1938 Radio Data Book

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At your finger-tips . . .

Radiomen, especially those who have seriously decided to get into the radio game, are always confronted by situations requiring immediate solution. Elusive bits of technical knowledge; a tip or hint that will make work easier and lead to the root of the problem; a design or a formula that escapes our memory; a method of measurement; these are some of the bothersome things that take so much time, detail, and experience when we should be devoting our efforts to more creative work.

In this new and helpful *Radio Data Book* for 1938, the Editors of RADIO NEWS have gotten together a wealth of easy-to-understand information on a wide range of radio subjects—just the kind of information that is usually hard to find in any one place. Here, carefully indexed, are to be found important items for any radioman, be he a radio beginner, an amateur, a short-wave fan or even the most experienced serviceman or technician.

Do you want to know how to figure decibel ratings? Do you need a new high-precision oscillator, voltmeter or cathode-ray oscilloscope? Do you wish to build a new receiver? Is there some experimental radio data you need on increasing selectivity? Are you arranging a new Work Bench? Do you know the best types of amplifiers for public-address systems? Do you wish to learn the code? Do you need a complete up-to-date Short-Wave Station List always at your finger-tips? Do you need, incidentally, the tube characteristics of any transmitting or receiving tube? These and many more questions are answered quickly by thumbing through the 1938 *Radio Data Book* you are holding in your hand.

And then, with television in the offing, are you fully acquainted with the latest developments of the main television systems of transmission and reception? This subject is clearly outlined as of the present date.

RADIO NEWS presents this worthwhile addition to the literature of radio, to its thousands of old friends and to many new ones with a conviction that it will be well received and will find a place of honor in the Work Shop, Experimental Laboratory or Listening Post as the case may be. Keep it handy and guard it well! It will be your friend and helper in all things radio. It will also be a constant reminder that RADIO NEWS magazine will serve you twelve months each year in a like manner, giving you new information, new developments, and newest circuits as they are being evolved in the world's laboratories.

LAURENCE M. COCKADAY
Editor, Radio News and Short-Wave Radio

TELEVISION

The Present Status of Television

ALTHOUGH television has not been commercialized in this country as yet, it has developed into a highly specialized branch of the radio industry. There will be many future opportunities for trained television operators, technicians, and engineers who, by their own foresight, have studied and trained along this specialized line. The television operator of tomorrow must be a trained, skilled worker with knowledge far exceeding that necessary for radio or electricity alone. This is not a technical discussion of television, but a practical analysis of what future television engineers and operators will be expected to know.

A thorough understanding of television is not complete unless the definite relation between the human eye and television is fully realized. Television, in part, is actually duplicating imperfectly the process of the eye. For this reason a study of the human organ of sight is essential. The eye is very complex, but all future developments and improvements will undoubtedly be based on this organ. All of the properties of the eye should be studied, with particular attention to the *persistence of vision*, the secret of television and motion pictures.

Optics Important

The future engineer or operator must also have an extensive knowledge of optics, lenses, and the properties of light. He must be familiar with the electron theory, and electronic properties and action, as correlated with the structure of matter. He must be well-grounded in the elements and principles of electricity and radio.

All of these underlying principles are basic fundamentals of television, and must be thoroughly understood. With these principles in mind their direct application to television can be specifically defined.

The future television engineer and operator must have an extensive knowledge of audio- and video-amplifiers, including a comprehensive understanding of their related circuits. He should be familiar with commercial electron tubes, and practical commercial amplification and attenuation circuits. He must be well-versed in the use and operation of the photo-electric cell. Since all television transmission will be accomplished with the very short waves, a thorough understanding of radio-frequency transmission with ultra-high-frequency oscillators is very necessary. The operator should be familiar with the theory, operation and use of the cathode-ray tube in modern installations.

It is generally believed that television in the future will take place through non-mechanical, non-moving circuits. Experimental receivers now being prepared by two leading set manufacturers have no moving parts, or scanning discs. However, it would be desirable to have a knowledge of the scanning disc, electric motor, and associated equipment. Synchronization in television is very important. This is performed either by use of motors, or by "relaxation" circuits designed for this work; both methods should be familiar to the television operator or engineer.

Competent Men Needed

Much of the early television broadcasting will be done by means of the motion-picture. This will be necessary because of the radical change imposed upon commercial broadcasting and the adaptability of the motion-picture to television transmission. Therefore the television engineer or operator should be familiar with the operation, use, and care of commercial motion-picture projectors and their related use to television.

A study of the Kerr Cell should also be considered. This important, though little-known, tube is used for obtaining large clear-white images, by action of the polarizing light which is in proportion to the impressed magnetic signal.

The potential television engineer, technician, operator or serviceman should keep constantly in touch with all new developments in the television field, through leading radio magazines and technical journals. Experimentation with television probably leads all other fields of research at the present time, and it is highly necessary to be well informed on new developments. It would be wise to construct and experiment with all types of smaller television receivers and transmitters, in order to become familiar with their operation, peculiarities and characteristics.

When television does arrive commercially it will be on a large scale and there will be an ever-increasing demand for competent, efficient, trained engineers, operators and technicians. The trained man will find himself very much in demand only if he has been well-trained and is thoroughly familiar with the various phases of television. There is probably no one technical school, college or other institution where all of this necessary training can be obtained. Only by patient personal study and application can the future engineer or operator completely master the many diversified complexities involved in the transmission and reception of television radio signals. Television will revolutionize broadcasting and radio transmission and reception. The industry will eventually discover that it has a large demand for competent men, but a very small supply actually existing.

THE RCA SYSTEM

NBC experimental transmissions from the video station atop the Empire State Building in New York were boosted from 343 to 441 lines in January, 1937. The earlier standard was put into effect in June, 1936. In just little more than a half-year, the definition grew by 100 lines! A finer image was achieved. The photograph of Felix The Cat shown in Figure 1 is a reproduction of an actual image received over the air on the new standard. Figure 3 is Felix as photographed a few years ago with the early 60-line transmissions. Here, indeed, is progress! Even the non-technical observer is readily impressed by such evidence.

Figure 2 will give you some idea of the complexity of modern television equipment. It shows the synchronizing signal generator, the heart of the RCA experimental television system.

The Empire State transmitter is fed by a coaxial transmission line with programs originating in the NBC television studio in

Figure 1

Figure 2

Figure 3

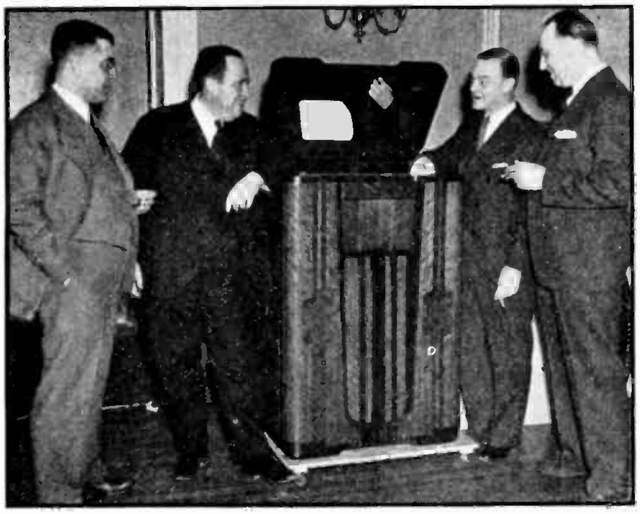


Figure 4, left, Lee Ellmaker, publisher of RADIO NEWS, chats with Philco officials; Figure 5, above, the Philco camera.

Radio City—about three-quarters of a mile away. The picture wave-frequency is 49.5 megacycles while the sound channel is 52.75 megacycles; provision of 2.5 megacycles is made on each side of carrier. The 441-line system is employed.

Interlaced scanning is being used, employing a picture frequency of 30 per second and a "frame-frequency" of 60 per second. This means that the scanning is arranged so that the vertical scanning takes place twice per picture and therefore, since the number of lines is *odd*, the second set of scanning lines falls between the first scanning lines. This arrangement reduces flicker.

Tests Successful

Images of motion pictures as well as live performers are being successfully received in about 100 homes of RCA engineers in the metropolitan New York area and in the outlying suburbs.

It is understood that the 100 test receivers around the New York area retain the tuning range of 42 to 84 megacycles. As in the case of other leading systems, the receiver gets sight and sound simultaneously. Single-knob tuning is employed and separating is easily achieved by the spacing of the transmitted carriers. A complex array antenna to produce a horizontally polarized field is employed.

That the tests have been highly instructive was emphasized in a recent Sarnoff-Harbord report: "Much has been learned about the behavior of ultra-short waves and how to handle them," they stated. "More is known about interferences, most of which are man-made and susceptible of elimination. The difficulties of making apparatus function outside the laboratory are being surmounted. The technical fundamentals of our system have been confirmed. Theory has been put into practice, and the experience gained thereby is enabling the laboratories to chart the needs of a practical television service.

"A major problem in television is that of network program distribution. The present facilities for distributing sound broadcasting cover the vast area of the United States and serve its 128,000,000 people. Similar coverage for television programs in the present state of the television art would require a multiplicity of transmitters and network interconnections by wire or by radio facilities still to be developed.

"The field tests are not completed, but the capabilities of the RCA television system are being constantly expanded, and we are moving toward ultimate realization of satisfactory high-definition television for public service."

(Editor's Note: The audio and video signals from the Empire State are regularly received up through Connecticut and as far as Massachusetts by amateurs, according to a representative of RADIO NEWS who interviewed many amateurs at a recent Amateur Convention in Middletown. At times when DX conditions prevailed on the ultra-high frequencies these signals came in with tremendous volume, exceeding that of locals. Just what this means in terms of interference between television stations using frequencies in other cities remains a question of controversy.)

THE PHILCO SYSTEM

HERE are some of the details of the Philco television system. Some of this information will be important to those amateurs or experimenters who are thinking of building experimental types of television receivers and are trying to learn the fundamentals on which future broadcasts will be based:

Sound Transmitter—Frequency 54 megacycles. Power .25 kilowatt.

Television Transmitter—Frequency 49 mc.; power 4 kw. (peak).

Modulation System—Philco high-fidelity system responding to an unusually wide band of modulating frequencies, the maximum being about 4.5 mc.

Call Letters—Both sound and television stations operate under a single set of call letters—W3XE, Philadelphia.

Antenna—Height above street level—210 feet. Television transmitter antenna consists of array composed of two dipoles, each fitted with a reflector. The sound antenna consists of a vertical half-wave. Both antennas are fed by coaxial transmission lines.

Number of Lines—441.

Frame Frequency—30 per second.

Field Frequency—60 per second, interlaced.

Aspect Ratio—4:3.

Polarity of Transmission—Negative.

Synchronizing—Amplitude selection is used in connection with the "narrow vertical" synchronizing pulse.

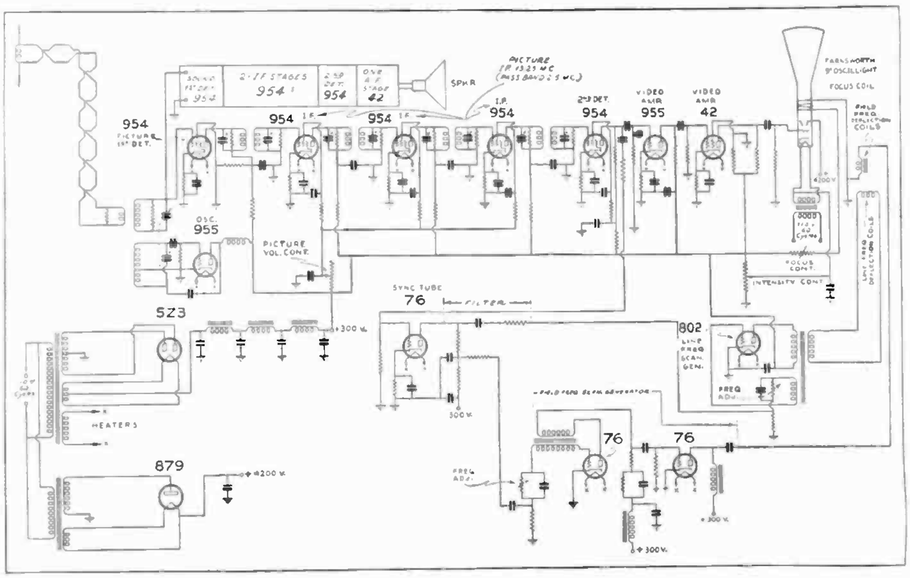
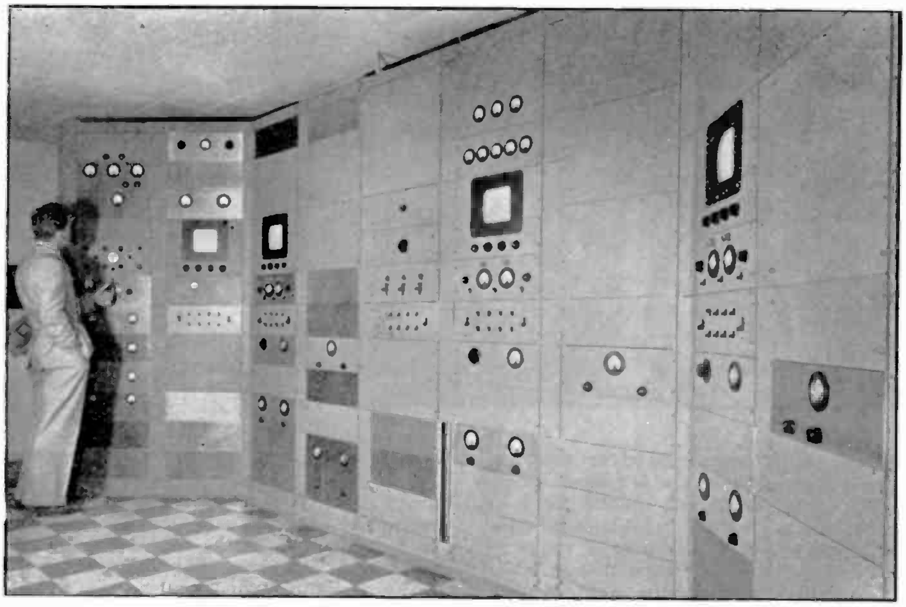


Figure 6, below, Philco camera tube; Figure 7, left, fundamental Farnsworth television receiver circuit.

Figure 8, above, a Farnsworth television receiver; Figure 9, right, the Farnsworth transmitter.



Philco Field Test Receivers—Receivers use independent television and sound sections for flexibility. These tune over the range 42-86 mc.

Total Number of Tubes Employed—26.

Picture Tube—12 inches in diameter, giving white and black pictures approximately, 7½ x 10 inches.

(High-fidelity picture reproduction on these receivers results from a design which gives an extremely wide receiver acceptance band, wider than 4.5 mc.)

Figure 4 shows a present-day Philco television receiver, used in a recent press demonstration. Lee Ellmaker, publisher of RADIO NEWS is shown at the left of the receiver.

The Focusing Device

The focusing device for picking up the television signal actually looks somewhat like a camera on wheels. (See Figure 5). It contains a large tube, as shown in Figure 6, operating on photo-electric and cathode-ray principles combined. This tube generates, by an electrical scanning method, voltages corresponding to the light and shade of the television picture which is focussed by the lens onto the signal plate of the tube. A special amplifier in the control room strengthens these varying voltages about 10,000 times, to modulate the ultra-high-frequency transmitter. Also mixed with this television signal, as it is transmitted, are the synchronizing and blanking impulses. These impulses when received by the receiving set control the movement of the electron beam in the receiving cathode tube which rebuilds the picture.

In the studio there are, of course, accompanying the picture transmitting apparatus microphones and audio-frequency amplifiers and another radio transmitter for sending the sounds to the receiving location.

A separate pick-up device consisting of a specially built projector, is used for transmitting the motion picture part of the program. This apparatus energizes the same radio transmitters that are used for televising the actual scenes.

THE FARNSWORTH SYSTEM

THE surprising highlight of a visit to the Farnsworth Television studio in Wyndmoor, Pennsylvania (a suburb of Philadelphia) is the studio. It is a chamber 40 feet long, 24 feet wide and 24 feet high equipped in cinematic fashion with lights, props and full-sized and miniature sets. Test air transmissions are made on a television carrier of 62.75 megacycles and a sound carrier of 66 megacycles. While the tests are not intended for public reception, any amateur within some thirty miles equipped with a receiver tuned to these channels and adjusted to the 441-line pictures with an interlace of two to one can get the program. The station will have an ultimate power of 4 kilowatts video and 1 kilowatt sound.

The great new transmitter for sight and sound is shown in Figure 9.

Mounted on a 150-foot mast, the antenna is of the vertical di-pole type.

It should be noted that the sound and video carriers are 3.25 megacycles apart, as recommended by the R.M.A. The Farnsworth station also intends to abide by the R.M.A. standards in the matter of band width, this being 2.5 megacycles.

The studio has a steel-beamed ceiling. There are no pillars. The pick-up cameras are mounted on tripods and permit the televising of any portion of the studio. Although all programs will originate in this single large room, the studio is so equipped that even with different scenes and settings, action will be unbroken and continuous. It is apparent that right from the start of a public-participating service, television will have no need for the "One minute, please!" sign that was so widely used in the early movie days when reels had to be changed.

Separate Unit for Movies

There is a separate unit in the building for the pick-up of movie film, which suggests the likelihood that live and filmed subjects will be combined for certain program effects.

Wyndmoor is twenty minutes from the Philadelphia business section by rail and arrangements will be made to shuttle talent back and forth. Subsequent to the launching of a regular commercial service, the station expects to be served by a remote-control coaxial link with a new studio in the heart of the Quaker City.

Although the receiver recently demonstrated had an image of black and green tone, Philo T. Farnsworth has already shown black and white pictures on other occasions. Also, according to A. H. Brolly, his chief engineer, the firm has developed a projector-type, cathode-ray tube capable of giving sharp pictures on a large-size screen. The commercial type of Farnsworth receiver, according to Mr. Brolly, will have "something less than thirty tubes." No estimate would be given of its approximate cost. The Farnsworth firm intends to license manufacturers and not to produce the equipment itself.

Figure 7 gives the fundamental circuit employed in the latest receiver types developed by Farnsworth.

The set differs from most other American types demonstrated in recent seasons in that the picture is seen right off the tube instead of by a mirror-lid reflection, as shown in Figure 8. This permits the cathode-ray tube to be mounted horizontally and, because the valve uses magnetic rather than electrostatic deflection, its length permits a shallow cabinet depth. Although the set demonstrated yielded a picture only six inches square, it was apparent that the direct framing of the tube's screen in the face of the cabinet gave an illusion of a still greater size. The use of a tilted mirror lid with a vertically mounted tube sets the picture back some inches from the face of the cabinet and seems to yield a smaller image.

THE DON LEE SYSTEM

THE Don Lee television transmitter W6XAO operates on the ultra high-frequency of 45,000 kilocycles (6 2/3 meters) daily except Sunday and holidays, from 3:00 to 5:00 p.m. and from 6:30 to 8:30 p.m. Voice announcements concerning the broadcast are made at the beginning and end of each transmission. A view of the television transmitter at W6XAO is shown in Figure 10.

For receiving the voice announcements of W6XAO and for preliminary experiments, any type of ultra short-wave receiver which will tune to 6 2/3 meters may be used. Receivers designed for 5-meter amateur work are suitable when provided with larger coils. Install coils with 50 per-cent more turns and remove one turn at a time while tuning for W6XAO. A simple line-image of constant intensity is broadcast for a short period of each schedule, and an appreciable change in its strength after a change in the circuit or operation of a receiver is a direct measure of the effect of the change.

The image broadcast is a 300-line sequentially-scanned picture, with a frame frequency of 24 per second. For receiving these images the receiver must tune very broadly and should be one of the superheterodyne type, with band-pass intermediate-frequency transformers arranged to operate on an intermediate frequency of approximately 8,000 kilocycles. The RCA 954 or 955 "acorn" tubes are recommended for use in circuits carrying ultra high-frequency radio energy, except for the first

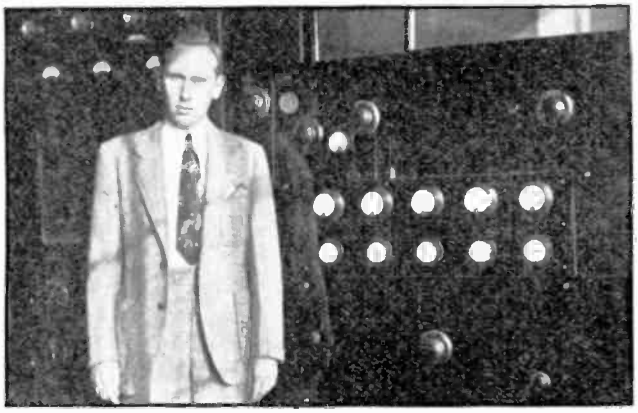


Figure 10
Harry R. Lubcke is shown standing in front of the W6XAO television transmitter which operates on 45 megacycles and transmits high-definition images daily in Los Angeles, Calif.

detector of a superheterodyne receiver, where the metal tube 6L7 is recommended.

The receiver "audio" channel must be resistance-coupled and capable of substantially uniform response over a range of from 24 cycles to 800 kilocycles, in order to reproduce faithfully the high-definition picture that is broadcast. A cathode-ray tube must be used as the image reproduction device, since it is practically impossible to construct a scanning disc of sufficient accuracy.

The high-frequency receiver scanning source should produce a saw-tooth wave-shape of a frequency of 7,200 cycles. This is applied to the pair of deflection plates, in the cathode-ray tube, which produce a horizontal deflection. The low-frequency scanning source should also produce a saw-tooth wave-shape, and of a frequency of 24 cycles. This is applied to the pair of deflection plates which produce a vertical deflection. If the image appears upside-down, reverse the connections to the low-frequency deflection plates; if printing reads backwards, to the high-frequency deflection plates.

A negative image is radiated from the transmitter. In the particular receiver constructed, if the image shown on the cathode-ray tube is a "negative" (white objects reproduced black and vice-versa) one more or less, stage of "audio" frequency amplification (following the second detector) will give the proper "positive."

Synchronizing pulses are transmitted at the end of each line and at the end of each complete image for keeping the receiver scanning sources in step at the 7200- and 24-cycle frequencies, respectively. A small amount of the image signal should be supplied to the grids of the gas triode tubes to synchronize the sources.

Reports on reception results are requested. Give the date, time, signal clarity and strength, amount and nature of interference, your address, location of nearby hills and large buildings, type of receiving antenna and its height above ground, type of receiver, and your signature. Standardized reception report forms may be had from the Television Division of the Don Lee Broadcasting System, Seventh and Bixel Streets, Los Angeles, upon the receipt of a stamped self-addressed envelope.

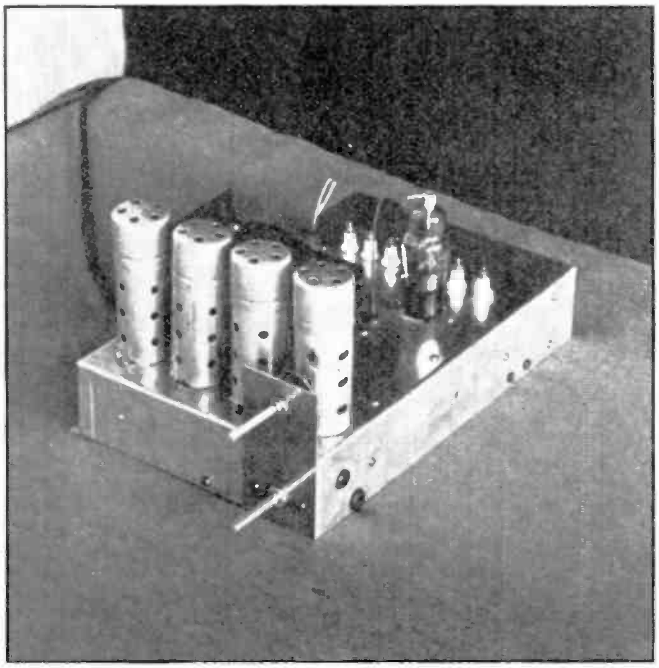
Building A Don Lee Television Receiver

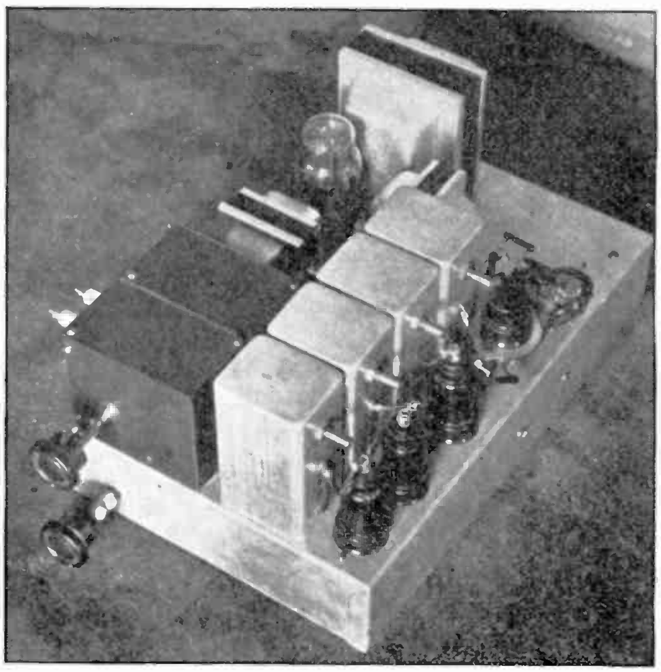
IN common with all high-definition television transmissions, a receiver for displaying the images must tune very broadly as compared to the usual communications type receiver used for receiving voice and music transmissions. A high intermediate frequency must be employed in a television receiver and band-pass transformers used to provide sufficient band width. In the "audio" section of the television receiver, abnormally low values of plate resistors must be used and great care exercised to keep the stray capacitance of wiring and components to a minimum.

The diagram of the Don Lee receiver is shown in Figure 14. It is of the television superheterodyne type embracing the design features set forth above. The antenna is indicated by the tubing at the upper left, separated in the center and connected to L1. The separate lengths of the tubing should be 63 inches long and ¼ inch or more in diameter. They should be joined mechanically by an insulator 2 or 3 inches long. The leads running from the antenna to L1 indicate a length of 70-ohm cable, known as "EO1," or the rubber-covered parallel pair feeders known as the Lynch "Giant Killer" Cable. It is desirable that the feeder should extend perpendicularly from the antenna for 5 feet or more. The antenna end of the feeder is fanned out for 6 inches and one conductor attached to each 63-inch length of the antenna. The receiver end is brought in through insulating bushings to the 1 to 2-turn coil, L-1.

The first resonant circuit, L2, C1, should be of "high-loss" construction; that is, no effort should be made, as is usually done, to keep the coil away from shielding, or use the best quality variable condenser. The radio-frequency resistance of this circuit *must be considerable* to insure that the high-frequency components of the wide image sideband will not be attenuated. This can be accomplished by using components of ordinary quality or by shunting a fixed resistor across the circuit. The components should be mechanically excellent, but the use of bakelite coil forms, bake-

Figure 11, left, the sweep circuits; Figure 12, right, the receiver proper.





lite pieces for coil support, and condenser end plates, is definitely allowable. This circuit, with vacuum tube VT1, comprises the superheterodyne first detector or converter. This is housed in the first dark shield can shown in the front left of Figure 12. The porcelain lead-through insulator at the left supports coil L1 and provides external binding posts for the incoming feeders. The upper of the two knobs is the tuning control and comprises the shaft and variable condenser C1. This is one of the front-panel knobs. The knob directly below it is the volume control, comprising resistor C7 in the circuit of Figure 14. Behind the first shield is the oscillator shield, and condenser C15 of this circuit is ganged with condenser C1. This is accomplished by an ordinary shaft coupling.

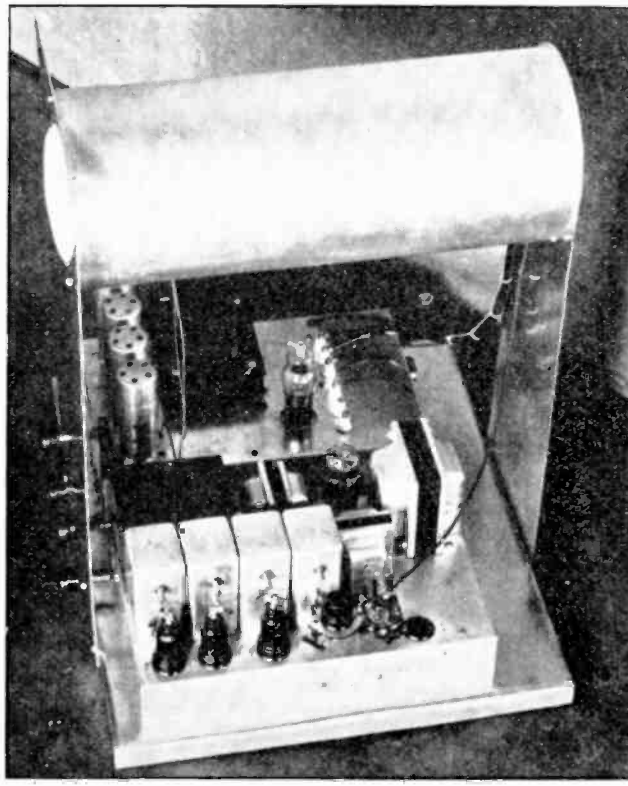


Figure 13

The completed chassis of the "Don Lee" television receiver. The super-heterodyne and low-voltage power supply are shown in the foreground, the sweep circuit and high-voltage power supply in the background, and the shielded cathode-ray tube above.

Shielding

These two shields are preferably made of copper, with as few joints as possible to give good shielding at ultra-high frequencies. They may be chromium, but not cadmium plated, if desirable. Cadmium plating is satisfactory for the chassis in general and aluminum shield cans may be used elsewhere. Copper shield cans with chromium plating are an extra refinement. The remainder of the circuits of the converter VT1 and oscillator VT7 are more or less standard. Oscillator coil L2 is placed over (surrounding) the grounded end of coil L11. No difficulty should be encountered in securing ultra-high-frequency oscillation with this circuit.

Coil condenser combinations C3, L3 and C4, L4 complete the band-pass intermediate-frequency transformers. These should also be of "high-loss" construction. Bakelite coil forms and small wire are specified, while the condensers may have bakelite end insulators, and may be of the mica compression type. The intermediate-frequency transformers are shown as the row of rectangular shield cans down the center of the chassis in Figure 12. The three 6K7 intermediate-frequency vacuum tubes are shown to the right of the several stages. It is not necessary that the arrangement shown be strictly adhered to. Increasing the space between shield cans and placing a tube between each one, or a staggered arrangement of shield cans and tubes is satisfactory. The diagram shows three stages of intermediate-frequency amplification, indicated by tubes VT2, VT3 and VT4, with the associated equipment. This amount of amplification is satisfactory where a moderate or strong signal is available, such as a hillside or unobstructed line of sight location on level ground, using an antenna 25 or more feet above surrounding objects. Where these conditions cannot be met, an additional stage of intermediate-frequency amplification is recommended. The addition is accomplished by merely constructing and installing another tube, VT3, another intermediate-frequency transformer, C3-L3, C4-L4; a socket, shield can, two isolating resistors, R37, and two by-pass condensers, C2. The adjustment of the several condensers, C3-C4, of each stage should be available from the outside, and they should be adjusted to give the best detail while looking at the image.

Special Values

VT5 is a diode second detector, the output of which appears at the righthand end of resistor R2. It will be noted that this resistor has a value of only 15,000 ohms. This resistor in the usual communications type receiver would have a value of perhaps one-half megohm. The low value here used is necessary in order to nullify the reactance of the unavoidable capacitance of the "high" side of the components and the "high" wiring to ground. It will be noted that the lead from R2 to the grid of VT6 is shown as a solid line, with a dotted line adjacent to it. This is to indicate that this lead, as well as others to follow, should be run in a direct manner, and as far away from the chassis as possible, so that its capacitance to ground will be small. The short metal tube in front of the last intermediate-frequency transformer shield can is the diode, and it will be noted that it is above the chassis by 1¼ inches. This is for the purpose of reducing the capacitance of the wire to ground.

Constructional Details

Similarly, the acorn triode, VT6, is elevated above the chassis. In this circuit the plate lead to the high end of resistors R4 and R40 and the associated components must all be located as far from grounded objects as possible. Condenser C12 and resistor R5, coupling condenser and grid leak for the cathode-ray tube respectively, can best be located adjacent to the grid terminal of the cathode-ray tube rather than immediately adjacent to VT6. The lead from the junction of resistors R4 and R40 to the synchronizing circuit condensers C30 and C31 and resistor R33, which comprise the synchronizing circuit, and the leads to the grids of the vacuum tubes VT11 and VT12 of the scanning sources should be of low capacitance by being short and by being removed from ground as far as convenient.

The glass tube in the rear of the chassis of Figure 12 is the 83-volt full-wave rectifier. Directly behind it is the power transformer TR2 and the chokes L13, associated with the low-voltage power supply shown in the lower left-hand corner of Figure 14. This power supply operates the television receiver and the two scanning sources.

The simple type of gas triode sweep-circuit oscillator, with a constant-current pentode as a plate resistor, has been used in the interest of simplicity. The high-frequency and low-frequency sweep circuits are alike, except for the value of condensers C22, C25, C23 and C26. Resistors R18 in each circuit vary the frequency. These two controls are front-panel controls, for adjusting the lock-in of both the low and high-frequency sweep circuits.

The components C30, C31 and R33 convey energy from the output of the receiver amplifier through circuits particularly suited to synchronize the low- and high-frequency sources.

Transformer TR1, rectifier tube VT8, condensers C28 and C29 and resistor chain R8, R9, R10, R11, comprise the high-voltage power supply for the cathode-ray tube. This is essentially standard cathode-ray tube practice. However, it is notably different from ordinary receiver tube practice in that the *plate* of the cathode-ray tube is grounded and the heater cathode and grid of the cathode-ray tube are the *high-voltage* leads of the device. These must be treated *with respect* in installation, and *not touched when in operation!* These leads are some 2000 volts "below ground" potential, but whether or not such a lead is "above" or "below" ground potential by a large amount makes no difference in its ability to give a severe shock. It is improbable that there is sufficient energy in the equipment to produce fatal results unless the subject should die of fright. Consequently, if the circuits are accidentally touched, attempt to minimize the effect in the mind, which should tend to put the person in the best condition. (It is to be understood that the Don Lee organization incurs no liability of any kind in connection with such accidents or in any other matter, because of the information furnished herewith. Such information is furnished free for non-commercial use and no patent or other license is granted or may be inferred.)

The Sweep Circuit

Figure 11 shows the sweep-circuit, high-voltage, power-supply chassis, with gas triodes and accompanying pentode resistor

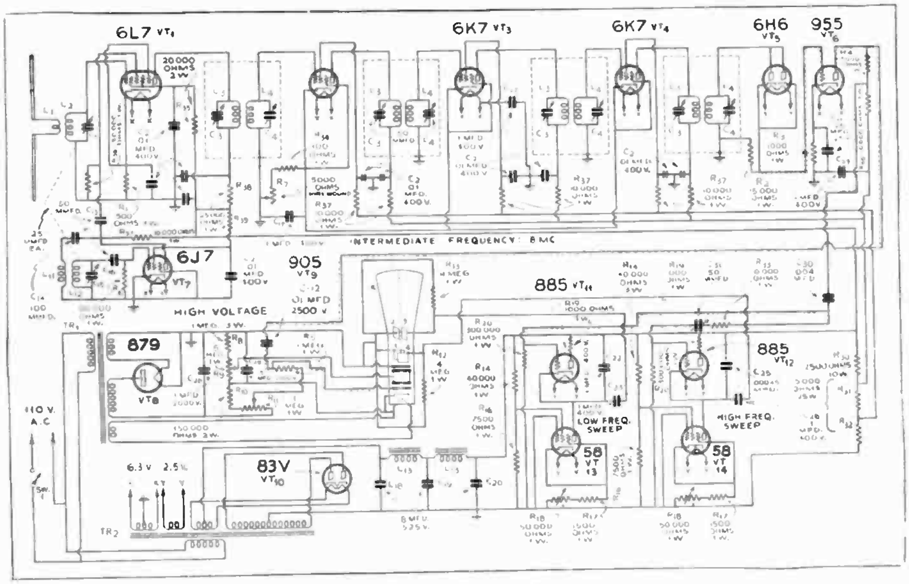


Figure 14—Schematic circuit diagram.

tubes shown in alignment at the front end of the chassis. Behind them is transformer TR1, rectifier VT8 and porcelain lead-through insulators, which carry the high voltage to the cathode-ray tube. Condensers C28 and C29 are below the chassis. Resistors R18 are shown on the small panel at the front right of the chassis. On the rear of the chassis are located controls R9 and R11, which control the focus and intensity of the cathode-ray tube respectively.

Figure 13 shows the completed receiver. The curving black lead in the foreground, from receiver to the rear of the cathode-ray tube shield, is the output "high" lead which goes to the grid of the cathode-ray tube. The cable leads in the rear which also enter the rear of the cathode-ray tube shield are the cathode-ray voltage supply leads. It is desirable that the cathode-ray tube be mechanically, electromagnetically and electrostatically shielded. To accomplish this, a piece of 6- or 7-inch diameter stove-pipe is suitable for a 5-inch diameter tube. In the receiver constructed, this shield, the two supporting panels and the bottom shelf were cadmium plated. This presents a pleasing appearance, regardless of the lowly origin of the stove-pipe.

Mechanical Layout

The mechanical arrangements shown in the photographs do not have to be rigidly followed. Several rules of construction must be observed, however. Most important: power transformers and chokes should not be located closer than one foot from the cathode-ray tube, particularly if near the rear end thereof. If located closer, the stray magnetic field from these devices deflects the electron beam directly by the mechanism of the electromagnetic deflection and an irregular vertical margin is found on both sides of the blank field of view of the cathode-ray tube, even if all signal circuit leads are disconnected therefrom. If it is desired that the tube and chassis be close together, the transformers must be located at the front of the tube near the fluorescent screen. All components may be located on one large chassis if these precautions are followed. Another allowable arrangement consists of locating the receiver and scanning sources on an upper chassis and the two power supplies on a lower, the latter being placed below the former in the cabinet.

Also, it is not necessary that metal vacuum tubes be employed. The corresponding glass types are suitable. *It is important that an acorn triode be used for VT6, however!* Another acorn triode connected as a diode may be used for VT5, if desired.

In connecting the cathode-ray, tube-deflection plates, the numbers on the diagram when viewed from the front of the cabinet are: (1) right rear; (2) lower front; (3) upper front; (4) left rear. When this arrangement is observed, the picture will appear right side up and printing will read from left to right.

Operating The Receiver

The receiver is put into operation in the following manner: All connections having been made and checked, the power circuit is turned on by SW1. After about a one-minute warm-up period, a rectangle of light should appear on the cathode-ray tube screen. This should be adjusted by resistor R11 until it is of average brilliancy. If the resistor R11 is adjusted too much in one direction the rectangle of light will be extinguished; if too far the other direction it will be very bright and unsuited for displaying the television image. The neutral or blank screen should be of half-brilliancy so that the black portions of the picture will extinguish the cathode-ray spot and the bright portions carry it to full brilliancy. The resistor R9 controls the focus of the tube, and this should be adjusted until the scanning lines are most clearly seen.

Eliminating Hum

With no signal being received, there should be no variation of intensity over the screen, except for a very slight darkening at the top, which is permissible. Any traveling or stationary variations of intensity having several dark and light horizontal portions, indicate the presence of alternating current hum. This might come from improper circuit connections or conditions in the high-voltage rectifier for the cathode-ray tube; hum in the output of the radio receiver or improper connection of the cathode and heater of the cathode-ray tube. It is usually found that connecting the cathode to one side of the heater gives less hum in the field than connecting to the other side. Whether or not the hum comes from the television receiver can be checked by removing the connection to condenser C12. If the horizontal variations of intensity disappear, the hum is in the receiver. As previously mentioned, irregularity of the vertical sides of the beam usually indicates deflection of the cathode-ray beam directly by transformers or magnetic field. This must be cured by further separation between these units and the cathode-ray tube. This type of interference might occasionally produce residual intensity variations of the field of view and give rise to the horizontal variations of intensity which are characteristic of power supply hum. A slight amount of such variation can be tolerated, since the incoming signal is much stronger and the variation is not seen, when an image is being received. When the receiver is properly constructed and adjusted, however, all hum will be removed.

Tuning Hints

After making the above adjustments without a television signal, the next step is to tune in the test signal of W6XAO. When this is properly received, it appears as 38 parallel horizontal bars in the field of view. In order to receive the signal, the several condensers C3, C4 of the intermediate-frequency transformers must be aligned. If necessary at the start, headphones (with a series blocking condenser) can be shunted from the plate of VT6 to ground and the weak signal, which will probably be received in any event, brought to maximum intensity by such adjustment, and the separate tuning condensers C1 and C15, which are best left free of each other in this preliminary adjustment. The intermediate frequency is 8000 kilocycles and the oscillator operates 8000 kilocycles above the incoming frequency. Its condenser, C15, will consequently be at a smaller capacitance than condenser C1 to bring this about. The setscrews of the coupling between C1 and C15 may be tightened when maximum signal is secured.

If fewer bars than 38 are received, the low-frequency scanning source is operating at *too high* a frequency and if more than 38 are received, it is operating at *too low* a frequency. The proper frequency is 24 cycles per second. The high-frequency source must operate 7200 cycles per second. With the low-frequency source properly adjusted, this is the point where the individual scanning lines just begin to merge into a solid field for the typical 5-inch cathode-ray tube.

Adjustments for Framing

The next step is to receive an image. With the high-frequency source "off" frequency, as it probably will be in this first adjustment, a great number of small black and white dots and dashes will undoubtedly be received. Vary the high frequency, adjusting knob R18 until this closes up to a single image. This is identified by a black bar at the right of the field of view and a single orderly representation of an image across the field of view. Preliminary to securing this adjustment, one or more images may appear slanting one way or the other, depending upon whether the source is adjusted to too high or too low a frequency. After proper high-frequency adjustment, it is possible that the image will be moving up or down. This is remedied by adjusting the low-frequency resistor, R18, until the image becomes stationary. Proper adjustment of both of these knobs should now make the image lock in step and continue to be displayed without further interruptions. It will be found with these simple types of sweep circuits that the natural frequency of the sources may tend to vary during the first few moments of receiver operation. Consequently, a few moments' warm up period is needed. If the receiver signal is not sufficient to fully modulate the cathode-ray tube, the synchronization may not be secure and steps should be taken to increase the signal strength.

To bring the detail in the image to a maximum, the several intermediate-frequency condensers, C3, C4 should now be adjusted while examining the picture. The condensers C1 and C15 should also be checked as to over-all tuning adjustment and relation between the two as determined by the setting of the coupling.

For Greater Gain

If insufficient signal is secured, the addition of one or even two more intermediate-frequency stages is indicated. This is not difficult, because these stages are of low gain compared to the usual communications type, intermediate-frequency stage. For instance, the gain of the three stages, when properly constructed and adjusted for wide band pass, may not be more than one or two high-gain stages as used in usual short-wave or broadcast reception. The use of a directional antenna is an excellent way to increase the signal strength and decrease the interference from automobiles or other sources, if this is required. This is accomplished by placing a parasitic reflector, consisting of one piece of ¼-inch diameter copper tubing, 11 feet long, 4 feet away from the antenna and on the side directly opposite to the television station from which it is desired to receive. This reflector is not connected to the antenna or any other metallic object in any way. It does not attenuate signals in a range of about 160 degrees in the direction toward the station to which it is aimed, but does reduce signals coming from the rear 200 degrees.

The ordinary 5-inch-size cathode-ray tube has been chosen for this receiver because of its low cost and availability. It is possible to employ any size tube with the receiver. The 1-inch or 3-inch sizes are not recommended, however, because the focus of the spot is not sufficiently fine to secure the proper detail in the present high-definition television images. For a larger cathode-ray tube, symmetrical push-pull amplifiers should be added to the scanning sources, if a plated type anode on the conical side of the tube is employed in its construction. It is understood that large-size tubes (without this feature) are available, that mercury-vapor, gas triode tubes can be used to give large scanning-source outputs without amplification (*DuMont*).

Figure 15 shows an unretouched photo of a television image received 3¾ miles away from the transmitter.

The confidential Don Lee television receivers, as used for demonstrations, differ materially from the design of this particular receiver. However, this unit has been constructed and adjusted according to the above directions by the Don Lee organization and also by a number of individual constructors in Southern California who already have receivers in operation.

It is felt that such constructors as can assemble a receiver of this type will not have difficulty in modifying or improving it in the future to keep pace with the forward march of the television art.

Figure 15—An unretouched photo of the television image received on a home receiver.

List Of Parts

R—500-ohm, 1-watt, Morrill or equal
R2—15,000-ohm, 1-watt, Morrill or equal
R3—1000-ohm, 1-watt carbon
R4—5000-ohm, 1-watt, Morrill or equal
R5—1-megohm, 1-watt, Morrill or equal
R6—50,000-ohm, 1-watt carbon
R7—5000-ohm, 4-watt potentiometer, wire-wound
R8—1-megohm, 3-watt carbon
R9—0.5 megohm, 1-watt potentiometer
R10—150,000-ohm, 2-watt carbon
R11—0.1 megohm, 1-watt potentiometer
R12—4-megohm, 1-watt carbon
R13—4-megohm, 1-watt carbon
R14—400,000-ohm, 3-watt (need 2)
R16—75,000-ohm, 1-watt carbon (need 2)
R17—1500-ohm, 1-watt carbon (need 2)
R18—50,000-ohm, 1-watt potentiometer (need 2)
R19—1000-ohm, 1-watt carbon (need 2)
R20—300,000-ohm, 1-watt carbon (need 2)
R30—2500-ohm, 10-watt, wirewound
R31, R32—15,000-ohm, 25-watt, vitreous enamel, adjustable
R33—10,000-ohm, 1-watt carbon
R34—100-ohm, 1-watt carbon
R35—20,000-ohm, 2-watt carbon
R36—50,000-ohm, 1-watt carbon
R37—10,000-ohm, 1-watt, Morrill or equal (need 7)
R38—25,000-ohm, 1-watt, Morrill or equal
R39—25,000-ohm, 1-watt, Morrill or equal
R40—10,000-ohm, 1-watt
L1—1 turn No. 14 enamel, 1" diameter
L2—6 turns No. 14 enamel, 1" diameter, spaced to make coil 1" long
L3-L4—23 turns No. 30 enamel per coil, wound solid on ½" bakelite form (outside diameter). Coils ¼" long spaced 1/16" apart
L11—5 turns No. 14 enamel, ¾" diameter, ¾" long
L12—3 turns No. 14 enamel 1" diameter spaced to make coil ½" long
L13—Inca D-22 or equal 20-henry choke (need 2 or 1 double one)
C1—25-mmfd. variable, isolantite insulation
C2—.01-mfd., 400-volt paper (12 needed)
C3—50-mmfd. midget variable (bakelite ends satisfactory or mica compression type may be used)
C4—ditto
C11—25-mfd. electrolytic condenser, 25 w.v.
C12—.01-mfd. mica, 2500-volt
C13—50-mmfd. mica, 500-volt
C14—100-mmfd., 500-volt mica
C15—25-mmfd. variable, isolantite insulation
C16—50-mmfd. mica, 500 volt
C17—0.1 mfd. paper, 400-volt (2 needed)
C18, C19, C20—3-section electrolytic, 8 mfd. per section, 525-volt peak
C22—0.1 mfd. paper, 400 w.v.
C23—1 mfd. paper, 400 w.v. (2 needed)
C25—.00045-mfd., including stray wiring capacity mica condenser
C26—0.1-mfd. paper, 400 w.v.
C28—1-mfd., 2000 w.v., Pyranol or equal
C29—0.5-mfd., 2000 w.v., Pyranol or equal
C30—.004-mfd., 500-volt mica
C31—50-mmfd. midget, set at 20 mmfd.
SW1—S.P.S.T. toggle switch, 110-volt
VT1—6L7 first detector
VT2—6K7 first i.f. amplifier
VT3—6K7 second i.f. amplifier
VT4—6K7 third i.f. amplifier
VT5—6H6 diode second detector
VT6—955 acorn television ("audio") amplifier
VT7—6J7 oscillator
VT8—879 half-wave rectifier, high-voltage
VT9—905 cathode-ray tube, 5" screen
VT10—83-V full-wave rectifier
VT11, VT12—885
VT13, VT14—58
TR1—Inca B-7 or equal, sec. 1200 r.m.s.
TR2—Inca C-66 or equal, sec. 750 r.m.s.

RADIO RECEIVERS

Tiny One-Tube Pocket Set

THIS tiny pocket set will serve you at sporting events, on the water, on camping trips, etc. Toss it in your suitcase or slip it in your pocket whenever you go away on holiday or business trips. It will always attract attention and provide you with the means for making many interesting experiments, beside its every-day practical uses or applications.

Of course the idea of a pocket receiver is not new, nor is there anything unusual about the super-regenerative circuit. Combinations of this type have been described since the early days of super-regeneration, which first made it possible to obtain tremendous power sensitivity from a single tube.

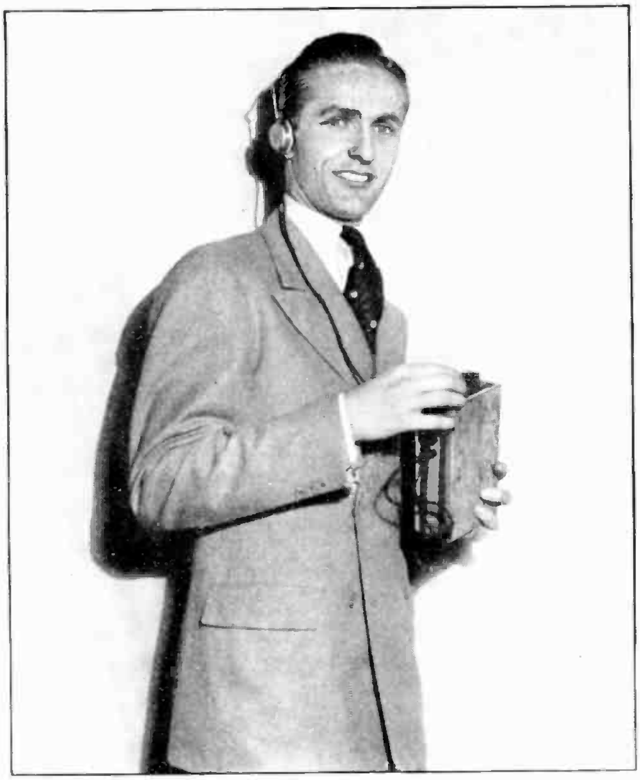
This latest type of super-regenerative receiver has not received the popularity it deserves; probably because its many practical uses and simplicity of construction have not been realized by the majority of radio fans. The forms in which they can be built are almost endless; while the circuit is so simple and the parts so few that few technical difficulties are ever encountered.

The case for the set may be built in any form desired, limited only by the constructors imagination and ingenuity. The model illustrated in Figures 1, 2 and 3 here was made from ¼-inch, 3-ply wood, which is advisable, if wood is used, to prevent warping. It is fastened together with glue and brads. The small partition which segregates the batteries is 4 inches long and placed 1/16 inch on the tube side of the center line.

The inside dimensions of the box are 7 inches by 3¾ by 1¾. This is about as small as is practicable, if standard parts are to be used, without undue crowding. The front and back covers can be allowed to project about 1/16 inch beyond the sides to protect the loop antenna, which is wound around the sides in two sections.

The loop consists of 56 turns of No. 32 single-silk-covered, enameled-copper wire; 28 turns being wound on each side. The ends of the loop pass through small holes drilled in the case adjacent to their connecting points. The loop tap, which connects directly to the rotor of the tuning condenser, is taken off between the variable condenser knobs.

This form of super-regenerative circuit (Figure 4) is designed to oscillate at two frequencies. It operates on a somewhat different principle than the well-known self-quenching circuit, so commonly used now for ultra-high-frequency reception. Its operation is similar to the separately-quenched circuit, except that only one tube



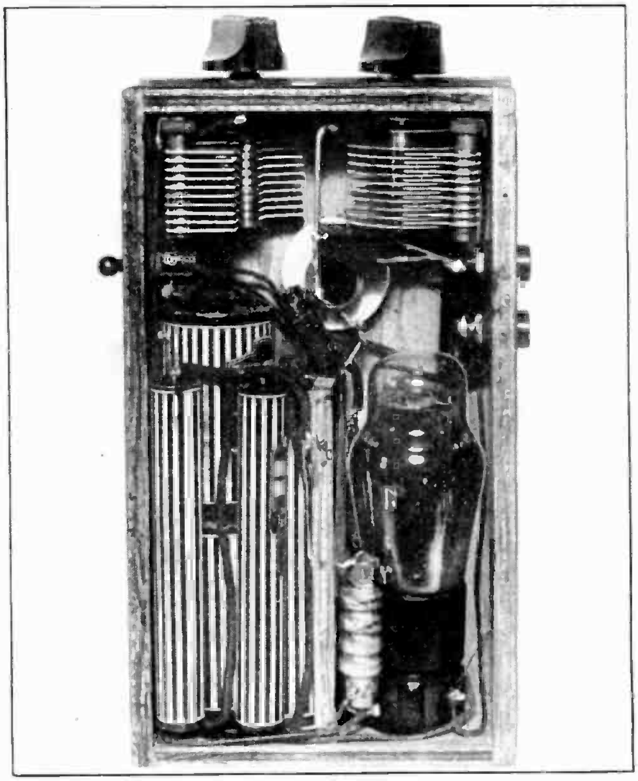


Figure 1, left, shows the receiver in use; Figure 2, right, gives the inside view.

is utilized; this tube being made to oscillate at the frequency of the received signal and at the same time at another lower quenching frequency, just above audibility.

The signal-frequency oscillation is varied by means of the tuning condenser C1, while the quenching frequency is adjusted by the proper balance of the tapped choke L2 and its fixed tuning condenser, C4. If a constant audio squeal is heard it indicates that the L2, C4 combination is too large and should be reduced, either by using a lower capacity condenser or by removing turns from the choke L2. This choke, L2, which is not particularly critical, is best purchased in the form of a close-wound universal choke of about 20 M.H. inductance, tapped about ½-way from the inside (about ⅓ of the inductance). For best sensitivity the condenser, C4, should be as large as possible without causing an audio squeal. The value of all the fixed condensers in this circuit vary to some extent with different layouts, but the given values should be about right. It may be well to try varying the position of the loop tap for the best regeneration control.

Current for the filament is supplied by two of the large, single-cell flashlight batteries such as the Burgess No. 2. If good batteries are used their life will be surprisingly long as the filament current of the 30 tube used is only .06 amps.

The 14-ohm resistor shown in the filament circuit can be easily made by winding some fine insulated copper wire on a small dowel or resistor form until the proper resistance has been reached. If you have no ohmmeter your radio store or any serviceman can wind it for you in a few minutes. Or a section of an old rheostat can be employed. The "B" or plate-circuit battery consists of four "pencil type," 2-cell, flash-light batteries (Burgess No. 22). As these are 3-volts each, a total of 12 volts is obtained when they are connected in series. The circuit will operate satisfactorily with only 3 batteries or 9 volts but there is room for the extra battery and 12 volts gives a little added improvement in volume and sensitivity.

L3 is an ordinary pie-wound 2.1 m.h. choke and is held in place by passing one of its leads through a small hole in the partition beside it; its other lead connecting directly to the plate terminal of the tube socket. The latter should be one of the small molded sockets which were so common a few years ago. If you haven't one in the "junk box" most any radio store will probably be able to produce one, and several manufacturers still make them (I.C.A. No. 2480).

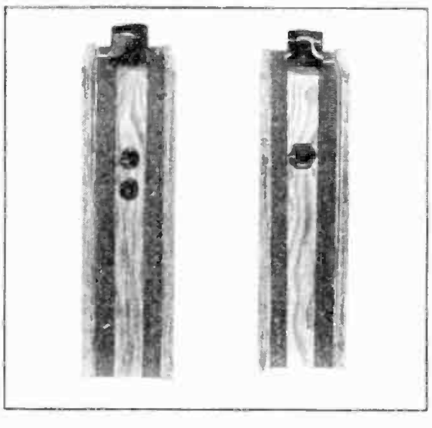
The placement of the various parts can be seen in the photographs. There is no over-crowding and the wiring presents no problem with the exception of the filament connections to the socket which should be made before it is fastened in place.

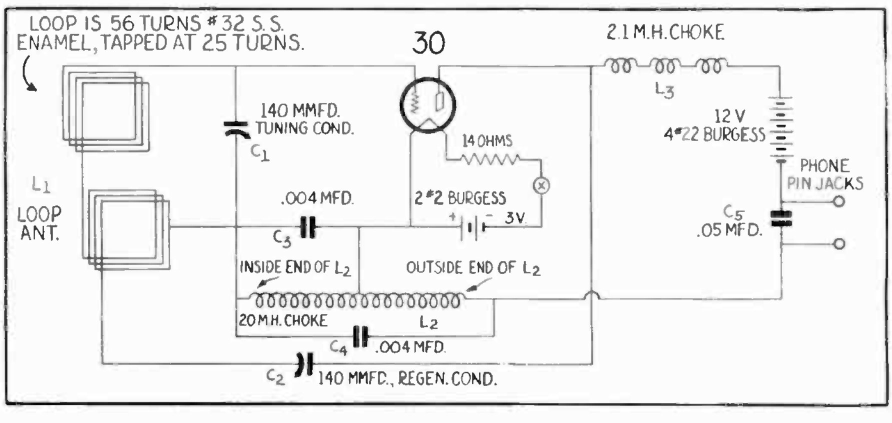
The grid end of the loop is brought through a small hole in the side of the case adjacent to the grid terminal of the socket to which it is soldered.

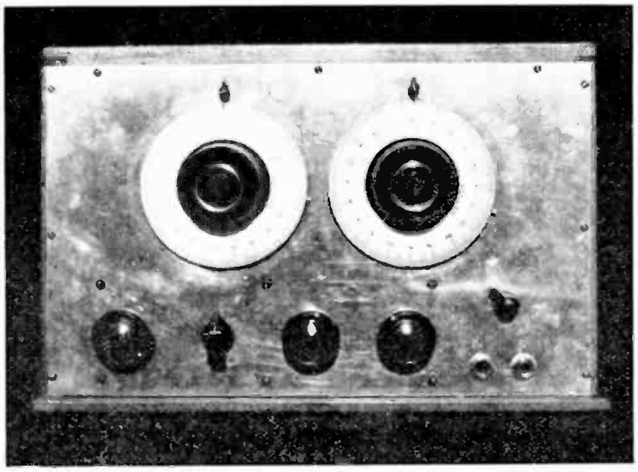
The filament resistor is below the 2.1 M.H. choke and lays along the angle formed by the partition and the back of the case.

The tuning is a bit unusual unless you have had experience with super-regeneration on the lower frequencies. C1 is of course the tuning condenser, while C2 controls the super-regeneration. And as there is bound to be some inter-action between these two it takes a little experimenting to learn the proper method of adjusting

Figure 3, left, the left and right external views; Figure 4, right, the circuit diagram.







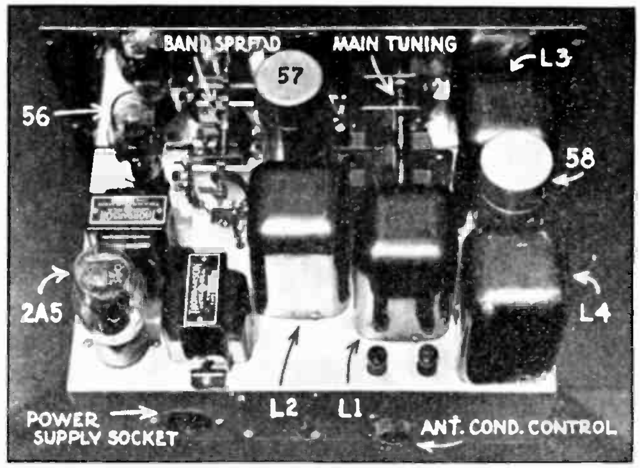


Figure 5, left, front view of the 4-tube set; Figure 6, right, the chassis layout.

the receiver. You will catch on to it quickly, however, and a tedious explanation of exactly how to proceed hardly seems necessary.

If more distant reception is desired, such as from a camp location, a short antenna may be connected directly to the grid in addition to the loop or a tap near the grid end of the loop may be provided.

You will find that this set will give you good reception on the major local stations from most any location within reason, so don't forget it when you take in the World Series or the big foot-ball games. Slip it in your over-coat pocket so that the controls are at the top. Then with a single 1000-ohm earphone in the palm of your hand you are all set to qualify as an expert on everything that takes place on the field.

Parts List

- 2—140-mmfd. midget variable condensers—Hammarlund Star
- 1—.05-mfd. tubular condenser
- 2—.004-mfd. mica condensers
- 1—2.1-m.h. choke—Hammarlund
- 1—20-m.h. choke
- 1—4-prong bakelite socket—I.C.A. No. 2480
- 1—S.P.S.T. toggle switch
- 2—Pin jacks
- 2—No. 2 Burgess flashlight batteries (1½ volts each)
- 4—No. 22 Burgess flashlight batteries (3 volts each)
- 1—14-ohm resistor
- 1—Type 30 tube, Sylvania

Easy-To-Build 4-Tube S. W. Set

THIS little receiver features ease of construction, low cost, band-switching, detector regeneration, a tuned preselector stage, electrical band-spread and a continuous range of 2.6 to 16 megacycles, all of which make it an ideal construction model for the "kitchen mechanic."

The receiver is a short-wave, band-switching, four-tube regenerative receiver with fine power and sensitivity. It is simple and economical to build and the coils may be easily wound by hand. The circuit diagram is shown in Figure 7. The set was designed primarily for the 20, 40, and 80-meter amateur bands, but can be tuned to any intermediate wavelength desired.

The band-switching arrangement is of straightforward design, the only precaution being to keep leads as short as possible, especially those comprising the highest-frequency circuits. The layout is shown in Figure 6. The coil shields were taken from an old, discarded Crosley receiver, but any three-inch diameter cans will be suitable. The detector grid-leak and condenser are mounted directly on the band-setting condenser.

Figure 5 shows a front view of the receiver. The large Remler dials were used to facilitate rapid tuning. The left-hand dial controls the band-setting condenser, while the one on the right serves as a band-spread control. On the lower portion of the panel, from left to right, are the sensitivity control, band switch, r.f. compensating condenser control, and regeneration control. Following these can be seen the phone and loudspeaker jacks, while directly above is the B— negative switch.

The whole set is mounted on a Bud steel chassis measuring 7 by 12 by 3 inches but a slightly larger chassis may prove preferable. The panel is made from a piece of sheet aluminum measuring 8 by 13 by 1/16 inches. A thin sheet of steel is used to cover the bottom of the receiver chassis to shield the wiring from external pick-up.

All secondaries are wound with No. 24 double-cotton-covered wire, and the plate coils with No. 30 double-cotton-covered wire. One-inch diameter bakelite tubing is used for all coils. The various leads are passed through 3/16-inch holes to the underside of the chassis.

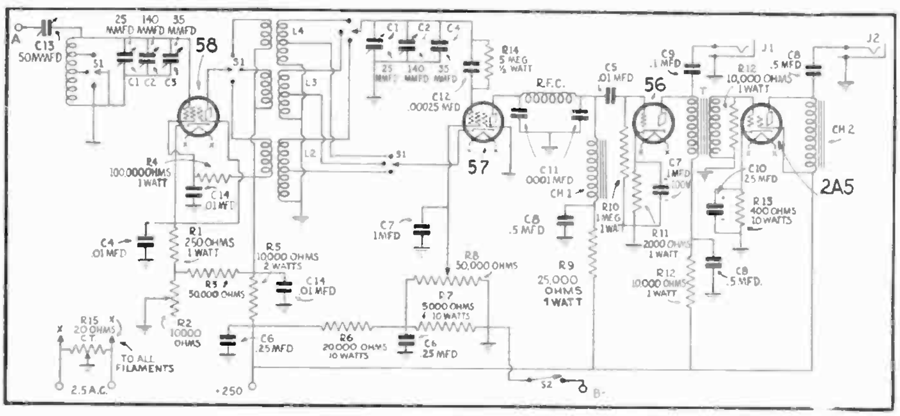
As the coil in the r.f. stage is the basis for the design of all the others, its construction will be considered first. Starting at one end of the bakelite tubing, and with spacing equal to the diameter of the wire, wind on 8 turns and make a tap by twisting out a small loop of the wire. From this point continue the same spaced winding and take off a tap at the 15th turn. From here on the coil is close-wound until a total of 35 turns is reached. This completes the winding. By employing these taps, the coils are made to tune the r.f. stage over the 20, 40 and 80 meter bands. The spacing between turns is secured by winding a cord alongside the wire and removing it when the coil is completed.

The various detector grid coils must be wound identically the same as the corresponding portion of the r.f. coil in order to make the circuits track properly. Although this may seem rather difficult at first, it is really comparatively easy. In winding the 80-meter grid coil it will be noted that the first fifteen turns are space-wound and the remainder close-wound in order to make it similar to the r.f. inductance.

The cathode tap for the 20-meter grid coil is made 2/3 of a turn from the end of the winding, that of the 40-meter coil is made 1¼ turns from the end, and that of the 80-meter coil is made 2 turns from the end (in the close-wound portion). The primaries for the 20, 40, and 80-meter bands consist of 7, 14, and 28 turns respectively, spaced 1/8 inch from the secondaries. The primaries are wound on the ground sides of the secondary coils. All the finished coils are given a coat of collodion.

The tuning condensers in the r.f. and detector circuits are ganged with the ex-

Figure 7—The circuit diagram.



ception of condensers C3 and C4, the latter being fixed and made from a few plates of a midget variable to equal about two thirds the capacity of C3. The condenser C4 is mounted on top of the chassis below the band-spread tuning condensers. The purpose of C4 is to balance the capacity of C3 so that the r.f. stage can be peaked exactly. At any setting of the tuning condensers it should be possible to peak the circuits with the aid of C3. If it is found that this cannot be done, tune the antenna series condenser, C13, until the desired result is obtained.

The receiver gain was so great it was necessary to shunt a 10,000 ohm resistor across the secondary of the audio transformer. Builders may prefer to omit this resistor, or use a higher value.

If any instability is experienced in the r.f. stage it can be cleared up by turning down the sensitivity control potentiometer, R2.

Low-Cost High-Fidelity Receiver

HOW many times have we heard people say, "All I want is a receiver which will bring in the local stations *right?* I don't care anything about getting distance, but I do want good tone quality." Here is a simple receiver which is designed to do just this. It can be assembled quickly and at negligible cost, requires no fussy adjustments, yet reproduces local programs with a purity of tone equalled only by far more elaborate and expensive high-fidelity instruments. It is very broad in tuning—there will be no side-band cutting with this design. Figure 9 shows the placement of parts.

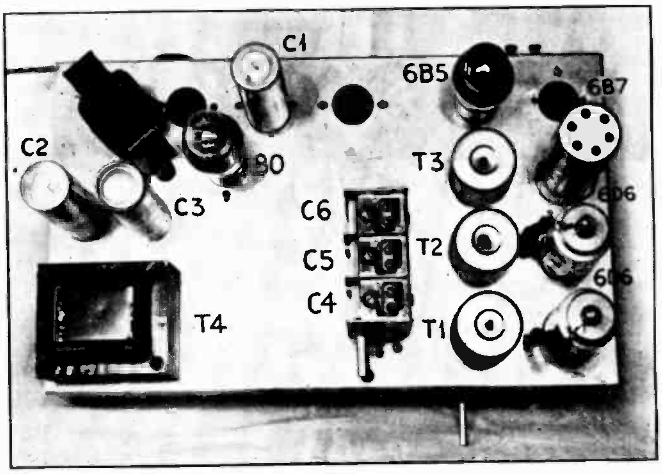
The schematic circuit giving the values of all parts used, is shown in Figure 8. As illustrated, it incorporates two stages of tuned r.f. using 6D6 remote cut-off radio-frequency pentodes feeding into a 6B7 duo-diode pentode which serves as a diode detector, a.v.c., and first-stage audio amplifier. The output tube is a 6B5 which has high power sensitivity and will deliver 4 watts in Class A operation.

The diode load resistance is unusually low, 10,000 ohms, permitting the use of .001 by-pass condenser across it with considerably less loss in high-frequency response than is obtained with the usual .5 megohm load and .001 by-pass condenser.

Installing automatic volume control in a tuned r.f. circuit usually introduces difficulties. The by-pass condenser across the diode load, C13, is effectively in series with the tuning condenser, C6, thereby throwing this stage considerably out of line if C6 is small in capacity and reducing the input voltage to the diode. The relatively large by-pass condenser permits a closer approach to proper alignment without resorting to a special coil or tuning condenser section.

Figure 9

A chassis from the bargain counter and inexpensive parts combine to form a simple receiver with excellent tone quality. The photo at the right shows the placement of the parts.

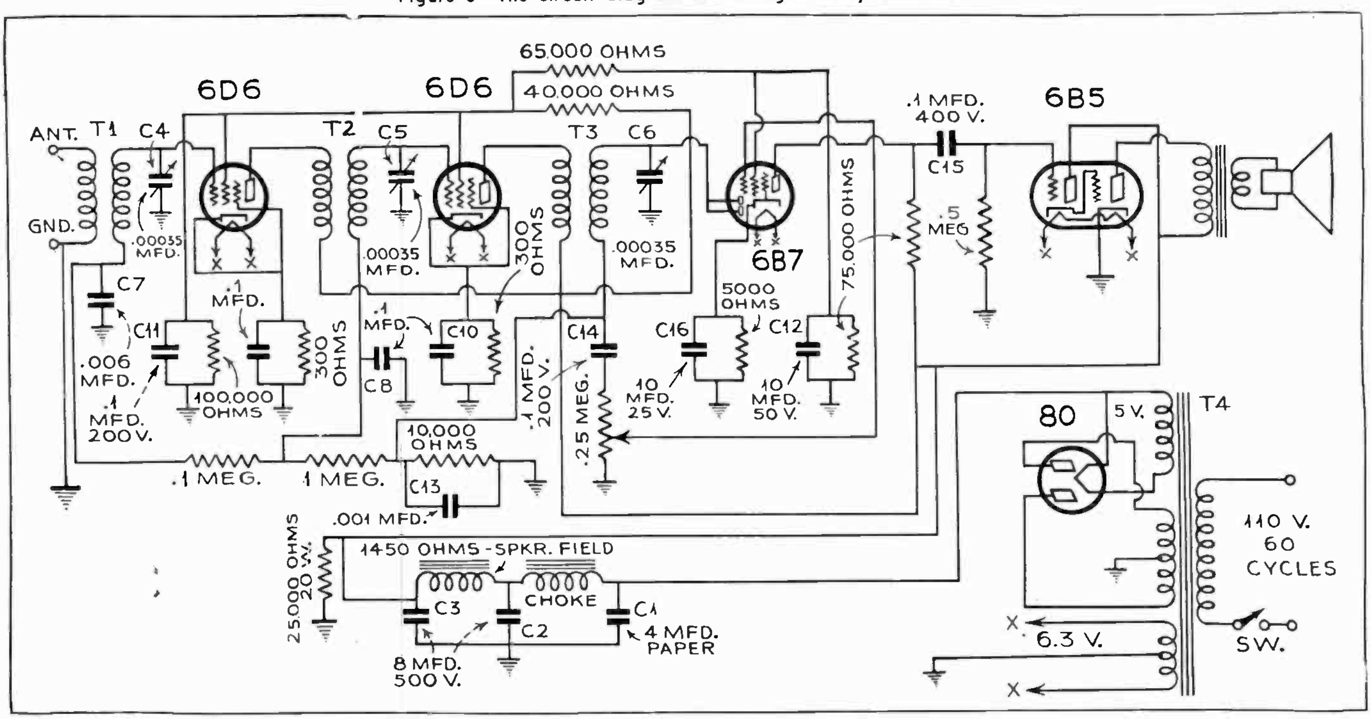


Delay action in this a.v.c. system is obtained by the voltage drop across the cathode biasing resistor of the 6B7. This applies a constant negative potential to the diode and reduces the circuit damping for weaker signals.

Since a fine speaker is essential for best results from any high-fidelity receiver, the Philco type U-7 high-fidelity model is employed in this design. The output transformer is mounted on the speaker, and though designed for push-pull output tubes, the full primary winding closely meets the proper load requirements of the single 6B5. The 1450 ohm field winding likewise is suitable as the second section choke in the filter circuit.

The coils and condensers are standard types, obtained from a mail-order house. The power transformer secondary is designed to give 375 volts each side of center tap at 90 ma. It has a center-tapped 6.3 volt 3 amp. winding and a 5 volt, 3 amp., winding for the rectifier tube. The choke is likewise designed to carry 90 ma. and is rated at 30 henries. The large 25,000 ohm bleeder resistor is an Electrad 50 watt type but a 20 or 25 watt one will be equally suitable.

Figure 8—The circuit diagram of the high-fidelity receiver.



5-550 Meter R-S-R Receiver

THE R-S-R (Regeneration-Super-Regeneration) Circuit here described represents a truly modern application of regeneration principles. The model receiver gave a surprising account of itself during tests by the editors.

This regenerative receiver provides a tremendous amount of radio-frequency amplification in proportion to the number of tubes and parts used, thus permitting good long distance reception at a minimum cost. High quality component parts can be employed and still keep the cost low, for they are few in number. Moreover, as a minimum of tubes and parts are in use, the noise inherent in the receiver itself is extremely low.

It has an extremely large tuning range, from the top of the standard broadcast band to below five meters. This includes practically every type of radio reception of interest to the experimenter. Moreover, its ultra-high frequency range (below 10 meters) is *not* a makeshift but can be used for serious communication work if desired; in this respect it stands quite alone among the all-wave commercial receivers which attempt to cover these extremely high frequencies. This is due to the use of super-regeneration below 10 meters while at 10 meters either super-regeneration or straight regeneration may be used.

The Circuit

The circuit, as shown in Figure 10, consists of one stage of untuned radio-frequency amplification using a 6K7 metal tube. Beside furnishing a substantial amount of r.f. gain this buffer amplifier stabilizes the regenerative detector action and eliminates dead spots due to antenna resonance. Moreover, this stage of r.f. is used on *all bands including 5 meters*.

The detector is a 6J5G; a high frequency super-triode particularly adapted to regeneration because of its combined high amplification factor, high mutual conductance and low inter-electrode capacities. A rather unusual combination of characteristics which are difficult to build into one tube.

The detector makes use of an unusually stable electron coupled circuit for both regeneration and super-regeneration. Smooth control of both types of regeneration is obtained by the 50,000 ohm potentiometer in the detector plate circuit. The cathode tap on the grid inductance is placed at only one or two turns from the grounded end, and this applies to the coils for all four bands from 22 megacycles to 550 kilocycles.

It will be noted that this circuit permits the rotors of the tuning condensers to be grounded which is a decided aid to stability.

R.F. Amplifier

The r.f. amplifier is coupled to the detector grid circuit by the now familiar condenser and choke coupling arrangement. This form of coupling can be greatly abused, and often is. The values of the semi-variable coupling condensers and choke must be proportioned very accurately for the particular circuit and tubes used. The coupling condenser C3 in this case, is used as a band set adjustment and when once properly adjusted, so that any one station falls on its correct calibration point on the dial, it may be left alone and all the calibrated frequencies will be found correct.

It will be noted that there are two tuning condensers: A .0003 mfd. tank condenser, which is controlled by the large calibrated dial to the left, and a small 3 plate, isolantite insulated, condenser which is tuned with the small center dial. The latter condenser serves two functions—as the band-spread condenser on the four calibrated bands up to 22 megacycles, and as the high-frequency tuning condenser on the ultra-high frequency bands below 10 meters. Band switching (no plug-in coils) is used up to 22 megacycles, but in order to secure really effective results on the ultra-high frequencies, interchangeable air coils are used below ten meters and the large tank condenser, together with the band switch, is dropped out of the circuit. It is this feature which makes it practicable to use the same detector for regeneration, with band switching, over the longer wavelengths and with interchangeable coils and super-regeneration, over the very short-wave bands.

Shifting to the high-frequency super-regenerative circuit is accomplished by the arrangement of three pin-jacks lettered A, B and C in the diagram. For the usual all-wave (so called) reception from 22 megacycles to 550 kilocycles, a plain bus-bar jumper is plugged into pin-jacks A and C. This places both condensers in parallel so that on positions 1, 2, 3 and 4 of the band selector switch the tuning frequencies are read directly from the big dial when the 3 plate condenser dial pointer is set in the middle, from which position it can be moved either right or left, acting as band-spread on both sides of the frequency which has been selected on the large dial.

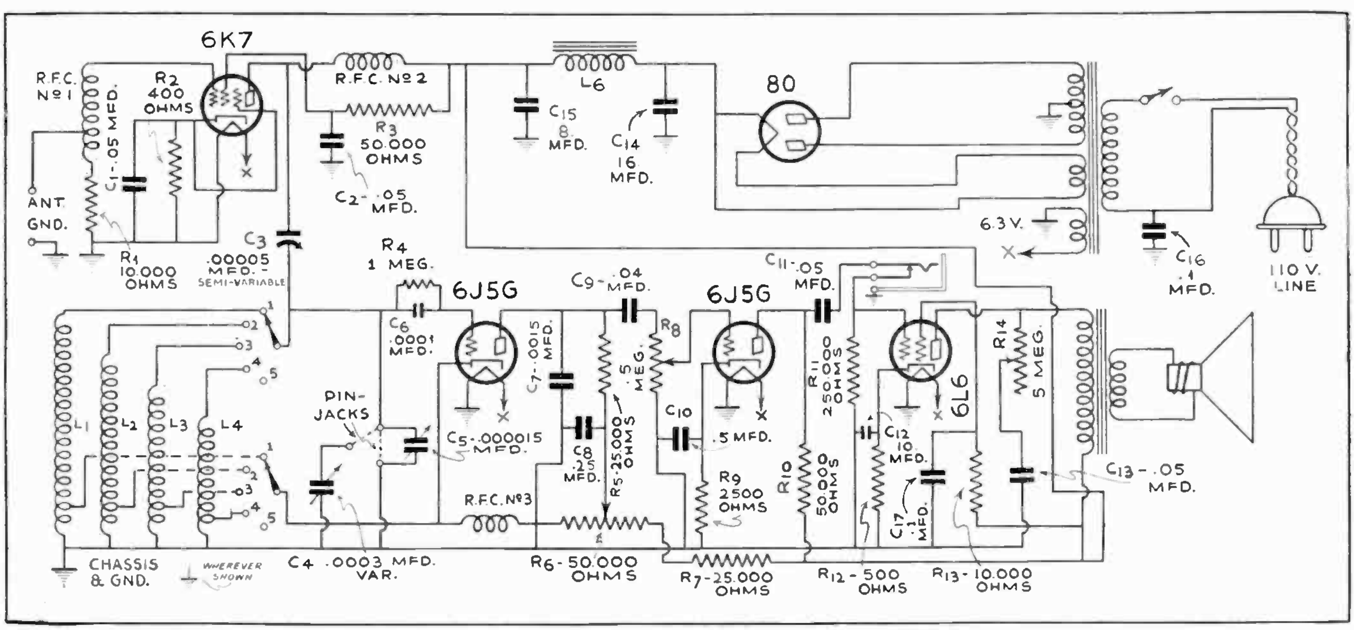
Super-Regeneration

On position 5 of the band selector switch (super-regeneration) all four coils are isolated from the circuit and the only cathode return is through the r.f. choke. If the jumper is now removed from pin-jacks A and C and a small high-frequency coil plugged into pin-jacks A and B, the circuit becomes an electron coupled super-regenerative one which will surprise you with its selectivity as well as sensitivity. All tuning is now done with the three-plate condenser and stations can be accurately logged on its dial. Tuning is not at all critical on these ultra-high frequencies and the 50,000 ohm potentiometer still acts as regeneration control, only now it controls super-regeneration. The three pin-jacks, together with the semi-variable r.f. coupling condenser are mounted on a small hard rubber or Victron sub-panel on the chassis just behind the 3-plate tuning condenser and adjacent to the detector tube socket. (It is important that r.f. leads be kept short.)

The Audio Amplifier

The audio amplifier is quite conventional although it makes use of the most efficient tubes possible. Another 6J5G is used as first audio as it shows a slight improvement over the 6C5, and the new 6L6 beam power tube with its high power sensitivity is used as the power amplifier.

Figure 10—The Regeneration-Super-Regeneration Circuit.



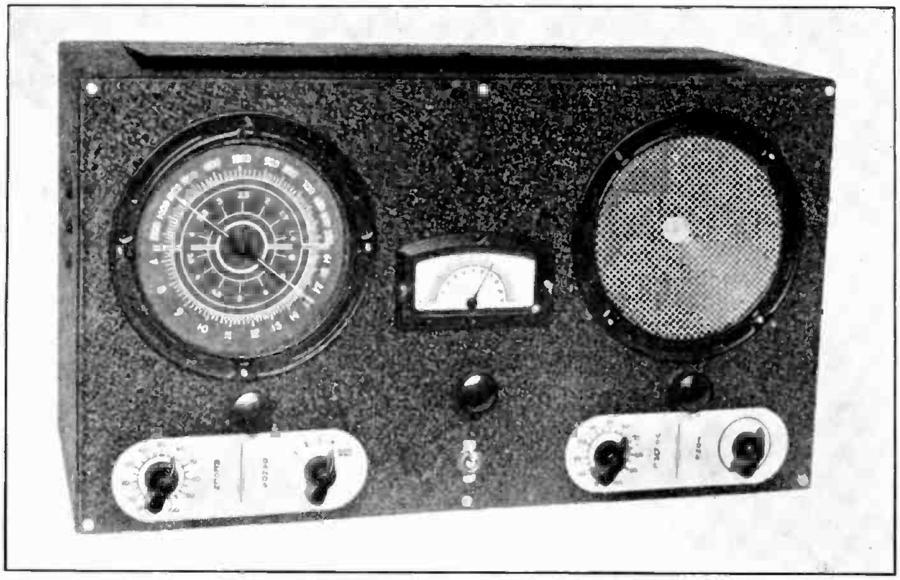


Figure 11—Front view of the R-S-R receiver.

The power output is limited to about four watts which is as much or more than is useful with even the heavy-duty 6-inch dynamic speaker used here. With this limited output the 6L6 is almost distortionless and the tone quality is excellent. The 6L6, as used, draws about 30 milliamperes and the high voltage current of the whole set is less than 60 milliamperes so that a small power transformer is adequate.

A tone control, volume control and stand-by switch are provided, as shown in Figure 11, while a phone jack, which cuts out the speaker, is mounted in the back of the chassis.

The power supply is quite conventional using an 80 rectifier and the speaker field as a smoothing choke with two filter condensers of 8 and 16 mfd. The hum level is extremely low and *no* tunable hum is present. Do not omit the grounding condenser on the power transformer primary.

Those who have not used the modern tubes in a well-built regenerative set will be considerably astonished at the results which can be obtained with them. You will find that a heterodyne beat note on the 20-meter band for instance, is smooth and steady.

Reception of weak foreign stations is even easier than with many superheterodynes, due partly to the type of band-spread employed.

Specifications

The values of the component parts shown in the schematic diagram are as follows:

Band Switch Coils—L1—88 turns No. 30 enamelled wire on 1¼-inch bakelite tube. Tapped at 2 turns from end.

L2—34 turns No. 26 enamelled wire on 1¼-inch bakelite tube. Tapped at 1½ turns from end.

L3—33 turns No. 26 enamelled wire on ½-inch hard rubber rod. Tapped 2 turns from end.

L4—8½ turns No. 24 cotton covered enamelled wire close wound on ½-inch hard rubber rod. Tapped at 1½ turns from end.

Interchangeable air coils—Wound with hard drawn No. 14 tinned copper wire on ½-inch dowel and then removed. Ends are bent down at right angles to coil axis to plug into pin-jacks which are spaced 1¾ inches apart. Coils should be spread to this length.

10 meter coil 12 turns
7½ meter coil 9 turns
5 meter coil 5 turns

R.F. Chokes:

R.F.C2—No. 31 enamelled copper wire; close wound on ⅜-inch dowel or hard rubber rod for a distance of 1⅝ inches.

R.F.C1—30 turns No. 20 cotton covered enamelled copper wire; close wound on ⅜-inch dowel or rubber rod.

R.F.C3—47 turns No. 26 enamelled wire; close wound on ⅜-inch dowel.

SERVICE AND LABORATORY APPARATUS

Simple Test Oscillator

A TEST oscillator is nothing but a miniature broadcasting station, which can be tuned to any frequency within the desired radio-frequency or intermediate-frequency ranges. The one shown in Figure 4 is of a simpler type which will serve to excellent advantage for alignment work, and for many other test purposes.

There are several possible oscillator circuits to choose from. The one selected here is the "series-feed Hartley" circuit. It has the advantage of requiring only one coil (for each range) and being easier to make oscillate all over the range.

The oscillator must cover the entire broadcast band and the intermediate frequency region of standard super-heterodyne circuits. It is not practical to cover these in a single range, therefore two ranges are provided, necessitating the use of two coils and a switch. This circuit is illustrated in Figure 1. A careful study of the diagram should enable the reader to add more ranges if he desires by adding more coils and employing a two-gang multi-point switch.

The instrument was made battery operated for the sake of simplicity, easy portability and avoidance of difficulties due to the inter-connection between receiver and oscillator through the power line.

In order that the oscillator shall produce an audible signal which is necessary for certain applications, it has to be modulated. The system of modulation employed here utilizes the grid-blocking method. This is nothing more than a grid leak and condenser combination wherein the condenser or leak or both are higher than normal. A large condenser receives a large charge during the periods when the grid becomes positive. This charge must leak off through the resistor. If the resistance is so high that the charge cannot leak off fast enough, the charge accumulates making the grid more and more negative until oscillation stops, allowing the charge to leak off. As soon as the condenser is sufficiently discharged, oscillations start again and the cycle repeats. The interruption occurs at audio-frequencies and the pitch of the note depends on

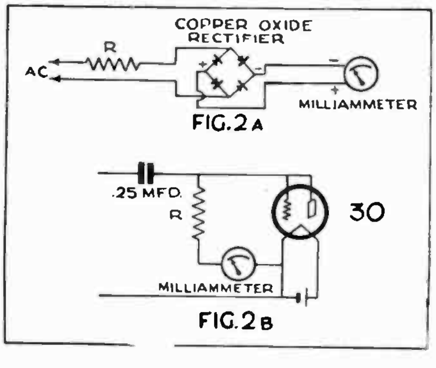


FIG. 2A

FIG. 2B

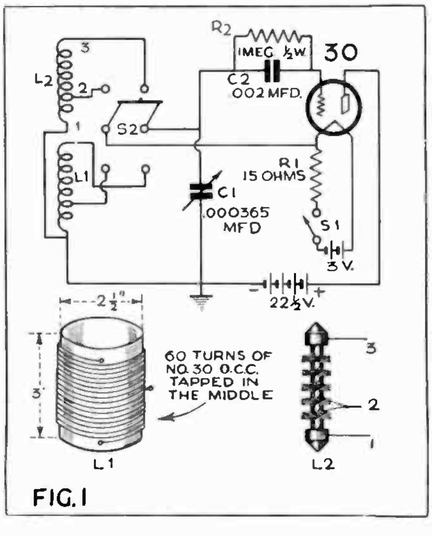


FIG. 1

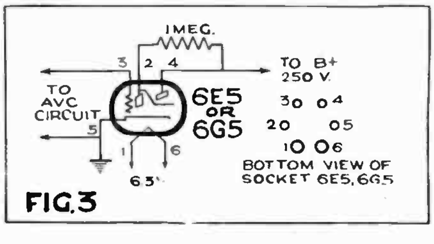


FIG. 3

the sizes of grid leak and condenser. This type of modulation produces a somewhat raucous note, but it is satisfactory as an audible signal.

When it is desired to use the oscillator unmodulated, the grid condenser C2 should be changed to .00025 mfd. and the resistance R2, to 50000 ohms. If desired, a switch could be used to change from the one to the other.

The layout and wiring should be easy. The broadcast band coil is home-made, wound on a 2½-inch bakelite form; 3 inches in length. It requires 60 turns of No. 30 d.c.c. magnet wire, with the tap at the 30th turn. Coil L2 is made from a Hammarlund r.f. choke, type CHX. This choke consists of five sections or "pies"; the tap is taken between the first and second pie. When making this tap, one must proceed carefully so as not to ruin the coil. The connecting wire between the two pies goes from the inside of one to the outside of the next. Unwind the wire, on the outside for several turns without cutting it. Then cut near the outside end, and unwind the short end several turns more so as to provide two leads each about 2 inches in length. Clean the ends by carefully scraping away both the covering and the enamel. The two ends can then be soldered together and to the center terminal of the terminal strip.

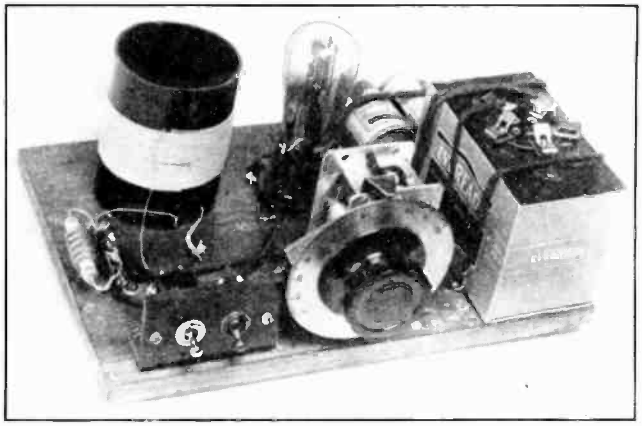


Figure 4

The top view of the 2-band oscillator which covers the range of 176 to 1550 kilocycles and offers the advantages of low cost, simplicity and wide utility.

No Panel Used

The whole unit, batteries and all, has been mounted on a base-board, not employing a panel. A small strip of bakelite supports the switches and an indicator for the dial is made of a piece of wire fastened to C1. Those who have a condenser with a ⅜-inch shaft will need a shaft reducer if the dial is for a ¼-inch shaft. The batteries are simply fastened with wood screws with insulated wires. The filament leads are soldered to the flashlight cells. First file or sandpaper a clean spot on the battery terminals, then tin the spot, tin the wire, and solder the wire to the batteries. Do not heat the batteries too much.

Calibrating The Broadcast Band

When the wiring is finished, it is necessary to calibrate the oscillator. The broadcast band can be calibrated by comparing with broadcast stations, picking up both the broadcast station and the oscillator on a receiver. Set the oscillator somewhere in the room (no connections needed), tune in a broadcast station of known frequency and turn the dial of the oscillator until it too is heard. When the oscillator signal is broad, move the instrument farther away from the aerial or reduce sensitivity on the receiver. Note at what point of the dial this known frequency was obtained. Repeat the procedure with other stations and make a curve for the oscillator, plotting dial setting against frequency. Thereafter it is possible to obtain a signal at any desired frequency by referring to this curve.

Calibrating The I.F. Band

To calibrate the i.f. band, harmonics must be used. Disconnect the aerial from the receiver, run a wire from the antenna post to the oscillator—just lay it near the instrument. Set the oscillator dial to 100 (C1 fully meshed) and search for the signal on the receiver, this will probably come in somewhere near 710 kc. and again at about 880. The actual frequency is now the difference between the two. To get it more exact, divide the difference into 880, which will give about 5. The exact frequency is 880/5. By reading the frequencies accurately, the result will be very close to the exact frequency. This method can be used to determine frequencies at other spots on the dial. Again a curve should be made of dial setting vs. frequency, so that an exact setting of 456 kc. can be obtained. The model constructed in the RADIO NEWS laboratory had ranges from 176-550 kc. and 540-1550 kc. Those who wish to cover 175 kc. and lower, can connect a fixed condenser of .00025 mfd. in parallel with C1, or across L2, which will cover this band adequately.

When aligning circuits for maximum response, the ear may be used and the best adjustment found by listening, this requires a modulated oscillator. However, the ear is not very sensitive to small changes in sound intensity. A sharper indication is obtained by means of some measuring instrument. Lamps or neon tubes have been used but these aren't any better than listening tests because the eye is just as inaccurate as the ear.

Types of Output Meters

The first type of "output meter" is some form of a.c. voltmeter. A low-reading a.c. voltmeter can be used, connected across the voice coil. This may have a range of 0-5 volts or 0-10 volts. The second type consists of a d.c. milliammeter with a rectifier. Rectifier-type voltmeters are on the market, but they can be made from a d.c. milliammeter by the addition of a rectifier as shown in Figure 2a. The rectifier used can be one of the copper oxide type, available from radio supply houses, or a tube as in Figure 2b. Some have used a carborundum crystal successfully. The resistance R determines the range of the voltmeter. If the milliammeter in Figure 2a has a 1-ma. range, the resistance R should be 850 ohms per volt. So for a 100-volt range R would be 85000 ohms; for a 10-volt range, 8500 ohms, etc. For a milliammeter with a range of 5 ma., divide the above values by 5.

Using A Milliammeter

In the case of Figure 2b, the resistor should be 20000 ohms to 50000 ohms, and a rather sensitive meter is required, 0-5 ma. or 0-1 ma. All the systems described so far, require a modulated oscillator.

A simple milliammeter, having a range of 0-15 ma. or less can be used in receivers equipped with a.v.c. The meter is simply placed in series with the plate lead of one or more of the controlled tubes. If the range of the meter is 0-15 ma., the current of two controlled tubes, should be sent through it. Meters with ranges of 0-10 ma. or less should receive the current of but one tube. If the range of the meter is less than 0-7 ma., it may be necessary to shunt it with a rheostat of 0-30 ohms, adjusting the resistance for full-scale deflection when no signal is coming in.

This type of meter will show a decreased current when a signal is tuned in and all adjustments are made for minimum current. Also, the oscillator may either be modulated or unmodulated; in the case of unmodulated signals sharper indications are obtained and the speaker is silent.

Special Tuning Indicator Tube

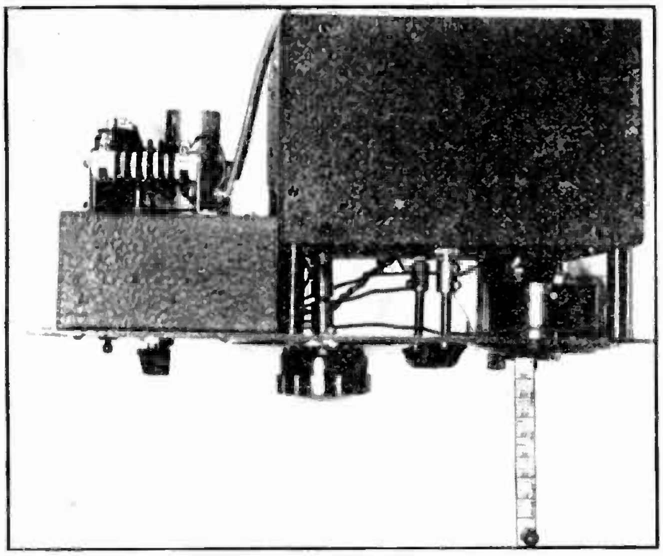
Finally, it is possible to get an indication without a measuring instrument by the use of a tuning indicator tube like the 6E5, 6G5, etc. These are used by RCA under the trade name "Magic Eye." The tube is cheaper than a good milliammeter and the associated equipment is inexpensive. Figure 3 shows how it should be connected. The tube is a miniature cathode-ray tube with a triode amplifier in one envelope. When in operation, the tube shows a luminous ring with a dark sector. This dark sector narrows down when a negative voltage is applied to the grid. Thus the grid can be connected to the a.v.c. circuit for alignment purposes. This again does not require a modulated signal. The tube requires a 6.3 volt filament supply and 250 volts plate supply at very low drain; all power can be taken from the receiver.

Every experimenter and set constructor needs a test oscillator and some form of output meter or indicator. These devices are indispensable in accurately aligning both r.f. and i.f. circuits in receivers, and for calibrating receiver tuning dials, checking such calibrations, etc.

The instrument herein described is the simplest possible device for this work. The constructional details are complete and the novice will encounter no difficulty in its construction.

Parts List

C1—single gang variable condenser. .00365 mfd.
C2—Solar mica condenser. .002 mfd. (for unmodulated oscillator. .00025 mfd.)
L1—see text and Figure 1
L2—Hammarlund r.f. choke, type CHX. prepared as described in text
R1—15 ohm wire wound resistor
R2—IRC carbon resistor. 1 meg., ½ watt (for unmodulated oscillator: 50000 ohms, ½ watt)
S1—Single-pole-single-throw toggle switch
S2—Double-pole-double-throw toggle switch
1—Eby base mounting socket. 4-prong
1—Bud tuning dial. type 713
3 inches bakelite tubing, 2½ inches diameter, for L1
2—Eveready flashlight cells, type 950
1—Eveready 22½-volt battery, type 768
1—Type 30 tube
Baseboard 9 x 6 inches
Small bakelite panel 2 x 3 inches, ¼-inch thick
1—lug terminal strip. 3 lugs
5—angle brackets



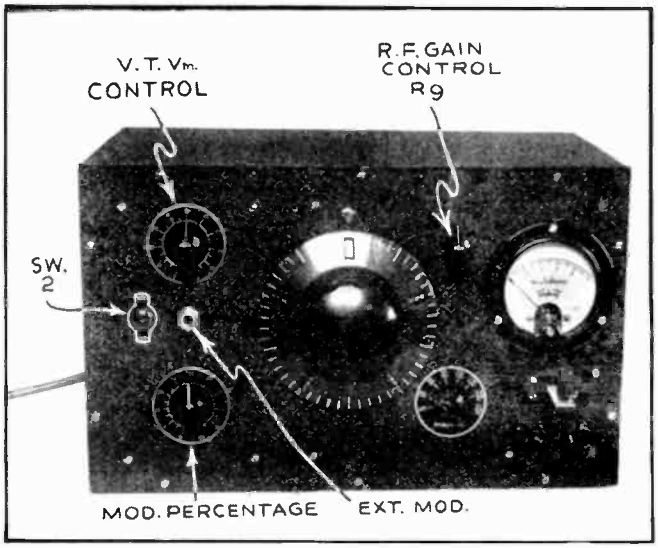


Figure 5, right, the signal generator removed from its case; Figure 6, right, front view.

Radio News "Capatron" Signal Generator

WHILE the better grade test oscillators now on the market fulfill the requirements of general work, the lack of any convenient provisions for determining the exact r.f. voltage or percentage modulation preclude their application to more complete receiver testing. Since the cost of strictly laboratory-type signal generators now available is prohibitive to most service organizations, RADIO NEWS started work some time ago toward the development of a simpler and less expensive design which would still meet all ordinary requirements.

The all-wave signal generator shown in Figures 5 and 6, is the result of this work. It is a.c. line-operated and the frequency range extends from 80 to 25,000 kc. in eight overlapping bands. The r.f. oscillator is a 6J7, electron-coupled to a special piston capacitance-type attenuator, giving known and mathematically exact attenuation. A highly-sensitive tube voltmeter is built in to provide a constant indication of the r.f. output level on all ranges. Maximum outputs of up to 2 volts are obtainable on the i.f. and broadcast bands, where high output is necessary in servicing, and even at the highest frequencies the output is 200,000 microvolts.

The built-in 400-cycle a.f. oscillator utilizes the negative conductance circuit described in the August, 1935, issue of RADIO NEWS. Provision is made for external modulation for overall receiver testing over a wide range of audio frequencies. Suppressor grid modulation is used, so designed that full 100 percent modulation may be obtained with excellent wave form. Several typical unretouched oscillograms are shown in Figure 13. A represents the a.f. wave form above while B, C, and D show the r.f. output at various modulation percentages.

The Piston Attenuator

The utterly simple piston attenuator shown in Figure 8 is a modified version of a theoretical design described in the I.R.E. Proceedings for June, 1935. It is one of the very few types which really work at high frequencies and, as is evident from the constructional details, it may be constructed for less than the cost of an ordinary volume control. As shown, the high oscillator voltage is applied to the insulated copper disc A. The movable disc, B, may be set at any desired distance from A and will pick up and deliver to the output terminals a voltage which decreases in an exact logarithmic ratio with an increase in separation of the two discs. In our design, the output voltage at 2 inch disc separation is approximately 20 db. lower than at 1 inch separation. At 3 inch separation, the voltage will be down 40 db., etc. This corresponds to voltage reductions from 1 volt to .1 and .01 volts respectively.

Output Voltage

The formula, Figure 9, shows that the actual output voltage is dependent upon the ratio of the capacity between the discs A and B and the output capacity, C2, which may consist of a shielded cable.

All the difficulties of oscillator coil design, construction, band-switching and coil shielding are eliminated by adapting our circuit, shown in Figure 7, to the RCA Conversion kit. This kit consists of an 8-band tickler-feedback oscillator coil assembly which is enclosed in a heavy copper shield. For clarity, the complicated coil and switch circuit is omitted in our diagram. It is included in the coil kit as supplied by the manufacturer.

The Circuit Used

Referring to Figure 7, the control-grid and screen-grid of the 6J7 oscillator connect to the leads emerging from the coil assembly can. The suppressor grid is biased about 18 volts negative through a high resistance-capacity filter network composed of R3, R6, R7, R4, R5 and the main biasing resistor R8. A blocking condenser prevents shorting out this bias when external modulation is used. Since less than 5 volts r.m.s. are required for 100 percent modulation and the input resistance is 1 megohm, negligible power is drawn from the a.f. source and good waveform is maintained. The suppressor grid remains negative throughout the modulation cycle.

In the 6J7 plate circuit, a 2.1 m.h., r.f. choke, shunted by a 10,000 ohm resistor to flatten peaks, provide the output load. The choke keeps the a.f. component fed to the tube voltmeter at a negligible value so that substantially the entire output is modulated r.f.

The output voltage fed to the attenuator is controlled by the potentiometer, R9. The moving arm connects to the output coupling condenser, C7, rather than to the v.t. voltmeter grid so that the r.f. output may be set at minimum and enable the tube voltmeter to be used for external voltage measurements. The low end of R9 returns to the junction of R4 and R5 to provide a bias of approximately 5 volts for the v.t. voltmeter grid.

The negative conductance a.f. oscillator is a very simple design requiring only a midget a.c.-d.c. type choke as the inductance. The control grid required a high negative bias to give the wave form desired and shown in the oscillogram. Still higher bias would make it perfect but would result in somewhat "sticky" operation. With the present bias, oscillation does not start until Sw. 2 is momentarily closed and opened but thereafter it operates beautifully.

Since the total B current drain of all the tubes is only about 10 ma. no hum filter chokes were found necessary in the power supply. R10 and R11, by-passed by C15 and C16 give adequate filtration.

R.f. filters are plentifully used throughout. In the oscillator, the small mica condensers are employed across the heater, and at the power transformer larger tubular condensers are added. In the transformer primary circuit, the transmitting type .5 amp. chokes in conjunction with by-pass condensers help to keep the little remaining r.f. from being conducted through the power cord. Electrostatic shielding should be employed in the power transformer.

Constructional Data

The chassis for the power supply and a.f. oscillator is formed by bending a piece of 18 gauge sheet steel to give the shape shown in the photograph. The dimensions are 4⅞ x 7⅛ x 2½ inches. No specifications are given for drilling since no critical positions are involved.

The panel and r.f. unit specifications are given. The r.f. shield-box unit is made in

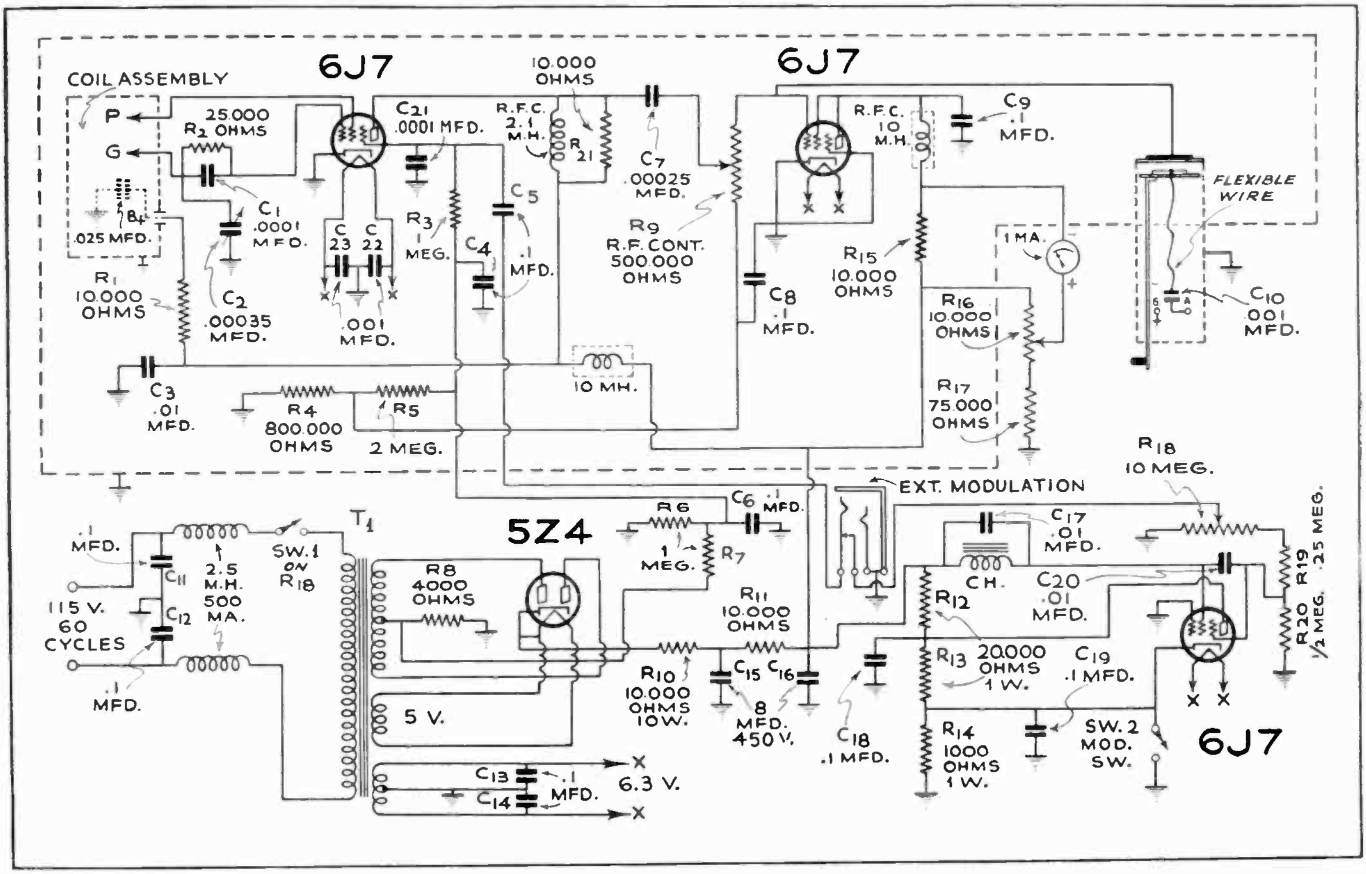


Figure 7—The circuit of the "Capatron" Signal Generator.

two sections, not counting the top and bottom covers. Aluminum is employed for both units as well as the cabinet. The panel is of 1/8th inch sheet and the other parts of 1/16th inch stock.

Full size working drawings should first be laid out, preferably on tissue drawing paper. When finished, place the r.f. unit drawing under the panel drawing and make certain that all shaft holes coincide. The slot for the attenuator strip had best wait until the attenuator is completed to make certain it will correspond to minor variations which may be found necessary. After these are complete, it will be best to let the job of construction of these parts to some metal worker in your neighborhood.

The location of the various parts is obvious from the photographs. The variable condenser is separately mounted on a piece of 4 by 4 inch bakelite, 1/4 inch thick since no part of either the rotor or stator must touch the shield save at a single point. The sockets are mounted on standoff supports 1/2 inch high. Preferably the shielded r.f. chokes should likewise be insulated from the r.f. box, using thin bakelite washers. The coil assembly can may not be conveniently isolated from the aluminum box since the switch shaft is short.

All the above precautions are necessary in order to provide as far as possible for a single point ground. Openings in the shield, when properly located, reduce the effectiveness but little, but utilizing the surfaces for the conduction of return currents changes the potential at different points and causes radiation. All wiring in the r.f. unit is grounded to a point on the r.f. coil can where the shielded wire emerges. This point gives extremely short connections to the heavy oscillator currents, and though those from the chokes will of necessity be much longer, the currents to be by-passed are considerably smaller.

Mounting The Parts

When the r.f. and power supply units have been wired, they are mounted on the front panel. The r.f. unit is spaced 2 inches back by 1/2 inch diameter bakelite rods, drilled and tapped for 3/4 inch 8/32 screws at each end. The smaller chassis and attenuator are mounted directly on the panel, but neither must touch the r.f. unit. A single heavy wire is now run from the grounding point of the r.f. can to the nearest attenuator mounting bracket. A similar lead is brought from the output ground terminal post to a lug under this bracket.

A suitable method of installing the dial assembly is illustrated in Figure 17. The variable condenser shaft is coupled to a 5/16th inch bakelite rod which passes through an eccentric hub mounted on the panel in the manner shown. This hub fits within the inner section of the dial assembly and is necessary to enable the dial numbers to change during rotation. The eccentric hub is a standard part available from the National Company. The mounting details should be clear from the diagram, but it should be emphasized again that the bakelite shaft must be perfectly aligned so that the dial will not bind.

The built-in vacuum-tube voltmeter was calibrated at radio frequency against a laboratory standard in accordance with the curve shown in Figure 18. Actually this curve shows the input voltage to the attenuator for a given reading of the tube voltmeter, since this is what we are primarily interested in. Leads should be kept as short as possible when making such calibrations. When the r.f. control

Figure 8

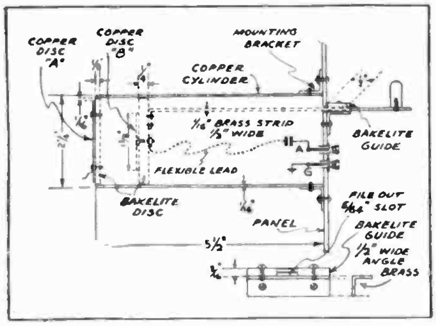


Figure 9

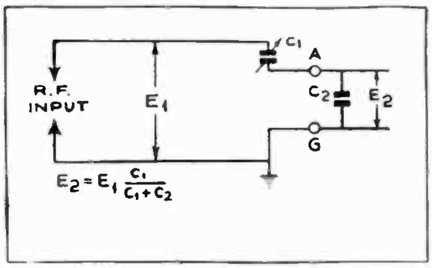
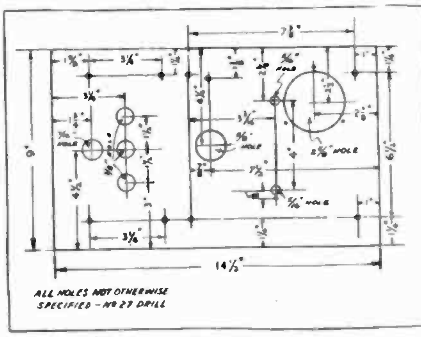


Figure 10



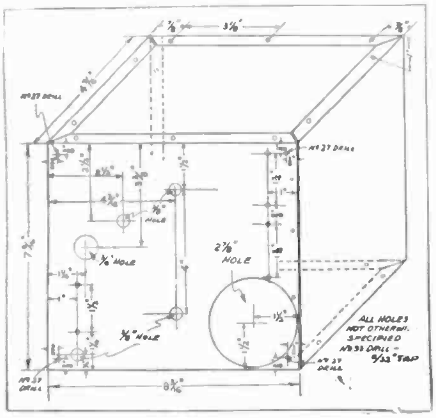


Figure 11

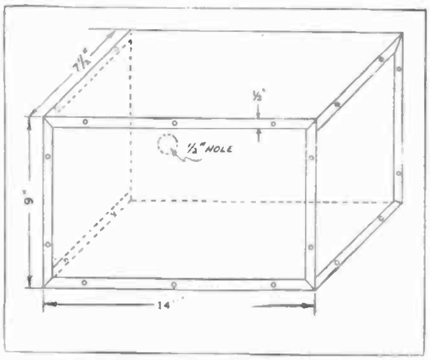


Figure 12

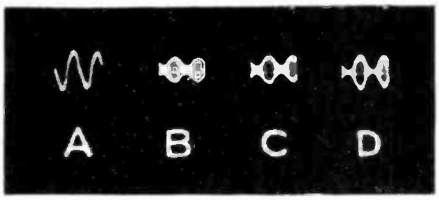


Figure 13

is at minimum setting and the attenuator shorted out, the tube voltmeter connects to the signal generator output terminal through the .001 blocking condenser.

A calibration point may be selected and checked at any future time at 60 cycles through the output terminals without taking the instrument apart. This provides a convenient means of getting an immediate check on the tube voltmeter whenever desired. There will be a slight discrepancy between the r.f. calibration and that at 60 cycles due to the small size of the blocking and by-pass condensers, but this can be allowed for in making the check.

Calibrating The Attenuator

The attenuator is calibrated in decibels according to the scale given in Figure 19. This scale is reproduced full size and may be used for a template or cutout and glued to the attenuator sliding strip. A thin piece of celluloid placed over the scale will serve to keep it clean and protect it from damage. The bakelite knob on the sliding strip was taken from a surplus anti-capacity key switch.

The screws mounting the stationary copper disc on its bakelite support at the end of the attenuator tube are arranged to project through the support so the movable disc will contact them and short out the attenuator when the sliding strip is pushed all the way in. The total output voltage of the oscillator as indicated on the tube voltmeter, will then be applied to the output terminals of the signal generator. This high voltage will be found a great convenience in checking detector and i.f. circuits and in preliminary aligning when installing a replacement i.f. transformer.

The modulation percentage calibration may conveniently be made with a cathode-ray oscilloscope, using either the trapezoidal method or, more roughly, from the modulated envelope. In the former method, no sweep circuit will be required. The ungrounded vertical plate of the cathode-ray tube is connected to the plate of the 6J7 oscillator through a blocking condenser. The corresponding horizontal plate is connected to the suppressor grid. The modulation percentage control is then adjusted until the trapezoid just becomes a triangle. About 6 volts r.m.s. will be required. This point represents 100 percent modulation. Add sufficient resistance in series with the modulation control and the jack to make this point occur at "full-on" setting. If a linear control is employed, as specified, the percentage modulation will then be well spread out over the range. With 3 volts at 400 cycles, 50 percent modulation is secured; at 1.2 volts, 20 percent, etc. If there is any difficulty in obtaining the 10-megohm linear control, which is not a stock size, R20 may be eliminated and a .5 megohm linear control substituted.

External modulation may be employed by plugging the output of a beat-frequency oscillator, or other a.f. source, in the jack provided. A separate tube voltmeter will be required for checking the audio voltage supplied.

Operating Data

In operation, the output level should first be adjusted with the r.f. control set to give some predetermined voltage, say 1 volt, using an unmodulated signal. The modulation percentage should then be set, disregarding any change in the voltmeter reading. If the attenuation ratio is 20 to 1, as described before, the zero level is now 50 millivolts. A dummy antenna is inserted between the output cable and the receiver input, not at the signal generator output, and tests may be conducted in the usual manner.

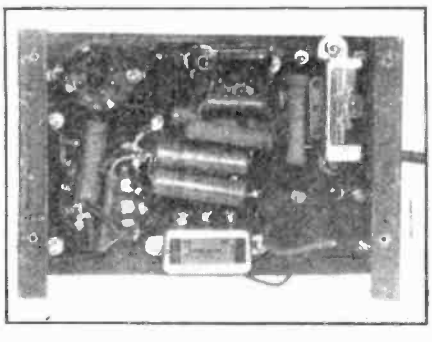
At ultra-high frequencies, it will not be possible to obtain accurate sensitivity measurements, due in part to the inherent difficulties in making such tests and partly to the low output of the oscillator. It is hard to read .2 volt with any degree of accuracy with such an inexpensive tube voltmeter design. Also, considerable care will be necessary in grounding the cable if the attenuator is to be most effective. In some cases, the cable will have to be very short and placed close to the receiver input, otherwise there will be an appreciable difference of potential between the receiver and signal generator. In such cases, the decreased capacity of the output circuit caused by shortening the cable may be made up by placing an equivalent mica condenser across the signal generator output. With a little practice, however, excellent results will be had. On the other bands, though, these difficulties are not present and tests may be conducted with ease and assurance.

With the cable connected to the receiver, it should be possible to obtain a minimum output of 1 microvolt at 17 megacycles. At lower frequencies, using additional capacity across the output terminals, even lower output is obtainable.

Parts List

C1, C21—Aerovox fixed mica condensers, type 1467, .0001-mfd.
C2—National Precision condenser and dial assembly, single gang, type PW-1, .00035-mfd.
C3, C17, C20—Aerovox tubular condensers, type 284, .01-mfd., 200 volts
C4, C5, C6, C8, C9, C18, C19—Aerovox tubular condensers, type 284, .1-mfd.
C7—Aerovox fixed condenser, type 1467, .00025-mfd.
C10—Aerovox fixed mica condenser, type 1467, .001-mfd.
C11, C12, C13, C14—Aerovox fixed paper condensers, type 460, metal cased, dual .1—.1-mfd., 400 volts
C15, C16—Aerovox electrolytic condensers, type 2GL, dual 8-8-mfd., 450 volts
R1, R15—I. R. C. insulated carbon resistors, 10,000 ohms, ½-watt
R2—I. R. C. insulated carbon resistor, 25,000 ohms, ½-watt
R3, R6, R7—I. R. C. insulated carbon resistors, 1 megohm, ½-watt
R4—I. R. C. insulated carbon resistor, 800,000 ohms, ½-watt
R5—I. R. C. insulated carbon resistor, 2 megohms, ½-watt
R8—I. R. C. insulated carbon resistor, 4,000 ohms, 1-watt
R9—I. R. C. volume control, 500,000 ohms, type 11-133, taper A
R10, R11—I. R. C. wire-wound resistors, 10,000 ohms, 10 watt
R12, R13—I. R. C. insulated carbon resistors, 20,000 ohms, 1 watt
R14—I. R. C. insulated carbon resistor, 1000 ohms, ½ watt
R16—I. R. C. volume control, 10,000 ohms, type 11-116 taper A
R17—I. R. C. insulated carbon resistor, 75,000 ohms, 1 watt
R18—I. R. C. volume control, type 11-143, linear taper, 10 megohms

Figure 14, left, bottom view of power supply; Figure 15, right, top view.



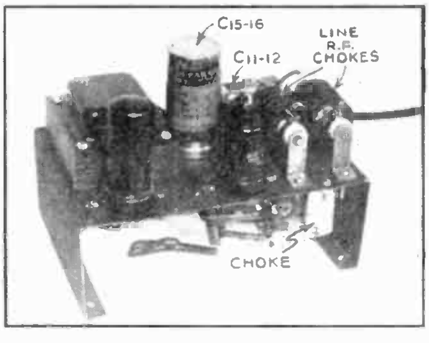
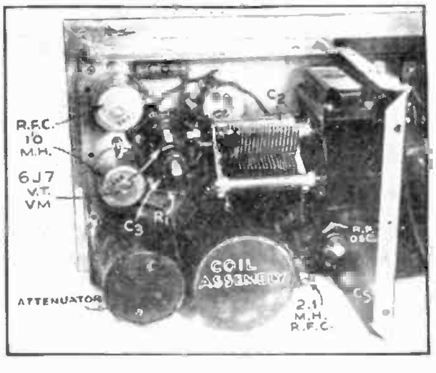


Figure 16—The R.F. Unit



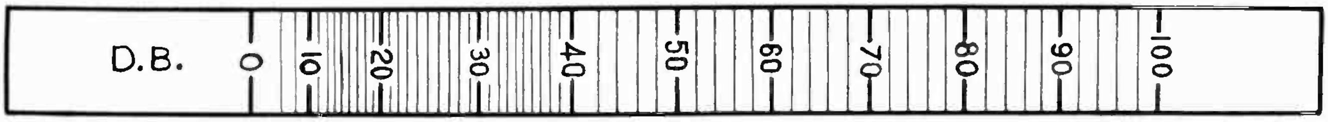
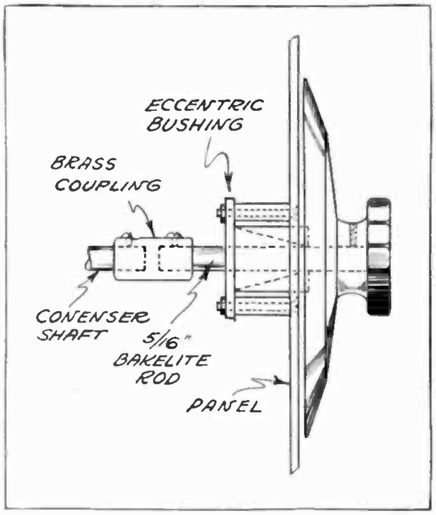
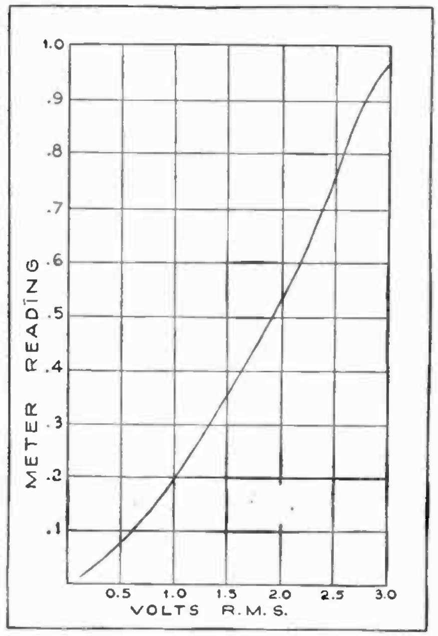


Figure 17, below at left; Figure 18, below at right; Figure 19, above.





R19—I. R. C. insulated carbon resistor, 250,000 ohms, ½-watt
R20—I. R. C. insulated carbon resistor, 500,000 ohms, ½ watt
SW1—I. R. C. volume control switch
SW2—S. P. D. T. toggle switch (included with RCA coil kit)

1 Hammarlund midget r.f. choke, type Ch-X, 2.1 m.h.
2 Hammarlund shielded r.f. chokes, type Ch-10S 10 m.h.
2 Hammarlund r.f. chokes, transmitting type, Ch-500, 2.5 m.h., 500 m.a.
1 RCA conversion kit, stock No. 9559, including all-wave oscillator coils band switch, toggle switch, indicator plates and resistors
1 Stancor power transformer type 2751, 115 volts, 60 cycles, 650v.—c.t. @ 40 ma., 5v. @ 2A, 6.3v. c.t. @ 1.6A.
1 Stancor filter choke, type C-1080, a.c.-d.c., 200 ohms
1 Triplett O-1 milliammeter, model 321, bakelite case
1 Yaxley midget 2 circuit jack
¼-inch bakelite rod, 6-inch length
⅜-inch bakelite rod, 1-inch length
½-inch bakelite rod, 1 foot length
1 piece bakelite 4 by 4 by ¼ inches
2 ¼ to ¼-inch brass couplings
1 special 5/16 to ⅜ coupling (see text)
1 ⅜ to 5/16 shaft coupling (see text)
3 6J7 metal tubes
1 5Z4 metal tube
4 octal sockets
4½-inch socket supports
4 small pointer knobs
1 output binding post assembly (marked A-G)
1 copper tube 5½ inches long, 2¼ inches O.D., 1/16-inch wall
Cabinet and shield box, 1/16-inch aluminum (see text)
Panel, ⅛-inch aluminum (see text)
Screws, nuts, rubber grommets and terminal strips

Multi-Range Tube Voltmeter

UNDOUBTEDLY a much larger number of servicemen, technicians and experimenters would employ the vacuum tube voltmeter in their work if its wide utility and specific applications were better understood. The technique to be followed in locating and correcting trouble in many representative cases is explained here.

The vacuum-tube voltmeter shown in Figures 20, 21 and 22 will provide the laboratory technician or advanced serviceman with a versatile instrument for the direct reading of many voltages which are not indicated, or at best only approximated with an ordinary meter. This particular voltmeter will accurately measure direct or alternating peak voltages up to 500 volts, with an a.c. frequency range from 20 cycles to 20 megacycles. With the original laboratory model, the actual measured error at 15 megacycles was only 2%. This device will save hours of time in locating trouble in receivers which apparently check satisfactorily but still do not perform properly. Mysterious cases of distortion, lack of sensitivity, and broad tuning unfold their secrets with ease.

Here are a few of the measurements that can be made with ease and accuracy:

1. Peak voltages—r.f., i.f. and a.f.
2. Diode detector peak voltage.
3. Automatic volume control voltage.
4. Audio, r.f. and i.f. gain.
5. Detector efficiency.
6. Amplifier power output.
7. Phase inverter output.
8. Superheterodyne oscillator voltage.
9. Transformer and choke impedance.
10. Capacities.
11. Peak voltage requirements for vibrator buffer condensers.

The vacuum-tube voltmeter shown here is somewhat unusual in design. The circuit is shown in Figure 23. Fundamentally, this is a combination slide-back tube voltmeter, plus a d.c. amplifier to give added sensitivity. The reference meter reading slide-back (bias) voltage is permanently connected in the circuit so that when balance is obtained the value of the unknown voltage may be read directly on this meter, eliminating confusing and time-wasting calculations.

The plate circuit of the d.c. amplifier operates into a bridge to permit the plate current to be balanced back to zero or any convenient reading, and also to prevent meter overload.

The merit of any voltmeter is mainly dependent on two factors, accuracy of calibration, and internal resistance (ohms per volt). Assuming that the reference meter is correct, the accuracy of this voltmeter is practically perfect up to high frequencies, except for potentials of less than 2 volts where an error of approximately 5% may be encountered owing to the difficulty of obtaining exact balance in this extremely low range.

The Power Supplies

Two power supplies are employed, one to furnish variable bias to the type 75 tube, the other to provide operating voltages for the 75 and 37 tubes. The drain on these power supplies is substantially only the power required to maintain the voltage across the bleeders; therefore, the smallest size midget power transformers will be adequate. It is possible to employ only a single power transformer, *but this practice is not recommended* because voltage regulation effects will cause considerable interaction between the controls which will affect the accuracy and ease of operation of the instrument.

The bias power supply should furnish about 500 volts negative bias. The plate power supply should deliver about 350 volts. If it is in excess of this, a small resistor may be inserted between the rectifier tube filament and the filter choke to drop the voltage to this value.

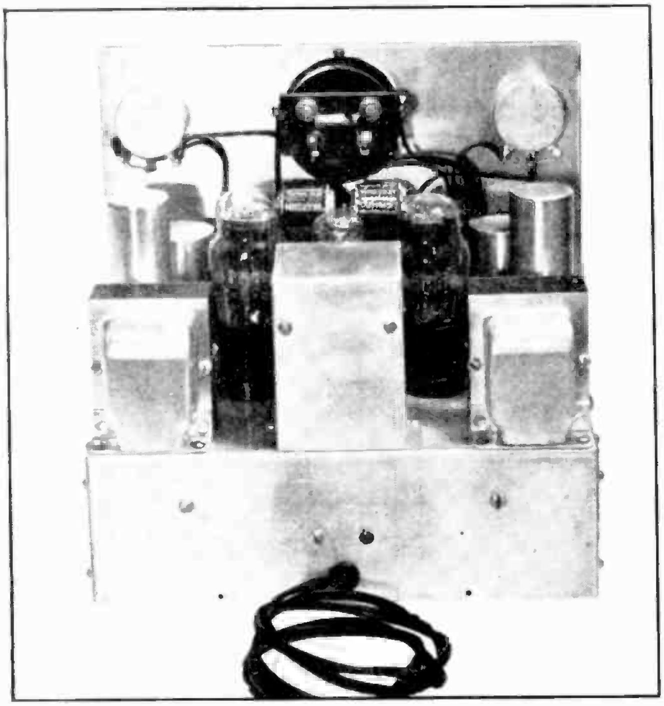
The heaters of the 75 and 37 tubes must be operated from separate filament windings because of the wide difference between the cathode voltages of the two tubes, as is the case in any direct-coupled amplifier.

The sensitivity switch (SW3) functions by inserting a 30,000-ohm current-limiting resistor in series with the 0-1 milliammeter used as the balance indicator. This protects the meter during the setting-up process, since otherwise the current might rise to a value that would endanger the meter. During measurements the switch is kept closed.

When measuring d.c. or low-frequency a.c. it is most convenient to have the 75 tube plugged in the panel socket. For r.f. measurements, however, the cap of the 75 tube must be brought to the point where the voltage measurement is desired. This is accomplished by using the goose-neck adapter, shown in Figure 22.

The adapter consists of a 6-wire cable terminating at one end in a 6-pin tube cable connector socket. Each cable lead from the tube base connects to the corresponding panel socket prong. In addition, a .05-mfd., 400-volt condenser, connected with as short leads as possible between the cathode and plate prongs of the cable connector socket, is required to keep the 75 tube from oscillating at some ultra-high frequency.

No detailed constructional data will be given, since every constructor will have his own idea of the proper layout and mechanical construction, and there is no reason why these personal preferences should not be indulged as long as the constants of the parts are not changed.



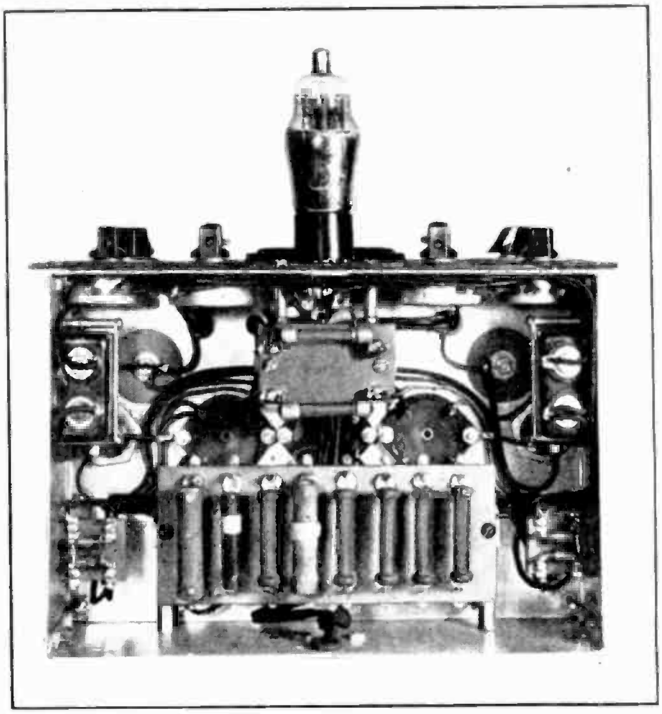


Figure 20, at left, rear view of the voltmeter; Figure 21, at right, bottom view.

Before the vacuum-tube voltmeter can be used, it must be properly balanced to obtain the proper bridge action. No difficulty will be encountered if the following procedure is used:

1. Turn the balance indicator sensitivity switch (SW3) to "Low." This connects the 30,000-ohm resistor (R6) in series with the milliammeter and prevents the possibility of damage from excessive current during the balancing operation.
2. Short input to voltmeter by clipping ground lead to cap of 75 tube.
3. Plug in the power cord, turn on the instrument and allow it to warm up for at least one minute.
4. Set bias-selector switch (SW1) to point 2 (0-10 v. range) and turn potentiometer 1 to the 10-volt position.
5. Turn switch 3 to "High."
6. Adjust bridge balance control (P6) until balance indicator reads 0.
7. Return balance-bias selector switch (SW2) to position 1 ("0" bias voltage).
8. Adjust voltmeter tube bias (P5) until a reading of approximately 1/10 ma. is obtained on the balance indicator. This adjustment is not critical. If difficulty is found in reducing the plate current to .1 ma., try another type 37 tube. Some have "remote cut-off" and are unsatisfactory for this purpose. The instrument is now ready to be used.

Connecting The Voltmeter

When connecting the voltmeter it must be remembered that a d.c. path must be provided to close the grid circuit. In measuring across coils and resistors, the return path can be the voltage source. On the other hand, when measuring a.c. voltages through a capacity, as would be required for eliminating the d.c. component in a circuit where both a.c. and d.c. are flowing, or because of the nature of the circuit, a separate d.c. path must be provided. This can easily be accomplished by connecting a high resistance (2 to 5 megohms) between the 75 tube cap and the voltmeter ground wire. The ground wire should also be attached to the low-potential point of the circuit. When measuring d.c. voltages, the 75 grid cap connects to the positive side of the voltage source, the voltmeter ground to the negative.

Using The Vacuum-Tube Voltmeter

Where approximate value of voltage is known:

1. Set reference voltmeter range switch (SW1) at a point sufficiently high to cover the maximum voltage which might be encountered (i.e., to measure a voltage having a value between 25 and 50 volts, set the reference voltmeter range switch so that 50 volts can be measured).
2. Set the bias selector switch (SW2) to cover the desired range.
3. Connect the vacuum-tube voltmeter input leads across the voltage source to be measured.
4. Slowly retard bias potentiometer until indication is found on balance indicator, and pointer returns to a position between 0 and the original setting, 1/10 ma.
5. Read peak voltage as indicated on reference meter.

Where voltage to be measured is unknown:

1. Set SW1 to highest position.
2. Set SW2 in highest position.
3. Slowly retard bias potentiometer 4.
4. If no indication of null point is found, move back one position on both the reference voltmeter range switch and the bias selector switch. Then, slowly retard bias potentiometer 3, noting balance indicator action. If no indication is found, repeat these operations on each preceding range until the null point is found. Then read peak voltage on reference meter.

Aligning Receivers Having A. V. C.

To align a receiver with the v.t. voltmeter, feed an unmodulated signal into the receiver with sufficient intensity to develop a small amount of a.v.c. action. Connect the v.t. voltmeter to the receiver chassis and to the a.v.c. lead connection to the grid returns. With this connection, the v.t. voltmeter will read the actual a.v.c. voltage. When a trimmer is now adjusted, a very sharp resonance point will be indicated by the sudden increase in a.v.c. voltage.

Balancing Phase-Inverter Circuits

The modern trend is to employ some form of resistance-coupled phase inversion, since this form of coupling presents a number of important advantages, such as freedom from hum, extended frequency response and economy. Proper values of resistances are essential if the full quality of tone and power output of the receiver are to be realized, and in some designs the tube characteristics are important.

In any case, the signal voltage delivered to the individual output tubes must be equal. This audio-frequency voltage is difficult to read with an ordinary voltmeter, not only because of the inaccuracy of the voltmeter at the reference frequency employed, but also because of the loading effect of the usual a.c. voltmeter on the circuit. The v.t. voltmeter adds no appreciable load to the circuit at any audio frequency and grid voltage can be read with close accuracy. By juggling inverter resistor values and measuring with the v.t. voltmeter, the serviceman will have no difficulty in adjusting a push-pull stage for correct balance.

Measuring Surge Voltages

When installing filter condensers, it is desirable to know the maximum surge voltage, since it is necessary for the filter condensers to withstand this momentary surge potential each time the set is turned on. The maximum surge voltage is frequently much higher than would be expected from the working voltage, owing to poor regulation in the power transformer, or to the action of line voltage regulating resistors. To check this surge with the v.t. voltmeter, simply remove the rectifier tube from its socket and measure the voltage between the chassis and one plate prong of the rectifier tube socket. The voltage indicated will be the highest that can be developed in the normal operation of the receiver. If the maximum range of the instrument, 500 volts, is not adequate to measure the voltage encountered in the application, the range can be doubled by using two 5-megohm resistors connected as shown in Figure 26.

The power output of a receiver or an audio amplifier can easily be measured with the v.t. voltmeter. Disconnect the voice coil from the output transformer and connect in its place a vitreous resistor having a d.c. resistance equal to the a.c. impedance of the voice coil. Operate the amplifier at the desired level and measure the voltage developed across the resistor. By using the formula

$$\frac{(E \text{ peak} \times .707)^2}{R}$$

the power output can be calculated.

Checking Class "A" Audio Stages for Overload

A Class A audio stage will overload and distort at the point where grid current starts to flow. In the case of resistance-coupled amplifiers with high-mu tubes and high-value grid leaks, the grid current may be too small to measure with a common milliammeter. However, with the circuit given in Figure 24, this measurement may be made with precision. Condenser (C) bypasses the audio signal, so it will not actuate the tube voltmeter. However, any d.c. flowing in the grid circuit will charge this condenser and the resulting voltage will be indicated by the v.t. voltmeter.

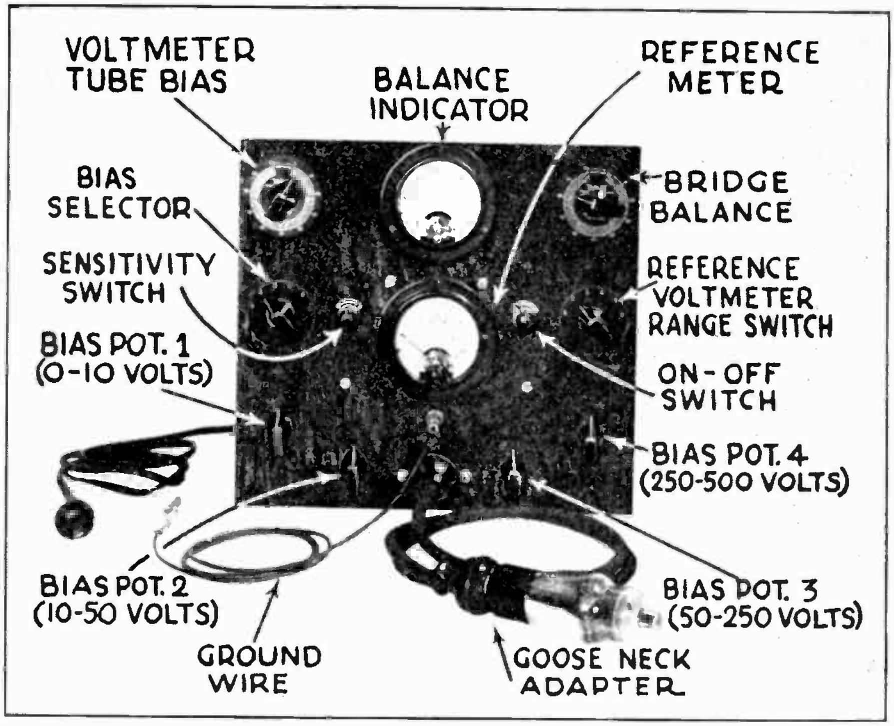
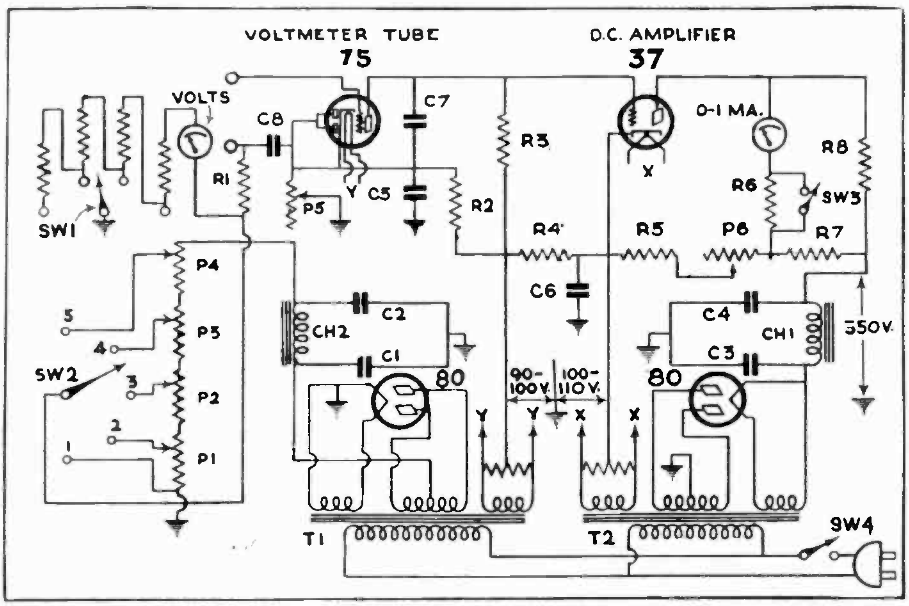


Figure 22—Front-panel view of the voltmeter.

Measuring Impedance

The following procedure will permit the measurement of a wide range of impedances, from voice coils to audio transformers: With reference to Figure 25, connect the unknown impedance in series with a potentiometer having a resistance greater than the unknown impedance. Then connect the pair to an a.c. source of the frequency at which the measurement is desired. Measure the voltage developed across the inductance (points "A" and "B") and note its value. Then re-connect the v.t. voltmeter to the junction of the inductance and potentiometer and to the moving arm of the potentiometer (points "B" and "C"); adjust the potentiometer until the voltmeter reading is the same as the first reading noted. The impedance of the unknown inductance will then be equal to the d.c. resistance of the portion of the resistance element that is in the meter circuit ("B" to "C"). This d.c. resistance can then be measured with a common ohmmeter.

Figure 23—Circuit diagram.

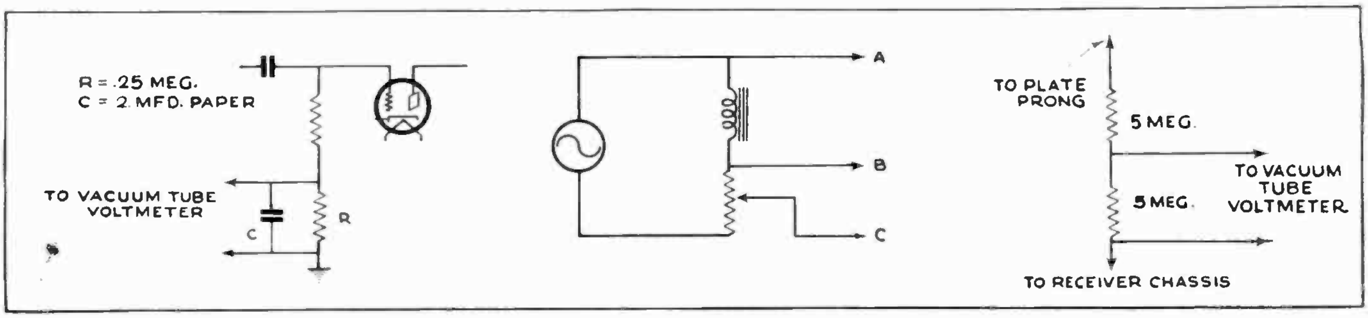


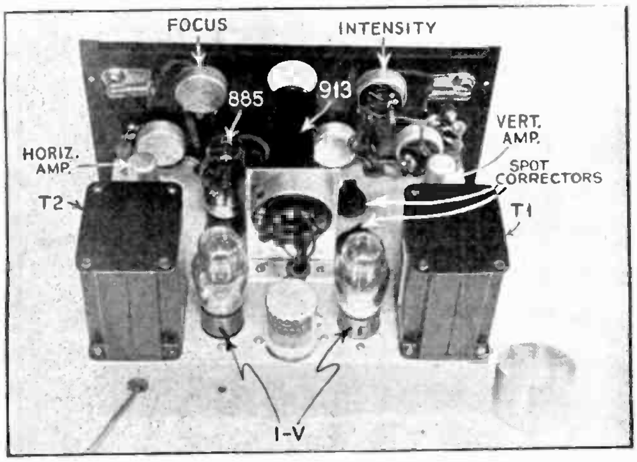
Measurement of R.F. and I.F. Potentials

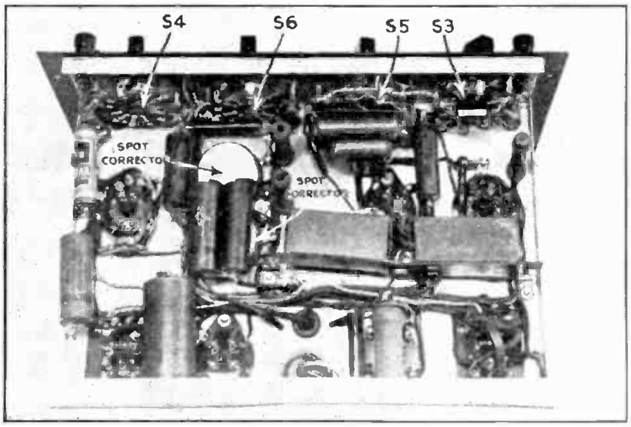
This versatile v.t. voltmeter provides an easy and accurate method of measuring r.f. and i.f. potentials which renders it invaluable for investigation of r.f. gain, detector efficiency, etc. These voltages are measured in exactly the same manner as low frequency voltages, except that the goose neck adapter is employed.

After making the necessary connections, the tuned circuit to which the v.t. voltmeter is attached should be readjusted for resonance as the small input capacity of the meter tube will slightly detune the circuit. If the frequency is very high, also connect a 1/10 mfd. paper bypass condenser between the cathode of the 75 tube and the low potential point of the circuit to be measured to bypass r.f. from the v.t. voltmeter. This connection can be made without disturbing the tube socket by using one of the little wafer type adapters commonly used for phonograph connections.

Figures 24, 25 and 26







Figures 27 and 28—The cathode-ray oscilloscope.

Parts List

C1, C2—Mallory HS693 8 mfd., 600 v. condensers
C3, C4—Mallory RN 242 8 mfd., 450 v. condensers
C5, C6, C7—Mallory TP443 1 mfd., 200 v. by-pass condensers
C8—2 mfd. 600 v. paper dielectric condenser
CH1, CH2—Midget filter chokes, 12 to 30 henry, 35 ma.
CT1, CT2—Yaxley 864C center-tapped resistors, 64 ohm
P1—Yaxley M1MP 1,000-ohm, linear wire-wound potentiometer
P2—Yaxley M4MP 4,000-ohm linear wire-wound potentiometer
P3—Yaxley M20MP 20,000-ohm linear wire-wound potentiometer
P4—Yaxley M25MP 25,000-ohm linear wire-wound potentiometer
P5—Yaxley M1MP 1,000-ohm linear wire-wound potentiometer
P6—Yaxley M70MP 70,000-ohm linear wire-wound potentiometer
R1—100,000-ohm 1 watt carbon resistor
R2—10,000-ohm 10 watt carbon resistor
R2—10,000-ohm, 10 watt wire-wound resistor
R3—250,000-ohm, 1 watt carbon resistor
R4—1,000-ohm, 5 watt wire-wound resistor
R5—25,000-ohm, 5 watt wire-wound resistor
R6—30,000-ohm, 1 watt carbon resistor
R7—10,000-ohm, 5 watt wire-wound resistor
R8—10,000-ohm, 5 watt wire-wound resistor
SW1—Yaxley 1316 single-circuit 6 point switch, with type 374 dial plate
SW2—Yaxley 1316 single circuit 6 point switch with type 375 etched dial plate
SW3—Yaxley midget jack switch No. 10
SW5—On-off switch for 110 volts
T1—Power transformer, midget receiver type: pri. 115 v 60 cycles, secondaries 700 v., c. t.; 5 v. at 2a.; 6.3 v. at .3a
T2—Power transformer, midget receiver type, pri. 115 v. 60 cycles, secondaries 600 v., c.t.; 5 v. at 2a.; 6.3 at .3a
2 Milliammeters, 0-1 ma.
One set of resistance multipliers for one of above meters to give voltage readings with the following ranges, 0-10 volts, 0-50 volts, 0-250 volts and 0-500 volts. If desired a high-grade three range 0-500 volt high resistance voltmeter can be substituted for one of the milliammeters and the set of multipliers
1 type 75 tube
1 type 37 tube
1 type 80 tube

Midget Cathode-Ray Oscilloscope

ONE might consider an oscilloscope as a voltmeter and milliammeter for all frequencies. The instrument shown in Figures 27, 28 and 29 can be used as a v.t. voltmeter, to check distortion in amplifiers, observe characteristics of tubes, measuring modulation percentage, adjusting vibrators in power packs and may be used to indicate resonance curves in conjunction with a suitable "wobbulated" oscillator. The number of applications are too numerous to be mentioned here.

The design of an oscilloscope using the 913 cathode-ray tube involves design problems not given much consideration heretofore. These include half-wave rectifiers, amplifiers, for saw-tooth voltage and saw-tooth oscillators.

Half-wave rectifiers, due to poor regulation, have seldom been used in the past. But with the low drain of the cathode-ray tube and the simplicity of the half-wave rectifier is ideal, provided that the necessary bleeder for the cathode-ray tube does not load the rectifier to the extent of reducing the high peak voltage present across the single filter condenser, at low current drain. If this drain is too great, the rectified voltage will drop to a very low level with a high hum component.

At the same time the total value of bleeder resistance must be kept reasonably low to prevent interaction of the adjustment controls of the cathode-ray tube. A drain of 1 ma. has been found satisfactory. As any of the present rectifier tubes would be suitable, the 1-V was chosen because the heater wattage is low.

The Kenyon T207 transformer was used as the power supply for the 913 tube. With a 1-mfd. condenser and the 575,000-ohm bleeder used, a voltage of 540 volts was secured. (See circuit diagram, Figure 30).

When the 913 is used with an anode potential of 500 volts it requires 140 volts peak for off-scale deflection of the D3 and D4 plates (normally vertical) and a peak voltage of 160 for off-scale deflection of the D1 and D2 plates (normal horizontal plates).

As it was desired to secure this necessary deflecting voltage from a single amplifier tube and still use a low coupling resistor in order to have a wide frequency range, it was necessary to have a high-voltage supply. So a second Kenyon transformer was tried with a 1-V rectifier and a filter of two 8-mfd. condensers and a 10,000-ohm resistance. This combination develops 360 volts at 9 ma. and the hum ripple is unnoticeable. In the vertical amplifier which is a 6J7, it was found necessary to use a small flashlight battery for bias, as tests showed that self-bias introduced distortion even when by-passed by an extremely high value of capacity. It was also found best to use a series resistance in the screen grid to reduce the voltage to a suitable value instead of taking the screen-grid voltage from the bleeder.

Circuit Details

The series-resistance method gave a higher output voltage, with less distortion. But in the horizontal amplifier the second 6J7, self bias, without any by-pass capacity, was found best. In fact, for good definition on the higher frequencies it was found necessary to keep the capacity due to wiring across the bias resistor, etc., as low as possible. Also the bleeder was found to be the best form of screen-grid voltage supply. It should be noted here that the horizontal amplifier was especially designed to amplify saw-tooth voltages and it is not necessarily the best design for other wave shapes. The vertical amplifier was designed for general purposes, requires .4 volt for edge-to-edge patterns and is good to well over 100 kc.

As the best wave form is secured from the 885 tube when the output voltage is low, the D3 and D4 deflector plates of the 913 were used for the horizontal deflection and D1 and D2 for the vertical deflection, which is the reverse of normal procedure.

In order to keep the output voltage low (on the 885) a bias of only 5 volts secured from the bleeder, the cathode of the 885 being positive with respect to ground. It is necessary to keep the stray capacity of the parts and wiring connected to the 885 low in order to prevent stray coupling to either amplifier tube and to allow high-frequency oscillation. The range of the sweep circuit is from 15-25,000 cycles.

In assembling the 'scope it is well to remember that a voltage of 900 volts is present between the negative of the 913 power supply and the positive of the amplifier power supply. Care should be taken at all times to make no adjustment or alteration of wiring while the unit is connected. This is one of the main reasons that a protective shield is placed on the 913 socket, due to the 500 volts.

In assembling the 'scope, the sockets are first placed on the chassis, the two rectifier sockets being arranged so as to secure the shortest possible leads which means that the heater of one socket is nearest the back of the chassis while the plate of the other is nearest the back of the vertical amplifier socket, has its locating pin to the front of the chassis, while the horizontal locating points to the back. The plate of 885 tube socket should be toward the back of the chassis. The two power transformers should be mounted next with the primary to the back of the chassis. In wiring the filament the wires should be kept in a group and as free and clear of all points of high signal potential. Because of the switching number of controls necessary it is impossible to have all low-potential circuits as clear as they should be.

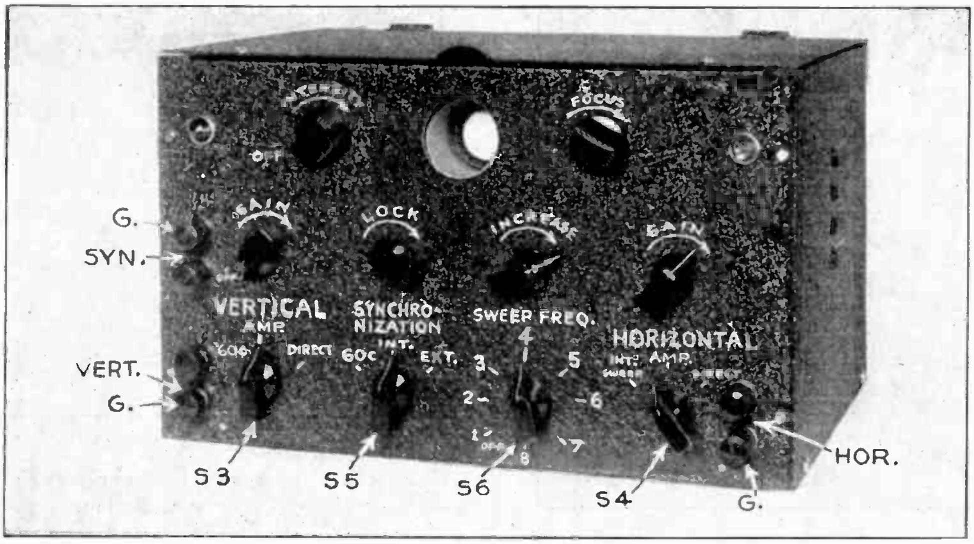


Figure 29—Panel layout of the instrument.

The Eby socket for the 913, which is held in place by an Aerovox electrolytic condenser clamp, should have the prongs cut off short and the wires soldered carefully in place, leaving enough slack to allow the socket to rotate. The shield for the back of the 913 socket was made from an old shield can and a tube shield base, the base being held in place by the two screws on the socket clamp. The coupling condensers used with each volume control are mounted by drilling a hole through the chassis directly over the switch so that this condenser acts as the shortest possible lead between the switch and volume control. In order to have the best shielding, the chassis is only grounded at one point; all other ground connections are made by a wire direct from each individual circuit to this common ground point. It is partly due to this that such stable operation has been secured.

The condenser necessary for the sweep frequency oscillator is mounted directly on the switch. The small mica condensers are held directly in place on the switch-connecting prong and the paper condensers are mounted on a strip of bakelite which is fastened on the two frame screws of the switch. The .007 mfd. condenser was built up of one .002 and one .005 mfd. condenser. The .0004 mfd. condenser was also built up, using .00015 and .00025 mfd. condensers in parallel.

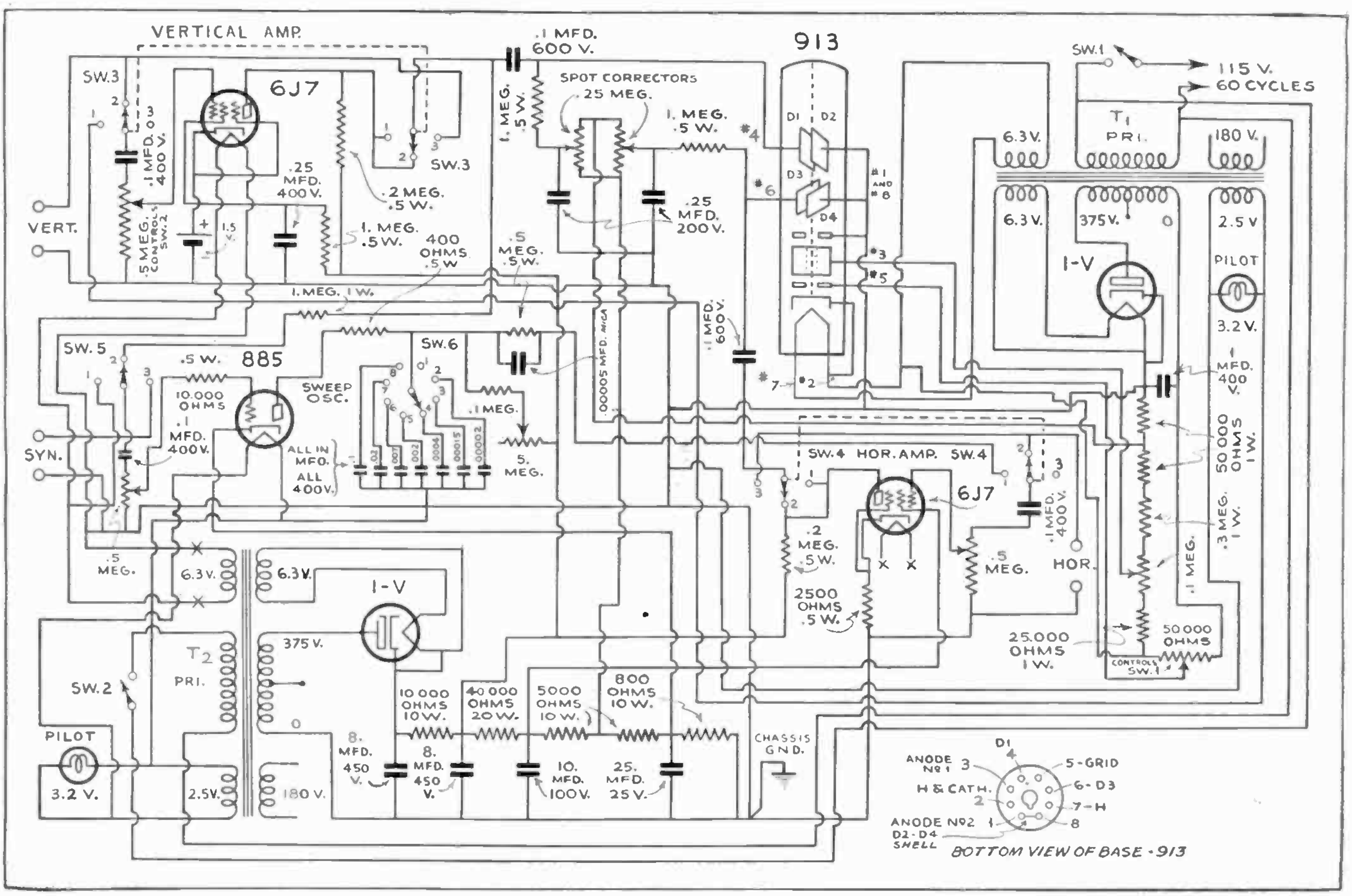
Parts List

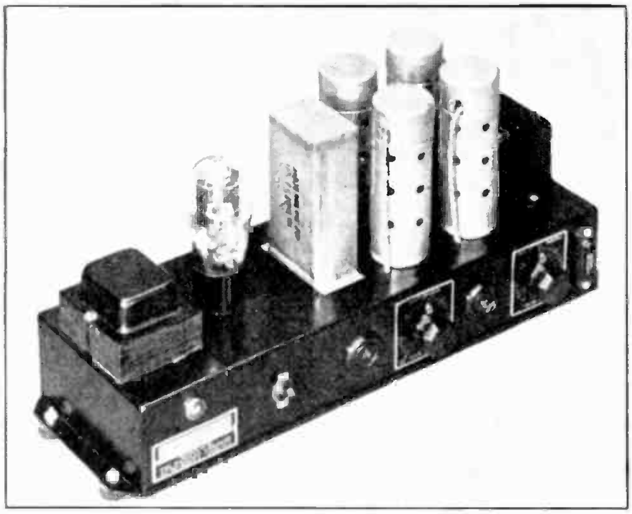
T1, T2—Kenyon power transformer, type 207
1 Yaxley volume control, type N with No. 9
2 Yaxley volume controls, type N, 500,000 ohms
2 Yaxley volume controls, type Y250MP, 250,000 ohms
1 Yaxley volume control, type Y100MP, 100,000 ohms
1 Yaxley volume control, type Y50MP with No. 9 switch, 50,000 ohms
1 Special volume control, 5 megohms
2 Yaxley 2-gang, 3-position switch, type 1315
1 Yaxley single-gang, 3-position switch, type 1316
1 Yaxley single-gang, 8-position switch, type 1311

I. R. C. Carbon Resistors
½ watt

4 1 meg.

Figure 30—In this circuit all grounds are wired to a single point on the chassis.





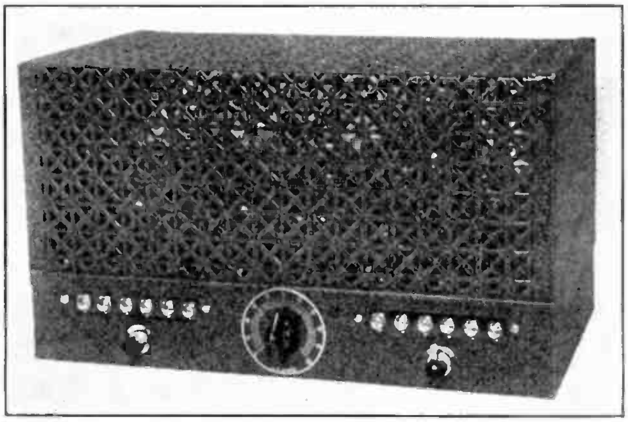


Figure 2, left, the 3-channel pre-amplifier; Figure 3, right, the 10-watt amplifier.

1 10,000 ohms
1 .5 meg.
1 2500 ohms
2 .2 meg.
1 400 ohms

1 watt

1 1 meg.
1 300,000 ohms
2 50,000 ohms
1 25,000 ohms

I. R. C. Wire-Wound Resistors

1 10,000 ohms, 10 watt
1 40,000 ohms, 20 watt
2 5,000 ohms, 10 watt
1 800 ohms, 10 watt

Aerovox Tubular Paper Condensers

4 .1 mfd., type 484, 400 volts
1 .25 mfd., type 484, 400 volts
2 .1 mfd., type 684, 600 volts
2 .25 mfd., type 284, 200 volts

Aerovox Tubular Paper Condensers
Type 484, 400 volts

2 .002 mfd.
1 1 mfd.
1 .02 mfd.
1 .005 mfd.

Aerovox Mica Condensers, Type 1460

1 .0004 mfd.
1 .00005 mfd.
1 .00015 mfd.
1 .00002 mfd.
1 Aerovox electrolytic condenser, type PB25, 25 mfd., 25 volts
1 Aerovox electrolytic condenser, type PB100, 10 mfd., 100 volts
1 Aerovox electrolytic condenser, type 2GL5 (short type), 8-8 mfd., 450 volts
2 Aerovox electrolytic condenser, clamps, 1⅜ inches diameter
1 Eby socket, type 12E, 8-prong
2 Eby wafer sockets, 4-prong
2 Eby wafer sockets, 8-prong
1 Eby wafer socket, 5-prong
6 Eby Junior binding posts
2 Yaxley dial lights, type 310, green and red, 3.2 volts
8 Yaxley bar knobs, type 366, 1¼ inches
4 Kurz Kasch bar knobs
1 I.C.A. steel cabinet, 12x8x7 inches
1 I.C.A. chassis, 11x7½x2½ inches

PUBLIC ADDRESS SYSTEMS

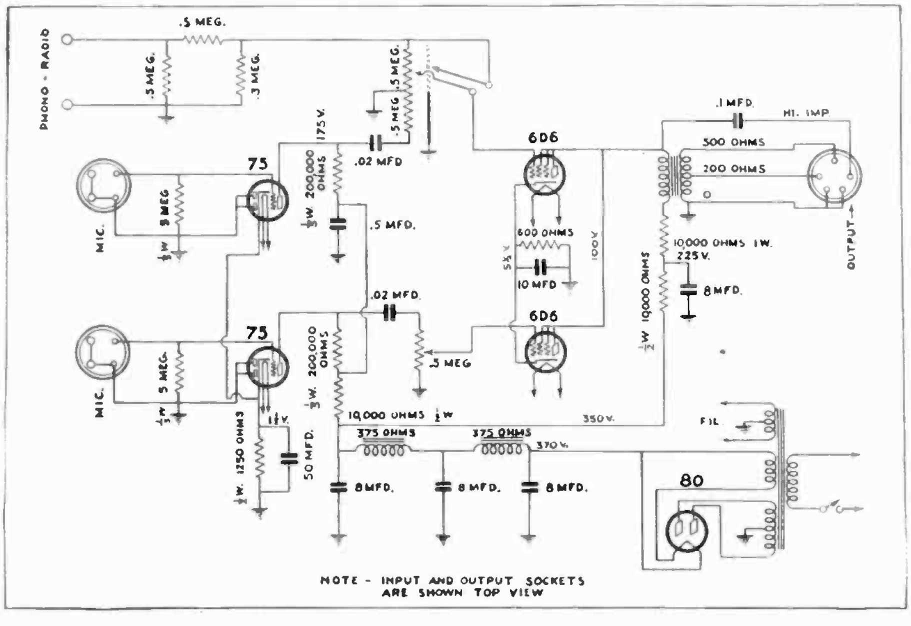
Three-Channel Pre-Amplifier

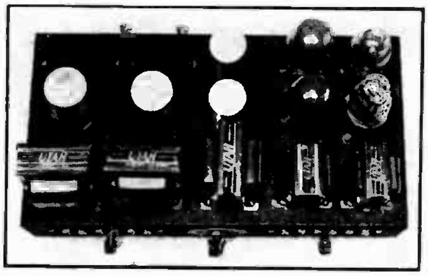
To obtain satisfactory performance from P.A. amplifiers with modern, low-level microphones, a pre-amplifier must be used. The instrument shown in Figure 2 has features of considerable value in this application. This modern pre-amplifier is compact, light and completely a.c. operated. It has excellent performance characteristics over the audio range from 50 to 9000 cycles, and adequate gain with negligible hum. Individual input circuits for two microphones and a phonograph pickup provide for mixing or blending the input sources to any desired degree. Speeches or announcements may be superimposed on a background of music picked up from a phonograph record or any other source.

The complete schematic circuit is shown in Figure 1. The two low-level microphone inputs connect to separate high-gain triode input stages each employing a type 75 high-mu tube. The diode sections are grounded since they are not used. The output of each 75 is individually coupled to a type 6D6, triode-connected. The phono-microphone volume control in the upper channel section is rather unique. A center-tapped 1-megohm control is employed, one half of which controls the "phono" input while the other half regulates the volume of the microphone channel. The extra arm is provided to short out the phono input when the microphone alone is employed. Mixing is accomplished by joining output sections of the 6D6 tubes.

The output transformer secondary is tapped to match either a 200 or 500 ohm line and a separate high impedance output is also taken from the primary side of the transformer. Thus the pre-amplifier may be either direct-connected or line-coupled to practically any type of amplifier on the market. All input and output connections are made with polarized plugs and sockets which simplify installation and eliminate possibility of error. The pilot light is a minor but very useful refinement which contributes to its professional appearance as well as providing visual assurance of proper line power connection.

Figure 1—The circuit diagram.





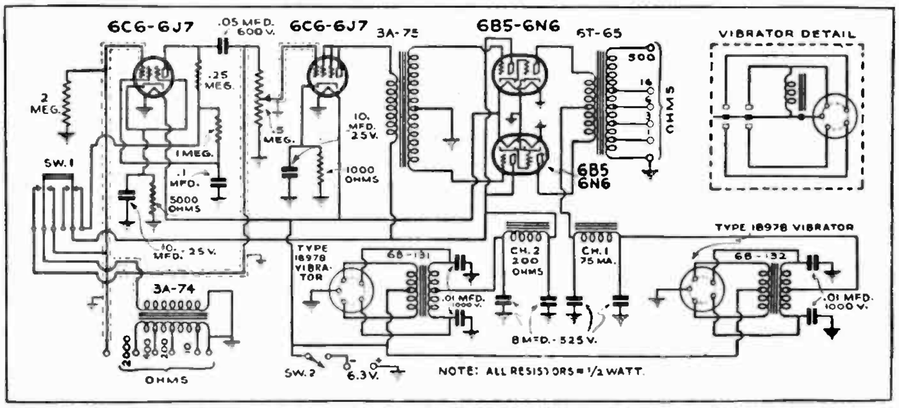


Figure 4, above, top view of the mobile unit; Figure 5, right, circuit diagram showing the tubes and parts used in this amplifier.

Mobile 10-Watt Amplifier

IN response to the ever-increasing demand for a simple, inexpensive, high-gain p.a. amplifier requiring only a 6-volt storage battery for operation, this easily-built instrument has been developed and parts for same have been made available in kit form. It is a truly universal p.a. amplifier for mobile, marine and other applications where regular line power is unobtainable.

Ordinarily apparatus of this type has been operated from relatively expensive motor-generators. By careful design it was found possible to adapt the amplifier to vibrator operation at a considerable saving in cost, weight and size. While the job could be done with a single vibrator, two are used in this case so that the operator may be assured of long, trouble-free operation, since neither vibrator is overloaded.

The Circuit Used

The input circuit is especially designed to accommodate any type of microphone or phonograph pickup. An input transformer, usually omitted on p.a. amplifiers, is mounted at right angles to the magnetic fields of the vibrator transformers to avoid induction hum and is tapped at 50, 200, 400 and 2,000 ohms. This provides an impedance match for single and double-button carbon, low and high impedance velocity and dynamic microphones as well as pickups. In addition a 2 megohm input circuit direct to the first grid is provided for crystal mikes of all types. The 2,000 ohm tap on the input transformer will be welcomed by those who have high impedance velocity mikes, since it enables a considerable gain ahead of the first grid.

Referring to the schematic diagram, Figure 5, the five primary leads of the input transformer are brought out to the terminals of the input terminal strip and the secondary "high" lead is connected to the movable blade of the switch S1 which is open-circuited in neutral position. This switch is employed to transfer the input transformer secondary to either the first or second tube, as required. The voltage step-up obtainable is so high that with some pickups the first stage would be overloaded. When the switch is in neutral, the transformer is out of the circuit. The control grid lead from the input 6C6 connects to the remaining terminal on the input terminal strip and is used for all microphones not requiring an impedance-matching transformer. It will be noticed that the switch, S1, has an extra section connecting the B supply to the plate and screen resistors of the first tube. When it is thrown so as to cut out the first tube and feed the secondary of T1 across the volume control, the high voltage supply to the first tube is opened to prevent stray electrostatic pickup when operating at full gain without any load.

Parts Layout

The second 6C6 is operated as a triode to permit transformer coupling at high gain. The output 6B5's are "dynamic" coupled internally to give high power output class A operation.

Tracing through the B supply circuits, it will be noted that the high voltages for the first two tubes as well as the input plates of the 6B5's are obained from the one vibrator and transformer 6B-131. The total drain on this circuit is approximately 22 ma. at 250 volts. The output plates of the 6B5's require 66 ma. at 250 volts. This current is drawn from the second power supply circuit and vibrator.

The layout of the apparatus is shown in the photographs, Figures 3 and 4. It should be followed rigidly in building the unit. Starting at the left, the first transformer is the 6B-132 with its associated vibrator. Next comes the 6B-131 with its vibrator right behind. The output transformer, and the interstage and input transformers follow in order. It will be noted that these three latter transformers are mounted at right angles to the vibrator transformers to obviate hum pickup. The filter chokes for each vibrator circuit are shown underneath the chassis, the larger choke, 75 ma., connecting to the larger transformer.

The vibrator sockets are standard 5-prong vibrator types and should be mounted with soft rubber bushings under the socket mounting holes. These will prevent the slight mechanical vibration which otherwise occurs when the apparatus is operating. The vibrator buffer condensers should be mounted close to the socket prongs.

Wiring Data

After all parts have been mounted in place, the filament wiring may be done, then the resistors, by-pass condensers and transformers. Leave the vibrator sockets for the last, then wire one at a time. Try connecting the primaries and secondaries one way; if there is no voltage output on test, reverse the secondary winding and try again. When one transformer is properly connected, repeat with the next.

Care should be taken that the grid leads on the first two tubes are carefully shielded and the shielding grounded. The input 6C6 tube should have a complete shield also. All the points shown at ground potential should be connected together; don't depend on the chassis to act as the sole conductor, though it should of course connect to the positive A lead.

Shielding

The maximum no-load voltage from each power supply does not reach a very high level, so no bleeder load was included. If desired as a further measure of filter condenser protection, a 100,000-ohm, 1-watt resistor may be shunted from each filter output to ground.

The "hot" A battery lead should preferably be shielded. It was found during early experiments that some "hash" would be picked up if the external "hot" A lead ran close to the chassis. When it is run directly away from the chassis, or when the bottom of the chassis is shielded, the output is free from objectionable hum even at maximum output levels. It is so quiet, in fact, that it may be used for modulating mobile transmitters.

The kit of parts for this apparatus is now available together with full constructional data.

Inverse Feedback 60-Watt Amplifier

THOUGH negative (or inverse) feedback has been applied to audio amplifiers since 1933, its use has been largely limited to communication systems and high-power P. A. apparatus. In radio receivers the distortion inherent in loudspeakers and other sections of the receiver rather than that remaining in the audio system of well-designed instruments has been considered the limiting factor in true reproduction. However, recent investigations, indicate that negative feedback minimizes "hangover" distortion in speakers, without power loss, and gives greater clarity and crispness of reproduction. This improvement is particularly evident when pentode output tubes are employed and is already having a far-reaching influence on receiver, amplifier and loudspeaker designs. Negative feedback likewise corrects phase distortion, which, though of little consequence in ordinary radio receivers, causes serious trouble in television amplifiers.

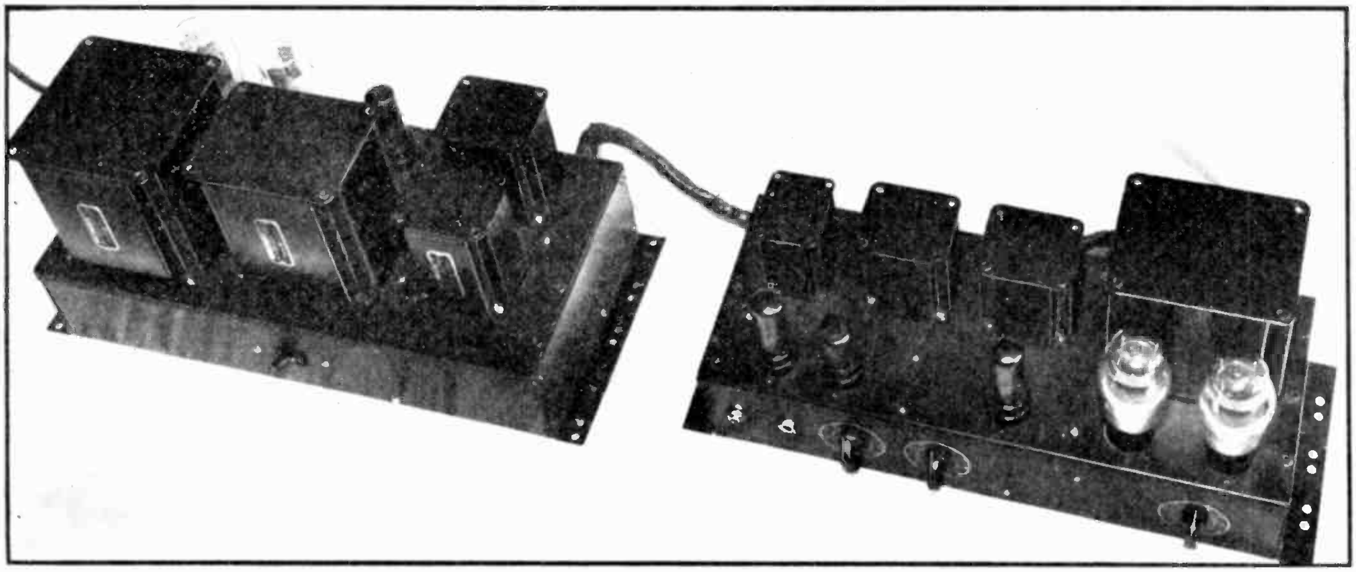


Figure 6—At left, the complete power pack; at right, the amplifier chassis.

Figure 8 shows a typical negative feed-back circuit. When a signal voltage Es is applied to the grid of an amplifying tube, it is amplified and reproduced across the plate load, Zp. Over the positive half-cycle of the input signal, the plate current increases and the voltage drop across Zp increases, making point b more negative with respect to point a. If a portion of the voltage across Zp is coupled back in series with the grid voltage, Es, it will buck or oppose in phase the input voltages and consequently reduce the output voltage.

In the circuit shown, assuming a normal gain of 10 without feedback, the output voltage would be 20 for a signal input of 2 volts. Now let us feed back 10 percent of the output voltages by selecting a combination of R2, C and R1 which will give a 1 to 10 feedback ratio. This will occur when R1 equals 9 times R2 if the blocking condenser C has negligible reactance at any audio frequency. The output voltage may now be determined from the formula:

$$\frac{\text{Gain} \times \text{signal voltage}}{1 - \text{gain} \times \text{feedback ratio}}$$

= output voltage with feedback.

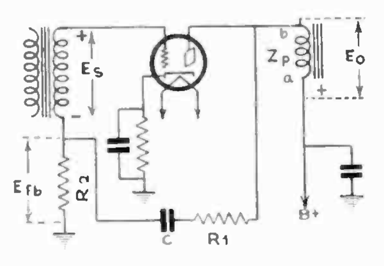
Substituting the assumed values, we get

$$\frac{10 \times 2}{1\text{-}10\ (-.1)} \text{ equals } \frac{20}{1\text{-}(-1)} = \frac{20}{2} = 10$$

We may bring the output up to 20 volts by simply doubling the input voltage.

The feedback voltage contains all the harmonics generated in the output circuit, as well as the basic frequency. The input signal Es is assumed to be free from harmonics. Therefore there are no harmonics in the input circuit to oppose the feedback-voltage harmonics and they will accordingly reappear in the output circuit amplified 10 times. Hence, while the effective gain for the original signal is 5, that for the harmonics is 10. The amplification of the harmonics serves to *reduce*, rather than increase the distortion. Thus, in this example, the output voltage will contain but one-half the harmonic content present without feedback. If the percentage distortion in the original output voltage without feedback were 10%, with feedback it will be reduced to 5%.

Figure 8



E_s = SIGNAL INPUT VOLTAGE
E_{fb} = FEEDBACK VOLTAGE
E = OUTPUT VOLTAGE WITHOUT FEEDBACK = GE_s
E_0 = OUTPUT VOLTAGE WITH FEEDBACK
G = GAIN OF TUBE AND CIRCUIT WITHOUT FEEDBACK

$$\frac{E_{fb}}{E} = \frac{R_2}{\sqrt{(R_1+R_2)^2 + X_c^2}} = \text{FEEDBACK RATIO} = \frac{R_2}{R_1+R_2} \text{ WHEN } X_c \ll \text{THAN } R_2$$

$$E_0 = \frac{GE_s}{1 - G\frac{E_{fb}}{E}}$$

Reducing Distortion

The example given above shows a very modest improvement. Actually, for maximum results, it is customary to build into the amplifier more gain than is really required and then sacrifice the excess gain to improve the performance through negative feedback. Another voltage amplifier stage may readily be added since this type of feedback improves stability. With an additional stage supplying a gain of 20, for instance, 20 percent distortion in the output stage can be reduced to approximately 1 percent. A corresponding reduction in hum and noise likewise results, so less filtering is required.

Let us assume that we add a stage giving a gain of 20 and see what it does to help the frequency response when this extra gain is sacrificed by negative feedback. We may feed back to a preceding stage to take full advantage of the possibilities obtaining a total feedback amplification of 200. The output, with the other conditions remaining as previously set forth will be:

$$\frac{200 \times 2}{1\text{-}200\ (-.1)} = 19 \text{ volts}$$

If the normal characteristics of the power stage are such that the frequency response is only half as good at, say 60 cycles and 10,000 cycles, the amplification will drop to 100 at these frequencies. The output, however, with feedback control, will be:

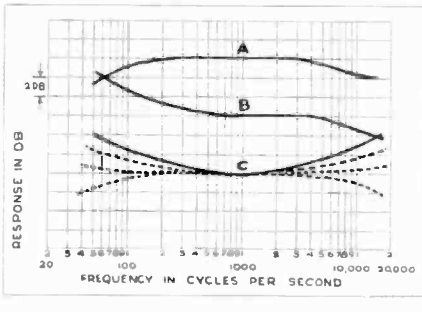
$$\frac{100 \times 2}{1\text{-}100\ (-.1)} = 18.2 \text{ volts}$$

Thus, without feedback, the output level would drop 50 percent at the high and low frequency ends of the range while, with the degree of feedback indicated above, the output level would change less than 5 percent throughout the range.

If a short electrical impulse is fed into a speaker voice-coil, the resulting movement of the speaker continues after the impulse ceases. This effect is known as "hangover" and occasionally causes raspy or blurred reproduction when output tubes of high plate resistance are used. Looking back into the amplifier output circuit from the speaker voice-coil, it becomes evident that a low-impedance load across the output-transformer primary will tend to damp these spurious vibrations. With negative feed-back, this damping effect is pronounced possibly because the speaker acts as a generator during such transient periods and the voltage developed reappears in the output-transformer primary where it is opposed by the negative-feed-back action.

The amplifier circuit shown in Figure 9 is one developed by engineers of the Kenyon Transformer Company and success-

Figure 7



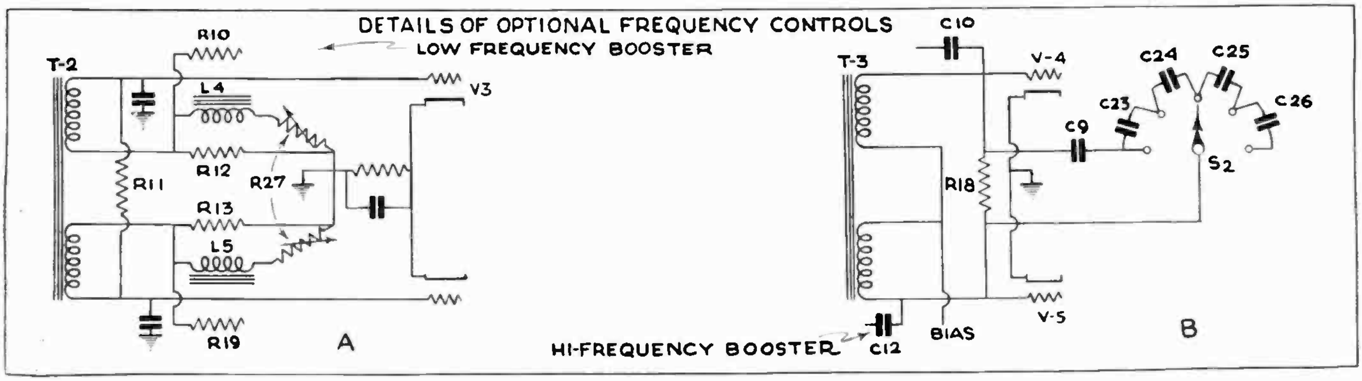


Figure 10—Circuits used to modify the low or high-frequency response.

fully incorporates negative feedback circuits. It was submitted for test to the Radio News laboratory and was found to deliver more than its rated output of 60 watts. The character of reproduction was noticeably more crisp and clear than is usually obtained from less well designed apparatus employing 6L6 tubes.

As shown, this is a 5-stage amplifier with the input circuit arranged so the full gain of over 100 db may be employed for low-level, high-impedance microphones, or transformer input for high-level operation, when the full gain is not required. A 6C5 triode feeds the push-pull 6N7 driver stage which in turn furnishes power to the push-pull, beam-power 6L6 output tubes, operating in Class AB2, with fixed grid bias. The screen supply voltage is controlled by a 6N7, with both sections in parallel, giving excellent regulation—an important factor in obtaining maximum power output.

Feedback is employed from the 500-ohm output through R10, R15 and C11 so that the overall performance of all transformer-coupled stages is improved. This enables the use of relatively low-priced components with excellent results. Additional control in the driver stage is obtained by feeding back from the grids of the 6L6 tubes to the input of the 6N7 driver.

The type 83 rectifier furnishes the plate voltage, giving adequate output with good regulation. The type 82 is employed in a half-wave circuit to provide C bias for the 6L6's.

The fidelity characteristics obtained with the circuit as shown in Figure 9 are indicated in curve A of Figure 7. In our tests this was found most satisfactory, but there are occasions where it may be found desirable to modify the low or high-frequency response in order to compensate for deficiencies in speakers or microphones. In Figure 10A, two small chokes are shown placed in the circuit so that the feedback voltage, at low frequencies, may be decreased. With R27 set for minimum resistance, the response characteristic of Figure 7B is obtained. Similarly, the high-frequency end may be raised by cutting in capacity across R18, as indicated in Figure 10B. Our tests showed that the action of the low frequency booster varied somewhat at different output levels so that it is better adapted for transmitter modulation purposes than for ordinary P. A. applications.

The designers recommend shunting a 5,000 or 10,000-ohm resistance across the 500-ohm line when the voice-coil terminals are used in order to reduce phase shift.

Curve C in Figure 7, illustrates the results secured when the high and low-frequency boosters are adjusted for maximum correction. The dotted curves show the characteristics at intermediate position of the booster controls.

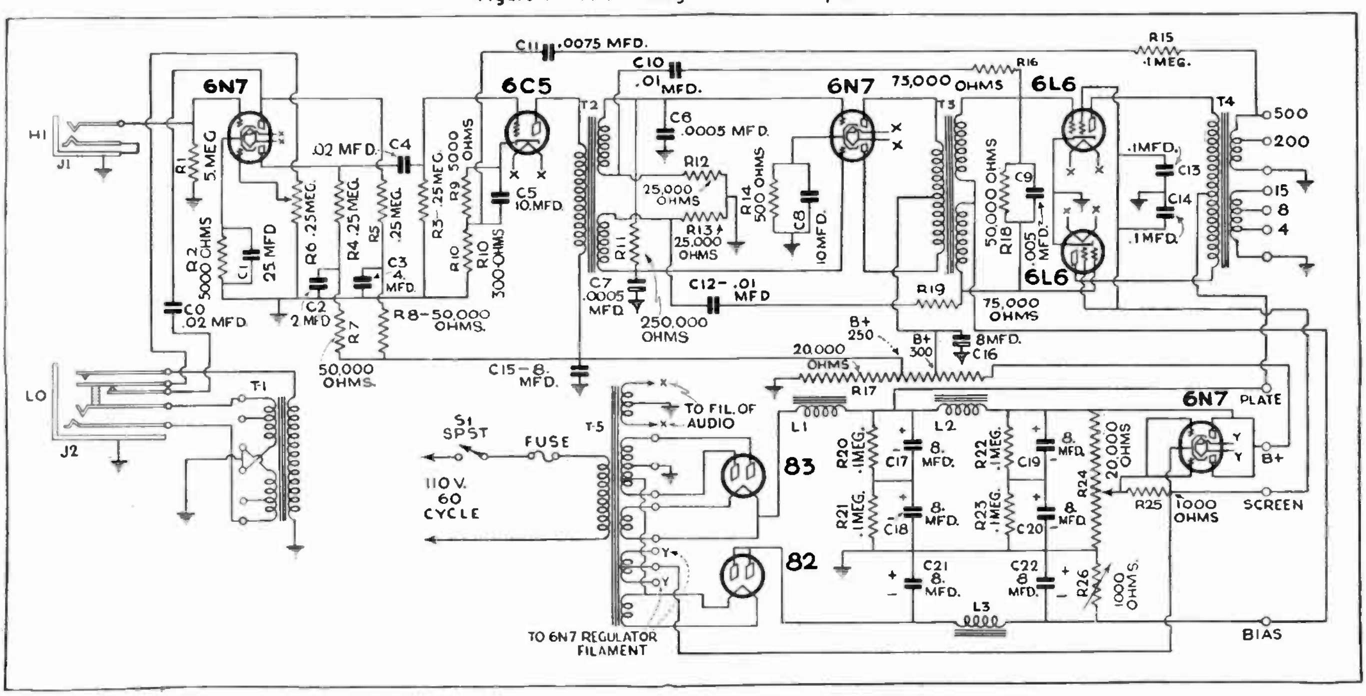
The general layout of the apparatus is shown in Figure 6. It should be carefully followed by constructors in order to avoid induction hum.

In arranging the feedback circuits, the blocking condensers C10, C11, and C12 should be kept between the feedback resistors as indicated in Figure 8, with the outer foil at lowest potential, otherwise oscillation may occur at some inaudible frequency. The 6L6 sockets should have high-grade insulation to avoid flashover. Glass type 6L6 tubes were used in the original model.

Parts List

CO—.02 mfd. paper condenser, 600 volt
C1—25 mfd. electrolytic condenser, 35 volt
C2—2 mfd. electrolytic condenser, 450 volt
C3—4 mfd. electrolytic condenser, 450 volt
C4—.02 mfd. paper condenser, 600 volt
C5, C8—10 mfd. electrolytic condenser, 35 volt
C6, C7—.0005 mfd. mica condenser
C9, C26—.005 mfd. mica condenser
C10, C12—.01 mfd. paper condenser, 400 volt
C13, C14—.1 mfd. paper condenser, 600 volt
C11—.0075 mfd. paper or mica, 400 volt
C15, C16, C17, C18, C19, C20, C21 C22—8 mfd. electrolytic condenser, 450 volt
C23, C24, C25—.010 mfd. mica condenser
R1—5 megohm, 1 watt fixed carbon resistor
R2, R9—5000-ohm, 1 watt fixed carbon resistor
R3, R4, R5, R11—250,000 ohm, 1 watt fixed carbon resistor
R6—250,000 ohm volume control
R7, R8—50,000 ohm, 1 watt fixed carbon resistor.
R10—300,000 ohm, 1 watt fixed carbon resistor
R12, R13—25,000 ohm, 1 watt fixed carbon resistor
R14—500,000 ohm, 1 watt fixed carbon resistor

Figure 9—Circuit diagram for the amplifier.



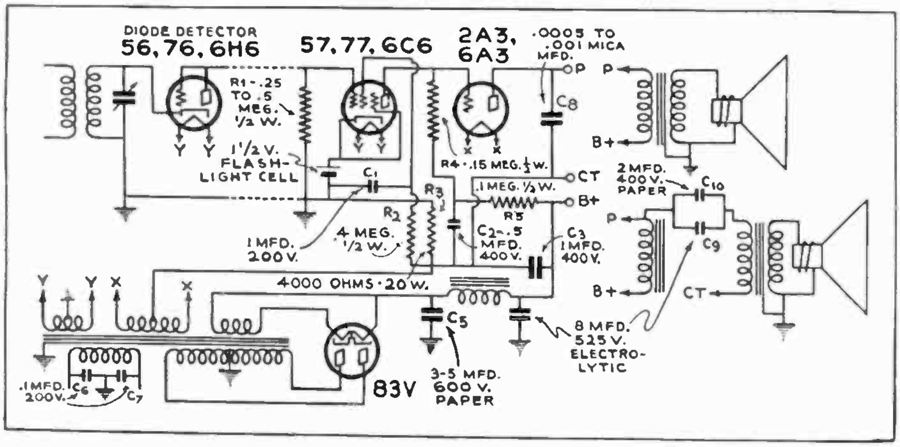


Figure 11—High-fidelity amplifier (see text below).

R15, R20, R21, R22—100,000 ohm, 1 watt fixed carbon resistor
R16, R19—75,000 ohm, 1 watt fixed carbon resistor
R17, R24—20,000 ohm 50 watt wire wound resistor
R18—50,000 ohm, 1 watt fixed carbon resistor
R23—100,000 ohm, 1 watt fixed carbon resistor
R25—1000 ohm, 5 watt wire-wound resistor
R26—1000 ohms, 25 watt adjustable wire-wound resistor
R27—Yaxley dual 100,000 volume control, audio grid taper
T1—Kenyon type T-1 or T-2 microphone transformer, 400, 300, 200, 100, 50-ohms to grid
T2—Kenyon type T-251 push pull input transformer
T3—Kenyon type T-255 Class AB interstage transformer, push-pull input to push-pull 6L6 grids
T4—Kenyon type T-319 push-pull output transformer, 6L6 Class AB2, 60 watts, 3800 ohms, to 500, 200, or 15, 8, 4 ohms
T5—Kenyon type T-216 power transformer; pri. 115 v., 60 cycles, 520-80-0, 520 v., 250 ma., 5 v. 3 a., 2.5 v. 3a., 6.3 v. 3 a., 6.3 v. 3 a.
L1—Kenyon type T-510 swinging choke, 6-19 H., 300-30ma., 125 ohms
L2, L3—Kenyon type T-153 filter choke, 30 H., 90 ma., 350 ohms
L4, L5—Kenyon type KC-200, filter choke, 20 H., 65 ma., 200 ohms
3 type 6N7 metal tubes
1 type 6C5 metal tube
2 type 6L6G tubes
1 type 83 tube, 1 type 82 tube
1 amplifier chassis, 17 x 8 x 3⅝ inches
1 power supply chassis, 17 x 6-3¼ x 3-⅝ inches
1 SPST line SW
Yaxley 6 point, single deck, rotary switch
Single closed circuit jack
3-contact switching jack

Direct-Coupled High-Fidelity Amplifier

THEORETICALLY, the direct-coupled amplifier permits the lowest amplitude, frequency or harmonic distortion with the widest frequency range. In this article a new type of direct-coupled amplifier is discussed which does not require critical adjustment of voltages or circuit constants, yet offers the same advantages as the old direct coupled amplifiers. Hum bucking circuits are no longer necessary either. Designs have been made for several amplifiers, including push-pull circuits, but this article describes a two-stage amplifier employing a pentode voltage amplifier stage and a 2A3 or 6A3 output tube.

It will be appreciated that any variation in the potentials of the first tube may result in an amplified change in the grid-bias of the last tube, with possible distortion. Such variations may be caused by ageing of tubes, heating, tolerance of parts, etc. Therefore, it is necessary to counteract the effect of these changes by a compensating circuit which works on d.c. only. This is accomplished by supplying the screen of the pentode tube from the cathode of the output tube. (See Figure 11). If for any reason the circuit constants have changed so as to result in too high a plate current in the 2A3, the voltage of the screen will be raised, resulting in more current in the pentode, more voltage drop in its load and increased bias on the 2A3. In this way the plate current always returns to approximately the same value. Due to the resistance capacity filter in the screen circuit, the compensation does not work on a.c. signals.

The high-frequency response, like in all other amplifier systems, depends on the capacity shunting the coupling device. This capacity consists of the output capacity of the first tube, the input capacity of the next tube and the capacity of the wiring connected to the coupling device. Since the direct-coupled amplifier uses less parts or coupling units, the capacity is lower.

The condenser across the diode load of a detector may be responsible for considerable loss in high frequencies. Therefore, it is recommended to omit this condenser and employ a small condenser (C8) in the output across a low impedance. Considerably better high frequency response is obtained in this way. There is enough capacity in the first tube to prevent instability.

Good regulation in the power supply is necessary for low-frequency response. The rectifier and the filter should have low resistance. The 83V has been found better than a mercury vapor tube because the latter would require filtering and shielding. The choke should have low resistance and high inductance. The output condenser should be at least 8 mfd., and may be an electrolytic. The imput condenser must be a paper type because of the high voltage. A suitable condenser from 3 to 5 mfd. capacity is made by Cornell-Dubilier (Type PEB6808).

Resonating the output by means of a shunt feed circuit is another way of bringing up the lows. The circuit of Figure 11 shows two output connections. If shunt feed is used, the blocking condenser (C9, C10) might be an 8 mfd. electrolytic and 2 mfd. paper in parallel to provide the odd total of 10 mfd. required. C3 can then be 1 mfd. paper and the choke is 30 henries. When series feed is employed, C3 should be increased to 8 mfd. (electrolytic). The shunt feed connection boosts low notes considerably more than the series connection.

Figure 12

Although simple to construct and adjust, this little amplifier will provide perfect tone with ample volume for home use.

Constructional Data

The best quality is obtained by direct coupling of the amplifier to the diode detector, as shown to the left of the dotted line. In some locations, a single tuned circuit coupled to a tuned antenna will bring in the local stations.

The wire-wound resistor (R3) in the filament circuit may be replaced by a speaker field of equivalent resistance value. Suitable power transformers are manufactured by Thordarson (type 7021) and U.T.C. (type 14552). They may be used without any change in constants.

Some readers may have difficulty obtaining a suitable transformer. The specifications are: secondary 750-900 volt, c.t., 100 ma.; two different filament windings, both center tapped. These may be either 2.5 or 6.3-volt windings depending on whether 6-volt or 2.5-volt tubes are used. The two transformers mentioned above satisfy the requirements. Other suitable transformers are: U.T.C. Type 21647 (all 6-volt tubes), Philco 32-7430 (6-volt tubes), Kenyon C809, Kenyon K90Y (both call for one 2.5-volt and one 6-volt tube).

This amplifier with a 57 and 2A3 or 6C6 and 6A3 is rated conservatively at 3 watts output. Its response curve into a resistive load is flat within 1 db. from 30 to 10,000 cycles. Although the output may seem low, it is ample for use in the average living room.

Figuring Decibel Ratings

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

$$\frac{P_1}{P_2} = \frac{R_2 E_1^2}{R_1 E_2^2} = \frac{R_1 I_1^2}{R_2 I_2^2}$$

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.

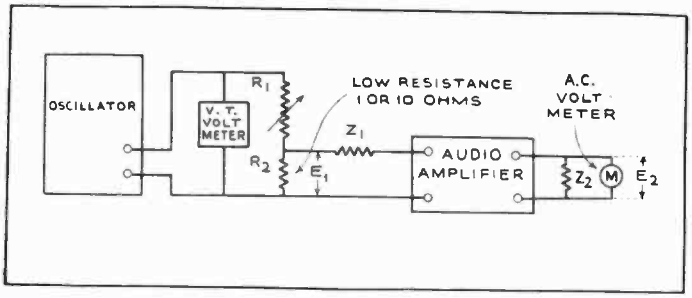


Figure 13

An economical way of measuring gain and frequency characteristics of receivers.

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. See Figure 13. 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

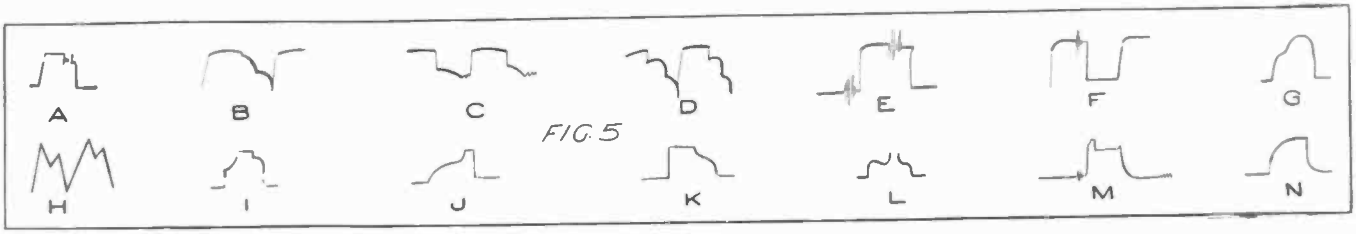
$$DB = 20 \log \frac{100}{.01} + 10 \log \frac{5,000,000}{500} =$$

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

Obviously, the type of rating should be different, and this is 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."



SERVICE HINTS

Vibrator Trouble Shooting With The Oscilloscope

THE possible variety of vibrator troubles is numerous; some of them so subtle in nature that they can be shown up only through oscilloscope investigation. Vibrators are often erratic in operation. Occasionally they blow out altogether—along with a few fuses. A light jar in removing the set from the car, or tapping, may return the vibrator to apparently normal operation. The points make and break so quickly that it is impossible to make an effective visual inspection, and the inertia of ordinary meters often makes voltage readings unreliable. Points may burn over a very small area no larger than the head of a pin. They may operate normally during partial disintegration—so far as ordinary tests are concerned—only to cause grief later on. Some vibrators will not start at the agreed low potential rating of four volts, but will operate satisfactorily at from six to eight volts. Some points will burn out as the potential approaches 8 volts. Such conditions are due to vibrator maladjustments, the exact nature of which can be determined only on the oscilloscope.

However, the vibrator is not alone guilty in the matter of power supply troubles in auto radio receivers. The buffer condensers across the secondary of the transformer often cause trouble, particularly when permanently or intermittently open. (A shorted buffer condenser is, of course, readily located.) Replacement of a buffer capacitor with a condenser of the wrong value will result in reduced life and incorrect operation that is best demonstrated on the oscilloscope.

The cathode-ray oscilloscope will detect not only vibrator and contact trouble (with both synchronous and non-synchronous vibrators) and abnormal conditions in the buffer circuit, but will also disclose the presence of "hash" in the r.f. system.

To familiarize oneself with the oscilloscopic portrayal of vibrator circuit conditions, the serviceman should produce known troubles in an otherwise perfect vibrating system and note the effects on the oscilloscopic screen. These should be sketched or photographed for future reference. (Photos, or oscillographs, are easily made with an exposure of 1/5 to ½ second at f-4.5 on fast, color-sensitive film or plates. Figure 1 is such a photo. A slightly more contrasty image will be secured by dimming the room light, Figure 2 being an example of this technique. The oscilloscopic image can even be discerned in Figure 3, which shows the layout in use on an auto radio. (This was made with a time exposure, followed with a flash-bulb shot of the ensemble.)

As the images vary with different conditions in different receivers, it is hardly practical to indicate more than a handful of typical conditions. The individual serviceman should experiment with the types of auto radios which he will be called upon most often to service. The general procedure will be the same in all cases.

Connect the high side of the vertical plates in the cathode-ray oscilloscope, through the usual amplifier, to one side of the primary of the power transformer. Connect the ground side of the oscilloscope to the chassis of the auto radio receiver. Adjust the amplifier gain control for satisfactory vertical deflection, and the horizontal sweep circuit for synchronization at one-half or one-third the vibrator frequency to obtain two or three waves on the screen.

If difficulty is experienced in obtaining a stationary image, this is *prima facie* evidence of vibrator trouble. Two types of moving wave-forms may be experienced. Voltage fluctuations will show vertical instability, as indicated in the oscillogram of Figure 4. This is an RCA synchronous vibrator with burned rectifying points. Frequency instability will be evident in an erratic horizontal movement of the pattern, and will usually be caused by dirty or burned vibrator points.

The technique of experimentation should be carried out as follows: First investigate the wave-form of a perfect vibrator. Using an Arvin 17A, the vibrator curve, if in perfect condition, will appear on the screen as indicated in Figure 1, 2 and 3, and as in "a" of Figure 5. Bend one stationary contact so that it is at a greater distance from the operating reed. This may alter the frequency slightly, necessitating resynchronization. Note the distortion produced in the curve. Press the contact too close and again observe the curve. Resetting the operating contact to its normal position, make similar tests with one of the rectifying contacts—in the case of a synchronous rectifier. Contacts can be opened by inserting a piece of paper between vibrating and stationary contacts. Remove the buffer condensers—two .02 mf. condensers with a common ground in the case of the Arvin. Note the wave-form.

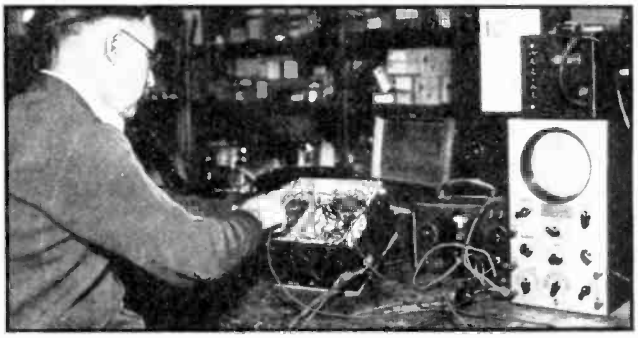


Figure 3

Checking set with an oscilloscope. Note the layout of receiver, oscillator and oscilloscope.

Figure 1

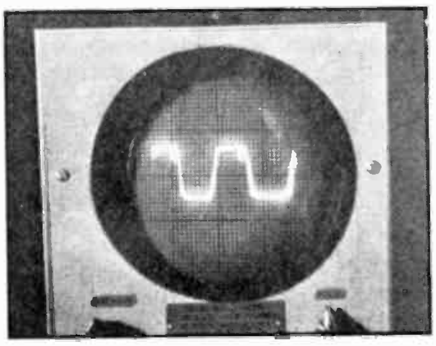
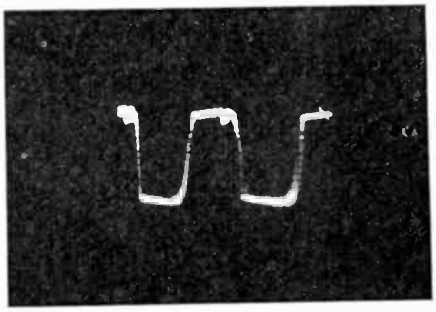
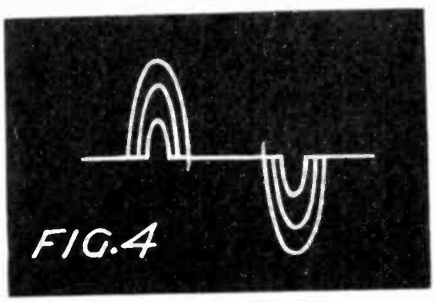
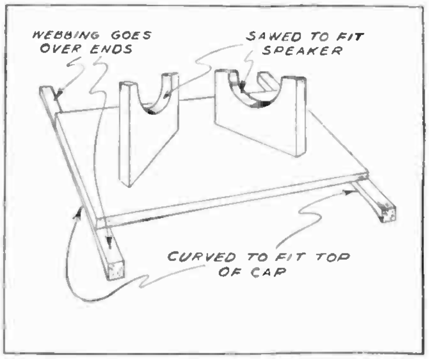


Figure 2







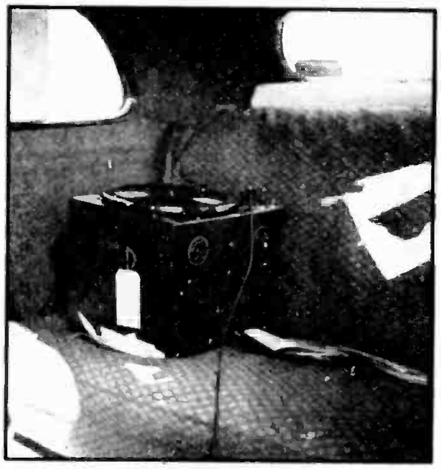


Figure 6, top; Figure 7, below.

Figure 8—Showing the instantly mountable speakers.

Replace one condenser and again observe the pattern on the screen. A further observation should be made with excess capacity buffers. *During this experimenting, remember high voltage is developed in the secondary circuit, so take care to avoid shocks.*

Most of these tests can be effected with the suggested oscilloscopic connections in the primary power circuit. Where the secondary circuit is affected, the load variations will be reflected in the primary circuit, thus making a change of set-up unnecessary, and facilitating the work of routine servicing.

Returning to Figure 5: Oscillograms "a" through "h" were made on the Arvin. Curve "b" shows one contact too close; "c", the other contact too close; "d", one contact open; "e", no buffer condensers; "f", one buffer condenser; and "g" shows too much buffer capacity. At "h" is shown the output of the 84 with the filter connected, but observed on the tube side of the filter. Figures 5-i-j-k-l were made with a Philco non-synchronous vibrator under different conditions, showing correct and maloperation. Oscillogram "i" indicates correct adjustment; "j" with the starting contact too close; "k", the other contact too close; "l", contacts too far apart. Figures 5-m and 5-n show respectively a Radiart 3313 replacement for the RCA synchronous vibrator (shown faulty in Figure 4) and a Radiart 3320 replacement in a Philco—normal operation being indicated in both instances.

By synchronizing with the output wave of the filter system, and then connecting the oscilloscope to the output of the set, it can be determined if any "hash" is being fed into the r-f system, and thence to the audio circuits. Sometimes this is not audible as "hash", but is evident as distortion when a signal is being received—the modulated carrier riding the "hash" wave. A modulated oscillator — 400 cycles — should be employed in making this test, and the "hash" will be disclosed as a distorted envelope. Radio-frequency chokes in the hot "a" lead and adequate by-pass condensers can then be added to filter the disturbance.

The layout in Figure 3 shows, in addition to the Arvin receiver, a National Union oscilloscope, with the RCA TMV-97-A oscillator at the left.

Installing A Mobile P. A. System

WHILE there is nothing new in renting mobile P.A. equipment, the design of special apparatus whereby any car can be converted into a sound truck in five minutes is new and presents definite money-making possibilities to the radio serviceman.

The set-up is shown in Figure 8. The two 12-inch Rola speakers with 6-volt fields are mounted on a substantial board base which in turn is supported on two skids running lengthwise with the car. The skids are curved to fit the tops of the automobile and project about six inches on each side of the speaker platform. Blanket padding protects the top of the sedan from the skins. Webbing passes over the projecting ends of the skids, down and through the car windows and is strapped inside, holding the entire assembly firmly in place. The speaker platform will fit practically any standard sedan or delivery truck, which fact broadens the possibilities for mobile P.A. work. A delivery car, carrying its usual sales message on the sides, is instantly converted into a sound truck carrying visual advertising, in addition to announcements and music, without the necessity of special art work. A new model car, of any make, can be made to advertise itself by converting it temporarily into a sound truck with this equipment.

The speakers are operated in conjunction with a 20-watt amplifier. Two 6L6's in the output are resistance-coupled to a 6J7 through a 6N7 phase inverter. The amplifier unit is shown in Figure 7, cushioned on the rear seat of the car. Astatic pick-up and microphone are used.

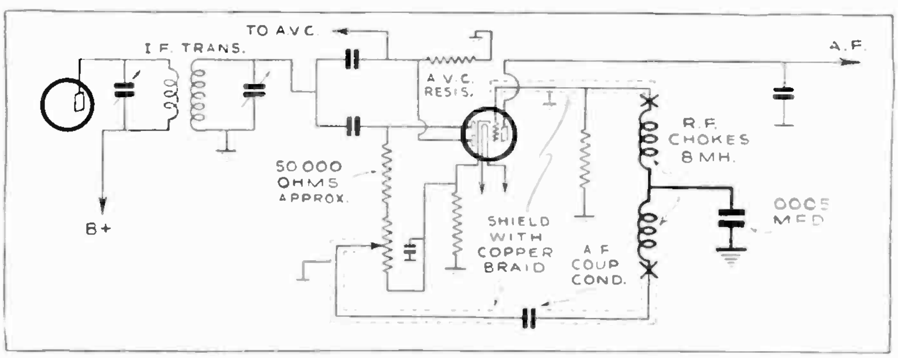
The mechanical details of the speaker platform are indicated in the drawing of Figure 6.

Oscillation And Noise In Supers

POSSIBLY the most annoying, and certainly one of the hardest-to-locate troubles encountered in modern radio service work is manifested by uncontrollable oscillation and an extremely high noise level. This seems to be particularly true of receivers in which the i.f. transformers have been replaced with those of the new high-gain iron-core type. This fact, however, does not necessarily mean that the trouble lies in this part of the circuit.

One serviceman recently had three sets in the shop which were noisy and oscillated despite every precaution in r.f. shielding, filtering and by-passing the plate and screen leads. In all cases it was noticed that the oscillations ceased when the volume control was turned down, suggesting that the trouble might be found in the first audio stage. Accordingly the filter circuit shown in Figure 9, consisting of two 8-millihenry chokes and a 500-mmfd. mica condenser was tried. This completely squelched all oscillations and reduced the

Figure 9—Shielding arrangement for noise reduction.



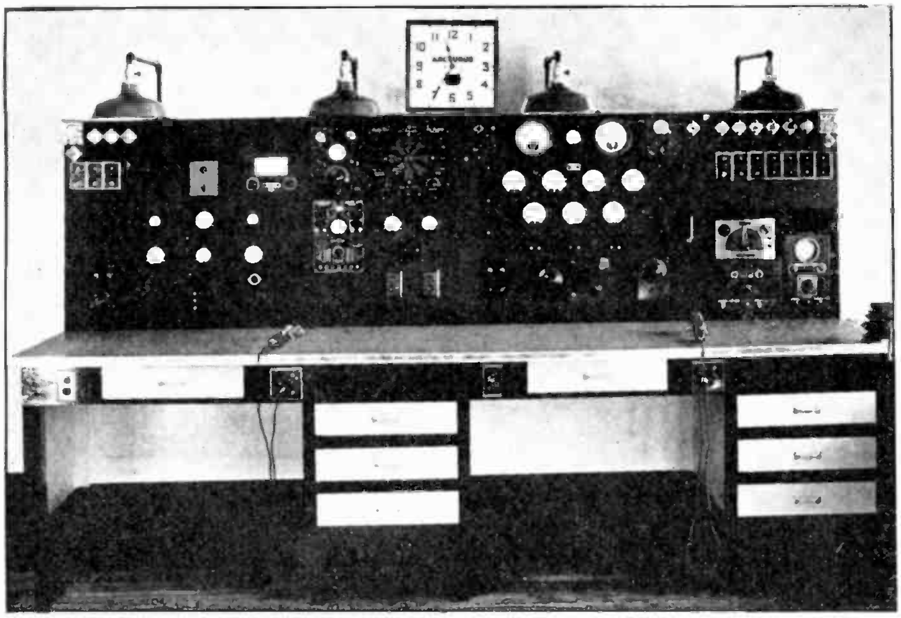


Figure 10—A service bench with every convenience, including plenty of light and elbow room. This was designed and constructed by L. F. Lyon, proprietor of Lyon Radio Service, Syracuse, N. Y.

noise to about 40% of its original value. Most of the remaining noise was eliminated by shielding all of the leads in the first a.f. grid circuit, as shown. All three sets were of different makes, and the results obtained with the filter were identical in each case. While the circuit shown in Figure 9 may not be encountered in every instance, it is typical, and illustrates the principles of filtering and shielding.

6-Volt Farm Sets

AFTER several complaints of noise with new 6-volt farm radios as the battery began to drop, showed that most of this trouble was due either to a poor battery or corroded connections to the power cable. Few set owners care to invest in a new battery, and corrosion can only be temporarily corrected. The noise can usually be eliminated by connecting a *paper condenser* of 6 mfd. or better, directly across the terminals of the 6-volt battery. In extreme cases the condenser may be employed in conjunction with two r.f. chokes consisting of 75 turns of number 18 wire on 1-inch forms—one choke in each leg of the battery. (The battery being a power source, a condenser filter arrangement should be effective in reducing noise—exactly as it is with line-power operated receivers. This should be particularly the case when the battery is being more or less constantly charged by a wind-driven generator where commutator and ring noises may be introduced. Noisy batteries are usually the result of mistreatment. While it is possible to get away with ordinary tap water in large cities, for long periods of time, the drinking water available on most farms is absolutely unfit for electrolytic purposes. Most spring and well water contains large percentages of mineral salts which rapidly build up deposits in the battery resulting in stray discharge currents, sulphating and noise. The farmer should be instructed to use only distilled water—or rain water collected, preferably, in a special barrel or other receptacle set aside for battery use. It goes without saying that the terminals should be inspected every so often, cleansed with ammonia or a solution of washing soda, greased and tightened.—Ed.)

Curing Noisy Volume Control

THE complaint was a noisy volume control—and the cure will apply to many similar complaints on other receivers. Try working a few drops of carbon tetrachloride into the control. Often this can be done by pouring a small amount on the shaft.

1937 Ford Auto Radios

MOTOR noise is a familiar complaint with these installations. The following routine will usually clear up the difficulty:

1—Try changing the generator condenser from one side of the cut-out to the other.

2—Sometimes it is better to eliminate the condenser supplied to be connected across the ignition switch to the dash.

3—Move the transmission-line antenna lead to various positions at the left of the car near the brake. You will generally find that there is some inductive pickup that can be eliminated. The line usually works best when tucked up as far as possible near the motor wall.

4—A condenser grounded to the speedometer and connected to either side of the resistor or fuse sometimes helps.

5—Inspect the ground on the oil pressure unit in the motor block.

6—A grating noise like a loose connection can usually be traced to faulty condensers on the oil and gas indicators, located respectively on the motor and on the gas tank. The condenser supplied by Ford for the gas tank is only .05 mfd. A .5 mfd capacity may be needed, especially when using fish-pole aerial, such as the Tobe Auto-Pole, mounted on the rear bumper.

7—Condensers from the oil and gas indicating instruments to ground are often beneficial.

8—If a buggy whip aerial is employed, shield the aerial side of the antenna filter (Phantom Filter with Arvin) through the door jam. This prevents pickup inside the metal car.

9—If a transmission line is used, lengthen this if necessary (if the manufacturer says that so doing will not affect reception) so that the antenna transformer can be located as closely as possible to the aerial. Arvin says you can lengthen their transmission lines.

10—Make sure that the aerial transformers are perfectly grounded. If a long transmission line is employed the shield should be grounded at the middle of the frame of the car.

11—Balance the radio-frequency and detector circuits for the antenna used. This usually improves reception 75 percent.

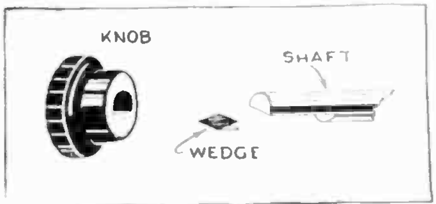
Eliminating Noise In The Majestic Series 90

THIS is an old set, but so well constructed that thousands are in use today. A loud scratching noise when turning—and occasionally complete cut-out over a wide portion of the dial—is always caused by the cast-lead, alloy rotor on the steel shaft, expanding in both directions short-circuiting to the stators. A similar trouble is sometimes encountered with other receivers and the location of the points of short-circuit is often difficult by mere visual inspection.

Put an ohmmeter on its lowest scale and connect it across the plates of an unshort-circuited tuning section. It will of course read "zero" due to the low resistance of the coil. Now turn the zero adjustment rheostat on the ohmmeter until you obtain a small deflection, at which point you are ready for the test. When the ohmmeter is connected across a defective condenser, and the condenser tuned, a slight movement of the needle will be noted at every short-circuited position. With a screw driver shift the stator plates and bend the rotor plates until no deflection is noticed as the condenser is tuned. Realign and the job is done.

Replacing Knob Wedges

WHEN knob wedges are lost, or lose their tension, they can be replaced by small lengths of clock spring bent as shown in the drawing. Where the spring is very difficult to bend, or it breaks, the



short length should be heated red-hot and permitted to cool slowly in air. When cool it can be readily bent into the "V" shape. It should then be reheated and tempered by immersing in cold oil or water. This will restore its spring qualities.

How Much To Charge For Service Work

THE fundamental problem in radio service business methods is not so much how to charge for radio service, but that of *how much* to charge. There are various ways of charging—list price of parts plus low labor charge, high labor charge with discount on parts, free examination, special inducements, etc., etc. But regardless of how the serviceman charges, the bill must be right! If too high, he will lose his customer—and eventually his business. If the bills are consistently too low, he will make no profit and lose his business anyway.

All too many servicemen make arbitrary

charges—charges not based upon the cost of running his own business plus a reasonable profit. It is too often a case of blindly following a leader—charging what some other serviceman charges, or what some manufacturer suggests as a logical method and rate of billing. However, bills for radio service must be tailor-made to fit the individual serviceman. But even servicemen who realize this fact often are incapable of computing an intelligent basis of charges. Their most serious blunder is the overlooking of overhead—an all important item that may well spell the difference between profit and loss!

It is really a very simple matter for each and every serviceman to determine exactly what he should charge for his work. We are considering now the one-man business. (When the serviceman has progressed to the point where he has employees, that fact in itself indicates that he is a good business man and is quite capable of computing costs and billing for a profit.)

Figure out approximately how many hours a month you actually work at radio servicing—perhaps five hours a day, six days a week or 120 hours per month. Your time is worth $1.00 an hour. (Oh, yes, it is undoubtedly worth more than that—and you will realize more than that if you will follow this system. Even so, $30.00 a week isn't bad by any means, and no serviceman should depend 100% upon radio servicing, unless he has built up a large, exclusive service organization. Sidelines do much to keep the cash register tinkling.) Now compute your overhead:

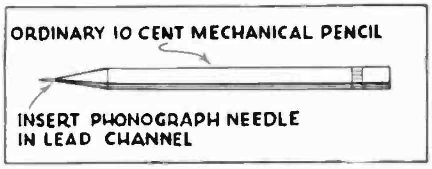
Depreciation of auto	$15.00
Depreciation of equipment plus fund for new	10.00
Rent	10.00
Electricity	3.00
Telephone	2.75
Heat (monthly average over the year)	3.00
Gas and oil	4.50
Miscellaneous (wire, solder, etc.)	2.00
Total monthly overhead	$50.75

Depreciation is easily figured. For instance, if your car is worth $410.00 now, and say $50.00 two years hence as a trade-in, the depreciation is at a rate of $15.00 per month.

Obviously, 120 hours of work must take care of this overhead. Dividing $50.75 by 120, we find that about $.42 must be charged against overhead for every hour of work. However, to be on the safe side, and for the ease of computation, we shall charge fifty cents an hour for overhead. Now let us see how this works out on a typical job—say the installation of a noise-reduction antenna system—assuming that

An Improvised Scriber

A SCRIBER of some kind is an absolute necessity when metal panels or chassis are being laid out. However, many experimenters do not have this tool. The drawing shows how you can improvise a scriber from an old mechanical pencil and



a steel phonograph needle. If the needle is too large for the lead channel, a large sewing needle, or a small nail, will serve equally well — though the steel phonograph needles designed for soft playing will usually fit okay. This scriber has the advantage that, when the point becomes dulled, it is only necessary to replace it with a new one.

---

the antenna kit lists for $6.75—your cost $4.05—and that it will take you two hours to effect the installation. We figure as follows:

Cost of kit	$4.05
Overhead on two hours' labor	1.00
Labor at $1.00 per hour	2.00
Total	$7.05

If you charge $7.05, all your expenses will be covered—and you will make two dollars on the job. *Under no circumstances should you charge less than this.* However there is no reason why your bill should not be in excess of this minimum amount. Here are four different ways in which you might bill your customer with greater but still fair profit to yourself.

List cost of antenna	$6.75
Labor—2 hours @ $1.50	3.00
Total	$9.75

There is nothing unreasonable about this bill, and customers in many service localities would consider it fair and square. Subtracting $7.05 (the minimum charge covering your salary and all expenses) leaves $2.70 as net profit to the company (your own one-man service business).

Another method of charging—using a discount as a bait:

Special price on antenna	$6.00
Labor—2 hours @ $1.50	3.00
Total	9.00
Minimum	7.05
Net profit to company	$1.95

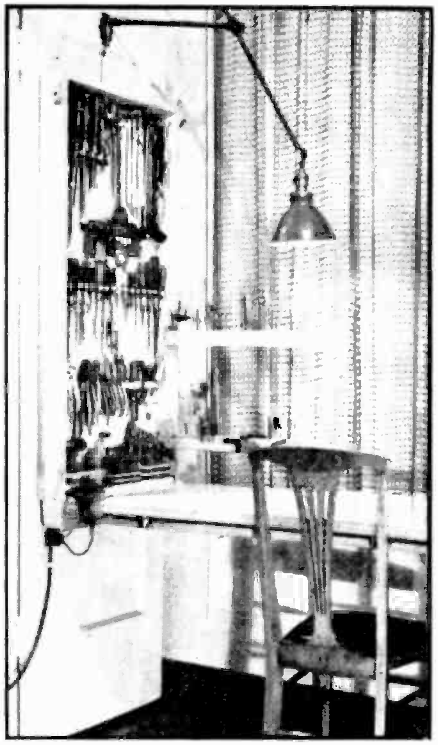


Figure 1—Closet-door work bench.

If it fits in with your scheme of things, you can charge the list price of the kit plus one dollar an hour for labor. This brings the total customer's bill to $8.75, with a net profit to the company of $1.70 (don't forget, your salary of $1.00 per hour has already been taken out—the $1.70 is a surplus). A still more attractive offer might be made of a special $6.00 price on the antenna and two dollars for labor—a total bill of $8.00, with a net profit to the company of $.95.

Net profits should be permitted to accumulate—preferably in the savings bank at interest. This fund can be used later for expansion and emergencies. As it exceeds a required minimum, of say $100.00, a dividend can be declared in your favor. This will be in addition to your salary of $30.00 per week.

It is obvious that the system, the fundamentals of which have been indicated above, can be applied by individual servicemen to fit their particular needs. If he is a good serviceman, and gets an average break so far as business conditions are concerned, he is bound to make a profit by following it.

EXPERIMENTAL RADIO DATA

A Closet-Door Work Bench

HERE is the ideal Work Bench for the small apartment as constructed by a reader of RADIO NEWS. Due to the ease with which it can be folded out of sight it meets with the hearty approval of the most critical housewife!

The plans called for a rectangular box, the cover of which was to be used as the drop-leaf, work-table. The size was determined by both the door and the fact that a standard sized 48 by 48 inch 5-ply veneer panel would supply all the main lumber without any waste. The overall size of the cabinet when closed is 48 inches high, 21 inches wide and 6½ inches deep. The back of the cabinet and the drop-lid are both 45 inches by 21 inches. The sides are 3 inches wide by 48 inches long and are mounted on the face of the back panel, even with the edges, extending 3 inches below the bottom. The top and bottom are 3 inches wide by 19½ inches long and fit between the sides, just even with the back edges. To have a firm support for the drop-leaf hinges, a piece of pine 2 inches by 3 inches by 19½ inches is fastened between the extended sides at the bottom.

To reinforce the plywood table-top a rectangular frame, made from 1 by 2 inch pine is attached to the underside. The legs are made of hard 1½ by 1½ inch pine and hinged to this frame with card-table hinges. A piece of 3-ply veneer, 12 inches high is fastened across both legs to reinforce them and prevent wobbling. Adjustable screw type levels are countersunk into the bottom of the legs to compensate for uneven flooring.

The bench-top is covered with Good-

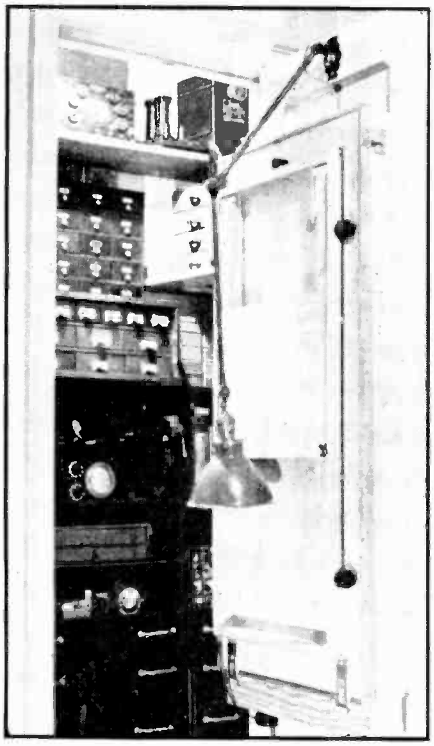


Figure 2

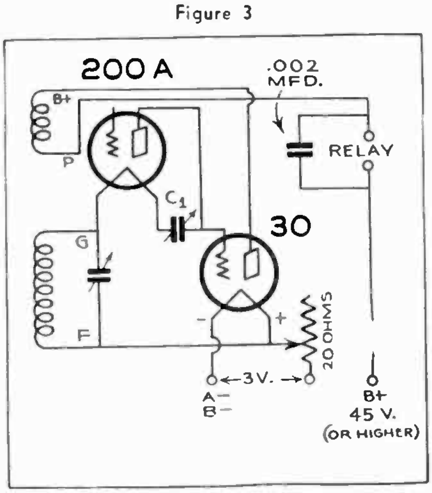
year rubber flooring which is thoroughly cemented down to prevent bulging when the lid is closed. The entire edge of the bench is finished with 1 inch wide flat moulding. Two strong, flat, inside-shutter hooks are placed near the top of the sides to hold the lid closed, while the legs are held folded in place inside the lid frame by means of two brass turn-buttons. The most suitable lid hinges are the refrigerator door type. Wood screws are used exclusively in the assembly of the cabinet so as to insure greatest strength.

The cabinet is a complete assembly in itself and is attached to the heavy part of the door by six long wood screws. When it is desired to remove the cabinet to another location it is only necessary to take out these six screws and the entire unit is then portable. Five convenient outlets are wired along the three outer sides of the lid frame, current being secured through a heavy flexible cord from a base outlet in the closet.

When the bench is opened to working position as shown in Figure 1, it is directly in front of a window. Ample light for night-work is available from an adjustable lamp which also folds out of the way against the closed cabinet. Clips are used to hold all handle-type tools, while others hang from rods or hooks. Two standard drill-stands accommodate a full set of twist drills. A pair of hinged 1 by 2 inch pine arms fold out of the open cabinet and are drilled with holes to hold an assortment of files and small tools. Figure 2 shows the closed cabinet.

The completed cabinet and Work Bench has proven so practical that other experimenters will find it practical to copy the design with slight modifications to suit their own special requirements. Several drawers can be added, or the cabinet can be made deeper to accommodate an amateur receiver and transmitter. The basic idea of design can be altered to suit any individual requirement and to provide for a personal working space in the smallest of homes.

Figure 3



Home-Built Photo-Electric Device

IT is not generally known that the type 200A tube has photo-electric properties, due to the caesium it contains. The accompanying diagram (Figure 3) shows a simple oscillating circuit in which this tube is employed as a photocell. The minute amount of current developed in the 200A tube being used to operate a relay. This circuit is highly sensitive and can be used to measure very high resistances or to test insulation.

The circuit consists merely of an oscillator using a triode tube, in this case the type 30, with a variable condenser of the trimmer type, C1, used as a grid condenser and the photocell used as a grid-leak. When the condenser C1 is adjusted so that the oscillator is just on the verge of stopping oscillation a small change in the value of the grid leak (200A) will have a large effect on the plate current. Very good insulation must be used in the grid circuit. In this application, no filament voltage is applied to the 200A tube. For the tuning inductance any oscillator coil and tuning condenser will serve, or if desired, an audio transformer can be used, in which case the B-plus terminal should be connected to the plate of the 30 tube. The B voltage can be anything between 45 and 200 volts. It should be maintained constantly as it has a large influence on the operation of the circuit at a given adjustment. Maximum sensitivity is obtained with high voltage.

In operation a sudden change in plate current starts the circuit to oscillating and thus charges the condenser C1. This charge leaks off through the 200A tube and when the charge has leaked off sufficiently the tube starts to oscillate again and the process is repeated. By correctly adjusting the condenser C1, the circuit could be so regulated to give anything from the series of clicks to a high-pitched whistle if connected to an amplifier and in the loudspeaker, or can be used like any photo-electric device to operate a relay directly to perform many functions.

The circuit is so sensitive that the light from a flashlight falling on the 200A tube several feet away will actuate a relay in the plate circuit. The 200A seems to be most sensitive in the blue end of the spectrum.

Midget Instrument Power Supply

QUITE often a laboratory technician or experimenter finds a need for a moderately high voltage — low current supply that can be used as a means of supplying grid-bias, for resistance-measurement work or as a power supply for taking characteristics of high impedance multi-element tubes. To be practical for this type of work, such a supply unit should be small and reasonable in cost. The little unit shown in Figure 4 meets these requirements to a "T."

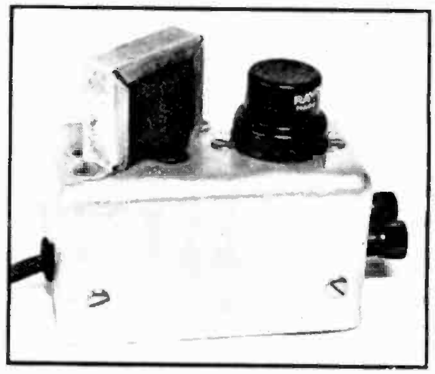


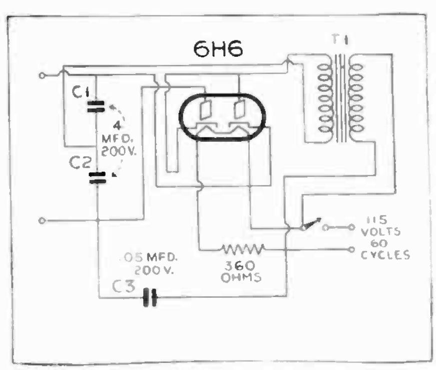
Figure 4

In the preliminary experimental work most of the rectifier tubes on the market were found unnecessarily large and their heat dissipation too high for the service proposed here. The small metal duplex-diode 6H6 type tube appeared to be the best tube for the job and accordingly a number of 6H6's were secured and characteristic and life curves taken. It was found that a steady current, up to 10 ma., could be secured with reasonable life. Next the 6H6 tube was tried as a voltage doubler and additional life tests were made, with excellent results. An output of 10 ma. was obtained at 190 volts and up to 300 volts at 1 ma.

The circuit of the power unit is shown in Figure 5. For the test set-up a high resistance voltmeter and a d.c. milliammeter were connected in the output and a suitable load resistance was connected directly across the output terminals of the supply.

In order to allow the greatest flexibility of the unit in conjunction with various types of equipment it was not deemed good practice to make a direct connection between the power-supply line and the d.c. output circuit as is standard with universal a.c.—d.c. receivers and therefore a line isolation transformer was employed. The most practical commercial transformer found for the purpose is the United Transformer Company type "UTM." This transformer is designed to couple the plate of a power tube to a magnetic speaker. The secondary has two taps, one for a 7,000 ohm speaker and the other for a 4,000 ohm reproducer, it is this latter winding which is used, making it a 1.1 transformer. To drop the power line input voltage to 6.3 volts for the filament of the 6H6 tube, a standard 360 ohm line resistance cord is used. One side of the power line is con-

Figure 5



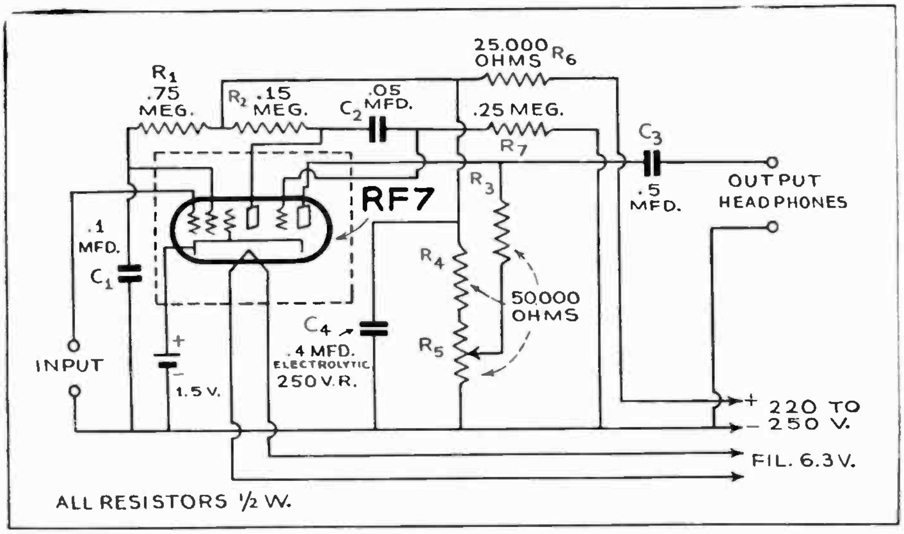


Figure 6—Circuit of the instrument amplifier.

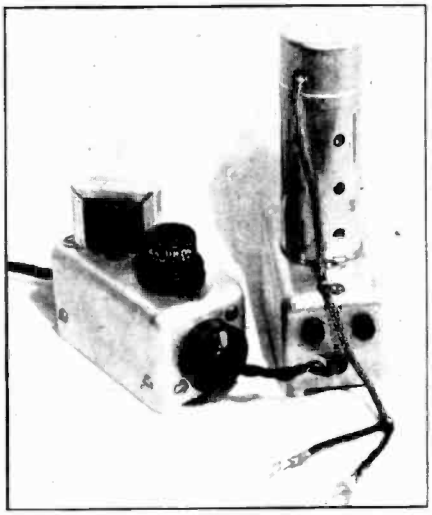


Figure 7

nected to the negative side of the output through the .05 mfd. condenser, C3.

In most applications the 2 voltage doubling condensers C1 and C2 provided the necessary filtering, where additional filterage was required, the resistance-capacity filters of the amplifier proved sufficient. When the unit is to be used to test condensers, it is best to use a 50,000 ohm resistor in series with the positive lead. This is to prevent a short circuited condenser from burning out the rectifier tube.

Instrument Amplifier

IN order to obtain a more accurate balance in bridge measurement work in which a thousand cycle note was used as the voltage source, the special audio amplifier using a 6F7 tube shown in Figure 6 was constructed and with phones connected in the output, very satisfactory results were obtained with it as a balance indicator.

What was needed for this purpose was an amplifier of reasonably high gain with an output suitable for phones and means of preventing the output from reaching too high a level.

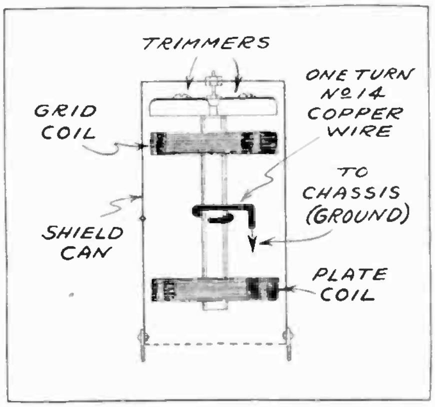
After experimenting with a number of tubes, the 6F7 type was selected, because it was possible to obtain a compact two-stage amplifier of high gain with a single tube. The phones are connected in the output of the triode section of the tube.

Limiting the output was secured simply by lowering the plate voltage through R4 resistor, thereby reducing the plate signal voltage swing. The high level signal was considerably distorted due to the tops of the signal being flattened out on the negative and positive peaks from overload. In order to control this action the triode plate voltage was made adjustable by means of the potentiometer R5.

The amplifier was so satisfactory that it was used as a general purpose amplifier for testing coils, as a detector-amplifier, as a preamplifier for a crystal microphone and as a means of increasing the sensitivity of an output meter.

The illustration (Figure 7) shows the amplifier connected to the midget instrument power supply described elsewhere in this section. This tiny power pack using the type 6H6 tube as a rectifier in a voltage-doubling arrangement supplies the operating voltages for the amplifier.

Figure 8



New Kink for Increased Selectivity

THE selectivity of a standard i.f. transformer can be increased considerably by simply winding a single turn of No. 14 bus wire around the core between the two coils and grounding it to the chassis as shown in Figure 8. The grounded turn reduces the coupling between the plate and grid tuned circuits.

Experiments with iron-core transformers seem to indicate that the single turn of copper wire has about the same effect as moving the two coils one-half inch farther apart. When the wire is disconnected from the chassis, the coupling and selectivity of the transformer returns to normal.

Useful Earphone Circuits

IT'S a proven fact that a good pair of earphones is superior to a loudspeaker for the reception of weak signals. The experienced DX hunter knows this and turns to his phones when fine work is to be done. There is, however, a decided prejudice against the use of phones by many of the newcomers to DX hunting. This feeling can usually be traced to an initial experience where phones were used in a set which did not provide them with proper volume control.

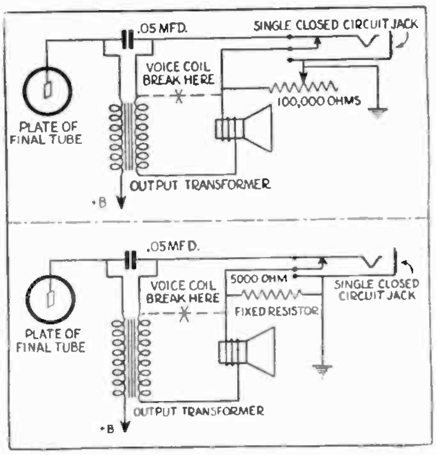
It has been a general practice to place the phone jack in the circuit directly after the first stage of audio amplification and in some receivers this works out satisfactorily. There are, however, many cases when more audio amplification could be used to advantage. The signal-to-noise ratio on most superheterodynes, for instance, can be increased by reducing the i.f. gain and increasing the audio amplification. Also on many regenerative and t.r.f. receivers one stage of audio, resistance-coupled to the phones, is not quite enough. On the other hand, when the phone-jack is installed in the final output stage there is too much gain for comfort and the volume control often becomes critical.

The two circuits shown are designed to overcome these common faults and give perfect earphone control on any type of set. Either one can be easily incorporated in sets which now lack phone connections. Figure 9 serves two purposes: it acts as a volume control for the earphones, when they are inserted in the jack and when the earphones are removed the same potentiometer serves as tone control for the speaker. Sets which already have a tone control in the plate circuit of the output tube can be shifted over to this circuit by the simple expedient of mounting a single closed circuit jack on the chassis and cutting it in on the voice coil of the speaker as shown in the diagram.

Figure 10 is essentially the same circuit except that a fixed resistor is used, the value of which has been chosen so that the maximum audio gain that can be utilized is delivered to the phones and yet they are protected against overloading even when the regular volume control on the receiver is fully advanced. Both of these arrangements allow the regular volume control on the receiver to operate smoothly in a normal manner, without critical adjustment.

In both of these circuits the earphones are isolated from the high-voltage d.c. so that they cannot be harmed and are operating at their maximum efficiency. This

Figure 9, top; Figure 10, bottom.



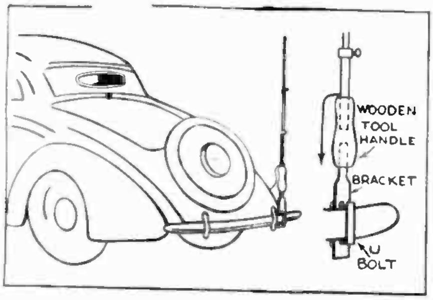


Figure 11

also eliminates any chance of shock from the phone plug or case. It will also be noted that the speaker is cut out when the phones are in use.

Car Aerial From Old Music Stand

THE trend of aerials for motor radio seems to be for the upright type, generally consisting of a telescopic rod insulated and mounted on the bumper rod. This little kink shows how to make a motor car antenna of this type from the metal upright support of an old music stand. It can be adjusted to its full length easily and quickly, and in tests has proven very satisfactory.

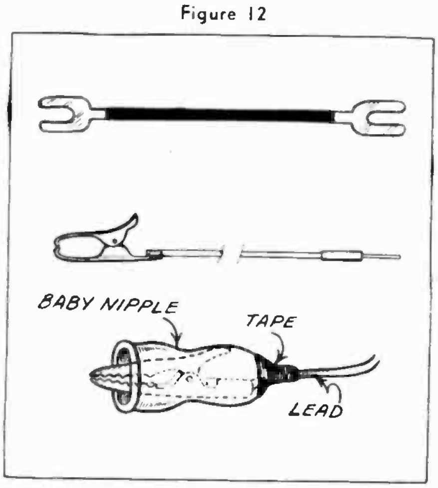
The drawing (Figure 11) shows that a long wooden tool handle is the insulated sleeve between the antenna rod and iron bracket. Do not drill the holes in this handle over-size; they should be a snug fit to prevent undue vibration. The iron bracket of the stand fastens to the car bumper by means of a U-bolt, as shown.

Rewinding Old Transformers For 6-Volt Tubes

PRESENT day radio apparatus more and more favors the use of 6.3 volt tubes and many amateurs and experimenters find themselves with surplus filament and power transformers useful only with the 2.5 volt tubes. These transformers can be easily revamped for use with 6.3 volt tubes. Here is how to rewind one of these units; first take the transformer laminations apart, then take the insulation off the coil uncovering the filament windings, they are usually the top windings. Knowing the voltage of one of these filament secondaries, then counting the turns on this same winding, you can find the turns-per-volt relation by dividing the turns by the voltage. Now then all you must do to find the turns for the 6.3 volt winding is to multiply the turns per volt value by 6.3. Since the 2.5 volt tubes require from three to six times as much current as the 6.3 volt tube, you can readily see that you can easily put the extra turns in the same winding space because the wire can be much smaller.

If you are going to draw a total filament current of 1 to 1½ amperes use No. 18 wire; for 2 to 2½ amperes use No. 16 wire, and for 4 amperes use No. 14 B and S wire. Another suggestion: One could take all the secondaries off one of these power transformers and rewind enough secondaries to make a universal filament power supply for use in a tube checker.

Figure 12



Handy Connecting Leads

THE following hints are of use to all radio experimenters and set builders. The devices shown in Figure 12 are easily made and are time savers in all kinds of radio testing.

The first is a handy connecting lead of No. 18 stranded push-back wire with large spade type lugs at each end. Use a half dozen leads of 6-inch length, and the same number of 12-inch length. The drawing for this kink is self-explanatory.

The second device is also a connecting lead, but it makes use of a Muller or Morse clip and a phone tip. Number 18 stranded rubber and cotton-covered wire is used for this lead. After the covering has been removed about ¾ of an inch at each end of the lead, clean, twist, and tin the wires. Set the phone tip in a vise and fill with solder, then push the lead into the tip and allow to cool. The other end can be made fast to the clip by pushing the lead through the sleeve and hole at the end of the clip. For a neat and lasting job, it is important that you use electrician's rubber tape for binding the ends.

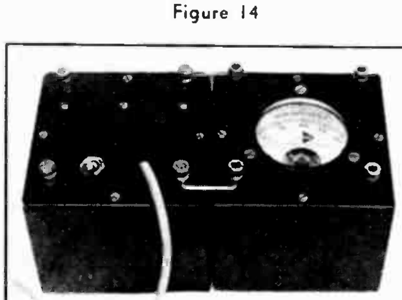
The third makes use of a baby's nipple and if you are a family man and have such things in the house, you can use discarded nipples to advantage for this idea. Cut a ¼-inch hole at the tip and stretch over the clip, tape as shown, and you have an insulated clip, neat in appearance and safe to use for those "hot" connections.

Output Meter Using 6H6 Tube

AN easily constructed output meter with a very low frequency error can be made with a type 6H6 rectifier tube used in conjunction with either a 1-milliampere or a 200-microampere meter as shown in the accompanying drawing and illustration (Figure 13 and 14).

The instrument has been tested up to 20,000 cycles with less than 5 percent error. To use it, simply connect the input leads across the voice coil. The 10-ohm resistor, R1, is utilized to reduce the filament voltage, thereby decreasing the contact (no signal) emission to less than 5 microamperes. An inexpensive transformer with a 6-volt winding is used to furnish the filament voltage.

Figure 14



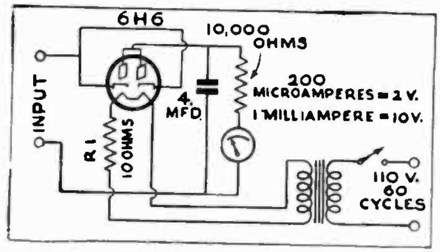


Figure 13

Referring to the illustration, the box at the left contains the filament transformer, tube, switch, resistors and condenser; the second box, as shown, houses the meter. The boxes are 4 inches square. The experimenter can set up this equipment to suit his individual convenience.

6H6 Oscillator

RECENTLY while working with several 6H6 type tubes in a laboratory setup where the metal sheel of the tube was floating, that is not grounded, it was noticed that there was current flow to the shell. Of course in a standard application of this type tube the shield is grounded and this effect would not occur.

The above conditions suggested that the tube might be used as a triode by tying the diodes together, also the cathodes and

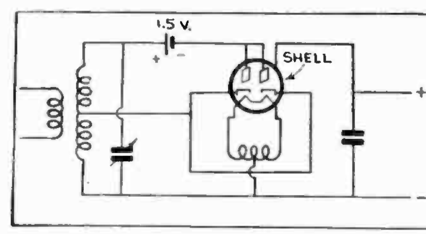


Figure 15

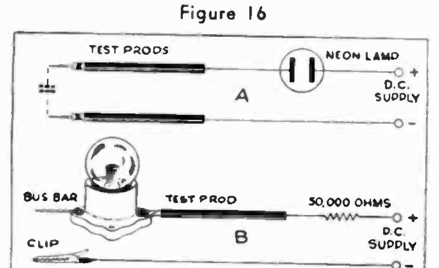
applying a potential to the shell. This was tried and it was found that, with 250 volts applied between the cathode and the shell the current measured was 1 milliampere. The amplification factor was from 4 to 7 with a plate resistance of .1 to 1 megohm.

Using the tube in this way it was found that it would oscillate at either radio or audio frequencies, depending upon the constants of the LC circuit employed. The circuit is shown in Figure 15.

Improved Condenser Tester

NEON condenser tester, as originally connected in Figure 16A, falsely indicated leakage in several good condensers. This condition was brought about by minute leakage through the insulation of the test leads, creating a high resistance path through the hands and the body. To remedy this condition the neon tube was connected at the end of the test handle as

Figure 16



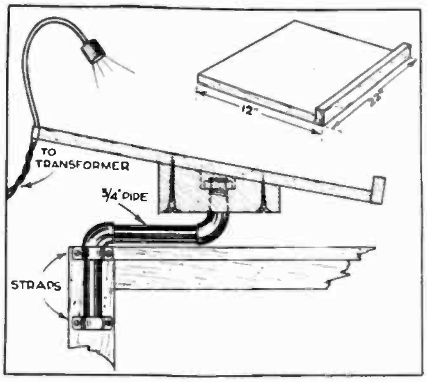


Figure 17

shown in Figure 16B. In this method any possible leakage across the leads can not go through the neon tube.

An alligator clip forms a convenient negative test lead, also facilitates testing. With the clip connected to one side of the condenser under test there will be only one hand in the circuit and therefore no circuit through the body. Also, both tube and prod are constantly in view, so you will not miss the quick flash produced by a small condenser and think it open. Using 90 to 250 volts, a quarter-watt neon tube with 50,000 ohms in series is an ideal combination. For 300 volts and higher, use 100,000 ohms in series to protect the tube in case of a short.

Removing Chassis Smudges

IF your radio receiver is without benefit of cabinet or dust-cover and has a number of unattractive finger marks and smudges, try using Gre-Solvent. It will remove the spots easily and quickly. Equally good results may be had on white metal, electroloy and other composition metals.

Rack For Radio Manuals

IT is the general experience of anyone connected with a service shop or laboratory, that aften ten minutes work, the bench even though it be a large one, is covered with various parts, test equipment, tools and whatnot and there is no place for the service manual or text book which one requires for the job at hand.

The accompanying drawing (Figure 17) shows a book rack arrangement which will prove extremely helpful. It is no job at all to construct and mount this rack and the builder will find the drawing complete with all dimensions. For the book rest itself, use ¾ inch pine and for its swivel support employ ¾ inch standard conduit. The most convenient place for mounting the rack is the front corner of the bench.

The light and bracket are made from an auto-fender guide. A coil shield from an old Readrite oscillator, came in handy as a reflector. A regular filament transformer operating from the 110 volt 60 cycle a.c. line, furnishes 6.3 volts for the dial lamp. Painting the inside of the coil shield with a flat white improves the reflection. The rack can be swung clear and away from the bench when not in use.

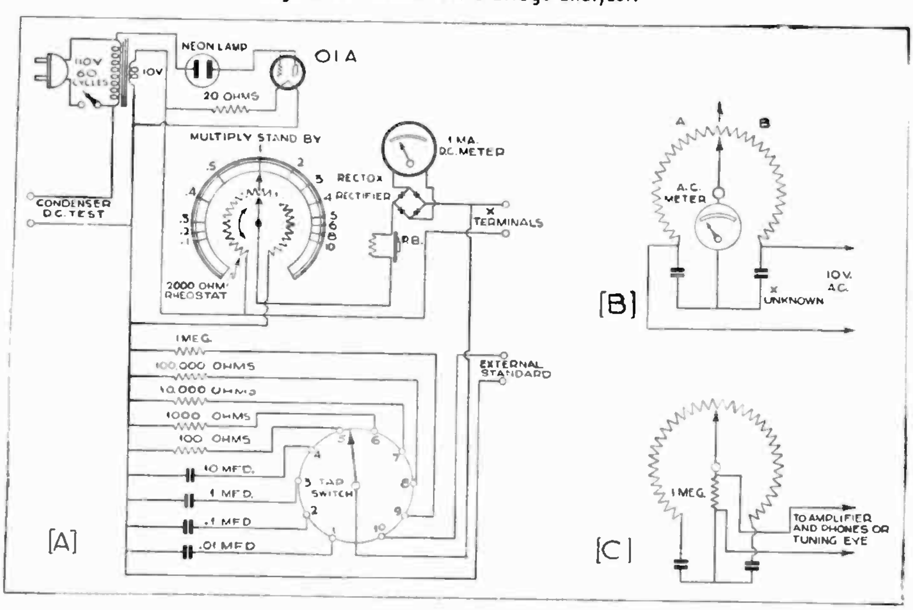
Homemade Bridge Analyzer

THIS handy testing and measuring device, useful to the experimenter as well as the serviceman, is easily constructed and its operation is extremely simple. It can be employed for checking condensers, for finding the value of fixed resistors, volume control, etc., for reactance measurements and other applications.

The operation of the instrument is based on the Wheatstone bridge balance principle, using a rectifier and sensitive meter. Ten volts a.c. is applied to the bridge circuit, and a balance is obtained by a continuous and uniformly variable A-B ratio as shown on the sketch. For this purpose a 2000-ohm wire-wound rheostat is used. To the rheostat knob a pointer is attached which indicates on a scale the A-B ratio multiplier. This ratio scale is marked in by connecting various known values in the X arm of the bridge (at terminals marked X in Figure 18) and balancing the bridge by turning the rheostat until the galvanometer shows zero deflection. Once the scale is marked any unknown value of capacity or resistance can be read quite accurately by connecting at X, setting tap switch for lowest reading on the meter and finally balancing the meter to zero by adjusting the rheostat. The value of X then is the product of the scale reading and the standard used. Unusual values may be obtained by connecting a special standard at the terminals provided and using in the same way, setting tap switch in Position 10. Choke coil or transformer impedance may readily be compared in the same way.

A d.c. condenser test is provided with the usual neon lamp and rectifier. This is so familiar that it does not need an explanation. This instrument can be used as an output meter, as a continuity tester for locating defective parts, etc. A tuning eye, type 6G5 or headphones could be used instead of the meter for the balance indicator. In this case a one-stage amplifier would be necessary and connected at the points in drawing "C."

Figure 18—Circuit for a bridge analyzer.



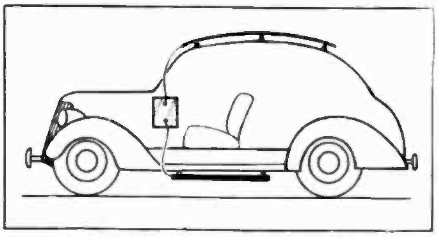


Figure 19

Antenna Kink For Motor Car Radios

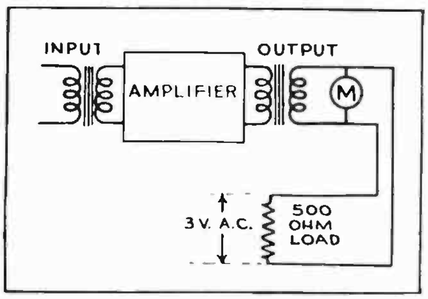
THE signal strength of an automobile set using any type of roof or car top antenna can be increased from 20 to 40 percent by using a counterpoise antenna as shown in Figure 19. The counterpoise can be mounted under the car chassis or under the running board and for this purpose a standard under-car aerial is used or an improvised antenna can be made from two or three continuous spans of No. 18 insulated wire fastened to any of the projecting bolts on the chassis at the front and rear of the car.

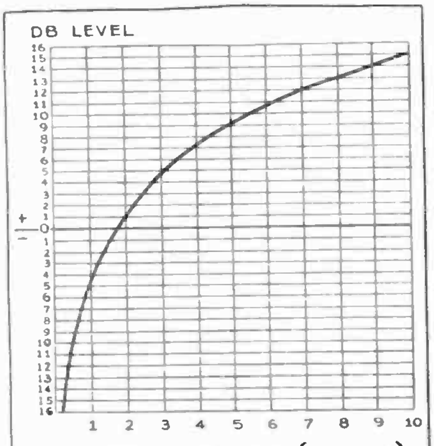
To make this item work, it is first necessary to perform a slight operation on the primary winding of the antenna coil. One end of this winding is connected to the aerial, while the other end, in most receivers, is connected to the ground end of the secondary winding thus completing the ground circuit. Now this end of the primary winding should be disconnected from the secondary and brought out to the counterpoise aerial under the car. Try this kink and you will be surprised at the increased pick-up.

A Decibel Meter

THERE are many occasions where the experimenter, the serviceman and the sound engineer desires to know the db. level at the output of an audio amplifier. He may wish to know the db. level of some sound installation that has to be run at a constant volume. After inspection of his measuring equipment he will probably find that while he has meters that may be used as output measuring devices none of them will be calibrated in decibels. Output meters used in service equipment

Figure 20





CALIBRATION OF A (0 TO 10 V.) METER IN DB UNITS.

Figure 21

are often nothing more than high-resistance a.c. meters, usually made by connecting a d.c. meter to a copper-oxide rectifier. These meters may be calibrated in decibels in a very simple manner.

Using an 0-10 voltmeter as an example and to calibrate it in db. the following formula is used.

(1) Above zero level, the db. level equals

$$10 \times \log \frac{\text{power in watts}}{.006}$$

(2) Below zero level, the db. level equals

$$-10 \times \log \frac{.006}{\text{power in watts}}$$

To determine the power level divide the square of the voltage by the resistance the meter is placed across, as in Figure 20 or in the example below. It is assumed, of course, that the measurements are made with a load connected of either a transformer or a resistance of 500 ohms.

$$\frac{3^2}{500} = \frac{9}{500} \text{ or } .018 \text{ Watts}$$

If you have an audio voltage of three volts developed across 500 ohms the power level equals .018 watts. To determine the db. level:

$$\frac{.018}{.006} = 3. \quad 10 \times \log 3 = 3.7 \text{ db.}$$

Since .006 watts is taken as our reference level, any power above this will give a positive db. level and any power less than this will give a reading below zero level. If we have an audio voltage of one volt developed across 500 ohms the db. level equals:

$$-10 \times \log \frac{.006}{.002} \text{ or } -4.78$$

as is shown by formula No. (2) as given above. Continuing this process we have the following table from which we may calibrate our meter.

.25 volts	minus	16.8 db.
.5 volts	minus	10.8 db.
1.0 volts	minus	4.78 db.
1.5 volts	minus	1.24 db.
1.73 volts	minus	0.00 db.
2.0 volts	plus	1.2 db.
2.5 volts	plus	3.8 db.
3.0 volts	plus	4.7 db.
3.5 volts	plus	6.00 db.
4.0 volts	plus	7.2 db.
4.5 volts	plus	8.3 db.
5.0 volts	plus	9.2 db.
6.0 volts	plus	10.7 db.
7.0 volts	plus	12.1 db.
8.0 volts	plus	13.00 db.
10.0 volts	plus	15.00 db.

This is the chart that would result when the meter is placed across a 500 ohm load (See Figure 21). Should we wish to use the meter across lower loads, we may do so by recalibrating the meter, but unless a meter of very high sensitivity is used, results are unsatisfactory.

NOTE: *The figures above neglect the resistance load of the meter, but will be sufficiently accurate for all practical purposes.*

Handy Containers For Nuts And Bolts

A PRACTICAL and time-saving container for small nuts, bolts, washers, soldering lugs, clips, etc., are ordinary muffin tins, obtainable for a dime apiece on the household-goods counter of any chain store. The six-muffin size is just right. Black molded-composition button trays are also very good.

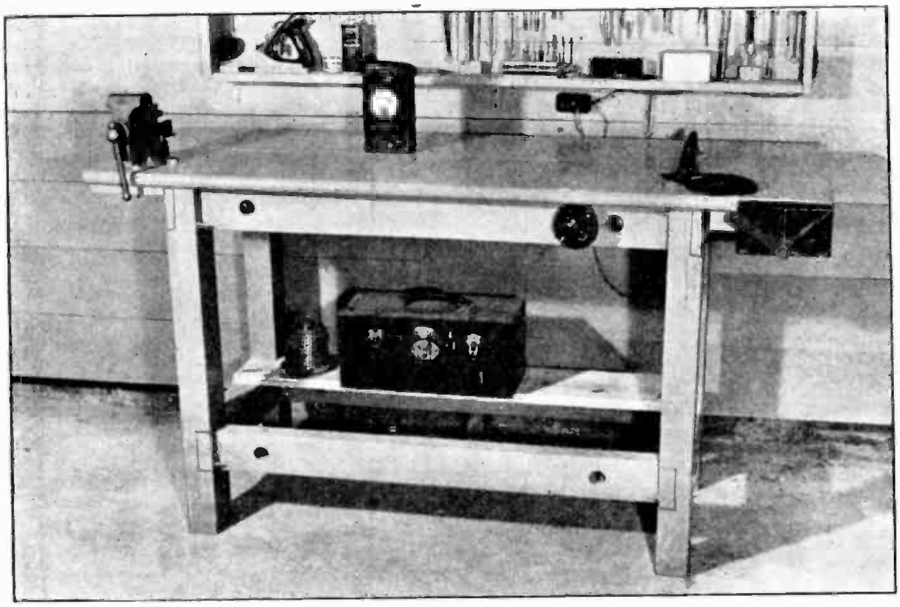
Keep only one type or size nut, bolt, etc., in each compartment and you will never have to fumble around when you're looking for that particular piece of hardware. The open tins also tell instantly when your

Figure 22

stock is getting low, and you'll order replenishments before you find yourself stuck with a service job that can't be finished because one nut is missing. Another advantage is that the muffin tins stack well where space is at a premium. (See Figure 22.)

Glass jars, cigar boxes and little wooden chests look nicer, but the muffin tins are much more practical.

Figure 23—An ideal work bench.



Work Bench For The Small Shop

A DAY or two spent in building a strong, solid work-bench is an excellent investment of time by any radio serviceman or experimenter who expects to obtain real profit or pleasure from his work. No great carpentering skill is necessary. and the only tools needed are a saw, a brace, the necessary bits, a chisel and a hammer.

The bench illustrated in Figure 23 is ideal for the small shop. The legs are made from 4 x 4 inch lumber 31 inches high. They are joined at the end in pairs. Flush with the tops, and 6 inches above the floor line, are 4 x 4 inch cross pieces 21 inches long, cut to form simple half lap joints. Five-inch long carriage bolts, 1/4 inch in diameter, hold these pieces in place. The long rails, running flush with the tops of the legs and also six inches above the floor (to meet the bottom half-lap joints) are "2 by 4's", each 44 inches long; four pieces are required. Now here is the whole secret of the excellent solidity of this bench: the rails are held against the inside surfaces of the upright legs by carriage bolts 6 inches long and 1/2 inch in diameter. The bolts run through the legs and endwise into the rails, the nuts being applied over their ends in 1 1/4-inch holes which are bored through the face of the rail about 4 inches from the ends as shown in the photo. To line up the legs and rails while boring the 1/2-inch holes, nail them together temporarily; remove the nails after the bolts are tightened.

The top of the bench consists merely of 2 pieces of "step boards," measuring 5 feet long by 11 1/2 inches wide, centered over

Figure 24

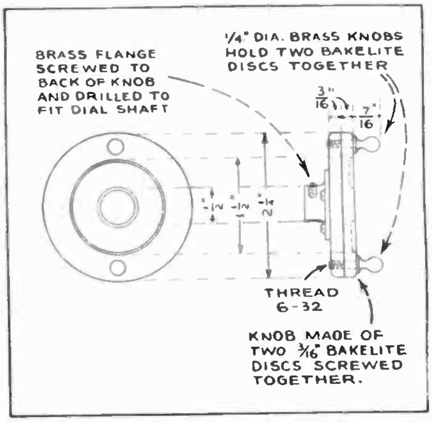


Figure 25

the framework and fastened by twelve 5-inch carriage bolts ¼ inch in diameter. These bolts run clean through the front and back rails and side rails.

The completed bench is given three coats of orange shellac to prevent absorption of moisture and possible warping. Important: don't forget to turn the table over and let the shellac soak into the end grain of the legs. Vises, electric outlets, shelves, etc., are readily installed to suit the builder's requirements. The total cost of materials for the bench was under five dollars.

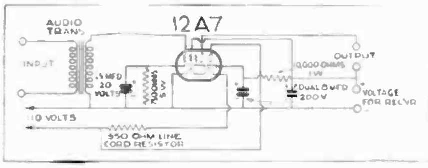
A few don'ts: Don't use nails, thin legs, ordinary soft "shelving" boards or knotty lumber. Follow the specifications and you'll have a sturdy workbench that will give you many years of service.

Handy Tuning Knob

FIGURE 24 shows a 2¼ inch diameter knob to use in place of the ordinary knob on a vernier dial on a short-wave set. Attached to such a dial, the large knob provides still finer vernier action and it does not cramp the fingers during a long hunt for short-wave stations. The two small brass balls allow the dial to be quickly turned from one end of the scale to the other. Single and double brass knobs were both tried but the use of two was found best.

Combination Power Supply And Audio Amplifier

THIS piece of equipment should be useful in any experimenter's workshop. It may be used with small r.f. tuners, for testing and other similar purposes. This combination unit is made possible by the



dual purpose 12A7 tube operating as a rectifier and a screen-grid amplifier. The speaker is connected to the terminals marked "output" shown in the circuit.

The knob is made up of two pieces of ⅛-inch bakelite from an old panel; the brass knobs hold both pieces together as one piece is drilled to clear a 6-32 thread while the rear piece is tapped for the 6-32 threaded ends of the brass knobs. While a lathe could be used to real advantage to turn up the bakelite discs, by careful work in sawing and filing and mounting upon a rod held in the chuck of a hand drill for finish turning, this work can be done by hand. A brass flange was turned up, drilled for the shaft and screwed to the rear of the disc.

Home-Made Stand For Single-Button Mikes

FROM all reports there are thousands of "Hams" using relatively inexpensive Western Electric single-button carbon microphones of the type shown in the illustration. Unfortunately, however, in many cases where this type of "mike" is used, the amateur is stumped for a neat and convenient mounting.

The accompanying photographs (Figures 25 and 26) show the microphone mounted in a home-made desk-style stand of smart professional appearance. The features that will recommend this stand to "Hams" are its simplicity of construction and low cost.

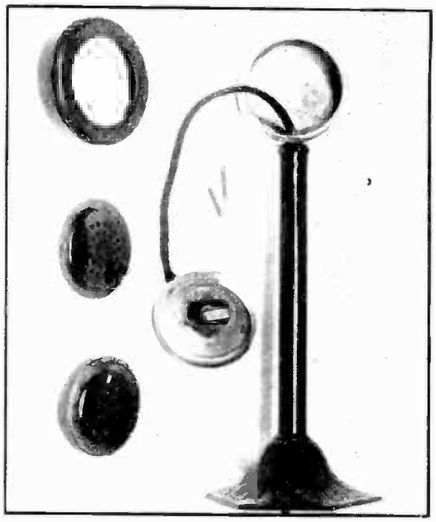


Figure 26

The few parts required for the stand consist of a 1931 Chevrolet chrome-plated crank-hole cover (from a neighboring auto junk yard) which serves to house the microphone; a piece of brass pipe about 8 inches long with gasoline line compression fittings soldered into each end, and a metal base which can take any form desired from an ornamental ash tray or a plain circular disk to whatever your junk pile or hardware dealer can supply. The case is made fast to one end of the brass pipe, serving as the upright by slipping the threaded end of the pipe through a hole previously made in the case and fastening it with a nut on the inside of the case as shown. The other end of the upright is passed through the base and secured in the same manner.

Figures 25 and 26 show the completed stand and the disassembled microphone. The aluminum case of the microphone is fastened in the crank hole cover by means of two machine screws, inserted through two holes drilled in this cover in line with the two threaded holes which are originally and conveniently in the microphone case. When the "mike" case has been secured to the stand, the carbon button dust cover and the cap are then replaced. Two coats of black enamel on the base and upright provide a finished appearance.

AMATEUR AIDS

Learning the Code

THE problem of learning the code is, and probably will continue to be, the principal obstacle in keeping many potential amateurs from qualifying for licenses. Many listeners have sufficient technical knowledge to meet the license requirements, but the bugaboo in most cases is mastering the art of telegraphy. Many have written to RADIO NEWS in the past asking how to go about it.

Few instructors agree on the best procedure to learn the code. To go about it, the first requirement is to master the Continental alphabet. Only a few hours are necessary to learn the code equivalents of the letters and numbers. This is of course the essential starting point. One learns that letter "a" is "dot-dash," etc. The ultimate goal is *to learn to think in the code equivalent of the letter!* That is, when "dot-dash" is heard in the earphones, it should not be necessary to go through the reasoning process by thinking: "Dot-dash—now that is 'a'." By the time this is reasoned out, the sender probably would have sent two or three more letters and the receiver would be completely lost.

The point is: Learning the code is like learning a new alphabet—a sound alphabet. When "dot-dash" is heard it should not be necessary to think of the "dot and dash" as such, but actually as the letter "a." It should have the same effect on the mental process as if a speaker said "a." When one learns to "think" in the code equivalents of the letters, he has mastered the art of telegraphy. Reduced to its simplest terms, it is like learning a new set of ABC's.

Usually a younger person grasps it much more quickly than an older person. But once the alphabet is mastered, copying is like listening to someone spell a series of words and speed is limited only by the accuracy of the ear in recording the dots and dashes and the speed at which the receiver can write.

In learning the Continental alphabet some instructors have found it simpler to learn all of the dot letters first, then all of the dash letters, then all of the combinations of dots and dashes that are similar; i.e., for instance, "d" (dash-dot-dot) and "u" (dot-dot-dash), etc. Others prefer learn-

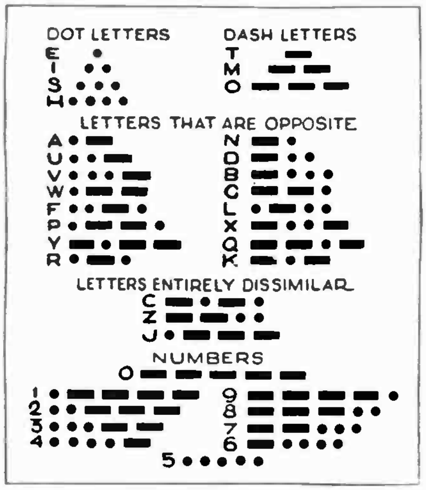


Figure 1

ing the code in the manner of learning the ABC's. The former method appears to be a little quicker than the latter, but actually there is not much difference. For the benefit of the beginner starting from scratch, these dot, dash and opposite combinations are illustrated here.

After the alphabet is mastered—that is, the dot-and-dash equivalents of the letters are memorized—the next step is to convert them into signals by means of a key. This is best done by taking the practice set, whether it be a key and buzzer or audio oscillator, and sending from a newspaper or magazine for a half hour at a time. Most important in this procedure is careful sending. Speed should not be a consideration at first. Each letter should be formed very carefully on the key, the dots being short and sharp, the dashes equivalent to about three dots and a slight pause between each letter.

Learning Alone

Sending to one's self by this method is the first step in actually learning the new alphabet. It will be found after several hours of practice it will no longer be necessary to think: "'a' is dot-dash. When the letter "a" is to be sent, the hand will automatically form the dot-dash equivalent.

When the operator has reached the stage where he believes himself capable of copying the sending of another person, he may listen in on the amateur telegraph bands and have a try at discovering what he can read. Don't be discouraged if at first only a letter here and there is identified. This represents real progress and it will be only a question of time before more and more letters are identified, then whole words, finally sentences. Learning the code sort

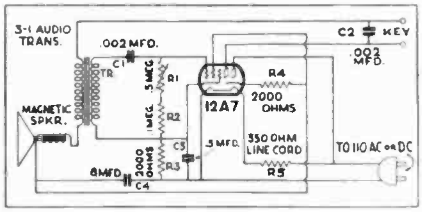


Figure 2

of proceeds in stages. The potential operator usually finds himself believing that he is making very poor progress and gets somewhat discouraged. Then, quite suddenly, his speed will take a jump. He might find himself stalled at say five words a minute for as much as a week, then he suddenly will find he can copy as much as ten words a minute accurately, and so on.

If the potential operator is fortunate in having someone who knows the code to help him by sending to him for half an hour or so at a time, or has a friend learning the code at the same time, progress will be made more rapidly.

Don't Use A "Bug"

One important suggestion is that the potential operator does not attempt to learn on a "bug" key. In the first place, under the present regulations it is necessary to qualify in sending at the same time the license code test is taken. The keys supplied by the Radio Supervisors are straight keys. Furthermore, it is much easier to learn to operate a "bug" key skillfully *after* the code is mastered.

The present code requirement for an amateur license is 13½ words a minute. This means approximately 67 characters a minute. A perfect copy is necessary, and the operator contemplating taking the examination should be able to copy at least seventy characters (letters and numbers) a minute with ease.

After one overcomes the barrier in learning the code equivalents of the letters, the matter of speed merely becomes a matter of practice.

Tone Oscillator Needed

While on the subject of learning the code, as stated above, good tools are necessary. A good key is important and a means of conveying the code sounds to the ear is essential. Something that will deliver a sharp, crisp tone is very helpful in mastering the dot-and-dash language. An excellent audio oscillator that is simple to construct and costs little is shown in Figures 2 and 3.

The gadget uses a small loudspeaker, a single tube, an audio transformer and a few resistances and operates directly from the 110-volt lighting lines. It is all contained on a chassis four inches square and

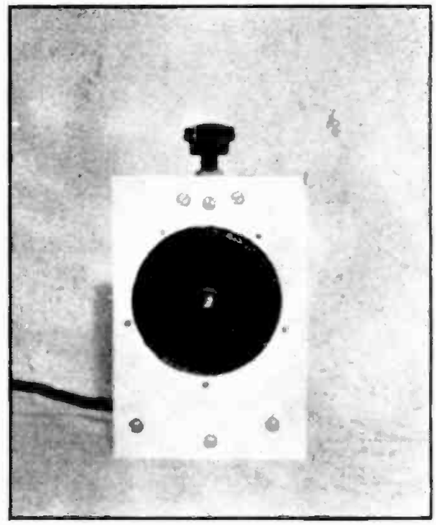


Figure 3

one inch high. The most interesting feature of this little unit is the use of a 12A7 tube which serves as both rectifier and oscillator tube. The filament is heated directly from the lighting lines, the voltage being reduced to the proper value by means of a 350-ohm resistor line cord.

The circuit for the oscillator portion of the unit is conventional. A 3-to-1 audio transformer is the integral unit. The secondary terminals are connected across the grid and cathode of the tube with a .002 mfd. by-pass condenser connected in series with the grid lead. Across the grid and cathode terminals of the tube are connected two resistances: one is 100,000 ohms fixed and the other a 500,000-ohm variable. This latter resistor provides a means for varying the pitch of the oscillator.

Another use for this device is as a tone modulator for a 5-meter transmitter. The output of the oscillator may be fed directly to the grid of the speech-input tube ahead of the modulators, or the loudspeaker may be placed fairly close to the microphone. In using it for modulating an ultra-high-frequency transmitter, care should be taken to prevent over-modulation.

Parts List
For The Audio Oscillator

One 3:1 audio transformer, TR
One 7-prong socket
One .002 mfd. condenser, 400 volts rating, C1
One .1 mfd. condenser, 400 volts rating, C2
One .5 mfd. condenser, 200 volts rating, C3
One 8 mfd. condenser, 200 volts rating, C4
One .5 meg. potentiometer, R1
One .1 meg. ½-watt resistor, R2
One 2,000-ohm, 1-watt resistor, R3
One 2,000-ohm, 1-watt resistor, R4
One 350-ohm line cord, R5
One 12A7 tube

Curing BCL Troubles

AMATEUR broadcast interference is, and has been since the inception of aural broadcasting, one of the most serious problems confronting the amateur operator. Recently there has been much discussion of this subject both editorially and before the Federal Communication Commission. There is much to be said about "rights" on both sides, but the fact remains that broadcast listeners outnumber the amateur at least twenty to one, and therefore, the amateur should do all within his power to keep such interference from becoming a handicap.

Indications are that most of the broadcast listeners' interference is caused by 'phone operators, and by far the greatest number of complaints are received by the authorities about stations operating on 160- and 75-meter bands. Higher frequencies seem to be comparatively free of interference complaints.

There is probably a good reason why 'phone operators bear the brunt of the complaints. Their signals obviously are understandable to the layman. Interference from c.w. stations, on the other hand, cannot be so easily tracked down. Frequently "key clicks" are mistaken for some form of electrical interference—in the same category with oil burners, vacuum cleaners, heating pads and other household appliances that cause much more interference than the amateur.

There is no reason why the amateur and broadcast listener cannot enjoy their respective hobbies and entertainment without serious interference. But the amateur should do all he can to keep interference at a minimum. He should constantly check with his neighbors to find out if he is causing any disturbance. He should co-operate in every way possible to prevent such complaints from becoming a menace.

Of course, it must be said, that listeners with antiquated receivers have little to hope for by way of eliminating an offending signal. The Federal regulations provide

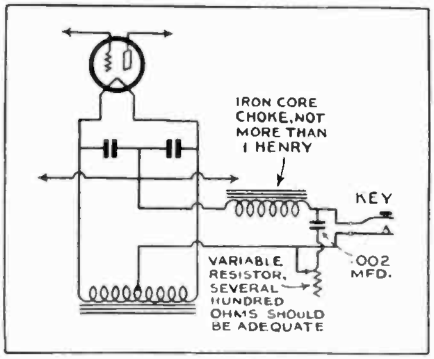


Figure 4

that amateurs are not required to observe quiet hours unless they interfere on "modern radio receivers." This automatically excludes old battery sets and others in the antiquated category wherein it would be impossible to eliminate interference from even the smallest-powered transmitter. In such sets, and particularly those with grid-leak detection, it frequently is possible to take out half the tubes in the set and still hear a nearby amateur signal.

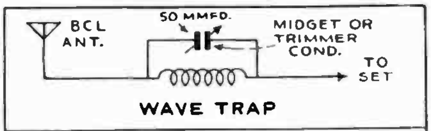
Elimination of broadcast interference should begin in the amateur's station. There is no reason why a station of reasonable power should cause any interference at all if it is properly adjusted. There are so many things that contribute to broadcast interference in a transmitter that the amateur operator should constantly check for trouble.

For instance, in a 'phone transmitter one of the most frequent causes of disturbance is the neutralization of the modulated and buffer stages. If the modulated amplifier is not properly neutralized, it will give the signal a "lisp," and the "lisp" will interfere with broadcast reception. Further, modulation percentage is another important factor. Over-modulation, of course, will cause serious disturbances, and frequently 100 percent modulation of a powerful transmitter is about as bad. If high power is to be used, it is a wise practice, particularly during the early evening when broadcasting listening is at a peak, to cut modulation peaks to between 80 and 90 percent. A transmitter so modulated, even up to a half-kilowatt of power, will cause practically no interference.

Killing Key Clicks

Key clicks are the severest form of interference caused by c.w. stations. Yet, key clicks are far more easily eliminated today than they were in the days of single tube transmitters. A filter will invariably do the trick. Diagrams of two such devices are illustrated in Figures 4 and 5. The keying method also is helpful. Keying in the oscillator circuit is one of the most practicable from this standpoint. If the key is inserted in series with the cathode-bias resistor, there will be practically no resultant click. This method may be employed with the 6L6 and 6A6 types of tubes more readily than with others. In the case of the 6L6 however, it is important that the voltage for the screen be obtained through a voltage divider, rather than a series-dropping resistor. Obviously, if the tube stops drawing plate current, the screen voltage will jump, with consequent damage to the tube if the latter method is used.

The main point in keeping BCL QRM at a minimum is keeping the transmitter in order. It will be found that the operator of the poorly-adjusted transmitter is the recipient of the most complaints. For this reason, 'phone stations on 160 meters frequently find themselves faced with many interference cases. In most instances the 160-meter man has a new



COIL DATA FOR FOUR PRINCIPAL BANDS

BAND	COIL SIZE
160 METERS	80 TURNS 2 IN.-No 24
80 "	35 " 2 " " 18
40 "	12 " 2 " " 18
20 "	7 " 2 " " 18

Figure 6

transmitter and it takes considerable experience before all of the "bugs" are ironed out. The majority of amateurs are eager to co-operate with the complaining listeners and help the hams who are causing trouble. If by any chance an operator finds himself in lots of "trouble" it might be a good plan for him to ask help of others who have been through the BCL QRM mill.

If interference cannot be eliminated by proper transmitter adjustment, and not all of it can, the simplest device for overcoming it is a wave-trap in the antenna circuit of the broadcast receiver. Circuits for such units are simple and they may be constructed for a few cents. It is better to spend a few cents, however, than to endure the complaints of listeners who frequently threaten to do everything under the sun to get the offending operator put "off the air." Wave-traps consist essentially of a resonant circuit, tuned to the frequency of the amateur's signal such as shown in Figure 6. They merely block out that frequency. They are effective in about 100 percent of otherwise incurable cases, and frequently will do the trick even on antiquated battery sets.

A Simple Method

Another and simpler method that frequently will work in not too serious cases is the insertion of an ordinary 2.5 millhenry choke coil in series with the antenna lead of the broadcast set. Such chokes, of course, cost only a few cents and in addition usually are effective at almost any amateur frequency. On the other hand it is necessary to install a wave-trap for each frequency used by the amateur causing the trouble.

Amateurs by and large are eager to co-operate with broadcast listeners. They naturally do not want to cause a disturbance in a neighborhood, and usually will go to great length to combat the problem. There are a few (a decidedly small minority) who seem to feel that they have a prior right to operate a transmitter by reason that they are licensed by the government.

Amateur—BCL Rights

Those who take this attitude are decidedly wrong. After all, both the amateur and the broadcast listener have their "rights"; the broadcast listener to his entertainment without interference; the amateur to his hobby. The broadcast listeners are in the majority, and should the "amateur menace" get beyond control, they undoubtedly would have a good case under the American system of government. It is up to the amateur to prevent any such situation from ever coming to pass.

If the amateur is courteous when he receives a complaint he undoubtedly can appease the listener to his satisfaction so each may enjoy radio. For instance, if a listener complains, the amateur should tell him it probably can be cleared up without difficulty. He should attempt to become friendly with the listener. It is not an unwise plan to invite him to see the "rig"

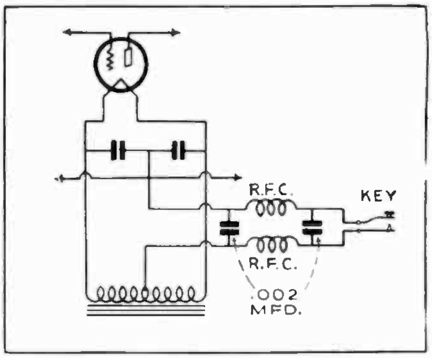


Figure 5

after things are straightened out. A majority of amateurs questioned on the problem have adopted this procedure. They find that by bringing the listener to the station, he becomes greatly interested in what the amateur is doing and usually departs a good friend and a firm believer in amateur activities, once in a while becoming an amateur himself.

What some amateurs will do to satisfy broadcast listeners is typically brought out in a case recently brought to our attention. In this particular case, the listener was next door to the amateur and his receiving antenna was directly under the transmitting antenna. The receiving set was a ten-year-old battery model. The listener complained not only to the amateur but to the Federal Communication Commission at Washington. Instructions were transmitted to the local radio supervisor to investigate.

The R. I. And His Kit

Accordingly, the inspector and an assistant appeared on the troubled scene, armed with all sorts of equipment including a "standard "receiver—a popular make midget super-heterodyne. Tests were made. It was found impossible to eliminate interference in the battery-operated set, despite the fact no signal could be heard on the "standard" set, except on the operating frequency of the amateur's station. Nothing could be found wrong with the operation of the transmitter. So it was suggested the two, listener and amateur, try to get together and solve the problem, it being explained to the listener that his antiquated receiver was the chief reason why he was experiencing interference. It was also suggested that the amateur keep off the air when there was something the listener wanted to hear.

However, the irate listener was not satisfied with this arrangement. He was not in position, financially, to buy a new set; so he demanded that the federal authorities require the amateur to buy him a "standard" set. This, of course, they could not do, it being entirely out of their province. However, the amateur in this particular case, to satisfy the listener, actually took his receiver out of his living room and "loaned" it to the listener.

This, of course, is an unusual case. There are not many amateurs in position to supply listeners with modern equipment to replace their antiquated sets. But, it does demonstrate the eagerness of the amateur to co-operate.

There are many amateurs who operate their equipment not knowing they are causing interference. It is a good plan to canvass the neighborhood frequently. In any event every effort should be made to prevent QRM cases from getting to the official files of the Commission; every one that does is a black mark, so the fewer in the future, the better for the amateur fraternity in general.

TRANSMITTING TUBE CHART

TYPE NO.	DESCRIPTION CATH	DESCRIPTION BASE	FILAMENT VOLTS	FILAMENT AMPS	CAPACITANCES (MICRO-MICRO FARADS) C_{GP}	C_{GF}	C_{PF}	APPLICATION	RATED VOLTAGES E_P	E_G	SC. GRID	SUP GRID	RATED MA. I_P	I_G	SC. GRID	POWER PL. DIS.	OUT PUT	DRIVER POWER WATTS	GRID LEAK OHMS
TRIODES																			
10	THOR. FIL.	MED. 4 PIN	7.5	1.25	7.0	4.0	3.0	CLASS C AMP-OSC.	450	-100			60	10		15	12	4.0	10,000
								CLASS B MOD. ⊗	425	-50	TWO TUBES		8				35		
UNITED HV12	THOR. FIL.	JUMBO 4 PIN	10.0	4.0	13.0	7.0	5.0	CLASS C AMP-OSC.	2000				250	60		200	300		
								CLASS C MOD-AMP.	1750				200	60		125	250		
RK18	THOR FIL.	MED. 4 PIN	7.5	1.25	5.0	3.8	2.0	CLASS C AMPLIFIER	1000	-150			85	15		40	50	3.0	15,000
T20*	THOR FIL.	MED 4 PIN	7.5	1.75	4.0			CLASS C AMP-OSC.	750	-100			75	17		20	42	5.0	6,000
								CL. B MOD. 2 TUBES⊗	800	-40			20				70		
RK24	OXIDE FIL.	SMALL 4 PIN	2.0	0.12	5.5	3.5	3.0	5 METER PORT. OSC	180	-45			20			1.5	1.2		
HV 27	THOR FIL.	JUMBO 4 PIN	10.0	4.0	14.0	7.0	4.5	CLASS C AMP-OSC.	2000				250	60		200	300		
								CLASS C MOD.-AMP.	1750				200	60		125	250		
								CLASS B MOD ⊗	2000										
RK30	THOR. FIL.	MED. 4 PIN	7.5	3.25	2.5	2.7	1.0	CLASS C AMPLIFIER	1250	-175			70	15		35	65	4.0	10,000
								CLASS C MOD.-AMP.	1000	-200			70	15		35	50	4.0	10,000
								CL. B LINEAR AMP.	1000	-55			42			35	14		
RK31	THOR. FIL.	MED. 4 PIN	7.5	3.0				CLASS C AMPLIFIER	1000	-50			85	15		35	50	5.0	3,000
								CLASS B MOD. ⊗	1250	0	TWO TUBES		30				140		
RK32*	THOR. FIL.	MED 4 PIN	7.5	3.25	3.0	2.0	1.0	CLASS C AMPLIFIER	1250	-250			100	25		50	75	7.5	10,000
								CLASS C MOD AMP.	1000	-185			100	25		50	50	7.5	7500
RK34*	OXIDE CATH.	MED. 7 PIN	6.3	0.8	2.7	4.2	2.1	CLASS C AMP-OSC.	300	-36			80	18		10	14		2000
								CLASS B MOD ⊗	300	-15			15				12		
RK35*	THOR. FIL.	MED. 4 PIN	7.5	3.25	2.7	3.5	0.4	TELEPHONY											
								CLASS C AMP. OSC.	1000	-320			100	20		35	65	7.0	20,000
								TELEGRAPHY											
								CLASS C AMP. OSC.	1500	-400			100	20		35	115	7.0	20,000
35T*	THOR. FIL.	MED. 4 PIN	5.0	4.0	1.9	2.5	0.3	TELEPHONY											
								CLASS C AMP-OSC.	1500	-180			100	20		35	120	4.0	5000
								TELEGRAPHY											
								CLASS C AMP-OSC	1500	-180			135	20		35	170	4.0	5000
	A MAXIMUM OF 2000 VOLTS CAN BE APPLIED TO THE 35T. PLATE DISSIPATION SHOULD NOT EXCEED 70 WATTS, 150 MA PLATE CURRENT FOR CW, 125 FOR PHONE							CLASS B MOD ⊗	1500				155				235		
RK36*	THOR FIL.	MED 4 PIN	5.0	8.0	5.0	4.5	1.0	CLASS C AMP-OSC.	3000	-360			165	35		100	370	15	
								CLASS C AMPLIFIER											
								TELEPHONY	2000	-360			150	30		100	200	15	15,000
RK37*	THOR FIL.	MED 4 PIN	7.5	3.25	3.2	3.5	0.2	CLASS C AMP-OSC	1250	-90			90	20		35	78	3.2	5000
								CLASS B MOD ⊗	1250	-32	TWO TUBES		32	29			125	2.8	
								CL. B LINEAR AMP	1250	-45			43			35	19	1.8	
								CL. B LINEAR AMP	PEAK OUTPUT 76 WATTS										
RK38*	THOR FIL.	MED 4 PIN	5.0	8.0	4.3	4.6	0.9	CLASS C AMP-OSC.	2000	-200			150	30		100	225	11.0	15,000
								CLASS B MOD ⊗	2000	-52	TWO TUBES		36	39			330	5.8	
								CL. B LINEAR AMP	2000	-100			75			115	55	7.0	
								CL. B LINEAR AMP	PEAK OUTPUT 220 WATTS										
T55*	THOR FIL	MED 4 PIN	7.5	2.75	3.75	4.0	1.5	CLASS C AMPLIFIER	1500	-200	40		150	25		55	168	15	8000
								OSCILLATOR	1250	-200	40		125			55	66		8000
F100	TUNGS FIL	SPECIAL	11.0	25.0	10.0	4.0	2.0	CLASS C AMPLIFIER	2000	-300			500			500	600		10,000
F108A	TUNGS FIL	JUMBO 4 PIN	10.0	11.0	7.0	3.0	2.0	CLASS C AMPLIFIER	3000	-350			200			175	400		15,000
HF100	THOR FIL	MED 4 PIN	10.0	2.0	4.5	3.5	1.4	OSCILLATOR	1200	-225			130	30		60	96		7500
								CL. B LINEAR AMP	1500	-55			75	1.5		80	42	PEAK 3	
								CLASS C AMPLIFIER	1500	-200			150	18		55	170	6.0	10,000
								CL. C AMP TELEPHONY	1250	-250			110	21		33	105	8.0	10,000
								CLASS B MOD ⊗	1500	-52	TWO TUBES		50				260	2.0	
100TL*	THOR FIL	MED 4 PIN	5.0	6.5	2.3	2.0	0.4	CLASS C AMPLIFIER	3000	-600			135	30		105	300		20,000
								TELEPHONY OR	2000	-400			150	30		75	225		15,000
								TELEGRAPHY	1000	-200			200	30		80	120		7000
100TH*	THOR FIL	MED 4 PIN	5.0	6.5	2.0	2.2	0.3	CLASS B MOD ⊗	1250	0							260		
								CLASS C AMPLIFIER	3000	-210			135	45		105	300		5,000
								TELEPHONY OR	2000	-140			150	45		75	225		3000
								TELEGRAPHY	1000	-70			200	45		80	120		1500
ZB120		JUMBO 4 PIN	10.0	2.0	5.2	5.3	3.2	CLASS B MOD ⊗	1250	0	TWO TUBES		95				245	4.0	
								CLASS B MOD ⊗	1500	-9	TWO TUBES		60				300	5.0	
								CL. B LINEAR AMP	1250	0	TELEGRAPHY		150	21		187	120	1.2	
	A SELF BIAS RESISTOR OF 750 OHMS SHOULD BE INCLUDED IN THE FIXED BIAS FOR THE CLASS C MOD-AMP							CL. B LINEAR AMP	1250	0	TELEPHONY		95	8		74	45	1.5	
								CLASS C AMPLIFIER	1250	-135	TELEGRAPHY		160	25		55	145	5.5	6000
								CLASS C AMPLIFIER	1000	-400			120	21		25	95	5.0	7000
								CL. C GRID MOD AMP	1250	-75			90	7		70	42	1.6	750
HK154*	THOR FIL	MED 4 PIN	5.0	6.5	5.9	4.3	1.1	CLASS C AMPLIFIER	1000	-380			175	20		48	127	10.0	20,000
								CL. C AMPLIFIER -1-	1250	-460			170	20		50	162	12.0	23,000
								CL. C AMPLIFIER -2-	1500	-590			167	20		50	200	15.0	30,000
					1-MAXIMUM FOR TELEPHONY			CL. B LINEAR AMP	1500	-265			52			50	28	5.0	
					2-MAXIMUN FOR TELEGRAPHY			CLASS B MOD ⊗	1500	-265	TWO TUBES		40			95	250	10.0	
								CLASS B MOD ⊗	1000	-155	TWO TUBES		60			100	200	10.0	
T155*	THOR TUNGS	JUMBO 4 PIN	10.0	4.0	3.0	2.5	1.0	CLASS C AMP-OSC	3000	-250			200	60		155	450		4200
T200*	THOR FIL	JUMBO 4 PIN	10-11	4.0	7.0	5.0	3.0	CLASS C AMP-OSC	2500	-300			350	80		200	500		3750
								CLASS C MOD AMP	2000	-300			350	80		200	500		3750
C200* HF200	THOR FIL	JUMBO 4 PIN	10.5	3.4	5.8	5.2	1.2	CLASS C AMPLIFIER	2500	-300	TELEGRAPHY		200	18		120	380	8.0	17,000
								CLASS C AMP *	1750	-300	TELEPHONY		200	30		80	270	14.0	10,000
								CLASS B MOD ⊗	2500	-130	TWO TUBES		60				600	8.0	
C201	THOR FIL	JUMBO 4 PIN	10.0	3.25	9.0	6.0	1.8	CLASS B MOD	1250	-45	TWO TUBES		160			75	250		
								CL. B. LINEAR	1250	-45			110			92	46		
								CLASS C AMPLIFIER	1250	-200	TELEPHONY		165	50		71	135		4000
								CLASS C AMPLIFIER	1250	-125	TELEGRAPHY		165	25		71	135		5000

*RECOMMENDED VALUES UP TO 56-60 MEGACYCLES—HIGH EFFICIENCY OBTAINED FROM THESE TUBES AT 56-60 MEGACYCLES.

⊗ STATIC PLATE CURRENT IS GIVEN UNDER "IP" FOR TWO TUBES.

TRANSMITTING TUBE CHART

TYPE NO.	DESCRIPTION CATH	BASE	FILAMENT VOLTS	AMPS	CAPACITANCES MICRO-MICRO FARADS C_{GP}	C_{GF}	C_{PF}	APPLICATION	RATED VOLTAGES E_P	E_G	SG	SUP	RATED MA I_P	I_G	SG	POWER PLATE DISS	OUT-PUT	DRIVER POWER WATTS	GRID LEAK OHMS
TRIODES																			
C202	THOR FIL	JUMBO 4 PIN	10.0	3.25	8.0	5.5	2.0	CLASS B MOD.	1250	-100	TWO TUBES		160			75	250		
								CL.B LINEAR AMP	1250	-100			110			92	46		
								CLASS C AMPLIFIER	1000	-260	TELEPHONY		165	50		55	110		5000
								CLASS C AMPLIFIER	1250	-260	TELEGRAPHY		165	25		71	135		10,400
203B	THOR-TUNGS	JUMBO 4 PIN	10.0	3.85	14.0	6.0	5.0	CLASS B MOD ⊗	1000	-35	TWO TUBES		40				200		
HD203A	THOR TUNGS	JUMBO 4 PIN	10.0	4.0	12.0	7.0	5.0	CLASS C AMP-OSC.	2000		TELEGRAPHY		250	60		150	300		3000
								CLASS C AMP-OSC.	1750	-180			250	60		150	300		3000
								CLASS B MOD ⊗	1750	-67.5	TWO TUBES		36				500		
203A 303A C203A	THOR TUNGS	JUMBO 4 PIN	10.0	3.25	14.5	6.5	5.5	CLASS C AMPLIFIER	1250	-125	TELEGRAPHY		150	25		100	130	7.0	5000
								CLASS C AMPLIFIER	1000	-135	TELEPHONY		150	50		100	100	14.0	3000
								CL.B LINEAR AMP	1250	-45			106			100	425		
HD203C	THOR TUNGS	JUMBO 4 PIN	10.0	4.0	9.0	6.0	4.0	CLASS C AMP-OSC.	2000	-200	TELEGRAPHY		250	60			250		3333
HD211C					9.0	5.0	4.0	CLASS C AMP-OSC.	1750	-200			250	60			250		3333
204A 304A 504A	THOR TUNGS	SPECIAL	11.0	3.85	15.0	12.5	2.3	CLASS C AMPLIFIER	2000	-175			250	50		250	350		5000
304B *	THOR TUNGS	MED 4 PIN	7.5	3.25	2.5	2.0	0.7	CLASS B MOD ⊗	1250	-110	TWO TUBES		40				140	10.0	
								CLASS C AMPLIFIER	1250	-180	TELEGRAPHY		100				85		
								CLASS C AMPLIFIER	1000	-180	TELEPHONY		100	25			65		7500
211 311	THOR TUNGS	JUMBO 4 PIN	10.0	3.25	14.5	6.0	5.5	CLASS C AMPLIFIER	1250	-225	TELEGRAPHY		150	18		100	130	70	10,000
								CLASS C AMPLIFIER	1000	-260			150	35		100	100	14.0	5000
								CL.B LINEAR AMP	1250	-100			106			100	425		
211C 311C	THOR TUNGS	JUMBO 4 PIN	10.0	3.10	9.0	6.0	5.0	SAME AS 311											
316A *#	THOR TUNGS	NO BASE	2.0	3.65	1.6	1.2	0.8	CLASS C AMPLIFIER	450		TELEGRAPHY		80	12			7.5	SPECIAL ULTRA	
								CLASS C AMPLIFIER	400		TELEPHONY		80	12			6.5	HIGH FREQ TUBE	
242C	THOR TUNGS	JUMBO 4 PIN	10.0	3.25	13.0	6.1	4.7	CLASS B MOD ⊗	1250	-80	TWO TUBES		50			100	200	25	
								CL.B LINEAR AMP	1250	-90			120				50		
								CLASS C MOD AMP	1000	-160			150	50			100		3200
250TL *	THOR FIL	JUMBO 4 PIN	5.0	10.5	3.5	3.0	0.5	CLASS C AMPLIFIER	3000	-600			330	45		240	750		13,500
								CLASS C AMPLIFIER	2000	-400			350	45		200	500		9000
								CLASS C AMPLIFIER	1000	-200			300	45		100	200		4500
250TH *	THOR FIL	JUMBO 4 PIN	5.0	10.5	3.3	3.5	0.3	CLASS C AMPLIFIER	3000	-210			330	55		240	750		3800
								CLASS C AMPLIFIER	2000	-140			350	55		200	500		2550
								CLASS C AMPLIFIER	1000	-70			300	55		100	200		1300
								CLASS B MOD ⊗	1400	0	TWO TUBES						575	APPROX.	
261A 361A	SEE 211C-311C																		
276A 376A	THOR FIL	JUMBO 4 PIN	10.0	3.0				SEE 211C-311C											
C300 HF300 *	THOR FIL	JUMBO 4 PIN	11.5	4.0	6.5	6.0	1.4	CLASS C AMP OSC.	3000	-400	TELEGRAPHY		250	28		150	600	16.0	14,300
								CLASS C AMPLIFIER	2000	-300	TELEPHONY		250	36		115	385	17.0	8300
								CL.B LINEAR AMP	2500	-100			120	0.5		195	105	6.0	
								CLASS B MOD ⊗	2000	-72	TWO TUBES		60				650	14.0	
300T *	THOR TUNGS	JUMBO 4 PIN	7.5	12.0	4.0	4.0	0.6	CLASS C AMPLIFIER	2500	-400			300	60		190	560	60.0	6700
								CL.B LINEAR AMP	2500	-150			200			300	200		
HK354C * HK354	THOR TUNGS	JUMBO 4 PIN	5.0	10.0	3.8	4.5	1.1	CLASS C AMPLIFIER	3000	-275			150	27		150	300		10,000
								CLASS B AMPLIFIER	3000	-275	TWO TUBES		390				665	36.0	
500T *	THOR TUNGS	SPECIAL	7.5	20.0	4.5	6.0	0.8	CLASS C AMPLIFIER	2000	-400			450	100		250	650		4,000
								CLASS C AMPLIFIER	3000	-600			450	100		350	1000		6000
								CLASS C AMPLIFIER	4000	-800			450	100		450	1350		8000
756	THOR TUNGS	MED 4 PIN	7.5	2.0	8.0	3.5	2.7	CLASS C AMP-OSC.	850	-75	TELEGRAPHY		110	20		34	60		3750
								CLASS C AMP-OSC	750	-75	TELEPHONY		110	20		34	48		3750
								CLASS B AMPLIFIER	850	-30	TWO TUBES		20				100		
800 *	THOR-TUNGS	MED 4 PIN	7.5	3.25	2.5	2.75	1.0	SEE RK30											
801	THOR TUNGS	MED 4 PIN	7.5	1.25	6.0	4.5	1.5	CLASS C AMP-OSC.	600	-150			65	15		20	25	4.0	10,000
								CLASS C AMP-OSC	500	-190			55	15		20	18	4.5	10,800
								CL.B LINEAR AMP	600	-75			45			20	7.5		
								GRID BIAS MOD-AMP	600				50	2.0		20	10	2.0	
805 905	THOR TUNGS	JUMBO 4 PIN	10.0	3.25	6.5	8.5	10.5	CLASS C AMP OSC.	1500	-105			200	40		85	215	8.5	2625
								CLASS C AMPLIFIER	1250	-160			160	60		60	140	16.0	2650
								CL.B LINEAR AMP	1500	-10			115	15		115	57.5	7.5	
								CL.B AMPLIFIER ⊗	1250	0	TWO TUBES		148				300	7.0	
806	THOR TUNGS	JUMBO 4 PIN	5.0	10.0	3.4	6.1	1.1	CLASS C AMP-OSC.	3000	-600			195	25		135	450	20.0	24,000
								CLASS C AMPLIFIER	2500	-600			195	40		97	390	32.0	15,000
								CL.B LINEAR AMP	3000	-240			70	0		140	70	5.0	
								CLASS B MOD ⊗	3000	-240	TWO TUBES		20				660	10.0	
808 *	THOR TUNGS	MED 4 PIN	7.5	4.0	3.0	5.0	0.2	CLASS C AMP-OSC.	1500	-200			125	30		47.5	140	9.5	6,700
								CLASS C AMPLIFIER	1250	-225			100	32		20	105	10.5	7,000
								CL.B LINEAR AMP	1500	-35			45	1.0			22	2	
								CLASS B MOD. ⊗	1250	-15	TWO TUBES		40				190	7.8	
814	THOR TUNGS	JUMBO 4 PIN	10.0	4.0	13.0	7.0	5.5	CLASS C AMP-OSC	2000	-400			300	75		200	400	300	5200
822	THOR TUNGS	JUMBO 4 PIN	10.0	4.0	14.0	8.0	6.0	CLASS C AMP-OSC	2000	-220			300	60		200	400		3700
								CLASS B MOD	2000	-90	TWO TUBES		50				500	30.0	
825	THOR TUNGS	MED 4 PIN	7.5	2.0	7.0	3.0	2.7	CLASS C AMP-OSC.	750	-180			110	25		40	50		7200
								CLASS B AMPLIFIER	850	-67.5	TWO TUBES		50				82		
830 930	THOR TUNGS	MED 4 PIN	10.0	2.15	9.9	4.9	2.2	CLASS C AMPLIFIER	750	-180			110	18		40	55	7.0	10,000
								GRID BIAS MOD AMP	1000	-200			50	2.0		40	15	3.0	
830B 930B	THOR TUNGS	MED 4 PIN	10.0	2.0	11.0	5.0	1.8	CLASS C AMP OSC	1000	-110	TELEGRAPHY		140	30		50	90	7.0	3670
								CLASS C AMP OSC	800	-150	TELEPHONY		95	20		26	50	5.0	7500
								CL.B LINEAR AMP	1000	-35			85	6.0			26	6.0	
								CL.B AMPLIFIER ⊗	1000	-35	TWO TUBES		20				175	6.0	
834 *	SEE RK32																		
841 941	THOR TUNGS	MED 4 PIN	7.5	1.25	7.0	4.0	3.0	CLASS C AMP OSC.	450	-32			50	12.5		8.5	14	1.25	2560
								CLASS C AMPLIFIER	350	-36			50	18		6.0	11.5	1.75	2000
								CL.B AMPLIFIER ⊗	425	-5	TWO TUBES		13				28		
841A	THOR TUNGS	MED 4 PIN	10.0	2.0	9.0	3.5	2.5	CLASS C AMP-OSC.	1250	-180			150	30			85		6000
								CLASS C AMPLIFIER	1000	-180			150	30					6000
838	THOR TUNGS	JUMBO 4 PIN	10.0	3.25	8.0	6.5	5.0	CLASS C AMP-OSC	1250	-80			150	30		100	130	6.0	3000
								CLASS C AMPLIFIER	1000	-35			150	60		100	100	16.0	3000
								CLASS B MOD ⊗	1250	0	TWO TUBES		74			100	130		

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TRANSMITTING TUBE CHART

TYPE NO	DESCRIPTION CATH.	DESCRIPTION BASE	FILAMENT VOLTS	FILAMENT AMPS	CAPACITANCES MICRO-MICRO FARADS Cgp	Cgf	Cpf	APPLICATION	RATED VOLTAGES Ep	Eg	SG	SUP	RATED MA Ip	Ig	SG	POWER PL DISS	OUT-PUT	DRIVER POWER WATTS	GRID LEAK OHMS
TRIODES																			
849 949	THOR TUNGS	SPECIAL	11.0	5.0	33.5	17.0	3.0	CLASS C AMPLIFIER	2000	-200			300	40		400	450		5000
								CLASS B MOD ⊗	2500	-130	TWO TUBES		20			400	500	7	
852 952	THOR TUNGS	MED 4 PIN	10.0	3.25	2.6	1.9	1.0	CLASS C AMP-OSC	3000	-600			85	15		100	165	12	10,000
								CLASS C AMPLIFIER	2000	-500			67	30		100	75	23	10,000
								CL. B LINEAR AMP	3000	-250			43			100	40		
831	THOR-TUNG	SPECIAL	11.0	10.0	4.0	3.8	1.4	CLASS C AMPLIFIER	3500	-400			275	40		400	590	30	10,000
TETRODES PENTODES																			
RK20 RK20A	THOR TUNGS	MED 5 PIN	7.5	3.0 3.25	.012	11.0	10.0	CLASS C AMPLIFIER	1250	-100	300	0	80	7-10	37	40	64	1.0	15,000
								CLASS C AMPLIFIER	1250	-100	300	+45	92	7-10	32	40	80	1.0	15,000
								SUPP. MOD. AMP	1250	-100	300	-45	43	7-10	36	40	18	1.0	15,000
RK23 RK25 RK25B	OXIDE CATH	MED 7 PIN	2.5 6.3	2.0 0.8	.02	10.0	10.0	CLASS C AMP-OSC	500	-90	200	0	50	6-8	40	10	18	0.8	15,000
								CLASS C AMP-OSC	500	-90	200	+45	55	6-8	35	10	24	0.8	15,000
								SUPP MOD. AMP	500	-90	200	-45	32	6-8	40	10	5.5	0.8	15,000
RK28	THOR TUNGS	JUMBO 5 PIN	10.0	5.0	.02	15.5	5.5	CLASS C AMPLIFIER	2000	-100	400	0	120	10-12	75	125	160	1.8	10,000
								CLASS C AMPLIFIER	2000	-100	400	+45	140	10-12	60	125	200	1.8	10,000
								SUPP. MOD. AMP	2000	-100	400	-45	80	10-12	85	125	60	2.7	10,000
RK39 RK41	OXIDE CATH	MED 5 PIN	6.3 2.5	0.9 2.4	0.2	13.0	10.5	CLASS C AMP-OSC	500	-60	250		95	3.0	12	42	35	0.26	10,000
								CLASS C AMPLIFIER	400	-50	250		95	2.5	8	33	25	0.18	10,000
								CLASS B R.F. AMP	500	-30	250		75	0.3	3		11		
305A*	THOR TUNGS	MED 4 PIN	10.0	3.1	0.14	10.5	5.4	CLASS C AMP-OSC.	1000	-270	200		125				85		
								CLASS C AMPLIFIER	800	-270	200		125				70		
								CLASS B RF AMP.	1000	-135	200		90			60	30		
306A	THOR TUNGS	MED 5 PIN	2.75	2.0	0.35	13.0	13.0	CLASS C AMPLIFIER PLATE & SCREEN MODULATED	300	-50	180		36	3.0	15		7		10,000
307A	THOR TUNGS	MED 5 PIN	5.5	1.0	0.55	15.0	12.0	SUPP MOD CL C AMP	500	-35	200	-50	40	1.5	20		6		
								CLASS C AMP-OSC.	500	-35	250	0	60	1.4	13		20		
802	OXIDE CATH	MED 7 PIN	6.3	0.95	0.15	12.0	8.5	CLASS C AMPLIFIER	500	-100	250	+40	45	2.0	12	10	16	0.25	15,000
								SUPP. MOD. AMP.	500	-90	200	-45	22	4.5	28	10	3.5	0.5	15,000
								CL. B LINEAR AMP	500	-28	200	0	25	0	7	10	3.5	0.18	
803	THOR TUNGS	JUMBO 5 PIN	10.0	3.25	0.15	15.5	28.5	CLASS C AMPLIFIER	2000		500	-30	160	16	42	125	210	1.6	5000
								SUPP MOD AMP.	2000		500	-50	80	1.5	55	125	53	1.6	5000
								CL. B LINEAR AMP	2000		500	-40	80	3.0	15	125	54	1.5	
804	THOR TUNGS	MED 5 PIN	7.5	3.0	0.01	16.0	14.5	CLASS C AMPLIFIER	1250	-100	300	0	80	7.0	33	40	64	0.9	15,000
								CLASS C AMPLIFIER	1250	-100	300	+45	92	7.0	27	40	80	0.9	15,000
								SUPP MOD AMP	1250	-100	300	-50	48	7.0	35.5	40	21	0.85	15,000
807	THOR TUNGS	MED 5 PIN	6.3	0.9	0.2	11.6	5.6	CLASS C AMP-OSC	400	-50	250		95	2.5	9		25	0.18	20,000
								CLASS C MOD-AMP	325	-75	270		80	1.5	9		17	0.15	50,000
								CL. B LINEAR AMP	400	-25	250		75	0	4		9	0.25	
					TWO TUBES			CL. AB MOD ⊗	400	-25	300		102	20			60	0.35	
850	THOR TUNGS	JUMBO 4 PIN	10.0	3.25	0.2	17.0	26.0	CLASS C MOD-AMP	1000	-100	140		125	45		60	65	10	5000
								CLASS C AMP-OSC	1250	-150	175		160	35		70	130	10	4300
860	THOR TUNGS	MED 4 PIN	10.0	3.25	0.08	7.75	7.5	CLASS C AMPLIFIER	3000	-150	300		85	15		100	165	7.0	10,000
								CLASS C MOD-AMP	2000	-225	300		67	30		69	75	15.0	10,000
								CL B LINEAR AMP	3500	-150	300		43			100	40		
861	THOR-TUNGS	SPECIAL	11.0	10.0	0.10	17.0	13.0	CLASS C AMPLIFIER	3500	-250	600		275	30		400	590	25	8000
865		MED 4 PIN	7.5	2.0	0.10	8.5	8.5	CLASS C AMP-OSC.	750	-80	125		40	5.5		14	16	1.0	14,000
								CLASS B MOD-AMP	500	-120	125		40	9.0			10	2.5	13,500
								CL. B LINEAR AMP	750	-30	125		22				45		

*RECOMMENDED VALUES UP TO 56-60 MEGACYCLES—HIGH EFFICIENCY OBTAINED FROM THESE TUBES AT 56-60 MEGACYCLES

⊗STATIC PLATE CURRENT IS GIVEN UNDER "IP" FOR TWO TUBES.

RECEIVING TUBES USED IN TRANSMITTERS

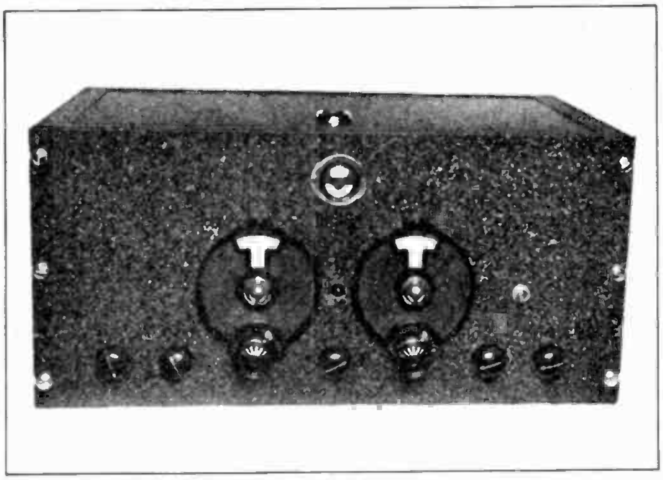
TYPE NO	CATH.	BASE	VOLTS	AMPS	Cgp	Cgf	Cpf	APPLICATION	Ep	Eg	SG	SUP	Ip	Ig	SG	PL DISS	OUT-PUT	DRIVER POWER WATTS	GRID LEAK OHMS
TRIODES																			
2A3	OXIDE	MED. 4 PIN	2.5	2.5	13.0	9.0	4.0	CLASS AB-PP-MOD	300	-62	TWO TUBES		80				15		750
								CLASS C AMP-OSC.	400	-180			100	10		15	25	3.0	50,000
6A3	OXIDE	MED. 4 PIN	6.3	1.0	16.0	7.0	3.5	SAME AS 2A3											
6A6	OXIDE	MED. 7 PIN	6.3	0.8				SEE RK34	PUSH PULL TRIODE										
6E6 #	OXIDE	MED. 7 PIN	6.3	0.6				SEE RK34	PUSH PULL TRIODE										
6N7G 6N7	OXIDE	SMALL OCTAL 8 PIN	6.3	0.8				SEE RK34	PUSH PULL TRIODE										
12A	THOR FIL	MED 4 PIN	5.0	0.25	8.0	3.5	2.5	CLASS C AMP.-OSC.	250	-90			80			9	11		20,000
19 #	THOR FIL	SMALL 6 PIN	2.0	0.26	PUSH PULL TRIODE			CLASS C AMP-OSC.	135	-50			27	10		1.6	2.0		5000
								CLASS B MOD.	135				100	MAX			2.1		
45 #	OXIDE	MED 4 PIN	2.5	1.5	6.5	3.6	3.0	CLASS C AMP-OSC.	400	-200			40			10	10	3.0	50,000
53	OXIDE	MED 7 PIN	2.5	2.0	PUSH PULL TRIODE			SEE RK34											
71A #	THOR. FIL	MED 4 PIN	5.0	0.25	6.6	3.2	2.9	SEE 12A											
46	OXIDE	MED 5 PIN	2.5	1.75	AS A TRIODE			CLASS C AMPLIFIER	400	-50			40	30		10	10	3.0	20,000
								CLASS B MOD	400	0	TWO TUBES		200	MAX		20	20		
955 ●	OXIDE	SPECIAL	6.3	0.15	ACORN-FOR ULTRA HIGH FREQ.			CLASS C AMP-OSC.	180	-35			7.0	1.5			0.5		20,000

\# SATISFACTORY OPERATION AS MODULATED OSCILLATOR CAN BE HAD ON 56-60 MC. BAND
TYPES 19 AND 6E6 IDEAL FOR PORTABLE AND PORTABLE MOBILE USE RESPECTIVELY ON 56-60 MC.
● WILL OSCILLATE AT THE VALUES DOWN TO 1 METER – BELOW THIS POINT REDUCE RATINGS

TETRODE-PENTODE TYPES

TYPE NO	CATH.	BASE	VOLTS	AMPS	Cgp	Cgf	Cpf	APPLICATION	Ep	Eg	SG	SUP	Ip	Ig	SG	PL DISS	OUT-PUT	DRIVER POWER WATTS	GRID LEAK OHMS
2A5	OXIDE	MED 6 PIN	2.5	1.75				CLASS C AMP-OSC.	400	-50	100		30	10		5.0	7.0		5000
6F6 6F6G	OXIDE	SMALL OCTAL 7 PIN	6.3	0.7				SAME AS 2A5											
6L6 # 6L6G	OXIDE	SMALL OCTAL 7 PIN	6.3	0.9				CLASS C AMP-OSC	450	-120	300		100	40	80	10	25		50,000
					TWO TUBES			CLASS AB MOD ⊗	400	-25	300		100	[illegible]			60		
42	OXIDE	MED 6 PIN	6.3	0.7				SAME AS 2A5											
47	OXIDE	MED 5 PIN	2.5	1.75	1.2	8.8	13.0	OSC. DOUBLER	350		100	50	40	30		7.0	7.0		50,000
59	OXIDE	MED 7 PIN	2.5	2.0				OSC. DOUBLER	SAME AS 47										
								CLASS B MOD	400	0	TWO TUBES		200	MAX		20	20		

⊗ STATIC PLATE CURRENT GIVEN



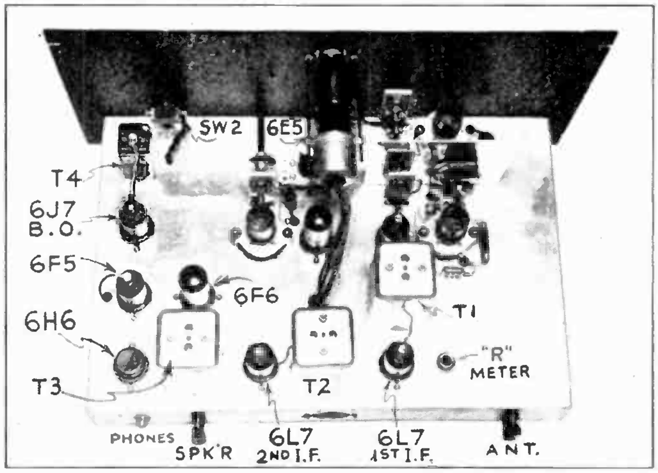


Figure 3, left, front view; Figure 4, right, inside view.

AMATEUR RECEIVERS AND TRANSMITTERS

"Quartet" Receiver for 5 and 10 Meters

THE "Ham's" most pressing need today is for a 5-meter receiver capable of receiving understandably the frequency "wobbulated" signals from self-excited oscillators, yet selective enough to minimize QRM and above all, capable of overcoming the havoc wrought by auto-ignition noise at these ultra-high frequencies. That this need is admirably met by the RN "Quartet" 5- and 10-meter superheterodyne, has been amply demonstrated by extensive tests.

In order that signals radiated by typical 5-meter, self-excited oscillators may be received with their original quality it is necessary that the intermediate amplifier of a superheterodyne pass a band of frequencies approximately 200 kilocycles in width. With the band width reduced to about 70 kilocycles the majority are still understandable, but this is about the minimum band-width that can be used and still maintain intelligibility of the more unstable signals. From the standpoint of good selectivity, on the other hand, a band width of around 10 kc. would be nearer the desired value. A compromise must therefore be made somewhere between these values.

In the receiver under discussion a wide range of choice is permitted through the use of Aladdin iron-core i.f. transformers in which adjustable coupling is provided, and which are tunable over a range of approximately 3000 to 5500 kc. Using the proper degree of coupling for maximum gain, and with the i.f. transformers tuned to 4000 kc. the receiver band width is such that all but a few of the most unstable transmitters are understandable.

An incidental yet highly important advantage of an intermediate frequency over 2000 kc. is that repeat points are widely separated. Using the 4000 kc. adjustment, for instance, the repeat point occurs 8 megacycles away from the normal oscillator condenser setting and therefore entirely outside of the 5-meter tuning range.

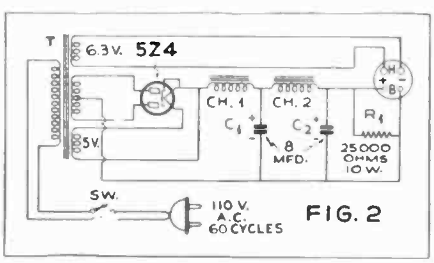


FIG. 2

Ignition noise constitutes one of the most serious drawbacks to the use of a superheterodyne on the ultra-high frequencies. This obstacle is so completely overcome in this receiver as to be almost negligible. At W2JCR, for instance, it is possible to pull through 1st and 3rd district stations with 100 percent intelligibility which with the noise suppressor control turned "off," had been absolutely unreadable, and which never before had been logged in this location. Time after time weak signals, barely audible through the noise level, are cleared up by means of the noise-suppressor adjustment to a point where every word is clear and distinct.

The noise-silencer system originally proposed for use in this receiver was worked out by Watzel and Bohlen and employed three diode sections. With the assistance and suggestions of J. H. Potts, Associate Technical Editor of RADIO NEWS, the proposed circuit was further simplified by eliminating one of the diodes, resulting in the final form shown in the circuit diagram and discussed later. As it stands, this is believed to be the most simple system yet developed—and the most workable because of its sheer simplicity.

The Circuit

In general the "Quartet" circuit (Figure 5) consists of one t.r.f. stage using a 954 acorn pentode, a regenerative first detector, a separate oscillator, two tuned i.f. stages, diode second detector, a.v.c. and noise suppressor; 6F5 audio amplifier, 6F6 power tube and a 6J7 beat-frequency oscillator. The r.f. and regenerative detector circuits are gang-tuned.

Separate tuning for the oscillator was considered desirable because of the complications involved in ganging this with the two other circuits, and also to permit changing the intermediate frequency as desired without having to worry about the r.f. alignment being thrown out. The oscillator works on 10 meters, its second harmonic being used in 5-meter reception. This is done to take advantage of the greater stability obtainable at the lower frequency. By employing a power tube the harmonic is strong enough to provide good conversion power.

The switch S1 combines several functions. When in the left-hand position the receiver is ready for normal operation, with the a.v.c. and plate supply "on" but the beat oscillator "off." In the center position all plate supply circuits are open. Turned to the right, the a.v.c. is off and the beat oscillator is on as required for c.w. reception. A separate toggle switch (S2) is also provided to cut off the beat oscillator if desired, when S1 is in the latter position.

Referring to the front-view photograph, Figure 3, the controls, left to right, are:

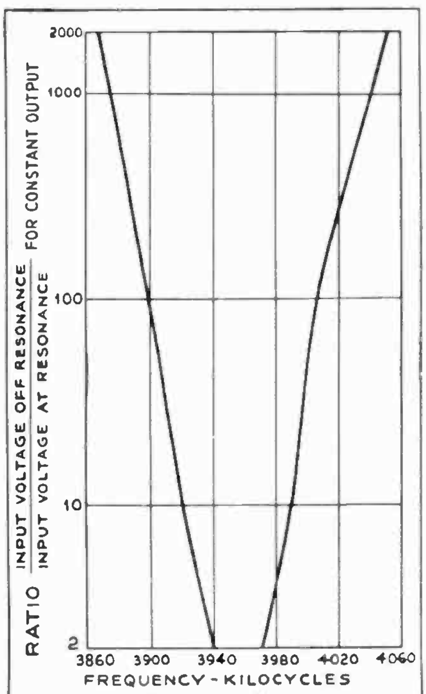


FIG. 1

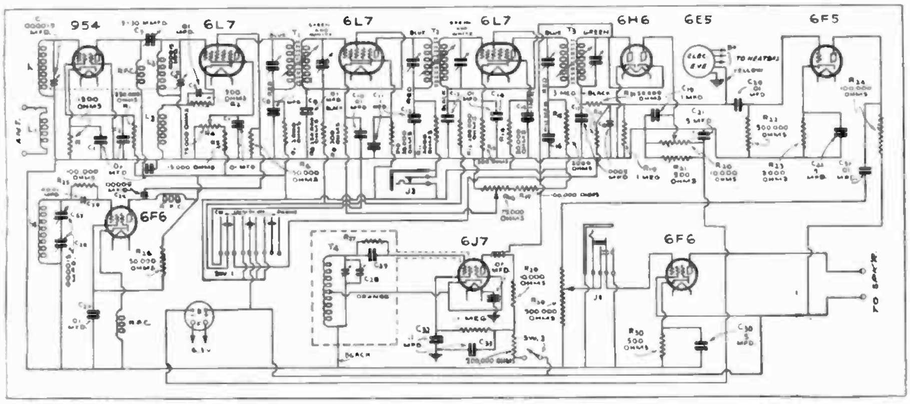


Figure 5—Schematic Diagram

i.f. gain, regeneration, r.f. tuning, noise suppression, oscillator tuning, phone-standby-c.w. switch, beat-frequency oscillator switch and a.f. gain. The "off-on" switch is in the separate power supply unit.

Three separate and distinct functions are handled by the single 6H6 second detector. The first is detection, the second is generation of a.v.c. voltage and the third is noise silencing. In the diagram it will be noticed that the diode section at the left is connected in the usual detector-a.v.c. circuit. The junction of the 50,000-ohm resistor and the 1-megohm resistor provides audio feed to the grid of the first audio stage and a.v.c. voltage to the grids of the 6L7 i.f. tubes, this a.v.c. voltage also operating the electric eye.

The diode section at the right provides the noise-silencing action, or "noise-damping," to be more correct. The cathode of this diode section is connected to the plate of the other section. The plate of the noise-damping section runs to the arm of a 10,000-ohm potentiometer, which varies the potential of this plate from about minus 20 or 30 volts to ground potential. With the arm set near the "negative" end of the potentiometer the plate of the noise-damping diode will be more negative than its cathode and this diode will therefore present a relatively high impedance across the detector-diode section of the 6H6. But with the potentiometer arm set toward the ground end, and a strong signal or noise pulse coming in, the polarity of the noise-damping, diode-section reverses. This causes the noise-damping section of the 6H6 to develop an opposing voltage across the diode load resistor, cutting the noise peaks down to the signal level. The result is an unbelievably simple yet extremely effective noise-silencing action.

The Beat Oscillator

The beat oscillator uses a 6J7 tube. A "twisted wire" coupling condenser may be used for feeding the beat oscillator output from its plate to the detector diode plate.

The 954 r.f. stage acorn tube is mounted through a hole in the shield separating the detector and r.f. stages. No trimmer or padding condensers are used on either of these two stages, tracking being effected by adjustment of the spacing of the turns of the two coils.

The two-dial tuning system permits of a simplified system of oscillator band-spread. An extra condenser (C24) is mounted on the chassis alongside the oscillator tuning condenser (C23) and is connected in series with it. By proper adjustment of this extra series condenser, band-spread of any desired degree can be obtained on the oscillator dial.

If wider coverage is desired with this dial, as would be the case if this receiver were used to tune frequencies other than the 5- and 10-meter bands, this extra series condenser may be short-circuited.

Lining-Up

In lining up the receiver a test oscillator that will cover the 5- and 10-meter bands, as well as the intermediate frequency, will save a considerable amount of work. If no such oscillator is available the oscillator of a superhet, or its harmonics will be satisfactory.

A lead which is inductively or capacity-coupled to this oscillator should be first clipped to the grid of the second i.f. tube. With this generator tuned to around 4000 kc., the diode input transformer should be tuned to resonance, as indicated by the electric eye. The lead should then be clipped to the first i.f. tube grid cap and the second i.f. transformer tuned to resonance. If the eye closes too much, reduce the coupling to the test oscillator. The lead from the generator may finally be connected to the grid of the first detector and the input i.f. transformer aligned.

This temporarily completes the alignment of the i.f. amplifier and the high-frequency section is now ready for adjustment. Condensers C3 and C24 should be set at maximum capacity and an antenna connected to the input. Now tune the two dials until noise is heard, indicating resonance. By means of the test oscillator or its harmonics the frequency of resonance can now be determined.

The Oscillator Stage

With the r.f.-detector dial tuned, attention should be turned to the oscillator stage. C24 should be gradually turned down from maximum capacity, retuning C23 to keep in resonance. As this procedure is gone through it will be found that the band will occupy more and more space on the oscillator dial and it may be necessary to adjust the spacing of turns on the oscillator coil to keep the desired range centered on the dial. A spread of 50 to 75 degrees is sufficient.

The r.f. and detector can be now tracked. This should be done on 5 meters first. The set-screws in the front flexible coupling should be loosened so that the detector tuning condenser may be temporarily tuned, independently of the r.f. condenser, by turning the rear coupling. The receiver should now be tuned to the test signal by operating both dials and the coupling connected to the detector condenser. It will probably be found that the r.f. and detector condensers will not set at the same capacity when tuned independently to resonance. The inductance of the r.f. and detector coils should now be varied slightly by moving the coil turns a bit until the r.f. and detector condensers tune over the whole range with the same capacity settings. The front coupling may now be tightened.

The setting of C3 and cathode-winding adjustment of the detector coil decide the point on the regeneration control at which oscillation of the detector stage will occur. This point should be at from half to three-quarters on this control if maximum gain is to be realized from the r.f. and detector stages. Varying and distance between the cathode and grid windings on the detector coil will change the degree of regeneration. It will probably be found best to leave C3 at full capacity.

The 10-meter coils should be next plugged in, the test oscillator set on 10 meters and the same procedure followed as in aligning the r.f. stages above.

Finally, with the test oscillator tuned to provide a signal in the 5- or 10-meter bands, recheck the i.f. alignment carefully.

The 6E5 electric eye tube is of value in tuning to exact resonance and making comparative checks on the strength of incoming signals. However, as a further refinement, an insulated jack is provided on the chassis for an "R" meter which may be an 0-1 ma. meter, shunted by a 25-ohm rheostat. With such a meter plugged in, the rheostat should be adjusted for full-scale deflection when no signal is tuned in. Then as each signal is tuned in it will retard the meter according to its strength —providing an accurate basis for "R" reports, an exact check on different antennas and adjustments, etc.

Measured Sensitivity

The sensitivity measurements were made under standard conditions (400-cycle, 30-percent modulation and an output of 50 milliwatts). The sensitivity at 30 megacycles was shown to be 2 microvolts *at a signal-to-noise ratio of 2 to 1.* This is actually a degree of sensitivity which relatively few receivers, even those designed for operation on the lower frequencies, can boast.

The sensitivity at 60 megacycles is probably somewhat less than this figure, but the difference should be relatively small. Due to the fact that a 954 acorn r.f. tube is employed, and also regeneration in the first detector, the gain of these two circuits is well maintained even at 60 megacycles and higher. The i.f. gain is of course the same regardless of signal frequencies.

The selectivity measurements of Figure 1 (made in accordance with standard practice) were made after the i.f. transformers had been adjusted, in both coupling and frequency, to provide the best compromise between maximum possible selectivity and the necessary band width to permit intelligible reception of all but the very worst of the modulation oscillator transmitters.

Selectivity

For operation on the 5-meter band the selectivity as shown here is very good indeed. This is amply demonstrated when actually using the receiver. Time and time again it has been successful in bringing in weak signals when stations in the same locality, equipped with super-regenerative receivers or resistance-coupled superhets were, due to QRM, unsuccessful in bringing in the same signals.

The third set of measurements was made to determine the undistorted output. Using a good choke in the output circuit of the 6F6 power tube, this was found to be slightly under 2 watts.

The power supply used with this model receiver is a general-purpose one capable of providing much more power than called for. The circuit is shown in Figure 2 and the parts list is given at the end of this article.

It actually delivers 265 volts, of which approximately 35 volts is lost across the resistors R20 and R21 in the noise-suppressor circuit. It might be well to point out that this 35-volt difference also exists between the power-supply chassis and the receiver chassis and therefore the two should never be connected together nor should they both be grounded. No damage would be done, but the receiver would not work.

Operation

The regenerative circuit of the first detector contributes a good deal of gain and a good additional measure of selectivity. When receiving stable signals, more regeneration can be used than when receiving "wobbulated" signals.

The a.v.c. system is capable of preventing overload even on extremely strong stations and for that reason the i.f. gain control may be left at the maximum setting at all times while a.v.c. is in use. The regeneration control may be left adjusted somewhat below the point of oscillation, although it may be necessary to vary this very slightly in tuning through the range. The audio volume control can be left at one setting practically all of the time, due to the good a.v.c. action. In a location where ignition noise is continuous the noise limiting control should be left in an advanced position.

When using a milliammeter plugged into the jack in the plate circuit of the first i.f. tube, wobbulation of the pointer indicates over-modulation or frequency modulation. On a crystal-controlled signal, modulated 100 percent or less, the needle will stand absolutely still and will give an accurate, relative indication of signal strength, except on signals at or below the noise level. The meter reading will be affected by noise on such weak signals.

The Noise-Squelch System

One final word about the operation of the noise-squelch system. When a signal is tuned in with accompanying QRN, the noise-squelch control is advanced to a point where the noise is completely eliminated or reduced to a marked degree. If this control is advanced too far the signal strength will fall off rapidly. A few minutes' experimental operation of this control will prove highly instructive.

Little has been said specifically about 10-meter operation. Not because the receiver is less effective at these frequencies than on 5 meters, but because the receiver was especially designed to overcome the problems in 5-meter reception. For the ham who operates on both 5 and 10 meters the "Quartet" provides an excellent combination of desirable features.

Varying I. F. Coupling

Before the coupling can be varied it will be necessary to loosen one of the two set screws found at the lower ends of the bakelite frame of each transformer. Only the set screw on the side of the frame nearest the side of the can where the coupling adjustment nut is located need be loosened. It is a good plan to drill a hole in the chassis immediately below this set screw so that it can be loosened and tightened without the necessity of removing the transformer. It is not essential that it be tightened, however, and it is only necessary to loosen it about 1/4 turn.

When the set screw is loose, the coupling is adjusted by rotating the nut reached through a hole in the side of the transformer can. Turning this nut in a clockwise direction loosens the coupling, and the coupling is tightened by turning the nut in a counter clockwise direction. Two complete turns of the nut in either direction represents the complete range of coupling obtainable. When turning the nut in the counter clockwise direction, it should be pressed in so that the nut lies against the bakelite support.

List Of Parts

Cornell-Dubilier condensers:
- C1, C2, C5, C7, C27, C34—.01 mica, type 3L-5S1
- C8, C10, C11, C12, C14, C15, C16—.1 mfd. tubular, 400 v.
- C9, C13, C20, C31—.01 mfd. tubular, 400 v.
- C17, C18—.005 mfd. midget mica
- C19—1 mfd. tubular, 200 v.
- C21, C22, C30—5 mfd. 50 v. electrolytic
- C25—.0001 mfd. midget mica
- C26—.00005 mfd. midget mica
- C32, C33—.1 mfd. tubular, 400 v.

Other condensers:
- C, C4, C23, C24—National 15 mmfd., type UM15
- C3—National 3-30 mmfd., type M30
- C28, C29—Included in beat osc. can.

IRC resistors:
- R—1500 ohms, 1/2 w.
- R1, R8, R12—250,000 ohms, 1/2 w.
- R2—500 ohms, 1/2 w.
- R5—15,000 ohms, 1 w.
- R6, R31—50,000 ohms, 1/2 w.
- R7, R11, R15, R23—2,000 ohms, 1/2 w.
- R9—300 ohms, 1/2 w.
- R10, R14—30,000 ohms, 1 w.
- R13—350 ohms, 1/2 w.
- R17, R24, R25, R28—100,000 ohms, 1/2 w.
- R18—3 megohms, 1/2 w.
- R19—1 megohm, 1/2 w.
- R22—500,000 ohms, 1/2 w.
- R26—50,000 ohms, 2 w.

Other resistors:
- R4, R16—Centralab 75,000 ohm potentiometers
- R20—Centralab 10,000 ohms potentiometer
- R29—Centralab 500,000 ohm potentiometer
- R21, R30—Ward Leonard 500 ohms, 10 w.
- R27—Included in beat osc. can.

RCA tubes:
- 1 type 954 acorn pentode
- 3 type 6L7
- 1 type 6H6
- 1 type 6F5
- 1 type 6C5
- 2 type 6F6
- 1 type 6E5

Miscellaneous:
- J1—Yaxley phone jack, type 705
- J2—Yaxley single-circuit closed pack
- 1 Yaxley pilot light bracket with bullseye
- S1—Yaxley t.p.d.t. jack switch, type 763
- SW2—S.p.s.t. toggle switch
- 1 National acorn tube socket, isolantite
- 2 National isolantite octal sockets
- 3 National type TX—10 shaft couplings
- 6 National type XR-1 coil forms
- 3 National 4-prong isolantite tube sockets (for coils)
- 2 National type B dials with 0-100-0 scales
- 3 National r.f. chokes, type R-100
- T1, T2—Aladdin type A-3500 interstage i. f. transformers
- T3, Aladdin type A-3502 diode i.f. transformer
- T4—Aladdin type 3550 beat frequency oscillator
- 1 Lafayette black crackle steel cabinet, type W-22194
- 1 Lafayette aluminum panel, black crackle, 8¾ by 19 inches, type W-22204
- 1 Lafayette chassis, cadmium-plated steel, 17 by 11 by 2½ inches, type W-22157
- 6 octal wafer sockets
- 1 4-pronged wafer socket
- 4 Eby binding posts with insulating washers
- 1 Amphenol electric eye holder
- 6 ICA bakelite knobs
- 1 piece sheet aluminum, 4 by 5 inches

COIL DATA
5 Meter Coils

R.F. { L—2 ¾T, ¼" long; L1—1 ¼T, close wound, 1/16" below L

Det. { L2—2 ¼T, ¼" long; L3—¾T, 1/16" below L2

Osc. L4—7 ¼T, 5/16" long

10 *Meter Coils*

R.F. { L—3 ¼T, spaced 1 diam., 1/16" below L; L1—6 ¾T, ⅜" long

Det. { L2—5 ¾T, ⅜" long; L3—1 ¾T, sp. 1 diam., ⅛" below L2

Osc. L4—5 ¾T, 5/16" long

All Windings of No. 22 enamelled wire, on 1-inch diameter National forms.

List Of Parts For Power Supply
- T—Stancor type XP3005 power transformer; 2.5 v., 10 a.; 6.3 v., 4 a.; 5 v., 3 a.; 360 v., 125 ma.
- CH1, CH2—Stancor type XC1421 filter chokes, 25 henries, 140 ma.
- C1, C2—Cornell-Dubilier type EB-8800, dual filter condensers, 8-8 mfd., 500 v.
- R1—I.R.C. wire-wound resistor, 25,000 ohms, 10 watts
- SW—Toggle switch
- One octal wafer socket
- One wafer socket, 4-prong
- One RCA rectifier tube, type 5Z4
- One black crackle-finished steel chassis, 8 by 8½ by 2 inches
- One a.c. cord and plug
- One 4-wire power cable with four-prong plugs for each end (cable of desired length)

10-Meter Converter

With increasing amateur activity around 28 megacycles (the 10-meter band) there is a real need for accessory equipment which will extend the range of present receiving apparatus up to these frequencies.

A large number of the switched-coil superhets do not lend themselves readily to range extension. Then, too, many efficient, well-made, plug-in coil receivers remain similarly limited because their design is such as to prohibit effective operation with new coils wound for the ultra-highs. As a result, the amateur with such limited equipment, if he desires to listen on 10 meters, must add either a separate 10-meter receiver or a practical converter which, used in conjunction with "on hand" apparatus, will provide coverage of this band. Of the two alternatives, the converter is by far the most economical.

A 10-meter converter for amateur service should have adequate band-spread, contain all the tried and tested low-loss features of modern ultra-high-frequency apparatus, be complete with an r.f. stage and self-contained power supply, have a high order of gain, sensitivity, and signal selectivity and be adaptable to a reasonably wide range of intermediate frequencies. Figure 6 shows an instrument which is believed to fully meet these requirements.

It has two tuning controls, one for the oscillator and one for the ganged preselector and mixer circuit, both with micrometer pointers for precise logging. A potentiometer governs detector regeneration and thus effective gain, sensitivity and, to a certain extent, selectivity. Switches for the a.c. line and antenna change-over from converter to receiver operation are provided. The conveniently sized (14-by 7- by 8-inch) metal cabinet houses the complete instrument with its self-contained power supply equipment.

Metal tubes are used throughout. All coils are of No. 14 tinned solid copper wire, self-supported on the midget tuning condensers. All tuning condenser shafts are insulated from each other and from the dial hubs by flexible couplings to eliminate metal-to-metal bearing noises and to secure maximum isolation of circuits.

The general layout as shown in the photographs represents the most satis-

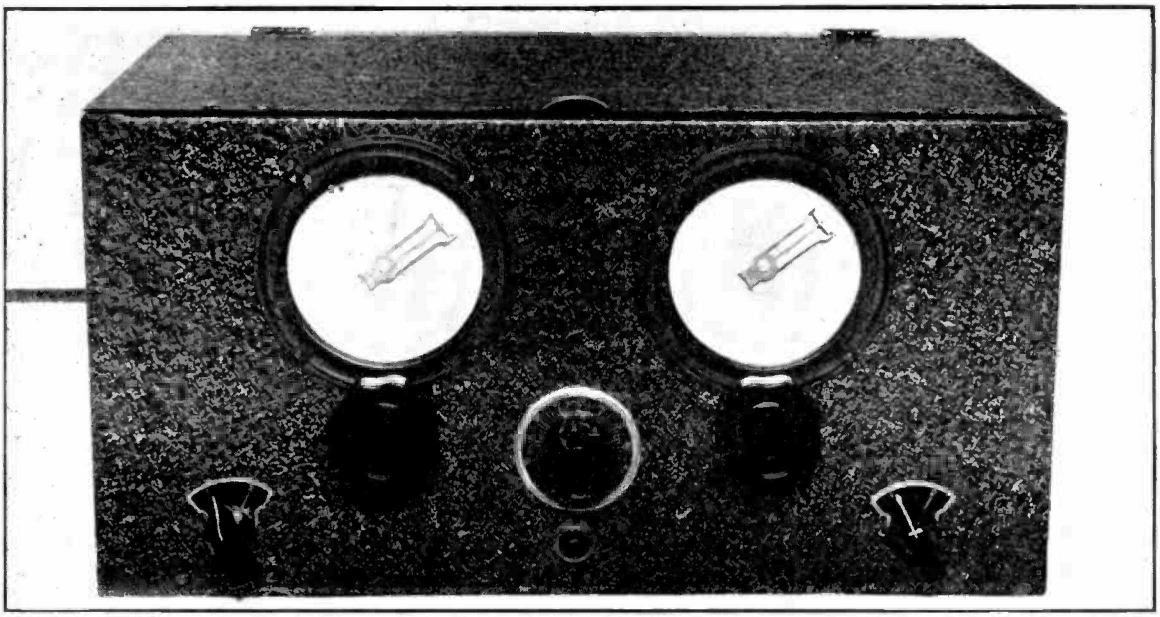


Figure 6—The 10-Meter Converter, all set to go places.

factory of several experimental set-ups. Humless, stable, and very effective performance feature this final model. The circuit is shown in Figure 7.

The oscillator employs a 6C5 in a Hartley circuit with plate voltage of approximately 100.

Detector (mixer) screen voltage is obtained from a 10,000-ohm potentiometer bridging a portion of the B supply divider, and its variation controls regeneration. The detector coil is cathode-tapped so that the circuit will break into oscillation at a little beyond the center position of the potentiometer.

Antenna connections are provided to permit the use of an ungrounded pick-up coil for doublet antennas. If doublet input is not desired, a single-wire antenna lead may be connected to one and the other two posts connected together, or the antenna may be brought directly to a suitable point on the grid coil through a trimmer condenser. Once the converter has been built and the coils adjusted for proper tracking, various antenna connection schemes may be tried, all realignment re-adjustments being made with C5.

Coverage of about 8 megacycles is had over a 270-degree scale using an i.f. between 1500 and 1800 kc.; 28 mc. strikes near the center. Of course, with 20 mmfd. variable condensers, the degree of 10-meter spread will be limited. Due to the extended dial scale and the 14:1 vernier action, the tuning of the ganged r.f.-mixed circuits is opened wide enough for practical communication purposes.

Band-Spreading Used

The oscillator is much too critical, however, and band spreading is therefore used in this circuit. This is accomplished by connecting the 20 mmfd. tuning condenser (C15) across only the lower 6 turns of the oscillator coil, and the screw-driver adjusted air trimmer condenser (C15A) across the whole coil. By properly adjusting the trimmer and the coil, the 10-meter band can be spread over the entire oscillator dial.

The output transformer is a broadcast r.f. job of the Ferrocart (iron core) type with its trimmer removed and its windings "in reverse." A Hammarlund APC midget variable paralleled across the "primary" permits us to tune the plate circuit to the desired intermediate frequency, which may be from 1700 to 1500 kc.

Some Needed Pointers

1. Give us credit for some serious "trial and error" experimentation and take it for granted that the layout as shown in the photographs is recommended.

2. Keep r.f. leads short and direct. Bring all ground returns for each circuit to one point wherever possible. One of the mounting screws for the associated variable condenser is the logical place. Connect by-pass condensers close to socket terminals and other components.

3. Don't center-tap the filament winding.

4. R.F. and detector coils should consist of 12 turns of No. 14 tinned copper wire and should be 5/8 inch inside diameter. The oscillator coil should have 11½ turns. All coils are spaced to length of about 1½ inches. An oscillator cathode tap 2½ turns up from the ground end will be satisfactory. On the detector coil the cathode tap is connected 1½ turns above ground.

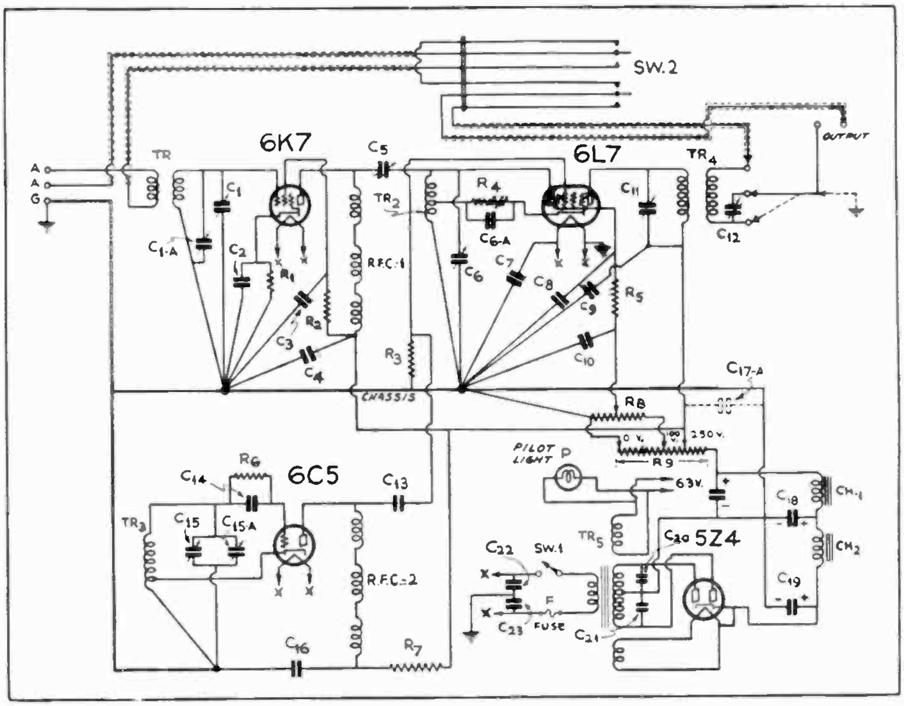
5. As the variable condenser rotor frames are secured to the isolantite insulation with hollow rivets, the ground leads from the coils may be conveniently mounted and soldered in them—affording excellent support for the inductances. The condenser spring contacts should be connected to the mounted ground leads.

6. The voltage supplied from the filter system will be much more than 250, so the voltage taps on R9 become quite necessary for proper converter operation. C17A will be optional. It is used in the model shown here and is, with C17, a dual 8-8 mfd. cardboard container electrolytic.

7. Leads from the change over switch to the r.f. coil and to other associated components should be *shielded in low-capacity shield tubing* to avoid undesirable interaction.

8. When using the particular cabinet specified, it will be necessary to set the

Figure 7—The Circuit



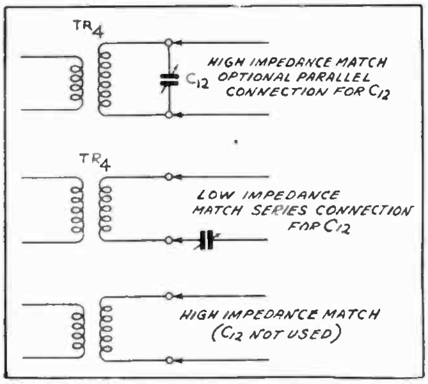
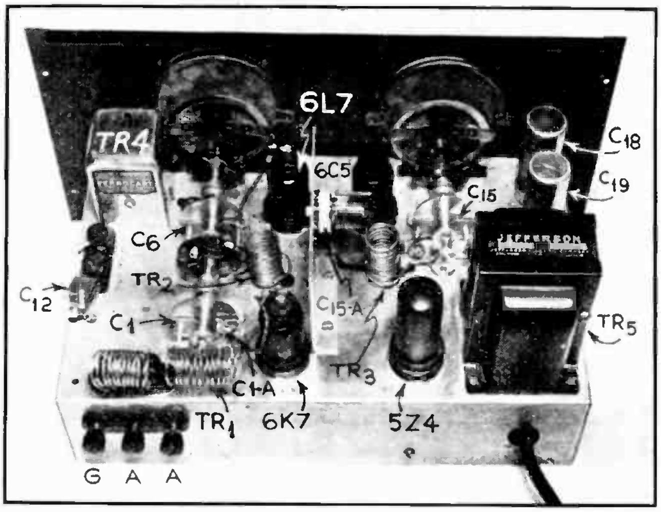


Figure 8, right, clearly showing the arrangement of parts for constructors who wish to duplicate this model; Figure 9, left, three methods for connecting the converter output to your receiver.



chassis back about one-eighth inch from the panel. This is done by placing spacers over the protruding shafts (SW1, SW2, and R8) before the panel is set in place. The dial assembly cutouts will be required to drop the dials for both condenser shaft alignment and proper panel hole matching.

With his converter constructed, a trial set of coils built and installed, and continuity and components carefully checked, a builder should first get voltage readings. Point X, on R9, must be adjusted to give 250 volts at full drain, and the 6L7 screen tap moved to provide 100 volts at the socket screen terminal. R2 should drop the B plus to about 100 for the 6K7 screen. The 6C5 plate should read 100 volts, the 6K7 cathode —3.

If hum is in evidence, add C17A to the circuit. If it still persists check the grounding and by-passing of the filament at the detector socket. There should be no hum trouble if the various components specified are used and the layout at least approximates that of the laboratory model.

Operating Data

The first step in placing the receiver in operation is to connect the antenna to the grid cap of the detector tube, tune the receiver to about 1600 kc. and then tune the output transformer (C11) for maximum noise. Also try the three coupling schemes shown in Figure 9 and adopt the one which provides the highest noise, retuning the plate condenser as each change is made.

The antenna should next be connected to the antenna terminals of the converter, and the two dials manipulated until noise is loudest. With the 75 mfd. oscillator trimmer condenser adjusted so its plates mesh about ¼ inch, this circuit will probably resonate in the 10-meter band, so forget about it for the moment, and concentrate on the r.f. and detector circuits. By spreading or closing the coils, and by adjusting the mica trimmer (C1A) these circuits are aligned in the usual manner. The 10-meter band covers only about 20 degrees on this tuning dial so it is not necessary to worry about alignment over the entire dial. In the model receiver this band extends from 61 to about 80 on the detector dial. If alignment is poor, the regeneration control will have to be varied considerably as the detector is tuned through the range so this provides a good check on the alignment.

Adjusting The Oscillator Coil

The oscillator coil is next adjusted. With the oscillator tuning condenser set at maximum capacity, adjust the trimmer C15A (tuning the r.f. and detector circuits at the same time) with a screw driver to a frequency a little lower than the lowest signal heard on the 10-meter band. Then tune the converter (both dials) to the highest signal heard on the 10-meter band. If the band is found spread over 50 degrees or more leave it that way for a while and practice tuning until familiar with its operation. Then by adjusting the oscillator coil and readjusting C15A it will be possible to spread the band over the full 100 degrees.

The R.F. Alignment

It is impossible in a limited space to give complete detailed directions for this adjustment of coils, trimmers, etc., but a little experimentation on the part of the constructor, based on the suggestions given above, will do the trick nicely. When finished, the r.f. alignment should be so good that in tuning from one end of the 10-meter band to the other, regeneration will remain maximum without having to readjust the regeneration control, more than 1 or 2 degrees at the most; the oscillator dial will just cover the 10-meter band; and this band will spread over about 20 degrees on the detector dial (or more if a turn or two are taken off the r.f. and detector coils so the ganged condensers will operate near full capacity).

The condenser C5 should finally be adjusted for best results. It is best to adjust this on a weak signal, striving not necessarily for maximum signal strength, but rather for the best signal-to-noise ratio. Slight readjustment of the r.f.-detector alignment may be necessary after this is done.

Leads from the converter to the receiver should be short and, if they show any tendency to pick up noise, twist them together.

The Antenna

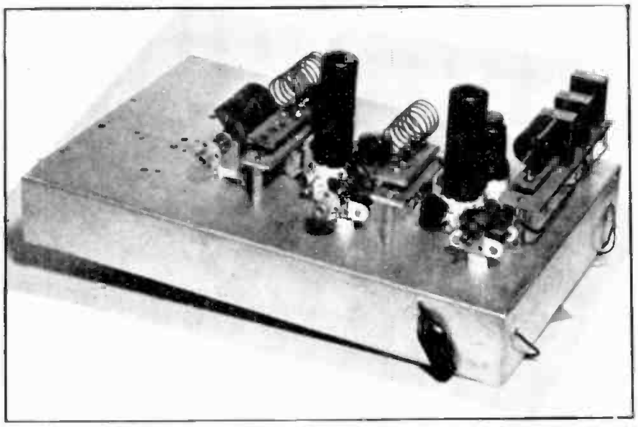
The model shown in the photographs does not have the antenna change-over switch wired in because it was intended for use with a special 10-meter antenna and another antenna was used when tuning the main receiver in other bands. Switching the receiver from the converter to its own antenna was accomplished externally.

While practically any type of antenna may be employed successfully, best results will be obtained with a short-wave type. A horizontal doublet, approximately 16 feet from end to end, with feeders spaced a few inches apart should give excellent pickup for the 10-meter band. Twisted pair, using weatherproof number 14 wire will also work well. It is well to experiment a little with the antenna pickup coil, varying the coupling and number of turns until maximum performance with your particular antenna is secured.

In closing, it is well to advise those who are not familiar with 10-meter operation, that ignition noise is a far greater nuisance on this band than any other. If you live on a street where auto traffic is heavy, don't blame the converter for the noise picked up. Other types of noise, on the other hand, will be negligible.

List Of Parts

TR1, 2, 3—See Text.
TR4—Meissner type 1497 Ferrocart (iron core) R.F. trans.
TR5—Jefferson type 463-381 power transformer.
SH1 and CH2—Jefferson type 466-420 filter chokes.
F—Jefferson 469-841 fuse block, with 188-534 fuse.
SW—ICA or EBY S.P.S.T. rotary line switch
SW2—Yaxley type 760 D.P.D.T. jack switch.
P—Yaxley type 310-G Dial light.
RFC1 and RFC2—Hammarlund CH-X 2.1 mh Rf chokes.
C1, C6, C15—Hammarlund MC-20-S variable condensers.
C1A—Hammarlund type MEX, 30 mmfd. mica trimmer condenser.
C5—Hammarlund IBT-70 isolantite-based trimmer.
C11—Hammarlund APC, APC-75, ACR trimmer, 75 mmfd.
C12—Hammarlund trimmer (size determined by trial).
C3, C2, C6A, C7, C8—Aerovox type 1467—.006 mmfds (mica).
C4, C9—Aerovox type 484—.1 mfds.
C10—Aerovox 284—.1 mfds.
C16—Aerovox 284—.05 mfds.
C13-C14—Aerovox type 1468—.0001 mfds.
C15A—Hammarlund APC-75, air trimmer, 73 mmfd.
C17-C17-A (latter optional) two PBS 5 8 mfd. single section electrolytics, or single dual section PBS 5 8-8 (Aerovox).
C18-C19—Aerovox (GLS-5, 8 mfd. miniature electrolytics.
C20-C21—Aerovox 1467—.002 mfds.
C22-23—Aerovox 484—.05 mfds.
R8—Electrad 995W (10,000 ohms wire wound) or 205 (50,000 ohms, carbon) potentiometer
R9—Electrad type A—100 ten-watt voltage divided, with two extra sliders.
D1—Continental, 500 ohms, 1 watt.
R2—Continental, 100,000 ohms, ½ watt.
R3, R6—Continental, 50,000 ohms, ½ watt.
R4—Continental, 600 ohms, 1 watt.
R5—Continental 5,000 ohms, ½ watt.
R7—Continental 10,000 ohms, 1 watt.
1—EBY three-post antenna-ground assembly.
2—EBY two-post assemblies (for output connection and antenna coil support).
1—EBY multi-port screw terminal strip for TR4 output winding connections underneath chassis.
1—ICA 3830 cabinet—14x8x7, lift cover.
1—ICA 1527 chassis to match (12x7x3 inches).
3—American Phenolic RSS-8 Steatite octal sockets.
1—American Phenolic S-8 moulded octal socket
2—Crowe type 371 Micrometer dials.
2—Crowe type 282 knobs, less pointers.
1—Crowe type 591 knob, with pointer.
1—Crowe type 541-A "Change-O-Name" dial plate.
2—Crowe 274 switchplates or equivalents.
10 feet No. 14 tinned wire.
3—Hammarlund 'FC' insulated couplings.
1—piece aluminum about 4"x4¼" for partition to serve as mounting for C15A.



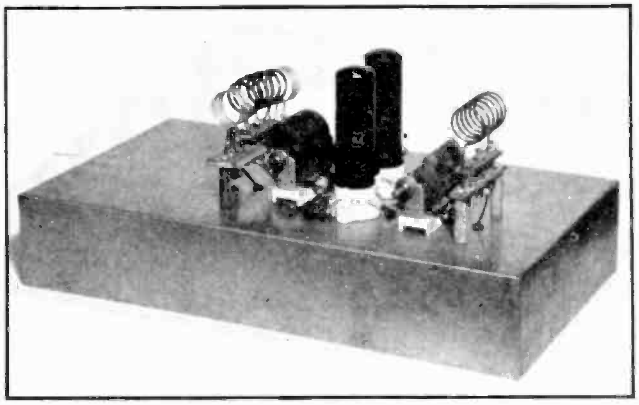


Fig. 10, left, oscillator-doubler; Fig. 11, right, final stage.

X'tal-Control 5-10-20 Meter Transmitter

WITH the announcement of the 6L6 beam-power tube designed especially for audio-frequency work, a great many experimenters immediately thought of this new tube's possibility as a radio-frequency amplifier and oscillator.

The 6C5, 6L6 combination in the Les-tet circuit illustrated in Figure 12 clearly indicates how these tubes are connected to form what is, in a sense, a direct-coupled, oscillator-doubler or multiplier circuit. The tube shields are connected to ground, as recommended by the manufacturer.

Using a 20-meter crystal in this Les-tet circuit, it was immediately apparent that the efficiency of this combination was quite a bit better than the tri-tet circuit. More output was obtained, superior stability, and the 20-meter crystal remained "ice-cold," regardless of how long this set-up was left oscillating.

Frequency Multipliers

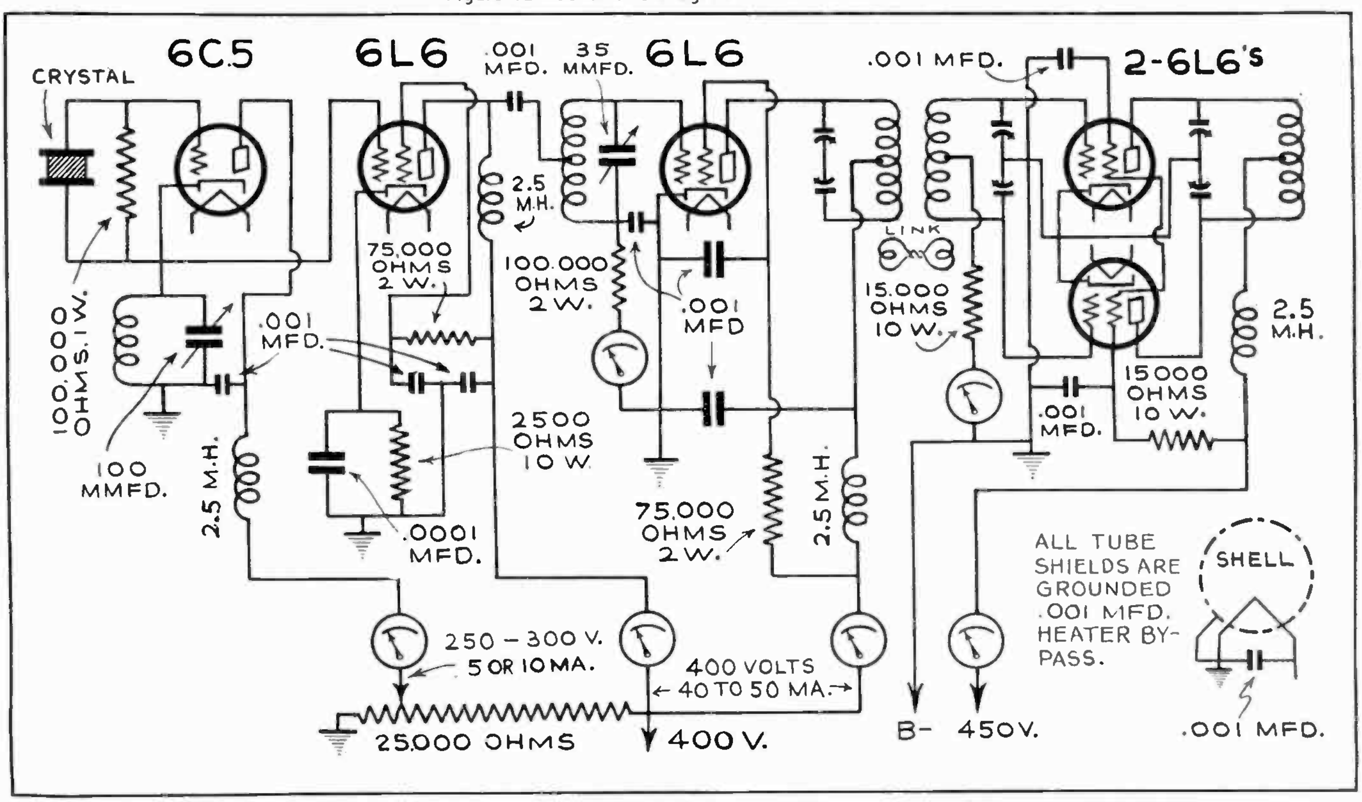
Frequency doubling was tried first with fine performance. Much to our surprise, when the circuit was *quadrupling*, the efficiency and output was only slightly less than when doubling, so we went still further and were actually able to octuple, or in other words, to use an 80-meter crystal for 10-meter output. When octupling, it was found that we could put from 1½ to 2½ mils grid current, into the following 6L6 doubler stage, which operates as a straight grid-leak bias type. This also means that the effective grid voltage applied to this tube would be between 150 and 250 volts. When quadrupling, this grid current ranges from 2½ to 5 mils and when doubling, a little higher. We might mention that for best performance of the 6L6 doubler, at no time should the grid current be more than 3 to 5 mils. Around 2½ to 3 mils is really an ideal value. At this grid current and with 450 volts on the plate of the doubler, with the plate circuit tuned to 5 meters, the combined plate and screen current will be in the vicinity of 40 to 50 milliamperes loaded. This results in producing 15 to 20 mils in the grid circuit of the push-pull 6L6's, with the plate and screen voltages of the push-pull, 6L6's not applied. With the 6L6's loaded, this grid current will vary, depending on the loading, and will most likely be in the order of 10 ma., also upon the link coupling between the 6L6 doubler plate and the push-pull 6L6 grids.

It was found that 6 to 8 mils grid current in the 6L6's in push-pull, loaded to 150 or 200 mils, was the optimum value.

No erratic performance or trouble of any kind was experienced up to the second 6L6 doubler stage which worked beautifully right from the start. Several experiments were conducted to obtain the best possible coupling between the oscillator circuit and the 6L6 doubler grid but it was found that the circuit shown was superior, as well as being the simplest for multiband operation on 5, 10 and 20 meters.

The entire part of the circuit that we have discussed so far, is so fool proof that any of the three tuning circuits may be varied throughout their entire range without any detrimental effects on the tubes,

Figure 12—Schematic Diagram of the Transmitter.



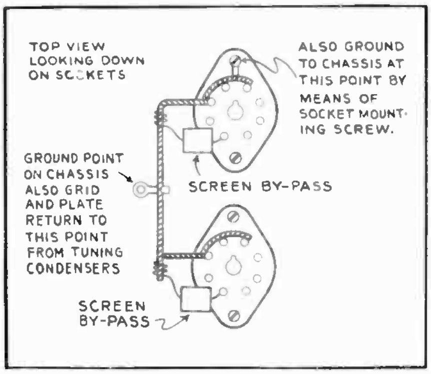


Figure 13

crystals or other parts in the circuits up to the 6L6 doubler. The 6L6 tube in the Les-tet circuit will draw only a very small amount of plate current and practically no screen current, unless the crystal and the 6C5 are oscillating. As soon as this tube starts to oscillate, the plate current of the 6L6 immediately rises. If the plate circuit of the 6L6 is not tuned to resonance, the maximum plate-screen current is limited to somewhere in the vicinity of 75 mils and upon tuning this circuit to resonance with any of the harmonics up to the fourth, quite a noticeable dip in plate current will be obtained.

Proper Grounding

The first set-up of the final stage was made using conventional short point-to-point leads, with the screen by-pass condensers underneath the chassis. Using this arrangement, it was found that neutralization was necessary, whereupon the usual form of criss-cross neutralization was attempted. This resulted in the condition getting worse instead of better. Not only was an appreciable amount of r.f. found in the plate coil of this stage, without any screen or plate voltage applied, but the grid current would dip quite badly when plate-circuit resonance was tuned through. By further experiment, it was found that on 5 meters the push-pull 6L6's *had to be neutralized from the grid of one tube to its own plate instead of to the opposite plate!* As soon as we would change the coils and go either to 10 or 20 meters, the usual criss-cross neutralization would apply. This immediately meant circuit complications for multi-band operation and possible erratic performance with different tubes.

We also found that every slight change of ground connection or placement of by-pass condensers, etc., seriously affected the neutralization.

After quite a little work, the parts layout and grounding shown in Figure 13 and the photograph resulted in our obtaining a perfectly self-neutralized push-pull amplifier on 5 meters. There was no dip in grid current when the plate current was tuned through resonance with the plate and screen voltages not applied, and furthermore, the final stage would not oscillate without driving power.

Duplicating Results

The parts layout of the final stage, as well as the ground returns, which are really more important, should be adhered to as closely as possible.

On 10 meters, the usual criss-cross neutralization must be resorted to, as well as on 20 meters. The capacity required is exceptionally small, being obtained by the piece of push-back wire coming from the plate of one tube, being brought near to the grid-circuit wiring of the other tube. It was also found that a little different neutralization adjustment was required when bands were changed.

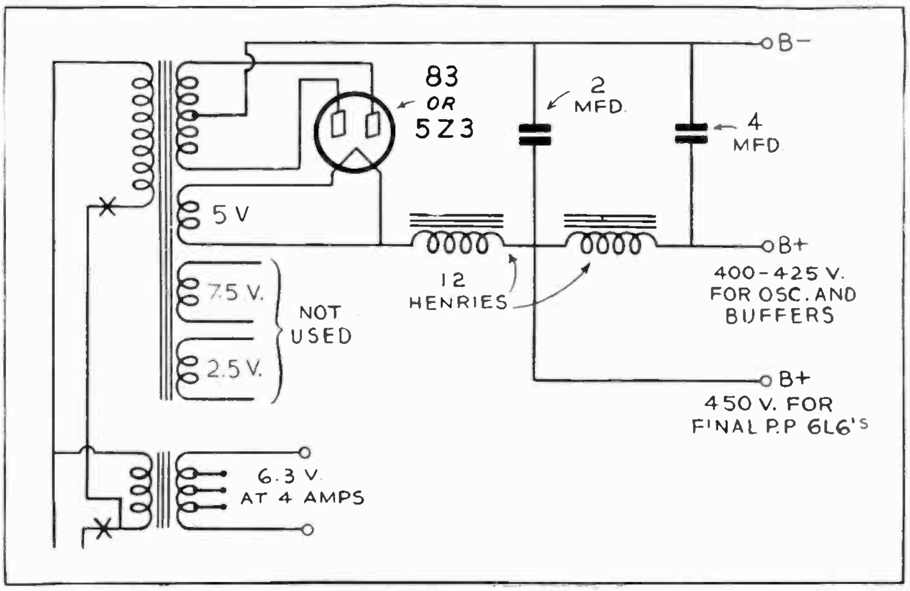


Figure 14—The Power Supply.

The output and efficiency of the push-pull 6L6 stage is unbelievably high. Plate efficiency of this stage, regardless of the band, was always at least 70%. With 69 to 70 watts input, 45 to 50 watts output was obtained. This was with the 6L6's loaded to 150 mils combined with the 6L6's loaded to 150 mils combined plate-screen current at 450 volts. With the tubes loaded to 200 mils, it was possible to get 50 to 55 watts output with the same plate efficiency.

It was decided to modulate the push-pull 6L6 tubes with the Lafayette B46 modulator using a pair of 46 tubes in Class B, as this was available and had the proper output impedance to modulate the 6L6 tubes at the input we were running them. Using this modulator and a crystal mike no trouble at all was experienced and it was found that we had more than sufficient driving power for the pair of 6L6's even under extreme modulation conditions. As mentioned above, 6 to 8 mils of grid current through the 15,000 ohms bias resistor was found to be the optimum value. This resulted in the maximum output being obtained with plenty of grid drive for modulation peaks. An oscillograph was used to observe the modulation characteristics of the push-pull 6L6 tubes and almost a perfect trapezoidal picture was obtained. At no time under modulation did any of the plate-screen current readings have any tendency to change, with the possible exception of the push-pull 6L6 plate-screen current, which, at 100% modulation, might tend to rise very slightly.

We were now ready to try the transmitter on the air, tuned up to 5 meters. All of the contacts on this band were made during the day and everyone remarked at the quality and stability of the signal that this transmitter put out.

Due to the three-position crystal switch, we were able to make rapid shifts from one end of the 5-meter band to the other. The transmitter was thoroughly tested over the entire band from 60 to 56 megacycles with no apparent change in efficiency or stability. At all times, a pure d.c. crystal note was obtained.

When we believed we had obtained sufficient data insofar as the 5-meter operation was concerned, we tuned it up on 10 meters with the same results.

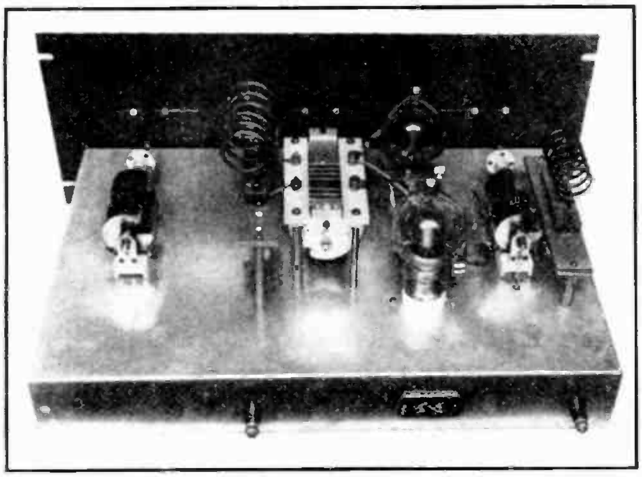
Our next step was to tune up the transmitter on 20 meters, and for simplicity's sake, we chose an 80-meter crystal. The reason we operated the circuit in this fashion was that the 6L6 driver was designed primarily for doubling, in view of 5-meter operation. This also eliminated any change in the resistance values.

Construction Details

The construction details of this transmitter are mostly explained by the diagrams and photos. The Hammarlund 100-mfd. oscillator tuning condenser, as well as the 35-mmfd. frequency-multiplier, plate-tuning condenser, are insulated from the chassis, and held at almost the same height above the chassis, insofar as the shaft center is concerned, as the double-spaced dual 35-mmfd. split stator condenser. The Isolantite tube sockets are mounted flush on the chassis. When mounting these tube sockets, care should be taken to obtain the shortest possible leads. In the case of the frequency multiplier circuit, the 6C5 is mounted as close to the 6L6 as possible, making the cathode-to-control-grid connection very short. All of the r.f. chokes, by-pass condensers and resistors are mounted underneath the chassis. Single-point grounds should be employed in each stage of the transmitter to avoid circulating current through the chassis. By this we mean that all of the by-pass condensers and resistors returning to ground should be made at one point in each of the stages. This point should also be where the cathode and shield of the tube, as well as one side of the heater, are grounded. These three connections can be tied together right at the tube socket and one wire run from the tube socket to the ground point underneath the chassis. The .001-mfd. heater by-pass condenser was located near the 6L6 doubler driver tube socket, with another one located underneath the chassis of the push-pull 6L6. Three 4-terminal terminal strips were used to bring out the necessary meter leads, two of them being used on the driver chassis, and the other one on the push-pull 6L6 chassis.

The Power Supply

For those who desire to make this transmitter real compact, the necessary power supply may be mounted on either of the two chassis. Care should be taken to keep



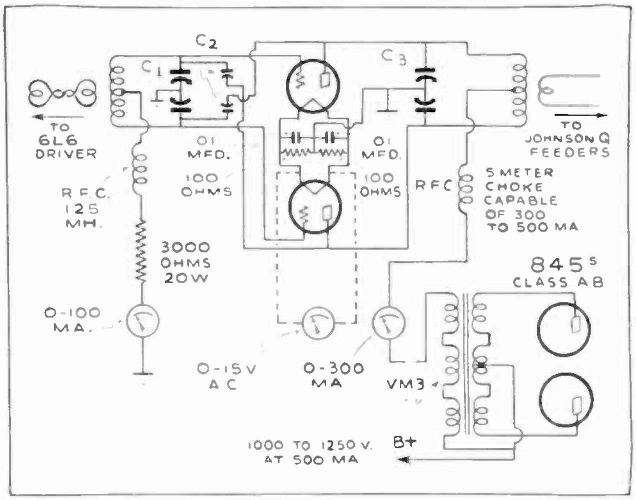


Figure 15, left; Figure 16, right.

the chokes and power transformers as far out of the fields of the coils as is possible. The filament-heating transformer as well as the filter condensers may be mounted underneath the chassis, as there is plenty of room for these parts which will have to be mounted horizontally. It is also possible to build this complete transmitter all on one chassis, which was later done in this case.

A complete list of all of the essential parts is given at the end of this article, including the suggested power supply equipment. See Figure 14.

Antenna coupling may be accomplished using this transmitter by inductive coupling; or conductive coupling, using an isolating condenser in series with each feeder. If a two-wire transmission line is to be used, a 2- to 4-turn pick-up coil may be employed enmeshed between the turns of the plate coil of the push-pull 6L6's.

The Final Amplifier

As there will doubtedly be quite a few of the amateur fraternity interested in higher power for the transmitter, despite what has been said previously on this subject, the final amplifier used at our home station is described herewith.

The illustration showing the arrangement and the diagram of the circuit of the final amplifier of this transmitter will supply practically all of the construction details for builders (See Figures 15 and 16). Looking at the illustration from right to left, we see first the grid coil, which is plugged in, and micalex strips supporting the necessary jacks, the coil being supported on another strip of micalex. No provisions for plug-in links were made, as the same link may be employed on all bands. The link circuit being used at the home station consists of two turns at each end. One end of the link is coupled to the exact center of the push-pull 6L6 plate circuit, the other being coupled to the exact center of the push-pull grid circuit of the final amplifier.

Referring to the illustration once again, looking at it from right to left, after the grid coil we have the Hammarlund split-stator, grid-tuning condenser, followed by the pair of neutralizing condensers, which are mounted on another piece of micalex. This assembly is located between the two tube sockets and for this reason is not visible in the illustration. The final amplifier split-stator, Cardwell condenser is next, with the final amplifier plate-coil following. The other condenser on the chassis is Hammarlund, split-stator, double-spaced 35 mmfd. per section condenser, which is not employed by the author at this time. This condenser was added for increasing the flexibility of antenna coupling should any other but the Johnson "Q" antenna be employed.

It will be noted that by mounting the Cardwell condenser upside down, the connections to the plate-tank coil are very short and also those to the plates of the tubes employed. The stand-off insulators are fastened to the condenser by removing the 6/32 screw, which enables the casein insulation, employed as a stand-off, to be drilled and tapped to fit onto the end of this screw.

When substituting the longer 6/32 screws, care should be taken to remove only one at one time, to avoid misalignment of the condenser. The height of the stand-offs will, of course, depend on each individual layout, and the choice of tubes. Three stand-offs are employed, the fourth support being 1/4-inch brass rod, drilled and tapped at both ends, this being the one ground point referred to previously. All the remaining parts, such as bias resistors, r.f. chokes, filament by-pass condensers, etc., are located below the chassis.

Symmetrical Wiring

When wiring the final amplifier, care should be exercised in making sure that each lead, employed in the grid and plate circuits, is exactly the same length on one tube as the other. If this care is taken, a perfectly symmetrical push-pull amplifier will result, which will neutralize very easily.

As mentioned previously, the push-pull 6L6 stage is capable of driving a rather large variety of tubes. The choice of tubes, therefore, will depend upon the available power-supply equipment, or the amount of money that is desirable to invest. The author chose the Raytheon RK-35. The new RK-37 was not available then but is being used at present. The RK-35 and the 37, as well as other tubes that are now available, have the grid lead coming out of the side of the tube envelope, which makes it possible to mount the sockets underneath the chassis in an effort to keep all of the hot r.f. above the chassis and all other wiring of low potential below the chassis.

When the RK-35's were used, a 380-volt bias supply was employed instead of grid-leak bias, for due to the low MU of these tubes, grid-leak bias was not safe, for should excitation fail, the tubes would be subjected to a tremendous overload.

When perfectly neutralized, and loaded to 150 watts input, it was possible to drive these tubes to 45 mils of grid current, with the 6L6 push-pull buffer stage loaded only to 115 ma., combined plate and screen current. When the RK-37 tubes were installed, due to their higher amplification factor, the C bias supply was no longer required for now grid-leak bias could be employed, for should excitation fail at any time, the plate current would not be excessive. A 3000-ohm, 20-watt, wire-wound grid leak was employed, although this did not seem to be very critical as to its value. With the RK-37 loaded to 150 watts input, the rectified grid current was 45 mils, but due to the lower driving power required the push-pull 6L6 buffer stage was loaded only to 75 ma., combined plate and screen current.

A Johnson "Q" antenna was employed, which loaded the final amplifier very nicely, merely by coupling to the final plate tank by means of a 2-turn pick-up coil shoved in between the center turns until the desired plate current was obtained. Other types of antenna coupling may, of course, be used to advantage, when different types of antenna systems are employed.

The modulator employed by the author consists of a pair of 845 tubes, operated in Class AB, which are supposed to deliver a good 200 watts of audio when they are fully driven.

The plate connection to the RK-35's or 37's (or any other tube of similar design) should not be soldered. Use a small bolt and nut to secure the plate lead to whatever plate terminal is employed.

Whatever tube is employed in the final amplifier, be sure and measure your filament voltage, which should always be at least what the manufacturer calls for, and if anything, a trifle more. Approximately 1/4 of a volt higher filament voltage will result in longer tube life.

Use good insulation where it is required, such as mycalex or isolantite, as this will save considerable trouble in the long run in addition to getting all of the power into the antenna instead of it being wasted, burning or bubbling poorer insulation.

List Of Parts

3 Hammarlund dual 35 double-spaced conds., type MCD35MX. Cat. No. W8490.
1 Hammarlund 100 mmf. condenser, type MC100S. Cat. No. W8508.
1 Hammarlund 35 mmf. condenser, type MC35S, Cat. No. W8504.
5 ICA octal base mtg. sockets, Insulex, Cat. No. M13089.
1 .0001 mfd. 600 v. mica bypass condenser. Cornell Dub., Cat. No. YD3719.
1 .0001 mfd. 600 v. mica bypass condensers, Cornell Dub., Cat. No. YD3716.
3 Hammarlund 2.5 mh. r.f. chokes, 125 m.a. d.c.
1 2500 ohm, 10 watt, wire wound resistor.
2 15000 ohm, 10 watt, wire wound resistors.
2 75000 ohm, 2 watt, carbon or metallized resistors.
1 100,000 ohm, 2 watt, carbon or metallized resistors
1 100,000 1 watt carbon or metallized resistor.
1 WRS 25,000 ohm, 75 watt, bleeder resistor, Cat. No. W20819.

2 cadmium plated chassis, undrilled, 17" long, 11" wide, 2½" deep, Cat. No. W22157.
2 black crystalline steel panels, 8¾" by 19", standard rack panel, Cat. No. W22161.
5 4" metal etched dials, Cat. No. W9858, marked as follows: Oscillator, 2-Buffer Doubler; 1—Amplifier Grid; 1—Amplifier Plate.
5 3" KK knobs for use with above, Cat. No. 13010.
3 4 terminal bakelite assembled terminal strips, Cat. No. 13142.
14 com. prod., buttins type CP19 button type feed through chassis insulators and condenser supports.
5 I.C.A. insulated shaft, flexible couplings, Insulex.
Approximately 5 to 6 feet of Mycalex strip 1" wide by ⅛" or 3/16" thick for coil plug-in bases. Amount needed depends on number of plug-in coils desired.
16 banana plugs and jacks. More plugs required for extra coils.
3 12" lengths of ⅜" dia. insulating rods for coil standoffs. WRS catalog No. 12903.
20 bakelite lug mtg. strips for mounting parts insulated from chassis such as r.f. chokes, resistors, etc. WRS catalog No. 13133.
100 rubber grommets to fit ¼" hole. WRS catalog No. 14765.
1 assortment of 6/32 screws, nuts, lugs and lockwashers.
1 mounted 40 meter crystal.
4 6L6 tubes.
1 6C5.

Power Supply Parts List

1 Thordarson power transformer: 1200 v. c.t. at 200 ma., 2.5 v. c.t. at 10 a., 5 v. at 3 a. for 83 or 5Z3, 7.5 v. c.t. at 3 a.
1 Jefferson type 464-221 filament trans. 6.3 v. or 5 v. c.t. at 4 a.
2 Thordarson filter chokes, 12 henrys at 250 m.a.
1 Cornell-Dubilier, 4 mfd. 600 v., type TD.
1 Thordarson power transformer: 1200 v. c.t. at 200 ma., 2.5 v. c.t. at 10 a., 5 v. at 3 a. for 83 or 5Z3, 7.5 v. c.t. at 3 a.
1 Jefferson type 464-221 filament trans.: 6.3 v. or 5 v. c.t. at 4 a.
2 Thordarson filter chokes, 12 henrys at 250 m.a.
1 Cornell-Dubilier, 2 mfd. 600 v., type TD.
1 Cornell-Dubilier, 4 mfd. 600 v., type TD.
1 4-prong wafer type socket for rectifier.
2 a.c. toggle switches, SPST. Cat. No. W12836.
1 chassis if desired, blank electralloy, 10 by 12 by 3 inches. Cat. No. W22334.
Necessary cord, plug, wire, etc.

Parts List For The Final Amplifier

1—8¾" x 19" Steel Panel.
1—17" x 11" x 2½" Blank Cadmium Plated Chassis.
3—4" Metal Etched Dials, marked, (Amplified Grid) (Amplifier Plate) (Antenna).
3—3" KK knobs for use with above.
2—Hammarlund MC P35 MX.
2—Cardwell ZS4SS.
1—Cardwell NP 35 GD.
1—Hammarlund 2.5 mh. r.f. choke.
1—5-meter choke for plate circuit return. Consists of 50T No. 26 DSC on ¼" form.
2—4-prong Isolantite tube sockets, Hammarlund.
1—100 ohm. Filament centre tapped resistor.
2—.01 Filament Bypass Conds., Mica.
1—2-Terminal Bakelite strip.
2—Feedthru Insulators.
A few Mycalex strips for Coils and Coil Bases, Hardware, etc.

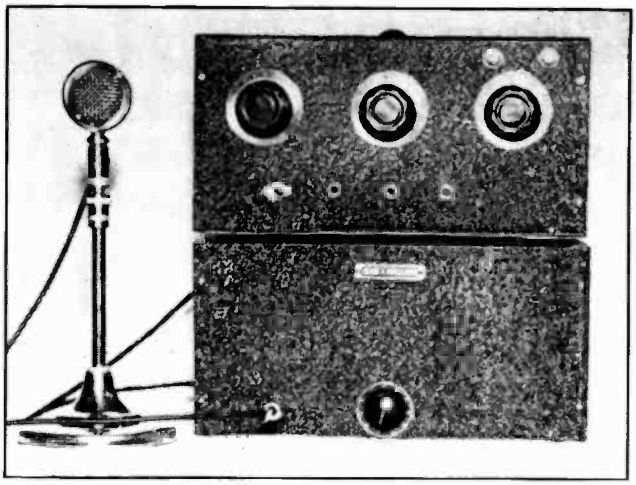


Figure 17. The completed rig of the two-tube M.O.P.A. transmitter. It will put out a 5-meter signal on phone and i.c.w. that will make your radio neighbors "sit up and take notice."

Coil Data For Final Stage

5 meters: Grid 6T No. 12 enamelled wire, 1" dia., spaced to make 3" long.
5 meters: Plate 6T No. 10 enamelled wire, 1½" dia., spaced to make 3" long.
10 meters: Grid 12T No. 12 enamelled wire, 1" dia., spaced to make 3" long.
10 meters: Plate 10T No. 12 enamelled wire, 1½" dia., spaced to make 3" long.
20 meters: Grid 16T No. 12 enamelled wire, 1½" dia., spaced to make 3" long.
20 meters: Plate 14T No. 12 enamelled wire, 2" dia., spaced to make 3" long.

Coil Data For The Doubler And Amplifier 6L6 Stages

Five meter coils using forty meter crystal
Osc. Cathode coil 16T 1" dia., 1½" long, No. 14 wire
Doublet grid coil 7T 1" dia., 2" long, tap at 2nd T from grid end, No. 14 wire
Ten meter coils using forty meter crystal
Same as above
19T 1" dia. tapped at 8th T from grid end 2" long, No. 14 wire
20 meter coils using eighty meter crystal
25T 1½" dia., 1½" long, No. 14 wire
26T 1½" dia., tapped at 7th T from grid end, No. 14 wire
Doubler plate coil, 6T 1" dia., 2" long, center tap. Link 4T 1" dia. No. 14 wire.
Final grid coil 6T 1" dia., center tap 2" long. No. 12 wire
Final plate coil 6T 1" dia., center tap 2" long. No. 12 wire
12T 1" dia., center tap 2" long. Link 5T 1" dia. No. 14 wire.
12T 1" dia., center tap 2" long. No. 12 wire
12T 1" dia., center tap 2" long. No. 12 wire
16T 1½" dia., center tap 2" long. Link 2T 1½" dia.
16T center tap 2" long. No. 12 wire
16T center tap 2" long. No. 12 wire

All the above coils are self-supporting, depending on the rigidity of the wire itself. The turns are spaced to make the coil the length specified above. They can be mounted on strips of mycalex or any other good insulation.

Two-Tube M.O.P.A. Transmitter

AMATEURS on the ultra-high frequencies have heard many tales of hard luck with 6L6 tubes in M.O.P.A. circuits, but, on the other hand, they know how well these tubes perform under proper working conditions. Here is a transmitter in which all the "bugs" have been worked out so that you can build it with assurance. It will do more than you expect in the way of an ideal 5-meter phone transmitter.

The transmitter was designed to provide: 1, stability of operation; 2, efficiency at moderate cost; 3, good quality, and 4, compactness. After considerable experimentation it was decided to build the unit around the 6L6 tube in an electron-coupled oscillator power-amplifier arrangement.

The transmitter itself is extremely compact. The radio-frequency portion of the unit is mounted in a standard cabinet 14 by 7 by 8 inches. The modulator and speech amplifier are mounted in a cabinet of the same size. The two, set one above the other, give the appearance of a rack-and-panel job. This provides a convenient layout and at the same time excellent shielding between the r.f. unit and the modulator—an essential precaution when using 6L6 type tubes at high frequencies. Without this adequate shielding it is almost impossible to eliminate feed-back between the modulator and r.f. amplifier.

Parts for the oscillator-amplifier are laid out to follow the schematic diagram practically as it is drawn. All components are mounted on a metal chassis 7 by 12 by 3 inches, designed to fit inside the cabinet. There are three tuning controls: the oscillator grid, the oscillator plate and the amplifier plate. At the left of the chassis is the oscillator tube and its associated apparatus. In the center is the oscillator plate-tuning coil and its condenser, and (at the right) the amplifier tuning control. All coils are mounted directly on the condensers which tune them with the exception of the grid coil of the amplifier. This is mounted on two porcelain bushings which provide leads through the chassis. The condensers themselves are mounted on 1- by 3-inch Victron strips.

The one thing that is important in laying out the transmitter is the placement of the parts to facilitate short leads.

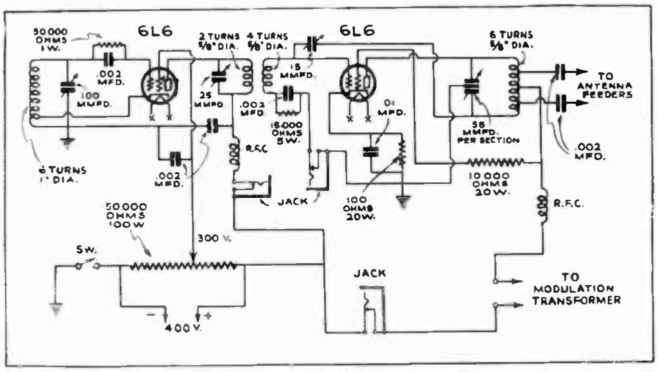
Jacks for reading the plate current of the oscillator, the grid current of the amplifier and the plate current of the amplifier are mounted on the front panel. A switch for cutting off the plate circuit is mounted at the left of the front panel. The two porcelain bushings at the rear of the chassis provide connections for the modulation transformer secondary.

Coils for the transmitter are very important. Their size and location were found to make a tremendous difference in the efficiency of its operation. The oscillator grid coil has 6 turns of No. 12 tinned copper wire and is 1 inch in diameter. The cathode tap is brought off exactly 1 turn from the grounded end of the coil. The position of this tap is rather critical. It is suggested it be varied until the greatest output is obtained in the plate circuit. It may be necessary to use as much as 2 turns, its position having been found contingent on the placement of the oscillator parts. The plate coil of the oscillator consists of 2 turns of No. 12 "push-back" wire and is interwound with the grid coil of the amplifier, which has 4 turns. Both coils are ⅝ inch in diameter. The plate coil of the modulated amplifier consists of 7 turns of No. 10 wire, wound in ⅝-inch diameter form.

The speech amplifier modulation is conventional in design. It provides more than sufficient gain to permit the use of a crystal type microphone to modulate a 30-watt input. The amplifier-modulator is mounted on the same size chassis and in the same size cabinet as the r.f. unit.

Shielding is used in the grid lead of the 6F5 to minimize any tendency to pick up r.f. in the input circuit. Also it was found desirable to use a shielded plug for the microphone.

This unit is capable of delivering 24 watts of audio power, with 400 volts on the plates of the 6L6's and 290 volts on the



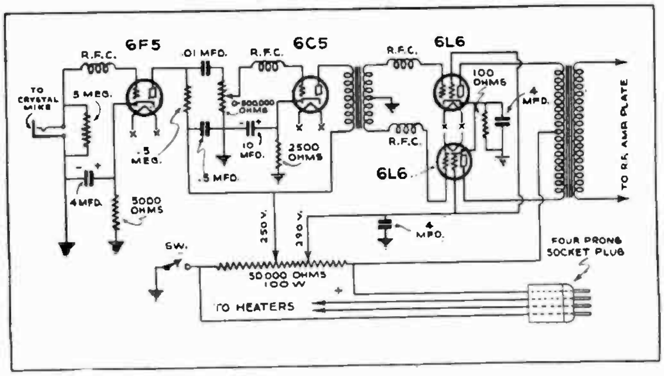


Figure 18, left, the r.f. unit; Figure 19, right, the modulator.

screens. This is sufficient to modulate 48 watts of Class C input.

Two power supplies are used with the complete unit, one for the amplifier and one for the r.f. unit. Both are identical and supply 400 volts at 200 milliamperes, which is adequate for both units. Type 83 rectifier tubes are used. In each a swinging choke input is used which provides good modulation and probably accounts somewhat for the stability of the signal. Electrolytic filter condensers capable of withstanding 475 volts are used. A 30,000-ohm "bleeder" is employed as insurance against blowing condensers when the plate load is taken off during stand-by periods. A smoothing choke provides additional filtration. Each power supply is mounted on a metal chassis 7 by 10 by 2½ inches. All connections, including both filament and plate voltages, are brought to the terminals of a four-prong socket. Two socket plugs and 4-wire cables are used to connect the power supplies to their respective units.

Putting the r.f. section in operation is no more difficult than the average transmitter. The one thing that is important is to be sure the correct harmonic is used to excite the amplifier. The grid tuning condenser controls the frequency. An excellent way to adjust the oscillator is to use a 10-meter receiver with a heterodyne oscillator as a frequency meter. Usually the calibration on such receivers is quite accurate and of course exceptionally accurate when used in conjunction with a good frequency meter. The receiver should be tuned to one-half the 5-meter band frequency it is desired to operate on; i.e., for 56 megacycles it should be set for 28 megacycles. Plate voltage should not be applied to the amplifier. The grid tuning control should be rotated until the signal emitted is at zero beat in the 10-meter receiver. If nothing is heard, the oscillator first should be checked to determine whether or not it is oscillating. A neon bulb (1-watt size) held near the grid coil will indicate the presence of radio-frequency energy. If the oscillator oscillates but no signal is heard on the 10-meter receiver, obviously it is not operating at the proper frequency. If the coil specifications are followed, however, this condition is not likely. When the grid control is set it should not be changed unless it is desired to change frequency later on (it might be regarded as a variable crystal). Of course, while the oscillator is being adjusted, the meter should be plugged into the oscillator plate jack.

Next the plate circuit of the oscillator should be adjusted to resonance. As resonance is passed there will be a decided dip in the plate current. Next the meter should be plugged in the grid circuit jack of the amplifier and the compression condenser across the grid coil adjusted until the rectified grid current is at a peak. It will be found, due to the tight coupling between the plate and grid coils, one condenser will react slightly on the other. Therefore it is necessary to find the combination of the two that will give the greatest grid current. This probably will occur with the compression condenser about half-way compressed. The grid current should be between four and six milliamperes. Four will be sufficient, but the best output may be obtained with somewhere between 4 and 6 milliamperes. When resonance in these two circuits is obtained, the plate current on the oscillator should be between 50 and 60 milliamperes.

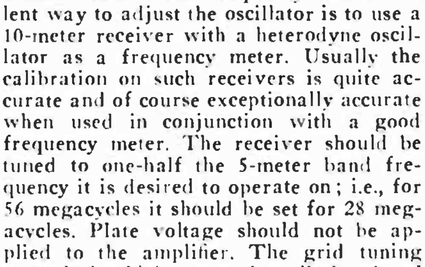
After these circuits are adjusted, the amplifier then should be neutralized. The simplest method is to use a 3-turn loop, 1 inch in diameter, connected across a 6-volt pilot light as a resonance indicator. This may be held near the amplifier plate tank coil. Unless the amplifier is accidentally neutralized, when the plate tank is tuned in resonance with the oscillator frequency the bulb will light faintly (of course, there should not be any plate voltage applied to the amplifier plate during this test). At this point the neutralizing condenser should be adjusted until there is no indication of r.f. in the amplifier plate tank *without plate voltage applied!* As a further neutralizing check, the grid current should remain absolutely stable as the plate tank condenser is rotated past the resonant point. If it dips, this is an indication of improper neutralization.

After neutralization, plate voltage may be applied to the amplifier. This may be done (during the tuning process) by short-circuiting the modulation transformer leads. When the amplifier is tuned to resonance there should be a husky amount of r.f. in the tank coil; enough to make a neon bulb glow brightly. The plate current (without antenna load) should be between 20 and 30 milliamperes. (It will be found the plate current will vary somewhat with different tubes).

The next step is to couple the antenna and connect the modulator to the r.f. unit. As the best type of antenna for 5-meter work uses untuned feeders of between 400 and 600 ohms, the simplest method of coupling is to tap directly on the tank coil through .002 mfd. condensers. These leads are brought to porcelain bushings mounted on the front panel. The taps should be adjusted to match the impedance of the line, which will be indicated by the highest minimum current setting with the antenna connected. The plate current, when the transmitter is coupled to the antenna, should be about 70 to 80 milliamperes. Higher plate currents may be used, but naturally they will shorten the life of the tubes. In no case allow it to go over 100 milliamperes for more than an instant during the tuning-up process.

After the r.f. unit is connected to the antenna and properly tuned, the modulator may be connected. This simply requires taking off the short-circuiting connection across the porcelain bushings on the r.f. unit and connecting these to the porcelain bushings on the output of the modulator. It virtually means detouring the plate voltage for the amplifier through the secondary of the modulation transformer in order that the audio voltage might be superimposed on the d.c. plate voltage. It is desirable to use shielded wire for connecting these two units. Grounding also may be necessary. After this the transmitter is ready for a test on the air.

Figure 20, the Power Packs



Parts List For R.F. Unit

1 I.C.A. 7- by 14- by 8-inch cabinet
1 I.C.A. 7- by 12- by 2½-inch chassis
1 I.C.A. 100 mmfd. variable condenser
1 I.C.A. 25 mmfd. variable condenser
1 Hammarlund split-stator variable condenser, 35 mmfd. per section
6 Aerovox .002 fixed mica condensers, 1000-watt rating
1 Cardwell 15 mmfd. midget variable condenser (for neutralizing)
1 Ohmite 50,000-ohm, 1-watt resistor
1 Ohmite 50,000-ohm, 100-watt resistor (voltage divider)
1 I.R.C. 15,000-ohm, 2-watt resistor
1 Ohmite 10,000-ohm, 20-watt resistor
1 Ohmite 100-ohm, 20-watt resistor
1 Hammarlund midget compression condenser
2 I.C.A. ceramic metal tube sockets
1 Triplett 0-100 milliampere meter
1 I.C.A. switch

Parts List For Amplifier-Modulator Unit

1 I.C.A. 7- by 14- by 8-inch cabinet
1 I.C.A. 2- by 12- by 2-inch chassis
1 United VM-1 output transformer
1 United push-pull input transformer
1 I.R.C. 5-megohm resistor, ½ watt
1 I.R.C. .5-megohm resistor, ½ watt
1 Electrad 0- to 500,000-ohm variable resistor
1 I.R.C. 5000-ohm resistor, 1 watt
1 I.R.C. 2500-ohm resistor, 1 watt
1 Ohmite 100-ohm resistor, 20 watts
1 Ohmite 100,000-ohm resistor, 100 watts
1 Aerovox 2 mfd. electrolytic audio bypass condenser
1 Aerovox 10 mfd. electrolytic condenser
2 Aerovox 4 mfd. electrolytic condensers
1 Aerovox .5 mfd. paper condenser
1 Aerovox .01 mfd. mica condenser
4 Ohmite high-frequency choke coils (for grids)
4 I.C.A. metal tube sockets
1 I.C.A. input jack
Necessary hardware, wire, etc.

Parts List For Power Supplies

(Two separate units are used: One for the r.f. unit, one for modulator)

2 7- by 10- by 2-inch chassis
2 United UH-5 power transformers
2 United CS-42 input swinging chokes
2 United CS-40 smoothing chokes
4 Aerovox 8 mfd. electrolytic filter condensers
2 I.C.A. power switches
2 I.C.A. pilot light sockets
2 Ohmite 30,000-ohm, 50-watt resistors
4 I.C.A. 4-prong tube sockets

RECEIVING TUBE CHART

Type	Description: Type	Glass or Metal	Fil or Htr	Base (see socket connection chart)	Fil Current Amps	Capacitances MMFD: Grid Plate	In Put	Out Put	Application	Plate Sup. Volts	Scr Grid Volts	Control Grid Volts	Cut Off Bias Volts	Plate Current MA	Scr Current MA	μ	Rp Ohms	Gm Micro Mhos	Max Undistorted Output Watts	Load Resistance Ohms
1.1 VOLT DETECTOR AND AMPLIFIER TUBES																				
WD11 / WX12	TRIODE	G	F	SPECIAL 4 PIN 4F / MED 4 PIN 4G	025	3.3	2.5	2.5	GRID LEAK DETECTOR	45		+A								
									AMPLIFIER	90		-4.5		2.5		6.6	15500	425	0007	15000
									AMPLIFIER	135		-10.5		3.0		6.6	15000	440	0.040	15000
864	TRIODE	G	F	SM. 4 PIN 4G	025				NON-MICROPHONIC AMPLIFIER	90		-4.5		2.9		8.2	13500	610		15000
									NON-MICROPHONIC AMPLIFIER	135		-9.0				8.2	12700	645		15000
1.5 VOLT DETECTOR AND AMPLIFIER TUBES																				
26	TRIODE	G	F	MED 4 PIN 4G	1.05				AMPLIFIER	90		-7		2.9		8.3	8900	935		
									AMPLIFIER	180		-14.5		6.2		8.3	7300	1150		
2.0 VOLT DETECTOR AND AMPLIFIER TUBES																				
1A4	VARIABLE MU PENTODE	G	F	SM 4 PIN 4J	0.060	0.007	4.6	1.1	R.F. AMPLIFIER	180	67.5	-3	-15	2.3	0.8	750	[illegible] MEG	750		
									R.F. AMPLIFIER	90	67.5	-3	-15	2.2	0.9	425	[illegible] MEG	720		
									MIXER	67.5-180	67.5	-5	OSCILLATOR PEAK 4 VOLTS							
1A6	PENTA GRID CONVERTER	G	F	SM. 6 PIN 6A	0.060	0.8	5	6	CONVERTER: OSCILLATOR SECTION	135	R_{G1} = 50000 OHMS			2.3	0.2	I_{G1}				
						0.25	10.5	9	CONVERTER: MIXER SECTION	180	67.5	-3	-22.5	1.3	2.4		[illegible] MEG	300	CONVERSION	I_c =
									CONVERTER: MIXER SECTION	135	67.5	-3	-22.5	1.2	2.4		[illegible] MEG	275	CONDUCTANCE	62 MA
1B4	PENTODE	G	F	SM. 4 PIN 4J	0.060	0.007	5	11	R.F. AMPLIFIER	180	67.5	-3	-8	1.7	0.6	1000	1.5 MEG	650		
									R.F. AMPLIFIER	90	67.5	-3	-8	1.6	0.7	550	[illegible] MEG	600		
									BIASED DETECTOR	135	45	-6								
									GRID LEAK DETECTOR	135	45	GRID CONDENSER 0.00025, RG: 1-3 MEG.								0.1 MEG
1B5 / 25S	DUO-DIODE TRIODE	G	F	SM. 6 PIN 6B	0.060	3.6	1.6	1.9	TRIODE SECTION CLASS A AMP.	135		-3		0.8		20	35000	575		
1C6	PENTAGRID CONVERTER	G	F	SM. 6 PIN 6A	0.120	1.5	6	6	CONVERTER: OSCILLATOR SECTION	135	50000 OHMS GRID LEAK			2.6	0.2	I_{G1} ANODE SUPPLY THROUGH 20000 OHMS BY PASSED BY 0.1 MFD				
									CONVERTER: OSCILLATOR SECTION	180				3.3	0.2					
						0.3	10	9	CONVERTER: MIXER SECTION	135	67.5	-3	-14	1.3	2		550,000	300	CONVERSION	I_c = 6.5
									CONVERTER: MIXER SECTION	180	67.5	-3	-14	1.5	2		150,000	325	CONDUCTANCE	I_c = 7
1C7G	PENTAGRID CONVERTER	G	F	OCT. 8 PIN 8A	SAME AS 1C6															
1D5G	VARIABLE MU PENTODE	G	F	OCT 7 PIN 7G	SAME AS 1A4															
1D7G	PENTAGRID CONVERTER	G	F	OCT 8 PIN 8A	SAME AS 1A6															
1E5G	PENTODE	G	F	OCT 7 PIN 7G	SAME AS 1B4															
1E7G	DOUBLE PENTODE	G	F	OCT. 8 PIN 8B	0.240				CLASS A PUSH-PULL AMP.	135	135	-7.5		[illegible]	[illegible]				0.65	24000 P-to-P
									CLASS A (ONE SECTION)	135	135	-4.5		7.5	2.1	350	[illegible]	1600		
1F4	PENTODE	G	F	SM. 5 PIN 5B	0.120				CLASS A AMPLIFIER	135	135	-4.5		8	2.6	340	[illegible]	1700	0.34	16000
									CLASS A AMPLIFIER	90	90	-3		4	1.3	340	[illegible]	1400	0.12	20000
1F5G	PENTODE	G	F	OCT. 7 PIN 7H	SAME AS 1F4															
1F6	DUO-DIODE PENTODE	G	F	SM. 6 PIN 6D	0.060	0.007	4	9	PENTODE UNIT: R.F. AMPLIFIER	180	67.5	-1.5	-12	2.0	0.6	650	[illegible] MEG	650		
									PENTODE UNIT: A.F. RESISTANCE COUPLED AMPLIFIER	135	135	-1.0	R PLATE 0.25 MEG	0.42	RG2 1 MEG.	GAIN 48 / 43	PEAK INPUT VOLTS 0.64		30.8 V / 28 V	R NEXT GRID: 1.0 MEG / R NEXT GRID: 0.5 MEG
									PENTODE UNIT: A.F. RESISTANCE COUPLED AMPLIFIER	135	135	-2.0	0.25 MEG	0.42	0.8 MEG.	46 / 41	0.62		28 V / 25.2 V	R NEXT GRID: 1.0 MEG / R NEXT GRID: 0.5 MEG
1F7G	DUO-DIODE PENTODE	G	F	OCT. 8 PIN	SAME AS 1F6															
1G5G	PENTODE	G	F	OCT. 7 PIN 7H	0.120				AMPLIFIER, CLASS A	90	90	-6		8.5	2.7	200	135000	1500	0.3	8500
1H4G	TRIODE	G	F	OCT. 7 PIN 7J	SAME AS 30															
1H6G	DUO-DIODE TRIODE	G	F	OCT. 8 PIN	SAME AS 1B5/25S															
1J6G	DOUBLE TRIODE	G	F	OCT 8 PIN	SAME AS 19															
15	PENTODE	G	H	SM. 5 PIN 5D	0.220	0.01	2.35	7.80	R.F. AMPLIFIER	135	67.5	-1.5		1.85	0.3	600	0.8 MEG.	750		
									R.F. AMPLIFIER	67.5	67.5	-1.5		1.85	0.3	450	0.63 MEG.	710		
19	DOUBLE TRIODE	G	F	SM. 6 PIN 6C	0.260				CLASS B AMPLIFIER (TWO SECTIONS)	135		0		5-13.5	PER TUBE		INPUT POWER MW. 170		2.1	10000 P to P
									CLASS B AMPLIFIER (TWO SECTIONS)	135		-3		2-12.5	PER TUBE		130		1.9	10000 P to P
									CLASS B AMPLIFIER (TWO SECTIONS)	135		-6		0.5-11	PER TUBE		95		1.6	10000 P to P
30	TRIODE	G	F	SM. 4 PIN 4G	0.060	6.0	3.0	2.1	CLASS A AMP.	180		-13.5		3.1		9.3	10300	900		
									CLASS A AMP.	135		-9		3.0		9.3	10300	900		
									CLASS A AMP.	90		-4.5		2.5		9.3	11000	850		
									CLASS A DRIVER (FOR 2 TYPE 30 CLASS B)	157.5		-11.3								18000
									CLASS B AMP. (2 TUBES)	157.5		-15		2.0 (STATIC)	DRIVING POWER 60 MW				2.1	8000 P to P
									BIASED DETECTOR	180		-18								
									GRID CIRCUIT DETECTOR	45 MAX.		GRID CONDENSER 0.00025 MFD. LEAK 1-5 MEG.								
31	TRIODE	G	F	SM 4 PIN 4G	0.130	5.7	3.5	2.7	CLASS A AMPLIFIER	180		-30		12.3		3.8	3600	1050	0.375	5700
									CLASS A AMPLIFIER	135		-22.5		8.0		3.8	4100	925	0.185	7000
32	TETRODE	G	F	SM. 4 PIN 4H	0.060	0.015	5.3	10.5	R.F. AMP.	180	67.5	-3		1.7	0.4	780	1.2 MEG.	650		
									R.F. AMP.	135	67.5	-3		1.7	0.4	610	0.95 MEG.	640		
									BIASED DET.	135	67.5	-6								0.1 MEG.
33	PENTODE	G	F	SM 5 PIN 5B	0.260				CLASS A AMPLIFIER	180	180	-18		22	5	90	55000	1700	1.4	6000
									CLASS A AMPLIFIER	135	135	-13.5		14.5	3	70	50000	1450	0.7	7000
34	PENTODE	G	F	SM. 4 PIN 4J	0.060	0.015	6.0	11.5	R.F. AMPLIFIER	180	67.5	-3	-22.5	2.8	1.0	620	1.0 MEG.	620		
									R.F. AMPLIFIER	135	67.5	-3	-22.5	2.8	1.0	360	[illegible] MEG	600		
									R.F. AMPLIFIER	67.5	67.5	-3	-22.5	2.7	1.1	224	[illegible] MEG	560		
									MIXER	67.5-180	67.5	-5	OSCILLATOR PEAK: 4 VOLTS							
49	TETRODE	G	F	SM. 5 PIN 5C	0.120				CLASS B AMP. (2 TUBES) G_1 AND G_2 CONNECTED TOGETHER	180		0		4	ZERO SIGNAL (2 TUBES)				3.5	12000 P to P
									CLASS B AMP. (2 TUBES) G_1 AND G_2 CONNECTED TOGETHER	135		0		1.6	ZERO SIGNAL (2 TUBES)				2.3	8000 P to P
									CLASS A AMP. G_2 CONNECTED TO PLATE	135		-20		6.0		4.7	4175	1125	0.17	11000 / 22000 (AS DRIVER)
3.3 VOLT DETECTOR AND AMPLIFIER TUBES																				
20	TRIODE	G	F	4G MED. 4 PIN	.132	3.7	2.4	2.3	AMPLIFIER	135		-22.5		6.5		3.3	6300	525	.110	6500
22	TETRODE	G	F	4H MED 4 PIN	.132	.02	4	12	AMPLIFIER	135	67.5	-1.5	-7.5	3.7	1.3	125	.25 MEG	500		
									RES. COUP. AMPLIFIER	180	22.5	-.75		.3		350	2 MEG	175		.25 MEG.
V-99 / X-99	TRIODE	G	F	SPEC. 4 PIN / MED. 4 PIN	.063	3.6	2.5	2.2	GRID LEAK DETECTOR	45		+A		1.5		6.6	17000	370		
									AMPLIFIER	90		-4.5		2.5		6.6	15500	425	.007	15500

RECEIVING TUBE CHART

2.5 VOLT DETECTOR AND AMPLIFIER TUBES

Type	Description	Glass or Metal	Fil or HTR	Base [See Socket Connection Chart]	Fil Current Amps	Capacitances MMFD Grid Plate	In Put	Out Put	Application	Plate Sup Volts	Scr Grid Volts	Control Grid Volts	Cut Off Bias Volts	Plate Current MA	Scr Current MA	μ	Rp Ohms	Gm Micro Mhos	Max Undistorted Output Watts	Load Resistance Ohms
2A3 / 2A3H	TRIODE	G	F / H	4G MED 4 PIN / 4K	2.5 / 2.8	13	9	4	CLASS A (ONE TUBE)	250		-45		60		4.2	800	5250	3.5	2500
									CLASS A B1 (2 TUBES) FIXED BIAS	300		-62		[illegible]					15	3000
									SELF-BIAS	300	Rc = 780 OHMS			[illegible]					10	5000
2A5	PENTODE	G	H	MED SIX-PIN 6E	1.75				CLASS A PENTODE	250	250	-16.5		34	6.5	190	0.8	2350	3.0	7000
										315	315	-22		42	8	260	[illegible]	2600	5.0	7000
									CLASS A TRIODE (ONE TUBE)	250		-20		31		6.2	2700	2300	0.65	3000
									CLASS AB2 PENTODE (TWO TUBES) FIXED BIAS	375	250	-26		34	5				19	10000
									SELF BIAS	375	250	Rc = 340 OHMS		54					19	10000
									CLASS AB2 TRIODES (TWO TUBES) FIXED BIAS	350		-38		45					18	6000
									SELF BIAS	350	Rc = 730 OHMS			50					14	10000
2A6	DUO DIODE TRIODE	G	H	SM.6PIN 6F	0.8	1.7	2	4	TRIODE AMPLIFIER	250		-2		0.8		100	91000	1100		
									TRIODE AMP. (RES. COUPLED)	300	Rc = 3900 OHMS			GAIN = 53					51	R PLATE 0.25 MEG R NEXT GRID 0.5 "
2A7	PENTAGRID CONVERTER	G	H	SM.7PIN 7A	.8	1.0	7	5.5	OSC. SECTION	250	RG1 = .05 MEG.			4	RG2 = .02 MEG.					
										100	RG1 = .01 "			3.3						
						.3	8.5	9	MIXER SECTION	250	100	-3	-45	3.5	2.2		.36 MEG.	520	CONVERSION CONDUCTANCE	
										100	50	-1.5	-20	1.3	2.5		.6 MEG.	350	"	
2B6	DIRECT COUPLED DUAL TRIODE	G	H	MED 7PIN 7X	2.25				INPUT SECTION	250		-24		4		72		600		8000
									OUTPUT SECTION	250		+25		40		18		3500	4	5000
2B7	DUO DIODE PENTODE	G	H	SM 7PIN 7B	0.8	.007	3.5	9.5	AMPLIFIER (PENTODE SECTION)	250	125	-3	-21	9	2.3	730	.065 MEG	1125		
										100	100	-3	-17	5.8	1.7	265	.35 MEG	950		
									AMP. (RES. COUPLED)	300	R0 = 1.2 MEG RC = 1600 OHMS GAIN = 79								100V	R PLATE .25 MEG R NEXT GRID .5 "
24A	TETRODE	G	H	MED 5PIN 5J	1.75	.007	5.3	10.5	AMPLIFIER	250	90	-3	-15	4	1.7	630	0.6 MEG	1050		
										180	90	-3	-15	4	1.7	400	0.4 MEG	1000		
27	TRIODE	G	H	MED 5PIN 5A	1.75	3.3	2.1	2.3	AMPLIFIER	250		-21		5.2		9	9250	975		
										180		-13.5		5		9	9000	1000		
										90		-6		2.7		9	11000	820		
									BIAS DETECTOR	250		-30		0.2						
35	VARIABLE MU TETRODE	G	H	MED 5PIN 5J	1.75	.007	5.3	10.5	AMPLIFIER	250	90	-3	-40	6.5	2.5	420	.4 MEG	1050		
										180	90	-3	-40	6.3	2.5	305	.3 MEG	1020		
45	TRIODE	G	H	4G MED 4PIN	1.5	7	4	3	CLASS A AMPLIFIER (1 TUBE)	275		-56		36		3.5	1700	2050	2.0	4600
										250		-50		34		3.5	1610	2175	1.6	3900
									CLASS AB2 (TWO TUBES) SELF-BIAS	275	Rc = 775 OHMS			72 TO 90					12	5060
									FIXED BIAS	275		-68		[illegible]					18	3200
46	TETRODE	G	F	5C MED.5PIN	1.75				CLASS A AMPLIFIER	250		-33		22		5.6	2380	2350	1.25	6400
									CLASS B AMPLIFIER (2 TUBES)	400		0		12 TO 75					20	5800
										300		0		8 TO 70					16	5200
47	PENTODE	G	F	5G MED 5PIN	1.75				CLASS A AMPLIFIER	250	250	-16.5		31	6	150	60000	2500	2.7	7000
53	DOUBLE TRIODE	G	H	7C MED 7PIN (LARGE PIN CIRCLE)	2.0				CLASS A DRIVER (2 SECTIONS IN PARALLEL)	294		-6		7		35	11000	3200	0.37	20000 to 40000
										250		-5		6		35	11300	3100		
									CLASS B AMP (2 SECTIONS IN PUSH PULL)	300		0		35-65					10	10000 P to P
										250		0		28-50					8	8000 P to P
55	DUO-DIODE TRIODE	G	H	6F SM 6PIN	1.0	1.5	1.5	4.3	TRIODE UNIT AMP.	250		-20		8		8.3	7500	1100		
									RES. COUP AMP.	300	Rc = 8300 OHMS					GAIN = 57			82V.	R PLATE 0.1 MEG R NEXT 0.25 "
56	TRIODE	G	H	5A SM 5PIN	1.0	3.2	3.2	2.2	AMPLIFIER	250		-13.5		5		13.8	9500	1450		
										100		-5		2.5		13.8	12000	1150		
									RES. COUP. AMPLIFIER	300	Rc = 6400 OHMS					GAIN = 10			95V	R PLATE .25 MEG R NEXT GRID .5 MEG
									BIASED DETECTOR	250	Rc = 30000 TO 150000 OHMS									
57	PENTODE	G	H	6J SM.6PIN	1.0	.007	5.0	6.5	AMPLIFIER	250	100	-3		2	.5	1500	1.5 MEG	1500		
										100	100	-3		2	.5	1185	1 MEG	1185		
									RES. COUP. AMPLIFIER	300	300	Rc = 1200 OHMS RG2 = 1.18 MEG GAIN = 140							97V	R PLATE .25 MEG R NEXT GRID .5 MEG
									BIASED DETECTOR	250	100	-4.3 (OR Rc = 10,000)								
										100	30	-1.83 (OR Rc = 10,000)								
58	PENTODE	G	H	6J SM.6PIN	1.0	.007	4.7	6.3	AMPLIFIER	250	100	-3	-50	8.2	2	1280	.8 MEG	1600		
										100	100	-3	-50	8	2.2	375	.25 MEG	1600		
									MIXER	250	100	-10	OSCILLATOR PEAK 7 VOLTS							
59	TRIPLE GRID TUBE	G	H	7T MED.7PIN (LARGE PIN CIRCLE)	2.0				CLASS A TRIODE G2-G3 TO P	250		-28		26		6	2300	2600	1.25	5000
									CLASS A PENTODE	250	250	-18		35	9	100	40000	2500	3	6000
									CLASS B TRIODES (2 TUBES) G1 TO G2, G3 TO P	400		0		[illegible]					20	6000 P to P
										300		0		20					15	4600 P to P

5.0 VOLT DETECTOR AND AMPLIFIER TUBES

Type	Description	Glass or Metal	Fil or HTR	Base	Fil Current Amps	Grid Plate	In Put	Out Put	Application	Plate Sup Volts	Scr Grid Volts	Control Grid Volts	Cut Off Bias Volts	Plate Current MA	Scr Current MA	μ	Rp Ohms	Gm Micro Mhos	Max Undistorted Output Watts	Load Resistance Ohms
00A	C5 VAPOR TRIODE	G	F	4G MED 4PIN	.25	8.5	3.2	2.0	GRID LEAK DETECTOR	45		0		1.5		20	30000	666		
01A	TRIODE	G	F	4G MED 4PIN	.25	8.8	3.1	2.2	AMPLIFIER	135		-9		3.0		8	10000	800		
12A	TRIODE	G	F	4G MED 4PIN	.25	8	4	2	AMPLIFIER	135		-9		6.2		8.5	5100	1650	.13	9000
										180		-13.5		7.7		8.5	4700	1800	.65	10700
71A	TRIODE	G	F	4G MED 4PIN	.25	9.5	302	29	AMPLIFIER	135		-27		17.3		3	1820	1650	.4	3000
										180		-40.5		20		3	1750	1700	.79	4800
40	TRIODE	G	F	4G MED 4PIN	.25	8.8	3.4	1.5	BIASED DETECTOR	180		-4.5		.1						.25 MEG.
									RES. COUP. AMPLIFIER	180		-3		.2		30	.15 MEG	200		.25 MEG.

6.3 VOLT DETECTOR AND AMPLIFIER TUBES

Type	Description	Glass or Metal	Fil or HTR	Base	Fil Current Amps	Grid Plate	In Put	Out Put	Application	Plate Sup Volts	Scr Grid Volts	Control Grid Volts	Cut Off Bias Volts	Plate Current MA	Scr Current MA	μ	Rp Ohms	Gm Micro Mhos	Max Undistorted Output Watts	Load Resistance Ohms
6A3	TRIODE	G	F	MED 4PIN 4G	1.0	16	7	3.5	CLASS A AMP.	250		-45		60		4.2	800	5250	3.2	2500
									CLASS AB1 TWO TUBES FIXED BIAS	325		-68		80-100						3000
									SELF BIAS	325	Rc 750 OHMS			80-150					1.0	5000
6A4 LA	PENTODE	G	F	MED.5PIN 5G	0.3				PENTODE AMPLIFIER	180	180	-12		22	4.5	150	0.6	2500	1.5	8000
										100	100	-6.5			1.6	150	83250	1700	0.3	11000
6A5G	TRIODE	G	H	OCT. 8PIN 8F	1.0	16	7	5	SAME AS 6A3 EXCEPT POWER OUTPUT SINGLE TUBE										3.75	
6A6	DOUBLE TRIODE	G	H	MED.7PIN 7C	0.8				CLASS A DRIVER (2 SECTIONS IN PARALLEL)	294		-6		7		35	11000	3200	0.37	20000 TO 40000
										250		-5		6		35	11300	3100		
									CLASS B AMPLIFIER (SECTIONS IN PUSH-PULL)	300		0		35-65					10	10000 P TO P
										250		0		28-50					8	8000 P TO P
6A7	PENTAGRID CONVERTER	G	H	SM.7PIN 7A	0.3	1.0	7.0	5.5	CONVERTER OSCILLATOR SECTION	250	RG1 = 0.05 MEG.			4.0	RG2 = 0.02 MEG.					
										100	RG1 = 0.01 MEG.			3.3						
						0.3	8.5	9.0	MIXER SECTION	250	100	-3	-45	3.5	2.2			520	CONVERSION CONDUCTANCE	
										100	50	-1.5	-20	1.3	2.5			350		
6A8	PENTAGRID CONVERTER	G	H	OCT. 8PIN 8G	0.3	0.8	6.5	5	CONVERTER OSCILLATOR SECTION	250	RG1 = 0.05 MEG.			4.0	RG2 = 0.02 MEG					
										100	RG1 = 0.05 MEG			1.6						
						0.3	8.5	9.0	MIXER SECTION	250	100	-3	-45	3.3	3.2		.36 MEG.	500	CONVERSION CONDUCTANCE	
										100	50	-1.5	-20	1.2	1.5		.6 MEG.	350		

RECEIVING TUBE CHART

6.3 VOLT TUBES (CONT.)

Type	Description	Glass or Metal	Fil or Htr	Base (See Socket Connection Chart)	Fil Current Amps	Capacitances MMFD Grid Plate	In Put	Out Put	Application	Plate Sup Volts	Scr. Grid Volts	Control Grid Volts	Cut Off Bias Volts	Plate Current MA	Scr. Current MA	μ	Rp Ohms	Gm Micromhos	Max Undistorted Output Watts	Load Resistance Ohms
6B4G	TRIODE	G	F	OCT 8PIN 8H	1.0	16	7	5	SAME AS 6A3											
											INPUT PLATE GRID VOLTS RMS									
6B5	DYNAMIC COUPLED DUAL TRIODES	G	H	MED 6PIN 6G	0.8				DYNAMIC COUPLED AMP. SINGLE	300	300	0	15	42	8	58	24000	2400	4.0	7000
									DYNAMIC COUPLED AMP. PUSH-PULL (2 TUBES)	325	325	0	42	102	18				13.5	10000
6B6	DUO DIODE TRIODE	G	H	OCT 7PIN 7K	0.3	1.7	2	4	SAME AS 75, 2A6											
6B7	DUO-DIODE PENTODE	G	H	SM.7PIN 7B	0.3	0.007	3.5	9.5	PENTODE UNIT R.F. AMPLIFIER	250	125	-3	-21	9.0	2.3	730	0.65 MEG	1125		
										100	100	-3	-17	5.8	1.7	285	0.3 MEG	950		
									RES. COUPLED A.F. AMP	300	R_{G2} = 1.2 MEG.			R_c = 1600 OHMS GAIN = 79					100 V	R PLATE = 0.25 MEG. R NEXT GRID = 0.5 MEG
6B8	DUO DIODE PENTODE	M	H	OCT 8PIN 8J	0.3	0.005	6	9	PENTODE UNIT R.F. AMPLIFIER	250	125	-3	-21	10.0	2.3	800	0.6 MEG	1325		
									FOR OTHER APPLICATIONS SEE 6B7											
6C5	TRIODE	M	H	OCT 6PIN 6H	0.3	1.8	4	13	AMPLIFIER	250		-8		8		20	10000	2000		
									RES. COUPLED AMPLIFIER	300	R_c = 12300 OHMS; R_g (NEXT STAGE) = 0.5 MEG. GAIN = 14								85 V	R PLATE = 0.[illegible] MEG.
6C6	PENTODE	G	H	SM.6PIN 6J	0.3	0.010	5.0	6.5	BIASED DETECTOR	250	100	-4.3	R_c = 10000 OHMS							R PLATE = 0.25 MEG.
										100	30	-1.83	R_c = 10000 OHMS							
									R.F. AMPLIFIER	250	100	-3	-7	2	0.5	1500	[illegible]	1225		
										100	100	-3	-7	2	0.5	1185	[illegible]	1185		
									RES. COUPLED A.F. AMP.	300	R_{G2} = 1.2 MEG. R_c = 1200 OHMS GAIN = 140								104 VOLTS	R PLATE = 0.25 MEG R NEXT GRID = [illegible]
									TRIODE AMPLIFIER	250		-8		6.5		20	10000	1900		
6C8G	DOUBLE TRIODE (SEPARATE CATHODES)	G	H	OCT 8PIN 8K	0.3	TRIODE WITH GRID CAP 2.4; OTHER TRIODE 2.5	2.5; 3.4	3.9; 3.5	CLASS A AMP. (ONE TRIODE)	250		-4.5		3.1		38	26000	1450		
									PHASE INVERTER	250		-3	PER SECT	R_c (COMMON) 1500 OHMS GAIN 26					80 VOLTS	R PLATE [illegible] R NEXT GRID 0.5 MEG
										250		-3	PER SECT	R_c (COMMON) 900 OHMS GAIN 46					60 VOLTS	R PLATES [illegible] R NEXT GRID 0.[illegible]
6D6	VARIABLE MU PENTODE	G	H	SM 6PIN 6J	0.3	0.010	4.7	6.5	R.F. AMPLIFIER	250	100	-3	-50	8.2	2.0	1280	[illegible]	1600		
										100	100	-3	-50	8.0	2.2	375	[illegible]	1500		
									MIXER	250	100	-10	OSCILLATOR PEAK 7 VOLTS							
6D8G	PENTAGRID CONVERTER	G	H	OCT 8PIN 8G	0.15	1.0	6.0	5.5	CONVERTER OSCILLATOR SECTION	250	R_G = 0.05 MEG.			4.5	R_{GL} = 0.02 MEG					
										100	R_G = 0.05 MEG.			1.8						
						0.3	8.0	11.0	CONVERTER MIXER SECTION	250	100	-3	-40	3.[illegible]	3.5		[illegible]	500	CONVERSION CONDUCTANCE	
										100	50	-1.5	-20	1.0	1.7		[illegible]	300		
6E6	DOUBLE TRIODE	G	H	MED 7PIN 7C	0.6				CLASS A AMP. (ONE SECTION)	250		-27.5		18		6	3500	1700	0.8	7000
									CLASS A PUSH-PULL AMP. TWO SECTIONS	250		-27.5							2.0	10000
										180		-20							0.65	15000
6F5	TRIODE	M	H	OCT 5PIN 5H	0.3	2	6	12	AMPLIFIER	250		-2		0.9		100	66000	1500		
									RES. COUPLED AMPLIFIER	300	R_c = 3200 OHMS GAIN = 65 R_g NEXT = 0.5 MEG.								5.4 VOLTS	R PLATE = 0.25
6F6	PENTODE	M	H	OCT 7PIN 7L	0.7				SINGLE CLASS A PENTODE	250	250	-16.5		34	6.5	200	80000	[illegible]	3.0	7000
										315	315	-22		42	8	200	[illegible]	2650	5.0	7000
									SINGLE CLASS A TRIODE	250		-20		31		7	2600	2700	0.85	4000
									CLASS AB1 PENTODES (2 TUBES) FIXED BIAS	375	250	-26		34	5	PK INPUT G TO G [illegible]			19	10000 P TO P
									CLASS AB1 PENTODES (2 TUBES) SELF BIAS	375	250	R_c = 340 OHMS		54	8	[illegible]			19	10000 P TO P
									CLASS AB1 TRIODES (2 TUBES) FIXED BIAS	350		-38		45		123 V			18	6000 P TO P
									CLASS AB1 TRIODES (2 TUBES) SELF BIAS	350		R_c = 730 OHMS		50		132 V			14	10000 P TO P
6F7	TRIODE PENTODE	G	H	SM.7PIN 7D	0.3	TRIODE 2.0	2.5	3.0	AMPLIFIER TRIODE UNIT	100		-3		3.5		8	16000	500		
									AMPLIFIER PENTODE UNIT	250	100	-3	-35	6.5	1.5	900	0.85 MEG	1100		
						PENTODE 0.008	3.2	12.5		100	100	-3	-35	6.3	1.6	300	0.29 MEG	1050		
									CONVERTER TRIODE OSC.	100	R_g 0.1 MEG.			2.4	0.15	GRID CURRENT				
									CONVERTER PENTODE MIXER	250	100	-10		2.8	0.6		[illegible]	300	CONVERSION CONDUCTANCE	
6H6	DUO-DIODE	M	H	OCT 7PIN 7M	0.3	P_1 to P_2 0.[illegible]; P to C 2.0			DIODE DETECTOR	MAX. A.C. PER PLATE 100 VOLTS R.M.S.; MAX PLATE CURRENT 4 MA										
6J5G	TRIODE	G	H	OCT 7PIN 7N	0.3	3.4	3.8	3.3	CLASS A AMPLIFIER	250		-8		9.0		20	7700	2600		
6J7	PENTODE	M	H	OCT 7PIN 7O	0.3	0.005	7.0	12.0	SAME AS 6C6											
6K6G	PENTODE	G	H	OCT 7PIN 7L	0.4				CLASS A AMPLIFIER	250	250	-18		32	5.5	150	64000	2300	3.4	7000
										100	100	-7		9	1.6	150	103500	1450	0.35	12000
6K7	VARIABLE MU PENTODE	M	H	OCT 7PIN 7O	0.3	0.005	7.0	12.0	R.F. AMPLIFIER	250	125	-3	-52.5	10.5	2.6	990	0.6 MEG	1650		
										250	100	-3	-42.5	7.0	1.7	1100	[illegible]	1450		
										90	90	-3	-38.5	5.4	1.3	400	[illegible]	1275		
6L5G	TRIODE	G	H	OCT 6PIN 6H	0.15	2.7	3	5	CLASS A AMPLIFIER	250		-9	-20	8		17	9000	1900		
										135		-5	-11	5.5		17	11300	1500		
6L6	BEAM TYPE TETRODE	M	H	OCT.7PIN 7P	.9				CLASS A AMP.	250	250	-14		72	5	135	22500	6000		
									CLASS A AMP (SINGLE TUBE) SELF BIAS	300	200	R_c = 220 OHMS		51	3				6.5	4500
									CLASS A AMP (SINGLE TUBE) FIXED BIAS	375	250	-17.5		57	2.5				11.5	4000
									PUSH PULL CLASS A1 SELF BIAS	250	250	R_c = 125 OHMS		120	10				13.8	5000
									PUSH PULL CLASS A1 FIXED BIAS	250	250	-16		120	10				14.5	5000
									PUSH PULL CLASS AB1 SELF BIAS	400	300	R_c = 200 OHMS		112	7				32	6600
									PUSH PULL CLASS AB1 FIXED BIAS	400	300	-25		102	6				34	6600
									PUSH PULL CLASS AB2 FIXED BIAS (2 TUBES)	400	250	-20		[illegible]	[illegible]				40	6000
										400	300	-25		[illegible]	[illegible]		35 W		60	3800
6L7	PENTAGRID MIXER	M	H	OCT 7PIN 7F	.3	G_1-G_3 = .12; G_1-P = .0005; G_3-P = .025; G_1 In = 11.5; G_3 In 8.5 OUTPUT 12.5			MIXER	250	150	-6 G_1; -15 G_3	-6 G_1; -45	3.3	8.3		1 MEG	350	OSC PEAK 18 V MIN	
									AMPLIFIER	250	100	-3 G_1; -3 G_3	-15 G_1; -15 G_1	5.3	5.5	880	8 MEG	1100		
6N6G	DYN-CPLD DUAL TRIODES	G	H	OCT 7PIN 7E	.8				DYNAMIC COUPLED AMP (1 TUBE)	300	INPUT 300	0		45	[illegible]	58	24000	2400	4	7000
									DYNAMIC COUPLED AMP PUSH PULL (2 TUBES)	325	325	0		102	18	INPUT SIGNAL 42 V RMS [illegible]			13.5	10000
6N7	DOUBLE TRIODE	M	H	OCT 8PIN 8L	.8	SAME AS 6A6														
6P7	TRIODE PENTODE	M	H	OCT 8PIN 8M	.3	2; .01	2.5; 3.5	3; 10	TRIODE PENTODE SAME AS 6F7											
6Q6G	SINGLE DIODE TRIODE	G	H	OCT 6PIN 6L	.15	1.8	2.5	5.2	TRIODE UNIT AMPLIFIER	250		-3		1.2		65		1050		
										135		-1.5		.9		65		1000		
6Q7	DUO DIODE TRIODE	M	H	OCT 7PIN 7Q	.3	1.3	2.7	5.7	TRIODE UNIT AMPLIFIER	250		-3		1.1		70	58000	1200		
										100		-1.5		.35		70	87500	800		
									RES. COUPLED AMPLIFIER	300	R_c = 3000 OHMS				GAIN = 45				52 V	R PLATE [illegible] R NEXT GRID 0.5 MEG
6R7	DUO DIODE TRIODE	M	H	OCT 7PIN 7Q	.3	2.3	2.5	4.5	TRIODE UNIT AMPLIFIER	250		-9		9.5		16	8500	1900		
									RES. COUPLED AMPLIFIER	300	R_c = 3800 OHMS				GAIN = 10				68 V	R PLATE & R NEXT GRID [illegible]
6S7G	VAR. MU PENTODE	G	H	OCT 7PIN 7O	.15	.007	4.6	7.8	AMPLIFIER	250	100	-3	-38.5	8.5	2	1100	.65 MEG	1750		
										135	67.5	-3	-25	3.7	.9	850	.68 MEG	1250		
6T7G	DUO DIODE TRIODE	G	H	OCT 7PIN 7Q	.15	1.7	1.8	3.1	TRIODE UNIT-AMPLIFIER	250		-3		.9		65	.65 MEG	1000		
										100		-1.5		.3		65	.95 MEG	680		
									RES. COUPLED AMPLIFIER	SEE 6Q7										
6U7G	VARIABLE MU PENTODE	G	H	OCT 7PIN 7O	.3	SAME AS 6D6														

RECEIVING TUBE CHART

6.3 VOLT DETECTOR AND AMPLIFIER TUBES (CONT.)

TYPE	DESCRIPTION	GLASS OR METAL	FIL. OR HTR.	BASE (SEE SOCKET CONNECTION CHART)	FIL. CURRENT AMPS.	CAPACITANCES MMFD. GRID PLATE	INPUT	OUTPUT	APPLICATION	PLATE SUP. VOLTS	SCR. GRID VOLTS	CONTROL GRID VOLTS	CUT OFF BIAS VOLTS	PLATE CURRENT MA	SCR. CURRENT MA	μ	Rp OHMS	Gm MICROMHOS	MAX. UNDISTORTED OUTPUT WATTS	LOAD RESISTANCE OHMS
6V6	BEAM TYPE TETRODE	M	H	OCT. 7PIN 7P	.45				CLASS A AMPLIFIER (SINGLE)	250	250	-12.5		45	4.5	218	52000	4100	4.25	5000
									CLASS AB₁ (2 TUBES)	300	300	-20		78 to 92	5 to 13.5				13.5	8000 (P to P)
										250	250	-15		70 to 79	5 to 12				8.5	10000 (P to P)
6V7G	DUO-DIODE TRIODE	G	H	OCT. 7PIN 7Q	.3	1.5	1.5	4.3	SAME AS 85											
6Y7G	DOUBLE TRIODE	G	H	OCT. 8PIN 8L	.6				SAME AS 79											
36	TETRODE	G	H	SM. 5 PIN 5J	.3	.007	3.7	9.2	AMPLIFIER	250	90	-3		3.2	1.7	595	.55 MEG	1080		
										180	90	-3		3.1		525	.5 MEG	1050		
										100	55	-1.5		1.8		470	.55 MEG	850		
									BIASED DETECTOR	180	67.5	-6		.1						.25 MEG.
37	TRIODE	G	H	SM. 5 PIN 5A	.3	2	3.5	2.9	AMPLIFIER	250		-18		7.5		9.2	8400	1100		
										180		-13.5		4.3		9.2	10200	900		
										90		-6		2.5		9.2	11500	800		
									BIASED DETECTOR	250		-28		.2						
38	PENTODE	G	H	SM. 5PIN 5D	.3	.3	3.5	7.5	CLASS A AMPLIFIER	250	250	-25		22	3.8	120	1 MEG.	1200	2.5	10000
										100	100	-9		7	1.2	120	.14 MEG	1100	.27	15000
39/44	PENTODE	G	H	SM. 5 PIN 5D	.3	.007	3.5	10	AMPLIFIER	250	90	-3	-42.5	5.8	1.4	1050	1 MEG	1050		
										180	90	-3	-42.5	5.8	1.4	750	.75 MEG	1000		
										90	90	-3	-42.5	5.6	1.6	360	.375 "	960		
									MIXER	250	90	-7	OSCILLATOR PEAK 6 VOLTS							
41	PENTODE	G	H	MED. 6PIN 6E	.4				CLASS A AMPLIFIER	250	250	-18		32	5.5	150	68000	2200	3.4	7600
										100	100	-7		9	1.6	150	103500	1450	.33	12000
42	PENTODE	G	H	MED. 6PIN 6E	.7				CLASS A PENTODE	315	315	-22		42	8	260	.1 MEG.	2600	5	7000
										250	250	-16.5		34	6.5	190	80000	2350	3	7000
									CLASS A TRIODE	250		-20		31		6.2	2700	2300	.65	3000
									FOR PUSH PULL SERVICE SEE 6F6											
75	DUO DIODE TRIODE	G	H	MED. 6PIN 6F	.3	1.7	1.7	3.8	TRIODE UNIT — AMP.	250		-2		.8			91000	1100		
									TRIODE UNIT — RES COUP.	300	Rc=3900				GAIN=53				51V	[illegible]
76	TRIODE	G	H	MED. 5PIN 5A	.3	2.8	3.5	2.5	AMPLIFIER	250		-13.5		5		13.8	9500	1450		
										100		-5		2.5		13.8	12000	1150		
									RES. COUP. AMP.	300	Rc=6400 OHMS				GAIN=10				95 V	R PLATE = .1 MEG. [illegible]
									BIASED DETECTOR	250	Rc = 30000 — 150,000 OHMS									
77	PENTODE	G	H	SM. 6PIN 6J	.3	.007	4.7	11	AMPLIFIER	250	100	-3		2.3	.5	1500	1.5 MEG	1250		
										100	60	-1.5		1.7	.4	715	.65 MEG.	1100		
									BIASED DETECTOR	250	100	-4.3 (OR Rc = 10000)								.5 MEG.
										250	50	-2 (OR Rc = 3000)								.25 MEG.
										100	36	-2 (OR Rc = 12500)								.25 MEG.
78	VAR. MU PENTODE	G	H	SM. 6PIN 6J	.3	.007	4.5	11	SAME AS 6K7											
79	DOUBLE TRIODE	G	H	SM. 6PIN 6N	.6				CLASS B (2 SECTIONS)	250		0		10.6 TO 50					8	14000 (P to P)
										180		0		7.6 TO 40					5.5	8000 (P TO P)
85	DUO. DIODE TRIODE	G	H	SM. 6PIN 6F	.3	1.5	1.5	4.3	TRIODE UNIT — AMP.	250		-20		8		8.3	7500	1100	.35	20000
										135		-10.5		3.7		8.3	11000	750	.075	25000
									TRIODE UNIT — RES COUP.	300	Rc = 8300 OHMS				GAIN=5.75				82V	[illegible]

7.5 VOLT DETECTOR AND AMPLIFIER TUBES

TYPE	DESCRIPTION	GLASS OR METAL	FIL. OR HTR.	BASE	FIL. CURRENT AMPS.	GRID PLATE	INPUT	OUTPUT	APPLICATION	PLATE SUP. VOLTS	SCR. GRID VOLTS	CONTROL GRID VOLTS	CUT OFF BIAS VOLTS	PLATE CURRENT MA	SCR. CURRENT MA	μ	Rp OHMS	Gm MICROMHOS	MAX. UNDISTORTED OUTPUT WATTS	LOAD RESISTANCE OHMS
10	TRIODE	G	F	4G MED. 4PIN	1.25	7	4	3	AMPLIFIER	350		-31		16		8	5150	1550	.9	11000
										425		-39		18		8	5000	1600	1.6	10000
50	TRIODE	G	F	4G MED. 4PIN	1.25	8.4	4.4	2.7	AMPLIFIER	350		-63		45		3.8	1900	2000	2.4	4100
										450		-84		55		3.8	1800	2100	4.6	4350
1602	LOW MICRO PHONIC TRIODE	G	F	4G MED. 4PIN	1.25	7	4	3	AMPLIFIER (FORMERLY TERMED 10 SPECIAL)	350		-32		16		8	5150	1550	.9	11000
										425		-40		18		8	5000	1600	1.6	10200

SERIES FILAMENT POWER OUTPUT TUBES

TYPE	DESCRIPTION	GLASS OR METAL	FIL. OR HTR.	BASE	FIL. CURRENT AMPS.	GRID PLATE	INPUT	OUTPUT	APPLICATION	PLATE SUP. VOLTS	SCR. GRID VOLTS	CONTROL GRID VOLTS	CUT OFF BIAS VOLTS	PLATE CURRENT MA	SCR. CURRENT MA	μ	Rp OHMS	Gm MICROMHOS	MAX. UNDISTORTED OUTPUT WATTS	LOAD RESISTANCE OHMS
12A5	PENTODE	G	H	7S SM. 7PIN	.3A/12.6V .6A/6.3V				CLASS A PENTODE AMP	100	100	-15		17	3	70	35000	1900		
										180	27	-27		36	6	80	32000	2500		
12A7	PENTODE DIODE	G	H	7R SM. 7PIN	.3A/12.6V				AMPLIFIER	135	135	-13.5		9		100	100000	975	.55	13500
									RECTIFIER	125		30 (MAX								
18	PENTODE	G	H	6G MED. 6PIN	.3A/14V				AMPLIFIER	250	250	-16.5		34	7.5	185	79000	2350	3	7000-9000
25A6	PENTODE	M	H	7L OCT. 7PIN	.3A/25V		SAME AS TYPE 43													
25A7G	PENTODE DIODE	G	H	8N OCT. 8 PIN	.3A/25V				AMPLIFIER	SAME AS TYPE 43										
									RECTIFIER	125		75 (MAX)								
25B5	DIRECT CPLD DUAL TRIODE	G	H	6G MED 6PIN	.3A/25V				DYNAMIC COUPLED AMPLIFIER	110	[illegible]	0	21	45	[illegible]	25	11400	2200	2	2000
										180	100+	0	21	46	5.8	35	15200	2300	3.8	4000
25B6G	PENTODE	G	H	7L OCT. 7PIN	.3A/25V				CLASS A AMPLIFIER	95	95	-15		45	4 to 12			4000	1.75	2000
25L6	TETRODE	M	H	7AC OCT. 7PIN	.3A/25V				CLASS A AMPLIFIER	110	110	-8		45	3.5	80	10000	8000	2.2	1500
25N6G				7 OCT. 7PIN	SAME AS 25B5															
43	PENTODE	G	H	6E MED. 6PIN	.3A/25V				AMPLIFIER	95	95	-15		20	4	90	45000	2000	.9	4500
										135	135	-20		37	8	85	35000	2450	2	4000
48	TETRODE	G	H	MED. 6PIN 4Q	.4A/30V				AMPLIFIER	96	96	-19		52	9			3800	2	1500
										125	100	-20		56	9.5			3900	2.5	1500

RECTIFIERS

TYPE NO	DESCRIPTION: HALF OR FULL WAVE	HIGH VACUUM OR MERCURY VAPOR	GLASS OR METAL	CATHODE	BASE (SEE SOCKET LAYOUT CHART)	FILAMENT V	FILAMENT AMP.	MAX. VOLTS RMS PER ANODE	MAX. PEAK INVERSE VOLTS	MAX. OUTPUT CURRENT MA	MAX PEAK PLATE CURRENT	MIN. CHOKE BEFORE FILTER HENRIES	MAX VOLTS HEATER CATHODE	MAX D.C. VOLTS AT INPUT OF FILTER AT 80 MA. DRAIN: CONDENSER INPUT 8 MFD.	CHOKE INPUT
1V	HALF	V	G	H	SM. 4 PIN 4D	6.3	0.3	350	1000	50			500	400 AT 50 MA. DRAIN	
5T4	FULL	V	M	F	OCT. 5 PIN 5E	5.0	2.0	450	1250	250				570	
								550	1550	250		10			480
5U4G	FULL	V	G	F	OCT. 8 PIN 8C OCT. 5 PIN 5E	5.0	3.0	500	1400	250				580	410
5V4G	FULL	V	G	H	OCT 8-PIN 8D	5.0	2.0	400	1100	200	700			490	325
5W4	FULL	V	M	F	OCT 5-PIN 5E	5.0	1.5	350	1000	110				390	
5X4G	FULL	V	G	F	OCT 8-PIN 8E	5.0	3.0	SAME AS 5U4G AND 5Z3 EXCEPT FOR BASE							
5Y3G	FULL	V	G	F	OCT 5 PIN 5E	5.0	2.0	SAME AS 80							

RECEIVING TUBE CHART

RECTIFIERS

TYPE NO.	DESCRIPTION: HALF OR FULL WAVE	HIGH VACUUM OR MERCURY VAPOR	GLASS OR METAL	CATHODE	BASE (SEE SOCKET LAYOUT CHART)	FILAMENT V.	FILAMENT AMP.	MAX. VOLTS RMS PER ANODE	MAX. PEAK INVERSE VOLTS	MAX. OUTPUT CURRENT MA.	MAX. PEAK PLATE CURRENT	MIN. CHOKE BEFORE FILTER HENRIES	MAX. VOLTS HEATER CATHODE	MAX. D.C. VOLTS AT INPUT OF FILTER AT 80 MA. DRAIN: CONDENSER INPUT 8 MFD.	MAX. D.C. VOLTS AT INPUT OF FILTER AT 80 MA. DRAIN: CHOKE INPUT
5Y4G	FULL	V	G	F	OCT. 8-PIN 8E	5.0	SAME AS 80								
5Z3	FULL	V	G	F	MED 4 PIN 4B	5.0	3.0	500	1400	250				580	410
5Z4	FULL	V	M	H	OCT. 5-PIN 5F	5.0	2.0	400	1100	125				500	330
6W5G	FULL	V	G	H	OCT 6 PIN 6M	6.3	0.9	350		100			500		
6X5	FULL	V	M	H	OCT 6 PIN 6M	6.3	0.6	350	1250	75	325		400	400	290
6Z4/84	FULL	V	G	H	SM 5 PIN 5M	6.3	0.3	350	1000	60	200		500	410	290
12Z3	HALF	V	G	H	SM 4 PIN 4D	12.6	0.3	250	700	60			350	280	
25Z5	DOUBLER	V	G	H	SM. 6 PIN. 6R	25.0	0.3	125		100	500			192 (16 MFD.)	
	HALF (2 SECT.)							125		85	500			85	
25Z6	DOUBLER	V	M	H	OCT 7 PIN 7W	25.0	0.3	125		85	500				
	HALF (2 SECT.)							125		85	500				
80	FULL	V	G	F	MED 4 PIN 4B	5.0	2.0	350		125				400	
								400		110				445	
								550		135		20			440
81	HALF	V	G	F	MED 4 PIN 4A	7.5	1.25	700		85				700	550
82	FULL	M V	G	F	MED 4 PIN 4B	2.5	3.0	500	1400	125	400			620 (4 MFD.)	440
83	FULL	M V	G	F	MED 4 PIN 4B	5.0	3.0	500	1400	250	800				
83V	FULL	V	G	H	MED 4 PIN 4C	5.0	2.0	400	1100	200	700			500	330
878	HALF	V	G	F	MED 4 PIN 4M	5.0	2.5	7100	20000	5					
879	HALF	V	G	F	MED 4 PIN 4M	2.5	1.75	2650	7500	7.5	100				
0Z3	FULL	GAS	G	COLD	SM 5 PIN 5K			350	1250	75 MAX. 30 MIN.	200			425	300
0Z4	FULL	GAS	M	COLD	OCT 5 PIN 5L										
0Z4G	FULL	GAS	G	COLD	OCT 5 PIN 5L										
BA	FULL	GAS	G	COLD	MED 4 PIN 4F			350	1000	350	1000				300
BH	FULL	GAS	G	COLD	MED 4 PIN 4F			350	1000	125	400				300
BR	HALF	GAS	G	COLD	MED 4 PIN 4E			300	850	50	200				

6.3 VOLT CATHODE-RAY TUNING INDICATORS

TYPE NO	DESCRIPTION		BASE (SEE SOCKET CONNECTION CHART)	FILAMENT CURRENT AMPS.	PLATE SUPPLY VOLTS	TARGET VOLTS	GRID BIAS FOR 0 SHADOW	GRID BIAS FOR 90° SHADOW	PLATE CURRENT MA (ZERO BIAS)	TARGET CURRENT MA	PLATE RESISTOR MEGS.
6AB5	SHADED SECTOR		SM. 6 PIN 6K	0.15	135	135	-7.5	0	0.5	4.5	0.25
6E5	SHADED SECTOR		SM 6 PIN 6K	0.3	250	250	-8.0	0	0.24	4.5	1.0
					100	100	-3.3	0	0.19	4.5	0.5
6G5	SHADED SECTOR	REMOTE CUT-OFF	SM. 6 PIN 6K	0.3	250	250	22	0	0.24	4.5	1.0
					100	100	-8	0	0.19	4.5	0.5
6H5	ONE FIXED 90% SHADED SECTOR, ONE VARIABLE	REMOTE CUT-OFF CURRENT LIMITING GRID	SM 6 PIN 6K	0.3	250	250	-22	0		4.5	1.0
					100	100	-8.0	0		1.5	
6N5	SHADED SECTOR	REMOTE CUT-OFF	SM 6 PIN 6K	0.15	135	135	-12	0	0.5	4.5	0.25
6T5	ANNULAR SHADOW	REMOTE CUT-OFF	SM 6 PIN 6K	0.3	250	250	22	0	0.24	3.0	1.0
6U5	SAME AS 6G5 EXCEPT FOR BULB SIZE										

A Few Words Of Explanation Concerning These Tube Charts

THE receiving tubes have been arranged in groups, each group of one common filament voltage. Tubes in each group are arranged numerically and alphabetically. In cases where a tube has characteristics equivalent to another tube in the same group, the data is given once and reference is made to the equivalent. When the equivalent tube is in another group the characteristics are given twice for added convenience.

In all cases of push-pull service where the notice "(2 tubes)" appears under applications, plate current, screen current and power output shown is the total for two tubes and the load impedance given is "plate to plate."

The characteristics given by the manufacturer show conditions as amplifiers where there is no appreciable voltage drop across the plate load. Therefore, tubes like the 6R7, 55, 85, 56, etc., have additional information for application as resistance-coupled amplifiers. In this case the "output" columns give the output in *volts*. This information is given for one set of conditions only — the one which is most generally used.

All tubes with octal bases reserve pin Number 1 for connections to the shell. When the tube is a G tube, this pin has no connection. In order to save space no extra base diagrams have been made of equivalent metal and G tubes. The 25A7G is the only exception—its pin Number 1 connects to a cathode.

The last two columns of the rectifier chart shows the maximum voltage obtained at the input of the filter for an 80 ma. drain. Where the tube has a maximum rating less than 80 ma. output voltage for maximum current is shown. In all cases, this voltage is obtained with the maximum allowable a.c. voltage per plate as shown on the same line in the chart.

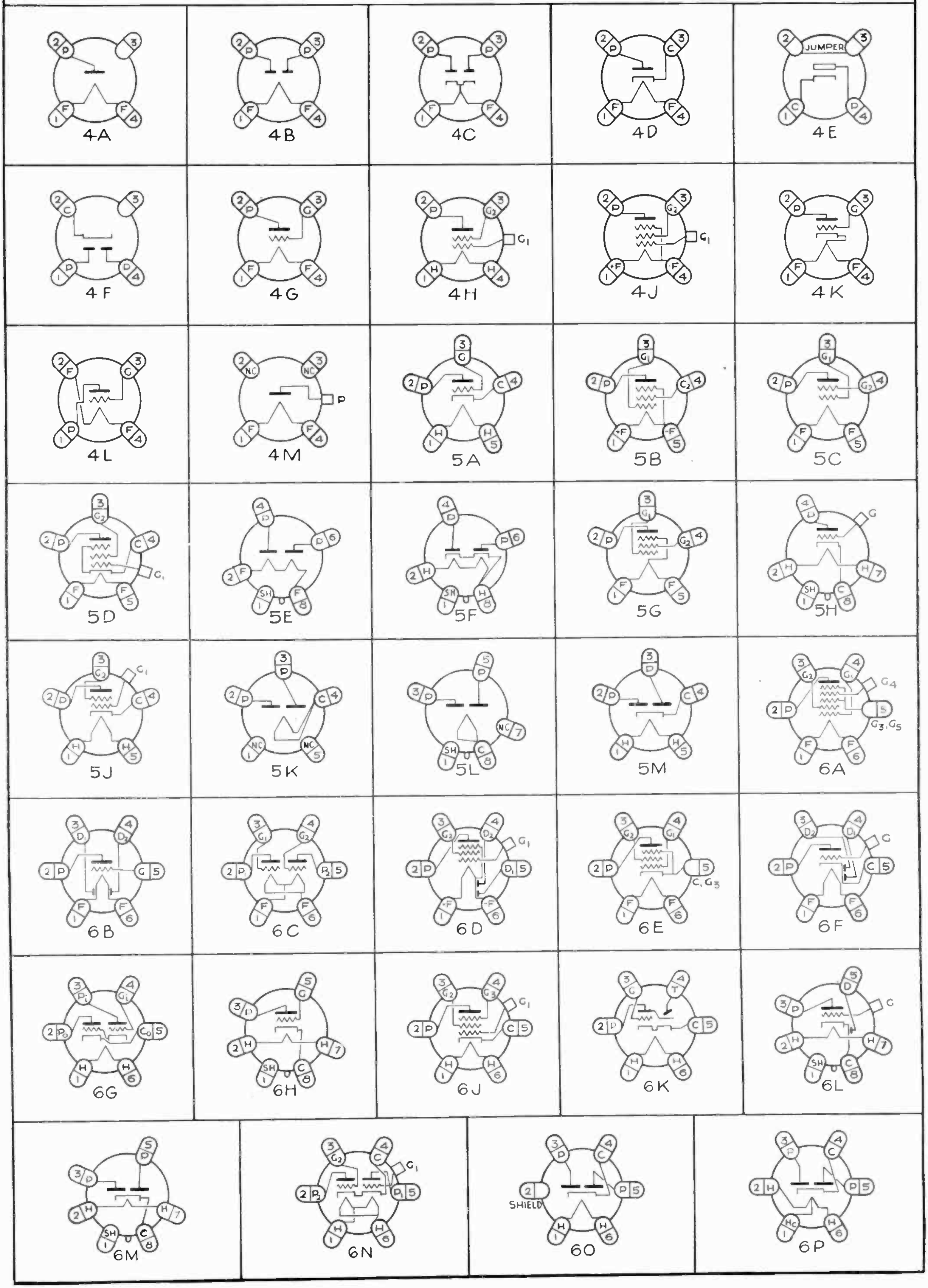
An additional tube not listed here is type 89, a triple grid power amplifier; filament 6.3 volts, 0.4 ampere, socket layout 6J. Used as a triode, G_2 and G_3 are tied to the plate and in Class A operation, the plate current is 31 ma. at 250 volts, grid bias 31 volts. Amplification factor is 4.7; mutual conductance, 1800 micromhos; plate resistance 2600 ohms. The recommended load resistance is 550 ohms and the maximum power output 0.9 watt.

Used as a class B triode amplifier, G_2 is tied to G_1 and G_3 to plate. The tube is used without bias and with a 180 volt power supply, two tubes have 3 ma. plate current per tube at zero signal and a maximum of 90 ma. total. The required load impedence is 9400 ohms, maximum output for two tubes, 3.5 watts. The driver should deliver 0.35 watt to the grids.

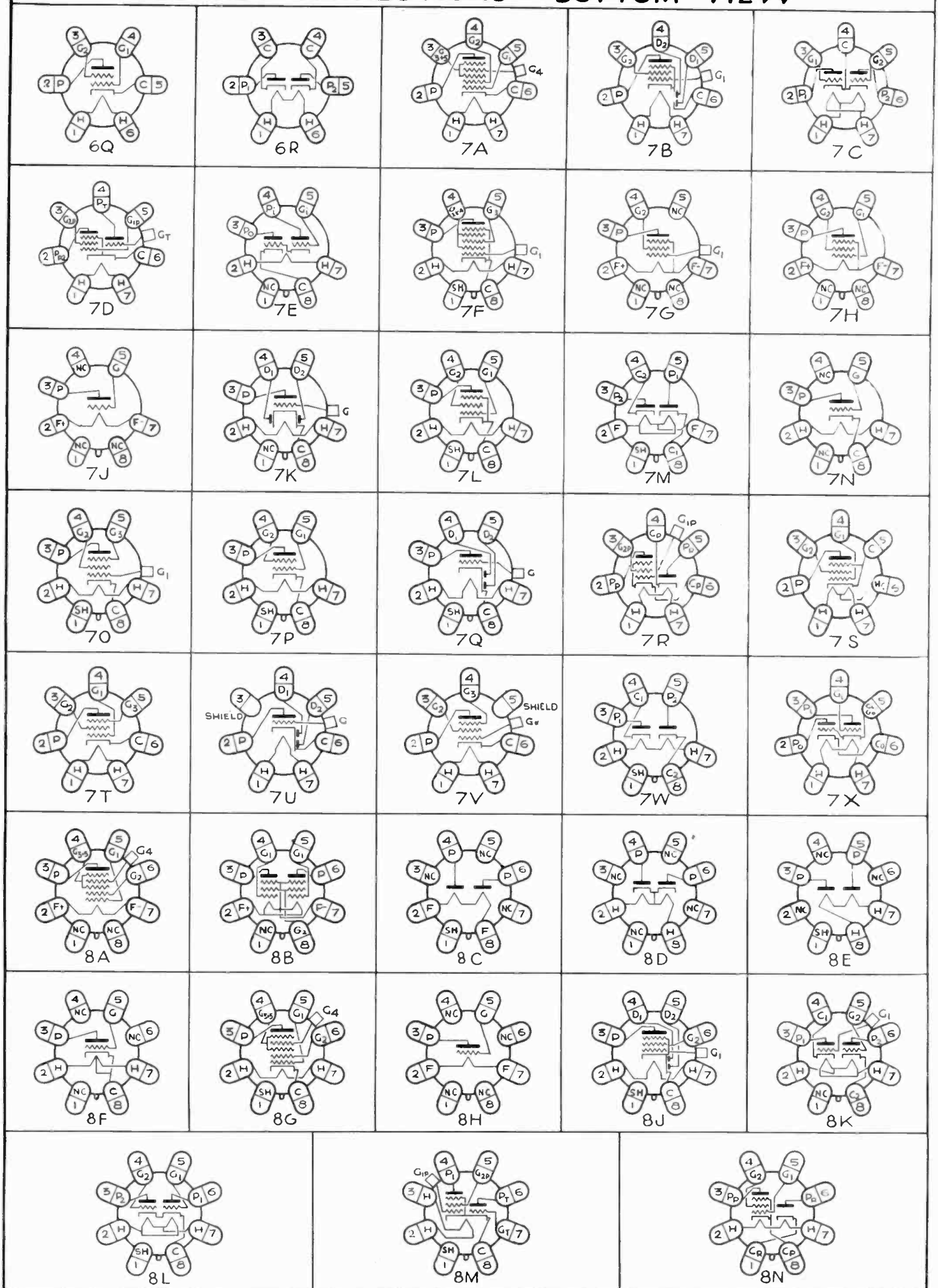
The tube can also be used as a pentode. Under class A conditions, with 250 volts on plate and screen, the plate current is 32 ma., screen current 5.5 ma., and grid bias 25 volts. Then, the plate resistance becomes 70,000 ohms, the mutual conductance 1800 micromhos, the amplification factor 125. The maximum power output is 3.4 watts for one tube in a load resistance of 6,750 ohms.

Some of the special tubes are the acorn types 954 and 955. These require 6.3 volts at 0.3 ampere for the filament. The 954 is a pentode amplifier, its characteristics resembling type 6C6. Type 955 is a triode which, when used as an amplifier, has an amplification factor of 25, mutual conductance of 2,000 micromhos and plate resistance of 12,500 ohms.

SOCKET CONNECTIONS BOTTOM VIEW



SOCKET CONNECTIONS BOTTOM VIEW



WORLD-WIDE SHORT-WAVE STATION LIST

Kc.	Meters	Call	Location	Kw.	Service, etc.
400,000	0.75	W1XEG	Storrs, Conn.	0.5	Experimental
60,500	4.96	W8XKA	Pittsburgh, Pa.	0.15	Experimental
55,500	5.41	W8XKA	Pittsburgh, Pa.	0.15	Exp.; relays KDKA
41,000	7.32	W2XG	New York, N. Y.	0.1	Experimental
31,600	9.50	W1XKA	Chicopee Falls, Mass.	0.5	Experimental
31,600	9.49	W3XKA	Philadelphia, Pa.	......	Exp., relays KYW
31,600	9.49	W8XAI	Rochester, N. Y.	0.1	Exp.; relays WHAM
31,600	9.49	W8XKA	Pittsburgh, Pa.	......	Experimental
31,600	9.49	W8XWJ	Detroit, Mich.	0.1	Exp.; relays WWJ
31,600	9.49	W9XPD	St. Louis, Mo.	0.1	Exp.; relays KSD
26,100	11.49	GSK	Daventry, England	20.0	Broadcast
21,540	13.93	W8XK	Pittsburgh, Pa.	40.0	Bc.; relays KDKA
21,530	13.93	GSJ	Daventry, England	15.0	Broadcast
21,520	13.94	W2XE	Wayne, N. J.	......	Bc.; relays WABC
21,520	13.94	JZM	Nazaki, Japan	......	......
21,470	13.97	GSH	Daventry, England	20.0	Broadcast
21,460	13.98	W1XAL	Boston, Mass.	5.0	Broadcast
21,450	13.99	OLR6A	Podebrady, Czechoslovakia	25.0	Broadcast
21,420	14.01	WKK	Lawrenceville, N. J.	20.0	Phone
21,160	14.18	LSL4	Hurlingham, Argentina	60.0	Phone to London and Rio; day
21,140	14.19	KBI	Manila, P. I.	10.0	Phone
21,080	14.23	PSA	Marapicu, Brazil	10.0	Phone; broadcast
21,060	14.25	WKA	Lawrenceville, N. J.	20.0	Phone to England
21,060	14.25	KWN	Dixon, Calif.	20.0	Phone
21,020	14.27	LSN6	Hurlingham, Argentina	60.0	Phone to New York; day
20,910	14.35	PSB	Marapicu, Brazil	10.0	Phone
20,860	14.37	EHY	Madrid, Spain	7.5	Phone to Buenos Aires
20,820	14.41	KSS	Bolinas, Calif.	40.0	Phone
20,780	14.44	KMM	Bolinas, Calif.	40.0	Phone
20,140	14.90	DWG	Nauen, Germany	......	Phone
20,010	14.97	OPL	Leopoldville, Belgian Congo	9.0	Phone to ORG; mornings
20,020	14.99	DFZ	Nauen, Germany	......	Phone to South America
19,980	15.02	KAX	Manila, P. I.	20.0	Phone to Calif.
19,820	15.14	WKN	Lawrenceville, N. J.	20.0	Phone to England
19,720	15.21	EAQ	Madrid, Spain	10.0	Phone to Latin America
19,700	15.23	DFJ	Nauen, Germany	......	Phone
19,660	15.26	SUY	Abuzabal, Egypt	0.1	Phone
19,600	15.31	LSF	Monte Grande, Argentina	7.0	Phone
19,520	15.37	IRW	Rome, Italy	20.0	Phone to South America
19,460	15.42	DFM	Nauen, Germany	......	Phone
19,345	15.51	PMA	Bandoeng, Java, D. E. I.	40.0	Phone; sometimes bc.
19,260	15.58	PPU	Sepetiba, Brazil	12.0	Phone
19,220	15.61	WKF	Lawrenceville, N. J.	20.0	Phone
19,200	15.62	ORG	Ruysselede, Belgium	8.0	Phone
19,140	15.68	LSM3	Hurlingham, Argentina	60.00	Phone to Madrid, Berlin, Paris; day
19,050	15.75	JVC	Nazaki, Japan	......	Phone; sometimes bc.
19,020	15.77	HS8PJ	Bangkok, Siam	......	Broadcast
18,910	15.86	JVA	Nazaki, Japan	20.0	Phone to Europe; occ. bc.
18,890	15.88	ZSS	Klipheuvel, S. Africa	5.0	Phone to Rugby
18,860	15.91	WKM	Rocky Point, N. Y.	40.0	Phone
18,830	15.93	PLE	Bandoeng, Java, D. E. I.	40.0	Phone to Dixon and Nazaki
18,670	16.08	OCI	Lima, Peru	......	Phone
18,620	16.11	GAU	Rugby, England	15.0	Phone to WMI, VWY
18,600	16.13	PDM	Kootwijk, Holland	40.0	Phone
18,545	16.18	PCM	Kootwijk, Holland	40.0	Phone
18,480	16.23	HBH	Prangins, Switzerland	20.0	Phone
18,405	16.30	PCK	Kootwijk, Holland	40.0	Phone to Bandoeng
18,340	16.36	WLA	Lawrenceville, N. J.	20.0	Phone to GAS
18,310	16.38	FZS	Saigon, French Indo-China	15.0	Phone to France
18,270	16.42	IUD	Addis Ababa, Ethiopia	......	Phone
18,190	16.49	JVB	Nazaki, Japan	10.0	Phone to Java; P. I.; bc.
18,165	16.51	PPZ	Sepetiba, Brazil	20.0	Phone
18,135	16.55	PMC	Bandoeng, Java	40.0	Phone: sometimes bc.
18,090	16.58	TYE	Pontoise, France	12.0	Phone to U. S. A.
18,040	16.63	KQR	Bolinas, Calif.	40.0	Phone
18,020	16.65	KQJ	Bolinas, Calif.	40.0	Transpacific phone
17,980	16.69	KQZ	Bolinas, Calif.	40.0	Phone
17,940	16.72	WQB-W2XBJ	Rocky Point, N. Y.	40.0	Phone
17,920	16.74	WQF	Rocky Point, N. Y.	40.0	Phone
17,790	16.86	GSG	Daventry, England	15.0	Broadcast
17,785	16.87	JZL	Nazaki, Japan	......	Broadcast
17,780	16.87	W8XK	Pittsburgh, Pa.	40.0	Bc.; relays KDKA
17,780	16.87	W3XAL	Bound Brook, N. J.	15.0	Broadcast; relays WJZ
17,780	16.87	W9XAA	Chicago, Illinois	0.5	Experimental
17,775	16.88	PHI	Huizen, Holland	23.6	Broadcast
17,760	16.89	W2XE	Wayne, N. J.	......	Bc. relays WABC
17,760	16.89	DJE	Zeesen, Germany	5-50	Broadcast
17,755	16.90	ZBW5	Hongkong, China	2.0	Broadcast
17,750	16.90	IAC	Coltano, Italy	14.0	Phone; early mornings
17,740	16.91	HSP	Bangkok, Siam	20.0	Phone to JVG
17,640	17.00		British Ships	......	Phone
17,520	17.12	DFB	Nauen, Germany	......	Phone to YVR
17,480	17.16	VWY2	Kirkee, India	......	Phone to Rugby
17,310	17.33	W3XL	Bound Brook, N. J.	20.0	Experimental
17,265	17.37	DAF	Norddeich, Germany	......	Phone
17,130	17.51	HAS5	Szekesfehervar, Hungary	20.0	Broadcast
16,820	17.84	NAA	Arlington, Virginia	......	Time signals; 9:55-10:00 a.m. E. S. T.
16,665	18.00		German Ships	......	Phone
16,305	18.40	PCL	Kootwijk, Holland	......	Phone to Bandoeng
16,270	18.44	WLK	Lawrenceville, N. J.	20.0	Phone to Rugby
16,240	18.47	KTO	Manila, P. I.	40.0	Phone to Dixon
16,120	18.61	IRY	Rome, Italy	20.0	Phone
16,030	18.71	KKP	Kahuku, Hawaii	40.0	Phone to KWO
15,985	18.77	KQH	Kahuku, Hawaii	40.0	Phone
15,950	18.81	PLG	Bandoeng, Java	......	Phone; afternoons
15,880	18.89	FTK	Ste. Assise, France	30.0	Phone to Saigon
15,865	18.91	CEC	La Granja, Chile	0.5	Phone
15,860	18.90	JVD	Nazaki, Japan	......	Phone to Shanghai
15,810	18.97	LSL3	Hurlingham, Argentina	60.0	Phone to London, Rio; morn. and eve.
15,750	19.05	JIA	Tyureki, Formosa	10.0	Phone to Nazaki
15,680	19.13	JZA	Kanjoshi, Manchukuo	20.0	Phone to Nazaki
15,660	19.16	JVE	Nazaki, Japan	10.0	Phone to PLE, P. I.; occ. bc.
15,620	19.21	JVF	Nazaki, Japan	20.0	Phone to KWU; occ. bc.
15,505	19.35	CMA3	Havana, Cuba	......	Tests, irr.
15,490	19.37	KEM	Bolinas, Calif.	40.0	Phone
15,475	19.39	KKL	Bolinas, Calif.	40.0	Phone
15,450	19.42	IUG	Addis Ababa, Ethiopia	......	Phone
15,420	19.45	XEBM	Mazatlan, Sinaloa, Mexico	......	Bc.; relays XEBL
15,420	19.45	KWO	Dixon, Calif.	20.0	Phone to Hawaii, Manila
15,370	19.52	HAS3	Szekesfehervar, Hungary	20.0	Broadcast
15,360	19.53	DZG	Zeesen, Germany	......	Phone
15,355	19.54	KWU	Dixon, Calif.	20.0	Phone to Hawaii
15,340	19.56	DJR	Zeesen, Germany	50.0	Broadcast
15,330	19.57	W2XAD	Schenectady, N. Y.	20.0	Bc.; relays WGY
15,320	19.58	OLR5B	Podebrady, Czechoslovakia	25.0	Broadcast
15,310	19.60	GSP	Daventry, England	20.0	Broadcast
15,300	19.60	CP7	LaPaz, Bolivia	1.0	Phone
15,280	19.63	DJQ	Zeesen, Germany	5-50	Broadcast
15,280	19.63	LRU	Buenos Aires, Argentina	5.0	Bc.; relays LR1
15,270	19.65	W2XE	Wayne, N. J.	15.0	Bc.; relays WABC
15,260	19.66	GSI	Daventry, England	15.0	Broadcast
15,250	19.67	W1XAL	Boston, Mass.	5.0	Broadcast
15,243	19.68	TPA2	Pontoise, France	12.0	Broadcast
15,230	19.70	OLR5A	Podebrady, Czechoslovakia	25.0	Broadcast
15,220	19.71	PCJ	Huizen, Holland	20.0	Experimental
15,210	19.72	W8XK	Pittsburgh, Pa.	40.0	Bc.; relays KDKA
15,200	19.74	DJB	Zeesen, Germany	5-50	Broadcast
15,190	19.75	ZBW4	Hongkong, China	2.0	Broadcast
15,180	19.76	GSO	Daventry, England	15.0	Broadcast
15,160	19.79	JZK	Nazaki, Japan	......	Broadcast
15,160	19.79	OLR5C	Podebrady, Czechoslovakia	25.0	Broadcast
15,150	19.80	YDC	Bandoeng, Java	......	Broadcast
15,140	19.81	GSF	Daventry, England	15.0	Broadcast
15,123	19.84	HVJ	Vatican City	10.0	Broadcast
15,110	19.85	DJL	Zeesen, Germany	5-50	Broadcast
15,070	19.91	PSD	Marapicu, Brazil	12.0	Phone
15,055	19.93	WNC	Hialeah, Florida	0.4	Phone
15,040	19.95	RKI	Moscow, U.S.S.R.	20.0	Phone to WQG, mornings
15,000	20.0	WWV	Beltsville, Md.	1.0	Freq. standard; Tue., Wed., Fri., 2-3 p.m. E. S. T.
14,985	......	YSL	San Salvador, El Salvador	......	Phones Mexican stations
14,980	20.03	KAY	Manila, P. I.	40.0	Phone to Dixon
14,970	20.04	LZA	Sofia, Bulgaria	......	Broadcast
14,960	20.05	YSL	San Salvador, El Salvador	......	Phone
14,935	20.09	PSE	Marapicu, Brazil	......	Phone; broadcast
14,910	20.12	JVG	Nazaki, Japan	10.0	Phone to Formosa; broadcast
14,690	20.42	PSF	Marapicu, Brazil	......	Phone: broadcast
14,600	20.55	JVH	Nazaki, Japan	20.0	Phone; broadcast
14,590	20.56	WMN	Lawrenceville, N. J.	20.0	Phone
14,535	20.64	HBJ	Prangins, Switzerland	20.0	Phone
14,530	20.65	LSN1	Hurlingham, Argentina	60.0	Phone to New York; morn., eve.
14,500	20.69	LSM2	Hurlingham, Argentina	60.0	Phone to Madrid, Berlin, Paris; morn., eve.
14,480	20.72	YNA	Managua, Nicaragua	......	Phone to WNC
14,460	20.75	DZH	Nauen, Germany	......	Phone
14,440	20.78	GBW	Rugby, England	15.0	Phone
13,980	21.46	VPD2	Suva, Fiji Islands	......	Experimental
13,820	21.70	SUZ	Abu Zabal, Cairo, Egypt	20.0	Phone
13,820	21.70	SU1CH	Cairo, Egypt	......	Amateur; broadcast
13,811	21.72	SUZ1	Abu Zabal, Egypt	8.0	Phone
13,760	21.80	TYE2	Pontoise, France	12.0	Phone to U. S. A.
13,690	21.91	KKZ	Bolinas, Calif.	40.0	Phone to Japan, Java
13,635	22.00	SPW	Warsaw, Poland	20.0	Broadcast
13,610	22.04	JYK	Kemikawa-Cho, Japan	......	Experimental; bc.
13,585	22.08	GBB	Rugby, England	15.0	Phone
13,560	22.12	JVI	Nazaki, Japan	10.0	Phone to Manchukuo; also bc.
13,337	22.47	YVQ	Maracay, Venezuela	20.0	Phone
13,320	22.70		British Ships	......	Phone
13,285	22.58	CGA3	Drummondville, Canada	15.0	Phone to ships
13,240	22.66	KBJ	Manila, P. I.	40.0	Phone
13,210	22.71	FNSK	S.S. Normandie	......	Phone
13,140	22.83	CWH	Cerrito, Uruguay	1.5	Phone
13,050	22.99		Italian Ships	......	Phone
13,020	23.04	JZE	Nazaki, Japan	10.0	Phone to ships
12,795	23.44	IAC	Coltano, Italy	52.0	Phone
12,885	23.28	NPG	San Francisco	......	Time signals; 4:55-5:00 p.m. E. S. T.
12,830	23.38	CNR	Rabat, Morocco	12.0	Phone to France
12,680	23.66	YNE	Puerto Cabezas, Nicaragua	0.1	Phone
12,630	23.75	NAA	Arlington, Va.	......	Time signals; 9:55-10:00 a. m. E. S. T.
12,290	24.41	GBU	Rugby, England	15.0	Phone
12,250	24.49	TYB	Pontoise, France	......	Phone to JVH, ships
12,235	24.52	TFJ	Reykjavik, Iceland	......	Broadcast
12,215	24.56	TYA	Pontoise, France	15.0	Phone
12,150	24.69	GBS	Rugby, England	15.0	Phone to U. S. A.
12,130	24.73	DZE	Zeesen, Germany	......	Phone
12,060	24.88	PDV	Kootwijk, Holland	60.0	Phone
12,020	24.96	VIY-VK3ME	Melbourne, Australia	......	Tests with Drummondville
12,000	25.00	RV59	Moscow, U.S.S.R.	20.0	Bc. and phone
11,955	25.09	IUC	Addis Ababa, Ethiopia	3.5	Phone
11,950	25.11	KKQ	Bolinas, Calif.	40.0	Phone
11,900	25.21	XEWI	Mexico, D. F., Mexico	......	Broadcast
11,900	25.21	CT1GO	Parede, Portugal	0.35	Broadcast
11,900	25.21	OLR4D	Podebrady, Czechoslovakia	25.0	Broadcast
11,895	25.22	HP5I	Aquadulce, Panama	0.05	Broadcast
11,895	25.22	XEXR	Mexico, D. F., Mexico	......	Broadcast
11,880	25.25	XEXA	Mexico, D. F., Mexico	0.1	Broadcast
11,880	25.25	TPA3	Pontoise, France	......	Broadcast
11,880	25.25	W9XF	Chicago, Illinois	......	Bc., relays WENR
11,875	25.26	OLR4C	Podebrady, Czechoslovakia	25.0	Broadcast
11,870	25.27	W8XK	Pittsburgh, Pa.	40.0	Bc.; relays KDKA
11,860	25.29	YDB	Soerabaja, Java, D. E. I.	1.0	Broadcast
11,860	25.30	GSE	Daventry, England	20.0	Broadcast
11,855	25.31	DJP	Zeesen, Germany	5-50	Broadcast

Kc.	Meters	Call	Location	Kw.	Service, etc.
11,840	25.34	OLR4A	Podebrady, Czechoslovakia	25.0	Broadcast
11,830	25.36	W2XE	New York, N. Y.	10.0	Bc.; relays WABC
11,830	25.36	W9XAA	Chicago, Illinois	0.5	Bc.; relays WCFL
11,830	25.36	XEBR	Hermosillo, Sonora, Mexico	....	Bc.; relays XEBH
11,820	25.38	GSN	Daventry, England	20.0	Broadcast
11,810	25.40	CRCX	Toronto, Canada	0.5	Broadcast
11,810	25.40	I2RO4	Rome, Italy	25.0	Broadcast
11,804	25.42	OAX5A	Ica, Peru	....	Broadcast
11,801	25.42	OER2	Austria, Vienna	1.5	Broadcast
11,800	25.42	JZJ	Nazaki, Japan	....	Broadcast
11,795	25.43	DJO	Zeesen, Germany	5-50	Experimental
11,790	25.45	W1XAL	Boston, Mass.	5.0	Broadcast
11,770	25.49	DJD	Zeesen, Germany	5-50	Broadcast
11,760	25.51	OLR4B	Podebrady, Czechoslovakia	25.0	Broadcast
11,750	25.53	GSD	Daventry, England	20.0	Broadcast
11,740	25.55	HP5L	David, Panama	0.35	Broadcast
11,730	25.57	PHI	Huizen, Holland	23.6	Broadcast; winter months
11,730	25.57	CJRX	Winnipeg, Man., Canada	2.0	Bc.; relays CJRC
11,720	25.60	TPA4	Pontoise, France	12.0	Broadcast
11,718	25.60	CR7BH	Lourenzo Marques, Mozambique	0.33	Broadcast
11,705	25.63	SM5SX	Stockholm, Sweden	....	Broadcast
11,680	25.68	KIO	Kahuku, Hawaii	40.0	Phone to Bolinas
11,670	25.71	PPQ	Sepetiba, Brazil	5.0	Phone
11,660	25.73	JVL	Nazaki, Japan	10.0	Phone to Formosa; bc.
11,595	25.88	VRR4	Stony Hill, Jamaica	....	Phone to Hialeah, Fla.
11,540	26.00	XGR	Shanghai, China	20.0	Phone
11,495	26.10	VIZ-3	Fiskville, Australia	....	Phone to Drummondville
11,435	26.24	COCX	Havana, Cuba	1.0	Bc.; relays CMX
11,430	26.25	YNE	Puerto Cabezas, Nicaragua	0.1	Phone
11,385	26.35	HBO	Prangins, Switzerland	20.0	Broadcast
11,340	26.46	DAF	Norddeich, Germany	....	Phone
11,280	26.50	HIN	Trujillo, D. R.	0.75	Broadcast
11,140	26.93		German Ships	....	Phone
11,040	27.17	HRW-HRY	La Ceiba, Honduras	0.1	Phone
11,040	27.17	CSW	Lisbon, Portugal	5.0	Broadcast
11,000	27.27	ZLT4	Wellington, New Zealand	....	
11,000	27.27	PLP	Bandoeng, Java	3.0	Phone; occ. bc.
10,955	27.38	HSG2	Bangkok, Siam	....	Phone; bc.
10,850	27.65	DFL	Nauen, Germany	....	Phone
10,840	27.68	KWV	Dixon, Calif.	20.0	Phone to Hawaii
10,770	27.86	GCP	Rugby, England	15.0	Phone
10,740	27.93	JVM	Nazaki, Japan	20.0	Phone to U. S. A.; occ. bc.; relays JOAK
10,670	28.12	CEC	La Granja, Chile	0.5	Phone
10,660	28.14	JVN	Nazaki, Japan	20.0	Bc.; relays JOAK
10,620	28.25	WEF	Rocky Point, N. Y.	40.0	Phone to Europe
10,610	28.28	WEA	Rocky Point, N. Y.	40.0	Experimental
10,578	28.36	FYB	Paris, France	....	Time signals; 7:55- 8 p. m., E. S. T.
10,535	28.48	JIB	Tyureki, Formosa	6.0	Phone to Japan
10,430	28.76	TYE3	Pontoise, France	12.0	Phone to U. S. A.
10,430	28.76	YBG	Medan, Sumatra, D. E. I.	3.0	Phone; occ. bc.
10,420	28.79	XGW	Shanghai, China	20.0	Phone
10,410	28.82	KES	Bolinas, Calif.	40.0	Phone
10,410	28.82	LSY	Monte Grande, Argentina	10.0	Phone
10,410	28.82	PDK	Kootwijk, Holland	60.0	Phone
10,400	28.85	KEZ	Dixon, Calif.	40.0	Phone
10,375	28.92	JVO	Nazaki, Japan	10.0	Phone to Manchukuo; bc.
10,370	28.93	EAJ43	Tenerife, Canary Islands	....	Broadcast
10,350	28.98	EAJ33	Caramaca, Spain	....	Broadcast
10,350	28.98	LSX	Monte Grande, Argentina	12.0	Phone; also bc.
10,335	29.03	ZFD	St. George, Bermuda	1.5	Phone; mostly telegraph
10,330	29.03	ORK	Ruysselede, Belgium	11.0	Broadcast
10,310	29.10	PPM	Sepetiba, Brazil	20.0	Phone
10,300	29.13	LSL2	Hurlingham, Argentina	60.0	Phone to London, Rio; night
10,290	29.16	DZC	Zeesen, Germany	....	Phone
10,260	29.24	PMN	Bandoeng, Java, D. E. I.	3.0	Phone; occ. bc.
10,250	29.27	LSK3	Hurlingham, Argentina	60.0	Phone to Madrid, Berlin, Paris; night
10,230	29.33	CED	Antofagasta, Chile	0.4	Phone; bc.
10,220	29.35	PSH	Marapicu, Brazil	....	Phone; bc.
10,170	29.48	RIO	Baku, U.S.S.R.	....	Phone
10,140	29.59	OPM	Leopoldville, Belgian Congo	15.0	Phone to ORK
10,080	29.76	RIR	Tiflis, U.S.S.R.	4.0	Phone to RIO, RNE
10,070	29.79	EDN	Madrid, Spain	10.0	Experimental
10,065	29.81	TDE	Kanjoshi, Manchukuo	20.0	Phone to JVO
10,055	29.84	ZFB	St. George, Bermuda	1.5	Phone
10,055	29.84	SUV	Abu Zabal, Egypt	20.0	Phone to Germany, England
10,042	29.87	DZB	Zeesen, Germany	....	Phone
10,000	30.00	WWV	Beltsville, Md.	....	Standard frequency
9,990	30.03	KAZ	Manila, P. I.	40.0	Phone
9,940	30.18	CSW	Lisbon, Portugal	....	Broadcast
9,890	30.32	LSN2	Hurlingham, Argentina	60.0	Phone to New York; nights
9,860	30.43	EAQ	Madrid, Spain	20.0	Broadcast
9,840	30.49	JYS	Kemikawa-Cho, Japan	10.0	Bc., tests
9,740	30.80	COCQ	Havana, Cuba	....	Bc.; relays CMQ
9,675	31.01	DZA	Zeesen, Germany	....	Phone
9,670	31.02	TI4NRH	Heredia, C. R.	....	Broadcast
9,665	31.04	CT1AA	Lisbon, Portugal	2.0	Broadcast
9,660	31.06	PSJ	Marapicu, Brazil	....	Phone
9,660	31.06	LRX	Buenos Aires, Argentina	5.0	Bc.; relays LR1
9,645	31.10	HH3W	Port-au-Prince, Haiti	0.03	Broadcast
9,635	31.14	I2RO3	Rome, Italy	20.0	Broadcast
9,618	31.18	HJ1ABP	Cartagena, Colombia	0.7	Broadcast
9,610	31.22	YDB	Soerabaja, Java, D. E. I.	1.0	Bc.; relays YDA
9,605	31.23	HP5J	Panama, Panama	0.16	Broadcast
9,600	31.25	CQN	Macao, Port China	....	Broadcast
9,600	31.25	CB960	Santiago, Chile	0.1	Broadcast
9,600	31.25	RAN	Moscow, U.S.S.R.	....	Broadcast
9,597	31.26	VK6ME	Perth, Australia	....	Experimental
9,595	31.27	HBL	Prangins, Switzerland	20.0	Broadcast
9,590	31.28	PCJ	Huizen, Holland	20.0	Exp.; broadcast
9,590	31.28	W3XAU	Philadelphia, Pa.	10.0	Bc.; relays WCAU
9,590	31.28	VK2ME	Sydney, Australia	20.0	Broadcast
9,580	31.31	VK3LR	Lyndhurst, Vic., Australia	20.0	Broadcast
9,580	31.31	GSC	Daventry, England	20.0	Broadcast
9,575	31.34	HJ2ABC	Cucuta, Colombia	0.25	Broadcast
9,570	31.35	W1XK	Millis, Mass.	10.0	Bc.; relays WBZ, WBZA
9,565	31.36	HP5S	.... Panama	0.1	Broadcast
9,565	31.36	VUB	Bombay, India	4.5	Broadcast
9,560	31.38	DJA	Zeesen, Germany	5-50	Broadcast
9,559	31.38	HJ1ABB	Barranquilla, Colombia	1.0	Broadcast
9,551	31.41	HH2Y	Port-au-Prince, Haiti	0.03	Broadcast
9,550	31.41	OLR3A	Podebrady, Czechoslovakia	25.0	Broadcast
9,540	31.47	LKJ1	Jeloy, Norway	1.0	Broadcast
9,540	31.47	DJN	Zeesen, Germany	5-50	Broadcast
9,535	31.46	JZI	Nazaki, Japan	....	Broadcast
9,530	31.48	W2XAF	Schenectady, N. Y.	40.0	Bc.; relays WGY
9,525	31.49	ZBW3	Hong-Kong, China	2.0	Bc.; relays ZBW
9,520	31.51	XEME	Merida, Yucatan, Mexico	0.015	Bc.; relays XEFC
9,520	31.51	HJ4ABH	Armenia, Colombia	....	Bc.; relays HJ4ABN
9,510	31.55	GSB	Daventry, England	20.0	Broadcast
9,510	31.58	HJU	Buenaventura, Colombia	1.0	Broadcast
9,510	31.58	VK3ME	Melbourne, Australia	5.0	Broadcast
9,504	31.57	OLR3B	Podebrady, Czechoslovakia	25.0	Broadcast
9,500	31.58	PRF5	Rio de Janeiro, Brazil	....	Broadcast
9,500	31.58	HJ1ABE	Cartagena, Colombia	0.05	Broadcast
9,493	31.60	XEFT	Veracruz, Ver., Mexico	.02	Broadcast
9,490	31.61	KEI	Bolinas, Calif.	20.0	Phone
9,490	31.61	WEF	Rocky Point, N. Y.	40.0	Phone
9,480	31.65	XEDQ	Guadalajara, Jalisco, Mexico	0.5	Bc.; relays XED
9,480	31.65	KET	Bolinas, Calif.	40.0	Phone
9,450	31.75	TGWA	Guatemala City, Guatemala	0.2	Experimental
9,441	31.78	HC2EBA	Guayaquil, Ecuador	....	Broadcast
9,428	31.82	COCH	Havana, Cuba	10.0	Broadcast
9,425	31.83	NAA	Arlington, Va.	....	Time signals; see article on time signals
9,415	31.86	PLV	Bandoeng, Java, D. E. I.	80.0	Phone; sometimes bc.
9,360	32.05	......	Fort de France, Martinique, F. W. I.	....	Broadcast
9,350	32.09	HS8PJ	Bangkok, Siam	....	Broadcast
9,320	32.15	OAX4I	Lima, Peru	....	Broadcast
9,300	32.26	YNGU	Managua, Nicaragua	....	Broadcast
9,220	32.54	YNE	Puerto Cabezas, Nicaragua	0.1	Phone
9,125	32.87	HAT4	Szekesfeherrar, Hungary	20.0	Broadcast
9,045	33.17	VWY	Kirkee, India	....	Phone to England; mornings
9,040	33.19	TYA2	Pontoise, France	15.0	Phone to Algeria
8,960	33.48	FYA	Algiers, Algeria	....	Phone
8,948	33.53	HCJB	Quito, Ecuador	0.5	Broadcast
8,830	33.96	......	British Ships, French Ships	....	Phone
8,795	34.11	HKV	Bogota, Colombia	....	Broadcast
8,775	34.18	PNI	Makassar, Celebes, D. E. I.	3.0	Phone; occ. bc.
8,710	34.44	KBB	Manila, P. I.	....	Phone
8,719	34.40	VPD2	Suva, Fiji Islands	....	Broadcast
8,665	34.62	CO9JQ	Camaguey, Cuba	0.20	Broadcast
8,505	35.27	YNLG	Managua, Nicaragua	0.5	Broadcast
8,470	35.42	......	German Ships	....	Phone
8,765	34.23	DAF	Norddeich, Germany	....	Phone to ships
8,400	35.71	HC2CW	Guayaquil, Ecuador	....	Broadcast
8,300	36.14	ZP10	Asuncion, Paraguay	0.015	Broadcast
8,290	36.19	HRW-HRY	La Ceiba, Honduras	0.1	Phone
8,185	36.65	PSK	Marapicu, Brazil	....	Phone; bc.
8,120	36.95	KAZ	Manila, P. I.	20.0	Phone to Dixon, Calif.
8,035	37.34	CNR	Rabat, Morocco	12.0	Phone bc.
8,035	37.34	CED	Antofagasta, Chile	0.4	Phone
7,901	37.98	LSL1	Hurlingham, Argentina	60.0	Phone to Rio; night
7,880	38.07	JYR	Kemikawa-Cho, Japan	5.0	Broadcast
7,860	38.12	SUX	Abu Zabal, Egypt	20.0	Phone
7,854	38.20	HC2JSB	Guayaquil, Ecuador	0.5	Broadcast
7,830	38.31	PGA	Kootwijk, Holland	60.0	Phone
7,810	38.41	YNE	Puerto Cabezas, Nicaragua	0.1	Phone
7,797	38.47	HBP	Prangins, Switzerland	20.0	Broadcast
7,740	38.76	CEC	LaGranja, Chile	0.5	Phone
7,620	39.32	IUB	Addis Ababa, Ethiopia	....	Phone
7,560	39.68	YNLF	Managua, Nicaragua	....	Broadcast
7,550	39.74	TI8WS	Puntarenas, Costa Rica	0.12	Broadcast
7,520	39.87	KKH	Kahuku, Hawaii	40.0	Phone
7,510	39.95	JVP	Nazaki, Japan	20.0	Bc.; phone
7,470	40.16	JVQ	Nazaki, Japan	10.0	Phone to Java
7,415	40.45	WEG	Rocky Point, N. Y.	40.0	Phone
7,370	40.71	KEQ	Kahuku, Hawaii	40.0	Phone
7,380	40.65	XECR	Mexico, D. F., Mexico	20.0	Broadcast
7,315	41.01	YNLAT	Granada, Nicaragua	....	Broadcast
7,288	41.14	VK5DI	Adelaide, Australia	....	Experimental
7,281	41.20	SM5SD	Stockholm, Sweden	0.03	Broadcast
7,220	41.55	ECN1	Barcelona, Spain	....	Broadcast
7,200	41.67	YNAM	Managua, Nicaragua	....	Bc.; amateur
7,210	41.61	EA8AB	Santa Cruz, Tenerife, C. I.	....	Broadcast
7,200	41.67	......	San Sebastian, Spain	....	....
7,177	41.80	CR6AA	Lobita, Angola Port. W. Africa	0.5	Bc.; C. W., phone
7,165	41.87	......	Valencia, Spain	....	Broadcast
7,100	42.25	FO8AA	Papeete, Tahiti	0.2	Broadcast
7,082	42.36	PI1J	Dordrecht, Holland	....	Amateur; sometimes bc.
7,020	42.73	EGP1	Barcelona, Spain	....	Broadcast
7,000	42.86	EA9AH	Tetuan, Sp. Morocco	....	Broadcast
7,000	42.86	PZH	Paramaribo, Dutch Guiana	....	Broadcast
6,970	43.04	HCETC	Quito, Ecuador	0.03	Broadcast
6,960	43.10	VK8SC	Port Hedland, Australia	....	Broadcast
6,900	43.48	HI2D	Ciudad, Trujillo	0.1	Broadcast
6,860	43.73	KEL	Bolinas, Calif.	40.0	Phone
6,848	43.81	XGOX	Nanking, China	....	Broadcast
6,805	44.07	HI7P	Trujillo, D. R.	0.025	Broadcast
6,775	44.38	HIH	San Pedro de Macoris, D. R.	0.15	Broadcast
6,750	44.44	JVT	Nazaki, Japan	20.0	Phone to U. S. A.; bc.
6,730	44.48	HI3C	La Romana, D. R.	0.25	Broadcast
6,718	44.66	KBK	Manila, P. I.	40.0	Phone
6,710	44.71	KEF	Bolinas, Calif.	40.0	Phone
6,687	44.86	TIEP	San Jose, Costa Rica	....	Broadcast
6,672	44.96	YVQ	Maracay, Venezuela	10.0	Phone
6,635	45.22	HC2RL	Guayaquil, Ecuador	0.15	Broadcast
6,630	45.25	HIT	Trujillo, D. R.	0.2	Broadcast
6,620	45.32	PRADO	Riobamba, Ecuador	....	Bc.; Thursdays
6,578	45.60	HCVT	Ambato, Ecuador	....	Broadcast
6,555	45.76	HI4D	Trujillo, D. R.	....	Broadcast
6,550	45.80	TIRCC	San Jose, Costa Rica	....	Broadcast
6,545	45.84	......	Tetuan, Morocco	0.2	Broadcast
6,545	45.84	YV6RB	Ciudad Bolivar, Venezuela	0.25	Broadcast
6,540	45.87	YN1GG	Managua, Nicaragua	0.1	Broadcast
6,520	46.01	YV4RB	Valencia, Venezuela	0.3	Broadcast
6,520	46.01	HRW-HRY	La Ceiba, Honduras	0.1	Phone
6,500	46.15	HIL	Trujillo, D. R.	0.05	Broadcast
6,500	46.15	YV1RM	Cristo de Aranza, Venezuela	....	Broadcast
6,479	46.31	HI8A	Trujillo, D. R.	....	Broadcast
6,477	46.33	HI4V	Trujillo, D. R.	0.025	Broadcast
6,425	46.67	OAX4K	Lima, Peru	....	Broadcast
6,425	46.69	W3XL	Bound Brook, N. J.	100.0	Experimental
6,420	46.73	HI1S	Santiago, D. R.	0.02	Broadcast
6,410	46.80	TIPG	San Jose, Costa Rica	1.0	Broadcast
6,400	46.88	YV5RH	Caracas, Venezuela	0.25	Broadcast
6,380	47.02	YV5RF	Caracas, Venezuela	0.1	Broadcast
6,375	47.10	HRW-HRY	La Ceiba, Honduras	0.1	Phone
6,365	47.14	YV1RH	Maracaibo, Venezuela	....	Bc.; relays YV1RF
6,360	47.17	TIFA	San Jose, Costa Rica	....	Broadcast
6,350	47.24	YNH6	Boom, Nicaragua	0.1	Phone

Kc.	Meters	Call	Location	Kw.	Service, etc.
6,350	47.24	YNJ5	Waspook, Nicaragua	0.1	Phone
6,350	47.24	YNJ7	Wapam, Nicaragua	0.1	Phone
6,357	47.20	HRP1	San Pedro Sula, Honduras	0.075	Broadcast
6,340	47.32	YNE	Puerto Cabezas, Nicaragua	0.1	Phone
6,340	47.32	HIX	Trujillo, D. R.	....	Broadcast
6,330	47.39	JZG	Nazaki, Japan	10.0	Phone to ships
6,310	47.54	HIZ	Trujillo, D. R.	0.02	Broadcast
6,300	47.62	YV4RD	Maracay, Venezuela	0.1	Broadcast
6,280	47.77	HIG	Trujillo, D. R.	0.05	Broadcast
6,280	47.77	COHB	Sancti Spiritus, Cuba	0.15	Broadcast
6,270	47.84	YV5RP	Caracas, Venezuela	....	Broadcast
6,260	47.92	OAX4G	Lima, Peru	....	Broadcast
6,250	48.00	YV5RJ	Caracas, Venezuela	....	Broadcast
6,243	48.05	HIN	Trujillo, D. R.	0.75	Broadcast
6,235	48.11	HRD	La Ceiba, Honduras	0.25	Broadcast
6,225	48.19	YV1RG	Valera, Venezuela	0.2	....
6,205	48.35	YV1RI	Coro, Venezuela	0.2	Broadcast
6,200	48.39	XEXS	Mexico, D. F., Mexico	0.1	Broadcast
6,200	48.39	COKG	Santiago, Cuba	2.4	Bc.; relays CMKB
6,198	48.08	HI8Q	Ciudad, Trujillo	0.025	Broadcast
6,190	48.47	HI1A	Santiago de los Caballeros D. R.	0.05	Broadcast
6,164	48.67	OAX1B	Chiclayo, Peru	0.3	Bc.; relays OAK1A
6,150	48.70	CJRO	Winnipeg, Man., Canada	....	Bc.; relays CJRC
6,150	48.78	FT4AJ	Tunis, Tunisia	....	Experimental
6,156	48.73	YV5RD	Caracas, Venezuela	1.0	Broadcast
6,150	48.78	CB615	Santiago, Chile	0.15	Broadcast
6,150	48.78	HI5N	Santiago de los Caballeros, D. R.	0.1	Broadcast
6,150	48.78	HJ4ABU	Pereira, Colombia	0.1	Broadcast
6,150	48.78	VE9CL	Winnipeg, Man., Canada	....	Broadcast
6,148	48.80	ZEB	Bulawayo, So. Rhodesia	0.325	Broadcast
6,140	48.86	W8XK	Pittsburgh, Pa.	40.0	Bc.; relays KDKA
6,137	48.88	CR7AA	Lourenzo Marques, Mozambique	0.33	Broadcast
6,133	48.91	XEXA	Mexico, D. F., Mexico	....	Broadcast
6,132	48.92	CT1GO	Parede, Portugal	0.35	Broadcast
6,130	48.94	COCD	Havana, Cuba	0.2	Bc.; relays CMCD
6,130	48.94	LKJ1	Jeloy, Norway	1.0	Broadcast
6,130	48.94	VP3BG	Georgetown, British Guiana	0.15	Broadcast
6,128	48.96	OAX7A	Cuzco, Peru	....	....
6,125	48.98	CXA4	Montevideo, Uruguay	1.0	Broadcast
6,122	49.01	HJ3ABX	Bogota, Colombia	....	Broadcast
6,122	49.01	OAX4P	Huancayo, Peru	....	Broadcast
6,122	49.01	OAX6A	Arequipa, Peru	....	....
6,120	49.02	YDA5	Bandoeng, Java, D. E. I.	1.5	Broadcast
6,120	49.02	XEPW	Mexico, D. F., Mexico	....	Broadcast
6,120	49.02	XEFT	Veracruz, Veracruz, Mexico	0.12	Broadcast
6,120	49.02	HP5Z	Panama City, Panama	0.2	Broadcast
6,120	49.02	W2XE	Wayne, N. J.	10.0	Bc.; relays WABC
6,117	49.04	XEUZ	Mexico, D. F.	....	Broadcast
6,115	49.06	XECU	Guadalajara, Mexico	....	Broadcast
6,115	49.06	HJ1ABB	Barranquilla, Colombia	1.0	Broadcast
6,115	49.06	OLR2C	Podebrady, Czechoslovakia	25.0	Broadcast
6,110	49.10	GSL	Daventry, England	20.0	Broadcast
6,110	49.10	VE9HX	Halifax, N. S., Canada	0.2	Bc.; relays CHNS
6,109	49.10	VUC	Calcutta, India	0.5	Broadcast
6,108	49.11	HJ4ABB	Manizales, Colombia	....	Broadcast
6,100	49.18	W3XAL	Bound Brook, N. J.	20.0	Bc.; relays WJZ
6,100	49.18	W9XF	Chicago, Illinois	5.0	Bc.; relays WENR
6,100	49.20	YTC	Belgrade, Yugoslavia	2.5	Broadcast
6,098	49.20	ZTJ	Johannesburg, S. Africa	5.0	Broadcast
6,097	49.20	HJ4ABE	Medellin, Colombia	0.1	Broadcast
6,090	49.26	ZBW2	Hong-Kong, China	2.0	Bc.; relays ZBW
6,090	49.26	HJ4ABC	Ibague, Colombia	....	Broadcast
6,090	49.26	CRCX	Toronto, Ont., Canada	0.5	Broadcast
6,085	49.30	HJ5ABD	....	....	....
6,083	49.32	VQ7LO	Nairobi, Kenya, Africa	1.25	Broadcast
6,080	49.34	ZHJ	Penang, Straits Settlements	0.05	Broadcast
6,080	49.34	CP5	La Paz, Bolivia	....	Broadcast
6,080	49.34	W9XAA	Chicago, Illinois	20.0	Bc.; relays WCFL
6,079	49.35	DJM	Zeesen, Germany	5-50	Experimental
6,075	49.38	HP5F	Colon, Panama	0.2	Broadcast
6,075	49.38	YV1RD	Maracaibo, Venezuela	....	Broadcast
6,073	49.37	CQN	Macao, Asia	0.5	Broadcast
6,070	49.42	VE9CS	Vancouver, B. C., Canada	0.01	Broadcast
6,070	49.42	CFRX	Toronto, Ontario	1.0	Broadcast
6,070	49.42	HJ3ABF	Bogota, Colombia	0.1	Broadcast
6,067	49.45	VPB	Colombo, Ceylon	....	Broadcast
6,065	49.46	XEXR	Mexico, D. F., Mexico	....	Broadcast
6,060	49.50	OXY	Skamlebaek, Denmark	0.5	Broadcast
6,060	49.50	W8XAL	Cincinnati, Ohio	10.0	Bc.; relays WLW
6,060	49.50	W3XAU	Philadelphia, Pa.	10.0	Bc.; relays WCAU
6,050	49.59	HJ3ABD	Bogota, Colombia	1.0	Broadcast
6,050	49.59	XEXF	Mexico, D. F., Mexico	....	Broadcast
6,045	49.62	XETW	Mexico, D. F., Mexico	....	Broadcast
6,042	49.65	HJ1ABG	Barranquilla, Colombia	0.15	Broadcast
6,040	49.67	W4XB	Miami Beach, Fla.	2.5	Bc.; relays WIOD
6,040	49.67	HI9B	Santiago de los Caballeros, D. R.	0.1	Broadcast
6,040	49.67	W1XAL	Boston, Mass.	5.0	Broadcast
6,040	49.67	YDA	Tandjongpriok, Java, D. E. I.	10.0	Broadcast
6,033	49.72	HJ4ABP	Medellin, Colombia	....	Broadcast
6,030	49.75	OLR2B	Podebrady, Czechoslovakia	25.0	Broadcast
6,030	49.75	HP5B	Panama, Panama	0.1	Broadcast
6,030	49.75	VE9CA	Calgary, Alberta, Canada	0.1	Bc.; relays CFCN
6,030	49.75	XEBQ	Mazatlan, Mexico	....	Broadcast
6,025	49.79	HJ1ABJ	Santa Marta, Colombia	0.025	Broadcast
6,020	49.83	DJC	Zeesen, Germany	5-50	Broadcast
6,020	49.83	XEUW	Veracruz, Ver., Mexico	....	Broadcast
6,015	49.88	XEWI	Mexico, D. F., Mexico	0.25	Broadcast
6,012	19.90	HJ3ABH	Bogota, Colombia	1.2	Broadcast
6,010	49.92	VP3MR	Georgetown, British Guiana	0.25	Amateur; bc.
6,010	49.92	COCO	Havana, Cuba	0.25	Broadcast
6,010	49.92	OLR2A	Podebrady, Czechoslovakia	25.0	Broadcast
6,005	49.96	CFCX	Montreal, Quebec	0.075	Bc., relays CFCF
6,005	49.96	VE9DN	Montreal, Quebec	4.0	Broadcast
6,003	49.97	XEBT	Mexico, D. F. Mexico	1.0	Bc : relays XEB
6,000	50.00	HJ1ABC	Quibdo, Colombia	0.1	Broadcast
6,000	50.00	YOI	Bucharest, Roumania	0.3	Broadcast
6,000	50.00	RV59	Moscow, U.S.S.R.	20.0	Broadcast
6,000	50.00	TGWA	Guatemala City, Guatemala	0.2	Broadcast
6,000	50.00	FIQA	Tananarive, Madagascar	....	Broadcast
5,980	50.17	HIX	Trujillo, D. R	1.0	Broadcast
5,969	50.26	HVJ	Vatican City	10.0	Broadcast
5,955	50.38	HJN	Bogota, Colombia	....	Broadcast
5,995	50.04	RPT	Tashkent, U.S.S.R.	1.0	Phone
5,990	50.08	HJ2ABD	Bucaramanga, Colombia	0.1	Broadcast
5,990	50.08	HP5K	Colon, Panama	....	Broadcast
5,940	50.50	TG2X	Guatemala City, Guatemala	0.2	Police; bc
5,925	50.64	HH2S	Port-au Prince, Haiti	0.1	Bc.; relays HH2T
5,917	50.71	YV4RH	Valencia, Venezuela	....	Broadcast
5,917	50.71	YV15RV	Maracay, Venezuela	....	Broadcast
5,899	50.84	YV3RA	Barquisimeto, Venezuela	0.25	Broadcast
5,882	51.00	ZEA	Salisbury, So. Rhodesia	0.325	Broadcast
5,880	51.02	IUA	Addis Ababa, Ethiopia	....	Phone
5,875	51.06	HRN	Tegucigalpa, Honduras	0.4	Broadcast
5,865	51.15	HI1J	San Pedro de Macoris, D. R.	0.04	Broadcast
5,850	51.28	YV1RB	Maracaibo, Venezuela	0.3	Broadcast
5,845	51.32	KRO	Kahuku, Hawaii	40.0	Phone
5,830	51.46	TDD	Shinkio, Manchukuo	....	Phone to Tokyo
5,830	51.46	CWD	Montevideo, Uruguay (Cerrito)	1.5	Phone
5,830	51.46	TIGPH	San Jose, Costa Rica	1.0	Broadcast
5,830	51.46	TIX2	San Jose, Costa Rica	0.5	Broadcast
5,800	51.72	YV5RC	Caracas, Venezuela	1.0	Broadcast
5,800	51.72	KZGF	Manila, P. I.	....	Phone; occ. bc.
5,790	51.81	JVU	Nazaki, Japan	10.0	Phone to Manchukuo; also bc.
5,780	51.90	OAX4D	Lima, Peru	20.0	Broadcast
5,780	51.90	HJ4ABD	Medellin, Colombia	....	Broadcast
5,758	52.10	YNOP	Managua, Nicaragua	....	Broadcast
5,735	52.31	HC1PM	Quito, Ecuador	0.3	....
5,730	52.36	JVV	Nazaki, Japan	10.0	Phone to Formosa; bc.
5,713	52.51	TGS	Guatemala City, Guatemala	0.2	Broadcast
5,710	52.54	YV2RA	San Cristobal, Venezuela	0.75	Broadcast
5,705	52.59	CFU	Rossland, B. C., Canada	....	Phone; bc.
5,670	52.91	DAF	Norddeich, Germany	....	Phone
5,555	54.00	YNE	Puerto Cabezas, Nicaragua	0.1	Phone
5,500	54.55	TI5HH	San Ramon, Costa Rica	0.2	Broadcast
5,490	54.64	ROI	Sverdlovsk, U.S.S.R.	15.0	Phone
5,435	55.19	LSH	Monte Grande, Argentina	....	Phone
5,415	55.40	PMY	Bandoeng, Java, D. E. I.	0.45	Phone, bc.
5,170	58.03	HRW-HRY	La Ceiba, Honduras	0.1	Phone
5,140	58.37	PMY	Bandoeng, Java, D. E. I.	0.6	Broadcast
5,110	58.71	KIKB	Bolinas, Calif.	40.0	Phone
5,105	58.76	KEC	Bolinas, Calif.	40.0	Phone
5,025	59.70	ZFA	Hamilton, Bermuda	1.5	Phone
5,000	60.00	WWV	Beltsville, Md.	1.0	Frequency Standard; Tue., Wed., Fri.; noon, 1 p.m. E. S. T.
5,000	60.00	ZUD	Pretoria, S. Africa	....	Experimental
4,975	60.30	GBC	Rugby, England	5.0	Phone to ships
4,820	62.24	GDW	Rugby, England	15.0	Phone to U. S.
4,795	62.56	VE9BK	Vancouver, B. C.	0.25	Broadcast
4,753	63.11	WOY	Lawrenceville, N. J.	20.0	Phone
4,753	63.11	WOO	Ocean Gate, N. J.	20.0	Phone
4,610	65.08	YNJ7	Wapam, Nicaragua	0.1	Phone
4,610	65.08	YNJ5	Waspook, Nicaragua	0.1	Phone
4,610	65.08	YNE	Puerto Cabezas, Nicaragua	0.1	Phone
4,610	65.08	YNH6	Boom, Nicaragua	0.1	Phone
4,605	65.16	HRW-HRY	La Ceiba, Honduras	0.1	Phone
4,600	65.22	HC2ET	Guayaquil, Ecuador	0.4	Broadcast
4,465	67.19	CFA2	Drummondville, P. Q. Canada	15.0	Phone
4,355	68.89	IAC	Coltano, Italy	56.0	Phone
4,273	70.21	RV15	Khabarovsk, U.S.S.R.	20.0	Broadcast
4,107	73.05	HCJB	Quito, Ecuador	0.5	Broadcast
4,100	73.17	LKJ1	Jeloy, Norway	1.0	Experimental
4,097	73.23	WND	Hialeah, Fla.	0.4	Phone
4,002	74.77	CT2AJ	San Miguel, Azores	0.5	Amateur; bc.
4,000	75.00	CT3AQ	Funchal, Madeira	....	Broadcast; exp.
3,175	94.48	YNJ7	Wapam, Nicaragua	0.1	Phone
3,175	94.48	YNJ5	Waspook, Nicaragua	0.1	Phone
3,175	94.48	YNH6	Boom, Nicaragua	0.1	Phone
3,170	94.48	YNE	Puerto Cabezas, Nicaragua	0.1	Phone
3,800	78.95	ZP11	Asuncion, Paraguay	....	Broadcast
3,770	79.56	HB9B	Basle, Switzerland	....	Broadcast
3,525	85.11	HB9AQ	Lausanne, Switzerland	....	Broadcast
3,376	88.83	HJA3	Barranquilla, Colombia	....	Phone
3,330	92.88	YDV2	Bandjermasin, Borneo, D. E. I.	20.0	Broadcast
3,040	98.68	YDA	Tandjongpriok, Java, D. E. I.	10.0	Broadcast