inserted into the socket for good or until the resistor burned out and required replacement.

**Selecting Antenna Wire**

In selecting wire for antennas it is too often the practice to simply go into a radio store and ask for so many feet of antenna wire, taking pretty much whatever the dealer offers. Where the wire is to be used for an ordinary "L" type antenna for broadcast reception there is no such procedure because the exact length of the antenna is not critical, nor the strain on the wire great.

Where the antenna is to be used for transmission, or for a self-receiving receiving antenna greater care is needed. Here the antenna length is critical and usually the antenna must be stretched taut under a considerable amount of tension. If a tree is used as a support the wire may be
under tremendous strain during storms. For such uses, solid wire is usually employed and is generally available in hard-drawn and soft-drawn forms.

Hard-drawn wire is recommended for such critical service. The reason is that it has close to the strength of the soft-drawn variety; and what is more important, soft-drawn wire under strain will stretch as much as 25 percent as against less than 1 percent for hard-drawn wire of the same size and subjected to the same strain. Actual tests made on such wire showed that soft wire broke at 150 pounds pull whereas the hard-drawn broke at almost exactly 300 pounds. Just before breaking, the soft wire had stretched from 5" to 5", whereas when subjected to the same strain of 150 pounds the hard-drawn wire showed no appreciable stretch. At just short of 300 pounds pull the hard-drawn wire showed elongation of approximately 1/4 inch.

To avoid sag, and for the antenna length to remain fixed, use hard-drawn wire. If the strain is likely to be greater than 300 pounds use copper-clad steel wire which is still stronger.

A Sharply Tuned Wavemeter

Despite modern and frequency meters the old style absorption type wavemeter still has its place in amateur equipment. Harmonics have no effect on its operation and with intelligent use it will give a definite check on frequency to a limited degree. In the past its chief handicap has been broad tuning and it was difficult to obtain a true reading. Presented herewith is a simple method for overcoming this objection.

Instead of connecting the indicating lamp in series with the tuning coil and condenser as in the usual manner, slunt the lamp across the circuit as shown in the diagram. Connecting the device in this way using a 6 volt dial lamp the tuning will be unusually sharp and when carefully tuned the instrument will be able to indicate the transmitted frequency to within a narrow percentage of the true frequency. Employ bushing for the leads as they can also serve as supports for the lamp socket.

Increasing Efficiency of Detector Tube

A five-prong cathode type triode will oscillate more readily if the grid prong is isolated from the composition base, especially so when used in a super-regenerative circuit as a self-quenching detector. This isolation may be easily accomplished with a highspeed hand grinder, using preferably a small saw in the chuck rather than an abrasive wheel.

Hold the tube with the base upward and cut away a section around the prong, similar to cutting a piece of pie. Cut away enough of the composition base to leave room for a small screwdriver or matchstick to be used to push the prong in place when the cone should be cemented in place. Care should be exercised not to cut the wire connecting the grid to the prong.

Handy File System

The experimenter, serviceman, amateur, and DX listener will find a small card file system unbelievably helpful in pursuit of their hobby. Using a file in an amateur station, for instance, you can tell in a few seconds whether you have ever worked a station. On each card you can record information on the station, equipment used, signal strength, reports on previous contacts, the "ham’s" name and location, type of antenna he uses, etc. On subsequent hook-ups with stations worked before, you will have all pertinent data at your fingertips.

In DX work, another such file could contain cards for each station heard, together with notations of information concerning these stations. When requesting a verification from a station, you can make up a report based on this information, covering a period of a week, month or a year, as the case may be.

A file of this kind will be found very handy in experimental work, for making notes of each experiment for future reference. It is surprising how often you will refer to these records. On these same cards note any articles or books that you may have read regarding the same subject and this file will therefore represent not only a record of experimental findings but a fairly comprehensive bibliography of technical information.

For most purposes a small metal file box with hinged cover capable of holding several hundred cards can be purchased complete with an alphabetical index and cards for a total of about 35 cents. These are standard 3 x 5 inch file cards. As the cards accumulate and outnumber the small file they can be transferred to a drawer type file which will accommodate something over a thousand cards, and which can be obtained for around a dollar.

A little work is involved in jottting the data down on the cards, but this is as nothing compared with the value of always having the desired information available when you need it.

Fix It Now

The experimenter and the DX listener should check over his equipment every so often, so as to eliminate the small troubles, which if neglected, may become serious problems. In many cases the DX listener can improve both the sensitivity and selectivity of his set, simply by replacing a single defective tube, by lining up the tuning coils, etc. It is a puzzling fact, how often a fan will tolerate distorted reception, due perhaps to an open resistor or some other part which could be found easily by a simple continuity check or the use of an ohmmeter.

The doctor and the dentist find it good business and good psychology to sell their patient the idea of a periodic examination. Many radio servicemen are applying this same idea with equal success. The Radio Gadgear who makes his own equipment can use a little of this psychology, and the advantage will be that his apparatus will operate as originally designed and constructed.

After a piece of radio apparatus has been in use for a period of time an inspection will often disclose that the screws used for fastening the condenser or other parts to the chassis and completing the ground circ-

A Practical Speaker Repair

Dynamic Speakers with rusty, nonremovable field pole pieces that the cone’s voice-coil fits over, may be easily repaired.

First cut out the cone carefully with a sharp knife so that an empire-cloth disc may be cemented between steel shell and cone.

Low Cost Tester

Here is a condenser and continuity checker that one can build and use for many tests that are commonly employed by a radio serviceman. The device uses a half-wave rectifier to change the current from a-c. to d-c. A resistance cord drops the line voltage to 12 volts for the required filament voltage to the 12Z3 tube. A simple filter system comprises a 50,000 ohm 1 watt resistor and a 200 volt, 8 mfd. condenser. The neon lamp can be either the 1/2 or 1 watt size. When testing the condition of condensers a pair of test probes should be plugged into the jacks marked “condenser test.” For testing resistors or other parts out of continuity the test probes should be plugged into the jacks marked “continuity test” as shown in the diagram.

It will be noted that the condenser under test is in series with the neon lamp and the
power source and following the general procedure employed in this method of testing it will be possible to determine if the condenser is normal, leaky, or short-circuited.

When one wishes to check the presence of voltage, or the polarity of the line, he must first turn off the power supply of the tester, then connect the test probes into the proper terminals as indicated on the drawing. One set of plugs are marked for voltages up to 400 volts, the other jacks are marked for voltages to 120 volts. The size of the resistor "R" depends upon the neon bulb. A resistor of about 40,000 ohms will answer this purpose. The neon lamp can be calibrated by the eye.

Although there have been a number of these neon checkers described in the past the experimenter will appreciate the low cost and simple design of this instrument.

Changing the Crystal Frequency

If you wish to raise the frequency of your crystal, the procedure is not so difficult as you might imagine. Ordinary kitchen cleaner, such as Old Dutch or Bon-Ami powder, will act as an excellent grinding medium. A small amount of the powder on a piece of plate glass and use just enough water to make a thin paste. Then simply polish down the crystal by rotating it in the paste solution, pressing down firmly in order to obtain an equal amount of pressure over the entire surface of the crystal. Do not attempt to grind too much, but after a minute or so, wash the crystal and test it in the oscillator.

To lower the crystal frequency, apply India drawing ink to both surfaces with a small brush or mark them evenly with drawing ink a 4" square. Here is a kink whereby the frequency of this tube can be enlarged to at least 3 times in diameter with good detail.

Obtain, from an old camera or second-hand shop, a plano-convex lens with a speed of about f 6.3. Next secure a mirror about 9" square. Then purchase from a camera shop a ground-glass screen, 4x5 inches. With this material at hand, install and mount the parts as shown in the drawing. The mirror is mounted on the wall of the cabinet by a wedge-shaped piece of wood. This mirror should be placed at a 45 degree angle and it is mounted approximately 4" above the tube. Place the ground-glass screen 4" to 5" from the mirror and over the 4" hole prepared for it in the side of the cabinet.

Exact focal distance can only be found by experimenting with the lens and the screen. A shadow box is necessary in order to observe image detail.

Twin-Triodes in Cascade

Twin-triode tubes such as the 53, 6A6, 6N7, and 79 are well known and popular when used with the two triode sections in parallel or in push-pull, but are not generally used with the two sections in cascade as shown in the drawing, because of the tendency toward motor-biasing. This is unfortunate because with the two sections cascaded in a resistance coupled circuit, voltage gains of from 700 to 2000 can be obtained with the single tube; or in terms of decibels, from 57 to 66 db. The reason for the tendency toward motor-biasing is that all of these tubes unfortunately have a common cathode. That is, each section has its own grid and plate, but there is only one cathode for both. This means, where cathode bias is used, that there is coupling between the first and second plate circuits, regardless of the size of the cathode by-pass condenser.

The simple remedy is to avoid this common coupling toward ground. Bias voltages on the two grids. Only two to three volts of bias is required for each and the biasing source may, therefore, conveniently be either flash-light cells (the smallest type will do), or better still the Mallory bias cells. The latter are preferred because they never required replacement and are extremely small.

The two sections enclosed in the one envelope are shown in the conventional cascade form for simplicity. The coupling condensers and resistors are of the usual values, 680 ohm, is necessary only when the microphone or other input is of a type which constitutes a closed circuit, and avoids shorting the bias battery or cells. The bias cells are shown at B1 and B2. If the Mallory bias cells are used they do not require by-passing but flash-light cells should be by-passed with 25 mfd. condensers.

Phone QRМ

Many an amateur who has had no QRМ difficulties whatever while operating on cw, finds that when he tries phone interference is caused in nearby broadcast receivers. Such complaints come, in many instances, from the owners of up-to-date modern receivers, and therefore, according to regulations, it behooves the amateur to aid in removing the interference. In most instances, a wire or other complicated tuning device is unnecessary and a simple method for eliminating this trouble is to place a 2.5 millihenry RF choke in series with the antenna lead to the broadcast receiver.

Single Tube Announcer

Designed for simplicity and economy, this announcing system employs a 12AT type tube in a conventional pentode amplifier and half-wave rectifier arrangement. A 300 ohm line-cord resistance is used to obtain the correct filament voltage. As only fair quality response covering the voice frequencies is desired any inexpensive single-button carbon microphone may be used. Sufficient power is provided to drive a small loud speaker with plenty of volume for the job.

Measuring Power Output

The standard equipment required for lining up a receiver generally comprises a modulated oscillator and an output meter. An experimenter may have the first instrument or can borrow one, but very often his measuring apparatus does not include the second device; that is, the output meter. As a simple substitution for the output meter you can use a Mazda flashlight bulb or a 110-volt, 8-watt pilot lamp to provide visual indication of power. Using the flashlight bulb, it is necessary to disconnect the voice coil of the speaker and connect the lamp across the secondary side of the output transformer. Keep the input voltage down; that is, the applied signal from the oscillator, so as to prevent burning out the lamp. The 10-watt lamp can be connected in series with a 2 mfd. condenser, ahead of the output transformer. The voice coil circuit should be open for this test.

Improving Quality

Even with the best of ordinary baffling, the range, both in quality and volume, of small dynamic speakers is rather limited. By adapting a discarded exponential horn as a baffle the ability of the speaker may be improved considerably. These horns—generally made of fibre—may be obtained quite cheaply from any obsolete orthophonic victrola.

The throat of the horn should be cut off at a point where the cross-sectional area, regardless of its shape, is approximately equal to the cone of the speaker. It may then be attached to the speaker with small brackets. A small section of the original baffling should be retained, however, to prevent distortion.

Soldering Iron Tip

By mixing a little powdered graphite with a drop of oil and applying it on the screw threads of the soldering iron tip it will prevent the tip from sticking. The graphite also helps to prevent corrosion.

Neon Lamp Substitute

Neon test lamps cost from 90c up, but if you will search around the five and ten cent store you may be able to pick up one or more of the little carbon filament lamps
that sell for 10c. These lamps are even more sensitive to r.f. current than a neon bulb.

For use in a wave meter the filament can be used either intact or "blown." With a whole filament the usual glow is produced just as with a neon. With a blown filament the tuning is sharper. Operating in this way series will produce a broader glow point than if the lamp is shunted across the circuit. The filament can be blown by shooting about 500 volts through it.

A.C.-D.C. Receiver Tube Tester

To quickly locate an open circuit in a.c.-d.c. receivers, a handy tester is a small neon light with two rubber covered electric wire probes soldered to the base and side of the bulb base.

Method of Testing

Placing one probe to negative, which is usually the chassis, move the other as follows:

To the high side of the line cord, then to the filament resister that is wound in the cord. (If a ballast tube is used, move probe to each live prong on the ballast tube.) The cord and filament resistor are checked this way for continuity.

Placing one probe to negative, move the other probe to each filament prong of the tube, starting at the rectifier, and then on through all the other tubes.

This step checks the tube continuity.

Placing one probe to the high side of the line cord, and the other probe to each contact of the dial lights, if they are 6-volt lights and are insulated from the chassis (or to the live side of the bulbs if they are 110-volt lights) check the continuity of the bulb filaments.

The a.c.-d.c. cord should be plugged in and the switch turned on for all tests.

Whenever the neon bulb does not glow, there is the open tube, light or resistance, as the case may be.

Replacing the Magnetic Speaker

There are a great many radio beginners who would like to replace their magnetic speaker with an electro-dynamic type. They hesitate because they think it is an involved procedure. Purchase an output choke or transformer of suitable impedance for the dynamic speaker. Connect this in series with the field supply which in turn is shunted by a 4 mfd. condenser. Connect this field in turn in series with the plate terminal of the output tube. The circuit then will run from the place of the output tube to the matching output transformer, from the matching output transformer to the field circuit just described, and from the field circuit to the positive lead of the power supply of the receiver.

A Few Cents Builds This C. P. Oscillator

The search for a simple code practice oscillator still continues and here is one that anyone can build in a few minutes. It employs the fewest possible parts and costs but little to construct. A quarter watt neon test lamp is connected in series with a .001 mfd. condenser as shown in the drawing. One side of the condenser also connects to one side of a telegraph key, the other side of the key then connects to the minus side of a 90 volt B battery or eliminator. Then a 0 to 5 megohm variable grid leak is connected between the plus side of the power source and the remaining side of the condenser.

Pressing the key completes the circuit between lamp, phones and resistor and causes the lamp to oscillate. For normal use set the resistor at about 1 1/2 megohms. Lowering or raising the resistance will alter the pitch of the signal.

Winterizing the Antenna

Whether you are continuously receiving, transmitting, or both, it should be given a good "once over" before winter sets in. Much of the pleasure and efficiency of good signal transmission and reception depends upon the antenna system. So give every joint the benefit of the doubt.

If you employ a mast, look it over for weak points in construction and remedy them. If possible, slap on a heavy coat of paint. An unpainted mast will deteriorate rapidly.

Look over the stays. Any stick that is kinked badly or rusted should be replaced with a new one. A broken stay during a 60 mile winter gale will probably mean disaster. Better fix it now.

A rope halyard, supporting any strain, is good for about a year. Any that appear suspiciously weak must be removed and new rope received through the pulleys. No need to climb the mast or lower it to do this. Just butt the ends of the new and old rope together and spiral a piece of wire along the joint from one to the other. Then carefully haul the joint up and through its pulley until the new rope is in place.

Handles for Phone Cord Tips

The tips of phone cords can be more easily withdrawn from the pin jack if a %" knurled nut from a battery binding post is soldered to the tip. The knurled nut should be drilled out so that it can be passed over the phone tip and soldered to the end, as illustrated. The knurled edge makes removal and insertion of the tips, extremely simple.

Mark the Resistors and Save Time

If you will mark each carbon resistor with its ohmage value, using quick drying lacquer and a small brush, much time will be saved when selecting the correct resistor in set building or in repairing. Condensers, r.f. chokes, etc., too, can also be labeled with their capacities.
HIGH-RESISTANCE VOLTOMETER

The function of a voltmeter is to measure the difference of potential existing between two points in a circuit. It should not influence in any way the circuit or device across which the difference of potential exists. Since every voltmeter will draw some current from the circuit across which it is connected, this current really puts a load on the circuit or device being measured. If the circuit or device has quite some resistance, the meter current flowing through it may produce an additional appreciable fall of potential through it. In this case, the voltage indicated by the meter is really lower than the actual voltage which exists across the circuit normally when the meter is not connected to it.

Thus in (A), suppose we are to measure the output voltage across the B battery eliminator circuit at A-B. An e.m.f. of say 100 volts is applied to the circuit by the rectifier tube, and a resistor of 20,000 ohms is in series with the voltage tap we are connecting the voltmeter across. Suppose the voltmeter has a range of 150 volts and total resistance of 1,000 ohms. The current actually flowing through the resistor and the voltmeter may be found by Ohm's law. Since the 20,000 ohm resistor and the voltmeter resistance are now in series we have:

\[ I = \frac{100}{20000 + 1000} = \frac{100}{21000} \]

This current flowing through the 20,000 ohm resistance causes a voltage drop across it of

\[ V = I \times R = \frac{100}{21000} \times 20000 = 96 \text{ volts.} \]

The voltage actually recorded on the meter then, is the difference between the applied circuit voltage and the drop across the 20,000 ohm resistor or:

\[ V = 100 - 96 = 4 \text{ volts.} \]

Thus the meter is not indicating the true voltage of the circuit, since it is drawing so much current from the circuit that the circuit voltage drops when it is connected. The meter reads 4 volts, whereas the voltage of this circuit when the meter is not connected, is 100 volts. Of course this is an exaggeration.

The remedy for this condition is to use a high-resistance voltmeter, that is, one having a high resistance connected in series with its moving coil. Suppose the meter has a resistance of 1,000 ohms for each volt range of its scale (1000 ohms-per-volt), then its total resistance is 150 \times 1000 = 150,000 ohms. The current from the circuit just considered would be:

\[ I = \frac{100}{20000 + 150000} = \frac{100}{170000} \]

0.0058 amperes, or 6.8 milliamperes.

The I x R drop across the resistance in

\[ E = I \times R = 0.0058 \times 20000 = 12 \text{ volts.} \]

and the voltage read at A-B would be

\[ 100 - 12 = 88 \text{ volts.} \]

This shows that the high resistance voltmeter gives a reading of 88 volts which is much nearer the true open-circuit or no-load voltage of 100 volts than before.

Since a voltmeter having a high resistance takes very little current from the line, the meter itself must be very sensitive, that is, it must require very little current to move its coil and pointer over full scale deflection. This means that either the permanent magnet must be stronger than in the usual meter, or else more turns of wire must be wound on the moving coil to obtain the same ampere-turn effect at a smaller value of amperes. The latter method is used in the construction of high resistance voltmeters used in radio work. The moving coil has several layers of exceedingly thin copper wire in order to produce the necessary magnetic field strength. Such meters have a resistance as high as 1000 ohms-per-volt. The term ohms-per-volt may be understood by considering the specific case of a 1000 ohms-per-volt meter having three ranges, 7.5, 150, and 750 volts. Then the resistance in series with the 7.5-volt terminal is 7.5 \times 1000 or 7500 ohms; that in series with the 150-volt terminal is 150 \times 1000 or 150,000 ohms; that in series with the 750-volt terminal is 750 \times 1000 or 750,000 ohms.

The "ohms-per-volt" value of \( R_w \) is equal to the total resistance \( R_t \) of the meter divided by the maximum voltage \( E_t \) marked upon the scale considered, or

\[ R_w = \frac{R_t}{E_t}. \]

Voltmeters having a resistance of 1000 ohms-per-volt are used extensively for voltage measurements in radio receivers and power packs. Voltmeters having an ohms-per-volt value as low as 100 are used in ordinary electrical work, since the few milliamperes of current taken by the meter is not objectionable here.

It should be remembered that it is not possible to make a high-resistance voltmeter of the same range from a low-resistance V.M. more upon boosting the desired signal than suppressing lead-in pickup. This is accomplished by tuning the antenna circuit to the desired wave-length. No impedance-matching transformers are needed. The antenna proper may be anything from 25 to 75 feet long. The lead-in, doubled upon itself, is made practically non-inductive, and its capacity minimized, by the spacing, 1/2 inches. Transpose every four feet with 2 inch square spacers, which can be threaded on and worked along to position.

The antenna is a quarter-wave, or Marconi, for broadcast, and a Zeppelin for short waves, receiving the latter best from either side. Two inverted L's, at 90 degrees angle, converging on a common lead-in, will receive from all directions—but this calls for a highly selective receiver.

Some experimentation will be necessary to find proper size of coils. Old style sets with low-impedance input may require the variable condenser in series with the wire that goes to antenna post, and loading coil in wire to ground post of the receiver. (It is important that these two wires be marked for identification so that they will not be connected to the wrong posts.)

The secondary of an r.f. transformer, designed for a .00035 condenser, will be about right for the broadcast coil L1. Short-wave coils 2, 3, and 4 consist of 45, 25, and 15 turns respectively, wound on 1-inch tubes.

R. M. A. COLOR CODE

For Fixed Condensers, Unit: Micro-Microfarads

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</table>
In order to reproduce the excellent fidelity of the amplifier, the selection of the output transformer and speakers must be considered. The use of a Universal type of output to line transformer permits a proper impedance match to be made to meet various loads at changes in plate voltage. The selection of the taps shown are correct for the average watts output as is had when using the 2nd position on the voltage switch. By using a 500 ohm secondary the change of plate load offers far less mismatch to 500 ohms line than it would if a low voice coil impedance were used, with a net result that the audio watts output may be changed by choosing various positions on the switch and the change in voltage applied to the 6L6 plates will not materially effect the response of the amplifier. One to four speakers may be used. When using all four speakers at one time, the 2000 ohm taps are used all in parallel, or a total impedance of 500 ohms.

The frequency response of the amplifier may further be enhanced by adding a simple network in order to provide stabilized feed-back. The values of R16 and R17, together with C8 and R19, control the amount of signal output voltage that may be fed back to the control grids.

A standard D.B. meter may be used in place of the O-25 ma. This meter has its scale marked from -10 to +6 D.B. and is calibrated for 500 ohm lines. In order to provide a means of setting the meter to a certain audio level, a 200,000 ohm potentiometer may be used as a series resistor and connected as shown on the schematic. This will not provide any accurate reading to be had, but is used simply to limit the maximum deflection of the needle to read zero on the scale at the peak volume required for a given application.

The complete amplifier is contained in a metal cabinet measuring 12 inches wide, 12 inches high and only $1/2$ deep. A durable leather carrying hand is bolted securely to the top of the cabinet.

Many P.A. installations that are set up in connection with stage presentations use two or more microphones, not only to permit greater range of pickup, but also to allow the gain to be reduced to the individual mikes in order to reduce the possibility of feedback from the speakers. The use of a pair of head phones to monitor the amplifier is highly recommended as it permits the operator to concentrate on the pickup from the various microphones where an unbalanced condition might easily be corrected. Provision is made for the operator’s head-set and a choice of jack position may be had for either high or low level.

In setting up the amplifier, the master gain should be adjusted so that the top level of volume on all the inputs can not be exceeded.
THAT'S the news about C-Ds. And it's news too big to hold. Cornell-Dubilier has combined Super Performance with New Economy to bring you a capacitor HIGH in quality, HIGH in efficiency, voltage and dielectric strength, yet down-to-earth in price. Take the shortest route to your jobber today. Ask for C-D—the capacitor with more abundant life at no extra cost.

Here are two of the popular amateur capacitors in the complete C-D line.

**DYKANOL TRANSMITTING CAPACITORS**

are genuine Dykanol, FIREPROOF transmitting filter capacitors that can be mounted vertically or inverted by means of the mounting ring supplied. Equipped with neat porcelain terminals. Available in a complete range from 2 mike 600 to 2 mike 5000 v, at new low prices. Type TJU is specified in the new Thordarson 100 watt x-mitter. Be sure to send for new Catalog No. 161 today.
A Silent Microphone Ring

A SIX inch embroidery hoop and eight small rubber bands can be made into a very serviceable microphone ring.

First, form four hooks by straightening off the paper clips out and cutting into 1½ inch lengths and bending with round nosed pliers.

The hooks are inserted into the holes intended for them in the mike and then two small rubber bands looped into each hook.

Set the mike on the table, hold the smallest hoop in the hand, and run the rubber band from one hook over the rim, around under and back into the hook again. Do the same with the other three. Move the mike into the exact center and then place the other hoop over the smaller one. This will keep the bands from sliding from the weight of the mike.

The mike may be mounted anyway desired; the suspension method is excellent.

In an apartment on the main street of town with street cars going by every few minutes, the rubber bands absorb more shock than the usual springs.

Holder for Test Leads

An efficient means of avoiding tangled messes of test leads is by the use of a piece of fiber tubing for holding the leads in the manner of the old-fashioned napkin holder.

An old cartridge fuse of a larger size, 60-amp., or 100-amp., which are often discarded by factories and power companies, is good enough for this purpose, although new fiber tubing may, of course, be used. The inner corners should be rounded away to permit easy insertion of the folded leads.

Low-Cost Field Strength Meter

A FIELD strength meter for the amateur need not be a complicated affair particularly for noting field patterns or plotting strength of field from directional systems. A fixed crystal, milliammeter and tunable tank are the essentials and can be put together quickly by any radio builder.

The outfit can be made breadboard style but more stable readings can be obtained by enclosing the hook-up in a can or metal box. Mount the 0 to 1 milliammeter and the condenser on the panel. Then fit a four prong socket on the top of the box for the tuning coils. The crystal is mounted within the box. The tuning condenser and tank coil should be of a size to suit the frequency being tested. A .0025 md. condenser will suit most anything down to 20 meters. Wind both the tank coil and absorption coil on the same form.

In testing the field strength and pattern of an antenna system it is only necessary to insert the coil to suit the transmitted frequency and note the various readings of the milliammeter in different locations with reference to the antenna after carefully tuning the meter for maximum readings. The readings can then be plotted on a suitable chart.

Tubing Antenna

THE use of metal tubing rather than wire offers a number of advantages for antennas designed for use in the ultra-high frequency ranges. There is the larger surface area and the resulting reduction in r.f. resistance.

INTERNATIONAL “Q” SIGS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>QRA</td>
<td>What is the name of your station?</td>
<td>The name of my station is.</td>
</tr>
<tr>
<td>QRB</td>
<td>How far approximately are you from my station?</td>
<td>The approximate distance between our stations is _______ nautical miles (or _______ kilometres).</td>
</tr>
<tr>
<td>QRC</td>
<td>What company (or Government Administration) settles the accounts for your station?</td>
<td>The accounts for my station are settled by the _______ company (or the Government Administration of _______).</td>
</tr>
<tr>
<td>QRD</td>
<td>Where are you bound and where are you from?</td>
<td>I am bound for _______.</td>
</tr>
<tr>
<td>QRG</td>
<td>Will you tell me my exact frequency (wave-length) in kc/s (or m)?</td>
<td>Your exact frequency (wave-length) is _______ kc/s (or _______ m).</td>
</tr>
<tr>
<td>QRH</td>
<td>Does my frequency (wave-length) vary?</td>
<td>Your frequency (wave-length) varies _______.</td>
</tr>
<tr>
<td>QRI</td>
<td>Is my note good?</td>
<td>Your note varies.</td>
</tr>
<tr>
<td>QRR</td>
<td>Do you receive me badly? Are my signals weak?</td>
<td>I cannot receive you. Your signals are too weak.</td>
</tr>
<tr>
<td>QRK</td>
<td>Do you receive me well? Are my signals good?</td>
<td>I receive you well. Your signals are good.</td>
</tr>
<tr>
<td>QRL</td>
<td>Are you busy?</td>
<td>I am busy (or I am busy with _______).</td>
</tr>
<tr>
<td>QRM</td>
<td>Are you being interfered with?</td>
<td>Please do not interfere.</td>
</tr>
<tr>
<td>QRN</td>
<td>Are you troubled by atmospherics?</td>
<td>I am being interfered with.</td>
</tr>
<tr>
<td>QRO</td>
<td>Shall I increase power?</td>
<td>I am troubled by atmospherics.</td>
</tr>
<tr>
<td>QRP</td>
<td>Shall I decrease power?</td>
<td>Increase power.</td>
</tr>
<tr>
<td>QRQ</td>
<td>Shall I send faster?</td>
<td>Decrease power.</td>
</tr>
<tr>
<td>QRR</td>
<td>Shall I send more slowly?</td>
<td>Send faster _______ words per minute.</td>
</tr>
<tr>
<td>QRS</td>
<td>Shall I stop sending?</td>
<td>Send more slowly _______ words per minute.</td>
</tr>
<tr>
<td>QRT</td>
<td>Have you anything for me?</td>
<td>Stop sending.</td>
</tr>
<tr>
<td>QRU</td>
<td>Are you ready?</td>
<td>I have nothing for you. I am ready.</td>
</tr>
<tr>
<td>QRV</td>
<td>Shall I tell _______ that you are calling on _______ kc/s (or _______ m)?</td>
<td>Please tell _______ that I am calling him on _______ kc/s (or _______ m).</td>
</tr>
<tr>
<td>QRW</td>
<td>Shall I wait? When will you call me again?</td>
<td>Wait (or wait until I have finished communicating with _______) I will call you at _______ o’clock (or immediately).</td>
</tr>
<tr>
<td>QRX</td>
<td>What is my turn?</td>
<td>Your turn is _______ (or according to any other method of arranging it).</td>
</tr>
<tr>
<td>QRY</td>
<td>Who is calling me?</td>
<td>You are being called by _______.</td>
</tr>
<tr>
<td>Qrz</td>
<td>What is the strength of my signals (1 to 5)?</td>
<td>The strength of your signals is _______ (1 to 5).</td>
</tr>
<tr>
<td>Qsa</td>
<td>Does the strength of my signals vary?</td>
<td>The strength of your signals varies.</td>
</tr>
<tr>
<td>Qsd</td>
<td>Is my keying correct; are my signals distinct?</td>
<td>Your keying is incorrect; your signals are bad.</td>
</tr>
<tr>
<td>Qsg</td>
<td>Shall I send _______ telegrams (or one telegram) at a time?</td>
<td>Send _______ telegrams (or one telegram) at a time.</td>
</tr>
<tr>
<td>Qsj</td>
<td>What is the charge per word for _______ including your internal telegraph charge?</td>
<td>The charge per word for _______ is _______ francs, including my internal telegraph charge.</td>
</tr>
<tr>
<td>Qsk</td>
<td>Shall I continue with the transmission of all my traffic, I can hear you through my signals?</td>
<td>Continue with the transmission of all your traffic, I will interrupt you if necessary.</td>
</tr>
<tr>
<td>Qsl</td>
<td>Can you give me acknowledgement of receipt?</td>
<td>I give you acknowledgment of receipt.</td>
</tr>
<tr>
<td>Qsm</td>
<td>Shall I repeat the last telegram I sent you?</td>
<td>Repeat the last telegram you have sent me.</td>
</tr>
<tr>
<td>Qso</td>
<td>Can you communicate with _______ direct (or through the medium of _______)?</td>
<td>I can communicate with _______ direct (or through the medium of _______).</td>
</tr>
<tr>
<td>Qsp</td>
<td>Will you retransmit to _______ free of charge?</td>
<td>I will retransmit to _______ free of charge.</td>
</tr>
<tr>
<td>Qsr</td>
<td>Has the distress call received from _______ been cleared?</td>
<td>This distress call received from _______ has been cleared by _______.</td>
</tr>
<tr>
<td>Qsu</td>
<td>Shall I send (or reply) on _______ kc/s (or m) and/or on waves of Type A1, A2, A3 or B?</td>
<td>Send (or reply) on _______ kc/s (or _______ m) and/or on waves of Type A1, A2, A3 or B.</td>
</tr>
<tr>
<td>Qsv</td>
<td>Shall I send a series of VVV _______?</td>
<td>Send a series of VVV _______.</td>
</tr>
<tr>
<td>Qsw</td>
<td>Will you send on _______ kc/s (or _______ m) and/or on waves of Type A1, A2, A3 or B?</td>
<td>I am going to send (or I will send) on _______ kc/s (or _______ m) and/or on waves of Type A1, A2, A3 or B.</td>
</tr>
</tbody>
</table>
I WILL TRAIN YOU TO START A SPARE TIME OR FULL TIME RADIO SERVICE BUSINESS WITHOUT CAPITAL

THE WORLD-WIDE USE OF RADIO HAS MADE MANY OPPORTUNITIES FOR YOU TO HAVE A SPARE TIME OR FULL TIME RADIO SERVICE BUSINESS OF YOUR OWN. FOUR OUT OF EVERY FIVE HOMES IN THE UNITED STATES HAVE RADIO SETS WHICH REGULARLY NEED REPAIRS, NEW TUBES, ETC. SERVICEMEN CAN EARN GOOD COMMISSIONS TOO, SELLING NEW SETS TO OWNERS OF OLD SETS. EVEN IF YOU HAVE NO KNOWLEDGE OF RADIO OR ELECTRICITY, I WILL TRAIN YOU AT HOME IN YOUR SPARE TIME TO SELL, INSTALL, FIX, ALL TYPES OF RADIO SETS TO START YOUR OWN RADIO BUSINESS AND BUILD IT UP ON YOUR OWN TIME. I WILL SHOW YOU HOW TO MAKE A GOOD INCOME IN SPARE TIME WHILE LEARNING. MAIL COUPON FOR MY 64-PAGE BOOK. IT'S FREE—SHOWS WHAT I HAVE DONE FOR OTHERS—WHAT I AM READY TO DO FOR YOU.

Many Make $5, $10, $15 a Week Extra In Spare Time While Learning

The day you enroll you start extra money job. We supply you with a small Radio repair job. Throughout your training you send plans and directions that made good space time money—$200 to $500—for huldlings, while learning. I send you special Radio equipment to conduct experiments and build up units. This simple method of training makes learning at home interesting, fascinating, practical.

Why Many Radio Experts Make $30, $50, $75 a Week

Radio is young—and it's one of our large industries. More than 20,000,000 homes have one or more Radios. There are more Radios than telephones. Every year millions of Radios get out of date and are replaced. Millions more need new tubes, repairs. Over $50,000,000 are spent every year for Radio repairs alone. Over $1,000,000 auto Radios are in use, more are being sold every day, offering more profit-making opportunities for Radio experts and Radio IS STILL YOUNG, GROWING, expanding into new fields. The few hundred $10, $50, $75, $150 a week of only a few years ago have grown to thousands. Yes, Radio offers opportunities—now and for the future!

Get Ready Now for Your Own Radio Business and for Jobs Like These

Radio broadcasting stations employ engineers, operators, station managers, and pay up to $5,000 a year. Fixing Radio sets in spare time pays many $200 to $500 a year—full time jobs with Radio dealers, manufacturers and dealers as much as $30, $50, $75 a week. Many Radio Experts open their own Radio sales and repair businesses. Radio manufacturers and jobbers employ testers, inspectors, foremen, engineers, servicemen, and pay up to $6,000 a year. Automobile, radio, aviation, commercial Radio, loud speaker systems are new fields offering good opportunities now and for the future. Television promises to open many good jobs soon. Men I trained have made good in these branches of Radio. Read how they got their jobs. Mail coupon.

I ALSO GIVE YOU THIS PROFESSIONAL SERVICING INSTRUMENT

Here is the instrument every Radio expert needs and wants—an All-Around, All-Purpose, Set Servicing Instrument. It contains everything necessary to measure A.C. and D.C. voltages and currents; to test tubes, receivers, microphones, and any test, old, or new. It satisfies your needs for professional servicing after you graduate—enables you to make extra money from sets while training.

SAVE MONEY—ENROLL AT HOME

Money Back Agreement Protects You

I am so sure I can train you to your satisfaction that I agree in writing to refund every penny you pay me if you are not satisfied with my Lessons and Instruction Service when you finish. A copy of this agreement comes with my Free book.

Find Out What Radio Offers

Act Today—Mail the coupon now for Sample Lesson and 64-page book. They're free to any fellow over 16 years old. They point out Radio's space time and full time opportunities and those coming in Television. Tell about my training in Radio and Television to show you letters from men I trained telling what they are doing and earning. Find out what Radio offers YOU—MAIL COUPON in an envelope, or paste on a postcard—NOW!

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Washington, D. C.

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Feverish Activity.

A recent experience with a Fada 21 demonstrated the close relation between heat and voltage failures. The owner reported that his set cut off in the middle of his favorite program, that it would not resume operation until the following day. Our "outside man" called at his home during various times in the day when he happened to be in the neighborhood, and reported each time that the set was normal.

We finally explained to the customer the only way we could find the phantom fault would be to live with the set. We did not want to pick it up because of our previous experience with mysterious faults in other sets we picked up and tested in the shop; usually, after wasting our time, we found the trouble to be in a neglected feature in the set owner's house.

He suggested, because the receiver failed most frequently between 8:00 and 9:00 p.m., that we come to his apartment to play cards with him every night until the music stopped. He hoped, he told us good-naturedly, that we would not pin the players than service men. We called at his home after we closed up one night, carrying an analyzer and a copy of Hoyle. We laid the power pack over on its side so that we could make tests, after the set stopped, with a minimum of chassis disturbance.

The Fada quit the first night. I laid down one of the highest mels I ever held in my life to follow the others to the front room. A filter condenser section was shorted; we unbolted the chassis and took it to the shop.

The next day we hooked up the set on the floor. It not only played, but continued to play without interruption during a four-day stalemate. We did not want to deliver the set without making sure we would not be installing a rather expensive filter block unnecessarily; the customer did not want to accept it until after we had given our unqualified okay. Luckily, he was one of those rare persons who realized how tricky a set can be at times, and did not require his repairman to be a cross between Steinmets and a Hindu mystic.

The next night we wrapped the power chassis in newspapers that the music was cut off. The filter block was defective, but the trouble did not appear until it had reached a certain operating temperature. We had, by reducing heat dissipation, simulated the operating conditions in the closed console, where the heat from the rectifier tube, assisted by the heat from the tuning tubes below, brought the block to a temperature which probably provided a shorting path when the pitch softened.

A higher voltage in the customer's house could have caused a similar occurrence, providing the shorting path did not burn badly enough to short out all lower voltages. In this particular case, the voltages were the same in both locations, but the breakdown voltage decreased as the temperature rose.

A shop underling, after reading about the mouse-in-chassis incident, offers a suggestion to set manufacturers. While it would not be wise to become too enthusiastic, the recommendation is passed quietly along to the trade for what it is worth: chassis holes should be made either too small for mice, or large enough for cats!
In a relatively short time Howard has risen to a dominating position in the communications field! Howard values in quality amateur receivers are made possible because Howard is also a large manufacturer of household receivers, with consequent savings in manufacturing and material costs to the amateur division.

**MODEL 450-A**

- 12 Tubes—6 Bands—Frequency Coverage 54 to 65 MC
- Ceramic Coil Forms
- B.F.O. with pitch control
- Iron Core I.F. transformers
- Electric bandspread
- Built-in Dynamic Speaker
- Headphone jack
- Accurately calibrated direct reading slide rule dial
- Provision for Howard tube type "R" meter

Price, complete with Tubes and Speaker: $29.95

**MODEL 430**

- 6 Tubes—4 Bands—Frequency Coverage 54 to 43 MC
- Ceramic Coil forms
- B.F.O. with pitch control
- Iron Core I.F. transformers
- Electric bandspread
- Built-in Dynamic Speaker
- Headphone jack
- Accurately calibrated direct reading slide rule dial
- Provision for Howard tube type "R" meter

Price, complete with Tubes and Speaker: $29.95

**MODEL 440**

- 9 Tubes—5 Bands—Continuous coverage 54 MC to 43 MC
- Ceramic Coil Forms
- S.L.F. Ceramic Insulated Tuning Condensers
- Electric bandspread
- Built-in Dynamic Speaker
- Headphone jack
- Accurately calibrated direct reading slide rule dial
- Provision for Howard tube type "R" meter

Price, complete with Tubes and Speaker: $66.50

**MODEL 438**

With the advent of the world famous 430, many have asked for a larger receiver—here it is! Model 438 embodies professional features never before associated with equipment in this price class... real "DX" with R-9 reception; Ceramic Coil Forms; R.F. Stage on all Bands; Separate Coils for each Band; Xtal Filter; Complete Coverage 540 to 43 MC; Electric bandspread with vernier control; (2-stage Iron Core I.F. Amplifier); Accurately Calibrated Slide Rule Dial; Provision for 6-volt Power Supply; Band-Indicator; B.F.O. with Pitch Control; 2 Watts Power Output; Built-in 6" Dynamic Speaker; Head Phone Jack; Douhet or Marconi Antennae Connections; Provision for External Speaker... Provisions for Howard tube type "R" Meter.

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Please send me more information on:
Model 438  ... Model 430
Model 450-A  ... Model 440

Name: ____________________________
Address: ____________________________
City: __________________ State: __________

America's Oldest Radio Manufacturer
New Application for the 6E5

The 6E5 or 2E5 tuning indicator tube can be used as a voltage. It differs from the conventional circuit as it does not employ a diode rectifier but is actually a vacuum tube voltmeter measuring a.c. or d.c. voltage without placing a load on the circuit to be measured.

The operation of the voltmeter is as follows: The cathode tap on the voltmeter divider is permanently adjusted so that the shadow angle of 6E5 tube is zero. When d.c. is applied to the terminals (negative to ground) the shadow angle will increase with an increase in voltage to a maximum of 90° with approximately 8 volts applied. For voltages over 8 volts the 10 megohm uniform tapered potentiometer may be set to calibrated points thereby multiplying the range indefinitely.

When an a.c. voltage is applied, a pulsating d.c. voltage appears in the plate circuit because the tube is biased to nearly cut-off. The condenser from the plate to ground holds these pulses to the peak value making the shadow angle change with voltage exactly as if there were d.c. applied to the terminals. The 0.1 mfd. condenser from plate to ground is very important as values less than this will cause the line of the shadow to be fuzzy on frequencies as low as 60 cycles, and a condenser with higher capacity will make the change of the shadow angle too sluggish for abrupt changes in voltage.

The diagram as shown is fine for all d.c. or audio frequency measurements such as an output indicator, detection of grid current or positive peaks on grids of a.f. amplifiers or measurements of impedance of choke coils, condensers and resistors at low frequencies. As the capacity of the test leads cause too much loss for r.f. measurements, an adapter is used. It consists of a six prong male and female plug wired together with a 5 wire cable, all connections being made straight through except the grid circuit which is left vacant. One plug of the adapter is inserted in the tube socket, the other receives the 6E5 tube.

A short length of stiff wire is wrapped around the grid prong of the tube and extended outward at the junction of the tube and plug as pictured in the drawing. A 5 or 10 megohm resistor should be connected from grid to ground if the circuit to be measured does not provide a d.c. path.

As no means are provided to insure permanent calibration, indication of absolute values of voltage may be inaccurate.

PRACTICAL REMOTE AMPLIFIER

The radio station where a great number of outside pick-ups form a large part of the daily operations schedule, must be equipped with not only a sufficient quantity, but also quality type, of amplifiers. Commercial amplifiers meet practically every demand of a broadcaster, however to be equipped with an adequate number is rather costly.

The circuit shown was used in the amplifier illustrated here. The first two stages using 6J7's as pentodes with a 6F6 working as a triode in the output. The input channels are 270 ohms and the output is 500 ohms working into a 5 DB pad to cut down line reflection. The main gain varies in steps of 2 DB from 0 P to 40 DB. The volume indicator can be attenuated from minus 10 DB to plus 6 DB, also in 2 DB steps. The frequency response is plus or minus 1 DB from 40 to 10,000 cycles. The overall gain including mixers and output pad is about 103 DB. The hum level is down 50 DB at zero level, loaded. The filament drain is .9 amps and the B battery drain is 25 mAs.

The front panel and chassis is constructed from 14 and 16 gauge aluminum, resp. The front panel is cut 19" long and 9" high. The chassis is bent from one piece as shown in Fig. 4, the top of chassis is 6" and bent down for 4". The sides of chassis are then cut in the shape shown in sketch, being 6" wide with the sides parallel to 4" and tapered to the 9" mark to fit behind the front panel. All these parts are then fastened together with angle brackets. As shown in sketch, 8 such angle brackets will be necessary. Ready made 5/8" tapped 6-32 brackets will solve this problem perfectly.

Obviously it is much easier to drill all necessary holes in panel and chassis as shown in sketch and then assemble the parts. After chassis has been assembled the tube sockets are mounted in a piece of aluminum 2" wide and 6" long, which can be cut from the...
waste from the chassis. This cradle like element is then fastened to chassis directly below the holes cut in chassis to allow tubes to pass. The cradle is mounted with 1" 6-32 machine screws which are inserted in sponge rubber washers on either side of the cradle and on the top of the chassis.

The tubes will then be free from mechanical jars that may cause undesirable microphonics in the first stages. With the transformers mounted in positions shown in Fig. 3, the microphone receptacle and battery plugs are mounted on the back of chassis as also shown in same picture.

Wiring is conventional, with care taken to shield all the grid leads and the plate leads from the coupling condenser. The placement of the parts in the under chassis is largely a matter of choice, keeping in mind that the shorter the leads the less trouble to be encountered.

After wiring has been completed the gains can be mounted and connected to proper channels, running temporary battery leads the amplifier can be checked for operation with a pair of phones. Now that everything is OK the batteries can be mounted on either side by the use of a large U clamp made from a piece of the 14 gauge aluminum or, if you are more ambitious, a piece of iron. It is drilled to pass a 10-32 machine screw and with batteries in position it can be fastened to side of amplifier. The amplifier can then be checked with an open microphone in the circuit and the output compared to other standard amplifiers.

If an audio oscillator is at hand with an output indicator, a low level in the order of zero can be applied to the input on the assumption that the output transformer has a load resistor connected across it, and the frequency characteristic found with the comparison of the two indicators, that is the one at the input of the amplifier and the output V. I. ordinarily used.

The case for the amplifier was custom built by a cabinet maker. It is made of ply wood covered with a tough leather and varnished. The amplifier can be constructed for a cost slightly over $80.00. For the ham or P. A. man who would need for a high gain amplifier and not necessarily need the mixers or V. I. it could be constructed for about $40 since these two components cost about half the total amount.

The unit will make a superb preamplifier for recordings or broadcasting.

Reducing Drift in Receivers
When constructing a communication receiver it is desirable that the filament transformer have a large safety factor to prevent excessive heat within the cabinet. By going a bit farther, it is good practice to allow the tube filaments or heaters to remain turned on at all times which will then maintain a fairly constant temperature around the various parts in the set and a great reduction in frequency drift will be the result. Many of the communication systems leave the receivers in constant operation, including the plate as well as the filament supply. It is a decided advantage to be able to come home with the intention of "looking over the band" as the Ham would say, and find the receiver ready and willing to remain as originally calibrated at the factory. The life of a vacuum tube operated under the above conditions is in-

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two new McMurdo Silver engineering triumphs

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Diversity reception is the only effective means known of eliminating fading and its accompanying noise in reception. Heretofore the very cheapest of diversity receivers has cost many hundreds of dollars.

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Available as a kit for only $16.80 net to amateurs, or $22.20 factory wired and tested with tubes, the Diversity Coupler has been described by RADIO NEWS as "THE invention of 1938." For an insignificant cost it turns any good set into a dual diversity receiver...such as only the commercials could afford up to now.

WAIT...WATCH! Something new in communication receivers will be offered by Guthman soon. Designed and built by McMurdo Silver to commercial construction standards, giving an order of efficiency quite extraordinary, and boasting features and performance worthy of $100.00 to $200.00 receivers, it's worth waiting for. Style and appearance to make your mouth water...price will delight you. Don't buy a new receiver until you see the Silver Super at your jobber, or write Dept. 408 for full details.

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creased as the heating and cooling effect is reduced when a constant temperature is maintained.

Tinning the Soldering Iron

Many servicemen do not know how to tin an iron with rosin-core solder after the iron has become hot and has been in use. If the iron is too hot to take hold, the cord should be removed for a minute or so to reduce this heat. As the iron cools off it will reach a temperature where solder will readily take hold, providing, of course, the tip of the iron is clean. Filing of the tip will improve matters in any case.

Reaming with Tools Made of Soft Steel

Much trouble can be caused by using handles of pliers, etc., as a reamer when enlarging holes in chassis and panels. The friction may magnetize the tool and handles of pliers, etc., will readily take hold, should be removed for iron.

Tin an iron with rosin-core solder and remove for tin an iron with rosin-core solder any short circuit that will enable you to continue using the set without any servicing expense.

Concerning Doublet Antennae

Many an experimenter and serviceman has installed the most expensive type of commercial doublet in an effort to reduce the noise level, and to increase the signal. Sometimes they have even made up elaborately double spaced double-doublets only to find that after they were hooked up to the set, that they did not work as well as a single wire.

The wire may be found not with the doublet, but with the match between the antenna and the set.

The first thing is to determine what the input-to-the-receiver impedance is. Next a doublet must be used that will match that input. We know of at least one receiver that has an impedance of only 200 ohms. It is wholly useless to match a 600 ohm doulet to it, since there will not be the maximum transfer of energy.

Always match the doublet to the set, and make the doublet so that it will match. Formulas are available in most handbooks.

Adapter for Determining Coil Frequency

In winding plug coils it is general experience to find that the prescribed number of turns in theory is not the number needed in practice. After the coil had been assembled on the core, the operating frequency was so far above or below the frequency coverage desired. Here is a little adapter that has proven an excellent aid for trying turns before making the final solder connection.

Using this adapter, wind on more turns than are called for, and solder all leads to their respective pins except one lead of the secondary coil as shown in the sketch. The adapter consists of a thin wafer socket.

Push the prongs of the form coil into this socket as far as they will go, then temporarily connect the loose lead of the coil to the proper prong on the adapter.

Now push the coil into the regular socket so that the prongs of the coil-form just make contact. In this way you will have freedom for working along the "cut and try" method without removing the coil from the socket.

Remove one turn at a time then check for bandwidth until the correct number is reached for the desired frequency. When this is determined, remove the adapter and run the lead down through the prongs and solder in place.

Cure for Noisy Volume Control

When the resistance strip of a volume control becomes worn or broken it will cause noisy operation and will ruin reception. Here is a simple procedure that will enable a user to continue using the set without any servicing expense.

Take out the volume control and remove the resistance strip. Locate the break and, cleaning the ends of the wire, solder them together. Then gently bend the strip until what was the back side becomes the front or convex side. Put it back on the form. This will present a fresh side over which the contact will slide or roll without interference or break and it will be as quiet as when new.

Home-Made Antenna Tuning Condenser

An efficient antenna tuning condenser can be made for ultra high frequency receivers from material found in the parts box. Use a piece of 1/2" brass or copper tubing about 2" long. Solder a small mounting bracket to one end and mount the tube horizontally on a baseboard. A binding-post and screw can be used to attach the bracket as shown.

Fashion a thin piece of bakelite or fiber for the opposite end of the tube. Drill and tap the center of the plug for a piece of standard threaded brass rod. Then find a brass nut to thread on the rod and solder a bracket to this nut and mount it vertically in front of the plugged end of the tube as shown.

Attach a bakelite binding post knob to one end of the threaded rod. Run the rod through the brass nut and threaded plug as shown. The antenna lead-in is connected to the binding post and the wire to the receiver grid circuit to the brass nut. Screwing the thread in the tube increases the capacitance of the tuning condenser.

If there is any tendency for the rod to touch the inside of the tube, line it with paper.

You will find that this condenser will make possible fine tuning of the antenna circuit to gain the maximum of signal strength.

WHAT IS ELECTRICITY?

Final Analysis

Interesting to reflect that, while electricity is utilized so expertly in our profession, there is yet much difference of opinion concerning its nature. Four sources are drawn upon in getting information as to its nature:

To Funk & Wagnalls, electricity is "a material agency, which, when in motion, exhibits magnetic, chemical, and thermal effects; and which, when at rest, is accompanied by stress."

To Croft, in Practical Electricity: "Electricity is the stuff of which everything tangible is made."

To Morecroft, in his Principles of Radio Communication: "The electron is nothing but electricity."

To the power company: 71/2¢ per kilowatt-hour.

AUTOMATIC FREQUENCY CONTROL MEASUREMENTS

AUTOMATIC frequency control, as applied to modern receivers, is easily serviced when once it is understood. As with other special circuits, (automatic volume control was an example), automatic frequency control was sprung upon many servicemen who were not in a position to understand it well enough to be able to meet service problems.

Basically each automatic frequency control system consists of a discriminator and an oscillator control circuit. The so-called discriminator is a selective rectifier-filter system which supplies a d.c. voltage, which varies with the exciting frequency, to the oscillator control tube. Oscillator frequency control is brought about through regulation of the gain (amplification) of the control tube by means of the voltage supplied by the discriminator.

Figure la illustrates a typical discriminator circuit. Consider the transformer T to be loosely coupled and tuned to the frequency of the receiver. The situation at resonant frequency is as follows:

As the voltage V1 builds up across the primary a current in phase with V1 is induced in the secondary. Because the current lags voltage by 90 electrical degrees in an inductance, the voltage V2 induced into the secondary by this current is 90° ahead of V1 at resonance. At the same time a current through C induces a voltage V3 in the secondary. Because these voltages induced in the secondary are in phase they alternate in step and hence cause equal currents to flow through the diodes. (The induced voltages reach similar values simultaneously.) The total voltage is equal to V4 plus V5 and is arbitrarily called Vp.

Under off resonance conditions either in-
ductive or capacitive reactance predominates and the phase of the voltage \( V \) changes accordingly. At frequencies greater than resonance, inductive reactance is predominant in the tuned circuits and \( V \) is a maximum. Conversely, for frequencies less than resonance, capacitive reactance is the greater and \( V \) leads \( V_i \) by more than 90°. Since \( V_i \) is unbalanced because of the alternating voltage, the phase of the tube is accordingly the same as the phase of the alternating voltage. The tube is then in the linear portion of its characteristic curve and hence causes the plate current of the tube to lag its plate voltage by approximately 90°. The result is apparent shunt inductance across the oscillator tank. Therefore, frequency change is readily accomplished by varying the gain of the tube and hence the amplitude of its output.

Essentially these are the basic principles underlying automatic frequency control. And now that they are understood, let's go looking for trouble. Probably the first thing to be done is...
to conduct careful tests of the tubes involved. Unbalanced diode currents can cause mistuning or even station rejection so a tester which checks both diodes is essential. Of course the control tube must be able to amplify evenly and well or it should be discarded. A power output or mutual conductance tester is preferable for these tests.

An open in the condenser C (Figure 1a) will result in negligible response of the discriminator. The effects of a shorted condenser should be evident.

Incorrect use, although not a defect, is also a responsibility of the serviceman. In order to be able to help his customers he must know how to use it himself. A set using A.F.C. will select the station (from two or three on adjacent channels) which has the greatest carrier voltage in the receiver's antenna, hence do not set up push button A.F.C. so that a stronger station may over-ride the desired one. If the stations involved have equal carriers the set will select the one with the highest percentage of modulation. Such a set is liable to swing from one to another if their modulation percentages differ enough. Swinging or shifting from one station to another is sometimes troublesome on short waves where fading is quite severe. Situations such as this must be carefully explained to the customer.

Naturally the question of suitable test equipment comes up. Several types of equipment may be used, depending upon the connection used for measurement.

A conventional output meter may be used across the output stage. If such an indicator is used the A.F.C. can be tuned in this manner. After aligning the r.f. and i.f. stages in the conventional way, tune the set to zero-beat with the signal generator which should be set at 1000 kc. Detune the discriminator secondary winding a bit and tune the primary for minimum output. Then adjust the secondary winding for maximum output. If the output reading does not change when the A.F.C. is switched off and on the adjustment is correct.

A high resistance voltmeter may be used across the output of the discriminator but is not reliable because it draws current and hence does not show zero voltage accurately. Connect the voltmeter from ground to the junction of the output resistors and tune the primary for maximum output. Then, with the meter across both resistors (from cathode to cathode), tune the secondary for minimum output. A vacuum tube voltmeter is by far the better instrument to use. Check these adjustments with an output meter. During these alignment operations the set should be tuned to the center of the band, 1000 kc, for the best results.

Testing the A.F.C. is quite important and is easily done if this method is used. Tune in and zero-beat a signal from a signal generator.

The Arvin 1237 and 1247 circuit, Figure 4, is very like the one in Figure 3 but the whole set is interesting because it employs the double superheterodyne system. A second oscillator converts the i.f. into another of a different frequency. A.F.C. applied to the second oscillator in the conventional manner results in very smooth and uniform control.

A.F.C. amplifier, a 6K7, which serves to isolate the A.F.C. circuit and provide more positive action. Such amplifiers are now quite common.

The Arvin 1237 and 1247 circuit, Figure 4, is very like the one in Figure 3 but the whole set is interesting because it employs the double superheterodyne system. A second oscillator converts the i.f. into another of a different frequency. A.F.C. applied to the second oscillator in the conventional manner results in very smooth and uniform control.

Philo has an interesting setup in their model 38-2, illustrated in Figure 5. The discriminator output is balanced above ground. Two "lines" supply bias to the two grids of the 6N7G used as the control tube. A small amount of voltage from the oscillator is introduced into both control grids simultaneously. The control grids are effectively in parallel for r.f. and so the voltages on the grids are in phase. However, the phases are in push pull and hence the output voltages are 180° out of phase.

The Arvin 1237-1247 set discussed in the article.

The Arvin 1237-1247 set discussed in the article.

The A. F. C. System of the Philco 38-2, which is explained.
Cancellation in the plate circuit governs the amplitude of the output.

As in other inductive control circuits the grid voltage undergoes a 90° shift across the coupling condenser and hence this current lags the plate voltage by 90 electrical degrees, again appearing as inductance. This apparent inductance is then reflected into the oscillator tank circuit. The amplitude of this shunt inductance is directly proportional to the amount of cancellation in the plate circuit of the control tube. From the foregoing discussion it may be seen that only the method of using the discriminator output is different from the ordinary.

\[ P_1 = \frac{R_q E_I^2}{R_1 I^2} \]

This can then be substituted in the first equation and we get an expression giving the number of db, to be found from voltage ratios direct, if \( R_1 = R_2 \). But this amounts to figuring out the power in each case and still the decibel expresses the power ratio, not the voltage ratio.

Since this decibel represents a ratio and not a number of watts, it cannot be used to refer to a given power level, directly, but it can be used to compare any power level with an arbitrary standard power level. As a reference level or "zero" level, 6 milliwatts is one of the most commonly used. Employing this zero level, a power of 6 milliwatts would be called "zero db."; 6 watts would be plus 30 db.; and 0.6 milliwatt would be -10 db. In all cases the zero level must still be known before the statement can have any meaning. The use of 6 milliwatts as a level, however, is by no means universal; some of the largest broadcasting chains use a different level. One milliwatt, 10 milliwatts, 12

WHAT IS A DB?

Most of the misconceptions in rating the merits and performance of amplifiers, microphones and receivers occur in the use of the decibel and the lack of a single standard zero level as a reference point.

It is not necessary, here, to go into the derivation of the decibel, but it would be best to restate its definition. The decibel is a unit which expresses the ratio of one power level to another. The power may be electrical power representing sound, or acoustic power (power of sound waves). To be exact, the number of decibels gain or loss is equal to ten times the logarithm of the power ratio.

\[ DB = 10 \log \frac{P_1}{P_2} \]

It should be particularly noted here that the decibel refers to a ratio and to power. It is not an absolute unit of power level and not a unit expressing voltage ratios. Sometimes, when the impedance of the circuits is the same, the ratio —- can be expressed

\[ P_1 \]

in terms of voltage or current, because:

RADIO NEWS 1940 RADIO & TELEVISION DATA BOOK
milliwatts, are also being used as reference levels. So it is necessary to make sure of the reference level before comparing such ratings given by different sources. As an example, suppose an amplifier has an output of 30 watts. When the zero level is 1 milliwatt, the output would be called 45 db, while a 10-milliwatt zero level would reduce it to 35 db.

Measurements of sound intensities in the air are also referred to various "zero" levels. At present, there seem to be two different levels in use: one at 1 milliwatt sound pressure (equivalent to 20.4 x 10^-16 watts per square centimeter), and the other, which will presumably become the standard, starts at 1 x 10^-16 watts per square centimeter (equivalent to 207 millibars). Any level of sound energy when measured in the second scale will be 14 decibels higher than in the first scale. Again, it is important to know the zero level before the level in db has any meaning.

There are all sorts of opportunities for misunderstanding when measuring the gain of amplifiers. The gain of an amplifier, in decibels, is simply 10 times the logarithm of P2/P1; where P2 is the output power and P1 is the input power. Since it is often customary to measure decibels only, one should not forget to take into account any difference in impedance. For example, taking an amplifier with transformer input and output; suppose the input impedance is 200 ohms, while the output impedance is 8 ohms (for a voice coil). Under measurement the voice coil will be replaced by an 8-ohm resistor, with a voltmeter across it. Similarly, the input circuit will be connected to the proper impedance network, again using a voltmeter. After the measurements are taken, the gain in db is given by:

\[
DB = 20 \log \frac{P2}{P1} \]

One should never forget to include the last term. When \(Z1 = Z2\), then the term can be omitted, for it will be equal to zero. This will happen when measuring amplifiers with transformer input and output if both are of the same impedance (both 500 ohms, or both 200 ohms, etc.).

There is an additional difficulty with resistance-coupled amplifiers. According to the definition, it is required to measure the input power, but on a resistance-coupled amplifier it would amount only to the power dissipated in the grid leak, for the tube itself does not draw any power. The result is that the rating depends on the size of the grid leak. The same amplifier, made by manufacturer A, can be made by manufacturer B, but changing the grid leak from \(\frac{1}{2}\) megohm to 5 megohms, he is justified to raise the gain 10 db higher. Yet, for all practical purposes, the gain remains the same. The trouble is with the system of rating.

Let us take an example: an amplifier has a resistance-coupled input and a transformer output. The grid leak is \(\frac{1}{2}\) megohm and the transformer output impedance is 500 ohms. During a test it was found that .01 volt across the grid leak resulted in 100 volts across the 500-ohm load. Now the gain is:

\[
DB = 20 \log \frac{100}{.01} = 20 \log 10,000 = 100 \text{ db.}
\]

This amplifier has an output level of 100 db at zero level.
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