RADIO NEWS

1939 RADIO and TELEVISION Data Book

Published by

ZIFF-DAVIS PUBLISHING COMPANY

608 South Dearborn Street, Chicago, Illinois.

RADIO NEWS

1939 Radio & Television Data Book

Edited by the staff of
RADIO NEWS

William B. Ziff, Publisher,
B. G. Davis, Editor,
Karl A. Kopetzky, W9QEA, Managing Editor,
Oliver Read, W9ETI, Technical Editor,
E. Stanton Brown, Associate Editor,
Herman Bollin, Art Director,
Eugene O. Gleeson, Engineering Draftsman,

S. L. Cahn, Advertising Manager,
John H. Reardon, Circulation Manager.

☆

Published by
Ziff-Davis Publishing Company,
608 South Dearborn St.,
Chicago, Illinois

☆

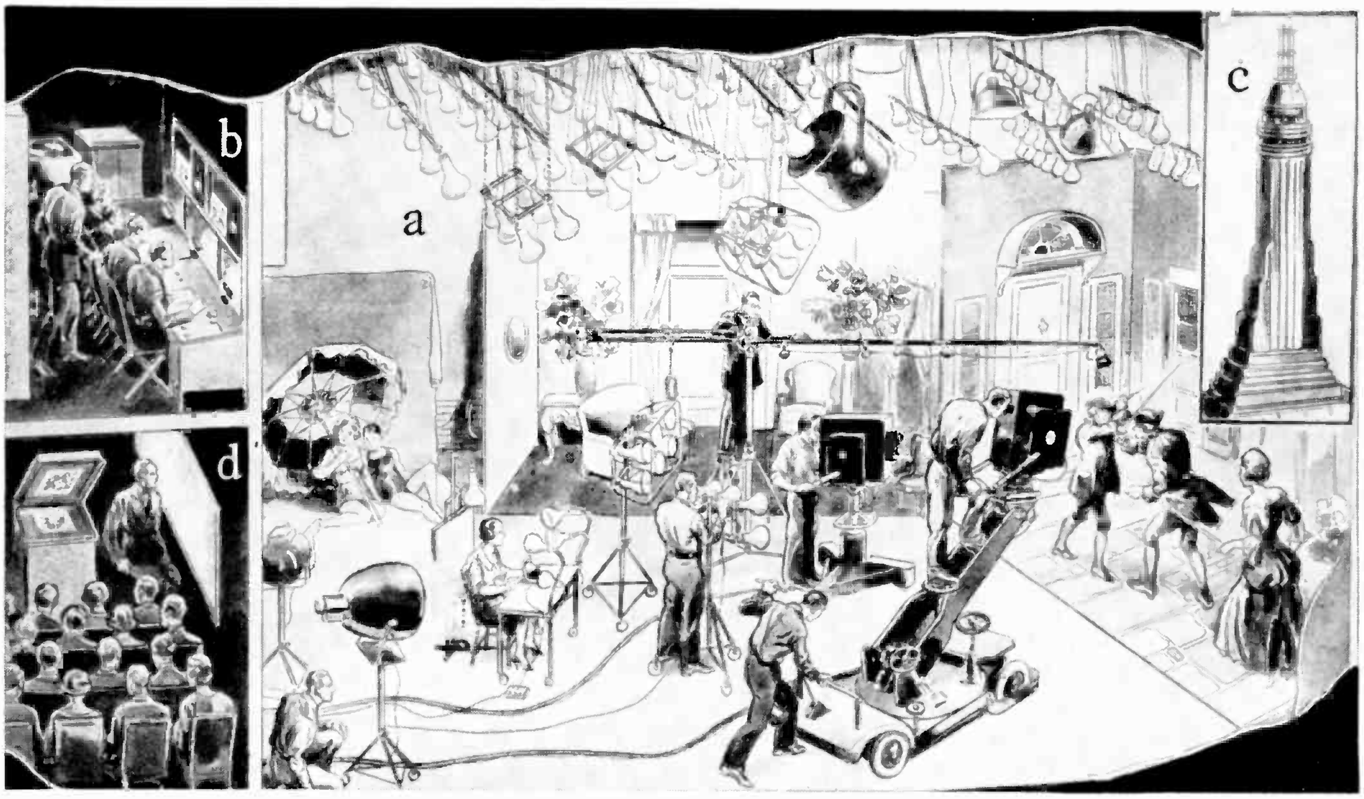
☆

Includes Articles by:
Alfred N. Goldsmith,
M. W. Thompson,
Frank C. Jones, W6AJF,
Raymond P. Adams,
Edmund P. Kelly, W9HPW,
Zeh Bouck,
Ernest A. Zadig,
Joseph H. Appel, Jr., W2FDA,
S. Gordon Taylor, W2JCR,
Lee Ward,
Chas. E. Chappel,
McMurdo Silver,
Lee Sheldon,
L. B. Robbins,
Alfred Ghirardi,
and others.

CONTENTS

TELEVISION

TELEVISION OCCUPATIONS OF THE FUTURE



The above shows the operating technique which will be used in putting on the Television Show this spring.

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.

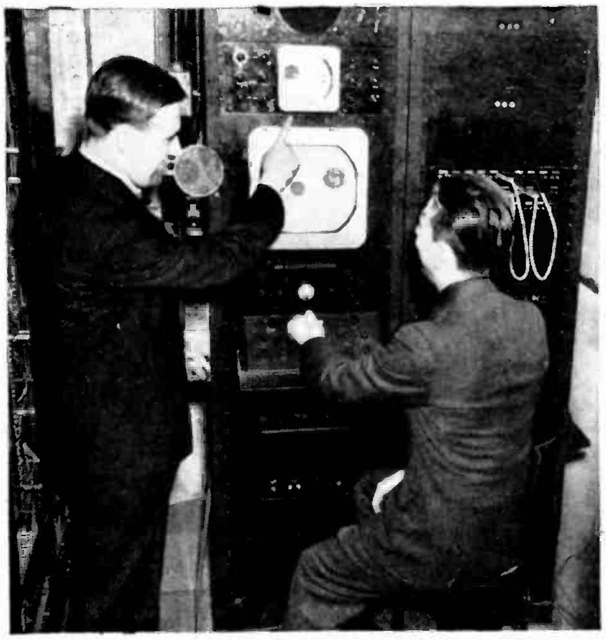
Opportunities in Manufacturing

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



F. J. Bingley (left) & B. E. Schnitzer, Philco television engineers, monitor a live program from Philadelphia station.

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 pick-up whereby 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 focussed. 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 receivers of the future 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.

[Reprinted by the courtesy of *Occupations, the Vocational Guidance Magazine* for April, 1938. (Copyright 1938.)]

Soldering Tubing

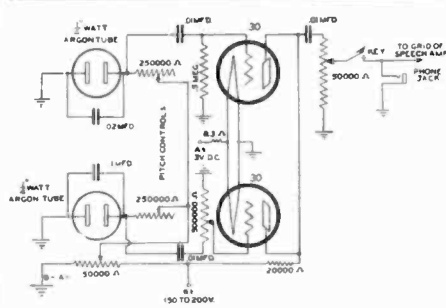
In soldering the copper tubing and its connections, a soldering iron is of little use, unless it be one of the very large, heavy type. Use a small, hot blow torch.

I C W 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 pitches 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



Circuit diagram of the tone modulator.

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

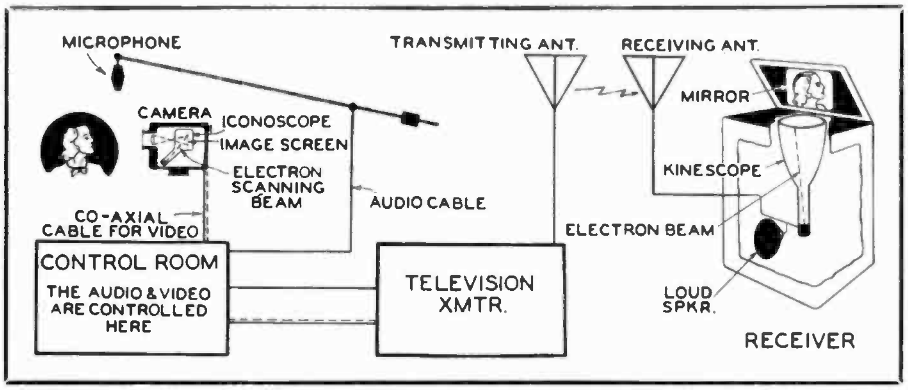


Diagram showing the various stages of the television and audio broadcast.

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 1/13230th-second and "V" is 220½ H's.

There is much of merit in the developments of Marconi, Telefunken, Fernseh, Mihaly-Traub, Scophony, Dumont, Farnsworth and many others. While it appears that American practice will be developed around electron optical scanning systems, based 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 unbelieveable number of combinations of lenses, apertures, prisms and mirrors mounted on drums, spirals and discs. As this is being written, announcement has been made 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 interlace, 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 merit 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 "heaviside" 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."

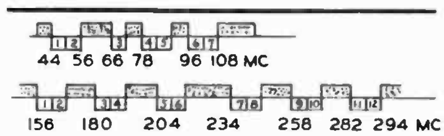


Figure 1.

Each channel is complete in itself, that is it will include 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, 4.0 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 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 58 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 12.74 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 re-creation of television transmission of a scene 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, every point 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 simplified sketch 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 systematically 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

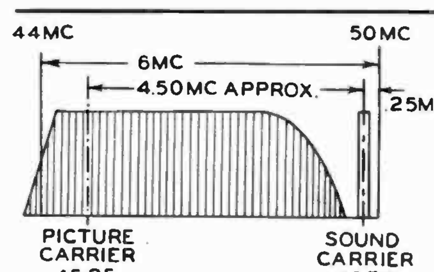


Figure 2.

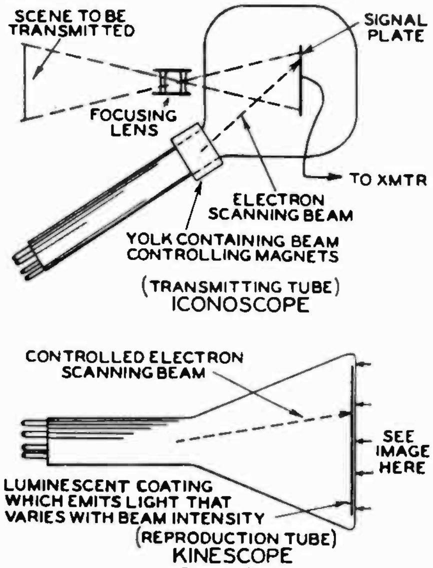


Figure 3.

toward white, varies the intensity of the electron stream in the *Kinescope* as the beam scans the inner surface of the glass end of the tube. As this inner wall of the tube is coated with a preparation (may be either a sulfide or a silicate of zinc) which is highly luminescent, the original scene is re-created in approximately 225,000 pin points of light with surprising fidelity. The negatively-charged particles that compose the beam are moving with velocities of the order of 30,000 miles per second.

Thus, what one will really see is a rapid sequence of pictures as "scanned" by a lightning-fast electron pencil. To avoid flicker, it was known that 24 complete pictures (movie standards) or better, would have to be created per second on the end of the *Kinescope*. The number 30 was chosen, because, being a multiple of the 60-cycle supply frequency, hum difficulties could more readily be avoided. Hum would, in this case, show itself as a dim pattern moving across the picture.

Further to eliminate flicker, it was decided to "scan" the image in a manner known as "interlacing" (see Figure 4). This means that, instead of picking up our lines in regular 1, 2, 3, 4, 5 order, we pick them up as 1, 3, 5, etc., until we have 220½ lines and then jump back and get 2, 4, 6, etc., through another 220½ lines—each complete operation taking not more than 1/60th-second. The full set of 441 lines is known as a "frame" while each half is a "field."

Quite a few factors entered into the choice of 441 as the correct number of scanning lines; any less than this did not give satisfactory detail from a complex scene, while more than this created serious problems. Important, however, as will be shown later, the number has simple factors and can be had by multiplying odd numbers—3x3x7x7. This enters into the generation of synchronizing signals at the transmitter.

To use the language of the RMA *Recommended Television Standards Report*, I will, hereafter, refer to the length of time required from the start of one line to the start of the next line in a field as "H," and the time required from the start of one field to the start of the next as "V." These times are, of course, 1/13230th-second and 1/60th-second respectively.

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 three lines of what would be a third field ("C"). This is necessary to show the differences in pulse arrangement, which explain how interlacing is accomplished.

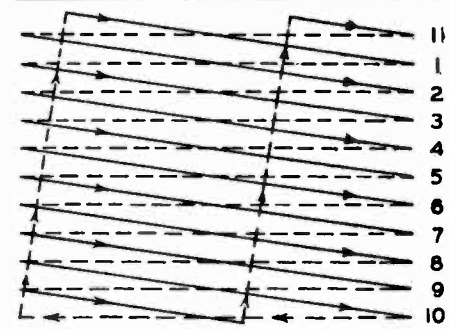
As in voice transmission, the carrier provided for video transmission has a definite amplitude (voltage maximum) which it maintains evenly until modulated, whereupon the voltage rise in each sideband varies with the impressed signals. In the television transmitters and receivers, it is so arranged that full black (of the picture) will be at 75 to 80% of maximum amplitude. The remaining 25% or 20% is to be used for synchronizing pulses. Thus, all variations in the image transmitted are taken care of by variations in carrier voltage from zero to 75 or 80% of maximum amplitude.

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 (sloping 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 full black. In other words, we do not "see" the last 0.15H 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 that 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 (1/60-second) which is, roughly 15 to 22 lines of our 220½ 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 interlace in the receiver, and their action will be described in article three.



VISUALIZATION OF INTERLACING

Figure 4.

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.

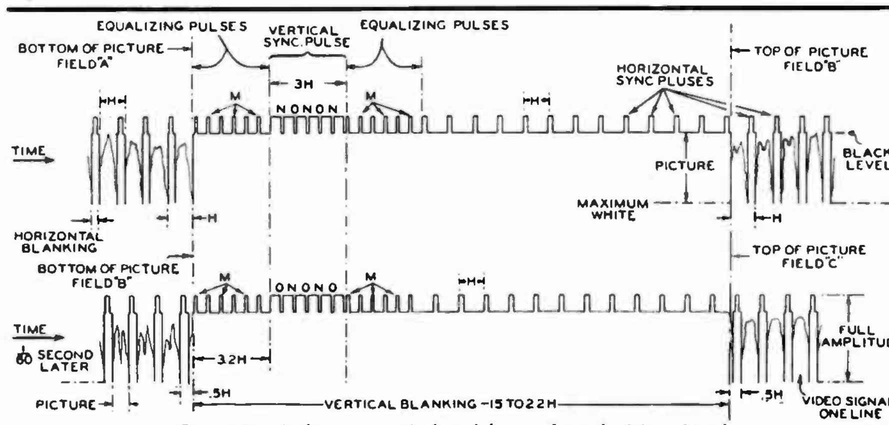


Figure 5. A diagrammatic breakdown of a television signal.

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 ½H "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 ¾ width, regardless of size *Kinescope* used.

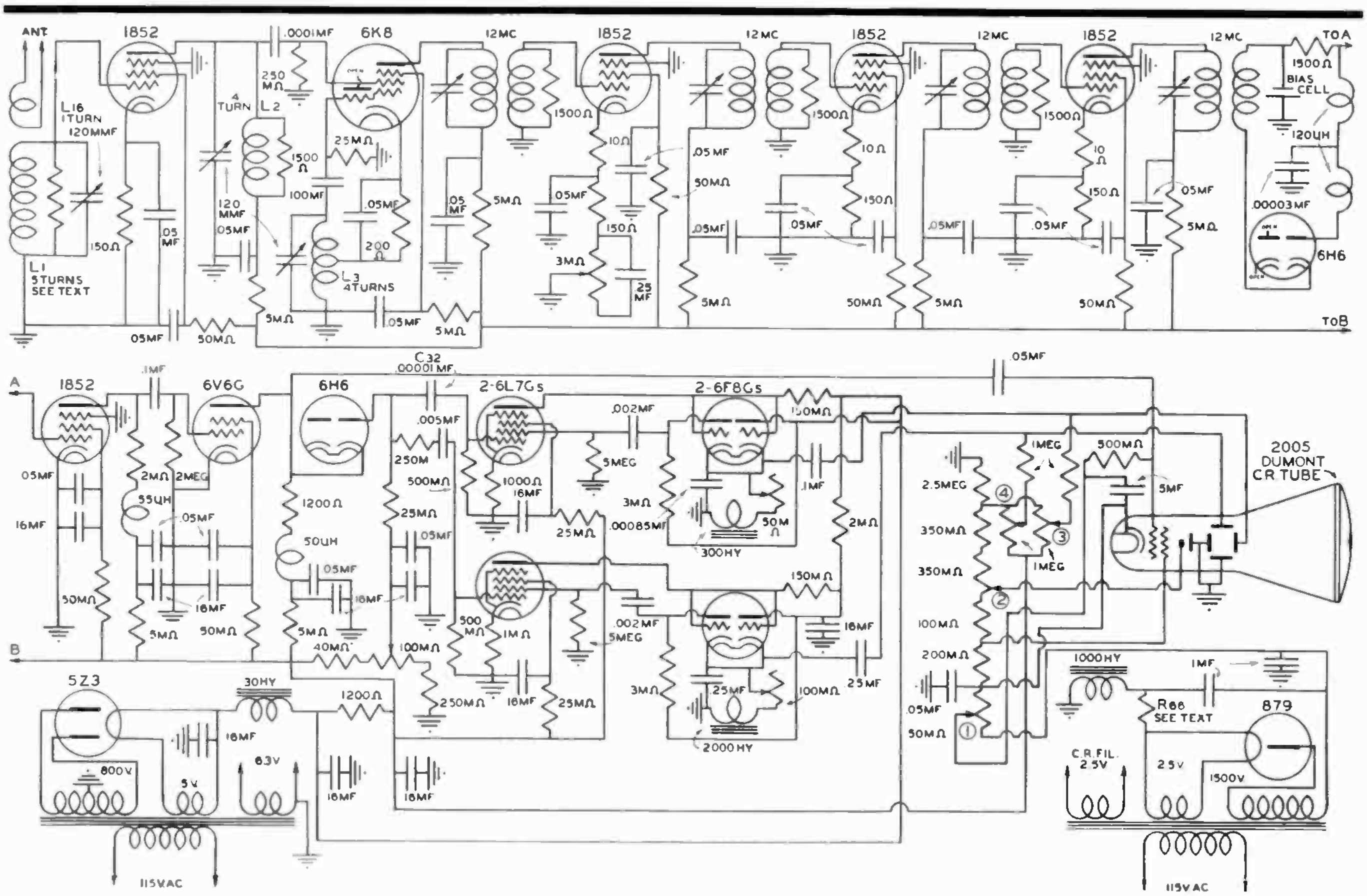
BUILDING A TELEVISION RECEIVER

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 intertwined 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 r.f. and i.f. circuit must be capable of passing a tremendously wide band of frequencies which constitutes the video signal. Even where only only a single side-band is transmitted the receiver circuits are called upon to pass a band approximately 2500 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.

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 receive pictures from stations using the R. M. A. standards of 441 lines, 30 pictures per second with interlaced 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 also the synchronizing impulses by 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 biased 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.

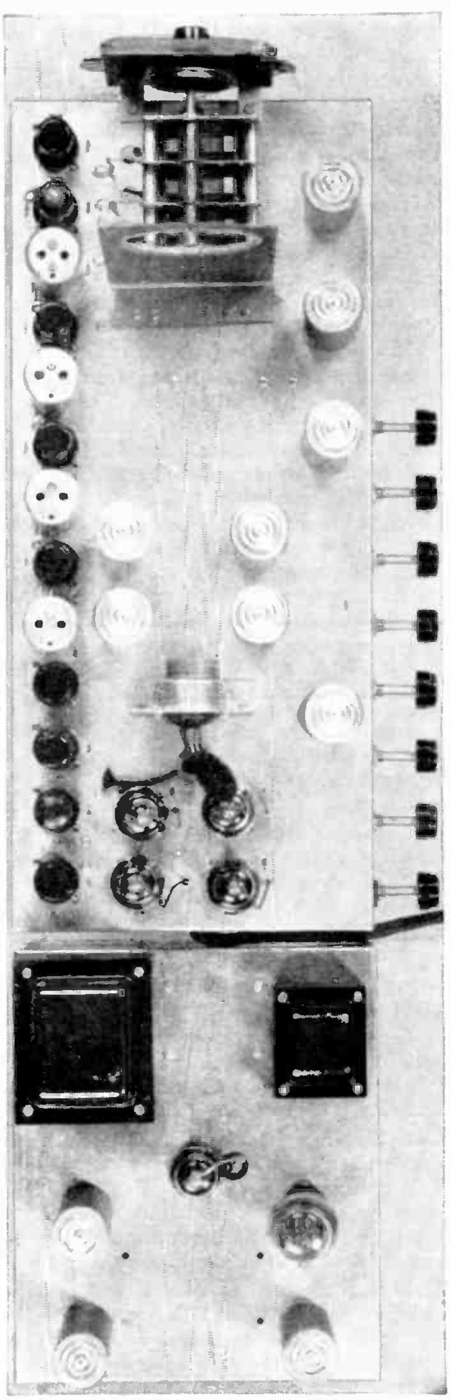
Separation of the synchronizing signals after rectification in the 6H6 is accomplished through selection of the proper resistance-capacity filter values. C32, having a value of only .00001 mfd. will not pass the low-frequency signal but will pass the high-frequency. impulses to the grid of the high-frequency 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 a 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 5Z3 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 .0001 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 L8-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 $1\frac{1}{2}$ volt cell such as is used for Pen-Lite flashlights supplies the "C" bias



The Television Receiver built up.

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 synch. separator.

The sweep circuit oscillators are of the multi-vibrator type, are very stable in operation, and can be readily controlled by the synch. pulses, which are introduced into the 6L7 tubes. Both sweeps 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 sawtooth 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 picture impulses 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 by changing the potential on the focusing electrode (R59) and adjust the bias on the cathode ray tube (R56) 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 ½" diameter form is used and removed after winding. Turns are spaced approximately ⅛". The number of turns is indicated in the diagram.

It is important that the wiring shown in diagram be followed carefully. As each wire or component is put in, it should be checked off. The grounds and heaters should be wired first, then the various B voltages, i.f. transformers; then resistors, mica and tubular condensers. All wiring should be as short and direct as possible. Particular care should be taken in wiring 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 Anode. 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

volt) voltmeter, measure all voltages, with respect to the chassis. Results should be approximately as tabulated. Variations will occur due to line voltage conditions and tubes. If there is any substantial deviation in voltage from that given in this table, ascertain the reason, and correct it before proceeding further, or damage to tubes or other parts may result.

WARNING

Be sure that the Voltmeter prongs are well insulated and use great care in making these measurements to avoid shock from the High Voltage supply.

Alignment and Operation

Set the picture tube bias control (No. 1) all the way to the right. Set the horizontal and vertical sweep (Nos. 6 and 7) controls half way.

Now turn the spot locating control (No. 3) all the way to the left and rotate the other spot control (No. 4) through its entire range. If neither a spot nor a raster (the scanning pattern) appears, move the first spot locating control (No. 3) slightly to the right and rotate the other locating control through its entire range again. Continue this procedure step by step until something appears upon the viewing screen of the C-R tube.

Now adjust the vertical and horizontal sweep controls until a complete *raster* appears. This should be approximately 4" square (the actual picture will be somewhat smaller due to the presence of the blanking and synch. pulses in the station carrier).

By means of the spot location controls (Nos. 3 and 4) this pattern may now be centered on the tube face.

The size of the picture is determined by two factors, namely: the sweep circuit voltage and the voltage applied to the second anode. The picture increases with increase in sweep voltage and decreases *inversely* as the square of the second or high voltage anode potential. The sawtooth voltage developed by the multi-vibrators is a function of the "B" voltage applied to the plates. Since we are operating near the voltage limit of the 5Z3 rectifier tube, it is impractical to obtain any improvement in this direction. Amplifiers could be used to increase the sweep voltages, but this would complicate matters greatly. The other alternative is to reduce the 2nd anode voltage. Referring to the circuit diagram, a 100,000 ohm (R66) dropping resistor is indicated in series with the low voltage filter system. This results in a larger picture, at only a slight sacrifice in brilliance. The use of this resistor is optional, depending upon which characteristic is the more desirable.

The image ratio should be 4:3. If the picture does not conform to this ratio, a rearrangement of resistors in the sweep plate and screen circuits will correct this. Potentiometers could be inserted to control the voltages applied to the deflection plates, but these additional controls are hardly necessary, since once this adjustment is made, it need not be changed, for a given set of tubes.

After this has been satisfactorily checked, we may proceed to the i.f. amplifier adjustments. An output meter or preferably an oscilloscope is connected across the output of the video amplifier (6V6 plate). A signal from a signal generator or equivalent source is now introduced at the converter grid (6K8). 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 readjusted by staggering the peaks to accept a wide band of frequencies (2 megacycles). This will result in considerable improvement in picture detail, with relatively slight loss in gain.

The i.f. transformers are heavily loaded (with 1500 ohms across each secondary). It is possible to omit 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 realigned for best tracking. It may be necessary to adjust the r.f. coil inductances 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 tune in a station quickly and clearly. Proper manipulation of the controls is important.

T_1—1500V. *Power transformer* 8C12
T_2—*Rcvr. power trans.* 8K93
L_{15}—*Rcvr. Filter choke 20H No. 1 L 11 R*
L_{14}—*Hi-Voltage filter choke 1000H No. 1 F45R*
L_{13}—*Low frequency sweep choke 2000H No. 1 F47A*
L_{12}—*High frequency sweep choke 300H No. 1 C42J*
L_{11}—*R.F.* Choke—50 MH
L_{10}—*R.F.* Choke—55MH
$L_{9,8}$—*R.F.* Choke—120 MH
$L_{4,5,6,7}$—*I.F. Transformers*—12 M.C., U100
SIZES:
C—21, 23, 25, 28, 30, 33, 34, 39, 46, 47, 48—525V. *Peak net electro.*
C—44, 45—2000V. (J347)
C—41—1000V. (J345)
C—37—1000V. (J344)
C—42, 50—2000V. (J346)
C—40, 43, 26, 5, 7, 9, 10, 12, 14, 15, 17, 18, 20, 22, 24, 27, 29, 49—400 *volts.*
C—51, 4, 13, 16—200V.
C—35, 36, 8, 52, 19, 31, 32, 38—*Mica*
C—1, 2, 3—3 *gaug variable*
R—64, 36, 52, 56, 44, 61, 62—*Wire wound pots.*

TELEVISION WORDS & TERMS

WORDS AND PHRASES COMMONLY USED IN TELEVISION

Aperture Distortion:

A loss of image definition of the scanning aperture. The height of the aperture is equivalent to the height of one scanning line.

Aspect Ratio:

This is known as the ratio of the width to the height of the picture framed area.

Automatic Background Control:

This is commonly referred to as "Black Control" and refers to an automatic means of controlling the illumination of the cathode-ray reproducer modulating the cathode-ray intensity.

Composite Signal:

When the video, blanking and synchronizing signals are combined or are present it is known as the "Composite Television Signal."

Consecutive Scanning:

This refers to the method in television of scanning the image in which the field-frequency and the frame-frequency are identical.

D.C. Video Component:

This is that part of the video signal component which appears as a steady background illumination of the scene being transmitted.

Direct Pickup:

This deals with the televising of objects, scenes or persons, etc., directly from life and is not to be confused with the film television method.

Even-line Interlacing:

This refers to the number of lines scanned in each frame and is an even integer.

Field Frequency:

The number of times per second the field area is fractionally scanned is called the "Field Frequency" when used in interlaced scanning.

The Blanking Impulse of the Field Frequency:

Is transmitted at the end of each vertical scanning of the picture field in order to erase the retrace path of the cathode-ray spot at the television receiver end.

Field Distortion:

When the velocity of the scanning spot or the departure from a rectilinear shape of scanning field takes place in the form of distortion of the shape of the object in television, it is known as "Field Distortion."

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:

This 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 in which an 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:
Is a rectilinear field in 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 to completely 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 electrostatically 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 transmitted 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 Interlace:
When the number of lines which are being scanned during each picture frame become an odd number they are known as "Odd-Line Interlace."

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.

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

Positive Polarity of Transmission:
When increase 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 scansion of the picture field and the start of the next vertical scansion. Or else, it might be the time-elapse between the ending of one 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 representative of the illumination 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 dissecting 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," or one which may be seen.

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 cut 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 outside of the amateur bands. It is therefore apparent from the above 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.

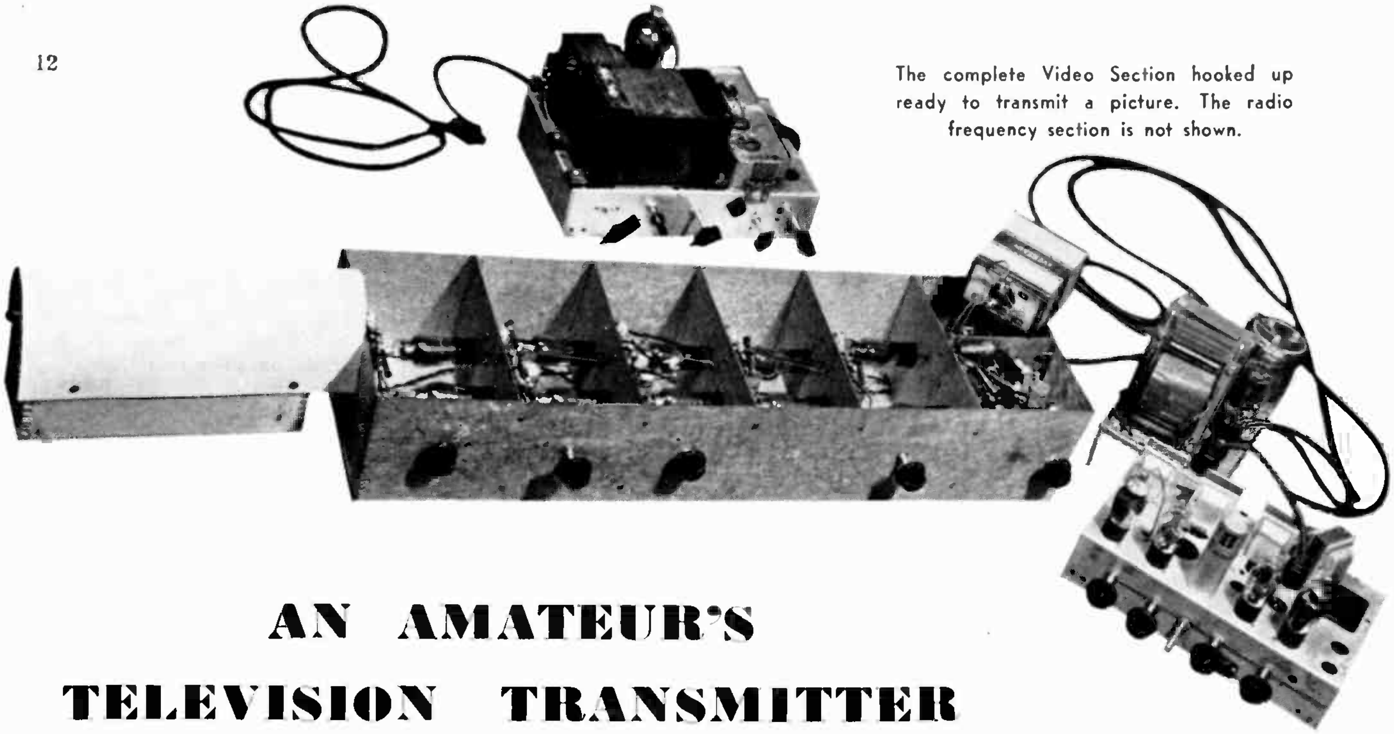
Never attempt to use a crystal itself as a power device. It is far better to use an oscillator which is idling than one which has a high plate voltage supplied. It is always good practice to incorporate some sort of a fuse in the crystal circuit and this may well be one of the popular type of pilot lamps, 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. Crystals 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 at the drug store in the form of "Carbona." The face of the crystal must never be handled by the hand and a clean handkerchief or piece of soft paper should be used when replacing the crystal to its holder.

WIRE TABLE

Winding Turns Per Inch

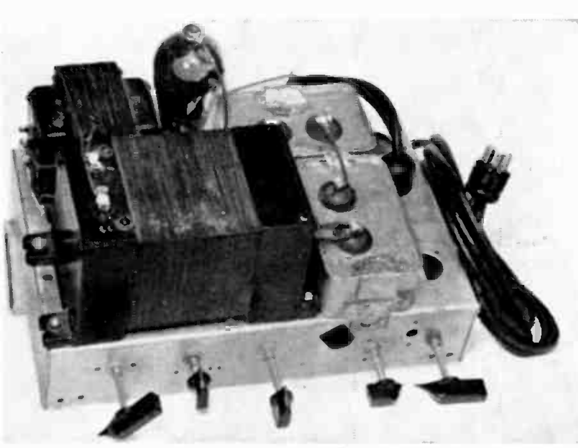
B & S Gauge No.	D.C.C.	S.C.C.	Enamel	B & S Gauge No.	D.C.C.	S.C.C.	Enamel
6	5.44	5.60		26	39.90	45.30	57.00
7	6.08	6.23		27	42.60	49.40	64.00
8	6.80	6.94		28	45.50	54.00	71.00
9	7.64	7.68		29	48.00	58.80	81.00
10	8.51	8.55		30	51.10	64.40	88.00
11	9.58	9.60		31	56.80	69.00	104.00
12	10.62	10.80		32	60.20	75.00	120.00
13	11.88	12.06		33	64.30	81.00	130.00
14	13.10	13.45	14.00	34	68.60	87.60	140.00
15	14.68	14.90	16.00	35	73.00	94.20	160.00
16	16.40	17.20	18.00	36	78.50	101.00	190.00
17	18.10	18.80	21.00	37	84.00	108.00	195.00
18	20.00	21.00	23.00	38	89.10	115.00	205.00
19	21.83	23.60	27.00	39	95.00	122.50	215.00
20	23.91	26.40	29.00	40	102.50	130.00	230.00
21	26.20	29.70	32.00	41	112.00	153.00	240.00
22	28.58	32.00	36.00	42	124.00	168.00	253.00
23	31.12	34.30	40.00	43	140.00	192.00	265.00
24	33.60	37.70	45.00	44	153.00	210.00	275.00
25	36.20	41.50	50.00				

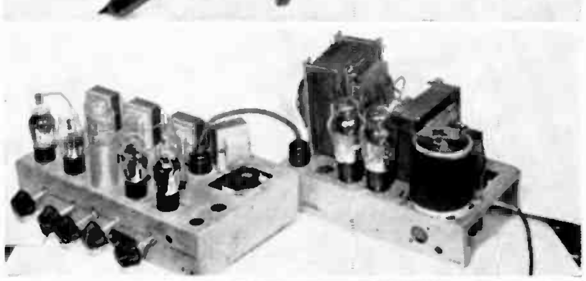


The complete Video Section hooked up ready to transmit a picture. The radio frequency section is not shown.

AN AMATEUR'S TELEVISION TRANSMITTER

THERE are two general television transmission systems in use today. First, is by means of the whirling disk and the second by means of tubes. The second classification is divided between the Iconoscope, used by RCA, and the Dissector, used by Farnsworth on the West Coast. Neither of these latter tubes are available to the amateur.





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.

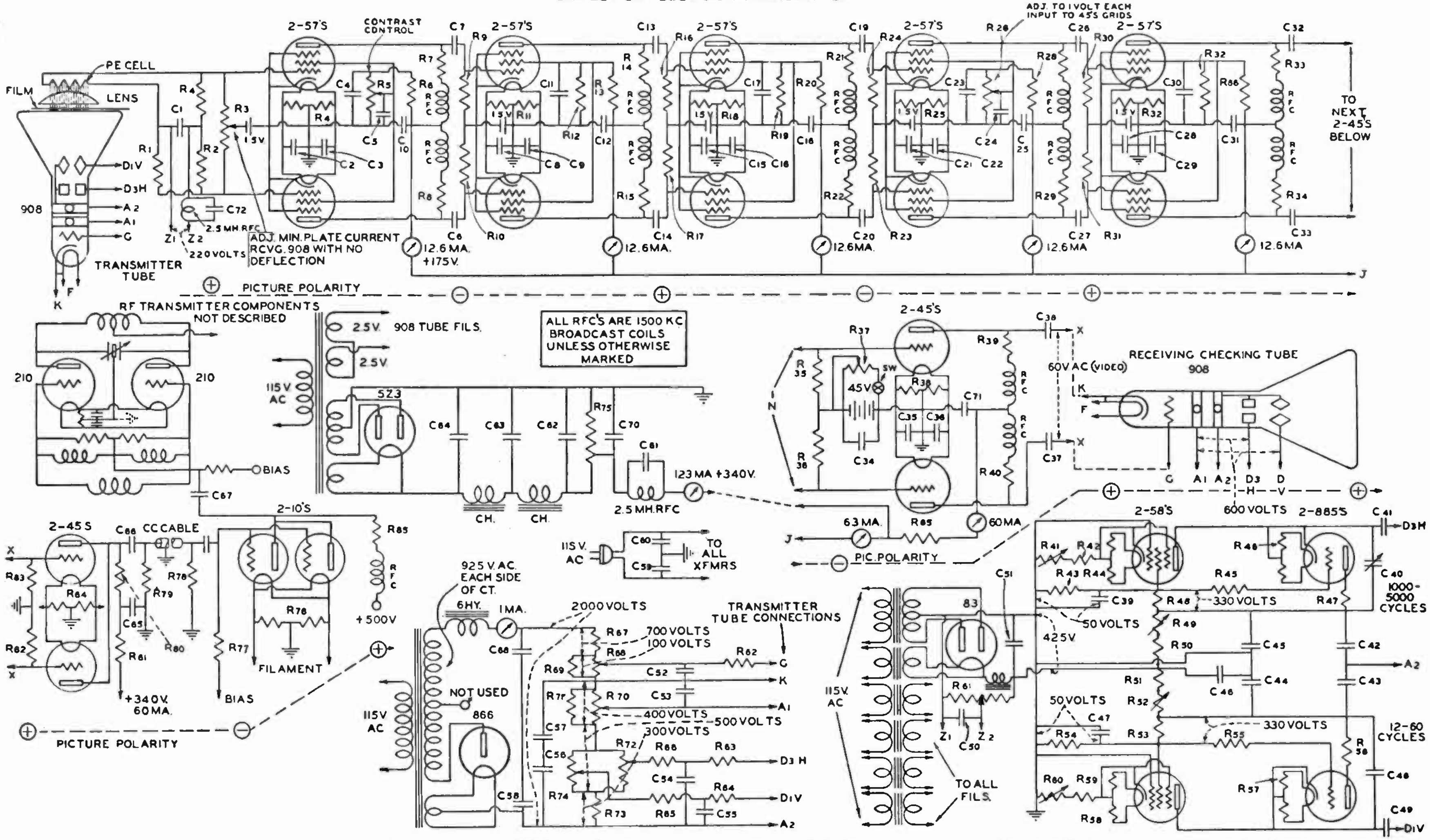
In our transmitter the total numbers of lines in the complete picture was 240 scanned sequentially, and horizontally 24 picture transversals per second or 24 complete frames per second. The line frequency of our transmitter then was 5,760 cycles horizontal deflection, and frame frequency of 24 pictures 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 oscilliscope and its associated circuits. If two 908 oscilliscope 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 milleampere 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 oscilliscope. It utilizes two 885 discharge tubes

SIMPLE FILM TELEVISION TRANSMITTER



Components

C1—8 mfd. 300 v. elect.
C2—.05 mfd. paper
C3—.05 mfd. paper
C4—.25 mfd. paper
C5—.25 mfd. paper
C6—1 mfd. paper
C7—1 mfd. paper
C8—.05 mfd. paper
C9—.05 mfd. paper
C10—.25 mfd. paper
C11—.25 mfd. paper
C12—.25 mfd. paper
C13—1 mfd. paper
C14—1 mfd. paper
C15—.05 mfd. paper
C16—.05 mfd. paper
C17—.25 mfd. paper
C18—.25 mfd. paper
C19—1 mfd. paper
C20—1 mfd. paper
C21—.05 mfd. paper
C22—.05 mfd. paper
C23—.25 mfd. paper
C24—.25 mfd. paper
C25—.25 mfd. paper
C26—1 mfd. paper
C27—1 mfd. paper
C28—.05 mfd. paper
C29—.05 mfd. paper
C30—.25 mfd. paper
C31—.25 mfd. paper
C32—2 mfd. paper
C33—2 mfd. paper
C34—2 mfd. paper
C35—.05 mfd. paper
C36—.05 mfd. paper
C37—1 mfd. paper
C38—1 mfd. paper
C39—8 mfd. elect.
C40—.0001 mfd. var.
C41—.1 mfd. paper
C42—.1 mfd. paper
C43—.1 mfd. paper
C44—8 mfd. elect.
C45—8 mfd. elect.
C46—8 mfd. elect.
C47—8 mfd. elect.
C48—.1 mfd. paper
C49—.1 mfd. paper
C50—8 mfd. elect.
C51—8 mfd. elect.
C52—.75 mfd. paper
C53—.1 mfd. paper
C54—.1 mfd. paper
C55—.1 mfd. paper
C56—.25 mfd. paper
C57—.25 mfd. paper
C58—4 mfd. 2000 v.
C59—2 mfd. 500 v.
C60—2 mfd. 500 v.
C61—.0053 mfd. mica
C62—4 mfd. 500 v.
C63—4 mfd. 500 v.
C64—4 mfd. 500 v.
C65—1000 mfd. 400 v.
C66—1000 mfd. 400 v.
C67—1000 mfd. 500 v.
C68—4 mfd. 2000 v.
Input to modulator, left out, 1000 mfd.
C70—4 mfd. 500 v.
C71—.25 mfd. paper
C72—.0053 mfd. mica
R1—5 meg 1 w.
R2—5 meg 1 w.
R3—2 meg pot.
R4—5 meg 1 w.
R5—.1 meg pot.
R6—40,000 ohms 1 w.
R7—10,000 ohms 1 w.
R8—10,000 ohms 1 w.
R9—1 meg 1 w.
R10—1 meg 1 w.
R11—50 ohms C. T.
R12—1 meg 1 w.
R13—40,000 ohms 1 w.
R14—10,000 ohms 1 w.
R15—10,000 ohms 1 w.
R16—1 meg 1 w.
R17—1 meg 1 w.
R18—50 ohms C. T.
R19—.1 meg 1 w.
R20—40,000 ohms 1 w.
R21—10,000 ohms 1 w.
R22—10,000 ohms 1 w.
R23—1 meg 1 w.
R24—1 meg 1 w.
R25—50 ohms C. T.
R26—.1 meg pot.
R27—Left out
R28—40,000 ohms 1 w.
R29—10,000 ohms 1 w.
R30—.1 meg 1 w.
R31—.1 meg 1 w.
R32—.1 meg 1 w.
R33—10,000 ohms 2 w.
R34—10,000 ohms 2 w.
R35—.5 meg 1 w.
R36—5 meg 1 w.
R37—.1 meg pot.
R38—50 ohms C. T.
R39—5000 ohms 10 w.
R40—5000 ohms 10 w.
R41—50,000 ohms pot.
R42—1500 ohms 10 w.
R43—6000 ohms 1 w.
R44—50 ohms C. T.
R45—300,000 ohms
R46—50 ohms C. T.
R47—1000 ohms 10 w.
R48—38,000 ohms 1 w.
R49—50,000 ohms pot.
R50—7500 ohms 10 w.
R51—7500 ohms 10 w.
R52—50,000 ohms pot.
R53—38,000 ohms 1 w.
R54—6000 ohms 1 w.
R55—300,000 ohms 1 w.
R56—1000 ohms 10 w.
R57—50 ohms C. T.
R58—50 ohms C. T.
R59—1500 ohms 10 w.
R60—50,000 ohms pot.
R61—250,000 ohms pot.
R62—1 meg 2 w.
R63—10 meg 2 w.
R64—10 meg 2 w.
R65—1 meg 2 w.
R66—1 meg 2 w.
R67—.7 meg 10 w.
R68—.5 meg pot.
R69—2 meg 5 w.
R70—.5 meg pot.
R71—2 meg 5 w.
R72—1 meg pot.
R73—.3 meg 5 w.
R74—1 meg pot.
R75—20,000 ohms adj.
R76—100 ohms C. T.
R77—5000 ohms 10 w.
R78—70 ohms 10 w.
R79—70 ohms 10 w.
R80—10,000 ohms 10 w.
R81—5000 ohms 10 w.
R82—.5 meg 2 w.
R83—.5 meg 2 w.
R84—100 ohms C. T.
R85—1341.4 ohms 5 w.
R86—40,000 ohms 1 w.
Fil. res. first 57's marked R4—; 50 ohms
Fil. res. last 57's marked R32 is 50 ohms
Plates res. opposite R29 unmarked, 10,000 ohms

and two '58 tubes. The associated power supply to which it is connected by means of a cable and plug arrangement 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 rear side of the sweep circuit chassis and 2½ volt filament transformers are used to light all of the heaters in the transmitter.

After the oscilliscope power supply and sweep circuits have been completed it will be well to test them with an oscilliscope. In the event that the sine 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 oscilliscope 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 unbalance 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 jointly by the diagram and the photograph.

After the amplifier has been completed tubes should be inserted and it should be checked for hum 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 must be removed 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 45 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 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 synchronization. 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 oscilliscope 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.

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

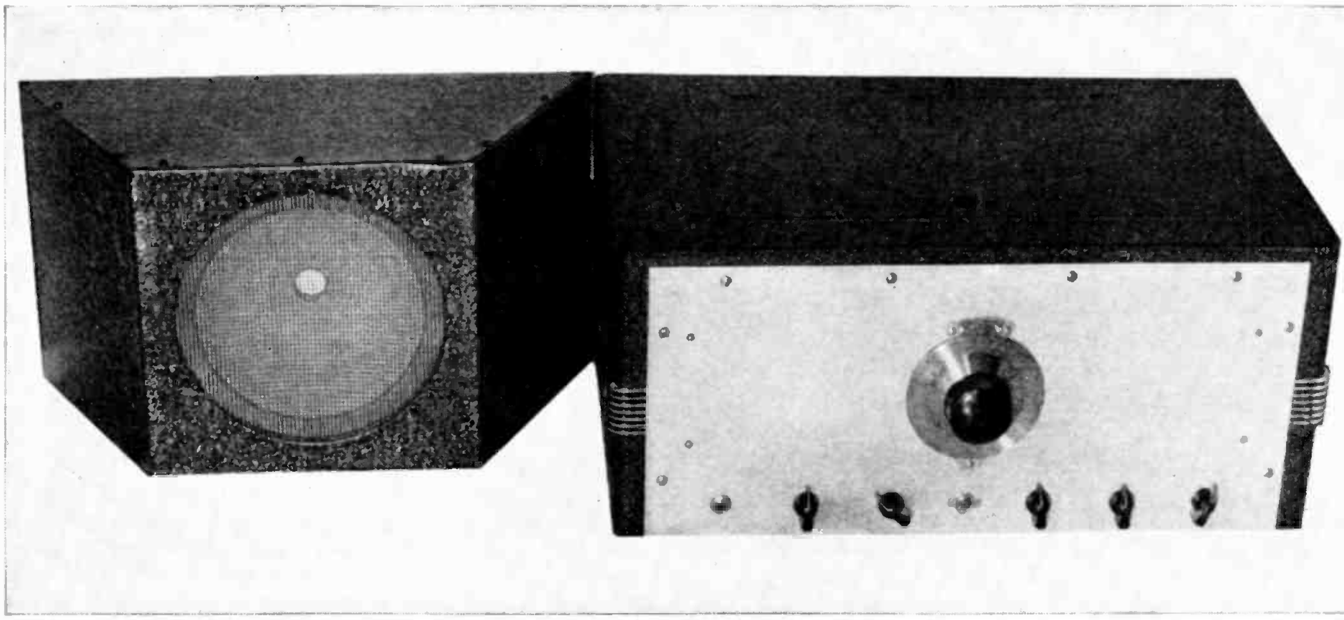
This sheet was evolved after a long search for some economical, sure-fire way of giving code practice to aspiring hams. I have tried sending from newspapers but the fault there is that only common letters appear while z, x, j, q, and numbers seldom appear. Also there is no way of estimating your speed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

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	zaqws	xcder	fvt,	gbyhn	mju.	ikolp	22q	32z	poiuy	trewq	98k	75m	lkjhg	66b
2	ghjkl	gfdsa	trgfb	bnvxs	mlk7	78f	qwsax	43g	bvcxs	ployg	74o	m96	42m	gtrwq
3	qplfg	hgjkp	92r	r65	74d	zzlpq	jnoet	35x	x01	23m	mzqzm	kdlpw	hydra	90k
4	w4dk	fus2	jpj1	ssdki	mnbxc	vsdfg	hdsja	k83	24y	cantk	leaky	quick	doggy	slipk
5	crock	swigq	z7zq	frtyu	kyrwq	awpja	12y	kra9	w98	pinky	boppq	scram	zincx	xer,
6	whose	ink8	mqz7	35m	kitty	sweet	kiddo	zlkjw	w3dg	hurry	w6tg	wzk7	clunk	tax,
7	meete	bendj	moq.	x-hi	ill?	xenia	pjm,	62m	as?m	dew2	wait,	break	sox6	wheng
8	cqdew	7hot	bghjk	,?j	frogs	soupy	piggy	io199	atf,	s3vu	squak	7-k	zzx6	yucyi
9	aqzsw	dxecf	frvgt	hby8	97j	nkm4	29i	lop,	90t	soq,	dew2	tht4	5s5	h55
10	d57	49g	ripto	bit3	73k	fplkj	awrgq	mkptg	,v,	lmcfq	jvjss	tinko	blabs	w9gt
11	cqcqd	ew9q	jrkkt	hisis	w9qj	r.ga	kpeek	rst4	82r	st,s	qrxps	comps	etnxo	b73
12	ursig	s92	7zqp	grhkm	csdkf	.r.	frank	poppy	w60	46v	cantl	eak7	58f	oru9
13	gak?	.sw15	34b	qlzfr	jpltd	?,s	yuhxs	wdjna	isu5	1jjp	twitt	steep	sleet	ar-s
14	pl,o	kmijn	uhb7	ygv6	5tfc	rdx4	3ess	waq2	8,z	?arh	SOS,1	dew5	tnxob	73s

RECEIVER SECTION



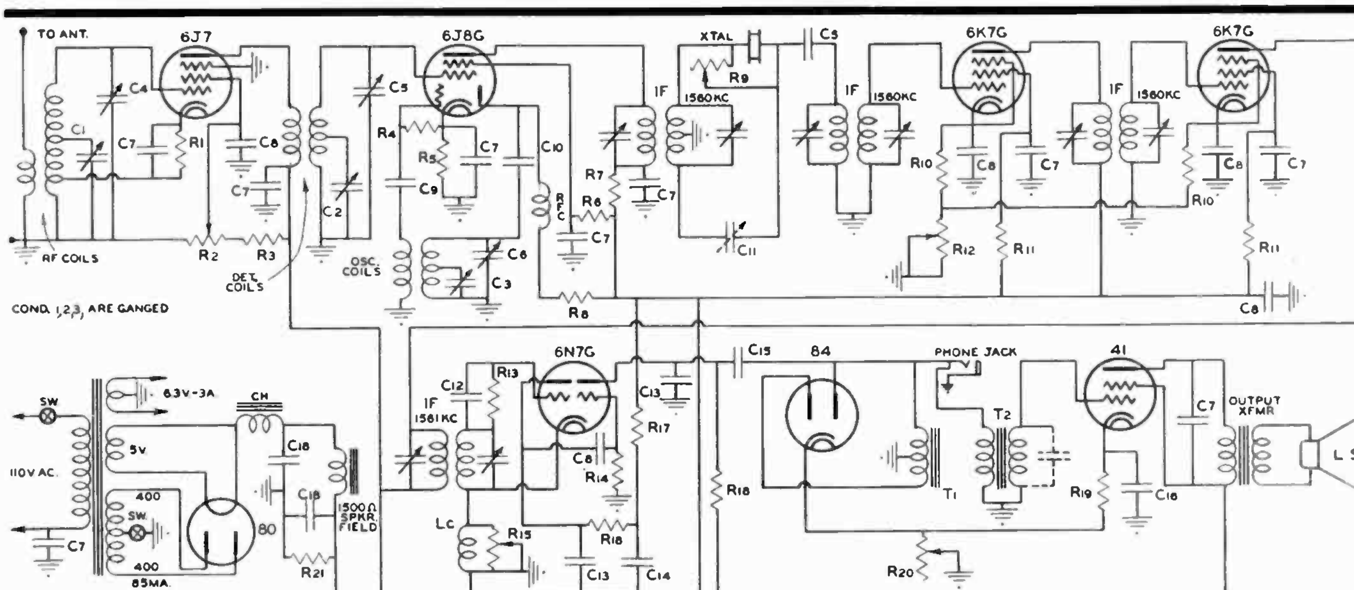
THE JONES 8-TUBE SPECIAL SUPERHET

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.

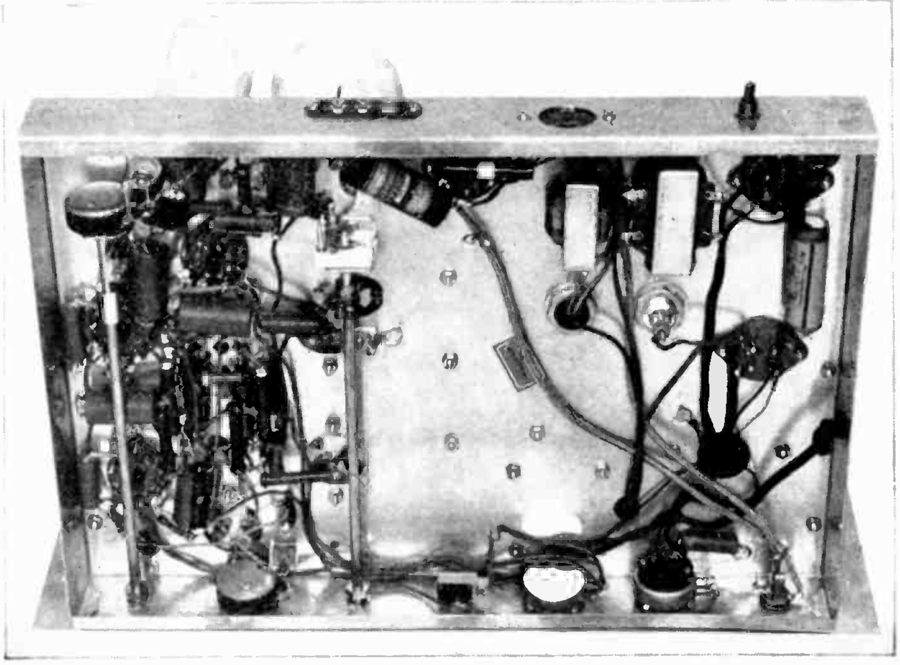
The receiver was primarily designed for code reception with a view to obtaining a high signal to noise ratio. It is quite satisfactory for phone reception though no AVC or R meter circuits were included. It would be possible to use AVC on the two IF stages with a separate amplified AVC circuit with a 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 bandswitching 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 circuit of the Jones 8-Tube Super.



Underside the receiver chassis.

ceiver) higher in value than the detector and r.f. circuits. This can be accomplished with either a low C or high C oscillator circuit with a low C r.f. and detector circuit.

The oscillator circuit has an effective capacity of about 3 or 4 times as great as that used in the r.f. circuits even though it is tuned to a higher frequency. The oscillator semi-fixed padder condenser C_6 is set at nearly 100 mmfd. for all bands, while the detector and r.f. padders C_5 and C_4 are set to about 10 or 15 mmfd. The oscillator tuning condenser C_3 has to have about twice as high a maximum capacity as the other tuning condensers C_1 and C_2. The latter each are 20 mmfd. and the oscillator condenser C_3 is 35 mmfd. These three condensers are mounted on individual 10 ga. aluminum brackets about three inches high by one and three-quarters inches wide, which act as shields between condensers as well as rigid supports. Flexible shaft couplings provide a method of single dial control. The oscillator tuning condenser is nearest the front panel in order to reduce any tendency for shaft and coupling backlash in the tuning dial. A flexible shaft coupling between the oscillator condenser and the dial is a necessity to prevent any detuning effects from slight movement of the pront panel.

The three plug in coils for each band fit into isolantite coil sockets mounted inside of the three large coil shields shown in the rear view of the receiver. These coil shields have removable covers and are reasonably rigid though not as heavy as would be desired.

The r.f. stage is regenerative, controlled by the screen grid potentiometer and the cathode tap on the tuned grid circuit. A 6K7 should be used in locations near strong signal stations such as broadcast stations in order to prevent cross-talk into the short wave bands. In other locations a 6J7 sharp cut-off tube will provide a little better signal to noise ratio and higher gain. An 1853 or 1851 tube will provide even more r.f. gain but are not easily handled when controllable regeneration is desired.

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. The 6J8G tube has an extra internal grid connected to the oscillator grid for injection similar to the 6L7 tube.

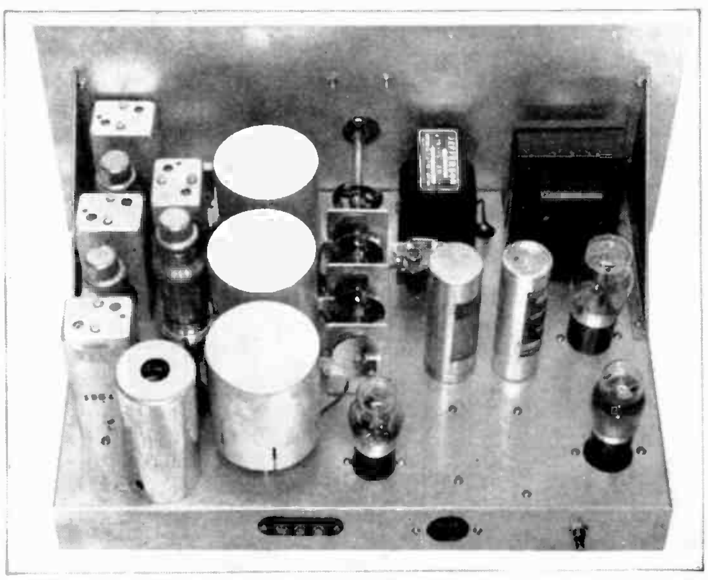
A high intermediate frequency was chosen in order to minimize image response in the high frequency amateur bands and to improve the sensitivity for 10 meter band reception. The usual 465 KC IF causes the oscillator to be tuned to more nearly the same frequency as the detector grid and space charge effects 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 variable 5 megohm resistor. This simple arrangement provides continuous selectivity from no crystal to full crystal selectivity without any appreciable detuning effect. It is quite easy to properly adjust the phasing condenser C_{11} for single signal reception even with a high frequency crystal. Condenser C_{11} was mounted near the crystal socket and is not adjustable from the front panel.

The second detector, audio amplifier and beat frequency oscillator are combined into one 6N7G tube which is a double triode similar to a 6A6. This portion of the circuit is quite similar to the one used in the "Super-Gainer" receivers. For phone reception the resistor R_{15} is set to a low enough value to practically short-circuit the external cathode coil which backs the second detector out of oscillation. This cathode coil is mounted underneath the chassis near the variable resistance R_{15} and the 6N7G socket. The resistor is controlled by a knob on the front panel and an extension shaft. The r.f. trimmer condenser C_4 is also controlled by an extension shaft and knob for precise adjustment with regeneration in the r.f. stage.

The second section of the 6N7G tube acts as an audio frequency amplifier with resistance coupling to the regenerative detector section. The noise limiter is a full wave diode type 84 tube in a push-pull circuit which limits both "positive" and "negative" peaks of noise. This type of noise limiter or suppressor is quite effective for reducing auto ignition noise. The center-tapped choke T_1 (the primary of a small push-pull output to speaker transformer) reverses the "negative" peaks to "positive" peaks for operation on the diode plates which only work on positive peaks.

The diode plates act as a partial short circuit across the audio amplifier during periods of noise pulses greater than the cathode bias on the 84 tube. This tends to punch a hole in the desired signal during periods of strong noise peaks but since noise peaks are of extremely short duration, this causes no apparent distortion. The delay bias on the 84 cathode is obtained from a small 70 ohm cathode bias variable



Topside the receiver chassis.

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 ½ to 5 volts eliminates this distortion and allows that amount of audio signal to pass through without distortion.

Component Parts List

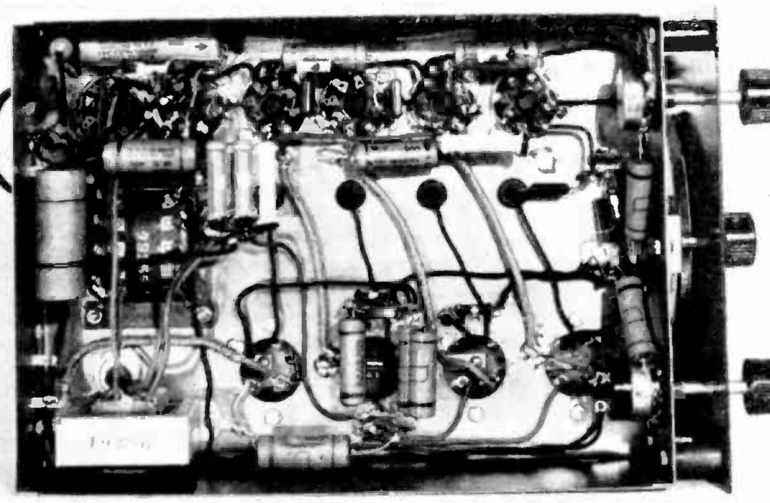
C_1—20 mmfd. var. Bud 323
C_2—20 mmfd. var. Bud 323
C_3—35 mmfd. var. Bud 322
C_4—15 mmf. var. Hammarlund HF15
C_5—3-30 mmfd. trimmer Hammarlund
C_6—100 mmfd. max. padder Bud 321
C_7—.01 mfd. 600 v. paper C-D
C_8—.1 mfd. 600 v. paper C-D
C_9—.0001 mfd. mica Mallory
C_{10}—.001 mfd. mica Mallory
C_{11}—25 mmfd. var. Hammarlund H
C_{12}—.00005 mfd. mica Mallory
C_{13}—.002 mfd. mica C-D
C_{14}—½ mfd. paper 400 v. C-D
C_{15}—¼ mfd. paper 400 v. C-D
C_{16}—20 mfd. elec. 50 WV C-D
C_{17}—9 mfd. elec. 450 v. C-D
C_{18}—16 mfd. elec. 450 v. C-D
T_1—center tapped audio choke—primary of PP pentode to loud speaker transformer—
T_2—3:1 interstage AF trans.
CH—15 henry 85 ma. filter choke
LC—2nd detector cathode coil—30 turns No. 28-DCC random wound on a ½" diameter porcelain rod insulator
R_1—300 ohms ½ w. Centralab
R_2—50,000 pot. (RF regeneration) Centralab
R_3—20,000 1 w. Aerovox
R_4—50,000 ½ w. Aerovox
R_5—300 ½ w. Centralab
R_6—50,000 1 w. Aerovox
R_7—5,000 ½ w. Aerovox
R_8—10,000 1 w. Aerovox
R_9—5 megohms (xtal selectivity control) Centralab
R_{10}—1,000 ohm ½ w. Centralab
R_{11}—100,000 1 w. Aerovox
R_{12}—50,000 pot. (IF control) Centralab
R_{13}—10 meg. 1/5 w. Centralab
R_{14}—20,000 ½ w.
R_{15}—1,000 pot. (2nd det. regeneration) Centralab
R_{16}—10,000 ½ w. Aerovox
R_{17}—25,000 ½ w. Aerovox
R_{18}—50,000 1 w. Aerovox
R_{19}—350 ohm 10 w. Ohmite
R_{20}—70 ohm rheostat (misc. silence bias) Frost
R_{21}—25,000 10 w. Ohmite

8 Tube Communication Receiver COIL DATA

COIL BAND in METERS	R. F.	DETECTOR	OSCILLATOR
	All coils 1½" diam. (except 10 osc.)		
10	4⅓ turns No. 20 DCC ¾" long Cond. tap at 4 turns Cath. tap at ¼ turn	4⅓ turns No. 20 DCC ¾" long Cond. tap at 4 turns	1⅘ turns No. 20 DCC ½" long—1⅛" diam. No cond. tap
	Ant.—2 turns No. 26	Primary—4 turns No. 34 DSC interwd.	Grid—2⅘ turns No. 26 DCC interwd.
20	12 turns No. 22 DCC 1¼" long Cond. tap at 5 turns Cath. tap at ⅓ turn	12 turns No. 22 DCC 1¼" long Cond. tap at 5 turns	4⅓ turns No. 20 DCC 1" long Cond. tap at 2⅔ turns
	Ant.—3½t No. 26 DCC	Primary 8 turns No. 34 DSC interwound	Grid—5 turns No. 26 DCC ¼" long
40	24 turns No. 22 DCC 1½" long Cond. tap at 12 turns Cath. tap at ½ turn	24 turns No. 22 DCC 1½" long Cond. tap at 12 turns	10 turns No. 20 DCC 1⅛" long Cond. tap at 5 turns
	Ant.—5 turns No. 26 DCC closewound	Primary—12 turns No. 34 DSC interwound	Grid coil—7 turns No. 26 DSC interwound
80	40 turns No. 24 DCC 1¼" long No cond. tap Cathode tap at ¾ turn	40 turns No. 24 DCC 1¼" long No cond. tap	15½ turns No. 20 DCC ⅞" long No cond. tap
	Ant. 8 turns No. 26 DCC closewound	Primary—20 turns No. 34 DSC interwound	Grid coil—10 turns No. 26 DCC closewound to plate coil
160	80 turns No. 26 E 1.4" long No cond. tap Cathode tap at ¾ turn	80 turns No. 26 E 1.4" long No cond. tap	24 turns No. 22 DCC 1" long No cond. tap
	Ant.—10 turns No. 26 E closewound	Primary—32 turns No. 34 DSC closewound below secondary	Grid coil—15 turns No. 26 DSS closewound below plate coil

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.



The parts connected to each tube are grouped around that socket to give the best reception afforded by short leads and feed-back free operation on local signals.

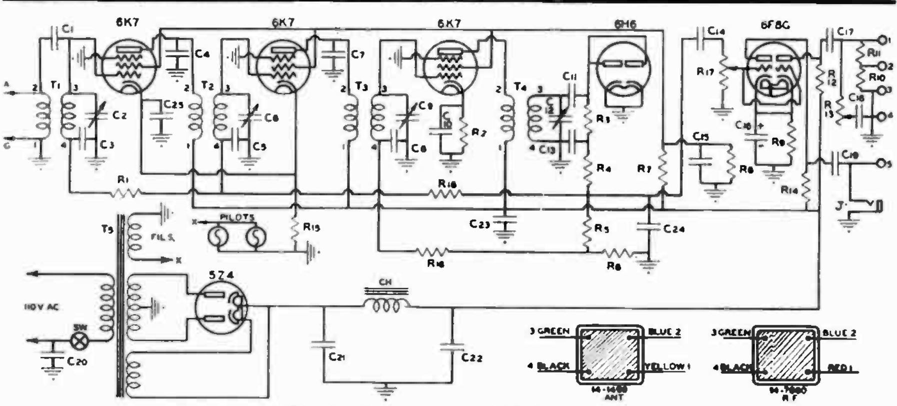
AN efficient radio tuner for Public Address application is something more than "any old receiver which will tune to and through the broadcast band." It is frankly an objectively engineered instrument, built specifically and therefore functionally for P. A. service to meet the particular requirements which program distribution facilities involve. It need not be an expensive item; as a matter of fact, the average job is neither costly nor complex, since it is called upon to do no more than pick up program stations in the broadcast band and produce an audio signal of sufficient level to drive any succeeding amplifier to proper output—something which a very simple set-up employing very few parts *can* be made to do.

Physically, the tuner is quite compact and certainly portable—cabinet dimensions being 8⅜"x8⅜"x13". In non-portable layouts, by the way, and particularly in assemblies of dual-channel design, two of these units may be mounted on one standard 19-inch relay panel—and operated simultaneously without interference one with the other, TRF design of course precluding any 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, the two r.f., and detector—with variable condensers in gang for single-dial control. The detector—a diode—provides both an AVC voltage and an a.f. voltage related to signal. The two-section a.f. tube, with its two output



Circuit diagram for the P.A. Tuner.
(Meissner PA-6)

C_1—Integral with coil
C_2, C_6, C_9, C_{12}—4 gang 365 mmfd., Meissner 21-5123
C_3—.05 mfd.
C_4—.0001 mfd.
C_5—.05 mfd.
C_7—.0001 mfd.
C_8—.05 mfd.
C_{10}—0.1 mfd.
C_{11}—.0001 mfd.
C_{13}—.00025 mfd.
C_{14}—.05 mfd.
C_{15}—0.1 mfd.
C_{16}—10 mfd., 25 v.
C_{17}—.25 mfd., 400 v.
C_{18}—0.1 mfd.
C_{19}—0.1 mfd., 400 v.
C_{20}—.01 mfd., 400 v.
C_{21}, C_{22}—8 mfd., 300 v. electro.
C_{23}—0.1 mfd., 400 v.
C_{24}—.00025 mfd.
C_{25}—0.1 mfd.
R_1—100,000 ohms
R_2—400 ohms
R_3—100,000 ohms
R_4—50,000 ohms
R_5—100,000 ohms
R_6—100,000 ohms
R_7—40,000 ohms, 1 watt
R_8—40,000 ohms, 1 watt
R_9—400 ohms
R_{10}—2,500 ohms
R_{11}—25,000 ohms
R_{12}—25,000 ohms, 1 watt
R_{13}—25,000 ohm pot.
R_{14}—25,000 ohms, 1 watt
R_{15}—400 ohms
R_{16}—500,000 ohms
R_{17}—500,000 ohms pot.
R_{18}—500,000 ohms
CH—30 Hy., 40 ma.
T_1—Meissner 14-1496 coil
T_2, T_3, T_4—Meissner 14-7860 coils
T_5—Power trans. (250 v.d.c. 30 MA)
SW—D.P.S.T.
J—Monitor jack

circuits, makes possible simultaneous headphone (monitoring) output and amplifier feed, the monitoring circuit, when in use, in no way affecting the operation of the other.

Consider first the detector circuit. Here we use a diode, its parallel plates connected to the high side of the last r.f. transformer's secondary *through* a small mica capacitor—rather than conventionally, which is to say directly. The return lead for the secondary winding is then grounded, the effect being to provide for a tuned circuit here which will track with those preceding it. The diode, which with a conventional arrangement would have considerable shorting effect on the secondary and in such a way as to make track-tuning here extremely difficult (and which would take considerable power from the third 6K7 stage, lowering the gain of that stage) has its own input circuit—in terms of physical make-up, a resistor connected from the plates to the high side of the effective 250,000 ohm load component.

The audio component of the rectified signal develops across 200,000 ohms of the load leg and is coupled to the volume level potentiometer, which controls the input to *both* grids of the 6F8G dual-triode, 50,000 ohms of the load being used to limit the amount of a.f. voltage available. The d.c. component of that signal is used for purposes of AVC, the total voltage developing across 200,000 ohms being applied to the first two r.f. stages and one-half that voltage being applied to the third. Note, by the way that .0001 mica capacitors are shown wired from plates to ground in the first two 6K7 circuits; this practice is desirable when the tuner is used largely for local signal reception (though gain remains high enough for extended range pickup) and if for no other reason than to prevent any possible circuit oscillation.

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 braid-shielded 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 5 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 scale markers and with the variable condenser plates at full mesh, tighten the hub-screws on the shaft.

Check and re-check for proper wiring continuity.

Alignment and Operation

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

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

The total "B" drain will measure 27 ma. if the receiver is properly wired 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. In most tuner applications 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

ANTENNA MAST FOR $7.50

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 housetop, tree or barn would suffice. Now, however, with short wave reception very much in the picture, the call is for all-wave doublets, double-doublets, spider-webs, and other complicated forms of antennae, 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 necesary 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 proven to be expensive failures for the inexperienced, but it is really no trick if you know how. This article will describe a 38-foot metal 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."

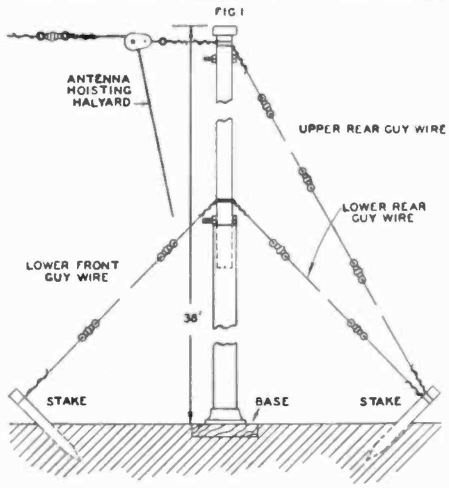
This mast is constructed, fundamentally, of two lengths of galvanized iron pipe, one of somewhat smaller diameter than the other, so that it will telescope within the larger section at the joint between the two. A galvanized iron cap and pulley are provided at the top of the mast and a galvanized mounting 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:

Material	Approximate Cost
1—20 foot section 1" iron pipe	$2.10
1—20 foot section 1½" iron pipe	3.30
1—1" pipe cap	.10
1—1½" floor flange	.25
2—⅜"x2½" machine bolts and nuts	.05
1—Galvanized iron clothesline pulley	.10
200 feet No. 10 galvanized iron wire	.60
20 "Egg" strain insulators	.50
Total	$7.00

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 expert. The actual outside diameter of those two sections are approximately 2" and 1⅜" 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 somewhat 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 ⅜" 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 ⅜" hole should be drilled in the smaller pipe about four 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.

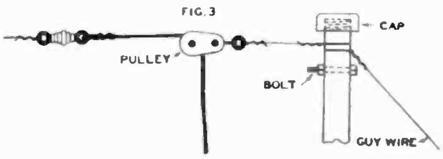
The approximate length of each guy wire can be calculated in advance, by considering it as the hypothenuse of a right triangle, with the mast as one other side and the distance from the foot of the mast to the stake as the third side. Then $(\text{height})^2$ plus $(\text{distance to stake})^2$ equals $(\text{hypothenuse})^2$. In the case of a 38-foot mast, with the stakes 20 feet from the base, this would give

$$\sqrt{(38)^2 + (20)^2} = \sqrt{1444 + 400} = \sqrt{1844} = 43'$$

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.

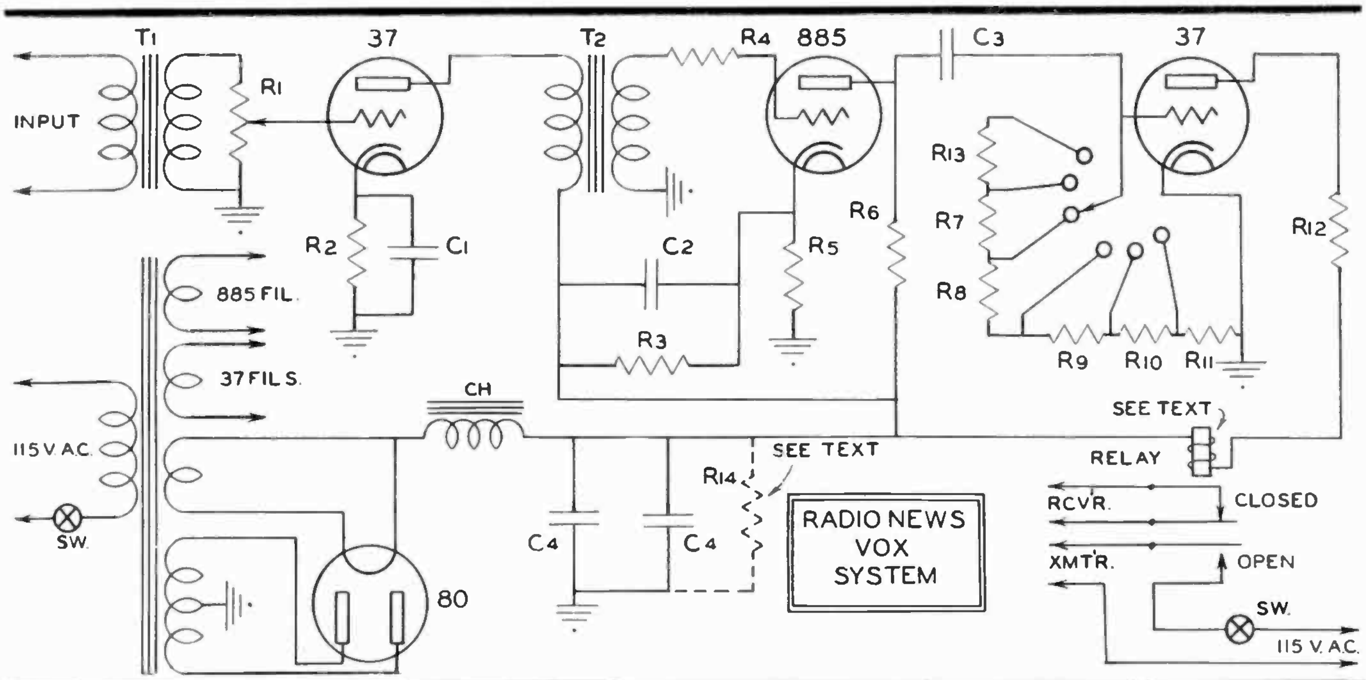
A metal mast such as this does not need any annual painting or, in fact, any attention at all, once it has been erected in a workmanlike manner. If a good grade of galvanized wire is used, to prevent rust, a mast of this type will give many years of faithful service, with no other attention than an annual 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.



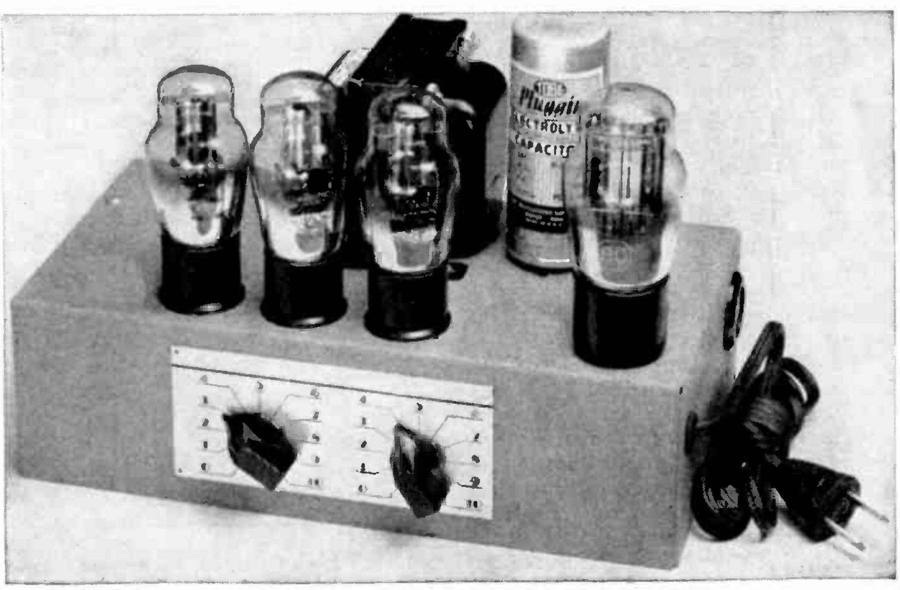
Pulley and Top details.

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.

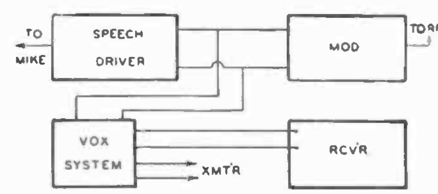
AMATEUR TRANSMITTER SECTION



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 xmtr.



Block diagram of the *VOX System*.

R_1—250,000 ohms pot.
R_2—3000 ohms ½ w.
R_3—0.5 megohms ½ w.
R_4—0.5 megohms ½ w.
R_5—5000 ohms 1 w.
R_6—30,000 ohms 1 w.
R_7—2 megohms ¼ w.
R_8—2 megohms ¼ w.
R_9—2 megohms ¼ w.
R_{10}—2 megohms ¼ w.
R_{11}—2 megohms ¼ w.
R_{12}—10,000 ohms 2 w.
R_{13}—10 megohms ¼ w.
R_{14}—25,000 ohms 10 w. adj.
C_1—10 mfd. 25v. electro.
C_2—1 mfd. 450v. paper.
C_3—0.1 mfd. 450v. electro.
C_4—8-8 mfd. 450v. electro. (Tobe 'Pluggin')
CH—30 hy choke (Stancor C-1706)
RY—D.P.D.T. Relay: To make one and to break one. (Pull in at 15ma, drop out at 10ma.) (Guardian Type 15-1000 A2-B3).
T_1—Audio 3:1 (3000 ohm primary). (Stancor A-53).
T_2—Same as T_1.
T_3—6.3v. AC, 2.5v. AC, 5v. AC, 250v. DC from filter. (Stancor P-4045).
SW—AC switch on R_1.

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 ½ 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 56's will re- 2.5 v. 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 (R_{14}) and tapping of that bleeder should be arranged for. The *VOX System* operates on exactly 250 v. d.c. under full load, and more than that will make for unstable operation of the 885 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 resistor. 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.

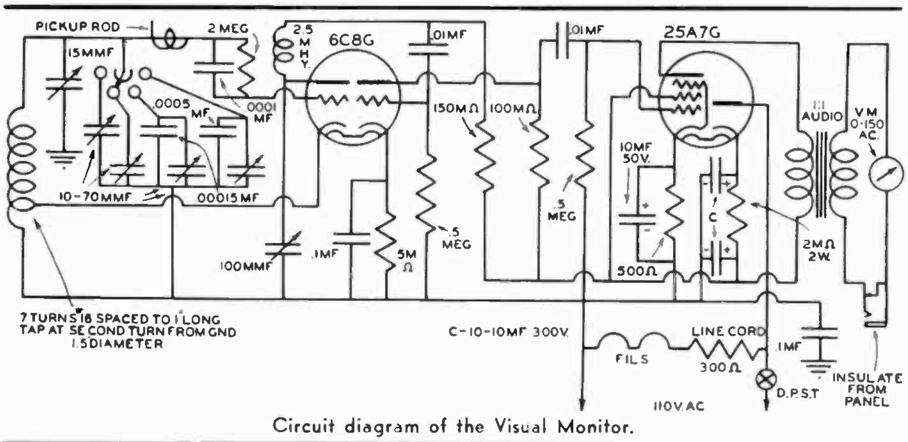
VISUAL DEVIATION FREQ. METER

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 resulting frequency, numerically, will be of zero *audio* amplitude and if either of the two frequencies are changed they will produce a beat note, the frequency of which is the difference, numerically, between the two carriers.

It was this condition of which advantage was taken and the frequency monitor was developed so as to have this beat note become 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 imposed 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 indication of the amount of a.c. voltage. From 5000 cycles to 10,000 cycles it drops off very rapidly and beyond 10,000 cycles it fails, or refuses, to register any voltage whatsoever. The frequency has passed beyond the scope of a normal 60 cps. meter. It was this additional phenomenon of which advantage was taken in building the visual frequency monitor.



Circuit diagram of the Visual 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 temperature 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. oscillating frequency of the detector would beat 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 registerable 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 considerable "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 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 output circuit and it can there be determined aurally that the frequency has shifted more than 500 cycles and has shifted beyond the audio range.

Still a third point presented itself, which was that the oscillating detector could be picked up in the receiver when in receiving position. This, of course, would be most 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 frequency of the transmitter, any further change by the transmitter 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 shifts 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 measures 9"x5" 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 2000 ohm carbon resistor in place of the usual choke. Meter is O-150 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 band-setting condensers mount along the inside of the chassis in order that they may afford short leads to the selector switch 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 selector switch. This switch is furnished with isolantite insulation to further aid the over-all efficiency. To the left of the switch control knob is mounted the regeneration control. This condenser controls the amount of feed-back 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 filaments 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 or the signal from the transmitter. In the 5 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 from 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 padder 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 padders 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 too much pickup as to do so will block the monitor signal.

The extreme sensitivity of the meter 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 monitored 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.

TABLES

CONVERSION TABLE

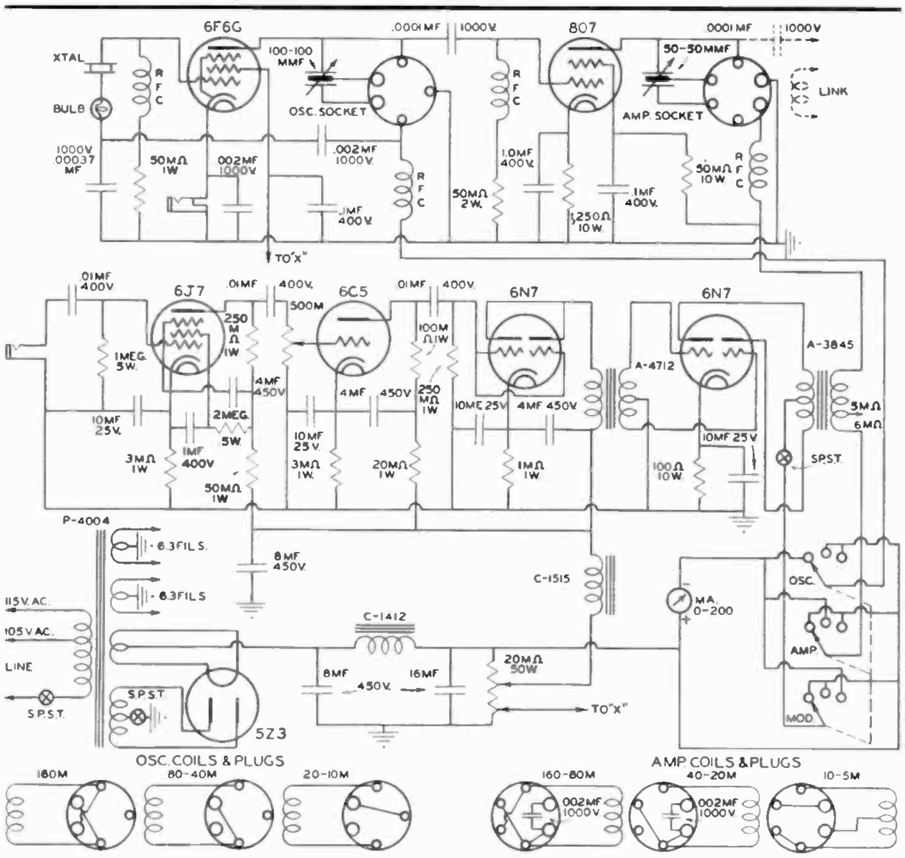
Factors for conversion, alphabetically arranged

MULTIPLY	BY	TO GET
Amperes	×1,000,000,000,000	micromicroamperes
Amperes	×1,000,000	microamperes
Amperes	×1,000	milliamperes
Cycles	×1,000,000	megacycles
Cycles	×.001	kilocycles
Farads	×1,000,000,000,000	micromicrofarads
Farads	×1,000,000	microfarads
Henrys	×1,000,000	microhenrys
Henrys	×1,000	millihenrys
Kilocycles	×1,000	cycles
Kilovolts	×1,000	volts
Kilowatts	×1,000	watts
Megacycles	×1,000,000	cycles
Mhos	×1,000,000	micromhos
Microamperes	×.000,001	amperes
Microfarads	×.000,001	farads
Microhenrys	×.000,001	henrys
Micromhos	×.000,001	mhos
Micro-ohms	×.000.001	ohms
Microvolts	×.000,001	volts
Microwatts	×.000,001	watts
Micromicrofarads	×.000,000,000,001	farads
Milliamperes	×.001	amperes
Millihenrys	×.001	henrys
Millimhos	×.001	mhos
Milliohms	×.001	ohms
Millivolts	×.001	volts
Milliwatts	×.001	watts
Ohms	×1,000,000,000,000	micromicro-ohms
Ohms	×1,000,000	micro-ohms
Volts	×1,000,000	microvolts
Volts	×1,000	millivolts
Watts	×1,000,000	microwatts
Watts	×1,000	milliwatts
Watts	×.001	kilowatts

FRACTIONAL—DECIMAL EQUIVALENTS

$\frac{1}{64} = .0165$	$\frac{7}{16} = .4375$
$\frac{1}{32} = .0312$	$\frac{1}{2} = .500$
$\frac{3}{64} = .0468$	$\frac{9}{16} = .5625$
$\frac{1}{16} = .0625$	$\frac{5}{8} = .625$
$\frac{3}{32} = .0936$	$\frac{11}{16} = .6825$
$\frac{1}{8} = .125$	$\frac{3}{4} = .750$
$\frac{3}{16} = .1875$	$\frac{13}{16} = .8125$
$\frac{1}{4} = .250$	$\frac{7}{8} = .875$
$\frac{5}{16} = .3125$	$\frac{15}{16} = .9375$
$\frac{3}{8} = .3750$	

20-W Bandswitch Transmitter



Schematic diagram of the 20-watt all band transmitter.

IN building this transmitter, the factors of flexibility, performance, and economy were carefully considered before the final design was adopted. Complete coverage of all bands with quick band change was desired, and crystal control with a minimum number of stages. The all-band feature dictated the use of both phone and C.W. and, therefore, a complete speech amplifier and modulator had to be included. Other features such as metering of all important circuits, oscillator keying for break-in operation, and front panel control were worked into the set as the design crystallized, while economy was the deciding factor in determining the tube lineup and the use of a single power supply and meter for the entire unit, as well as the over-all size.

The result is a complete phone and C.W. transmitter, including its a.c. power supply, in a cabinet measuring 19" x 13" x 8¾" 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 amplifier tank 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 set by means of a link or by capacity coupling to the amplifier tank circuit.

The speech amplifier and modulator tube lineup 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 modulation 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 condenser input. An additional filter section is inserted to the supply power circuit to the three speech 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 speech amplifier and modulator. 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 tube, and the pilot light 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 of 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 tuned to resonance. With the meter switch in the "amplifier" position the current should dip to a value ranging from 5 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.

U. S. GOV'T AMATEUR RADIO REGULATIONS

FEDERAL COMMUNICATIONS COMMISSION
Washington, D. C.
ORDER

In a regular meeting of the Federal Communications Commission held at its offices in Washington, D. C., on the 4th day of October, 1938:

The Commission having under consideration a revision of its rules in respect to the amateur service and having adopted the attached "Rules Governing Amateur Radio Stations and Amateur Radio Operators" to become effective on December 1, 1938,

IT IS ORDERED, That the following rules, which are now in effect, are hereby cancelled as of December 1, 1938:

361	376	402, as amended
362	377	403
364	378	404, as amended
365	379	405
366	380	406
366 (a)	381, as amended	407
367	382, as amended	408
368, as amended	383	409
370	384	410
371, as amended	384 (a)	411
372	385	412
373	386	413
374	387, as amended	414
374 (a)	400	415
375	401	

By the Commission,
(Sgd.) T. J. Slowie,
October 4, 1938. Secretary.

Table of Contents

PART 150—DEFINITIONS

Sec. 150.01 *Amateur service.* The term "amateur service" means a radio service carried on by amateur stations.

Sec. 150.02 *Amateur station.* The term "amateur station" means a station used by an "amateur," that is, a duly authorized person interested in radio technique solely with a personal aim and without pecuniary interest. It embraces all radio transmitting apparatus at a particular location used for amateur service and operated under a single instrument of authorization.

Sec. 150.03 *Amateur portable station.* The term "amateur portable station" means an amateur station that is portable in fact, but that is so constructed that it may conveniently be moved about from place to place for communication, and that is in fact so moved from time to time, but which is not operated while in motion.

Sec. 150.04 *Amateur portable-mobile station.* The term "amateur portable-mobile station" means an amateur station that is portable in fact, that is so constructed that it may conveniently be transferred to or from a mobile unit or from one such unit to another, and that is in fact so transferred from time to time and is ordinarily used while such mobile unit is in motion.

Sec. 150.05 *Amateur radio communication.* The term "amateur radio communication" means radio communication between amateur stations solely with a personal aim and without pecuniary interest.

Sec. 150.06 *Amateur operator.* The term "amateur operator" means a person holding a valid license issued by the Federal Communications Commission authorizing him to operate licensed amateur stations.

PART 151—AMATEUR OPERATORS

Licenses; Privileges

Sec. 151.01 *Eligibility for license.* The following are eligible to apply for amateur operator license and privileges:

Class A—A United States citizen who has within five years of receipt of application held license as an amateur operator for a year or who in lieu thereof qualified under Section 151.20.

Class B—Any United States citizen.

Class C—A United States citizen whose actual residence, address, and station, are more than 125 miles airline from the nearest point where examination is given at least quarterly for Class B; or is shown by physician's certificate to be unable to appear for examination due to protracted disability; or is shown by certificate of the commanding officer to be in a camp of the Civilian Conservation Corps or in the regular military or naval service of the United States at a military post or naval station and unable to appear for Class B examination.

Sec. 151.02 *Classification of operating privileges.* Amateur operating privileges are as follows:

Class A—All amateur privileges.

Class B—Same as Class A except specially limited as in Section 152.28.

Class C—Same as Class B.

Sec. 151.03 *Scope of operator authority.* Amateur operators' licenses are valid only for the operation of licensed amateur stations; *provided, however,* any person holding a valid radio operator's license of any class may operate stations in the experimental service licensed for, and operating on, frequencies above 300,000 kilocycles.

Sec. 151.04 *Posting of license.* The original operator's license shall be posted in a conspicuous place in the room occupied by such operator while on duty or kept in his personal possession and available for inspection at all times while the operator is on duty, except when such license has been filed with application for modification or renewal, or has been mutilated, lost, or destroyed, and application has been made for a duplicate.

Sec. 151.05 *Duplicate license.* Any licensee applying for a duplicate license to replace an original which has been lost, mutilated, or destroyed, shall submit to the Commission such mutilated license or affidavit attesting to the facts regarding the manner in which the original was lost or destroyed. If the original is later found, it or the duplicate shall be returned to the Commission.

Sec. 151.06 *Renewal of amateur operator license.* An amateur operator license may be renewed upon proper application and a showing that within three months of receipt of the application by the Commission the licensee has lawfully operated an amateur station license by the Commission, and, that he has communicated by radio with at least three other such amateur stations. Failure to meet the requirements of this section will make it necessary for the applicant to again qualify by examination.

Sec. 151.07 *Who may operate an amateur station.* An amateur station may be operated only by a person holding a valid amateur operator's license, and then only to the extent provided for by the class of privileges for which the operator's license is endorsed. When an amateur station uses radiotelephony (type A-3 emission) the licensee may permit any person to transmit by voice, provided a duly licensed amateur operator maintains control over the emissions by turning the carrier on and off when required and signs the station off after the transmission has been completed.

Examinations

Sec. 151.15 *When required.* Examination is required for a new license as an amateur operator or for change of class of privileges.

Sec. 151.16 *Elements of examination.* The examination for amateur operator privileges will comprise the following elements:

1. Code test—ability to send and receive, in plain language, messages in the International Morse Code at a speed of not less than thirteen words per minute, counting five characters to the word, each numeral or punctuation mark counting as two characters.
2. Amateur radio operation and apparatus, both telephone and telegraph.
3. Provisions of treaty, statute and regulations affecting amateurs.
4. Advanced amateur radiotelephony.

Sec. 151.17 *Elements required for various privileges.* Examinations for Class A privileges will include all four examination elements as specified in Section 151.16.

Examinations for Classes B and C privileges will include elements 1, 2, and 3 as set forth in Section 151.16.

Sec. 151.18 *Manner of conducting examination.* Examinations for Class A and Class B privileges will be conducted by an authorized Commission employee or representative at points specified by the Commission.

Examinations for Class C privileges will be given by volunteer examiner(s), whom the Commission may designate or permit the applicant to select; in the latter event the examiner ghiving the code test shall be a holder of an amateur license with Class A or B privileges, or have held within five years a license as a professional radiotelegraph operator or have within that time been employed as a radiotelegraph operator in the service of the United States; and the examiner for the written test, if not the same individual, shall be a person of legal age.

Sec. 151.19 *Additional examination for holders of Class C privileges.* The Commission may require a licensee holding Class C privileges to appear at an examining point for a Class B examination. If such licensee fails to appear for examination when directed to do so, or fails to pass the supervisory examination, the license held will be canceled and the holder thereof will not be issued another license for the Class C privileges.

Whenever the holder of Class C amateur operator privileges changes his actual residence or station location to a point where he would not be eligible to apply for Class C privileges in the first instance, or whenever a new examining point is established in a region from which applicants were previously eligible for Class C privileges, such holders of Class C privileges shall within four months thereafter appear at an examining point and be examined for Class B privileges. The license will be canceled if such licensee fails to appear, or fails to pass the examination.

Sec. 151.20 *Examination abridgment.* An applicant for Class A privileges, who holds a license with Class B privileges, will be required to pass only the added examination element No. 4 (see Section 151.16).

A holder of Class C privileges will not be accorded an abridged examination for either Class B or Class A privileges.

An applicant who has held a license for the class of privileges specified below, within five years prior to receipt of application, credited with examination elements as follows:

Class of license or privileges	Credits
Commercial extra first	Elements 1, 2 & 4
Radiotelegraph 1st, 2nd, or 3rd	Elements 1 & 2
Radiotelephone 1st or 2nd	Elements 2 & 4
Class A	Elements 2 & 4

No examination credit is given on account of license of Radiotelephone 3rd Class, nor for other class of license or privileges not above listed.

Sec. 151.21 *Examination procedure.* Applicants shall write examinations in longhand,—code tests and diagrams in ink or pencil, written tests in ink—except that applicants unable to do so because of physical disability may typewrite or dictate their examinations and, if unable to draw required diagrams, may make instead a detailed description essentially equivalent. The examiner shall certify the nature of the applicant's disability and, if the examination is dictated, the name and address of the person(s) taking and transcribing the applicant's dictation.

Sec. 151.22 *Grading.* Code tests are graded as passed or failed, separately for sending and receiving tests. A code test is failed unless free of omission or other error for a continuous period of at least one minute at required speed. Failure to pass the required code test will terminate the examination. (See Sec. 151.23.)

A passing grade of 75 per cent is required separately for Class B and Class A written examinations.

Sec. 151.23 *Eligibility for reexamination.* An applicant who fails examination for amateur privileges may not take another examination for such privileges within two months, except that this rule shall not apply to an examination for Class B following one for Class C.

PART 152—AMATEUR RADIO STATIONS

Licenses

Sec. 152.01 *Eligibility for amateur station license.* License for an amateur station will be issued only to a licensed amateur operator who has made a satisfactory showing of control of proper transmitting apparatus and control of the premises upon which such apparatus is to be located; provided, however, that in the case of an amateur station of the military or Naval Reserve of the United States located in approved public quarters and established for training purposes, but not operated by the United States Government, a station license may be issued to a person in charge of such a station although not a licensed amateur operator.

Sec. 152.02 *Eligibility of corporations or organizations to hold license.* An amateur station license 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 152.01 to a licensed amateur operator as trustee for such society.

Sec. 152.03 *Location of station.* An amateur radio station, and the control point thereof when remote control is authorized, shall not be located on premises controlled by an alien.

Sec. 152.04 *License period.* License for an amateur station will normally be for a period of three years from the date of issuance of a new, renewed, or modified license.

Sec. 152.05 *Authorized operation.* An amateur station license authorizes the operation of all transmitting apparatus used by the licensee at the location specified in the station license and in addition the operation of portable and portable-mobile stations at other locations under the same instrument of authorization.

Sec. 152.06 *Renewal of amateur station license.* An amateur station license may be renewed upon proper application and a showing that, within three months of receipt of the application by the Commission, the licensee thereof has lawfully operated such station in communication by radio with at least three other amateur stations licensed by the Commission, except that in the case of an application for renewal of station license issued for an amateur society or reserve group, the required operation may be by any licensed amateur operator. Upon failure to comply with the above requirements, a successor license will not be 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 by the licensee in a conspicuous place in the room in which the transmitter is located or kept in the personal possession of the operator on duty, except when such license has been filed with application for modification or renewal, or has been mutilated, lost, or destroyed, and application has been made for a duplicate.

Call Signals

Sec. 152.08 *Assignment of call letters.* Amateur station calls will be assigned in regular order and special requests will not be considered except that a call may be reassigned to the latest holder, or if not under license during the past five years to any previous holder, or to an amateur organization in memoriam to a deceased member and former holder, and particular calls may be temporarily assigned to stations connected with events of general public interest.

Sec. 152.09 *Call signals for member of U.S.N.R.* In the case of an amateur licensee whose station is licensed to a regularly commissioned or enlisted member of the United States Naval Reserve, the Commandant of the naval district in which such station is located may authorize in his discretion the use of the call-letter prefix N in lieu of the prefix W or K, assigned in the license issued by the Commission, provided that such N prefix shall be used only when operating in the frequency bands 1715-2000 (Subject to change to "1750 to 2050" kilocycles in accordance with the "Inter-American Arrangement Covering Radiocommunication," Havana, 1937) kilocycles, 3500-4000 kilocycles, 56,000-60,000 kilocycles, and 400,000-401,000 kilocycles in accordance with instructions to be issued by the Navy Department.

Sec. 152.10 *Transmission of call signals.* An operator of an amateur station shall transmit its assigned call at the end of each transmission and at least once every ten minutes during transmission of more than ten minutes' duration: *provided, however,* that transmission of less than one minute duration from stations employing break-in operation need be identified only once every ten minutes of operation and at the termination of the correspondence. In addition, an operator of an amateur portable or portable-mobile radiotelegraph station shall transmit immediately after the call of the station the fraction-bar character (DN) followed by the number of the amateur call area in which the portable or portable-mobile station is then operating, as for example:

Example 1. Portable or portable-mobile amateur station operating in the third amateur call area calls a fixed amateur station: W1ABC W1ABC W1ABC DE W2DEF DN3 W2DEF DN3 W2DEF DN3 AR.

Example 2. Fixed amateur station answers the portable or portable-mobile amateur station: W2DEF W2DEF W2DEF DE W1ABC W1ABC W1ABC K.

Example 3. Portable or portable-mobile amateur stations calls a portable or portable-mobile amateur service station: W3GHI W3GHI W3GHI DE W4JKL DN4 W4JKL DN4 W4JKL DN4 AR.

If telephony is used, the call sign of the station shall be followed by an announcement of the amateur call area in which the portable or portable-mobile station is operating.

Sec. 152.11 *Requirements for portable and portable-mobile operation.* A licensee of an amateur station may operate portable amateur stations (Section 150.03) in accordance with the provisions of Sections 152.09, 152.10, 152.12 and 152.45. Such licensee may operate portable and portable-mobile amateur stations without regard to Section 152.12, but in compliance with Sections 152.09, 152.10 and 152.45, when such operation takes place on authorized amateur frequencies above 28,000 kilocycles.

Sec. 152.12 *Special provisions for portable stations.* Advance notice in writing shall be given by the licensee to the inspector in charge of the district in which such portable station is to be operated. Such notices shall be given prior to any operation contemplated, and shall state the station call, name of licensee, the date of proposed operation, and the locations as specifically as possible. An amateur station operating under this Section shall not be operated during any period exceeding one month without giving further notice to the inspector in charge of the radio inspection district in which the station will be operated, nor more than four consecutive periods of one month at the same location. This Section does not apply to the operation of portable or portable-mobile amateur stations on frequencies above 28,000 kilocycles. (See Section 152.11.)

Sec. 152.13 *Special provisions for non-portable stations.* The provisions for portable stations shall not be applied to any non-portable station except that:

(a.) An amateur station that has been moved from one permanent location to another permanent location may be operated at the latter location in accordance with the provisions governing portable stations for a period not exceeding sixty days, but in no event beyond the expiration date of the license, provided an application for modification of license to change the permanent location has been made to the Commission.

(b.) The licensee of an amateur station who is temporarily residing at a location other than the licensed location for a period not exceeding four months may for such period operate his amateur station at his temporary address in accordance with the provisions governing portable stations.

Use of Amateur Stations

Sec. 152.14 *Points of communication.* An amateu station shall communicate only with other amateur stations, except that in emergencies or for testing purposes it may be used also for communication with commercial or Government radio stations. In addition, amateur stations may communicate with any mobile radio station which is licensed by the Commission to communicate with amateur stations, and with stations of expeditions which may also be authorized to communicate with amateur stations. They may also make transmissions to points equipped only with receiving apparatus for the measurement of emissions, observation of transmission phenomena, radio control of remote objects, and similar purely experimental purposes.

Sec. 152.15 *No remuneration for use of station.* An amateur station shall not be used to transmit or receive messages for hire, nor for communication for material compensation, direct or indirect, paid or promised.

Sec. 152.16 *Broadcasting prohibited.* An amateur station shall not be used for broadcasting any form of entertainment, nor for the simultaneous retransmission by automatic means of programs or signals emanating from any class of station other than amateur.

Sec. 152.17 *Radiotelephone tests.* The transmission of music by an amateur station is forbidden. However, single audio-frequency tones may be transmitted by radiotelephony for test purposes of short duration in connection with the development of experimental radiotelephone equipment.

Allocation of Frequencies

Sec. 152.25 *Frequencies for exclusive use of amateur stations.* The following bands of frequencies are allocated exclusively for use by amateur stations: 1715 to 2000 kilocycles (subject to change to "1750 to 2050" kilocycles in accordance with the "Inter-American Arrangement Covering Radiocommunication," Havana, (1937), 3500 to 4000 kilocycles, 7000 to 7300 kilocycles, 14000 to 14400 kilocycles, 28000 to 30000 kilocycles, 56000 to 60000 kilocycles, 112000 to 118000 kilocycles (the Commission reserves the right to change or cancel these frequencies without advance notice or hearing), 224000 to 230000 kilocycles (the Commission reserves the right to change or cancel these frequencies without advance notice or hearing), 400000 to 401000 kilocycles.

Sec. 152.26 *Use of frequencies above 300000 kilocycles.* The licensee of an amateur station may, subject to change upon further order, operate amateur stations, with any type of emission authorized for amateur stations, on any frequency above 300000 kilocycles without separate licenses therefor.

Sec. 152.27 *Frequency bands for telephony.* The following bands of frequencies are allocated for use by amateur stations using radiotelephony, type A-3 emission: 1800 to 2000 kilocycles, 28500 to 30000 kilocycles, 56000 to 60000 kilocycles, 112000 to 118000 kilocycles (the Commission reserves the right to change or cancel these frequencies without advance notice or hearing), 224000 to 230000 kilocycles (the Commission reserves the right to change or cancel these frequencies without advance notice or hearing), 400000 to 401000 kilocycles.

Sec. 152.28 *Additional bands for telephony.* An amateur station may use radiotelephony, type A-3 emission, in the following additional bands of frequencies; *provided* the station is licensed to a person who holds an amateur operator's license endorsed for Class A privileges, and actually is operated by an amateur operator holding Class A privileges: 3900 to 4000 kilocycles, 14150 to 14250 kilocycles.

Sec. 152.29 *Television and frequency-modulation transmission.* The following bands of frequencies are allocated for use by amateur stations for television and radiotelephone frequency-modulation transmission: 112000 to 118000 kilocycles (the Commission reserves the right to change or cancel these frequencies without advance notice or hearing), 224000 to 230000 kilocycles (the Commission reserves the right to change or cancel these frequencies without advance notice or hearing), 400000 to 401000 kilocycles.

Sec. 152.30 *Facsimile transmission.* The following bands of frequencies are allocated for use by amateur stations for facsimile transmission: 1715 to 2000 kilocycles (subject to change to "1750 to 2050" kilocycles in accordance with the "Inter-American Arrangement Covering Radiocommunication," Havana, 1937), 56000 to 60000 kilocycles, 112000 to 118000 kilocycles (the Commission reserves the right to change or cancel these frequencies without advance notice or hearing), 224000 to 230000 kilocycles (the Commission reserves the right to change or cancel these frequencies without advance notice or hearing), 400000 to 401000 kilocycles.

Sec. 152.31 *Individual frequency not specified.* Transmissions by an amateur station may be on any frequency within the bands above assigned. Sideband frequencies resulting from keying or modulating a transmitter shall be confined within the frequency band used.

Sec. 152.32 *Types of emission.* All bands of frequencies allocated to the amateur service may be used for radiotelegraphy, type A-1 emission. Type A-2 emission may be used in the following bands of frequencies only: 56000 to 60000 kilocycles, 112000 to 118000 kilocycles (the Commission reserves the right to change or cancel these frequencies without advance notice or hearing), 224000 to 230000 kilocycles (the Commission reserves the right to change or cancel these frequencies without advance notice or hearing), 400000 to 401000 kilocycles.

Equipment and Operation

Sec. 152.40 *Maximum power input.* The licensee of an amateur station is authorized to use a maximum power input of 1 kilowatt to the plate circuit of the final amplifier stage of an oscillator-amplifier transmitter or to the plate circuit of an oscillator transmitter. An amateur transmitter operating with a power input exceeding nine-hundred watts to the plate circuit shall provide means for accurately measuring the plate power input to the vacuum tube, or tubes, supplying power to the antenna.

Sec. 152.41 *Power supply to transmitter.* The licensee of an amateur station using frequencies below 60000 kilocycles shall use adequately filtered direct-current plate power supply for the transmitting equipment to minimize frequency modulation and to prevent the emission of broad signals.

Sec. 152.42 *Requirements for prevention of interference.* Spurious radiations from an amateur transmitter operating on a frequency below 60000 kilocycles shall be reduced or eliminated in accordance with good engineering practice and shall not be of sufficient intensity to cause interference on receiving sets of modern design which are tuned outside the frequency band of emission normally required for the type of emission employed. In the case of A-3 emission, the transmitter shall not be modulated in excess of its modulation capability to the extent that interfering spurious radiations occur, and in no case shall the emitted carrier be amplitude-modulated in excess of 100 per cent. Means shall be employed to insure that the transmitter is not modulated in excess of its modulation capability. A spurious radiation is any radiation from a transmitter which is outside the frequency band of emission normal for the type of transmission employed, including any component whose frequency is an integral multiple or submultiple of the carrier frequency (harmonics and subhamonics), spurious modulation products, key clicks, and other transient effects, and parasitic oscillations. The frequency of emission shall be as constant as the state of the art permits.

Sec. 152.43 *Modulation of carrier wave.* Except for brief tests or adjustments, an amateur radiotelephone station shall not emit a carrier wave unless modulated for the purpose of communication.

Sec. 152.44. *Frequency measurement and regular check.* The licensee of an amateur station shall provide for measurement of the transmitter frequency and establish procedure for checking it regularly. The measurement of the transmitter frequency shall be made by means independent of the frequency control of the transmitter and shall be of sufficient accuracy to assure operation within the frequency band used.

Sec. 152.45. *Logs.* Each licensee of an amateur station shall keep an accurate log of station operation, including the following data:

(a.) The date and time of each transmission. (The date need only be entered once for each day's operation. The expression "time of each transmission" means the time of making a call and need not be repeated during the sequence of communication which immediately follows; however, an entry shall be made in the log when "signing off" so as to show the period during which communication was carried on.)

(b.) The signature of the person manipulating the transmitting key of a radiotelegraph transmitter or the signature of the person operating a transmitter of any other type (type A-3 or A-4 emission) with statement as to type of emission, and the signature of any other person who transmits by voice over a radiotelephone transmitter (type A-3 emission). (The signature need only be entered once in the log provided the log contains a statement to the effect that all transmissions were made by the person named except where otherwise stated. The signature of any other person who operates the station shall be entered in the proper space for his transmissions.)

(c.) Call letters of the station called. (This entry need not be repeated for calls made to the same station during any sequence of communications, provided the time of "signing off" is given.)

(d.) The input power to the oscillator, or to the final amplifier stage where an oscillator-amplifier transmitter is employed. (This need be entered only once, provided the input power is not changed.)

(e.) The frequency band used. (This information need be entered only once in the log for all transmissions untill there is a change in frequency to another amateur band.)

(f.) The location of a portable or portable-mobile station at the time of each transmission. (This need be entered only once provided the location of the station is not changed. However, suitable entry shall be made in the log upon changing location, showing the type of vehicle or mobile unit in which the station is operated and the approximate geographical location of the station at the time of operation.)

(g.) The message traffic handled. (If record communications are handled in regular message form, a copy of each message sent and received shall be entered in the log or retained on file for at least one year.)

The log shall be preserved for a period of at least one year following the last date of entry. The copies of record communications and station log, as required under this section, shall be available for inspection upon request by an authorized Government representative.

Special Conditions

Sec. 152.50 *Additional conditions to be observed by licensee.* An amateur station license is granted subject to the conditions imposed in Sections 152.51 to 152.54 inclusive, in addition to any others that may be imposed during the term of the license. Any licensee receiving due notice requiring the station licensee to observe such conditions shall immediately act in conformity therewith.

Sec. 152.51 *Quiet hours.* In the event that the operation of an amateur station causes general interference to the reception of broadcast programs with receivers of modern design, such amateur station shall not operate during the hours from 8 o'clock p.m. to 10:30 p.m., local time, and on Sunday for the additional period from 10:30 a.m. until 1 p.m., local time, upon such frequency or frequencies as cause such interference.

Sec. 152.52 *Second notice of same violation.* In every case where an amateur station licensee is cited a second time within a year for the same violation under Section 152.25, 152.27, 152.28, 152.30, 152.31, 152.41, or 152.42, the Commission will direct that the station remain silent from 6 p.m. to 10:30 p.m., local time, until written notice has been received authorizing full-time operation. The licensee shall arrange for tests at other hours with at least two amateur stations within fifteen days of the date of notice, such tests to be made for the specific purpose of aiding the licensee in determining whether the emissions of his station are in accordance with the Commission's Regulations. The licensee shall report under oath to the Commission at the conclusion of the tests as to the observations reported by amateur licensees in relation to the reported violation. Such reports shall include a statement as to the corrective measures taken to insure compliance with the Regulations.

Sec. 152.53. *Third notice of same violation.* In every case where an amateur station licensee is cited the third time within a year for the same violation as indicated in Section 152.52, the Commission will direct that the station remain silent from 8 a.m. to 12 midnight, local time, except for the purpose of transmitting a prearranged test to be observed by a monitoring station of the Commission to be designated in each particular case. Upon completion of the test the station shall again remain silent during these hours until authorized by the Commission to resume full-time operation. The Commission will consider the results of the tests and the licensee's past record in determining the advisability of suspending the operator license and/or revoking the station license.

Sec. 152.54 *Operation in emergencies.* In the event of widespread emergency conditions affecting domestic communication facilities, the Commission may confer with representatives of the amateur service and others and, if deemed advisable, will declare that a state of general communications emergency exists, designating the licensing area or areas concerned (in general not exceeding 1,000 miles from center of the affected area), whereupon it shall be incumbent upon each amateur station in such area or areas to observe the following restrictions for the duration of such emergency:

(a.) No transmissions except those relating to relief work or other emergency service such as amateur nets can afford, shall be made within the 1715-2000 (subject to change to "1750 to 2050" kilocycles in accordance with the "Inter-American Arrangement Covering Radiocommunication," Havana, 1937) kilocycle or 3500-4000 kilocycle amateur bands. Incidental calling, testing, or working, including casual conversation or remarks not pertinent or necessary to constructive handling of the general situation shall be prohibited.

(b.) The frequencies 1975-2000, 3500-3525, and 3975-4000 kilocycles shall be reserved for emergency calling channels, for initial calls from isolated stations or first calls concerning very important emergency relief matters or arrangements. All stations having occasion to use such channels shall, as quickly as possible, shift to other frequencies for carrying on their communications.

(c.) A five-minute listening period for the first five minutes of each hour shall be observed for initial calls of major importance, both in the designated emergency calling channels and throughout the 1715-2000 (subject to change to "1750 to 2050" kilocycles in accordance with the "Inter-American Arrangement Covering Radiocommunication," Havana, 1937) and 3500-4000 kilocycle bands. Only stations isolated or engaged in handling official traffic of the highest priority may continue with transmissions in these listening periods, which must be accurately observed. No replies to calls or resumption of routine traffic shall be made in the five-minute listening period.

(d.) The Commission may designate certain amateur stations to assist in promulgation of its emergency announcement, and for policing the 1715-2000 (subject to change to "1750 to 2050" kilocycles in accordance with the "Inter-American Arrangement Covering Radiocommunication," Havana, 1937) and 3500-4000 kilocycle bands and warning noncomplying stations noted operating therein. The operators of these observing stations shall report fully the identity of any stations failing, after due notice, to comply with any section of this regulation. Such designated stations will act in an advisory capacity when able to provide information on emergency circuits. Their policing authority is limited to the transmission of information from responsible official sources, and full reports of noncompliance which may serve as a basis for investigation and action under Section 502 of the Communications Act. Policing authority extends only to 1715-2000 (subject to change to "1750 to 2050" kilocycles in accordance with the "Inter-American Arrangement Covering Radiocommunication," Havana, 1937) and 3500-4000 kilocycle bands. Individual policing transmissions shall refer to this Section by number, shall specify the date of the Commission's declaration, the area and nature of the emergency, all briefly and concisely. Policing observer stations shall not enter into discussions beyond essentials with the stations notified, or other stations.

(e.) These special conditions imposed under this Section will cease to apply only after the Commission shall have declared such emergency to be terminated.

COMMON WORD ABBREVIATIONS

ABT	about	GA	go ahead	ND	nothing doing	TNK	think
AHD	ahead	GM	good morning	NG	no good	TR	there
AHR	another	GN	good night	NL	night letter	TT	that
ANI	any	GT	get, got	NM	no more	UD	it would
BD	bad	GG	going	NR	number	UL	you'll
BK	break	HA	laughter	NW	now	V	from
BUG	speed key	HI	laughter-high	OB	old boy	VB	very bad
BN	been	HR	hear—here	OL	old lady	VY	very
B4	before	HW	how	OM	old man	WA	word after
BI	by	HV	have	OP	operator	WB	word before
BCUZ	because	I	"ok"	OW	old woman	WD	would
BTWN	between	IC	I see	PLS	please	WF	word following
BIZ	business	K	go ahead	PSE	please	WK	work
CK	check	LID	poor operator	PX	press	WL	will—would
CN	can	LIL	little	R	ok	WN	when
CUL	see u later	LST	last	RI	radio inspector	WL	wavelength
C	see	LTR	letter	SA	say	WT	what
CW	continuous wave	MI	my	SS	single signal	WX	weather
DE	from	MA	milliamp.	SIG	signal	X	interference
DX	distance	MSG	message	STICK	pencil	XMTR	transmitter
DA	day	MILL	typewriter	SKED	schedule	YF	wife
DH	dead-head	MST	must	TFC	traffic	YL	young lady
DC	direct current	MNI	many	TKS	thanks	YR	your
ES	and	MI	my	TNX	thanks	30	finish
FB	fine business	MK	make	TK	take	73	regards
FM	from	MO	more	TMW	tomorrow	88	love and kisses
FR	for						

R-S-T REPORTING SYSTEM

READABILITY

1—UNREADABLE

2—BARELY READABLE — OCCASIONAL WORDS DISTINGUISHABLE.

3—READABLE WITH CONSIDERABLE DIFFICULTY.

4—READABLE WITH PRACTICALLY NO DIFFICULTY.

5—PERFECTLY READABLE.

SIGNAL STRENGTH

1—FAINT — SIGNALS BARELY PERCEPTIBLE.

2—VERY WEAK SIGNALS.

3—WEAK SIGNALS.

4—FAIR SIGNALS.

5—FAIRLY GOOD SIGNALS.

6—GOOD SIGNALS.

7—MODERATELY STRONG SIGNALS.

8—STRONG SIGNALS.

9—EXTREMELY STRONG SIGNALS.

★

TONE

1—EXTREMELY ROUGH, HISSING NOTE.

2—VERY ROUGH A.C. NOTE—NO TRACE OF MUSICALITY.

3—ROUGH, LOW-PITCHED A.C. NOTE—SLIGHTLY MUSICAL.

4—RATHER ROUGH A.C. NOTE—MODERATELY MUSICAL.

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.

IF THE NOTE APPEARS TO BE CRYSTAL CONTROLLED, SIMPLY ADD AN X AFTER THE APPROPRIATE NUMBER.

INSTRUMENTS

AN ELECTRIC CALIBRATOR

The Electric Calibrator.

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.

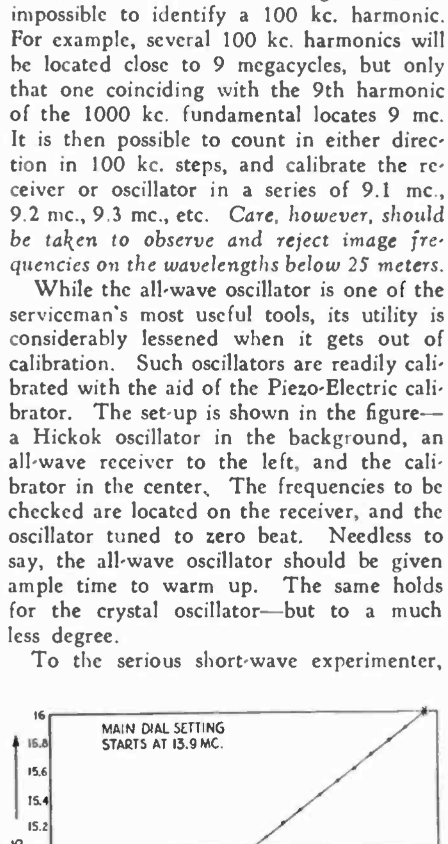
This instrument will fit readily even into a small service kit, and therefor provides the quickest and most simple check on a receiver's calibration in the home as well as in the shop. Plugged in on any a. c. line, 11 frequency checks are supplied on the standard broadcast band employing the 100 kc. 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, on 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!"

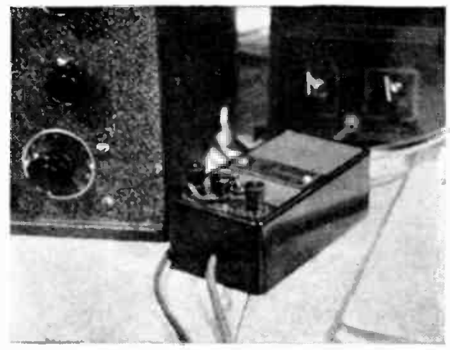
The 1000 kc. steps are used for spotting rather than calibration. It might often be impossible to identify a 100 kc. harmonic. For example, several 100 kc. harmonics will be located close to 9 megacycles, but only that one coinciding with the 9th harmonic of the 1000 kc. fundamental locates 9 mc. It 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 set-up 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,



A receiver calibration. The vernier dial setting graphed.



The Piezo-Electric Calibrator set up to measure the efficiency of the receiver.

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.

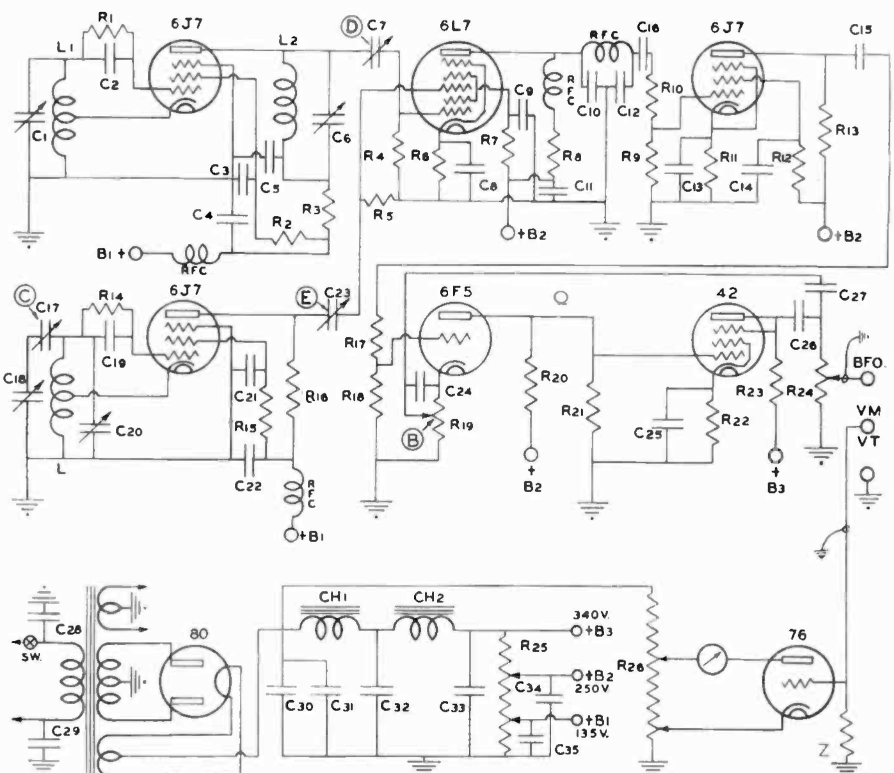
A similar curve on an amateur receiver provides an immediate answer to a request for a frequency check. Explanation of the use of the calibrator will furnish the answer to the inevitable government license examination question, "Explain how you would determine whether the frequency of your transmitter 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 filming the cleaned parts.

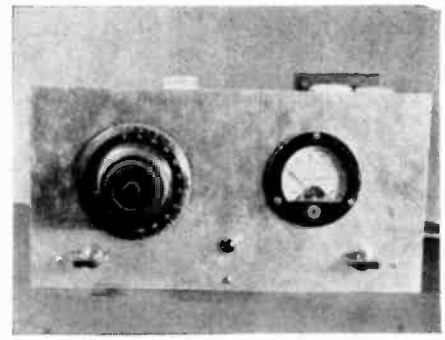
The crystal is then replaced and the plates evenly tightened until the crystal will not oscillate. Letting up equally on the three nuts thus loosening the plates until the 100 kc. harmonic on a high frequency coincides with the 1000 kc. harmonic.

Occasionally the oscillator should be checked against a reliable broadcasting station, or better yet, WWV's standard frequency transmissions. These occur daily at 5000 kc., the 5th harmonic of the "high" top or 50th 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.

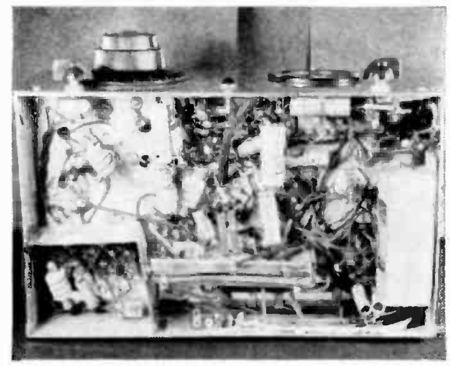
A chart should then be made for all frequencies to maintain accuracy.



FOR INFORMATION ON (B)(C)(D)(E) SEE TEXT
The circuit of the B.F.O. combination V.T.M.



The front of the unit. The dial controls the pitch of the audio note, the meter is used in the Vacuum tube voltmeter.



While it seems complicated, the wiring is extremely simple. Shielding should be followed wherever indicated for best results.

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 serviceman 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 enforced 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 uses 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.

Parts of the Audio Oscillator.

C_1—Trimmer of IF
C_2—.00025 mfd mica
C_3—.01 mfd 200v paper
C_4—.01 mfd 200v paper
C_5—.01 mfd 200v paper
C_6—Trimmer of IF
C_7—.00001 mfd trimmer
C_8—.01 mfd 350v paper
C_9—.01 mfd 350v paper
C_{10}—.00025 mfd 400v mica
C_{11}—.01 mfd 350v paper
C_{12}—.00025 mfd 400v mica
C_{13}—5. mfd 450v electro.
C_{14}—.1 mfd 450v paper
C_{15}—.1 mfd 450v mica
C_{16}—.1 mfd 450v paper
C_{17}—.0002 padder air cond.
C_{18}—35 mmfd var. midget
C_{19}—.00025 mfd mica
C_{20}—Trimmer of IF
C_{21}—.01 mfd 200v paper
C_{22}—.01 mfd 200v paper
C_{23}—.00001 mfd trimmer
C_{24}—5 mfd 450v electro.
C_{25}—5 mfd 450v electro.
C_{26}—.1 mfd 450v paper
C_{27}—.002 mfd mica
C_{28}—.01 mfd mica
C_{29}—.01 mfd mica
C_{30}—8 mfd 500v electro.
C_{31}—8 mfd 500v electro.
C_{32}—8 mfd 500v electro.
C_{33}—8 mfd 500v electro.
C_{34}—8 mfd 500v electro.
C_{35}—8 mfd 500v electro.
C_{36}—.1 mfd 450v paper
R_1—25000 ohms 1 w.
R_2—50000 ohms 1 w.
R_3—10000 ohms 1 w.
R_4—.5 megohm 1 w.
R_5—50000 ohms 1 w.
R_6—7500 ohms 10 w.
R_7—100000 ohms 10 w.
R_8—50000 ohms 10 w.
R_9—.25 megohm 5 w.
R_{10}—100000 ohms 2 w.
R_{11}—13000 ohms 10 w.
R_{12}—.25 megohm 10 w.
R_{13}—100000 ohms 10 w.
R_{14}—25000 ohms 1 w.
R_{15}—50000 ohms 1 w.
R_{16}—10000 ohms 1 w.
R_{17}—500000 ohms 5 w.
R_{18}—25000 ohms 5 w.
R_{19}—10000 ohms pot.
R_{20}—100000 ohms 10 w.
R_{21}—.25 megohm 5 w.
R_{22}—1000 ohms 10 w.
R_{23}—5000 ohms 10 w.
R_{24}—5000 ohms pot.
R_{25},R_{26}—40000 ohms 25 w. adj.
Z—2 megohms 1 w.
SW—AC switch
Meter—0-50 Milliammeter with internal shunt removed.
L, L_1, L_2—Rebuilt IF transformers. See text for details.
RFC—Standard broadcast band, radio frequency chokes.
Q—Insert .01 mfd at pt Q

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 fibre 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 volume control (marked A in the diagram) is an ordinary 5,000 ohm wire 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 beat frequency oscillator constant regardless of the output level. In the described unit, this output impedance changes with each change in volume.

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 introducer of out-of-phase 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 .01 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 padder 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 (the switch is the knob under the dial) 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 loud speaker 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 audible 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 wave form, 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. Another way, and the one used for the instrument being described, is to check it against a broadcast station making a frequency run at night after the programs cease.

It is customary for the large broadcasters to make these frequency runs at regular intervals. They do this by modulating their transmitters with audio frequencies from the lowest to the highest. A telephone call to the operator will identify the frequency in cycles per second; the identical frequency on the oscillator is then logged by dial degrees. The lowest frequencies, that is harmonics and sub-harmonics of sixty cycles, can also be obtained by beating against the power supply using two speakers or phones, one connected to the AC line through a resistance, the other to the oscillator.

The vacuum tube voltmeter is quickly calibrated in RMS values by means of the 25,000 ohm potentiometer and the AC voltmeter hooked up as shown in the diagram. The tube is of course first set practically at cut-off by means of a variable cathode tap on its voltage divider. The plate tap is set at a value which will allow the tube to draw a maximum current just enough to swing the meter full scale. The false zero will be slightly above the actual zero on the meter; the needle is set back before calibration by means of the screwdriver slot on the meter face.

The power transformer is the standard broadcast receiver type. The chokes are the small ones usually found in low priced receivers. Three wet electrolytic condensers are used in the two *pi* section filter and a dual dry electrolytic is used across the taps of the main voltage divider.

A milliammeter of 0-50 range was incorporated in the beat frequency oscillator being described because it was the only one available. The internal shunt was removed and it was then possible to get full scale deflections easily with the type 76 tube when measuring the output of the unit.

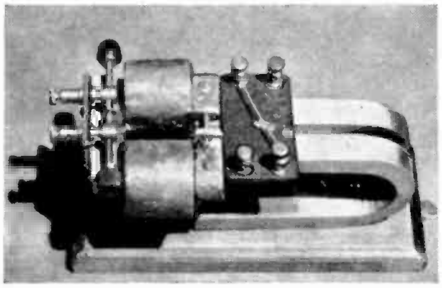
CONSTRUCTING A POLARIZED RELAY

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 milliampere or less.

The relay to be described is very sensitive; the one constructed operating well on currents as low as 250 microamperes. In one 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 .25 watt should be used.

Auxiliary relays should always be used when the sensitive relay is operating on currents of a milliampere 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 reverses direction. It remains on the other contact until again reversed.



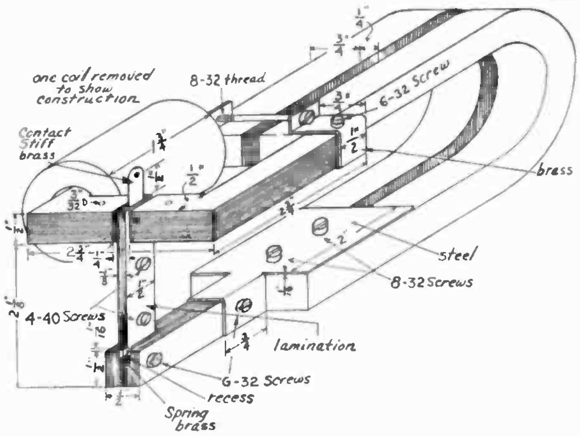
The completed polarized relay. Simple, compact and efficient, it will give excellent service.

This also makes it applicable as a circuit breaker. It can be made to close on a given current in a predetermined direction, and open again as the current is reduced. The current change to open, when the relay is being held closed by the minimum current required to close, can be adjusted within rather wide limits. About 250 microamperes is the minimum, when the closing current is a milliampere or over. It is very useful in "squelch" circuits used to reduce, or cut off entirely, the output of radio sets 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. However, if a current is passed through the coils in the direction shown, the polarity of N_1 will be strengthened, and the polarity of N_2 weakened or even changed to the opposite. This, of course, tends to move the armature toward N_1. 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 from any motorcycle shop or airport repair station. The poles are made of laminated iron of good permeability. The cores of old audio transformers are especially good. The coils can be obtained from a vibrating spark coil of the model T Ford variety. Both coils in series should have a resistance of about 3,000 to 5,000 ohms, each being half that value.

The drawing is more or less self explanatory. The dimensions, of course, do not have to be followed exactly, but can be



The drawing clearly shows details.

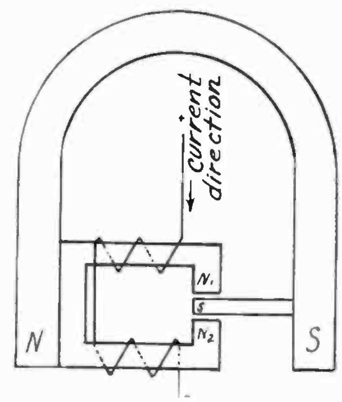
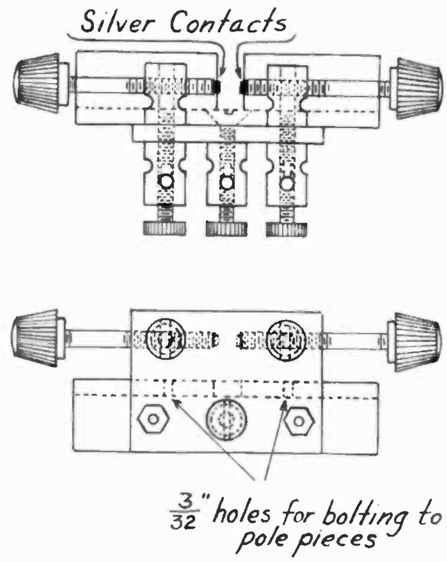


Diagram of how the circuit works.



The method of mounting the contact points which are really activates.

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 $\frac{1}{16}$" 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.

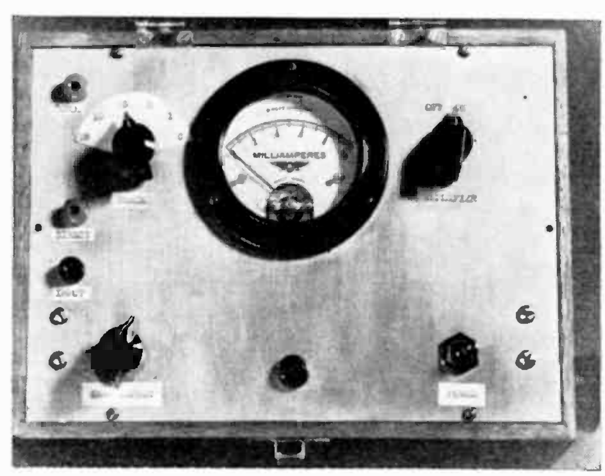
To adjust as a sensitive simple relay, one contact is screwed to just past center so that the armature when pressed to this contact, with no current flowing in the coils, will just fall back to the other position. Then with the current desired to close the relay, flowing in the coils (in the proper direction), 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 ½ volt. Throwing a single switch and re-adjusting 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.

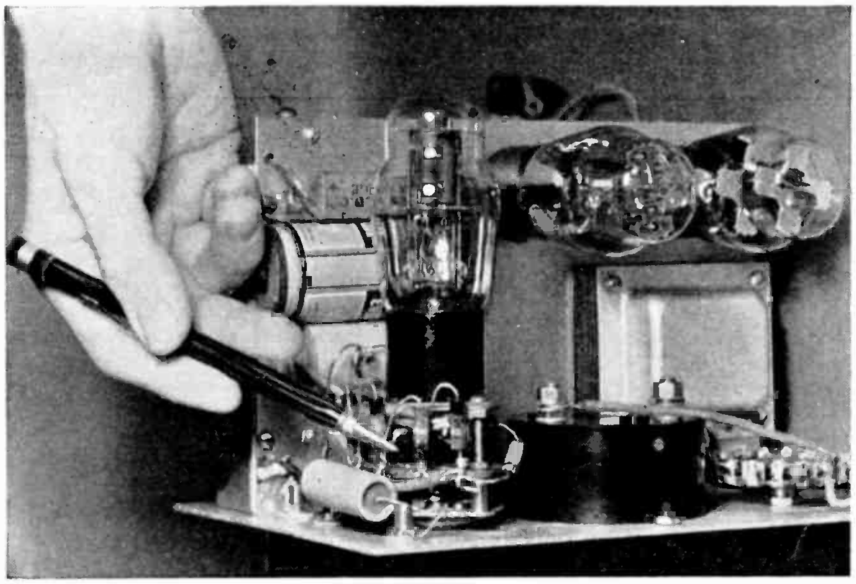
Construction of the 2-5 is quite simple. A few points concerning the input circuit will be explained. The parts specified are not critical and good components of the same values can be substituted. Wire wound resistors and paper condensers must be used where specified. The sub-panel brackets were revamped from one standard 2½" 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.

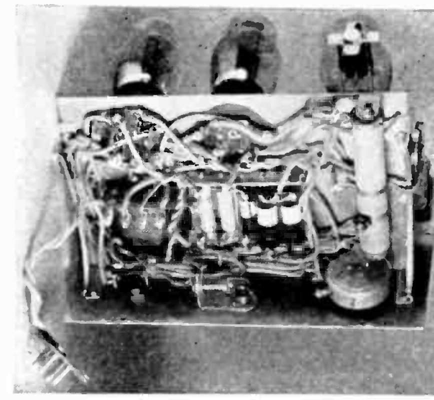


A 6"x9" hardwood cabinet houses the entire unit.

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 ears 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.

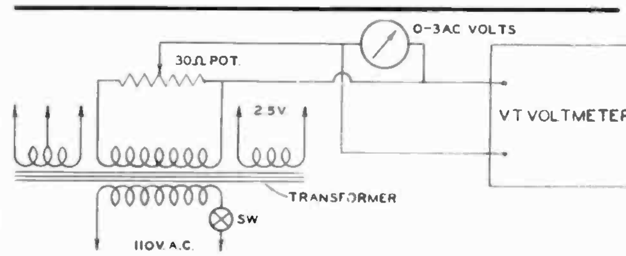

Under chassis view, showing resistor bank.

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 metallized 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 metallized 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.

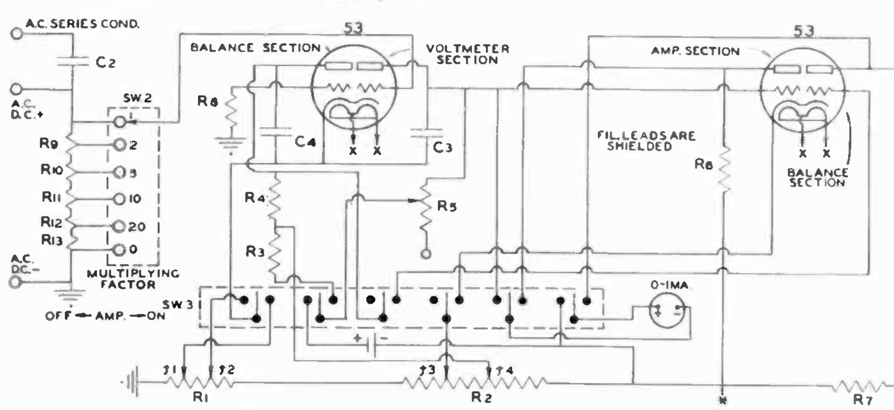
The circuit adjustments are made by changing the positions of taps on R1, R2 and R6. These adjustments are important and must be carried out carefully if the meter is to operate at its best and give the sensitivity of which it is capable.

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

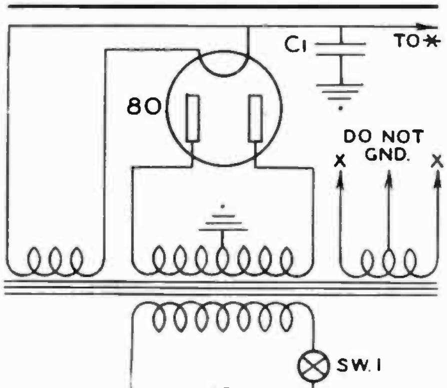


Test circuit used for calibration.

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.



The circuit of the 2-5 Vacuum Tube Voltmeter.



The power supply of the 2-5.

Sw_2—Single gang, shorting type selector switch. Single circuit, six pole. Yaxley 1216L.
Sw_1—SPST toggle switch.
Sw_3—Six pole, double throw switch Yaxley No. 3263J, non shorting type. Set adjustable stop for two position operation.
R_1—1,000 ohm, 10 w. adjustable wire wound
R_2—15,000 ohms, 50 w. adjustable wire wound, Electrad Truvolt.
R_3—90,000 ohm wire wound, 20 w.
R_4—100,000 ohm wire wound, 20 w.
R_5—10,000 ohms. Yaxley universal wire wound volume control. Linear taper.
R_6—10,000 ohms, 10 w. wire wound
R_7—10,000 ohms, 10 w. wire wound
R_8—2 megohms, ½ w. metallized
R_9—1 megohm, ½ w. metallized
R_{10}—600,000 ohms, ½ w. metallized
R_{11}—200,000 ohms, ½ w. metallized
R_{12}—100,000 ohms, ½ w. metallized
R_{13}—100,000 ohms, ½ w. metallized
C_1—8 mfd. 500v. electro
C_2—¼ mfd. 200v. paper
C_3 and C_4—½ or 1 mfd. 400v. paper
0-1 MA milliammeter
Power transformer. 2.5v. @ 4A; 5v. @ 2A; 300-0-300
Aluminum or electraloy panel, size 1-16 by 6½ by 9 inches
Aluminum or electraloy sub-panel, size 1-16 by 5¼ by 8½ inches
Cabinet. ¼ inch hardwood, with a slip hinged cover. Size, inside measurements, 6 by 9 inches by 5¾ inches, in depth. The lid was 6 by 9 by 1½ inches deep.

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 lower values will give a little better accuracy, but less sensitivity. Higher values only cut down the sensitivity. Replace the milliammeter in its regular position, apply an a.c. 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 *on*, the range switch on 0, and plug in the amplifier tube. Connect an 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 in the 2-5 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 1.3 ma. total current to the voltmeter tube.

A 1000 ohm per volt meter with a range of 250 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 R5 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 a.c. input. Full scale should be reached at ½ 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.

DB 2—4000 OHM CONVERSION CHART

POWER LEVEL DB	VOLTS 500 OHM LINE	POWER WATTS 0-6mw
−20	0.1730	0.00006
−19	0.1990	0.00007
−18	0.2180	0.00009
−17	0.2340	0.00011
−16	0.2730	0.00015
−15	0.3000	0.00018
−14	0.3390	0.00023
−13	0.3890	0.00030
−12	0.4450	0.00039
−11	0.4860	0.00047
−10	0.5477	0.00060
−9	0.6145	0.00070
−8	0.6895	0.00090
−7	0.7737	0.00110
−6	0.8681	0.00150
−5	0.9740	0.00180
−4	1.0928	0.00230
−3	1.2262	0.00300
−2	1.3758	0.00370
−1	1.5437	0.00470
0	1.7321	0.00600
+1	1.9431	0.00750
+2	2.1805	0.00950
+3	2.4466	0.01190
+4	2.7451	0.01500
+5	3.0801	0.01890
+6	3.4559	0.02380
+7	3.8776	0.03000
+8	4.3507	0.03800
+9	4.8680	0.04740
+10	5.4772	0.06000
+11	6.1600	0.07590
+12	6.8100	0.09480
+13	7.7368	0.11970
+14	8.7100	0.15070
+15	9.7400	0.18970
+16	10.9285	0.23880
+17	12.2620	0.30070
+18	13.7578	0.37850
+19	15.4369	0.47660
+20	17.3205	0.60000
+21	19.4340	0.75530
+22	21.8050	0.95090
+23	24.4660	1.19710
+24	27.4510	1.50710
+25	30.8010	1.89740

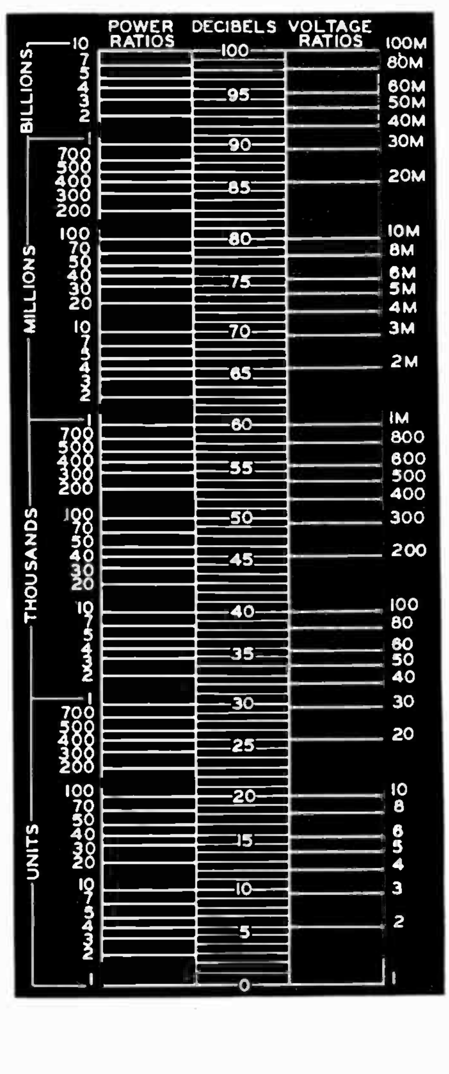
POWER LEVEL DB	VOLTS 500 OHM LINE	POWER WATTS 0-6mw
+26	34.5590	2.3886
+27	38.7760	3.0071
+28	43.5070	3.7857
+29	48.8160	4.7660
+30	54.7720	6.0000
+31	61.4550	7.5535
+32	68.9540	9.5093
+33	77.3680	11.9716
+34	86.8080	15.0713
+35	97.4000	18.9747
+36	109.2850	23.8865
+37	122.6200	30.0710
+38	137.5820	37.8570
+39	154.3690	47.6600
+40	173.2050	60.0000
+41	194.3400	75.5350
+42	218.0500	95.0930
+43	244.6600	119.7160
+44	274.5100	150.7130
+45	308.0100	189.7470
+46	345.5900	238.8650
+47	389.0700	300.7100
+48	435.6000	379.5000
+49	487.0100	474.3700
+50	547.7200	600.0000
+51	616.0300	759.0000
+52	688.7400	948.7500
+53	770.4000	1185.9400
+54	871.2000	1518.0000
+55	974.0300	1897.5000

Impedance		DB
4000 Ohms	Add	9
2000 Ohms	Add	6
600 Ohms	Add	1
500 Ohms	....	0
250 Ohms	Subtract	3
24 Ohms	Subtract	13
15 Ohms	Subtract	15
10 Ohms	Subtract	17
8 Ohms	Subtract	18
6 Ohms	Subtract	19
5 Ohms	Subtract	20
4 Ohms	Subtract	21
2.5 Ohms	Subtract	23
2 Ohms	Subtract	24

$E = \sqrt{WZ}$ where—
E = AC volts across load.
Z = loaded line impedance.
W = watts.

Cond. in Series with DB Meter = .25 Mfd.

DB—VOLTAGE POWER RATIO CHART



SERVICE PROBLEMS

The author adjusts a wave trap.

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 at distant points. Both phenomena add to the problems of the serviceman.

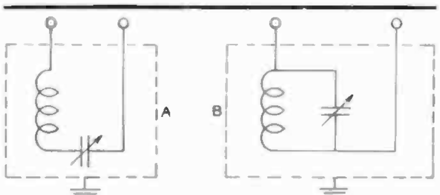


Fig. 1—Two Basic Types of Wave Traps.

High Percentage Modulation makes itself known when you are near the station, as distortion. This fact alone complicates servicing by causing the distortion to be intermittent and dependent upon the carrier level.

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.

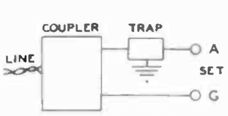


Fig. 2—Wave Trap.

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, it 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 one 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 .01 mfd. condensers are connected from the line to ground. This also helps to control volume on local stations.

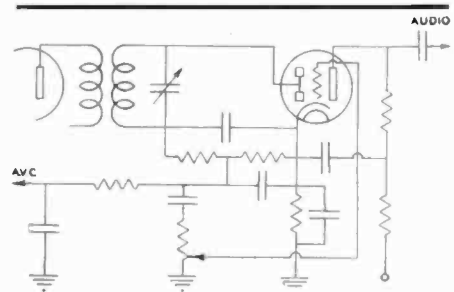


Fig. 3—Original Circuit.

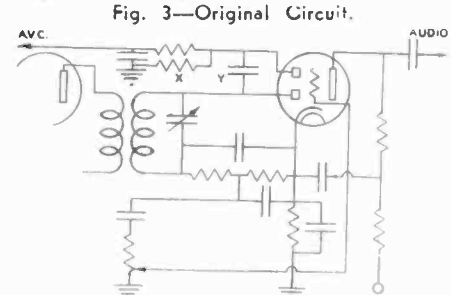


Fig. 4—New Circuit.
X—1 megohm. Y—100 mfd.
All other parts are the same.

5. Many early all-wave aerials of the so-called noise reducing type are causes of overload on the broadcast band because the *transmission line acts as an aerial.* If the aerial has no transformer at the aerial end of the transmission line, this undoubtedly is the case. Make sure the can does contain a transformer. Many cans formed only a junction box for the leads. To test this,

Fig. 5—Old Circuit.

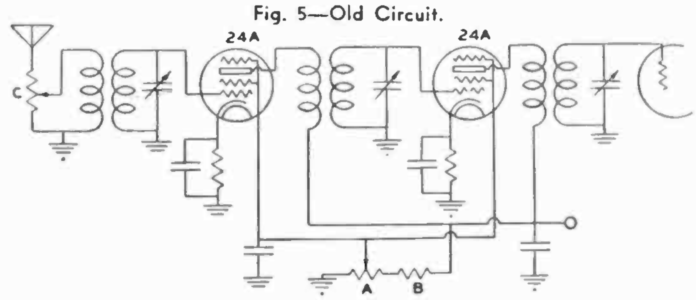
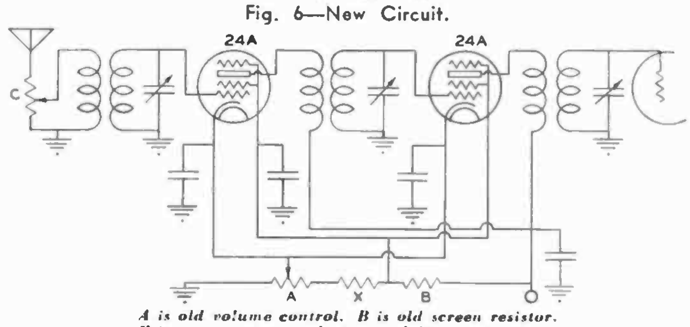
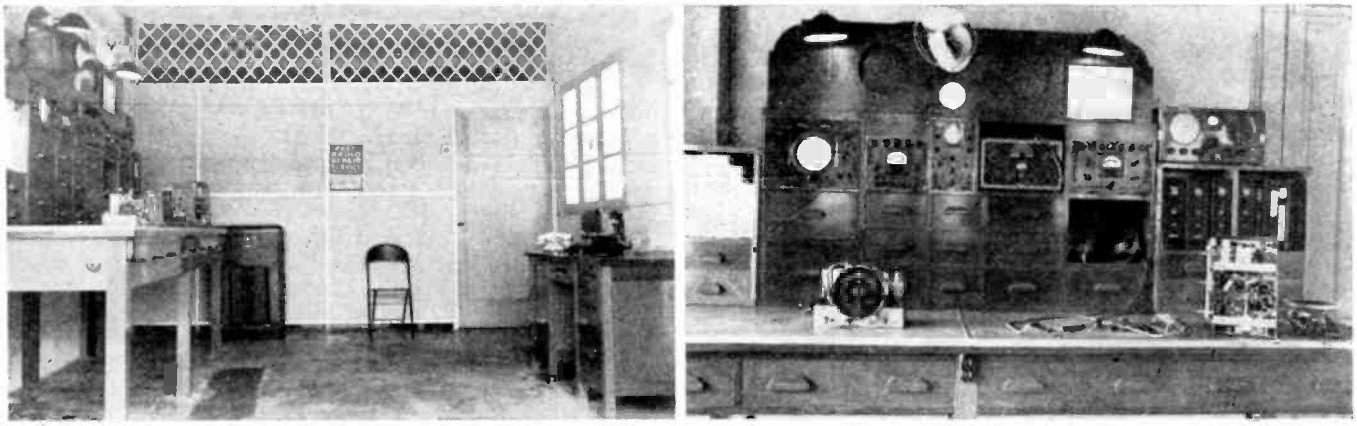


Fig. 6—New Circuit.



A is old volume control. B is old screen resistor.
X is a new resistor to be inserted (2—5 watt size).



Tilley's Radio Service of Ancon, Canal Zone, features a fine service bench of solid mahogany with a linoleum top.

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 overloading due to excessive aerial, whether it be 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 across the transmission line. 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 into noticeable hiss. It is a cross talk eliminator, whose action is that of a *selective shunt,* for 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 whatsoever. 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. Size 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 1/4 megohm.

C is the antenna section, if the 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 that certain peculiar cases of 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 reradiated into the air on frequencies other than their original. 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 below in addition to their regular frequencies:

A= 600 kc.	2A+B=1900 kc.
B= 700 kc.	2A—B= 500 kc.
A+B=1300 kc.	2B+A=2000 kc.
A—B= 100 kc.	2B—A= 800 kc.
2A=1200 kc.	3A=1800 kc.
2B=1400 kc.	3B=2100 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 open wire. The result is 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. Do not confuse 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 arrestor to the set.

Poor ground clamps, loose connections, or *bad lead-in strips* in the *ground lead* may be the cause of hum-on-carrier and cross talk. *Leakage between* the *terminals* of the *lightning arrestor* has been a frequent cause of cross modulation and hum-on-carrier too, if the set and arrestor 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 line 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 out the window 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 behooves any serviceman who goes to a roof to inspect his customer's aerial to also inspect all other aerials on that roof, eliminating all shorts 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 offending conductors 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 aerial may be used 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 apparent. 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 build 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. 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 I. F. 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 of approximately equal power on 710 kc. that we wish to receive, we will 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. See table below:

Carrier			
Desired Station 710,000 cycles (710 kc.)		Interfering Station 700,000 cycles (700 kc.)	
Modulation Carriers			
Monkey Chatter		Monkey Chatter	
714,000	706,000	706,000	694,000
4000 cycle Modulation		6000 cycle Modulation	

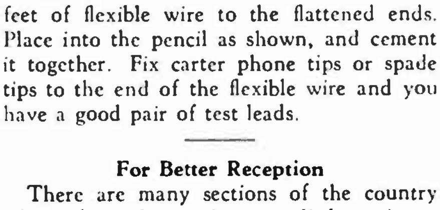
It is apparent that 4000 cycle modulation on 710 kc. produces a sideband which is identical with a 6000 cycle sideband on 700 kc.

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 10 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 pencils in half, the long way, 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 5¼-inch lengths, sharpen points on one end, flatten the other ends. Then solder four feet of flexible wire to the flattened ends. Place into the pencil as shown, and cement it together. Fix carter 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 solution 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 radio men, not advertising experts. 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: 1¾x4 inches. The width was decided upon because it is the greatest which permits entrée 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 boldface; 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.

Copy: Say whatever you wish, but keep it 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 they meet; 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. A 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.

> Ours is a radio repair shop fitted exclusively for maintenance. No frills—
>
> **NO DRAPERIES**
>
> —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

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. Hew 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 these 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 kitchenetters.

It is easier to give out cards in large apartment houses than in private homes, but the apartment resident is sated by a continual shower of mailbox advertising. The greatest response *per thousand cards* comes from smaller buildings. They find fewer pieces of advertising in their mailboxes, and give each piece more attention, for the same reason a child in a small family gets more attention than a child who is one of many.

Many persons, pretending they are discouraging a bothersome practice, make rules which say they will never trade with any concern that uses door advertising. It has been my experience that such a person, when he wants his set repaired in a hurry, forgets all principle and calls the repair shop which has put its 'phone number closest to his hand. Don't be frightened by any thought of making ill-will with advertising of any type. If you do *anything* ninety thousand times, *someone* is going to be offended.

Once, following an especially weak moment, I distributed cards advertising free radio service in a six-block area. Then, to compare results, I covered the same neighborhood with cards announcing a dollar service charge. Although the cards were nearly identical in size and makeup, the results were very different. We got the expected response from the latter; the former, however, provoked calls from the cheapest bunch of chiselers I ever came across in my life. I learned then that, even though free service advertising resulted in more calls, they were from customers I didn't want.

If you are the type of person who is too proud, or too occupied with a rushing business to distribute cards, you can hire some kids to get rid of them for you. They will —down a sewer!

Speaker Troubles

Intermittent blasting of dynamic speakers is very often traceable to the presence of minute metal particles. These particles generally collect in the air gap between the moving coil and the field magnet and become magnetized. To remove the particles simply disconnect the field supply and pass a thin piece of magnetized iron around the air gap.

What's the Line Voltage?

More Power to You

HAS 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 final step of its 5-volt 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 power companies. Starting with the 115-volt level, periodic boosts are made every month or two until 120 is reached. Consumers are usually notified of the change by means of a printed slip accompanying their light bill. It is probable that few of these notices are read. They are too easily mistaken for washing-machine ads to command attention during their quick trip from envelope to waste-paper basket.

The various State Commissions allow a certain excursion from the level in use. In one section, a 5% over-voltage and a 4% under-voltage are specified as the limits. It is probable that your power company stays within these limits as a matter of operating policy, except when unusually severe load or supply conditions are met. Regardless of the *range*, it is important for the serviceman to know what maximum voltages he is working with from day to day in his territory.

Random voltmeter readings are of little value. 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 for the daily maximum in each section. 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 those at the *same time of day* in your shop. 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 13% overload, and, although it be the operating policy of your power company to keep well within the 5% 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 of them, because of miserly engineering practice 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 "guarantee" 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 in the same number running cooler. Heat and voltage failures walk hand-in-hand, and cannot be considered separately.

If the higher voltage level is in use in your neighborhoods, change transformer taps when the set is delivered; you will find many of them set for the old 115-volt level. Secondary overload is as important a heat factor as high primary voltage; check against this by noticing, with the proper primary voltage across the power transformer, whether the socket voltages are the correct ones. An overloaded transformer—at any primary voltage—can be detected by socket readings which are too low when the power transformer is too hot. If resistors fail, use the next higher wattage; condensers, the next higher voltage. In properly designed sets, the easiest way to compensate for a raised voltage is, of course, to bring down all secondary voltages by use of the optimum primary voltage. In the cheaply-designed sets, a little good judgment will be required, as no two sets of conditions will be alike. The important fact to remember is that, regardless of good or poor design, failures are a result of increased heat and voltage.

If your town is planning a voltage boost, notify all your customers, recommending a voltage regulator, reducer, or anything you think best, for your location. Even though the immediate response might be small, your warning will be remembered later, if their set stops for *any* reason after the line voltage has been increased. There is nothing which reconciles a customer to payment quicker than a set failure you have prophesied.

Magnifying Meter Reading

It is sometimes desirable to detect minute fluctuations in the movement of a meter pointer to check surges in a circuit. It is also necessary at times, to obtain meter readings with the instrument placed at a position remote from the observer. To meet these requirements obtain a folding type magnifying mirror of the 25 and 50-cent store variety. The mirror faces are over five inches in diameter and when placed in the back of the meter, the image of the meter is greatly magnified.

Cushioning Radio Equipment

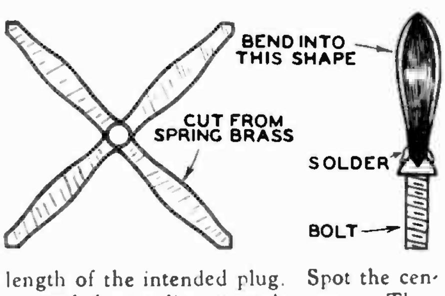
Ordinary sponge rubber, such as kneeling pads which can be purchased for twenty cents in the "five-and-dime" stores, finds many applications around radio equipment. Microphone trouble in regenerative and other receivers can oftentimes be eliminated by placing the receiver on strips of this material, for instance. Microphonism in preamplifiers can usually be cured in the same way as can hum pick-up resulting from using preamplifiers around amateur transmitters where they are subject to mechanical vibrators from vibrating units.

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

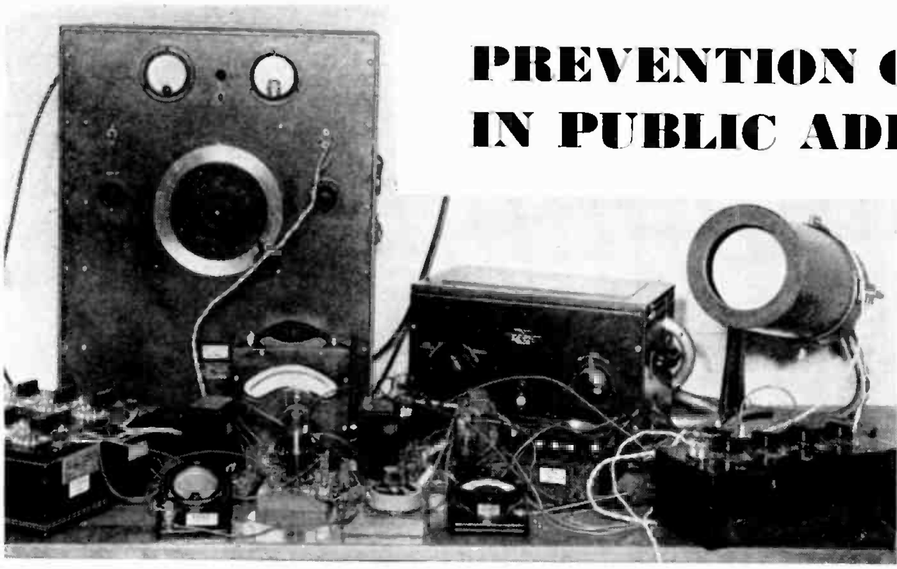
Cut a suitably size square of thin spring brass. The distance from the center to each corner should be slightly greater than the



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.

AMPLIFIER SECTION

PREVENTION OF OSCILLATION IN PUBLIC ADDRESS SYSTEMS

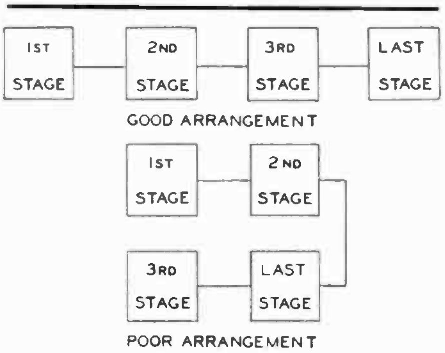


The equipment used in checking P. A. Oscillation.

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:



Two types of circuits discussed above.

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 tubes of the amplifier will be found to vary, exactly as the plate currents of the last tubes. 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.

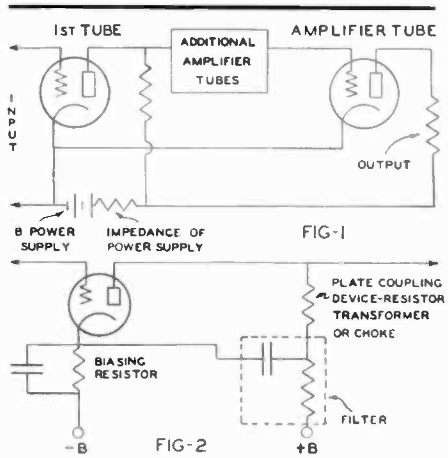
There are two methods by which coupling through the power supply may be minimized. The first is to employ a separate power supply for the last stages of the amplifier, generally for the power output stage alone. A second method is to reduce the effective resistance of the power supply, by alterations 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



Two types of P. A. stage arrangements.

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 interelectrode, 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.)

1st Stage Tube	2d Stage Tube	Input Coupling	3rd Stage Tube	3rd Stage Input Coupling	Filter Required (as given in Table 2) 1st Stage High Res. Supply	1st Stage Low Res. Sup.	2d Stage High Res. Sup.	2d Stage Low Res. Sup.
57	56	Resis.	45	Resis.	IV	III	II	I
57	56	Resis.	2-45s	pp Trans.	II	I	none	none
57	56	Resis.	2-2A3	pp Trans.	III	II	I	none
57	56	Resis.	2A5	Trans.	IV	III	II	I
57	56	Resis.	2-2A5	pp Trans.	III	II	I	none
56	56	Resis.	45	Resis.	III	II	I	none
57	59	Resis.	2-59	Class B	—	IV	—	none
56	56	Trans.	45	Trans.	IV	III	II	I
57	57	Resis.	2-2A5	pp Trans.	IV	III	III	II
56	56	Trans.	2-2A3	pp Trans.	III	II	I	none
57	57	Resis.	56	Resis.	IV	III	III	II

4-Stage Amplifiers (including detector)

1st Stage Tube	2d Stage Tube	2d Stage Input Coupling	3rd Stage Tube	3rd Stage Input Coupling	4th Stage Tube	4th Stage Input Coupling	1st Stage High Res. Sup.	1st Stage Low Res. Sup.	2d & 3d Stages High Res. Sup.	2d & 3d Stages Low Res. Sup.
56	56	Resis.	56	Resis.	2-2A3	pp Trans.	III	II	II	I
57	56	Resis.	56	Resis.	2-45	pp Trans.	IV	III	III	II
57	56	Resis.	56	Resis.	47	Trans.	—	V	—	IV
56	56	Trans.	56	Trans.	2-42	pp Trans.	V	IV	IV	III

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 Number (Refers to Table 1)	C in mfds.	R in ohms
I	2	10000
	1	20000
	.5	40000
II	4	10000
	2	20000
	1	40000
III	8	10000
	4	20000
	2	40000
IV	16	10000
	8	20000
	4	40000
	2	80000
V	16	20000
	8	40000
	4	80000

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 "Scotchmen'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 will have up to 40 watts output per pair are in the last stages of experimentation. The new 6AC5G 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 is used as a driver and also supplies bias for the 6AC5 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 by having both the tubes in the same envelope.

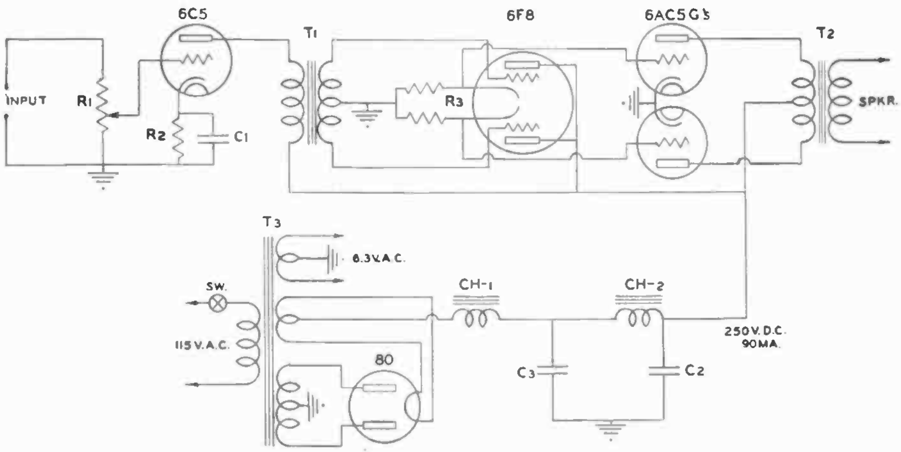
The grids of the 6F8 have to be fed with an out-of-phase signal for correct push-pull operation so the simplest method was chosen—a push-pull inter-stage transformer. For phonograph operation or from a radio tuner output, a 6C5 as shown in the diagram is plenty to overdrive the amplifier. But if microphone operation is desired, the 6F5 will provide sufficient 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 practically 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 6AC5's draw 32 milliamperes each and the 6F8 draws a total of 18 milliamperes, the 6C5 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 "Scotchman'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.



The circuit diagram of the "Scotchman's Special" P. A. System.

R_1—500,000 ohm pot.
R_2—2000 ohm 2 w.
R_3—25000 ohm 2 w.
C_1—25 mfd. 10 v. electro.
C_2—8 mfd. 450 v. electro.
C_3—Same as C_2.
T_1—Single plate to p.p. grids.
T_2—10,000 ohms p.p. plates to v.c.
T_3—Power trans. to deliver 250 v. d.c. from filter.
CH_1, CH_2—Up to 30 hy. filter chokes. (15 hy. min.)

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 pa. 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 6C5 which was in turn transformer coupled to a power of 25L6's. The rectifiers were two 25Z5'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 6C5. Fixed bias is supplied by a Mallory bias cell and the 6J7, pentode connected, capacity coupled to the gain control of the 6C5 serves the purpose of mixing volume from the phonograph as well as the gain from the crystal microphone input.

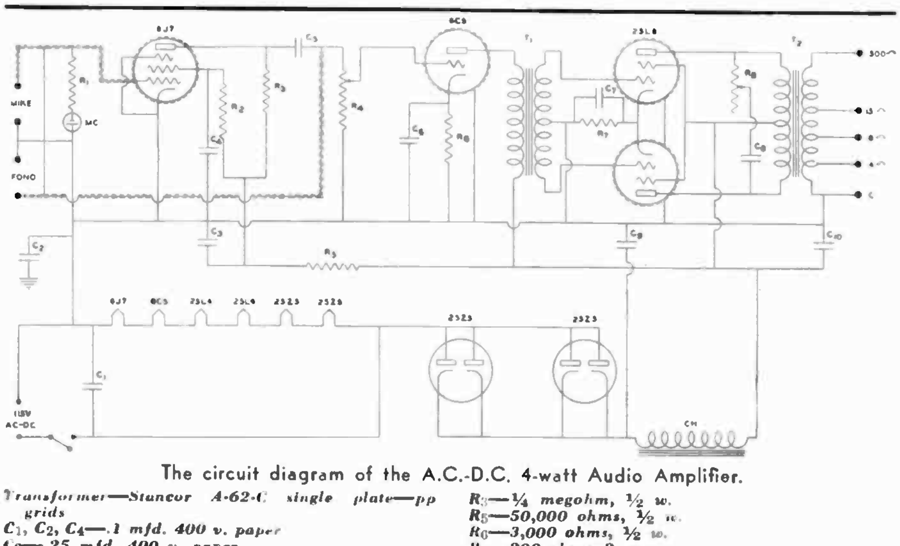
A tone control consisting of a one-half megohm rheostat in series with a .01 mfd. condenser serves to control the high frequency output of the amplifier and to produce the effect of a greater low frequency response at lower volume levels. Most important of all is the fact that this tone control acts 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 .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 4-watt Amplifier.

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



The circuit diagram of the A.C.-D.C. 4-watt Audio Amplifier.

Transformer—Stancor A-62-C single plate—pp grids
C_1, C_2, C_4—.1 mfd. 400 v. paper
C_3—.25 mfd. 400 v. paper
C_5, C_8—.01 mfd. 400 v. paper
C_6, C_7—10 mfd. 25 v. elect.
C_9, C_{10}—15-15 mfd. 250 v. elect.
R_1, R_2—1 megohm, ½ w.
R_3—¼ megohm, ½ w.
R_5—50,000 ohms, ½ w.
R_6—3,000 ohms, ½ w.
R_7—200 ohms, 2 w.
R_4—½ megohm vol. control
R_8—½ megohm tone control with switch
MC—Mallory cell
CH—30 hy. Fil. choke (Stancor C-1002)

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 serviceman. 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 used making 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 25L6G's and one 25Z5G 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 record, accurate reproduction is had of what has been impressed upon the record blank.

Never use more audio than is necessary to get a full recording. The acetate upon which the average recordings are made is only a few 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 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 ten 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 "scrap" which will unfurl as the record is cut. This scrap 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 micrometers 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.

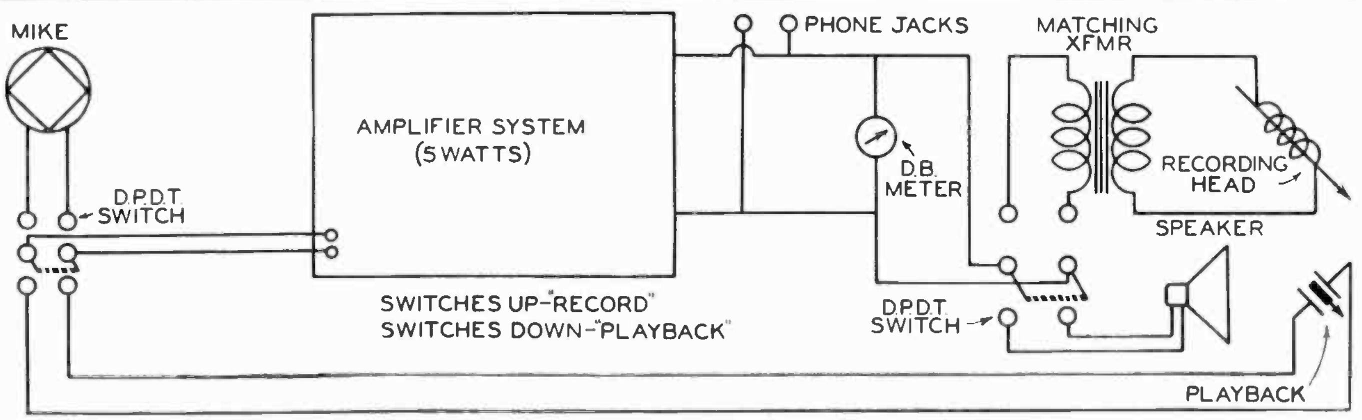
The recording machine can also be used without the amplifier to make records from the "air." This is a profitable source of income for servicemen living in small towns and communities, which support a local broadcast station. There are any number of artists both amateur and professional who would value 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 33⅓ 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 33⅓ 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 "fine" 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.



How to hook up the home-recorder.

GENERAL & GADGET SECTION

RADIO-EQUIPPED TREASURE LOCATOR

The Treasure-Hunter, or M-Scope, is light in weight and can be easily carried about. (The set cannot be used for the benefit of others without violating the Fisher patents.)

RADIO has supplanted the "doodle-bug" in the search for oil, precious ores, and buried treasure. More than 150 large corporations are now using the radio equipment invented by Dr. Gerhard Fisher of Palo Alto, California, in their every-day work of locating oil and metal beneath the surface of the earth. Hundreds of individuals who have tried the Fisher sets in prospecting and treasure-hunting have reported successful finds. Now you can make your own set at home for a small sum, by following the simple and easy directions which RADIO NEWS is authorized by Dr. Fisher to release for amateur use only.

Diagrams for making treasure-locating radio equipment are presented here with Dr. Fisher's permission. The first, called the *Metallascope*, or *M-Scope*, was developed in 1929, and is protected by U. S. Patent No. 2066561.

The principle 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 59.9 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.

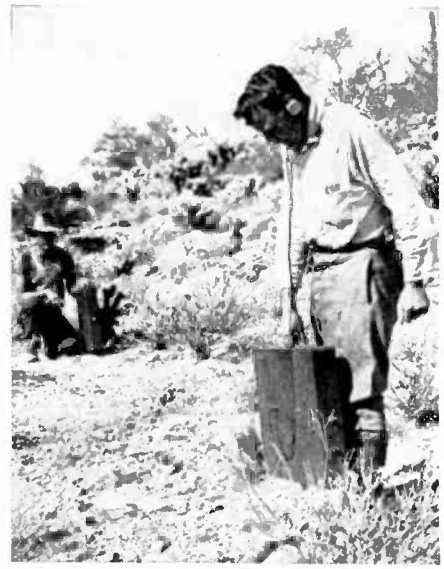
In looking at the diagram, you will see that we have indicated conventional type-30 tubes for the receiver, and type-31 tubes for the transmitter. These weigh less than shielded-grid or pentode tubes which some experimenters prefer, require less plate voltages, and are less noisy in operation than the 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, 1½" wide, and ¾" thick. These should be planed and sand-papered and the holes should be drilled in accordance with the drawing. Use no paint on them; a simple stain is sufficient to protect them from the elements.

Next, you will want the r.f. Chokes, each with 1500 turns, of No. 34 copper wire, enamel covered. Be sure to get No. 34, enamel covered, for another gauge or different covering may throw out the balance of this design. The windings can be either "Random" or "Duo-lateral"; this makes no



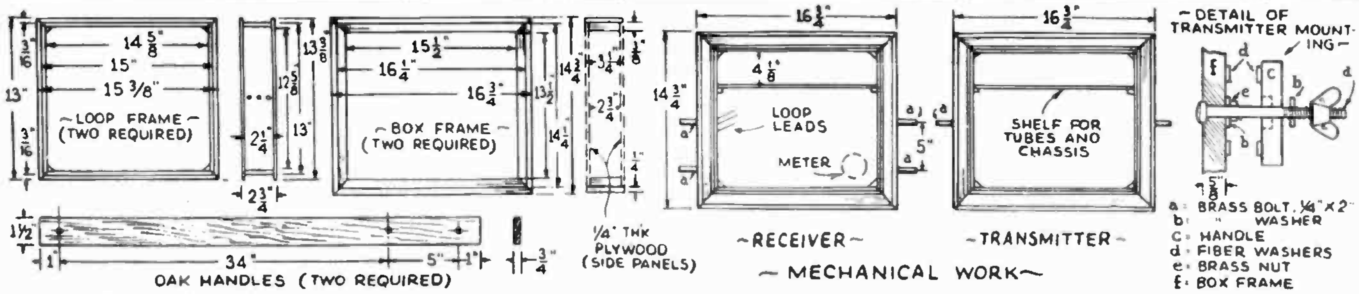
An M-Scope with separate transmitter and receiver. One man has the receiver, the other holds the transmitter at a distance.

difference in the result. The Chokes are labelled "2" in the drawings.

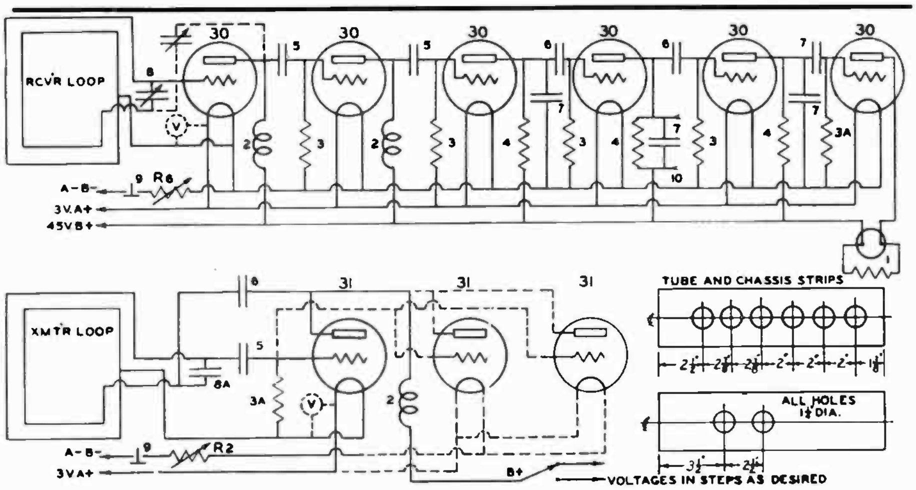
Now we jump down to the loop frames which are wound with 80 turns of No. 33 D.C.C. copper wire, center-tapped, and here again we must caution against using anything outside of the specifications if you want to have a perfect balance on the completion of your set.

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 length 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 3½ 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



Constructional details for the loop frames, transmitter and receiver boxes, and the handles for the Fisher Treasure-Hunter.



Circuit of the 2-unit M-Scope.

1—Milliammeter
2—R. F. Choke, 1500 turns, No. 34 enamel copper
3—1 meg. resistor
3A—3 meg. resistor
4—.1 meg. resistor
5—.0005 mfd., 1 w., fixed
6—.006 mfd., 1-w., fixed
7—.001 mfd., 1 w., fixed
8—0 to .0005 mfd. trimmer adjuster
8A—.00025 mfd., 1 w., fixed
9—push-pull switches
10—Tip jacks for phones
R_2—5 ohms, 1 w.
R_6—2 ohms, 1 w.

The author using the locator.

is in balance when the transmitter 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 transmitter, 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 transmitter to set up eddy currents which re-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 tronble 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.

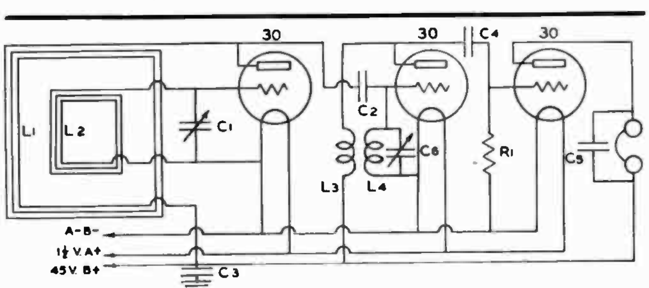
Having made the handles and frames, we are ready for the actual radio equipment. If you do not have one already, buy a milliammeter (d.c.) with enough shunt resistance to permit about ¾ full scales deflection with the receiver switch ON, and the transmitter switch OFF. The case of the meter should be 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 transmitter 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.

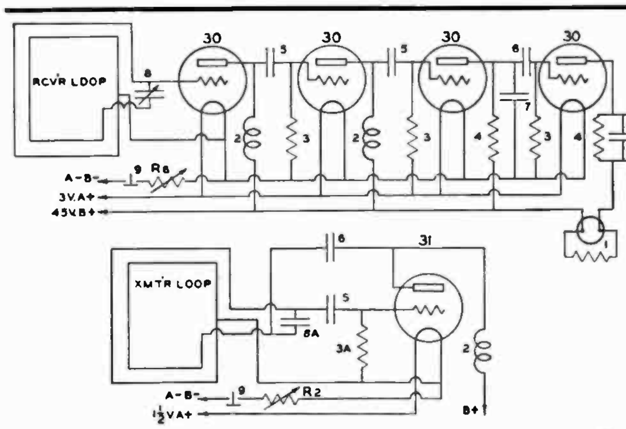
The equipment which we have described is the M-Scope, which sells for about two hundred dollars. The simpler set, which is sold for ninety-five dollars, is the MT-Scope, which is also covered by a patent, but can be copied by readers of this magazine by permission of the patent-owner.

Internal parts of MT-Scope are fewer in number, and better adapted to the beginner who is content with a set of medium



A small M-Scope with both xmtr. & rcvr. combined.

C_1—.00025 mfd., 1 w.
C_2—.00005 mfd., 1 w.
C_3—.0 mfd., 1 w.
C_4—.001 mfd., 1 w.
C_5—.001 mfd., 1 w.
C_6—.0001 variable, 1 w.
R_1—1 meg.
L_1—9 turns
L_2—7 turns
L_3—15 turns, 1" form
L_4—25 turns, 1" form



A more elaborate M-Scope using "in-front-in-back loops."

R_2—5 ohms, 1 w.
R_6—2 ohms, 1 w.
1—Milliammeter (0-1)
2—R. F. Choke, 1500 turns No. 34ECC
3—1 megohm
3-A—3 megohms
4—.1 megohm
5—.0005 mfd., fixed
6—.006 mfd., fixed
7—.001 mfd., fixed
8—0 to .0005 mfd., trimmer adjuster
8-A—.00025 mfd., fixed
9—Push-pull switches
10—Phone tip jacks

sensitivity. This has six type-30 tubes in the Receiver, and one type-31 tube in the transmitter. It has a filament voltmeter; filament rheostat; a balanced loop antenna which eliminates body and ground capacity; a portable type 45-volt B battery, and two type "Little Six" filament batteries.

In the transmitter, the MT-Scope, has, in addition to the transmitter tube, a filament voltmeter to adjust the depth range of the transmitter; this gives a depth range of over 20 feet which is sufficient for locating most buried treasure. Operating the batteries four hours a day, they should last three to four months, which shows that this set is designed for economy in use.

For the experimenter who wants to try something extremely simple to build, there is a third Fisher circuit, which has never been placed on the market commercially. This uses only three tubes, and employs only the one double-loop, instead of separate loops for the transmitter and receiver.

Whichever set you build, you can be confident that efficient operation will locate any buried metal, whether you are looking for a lost pipe-line or Captain Kidd's treasure.

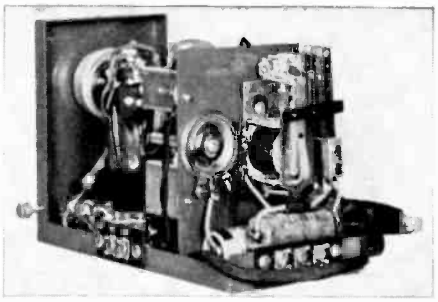
DUAL - DIVERSITY COUPLER

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 *Heavyside* 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 *Heavyside* 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 act 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 two complete receivers with 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



The change-over relay is at rear.

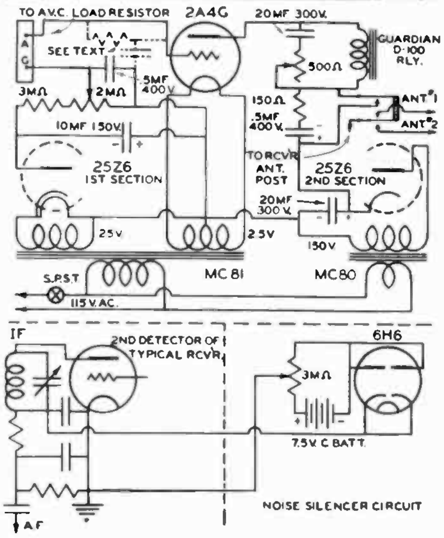


Diagram of the diversity coupler.

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 afflicts 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 8" x 4" x 5½". 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 to 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 signal 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 eight to ten watts of power 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 connection across the receiver's a.v.c. load resistor 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 Thyratron control tube provided by the 25 volt filament secondary (for 25Z6 dual rectifier tube) of transformer MC81.

This negative grid bias is obtained by using one diode of the 25Z6 rectifier, a 12 mfd. dry electrolytic condenser, a 3000 ohm, ½ 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 adds to it to prevent ignition, but when the signal fades downward, the grid bias drops, the Thyratron 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 it suddenly draws, not zero plate current, but about 85 ma., which drops the plate voltage from MC80 and, were MC80 and MC81 combined, would 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 drop 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 the 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 150 volts a.c. for 2A4G plate power, through the second diode of the 25Z6 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 25Z6, 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.

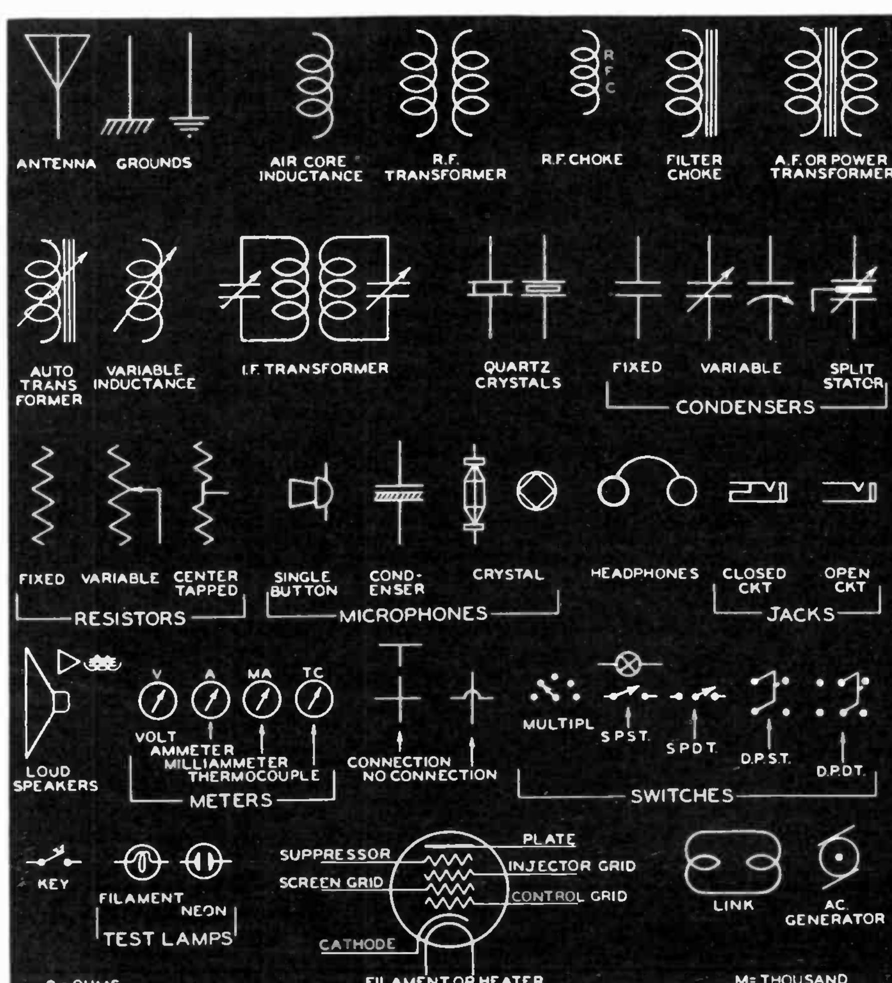
Before turning to the illustration showing this partition assembly, the Guardian D100 magnetic switch may be profitably studied with a magnifying glass. At its left can be seen a black rectangle, which is the magnet operating bar, which, when the magnet pulls, breaks the contact between the two extreme 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 cloverleaf 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 completely its downward stroke or application of current.

Interior illustration shows clearly the three antenna binding posts, the 400 ohm rheostat and 150 ohm, ½ watt resistor, and the ½ mfd. and 12 mfd. condensers across the plate switch contacts and switch coil. The ½ 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.

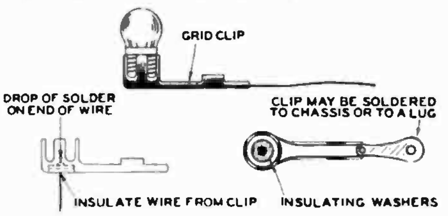
In operation, no consciousness of the operation of the *Diversity Coupler* is had except a "click" every time the signal fades down. This is due to the antenna circuit switching, and is a very small price to pay for the elimination of fading and its steady, long duration noise on downward fades. It can 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 shunt the signal diode 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 ½ megohm, ½ watt resistor in series with the 2A4G grid lead, and a ½ 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 insulating washers. A drop of solder on the end of the bottom lead 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 of course does not apply. It is in the case of non-resonant feeders 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.

Where the antenna is a type that employs a matching section, such as the "J", the "half-waves in phase" and various other arrays 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. Or when 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 shorting bar position near the bottom 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."

Screw Number	Threads Per Inch	Drill Per Tap	Number Clearance
2	48	50	44
2	56	50	44
2	64	50	44
3	40	49	39
3	48	45	38
3	56	44	38
4	32	43	31
4	36	42	31
4	40	41	31
5	30, 32	40	29
5	36	38	29
5	40	37	29
6	30, 32	35	26
6	36	33	26
6	40	32	26
7	30	31	21
7	32	30	21
8	24, 30	30	17
8	32	29	17
9	24	29	13
9	28	28	13
9	30	27	13
9	32	25	13
10	24	25	8
10	30	22	8
10	32	21	8
12	20	19	2
12	24	16	2
12	28	14	2
14	20	10	¼
14	24	7	¼

Meter Kinks

Presented herewith are simple methods whereby two separate meters are employed to obtain multiple current, voltage and resistance measurements.

An 0-15 milliammeter of 295 ohms resistance can be purchased for about 60 cents and one with zero adjustment for about $1.00. A meter of this type will take care of all current measuring requirements with sufficient accuracy. A shunt equal to one-ninth of the meter resistance will increase the range ten times, measuring current up to 150 mas. Connected as in Figure 1, the meter is always prepared for the highest reading and is a safeguard against burn-out. To read 0-15 ma. press down the key, this will momentarily disconnect the shunt.

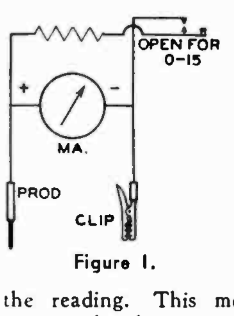


Figure 1.

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 reading, 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 ampere. 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 shunting out part of the multiplier resistance. A cheap a.c. voltmeter can be extended in the same manner with a top range of 700 or 800 volts.

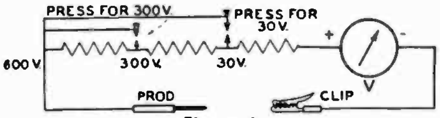
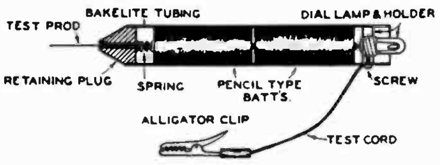


Figure 2.

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 50 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 other protective 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 the mountings about a dime. 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.

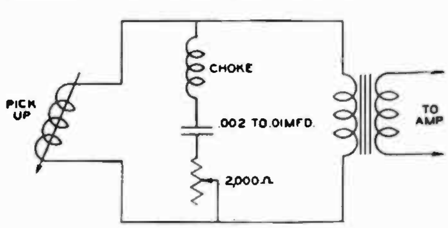
Tips on Radio Noises

The basic cause for the interference from small motors is due to dirt on the commutator, which in turn prevents the brushes from making correct contact, resulting in sparking. The first job to do is to clean the motor. If the frame of the motor is ungrounded make this connection, it helps greatly in minimizing this type of noise. If there is still some interference marring your reception, traceable to the motor, connect a 2 mfd.—1000 v. condenser across the brushes. For very small motors, such as are used in hair driers, vacuum cleaners, and soda mixers, 0.5 mfd. condenser will do the trick.

In the case of a refrigerator or furnace control, try connecting an 0.25 or 0.5 mfd. condenser across the input. From hard usage the thermostat contacts of these devices often become mechanically defective, resulting in sparking and considerable radio noise.

Homemade Scratch Filter

A scratch filter generally consists of a choke, condenser and a resistance connected in a series-resonant circuit. It is connected directly across the input transformer of the pick-up and is employed to attenuate the hissing frequencies caused by the needle scratch. The choke can be a 1500 turn

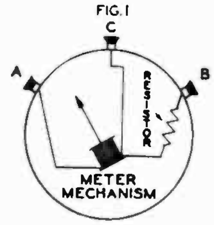


honeycomb coil or a standard 125 or 85 millihenry choke. All three units are obtainable from any radio store but if the reader wants to roll his own, wind approximately 1800 turns of No. 28 d.c.c. wire on a form 2 inches in diameter by 1½ inches long.

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 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

FIG. I



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 the resistor and mount 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 voltmeter terminals 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)-(C) will increase the current range. Inserting suitable resistors between (B) and the voltage to be measured will increase the voltage range.

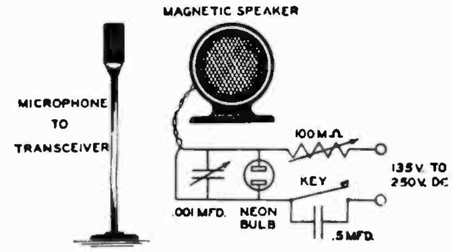
Fish Pole Antenna

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 other makes 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 home-made 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 ¼ to ½ watt neon bulb, a .001 mfd. variable condenser, a 100,000 ohm variable resistor and a key as shown. A ½ 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.

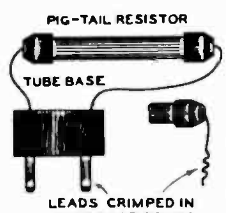


Connect the output to an old magnetic speaker, turn on the power and press the key. The neon bulb will oscillate and produce a tone in the speaker. Its strength can be controlled by the variable resistance while the pitch can be varied from a low note of only a few cycles to one of the highest audible frequency by means of the tuning condenser. The note can be transferred to the transceiver by placing the mike 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 breadboard 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 could 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 little harm in this 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-resonant 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. Moreover, 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.

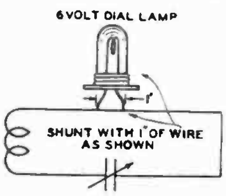
Hard-drawn wire is recommended for such critical service. The reason is that it has close to twice the strength of the soft-drawn variety; and what is more important, soft-drawn wire under strain will stretch as much as 25 per cent as against less than 1 per cent for hard-drawn wire of the same size and subjected to the same strain. Actual tests made on No. 12 wire showed the 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', 11", 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 1/8 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 monitors 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, shunt the lamp across the circuit as shown in the drawing. 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 busbar 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 tube is inserted in the socket. 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 hookups with stations worked before, you will have all pertinent data at your finger tips.

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 covering 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 outgrow 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 jotting 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

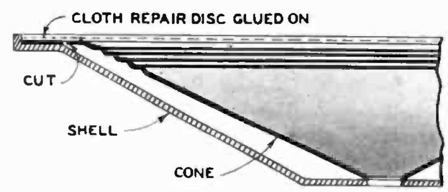
The experimenter and the DX listener should check over his equipment every so often, so as to eliminate the small troubles, which if neglected, may become serious problems. In many cases the DX listener can improve both the sensitivity and selectivity of his set, simply by replacing a single defective 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 Gadgeteer 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 circuit are loose and the cause of considerable radio interference. Look for corroded connections responsible for high-resistance contacts. Check the line cord—the handling that this part has to undergo is considerable and quite often it is hanging by a single strand of wire. Replace the line cord plug with the new tight-grip plug. Inspect the volume control, this part can be replaced very often with a big improvement in results. Clean the contacts on the tube sockets; also check these contacts for proper grip on the tube prongs. Brush or blow out the dust particles on the variable condensers, etc. There are numerous other inspections and jobs that can be made on any piece of radio equipment that will pay dividends in better all around results.

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.



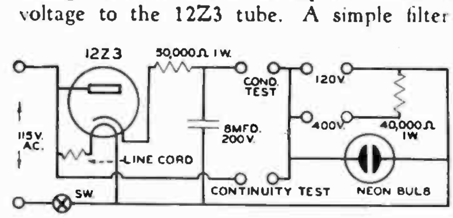
After cone is removed the No. 243 pole piece may be cleaned with a piece of emery paper. Turn the speaker upside down and tap it lightly to remove small particles of rust and other debris.

Place cone back on speaker by applying rubber cement to its outer top edge and strip it on the steel shell. Before the cement is dry, put the empire-cloth disc in place and press it firmly in position with a pencil eraser end.

When the cement is dry the cone is centered, finishing the repair.

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 prods should be plugged into the jacks marked "condenser test." For testing resistors or other parts for continuity the test prods 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 prods 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

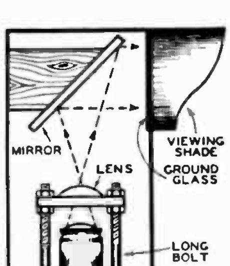
If you wish to raise the frequency of your crystal, the procedure is not so difficult as you might imagine. Ordinary kitchen cleanser, such as Old Dutch or Bon-Ami powder, will act as an excellent grinding material. Place a small amount of the powder on a piece of plate glass and use just enough water 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 a lead pencil. Frequency response can usually be lowered from 10 to 30 KC. The lead pencil method has the advantage that one can merely erase a few kilocycles when this is desired!

Projection Device for C.R. 913 Tube

Amateurs, experimenters, and servicemen are familiar with the CR913 tube, because of its application, low-cost, and adaptability to compact design in cathode ray oscilloscopes. Here is a kink whereby the image of this tube can be enlarged to at least 3 inches 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.

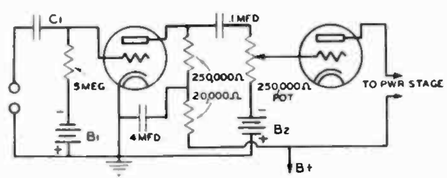


The tube should be placed in a vertical position. The lens is mounted 1" to 2" above the tube by means of two long bolts. The mirror is mounted on the wall of the cabinet by a wedge-shaped piece of wood. This mirror should be placed at a 45 degree angle and it is mounted approximately 4" above the tube. Place the groundglass screen 4" to 5" from the mirror and over the 3" 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-boating. 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-boating 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 by using individual 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.

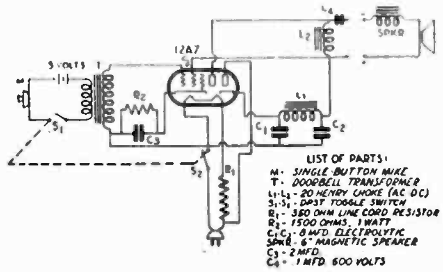
The two sections enclosed in the one envelope are shown in the conventional cascade form for simplicity. The coupling condensers and resistors are of the usual values and C_1 is necessary only when the microphone or other input is of a type which constitutes a closed circuit, and avoids shorting the bias battery or cells. The bias cells are shown at B_1 and B_2. 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 QRM

Many an amateur who has had no QRM 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 wave trap 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 12A7 type tube in a conventional pentode amplifier and half-wave rectifier arrangement. A 350



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.

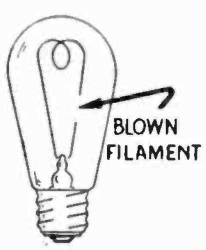
The throat of the horn should be cut off at a point where the cross-sectional area, regardless of its shape, is approximately equal to the cone of the speaker. It may then be attached to the speaker with small brackets. A small section of the original baffling should be retained, however, to prevent 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 50c 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 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 resistor 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 tubes, 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.

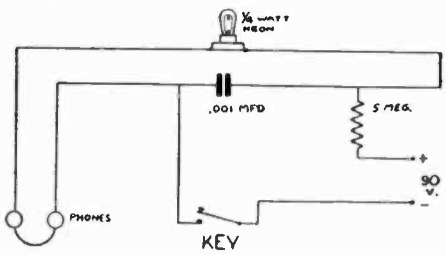
Whenever the neon bulb does not glow, there is the open tube, light or resistance, as the case may be.

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 posible 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 1½ megohms. Lowering or raising the resistance will alter the pitch of the signal.

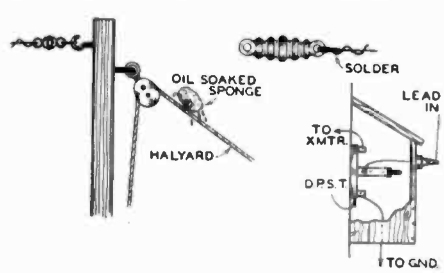
Winterizing the Antenna

Whether your antenna is used for receiving, transmitting, or both, it should be given a good "once over" before winter sets in. Much of the pleasure and efficiency of good radio 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 stay 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 reeved 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.



Before reeving in any new halyard it will be wise to weatherproof it as follows. Fill a bucket with boiled linseed oil and coil the rope into the bucket. Leave it there overnight. Then stretch it between posts and wipe off all extra oil, catching this in a bucket as you work along. Such treatment makes the rope pliable and just about doubles its life.

Metal pulleys will rust in time making them hard or impossible to turn. To cure a hard turning pulley without taking down the mast is a simple matter. Tie a small sponge to the halyard, as shown. Soak the sponge in oil and then pull it up to the pulley by the halyard. Slapping it against the pulley will squeeze some of the oil out onto the pulley and thus thoroughly lubricate it.

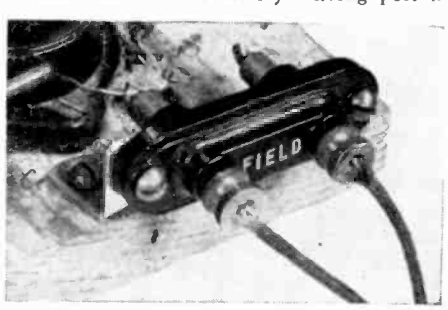
Finally, lower the antenna and go over it carefully for bad joints and contacts. Where corrosion or broken soldering is evident, remake the joint and resolder. The electrical connection must be perfect or efficiency is lost. It is very important that all electrical resistance must be overcome in soldered joints and time given to this will be well repaid in increased signal transmission and reception.

If your antenna system employs a lightning switch, see to it that snow and ice cannot collect in the winter and short signals to ground. The best way is to build a simple shed roof shelter for it as indicated in the sketch. Bring the feeder or feeders down to long stand-off insulators. From there the leads pass inside the shelter to the switch and to their proper connections without fear of weather conditions.

Look over all other points for weaknesses such as cracked or chipped insulators, loose halyard cleats, stay connections to ground, and mast base supports. When winter gales blow and temperatures drop into the zero region a strong mast and efficient antenna will add to your radio pleasure and not be a constant source of worry.

Handles for Phone Cord Tips

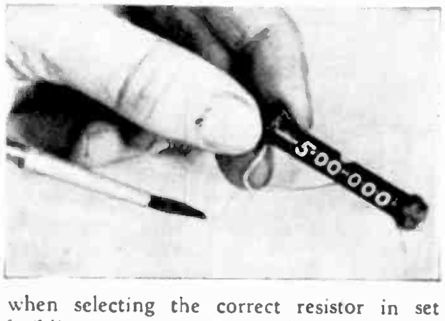
The tips of phone cords can be more easily withdrawn from the pin jack if a 6/32" knurled nut from a battery binding post is



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

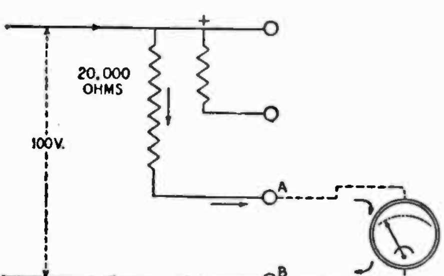


when selecting the correct resistor in set building or in repairing. Condensers, r.f. chokes, etc., too, can also be labeled with their capacities.

HIGH-RESISTANCE VOLTMETER

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



(A)

High-resistance Voltmeter.

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 a 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:

$$I = \frac{E}{R} = 100 \div (20{,}000 + 1{,}000) =$$

.0048 amperes, or 4.8 milliamperes.

This current flowing through the 20,000 ohm resistance causes a voltage drop across it of $E = I \times R = .0048 \times 20{,}000 = 96$ 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,

$$\text{Voltage at A B} = E - (I \times R) = 100 - 96 = 4 \text{ volts.}$$

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 exaggerated case.

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:

$$I = \frac{E}{R} = 100 \div (20{,}000 + 150{,}000) =$$

.0006 amperes, or .6 milliamperes.

and the $I \times R$ drop across the circuit resistor is,

$E = I \times R = .0006 \times 20{,}000 = 12$ 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 7.5×1000 or 7,500 ohms; that in series with the 150-volt terminal is $150 \times 1000 = 150{,}000$ ohms; that in series with the 750-volt terminal is $750 \times 1000 = 750{,}000$ ohms.

The "ohms-per-volt" value of R_{pv} is equal to the total resistance R_t of the meter divided by the maximum voltage E_t marked upon the scale considered, or

$$R_{pv} = \frac{R_t}{E_t}$$

Voltmeters having a resistance of 1000 ohms-per-volt are used extensively for voltage measurements in radio receiver 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.

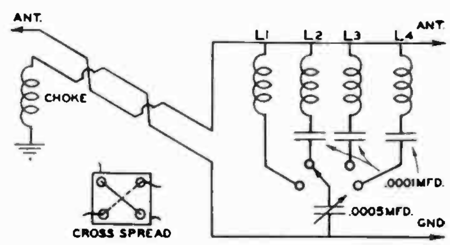
It should be remembered that it is not possible to make a high-resistance voltmeter of the same range from a low-resistance V. M.

All-Wave Tuned Antenna

In many places it is impossible to properly erect the doublet type antenna with a center lead-in. Also, this type is not satisfactory on the 200-500 meter band, without prohibitive length or complicated transformers.

The old reliable inverted "L" antenna, which can be erected almost anywhere, is excellent on the broadcast band and very good on short-waves. However, the end connection makes it voltage-operated on short-waves; hence an electrostatic shield between primary and secondary of the receiver transformer would cause great loss.

The circuit illustrated herewith relies



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, 1½ 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

First Dot		*Second Dot*		*Third Dot*	
Black	0	Black	0		
Brown	1	Brown	1	Brown	0
Red	2	Red	2	Red	00
Orange	3	Orange	3	Orange	000
Yellow	4	Yellow	4	Yellow	0000
Green	5	Green	5	Green	00000
Blue	6	Blue	6	Blue	000000
Purple	7	Purple	7	Purple	0000000
Gray	8	Gray	8	Gray	00000000
White	9	White	9	White	000000000

For Resistors, Unit: Ohms

Body Color		*End Color*		*Dot Color*	
Black	0	Black	0		
Brown	1	Brown	1	Brown	0
Red	2	Red	2	Red	00
Orange	3	Orange	3	Orange	000
Yellow	4	Yellow	4	Yellow	0000
Green	5	Green	5	Green	00000
Blue	6	Blue	6	Blue	000000
Purple	7	Purple	7	Purple	0000000
Gray	8	Gray	8	Gray	00000000
White	9	White	9	White	000000000

PORTABLE P. A. SYSTEM

Easy to operate is this P.A. rig.

THE use of high-impedance microphones such as crystal, velocity, etc., as standard equipment for most public address applications is now almost universally adapted. Likewise, the modern Permanent Magnet type of speaker having a Universal line transformer makes for a rapid installation. The amplifier shown and described in this article was designed to have four individual high gain input channels to accommodate four microphones at one time. These may be any of the high impedance types designed to work directly to grid, or may be low impedance types with a line transformer to grid. A master gain is used, permitting general volume control or for pre-setting of the audio gain. And a means of adjusting the audio watts output from eight watts to approximately thirty watts by means of a special tapped plate supply transformer which supplies various potentials to the rectifier is incorporated. The use of p.m. speakers with Universal line inputs of 500-1000-1500 and 2000 ohms makes it convenient to use a 500 ohm output at the amplifier. The use of 500 ohms permits standard characteristics in the speaker line and a db. meter may be used to indicate various output levels.

The use of phase inversion is becoming very popular in amplifier design, as its use in conjunction with resistors eleminates another source of hum-pickup, namely, the input transformer. Certain precautions are needed if proper drive ratio to the amplifier stage grids is to be obtained. The phase inverter tube type 6C8G contains two high *mu* triodes with separate cathodes.

The control grid of the first section receives the input voltage, from the mixer tubes and by means of the coupling condenser in the first plate circuit, feeds the No. 2 control grid with voltage of identical amplitude, but opposite in phase to the No. 1 grid. The setting of the correct proportion between the two No. 1 plate resistors determines the amplitude voltage and may be adjusted by means of a vacuum tube voltmeter if one is available. The 6L6 amplifier tubes are resistance coupled to the inverter and the quality of the audio is extremely free from distortion at the grids of the 6L6's. No grid driving power is required in the amplifier stage due to the use of "Class A" amplification. This adds to the economy of the unit, as self bias may be used with only 2% total harmonic distortion.

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.

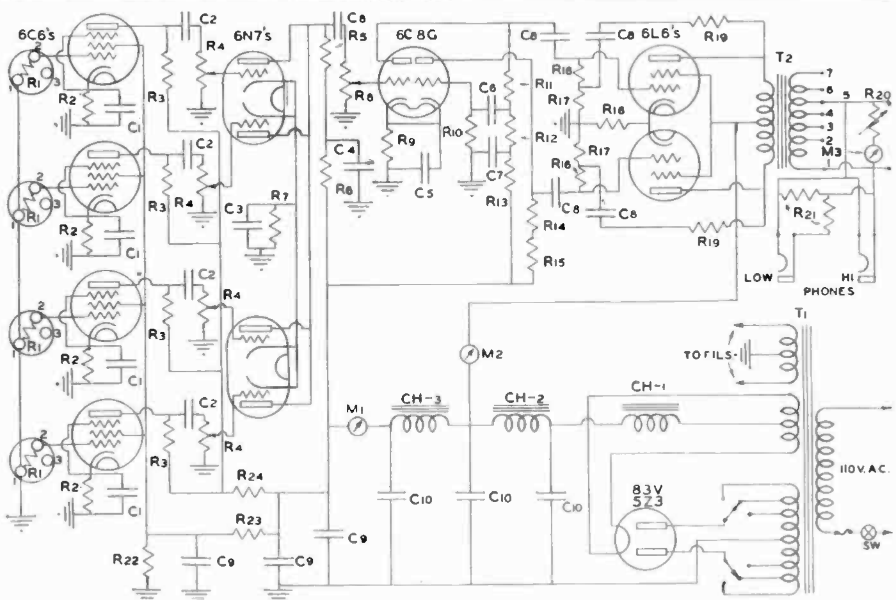
The frequency response of the amplifier may further be enhanced by adding a simple network in order to provide stabilized feed-back. The values of R16 and R17, together with C8 and R19, control the amount of signal output voltage that may be fed back to the control grids.

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 7½" deep. A durable leather carrying handle 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 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.



The hook-up of the 4 channel input portable P.A. system.

R_1—5 megohms ¼ w.
R_2—4000 ohms ½ w.
R_3—250,000 ohms 1 w.
R_4—500,000 ohms
R_5—20,000 ohms 1 w.
R_6—10,000 ohms 1 w.
R_7—400 ohms 1 w.
R_8—200,000 ohms
R_9—1500 ohms 1 w.
R_{10}—50,000 ohms ½ w.
R_{11}—100,000 ohms ½ w.
R_{12}—10,000 ohms ½ w.
R_{13}—10,000 ohms ½ w.
R_{14}—100,000 ohms ½ w.
R_{15}—10,000 ohms ½ w.
R_{16}—100,000 ohms ½ w.
R_{17}—5,000 ohms ½ w.
R_{18}—200 ohms 10 w., Utah CC 200
R_{19}—50,000 ohms ½ w.
R_{20}—200,000 ohms Utah RC 200 M
R_{21}—5,000 or 10,000 ohms ¼ w.
R_{22}—25,000 ohms ½ w.
R_{23}—100,000 ohms 1 w.
R_{24}—35,000 ohms 1 w.
C_1—10 mfd. 25v. elctro.
C_2—.05 mfd. 400v. paper
C_3—25 mfd. 25v. electro.
C_4—4 mfd. 25v. electro.
C_5—10 mfd. 25v. electro.
C_6—.1 mfd. 400v. paper
C_7—8 mfd. 450r. electro.
C_8—.1 mfd. 400v. paper
C_9—8 mfd. 450r. electro.
C_{10}—8 mfd. 450v. electro.
T_1—pl. & fil. trans.
T_2—universal Cl. A Output
CH_1—Swgg. ch. 200 M.A.
CH_2—Filt. ch. 200 M.A.
CH_3—Filt. ch. 100 M.A.
M_1—0-25 D.C. milliammeter
M_2—0-200 D.C. milliammeter
M_3— —10+6 DB Meter

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 office 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 slipping 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 fibre 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 fibre 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 near the antenna system 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 .00025 mfd. 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

Abbreviation	*Question*	*Answer*
QRA	What is the name of your station?	The name of my stations is ....
QRB	How far approximately are you from my station?	The approximate distance between our stations is .... nautical miles (or .... kilometres).
QRC	What company (or Government Administration) settles the accounts for your station?	The accounts for my station are settled by the .... company (or by the Government Administration of ....).
QRD	Where are you bound and where are you from?	I am bound for.......from.......
QRG	Will you tell me my exact frequency (wave-length) in kc/s (or m)?	Your exact frequency (wave-length) is .... kc/s (or .... m).
QRH	Does my frequency (wave-length) vary?	Your frequency (wave-length) varies.
QRI	Is my note good?	Your note varies.
QRJ	Do you receive me badly? Are my signals weak?	I cannot receive you. Your signals are too weak.
QRK	Do you receive me well? Are my signals good?	I receive you well. Your signals are good.
QRL	Are you busy?	I am busy (or I am busy with.......). Please do not interfere.
QRM	Are you being interferred with?	I am being interfered with.
QRN	Are you troubled by atmospherics?	I am troubled by atmospherics.
QRO	Shall I increase power?	Increase power.
QRP	Shall I decrease power?	Decrease power.
QRQ	Shall I send faster?	Send faster (...... words per minute).
QRS	Shall I send more slowly?	Send more slowly (........ words per minute).
QRT	Shall I stop sending?	Stop sending.
QRU	Have you anything for me?	I have nothing for you.
QRV	Are you ready?	I am ready.
QRW	Shall I tell .... that you are calling him on .... kc/s (or .... m)?	Please tell .... that I am calling him on ...... kc/s (or ...... m).
QRX	Shall I wait? When will you call me again?	Wait (or wait until I have finished communicating with ....) I will call you at .... o'clock (or immediately).
QRY	What is my turn?	Your turn is No. .... (or according to any other method of arranging it).
QRZ	Who is calling me?	You are being called by ....
QSA	What is the strength of my signals (1 to 5)?	The strength of your signals is .... (1 to 5).
QSB	Does the strength of my signals vary?	The strength of your signals varies.
QSD	Is my keying correct; are my signals distinct?	Your keying is incorrect; your signals are bad.
QSG	Shall I send .... telegrams (or one telegram) at a time?	Send .... telegrams (or one telegram) at a time.
QSJ	What is the charge per word for...... including your internal telegraph charge?	The charge per word for .... is ....francs, including my internal telegraph charge.
QSK	Shall I continue with the transmission of all my traffic, I can hear you through my signals?	Continue with the transmission of all your traffic, I will interrupt you if necessary.
QSL	Can you give me acknowledgement of receipt?	I give you acknowledgment of receipt.
QSM	Shall I repeat the last telegram I sent you?	Repeat the last telegram you have sent me.
QSO	Can you communicate with .... direct (or through the medium of ....)?	I can communicate with .... direct (or through the medium of ....).
QSP	Will you retransmit to .... free of charge?	I will retransmit to .... free of charge.
QSR	Has the distress call received from .... been cleared?	The distress call received from .... has been cleared by ....
QSU	Shall I send (or reply) on .... kc/s (or m) and/or on waves of Type A1, A2, A3 or B?	Send (or reply) on .... kc/s (or .... m) and/or on waves of Type A1, A2, A3, or B.
QSV	Shall I send a series of VVV ....?	Send a series of VVV ....
QSW	Will you send on ....kc/s (or .... m) and/or on waves of Type A1, A2, A3 or B?	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.

I WILL TRAIN YOU
TO START A SPARE TIME OR FULL TIME
RADIO SERVICE BUSINESS
WITHOUT CAPITAL

J. E. SMITH
President
National Radio Institute
Established 1914

The man who has directed the home study training of more men for the Radio Industry than any other man in America.

HERE ARE A FEW EXAMPLES OF THE KIND OF MONEY I TRAIN MY MEN TO MAKE

$200 TO $300 A MONTH IN OWN BUSINESS

"For the last 18 months I have been in business for myself, making between $200 and $300 a month. I have N.R.I. to thank for my start in this field."—ARLIE J. FROEHNER, 224 W. Texas Ave., Goose Creek, Texas.

$10 TO $25 A WEEK IN SPARE TIME

"I am making from $10 to $25 a week in spare time while still holding my regular job as a machinist. I owe my success to N.R.I."—WM. F. RUPP, 203 W. Front St., West Conshohocken, Pa.

CHIEF OPERATOR BROADCASTING STATION

"When I completed 20 lessons, I obtained my Radio Broadcast Operator's License and immediately joined Station WMPC, where I am now Chief Operator."—HOLLIS F. HAYES, 85 Madison St., Lapeer, Mich.

EARNINGS TRIPLED BY N.R.I. TRAINING

"I have been doing nicely, thanks to N.R.I. Training. My present earnings are about three times what they were before I took the Course. I consider N.R.I. Training the finest in the world."—BERNARD COSTA, 952 Manhattan Ave., Brooklyn, N. Y.

OVER $1,000 BEFORE GRADUATING

"Before completing half the N.R.I. Course I was servicing sets, and I made $1,000 to $1,200 before graduating. I am doing Radio service work for myself now."—ASHLEY G. ALDRIDGE, 1228 Shepherd St., Petersburg, Va.

Get My LESSON on Radio Servicing Tips FREE

I want to prove my Training gives practical, money-making information, that it is easy to understand—what you need to master Radio. My sample lesson text, "Radio Receiver Troubles—Their Cause and Remedy," covers a long list of Radio receiver troubles in A.C., D.C., battery, universal; auto, T. R. F., superheterodyne, all-wave, and other types of sets. And a cross reference system gives you the probable cause and a quick way to locate and remedy these set troubles. A special section is devoted to receiver check-up, alignment, balancing, neutralizing, testing. You can get this lesson Free by mailing the coupon.

The Tested WAY to BETTER PAY

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 models. 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 money you make in your spare time while learning. Mail coupon for my 64-page book. It's Free—it 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 I start sending Extra Money Job Sheets; shows you how to do Radio repair jobs. Throughout your training I send plans and directions that made good spare time money—$200 to $500—for hundreds, while learning. I send you special Radio equipment to conduct experiments and build circuits. This 50-50 method of training makes learning at home interesting, fascinating, practical.

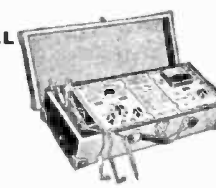
Why Many Radio Experts Make $30, $50, $75 a Week

Radio is young—yet it's one of our large industries. More than 28,000,000 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 5,000,000 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 $30, $50, $75 a week jobs of 20 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 jobbers, manufacturers and dealers as much as $30, $50, $75 a week. Many Radio Experts open full or part time Radio sales and repair businesses. Radio manufacturers and jobbers employ testers, inspectors, foremen, engineers, servicemen, and pay up to $6,000 a year. Automobile, police, aviation, commercial Radio, loud speaker systems are newer fields offering good opportunities now and for the future. Television promises to open many good jobs soon. Men I trained have good jobs 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-Wave, All-Purpose, Set Servicing Instrument. It contains everything necessary to measure A.C. and D.C. voltages and current; to test tubes, resistance; adjust and align any set, old or new. It satisfies your needs for professional servicing after you graduate—can help you make extra money fixing sets while training.

Save Money—Learn 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 You

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 spare time and full time opportunities and those coming in Television; tell about my training in Radio and Television; 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!

J. E. SMITH, President
National Radio Institute,
Dept. 9BJ9
Washington, D. C.

GOOD FOR BOTH 64 PAGE BOOK SAMPLE LESSON FREE

J. E. SMITH, President National Radio Institute,
Dept. 9BJ9, Washington, D. C.

Without obligating me, send your Lesson "Radio Receiver Troubles—Their Cause and Remedy" and free book about spare time and full time Radio opportunities and how I can train for them at home in my spare time—about the N.R.I. Set Servicing Instrument. I am particularly interested in the branch of Radio checked below.

- ☐ Radio Service Business of My Own
- ☐ Spare Time Radio Repair Work
- ☐ Retail Sales of Radio Sets and Equipment
- ☐ Service Expert for Retail Stores
- ☐ Broadcasting Station Operator
- ☐ Aviation Radio Operator
- ☐ Loud Speaker Systems, Installations and Service
- ☐ Auto Radio Installation and Service
- ☐ Television Station Operator
- ☐ Service Expert with Radio Factory
- ☐ Commercial Radio Station Operator
- ☐ All-around Servicing Expert

(If you have not decided which branch you prefer—mail coupon now, for information to help you decide.)

NAME .... AGE ....

ADDRESS 14X1

Feverish Activity.

A recent experience with a Fada 25 demonstrated the close relation between heat and voltage failures. The owner reported that his set cut off in the middle of his favorite programs, and 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 were better pinochle players than servicemen. 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 melds 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 Steinmetz and a Hindu mystic.

It was only after 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.

Pet vs. Pest

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!

INTERNATIONAL "Q" SIGS

Abbreviation	*Question*	*Answer*
QSX	Will you listen for .... (call sign) on .... kc/s (or .... m)?	I am listening for .... (call sign) on .... kc/s (or .... m).
QSY	Shall I change to transmission on .... kc/s (or .... m) without changing the type of wave? or Shall I change to transmission on another wave?	Change to transmission on .... kc/s (or .... m) without changing the type of wave or Change to transmission on another wave.
QSZ	Shall I send each word or group twice?	Send each word or group twice.
QTA	Shall I cancel telegram No. .... as if it had not been sent?	Cancel telegram No. .... as if it had not been sent.
QTB	Do you agree with my number of words?	I do not agree with your number of words; I will repeat the first letter of each word and the first figure of each number.
QTC	How many telegrams have you to send?	I have .... telegrams for you (or for ....).
QTE	What is my true bearing in relation to you? or What is my true bearing in relation to ....(call sign)? or What is the true bearing of .... (call sign) in relation to .... (call sign)?	Your true bearing in relation to me is .... degrees or Your true bearing in relation to ...... (call sign) is .... degrees at .... (time) or The true bearing of .... (call sign) in relation to .... (call sign) is .... degrees at .... (time).
QTF	Will you give me the position of my station according to the bearings taken by the direction-finding stations which you control?	The position of your station according to the bearings taken by the direction-finding stations which I control is ...... latitude ...... longitude.
QTG	Will you send your call sign for fifty seconds followed by a dash of ten seconds on .... kc/s (or .... m) in order that I may take your bearing?	I will send my call sign for fifty seconds followed by a dash of ten seconds on .... kc/s (or .... m) in order that you may take my bearing.
QTH	What is your position in latitude and longitude (or by any other way of showing it)?	My position is ...... latitude ...... longitude (or by any other way of showing it).
QTI	What is your true course?	My true course is .... degrees.
QTJ	What is your speed?	My speed is .... knots (or .... kilometers) per hour.
QTM	Send radioelectric signals and submarine sound signals to enable me to fix my bearing and my distance.	I will send radioelectric signals and submarine sound signals to enable you to fix your bearing and your distance.
QTO	Have you left dock (or port)?	I have just left dock (or port).
QTP	Are you going to enter dock (or port)?	I am going to enter dock (or port).
QTQ	Can you communicate with my station by means of the International Code of Signals?	I am going to communicate with your station by means of the International Code of Signals.
QTR	What is the exact time?	The exact time is ....
QTU	What are the hours during which your station is open?	My station is open from .... to ....
QUA	Have you news of .... (call sign of the mobile station)?	Here is news of .... (call sign of the mobile station).
QUB	Can you give me in this order, information concerning: visibility, height of clouds, ground wind for .... (place of observation)?	Here is the information requested ....
QUC	What is the last message received by you from......... (call sign of the mobile station)?	The last message received by me from .... (call sign of the mobile station) is ....
QUD	Have you received the urgency signal sent by .... (call sign of the mobile station)?	I have received the urgency signal sent by .... (call sign of the mobile station) at .... (time).
QUF	Have you received the distress signal sent by .... (call sign of the mobile station)?	I have received the distress signal sent by .... (call sign of the mobile station) at .... (time).
QUG	Are you being forced to alight in the sea (or to land)?	I am forced to alight (or land) at .... (place).
QUH	Will you indicate the present barometric pressure at sea level?	The present barometric pressure at sea level is .... (units).
QUJ	Will you indicate the true course for me to follow, with no wind, to make for you?	The true course for you to follow, with no wind, to make for me is .... degrees at .... (time).

When the signal is followed by a question mark, such as QTR?, it refers to the first column, and when no question mark is used, becomes the answer (column two).

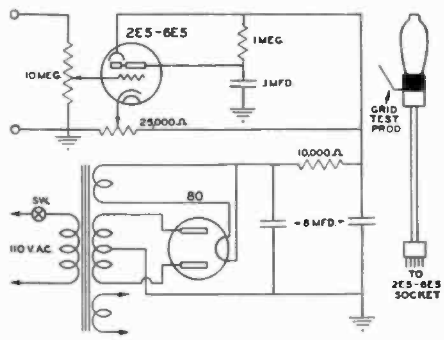
New Application for the 6E5

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 voltage divider is permanently adjusted so that the shadow angle of the 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 .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.

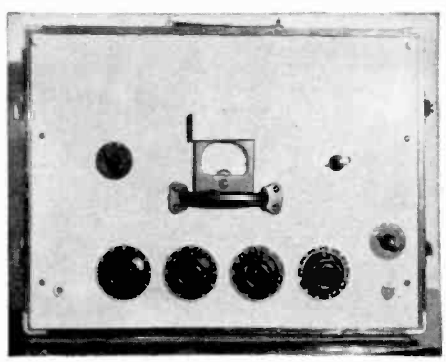
A short length of stiff wire is wrapped around the grid prong of the tube and extended outward at the junction of the tube and plug as pictured in the drawing. A 5 or 10 megohm resistor should be connected from grid to ground if the circuit to be measured does not provide a d.c. path.

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.

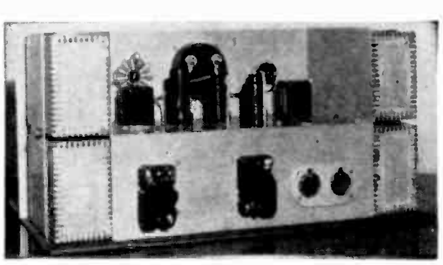
The circuit shown was used in the amplifier illustrated here. The first two stages using 6J7's as pentodes with a 6F6 working as a triode in the output. The input channels are 250 ohms and the output is 500 ohms working into a 5 DB pad to cut down line reflection. The main gain varies in steps of 2 DB 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 105 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 mils.



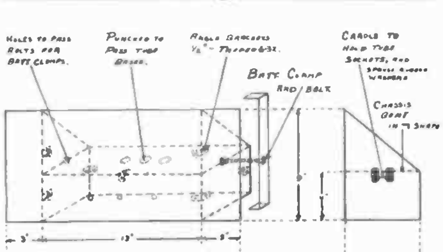
Front panel controls enable easy operation.

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 ½″ tapped 6-32 brackets will solve this problem perfectly.

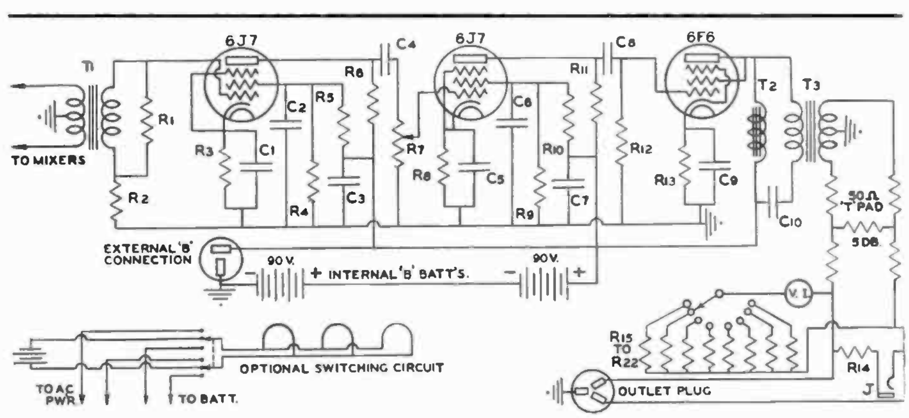
Obviously it is much easier to drill all necessary holes in panel and chassis as shown in sketch and then assemble the parts. After chassis has been assembled the tube sockets are mounted in a piece of aluminum 2″ wide and 6″ long, which can be cut from the



Rear view shows ease of servicing the unit.



Construction details of chassis.



Circuit of the remote amplifier.

C_1—20 mfd. 25v.	R_1—.5 meg.	R_{11}—.25 meg.	R_{17}—649 ohms
C_2—10 mfd. 50v.	R_2—.5 meg.	R_{12}—.25 meg.	R_{18}—817 ohms
C_3—8 mfd. 200v.	R_3—1,250 ohms	R_{13}—1,000 ohms	R_{19}—1,028 ohms
C_4—.1 mfd. 400v.	R_4—10,000 ohms	R_{14}—2,000 ohms	R_{20}—1,249 ohms
C_5—20 mfd. 25v.	R_5—50,000 ohms		R_{21}—1,630 ohms
C_6—10 mfd. 50v.	R_6—.25 meg.	All Weston Precision wire wound	R_{22}—2,052 ohms
C_7—8 mfd. 200v.	R_7—.5 meg. Pot.		T_1—UTC A-10
C_8—.1 mfd. 400v.	R_8—2,000 ohms		T_2—3,000 ohm choke
C_9—20 mfd. 25v.	R_9—10,000 ohms	R_{15}—410 ohms	T_3—UTC A-24
C_{10}—1 mfd. 400v.	R_{10}—50,000 ohms	R_{16}—515 ohms	

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, making sure 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 have 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 increased 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 then when it is further used near small parts will pick these up and cause no end of grief. Heating the afflicted tool over the gas burner will usually restore the tool to good condition.

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 input. 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.

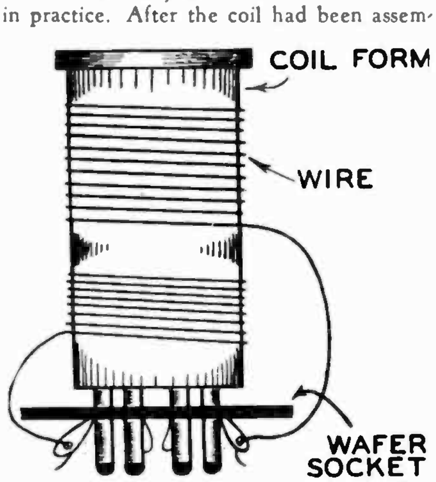
The fault lies not with the doublet, but with the match between the antenna and the set.

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 doublet 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. Formulae are available in most handbooks.

Adapter for Determining Coil Frequency

In winding plug-in 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 assem-



bled with the leads soldered in the prongs, the tuning range is, unfortunately, either 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 prongs 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 coil form into this socket as far as they will go, then temporarily connect the loose lead of the coil to the proper adapter connector.

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 band width until the correct number is reached for the desired frequency. When this is determined, remove the adapter and run the lead down through the prong and solder in place.

Cure for Noisy Volume Control

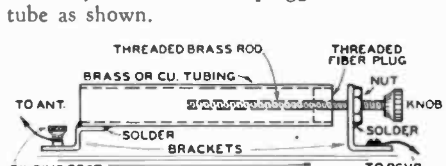
When the resistance strip of a volume control becomes worn or broken it will cause noisy operation and will ruin reception. Here is a stunt that will enable the user to continue using the set without any servicing expense.

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 ½" 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 tight fitting plug 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 capacity; threading it out decreases it. 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: 7½c 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 1a 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 V_1 builds up across the primary a current in phase with V_1 is induced into the secondary. Because the current lags voltage by 90 electrical degrees in an inductance, the voltage V_a induced into the secondary by this current is 90° ahead of V_1 at resonance. At the same time a current through C induces a voltage V_b 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 V_a plus V_b and is arbitrarily called V_2.

Under off resonance conditions either inductive or capacitive reactance predominates and the phase of the voltage V_a changes accordingly. At frequencies greater than resonance, inductive reactance is predominant in the tuned circuits and V_a leads V_1 by less than 90°. Conversely, for frequencies less than resonance, capacitive reactance is the greater and V_a leads V_1 by more than 90°. Since V_b is unchanged in phase, the alternations of V_a and V_b no longer coincide and the rectifier currents become unbalanced because a greater voltage results in one side of the secondary than the other. At higher frequencies than resonance diode 1 will have the greater current flow and vice versa for lower frequencies.

In Figure 1b we see just how the control voltage is developed. From this illustration it becomes evident that this control voltage may be either positive or negative and of various amplitudes. Electrons move from negative to positive so that all one must do to determine the polarity of the voltages E_1 and E_2 is to visualize the electron flow. Since these are in series E_c, the control voltage, equals E_1 plus E_2 added algebraically.

When suitably filtered, the control voltage is delivered to the control tube where the actual frequency control is accomplished. Two methods of utilizing vacuum tubes for frequency control are shown in Figures 2a and 2b. Figure 2a illustrates a typical type involving variation of effective capacity to change frequency, while Figure 2b depicts the inductance variation type.

A triode with a choke in its plate circuit reflects capacity into its grid circuit. Degeneration resulting from the condenser C_1 increases this effect. The actual amount of reflected "capacity" depends upon the gain of the tube and it is this fact which is used to affect frequency control by varying the effective bias on the grid of the tube. R and C are filter components. In actual practice this circuit is not commonly used because it has several disadvantages. The tube acts as a poor condenser and hence introduces losses into the oscillator tank. The amount of control varies considerably with frequency and is unsymmetrical about resonance.

A better system involves inductive control as shown in Figure 2b. In this circuit a pentode is used to control the oscillator frequency. Screen grid, suppressor and cathode connections are made in the standard manner. The gain of the tube is controlled by means of the additional bias supplied by the discriminator.

A small amount of the voltage developed across the oscillator tank is fed into the control grid of the pentode (this same grid is biased by the control voltage) and amplified. This exciting signal voltage undergoes a 90° phase shift across condenser C, 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.

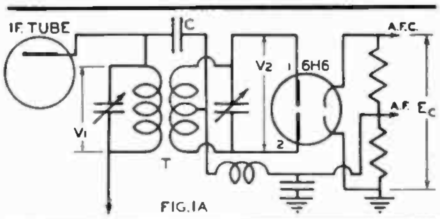
Essentially these are the basic principles underlying automatic frequency control. And now that they are understood, let's go looking for trouble.

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 neglible response of the discriminator. The effects of a shorted condenser should be evident.

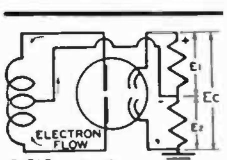
Incorrect use, although not a defect, is also a responsibility of the serviceman. In order to be able to help his customers he must know how to use it himself. A set using A.F.C. will select the station (from two or three on adjacent channels) which has the greatest carrier voltage in the receiver's 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.

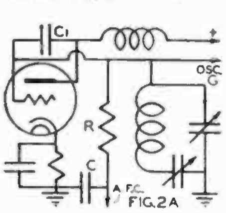


Naturally the question of suitable test equipment comes up. Several types of equipment may be used, depending upon the connection used for measurement.

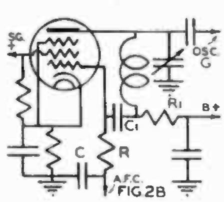
A conventional output meter may be used across the output stage. If such an indicator is used the A.F.C. can be tuned in this manner. After aligning the r.f. and i.f. stages in the conventional way, tune the set to zero-beat with the signal generator which should be set at 1000 kc. Detune the discriminator 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 broadcast band.





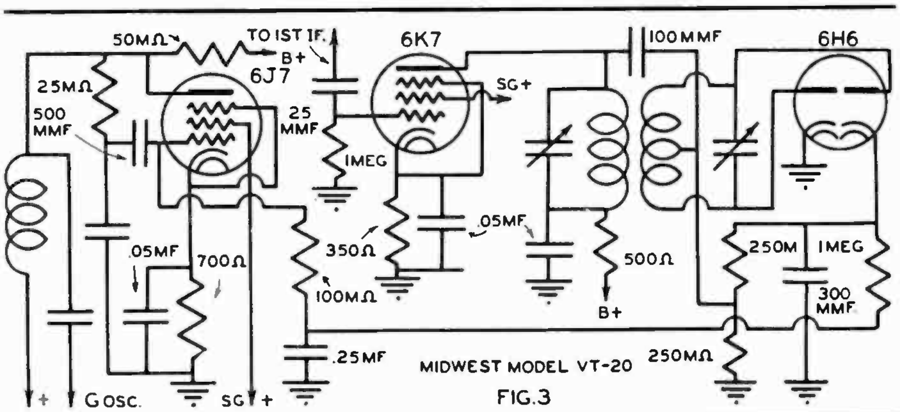
Two circuits described by author.



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 set to 1000 kc., with the A.F.C. off. Then, with the A.F.C. on, the output should not change. After this test try several stations and listen for a change in quality (which should not occur). Try tuning considerably off resonance. The station should snap in.

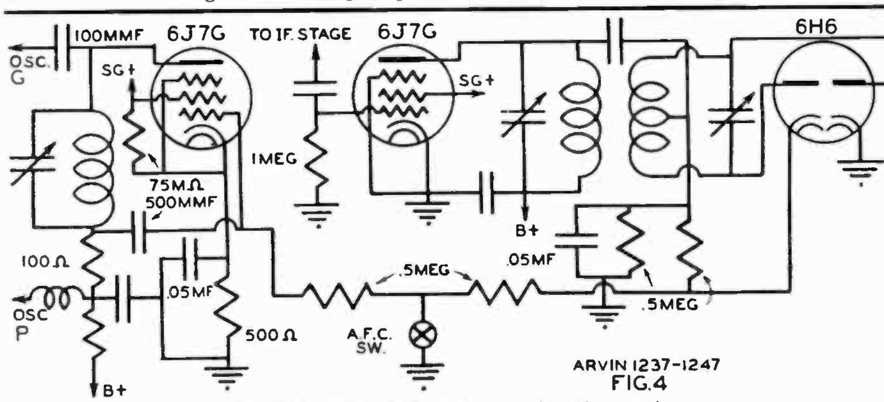
Commercial versions of the basic circuits previously discussed are presented in Figures 3, 4 and 5.

Figure 3, the Midwest model VT-20, is nearly standard except for the separate 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.



MIDWEST MODEL VT-20
FIG.3

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.



ARVIN 1237-1247
FIG.4

The Arvin 1237-1247 set discussed in the article.

Philco 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 plates are in push pull and hence the output voltages are 180° out of phase.

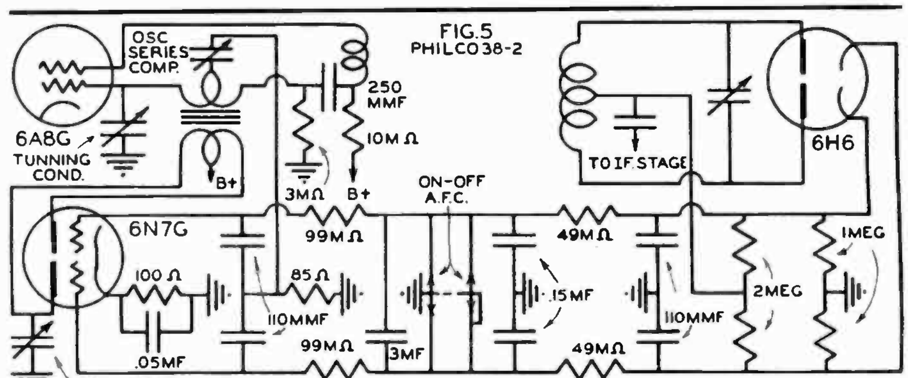


FIG.5
PHILCO 38-2

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 the plate 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.

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.

$$DB = 10 \log_{10} \frac{P_1}{P_2}$$

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 $\frac{P_1}{P_2}$ can be expressed in terms of voltage or current, because:

$$\frac{P_1}{P_2} = \frac{R_2E_1^2}{R_1E_2^2} = \frac{R_1I_1^2}{R_2I_2^2}$$

This can then be substituted in the first equation and one gets 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 the 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 .6 milliwatt would be —10 db. In all cases the *zero level must 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 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.

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 starts at 1 millibar sound pressure (equivalent to 24.4×10^{-16} watts per square centimeter), and the other, which will presumably become the standard, starts at 1×10^{-16} watts per square centimeter (equivalent to .207 millibar). 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 P_2/P_1; where P_2 is the output power and P_1 is the input power. Since it is often customary to measure voltages 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 decibels is

$$DB = 20 \log \frac{E_2}{E_1} + 10 \log \frac{Z_1}{Z_2}$$

One should never forget to include the last term. When Z_1 equals Z_2, 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 that 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 input grid leak from ½ megohm, to 5 megohms, he is justified to rate 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 ½ 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:

$$DB = 20 \log \frac{100}{.01} + 10 \log \frac{500{,}000}{500}$$

$$DB = 20 \log 10{,}000 + 10 \log 1000$$

$$DB = 20 \times 4 + 10 \times 3 = 110 \text{ db.}$$

But if the grid leak is changed to 5 megohms, the result will still be: .01 volt across the input delivers 100 volts across the output, and the gain is

$$DB = 20 \log \frac{100}{.01} + 10 \log \frac{5{,}000{,}000}{500} =$$

$$20 \times 4 + 10 \times 4 = 120 \text{ db.}$$

Obviously, the type of rating should be different, and this as a good thing to remember when comparing the merits of resistance-coupled amplifiers. A suggested remedy is to agree on a standard value of grid resistor for measurement purposes. (Some firms are doing this and use 150,000 ohms.) An alternative way would be to rate amplifiers in terms of power sensitivity like power tubes.

Finally, there is the great bugaboo, rating microphones. Many manufacturers are rating their microphones as "so many db. down." Trusting amateurs and P.A. men construct their amplifiers figuring that they need the difference between that figure and the desired output in db. (6-milliwatt zero level). Of course, that doesn't work. Such a rating of microphones *does not mean anything* until it is known what zero level is employed and how loud a sound must be made to get the stated output.

All that was originally taken care of because the zero level was defined as "output of 1 volt at open circuit with a sound pressure of 1 bar." This zero level does not mean very much to the average user, for he does not know how loud one bar is and the 1 volt across open circuit will become considerably less when the microphone is connected to a load. As a matter of information, 1 bar is +74 db. in the scale with zero level at 10^{-16} watts per square centimeter. According to Dr. E. E. Free, it is equal to "average conversation."

SOME INTERNATIONAL PREFIXES

AR	SYRIA
CE	CHILE
CM	CUBA
CN	MOROCCO
CO	CUBA (fones)
CP	BOLIVIA
CR4	CAPE VERDE
CR5	PORTUGUESE GUINEA
CR6	ANGOLA
CR7	MOZAMBIQUE
CR8	PORTUGUESE INDIA
CR9	MACAO
CR10	TIMOR
CT1	PORTUGAL
CT2	AZORES
CT3	MADEIRA
CX	URUGUAY
D	GERMANY
EA	SPAIN
EA8	CANARY ISLANDS
EI	IRISH FREE STATE
EL	LIBERIA
EP, EQ	IRAN (ex-Persia)
ES	ESTONIA
F3	FRANCE
F8	FRANCE
FA	ALGERIA
FB8	MADAGASCAR
FD8	TOGOLAND (French)
FE8	CAMEROONS (French)
FF8	FRENCH WEST AFRICA
FG8	GUADELOUPE
FI8	FRENCH INDO-CHINA
FK8	NEW CALEDONIA
FL8	SOMALI COAST
FM8	MARTINIQUE
FN8	FRENCH INDIA
FO8	FRENCH OCEANIA, TAHITI
FP8	ST. PIERRE MIQUELON
FQ8	FR. EQUATORIAL AFRICA
FR8	REUNION
FT4	TUNIS
FU8	NEW HEBRIDES
FY8	FRENCH GUIANA
G	GREAT BRITAIN
GI (see G)	NORTHERN ISLAND
GM (see G)	SCOTLAND
GW (see G)	WALES
HA	HUNGARY
HB	SWITZERLAND
HC	ECUADOR
HH	HAITI
HI	DOMINICAN REPUBLIC
HJ, HK	COLOMBIAN REPUBLIC
HP	PANAMA
HR	HONDURAS
HS	SIAM
HZ	HEDJAZ
I	ITALY
J	JAPAN
K4	PORTO RICO, VIRGIN ISLANDS
K5	CANAL ZONE
K6	GUAM, HAWAII, MIDWAY ISLAND, SAMOA (U. S.)
K7	ALASKA
KA	PHILIPPINE ISLANDS
LA	NORWAY
LU	ARGENTINA
LX	LUXEMBOURG
LY	LITHUANIA
LZ	BULGARIA
MX	MANCHUKUO
N	U. S. NAVAL COMMUNICATIONS RESERVE
NY	CANAL ZONE
OA	PERU
OE	AUSTRIA
OH	FINLAND
OK	CZECHOSLOVAKIA
OM	GUAM
ON	BELGIUM
OQ5	BELGIAN CONGO
OX	GREENLAND
OY	FAROE ISLANDS
OZ	DENMARK
PA	NETHERLANDS
PI	NETHERLANDS (schools)
PJ	CURACAO
PK	NETH. INDIES
PX	ANDORRA
PY	BRAZIL
PZ	SURINAM
SM	SWEDEN
SP	POLAND
ST	SUDAN
SU	EGYPT
SV	GREECE
TA	TURKEY
TF	ICELAND
TG	GUATEMALA
TI	COSTA RICA
U, UE, UK, UX	U.S.S.R.
VE	CANADA
VK	AUSTRALIA
VO	NEWFOUNDLAND
VP1	BRITISH HONDURAS
VP2	DOMINICA, GRENADA, ST. LUCIA, ANTIGUA, ST. KITTS-NEVIS
VP3	BRITISH GUIANA
VP4	TRINIDAD & TOBAGO
VP5	CAYMAN ISLANDS, JAMAICA, TURKS & CAICOS ISLANDS
VP6	BARBADOS
VP7	BAHAMAS
VP8	FALKLAND ISLANDS, SOUTH GEORGIA

VP9	BERMUDA
VQ1 (*VR3)	FANNING ISLAND
VQ2	NORTHERN RHODESIA
VQ3	TANGANYIKA
VQ4	KENYA
VQ5	UGANDA
VQ6	BRITISH SOMALILAND
VQ8	MAURITIUS
VQ9	SEYCHELLES
VR1	GILBERT & ELLICE ISLANDS
ZC5	PALESTINE
ZD1	SIERRA LEONE
ZD2	NIGERIA, CAMEROONS (British)
ZD3	GAMBIA
ZD4	GOLD COAST, TOGOLAND (British)
ZD6	NYASALAND
ZD7	SAINT HELENA
ZD8	ASCENSION
ZE1	SOUTHERN RHODESIA
ZK1	COOK ISLANDS
ZK2	NIUE
ZL	NEW ZEALAND
ZM	WESTERN SAMOA
ZP	PARAGUAY
ZS, ZT, ZU	SOUTH AFRICA
*ZU9	TRISTAN DA CUNHA

*Suggested by the British Empire Radio Union.
**Official, by French Govt.

VR2	FIJI ISLANDS
VR3	FANNING ISLAND
VR4	BR. SOLOMON ISLANDS
VR5	TONGA ISLANDS
VR6	PITCAIRN ISLAND
VS1, VS2, VS3	MALAYA
VS4	BORNEO
VS5	SARAWAK
VS6	HONG KONG
VS7	CEYLON
VS8	BAHRAIN ISLAND
VS9	MALDIVE ISLANDS
VU	INDIA
W, K, N	UNITED STATES
XE	MEXICO
XT, XU	CHINA
XZ	BURMA
YA	AFGHANISTAN
YI	IRAQ
YJ (**FU8)	NEW HEBRIDES
YL	LATVIA
YM	DANZIG
YN	NICARAGUA
YR	ROUMANIA
YS	SALVADOR
YT, YU	JUGOSLAVIA
YV	VENEZUELA
ZA	ALBANIA
ZB1	MALTA
ZB2	GIBRALTAR
ZC1	TRANSJORDANIA
ZC2	COCOS ISLANDS
ZC3	CHRISTMAS ISLAND
ZC4	CYPRUS