RADIO

Amateur Newcomer's HANDBOOK

2nd Edition

ANOTHER PUBLICATION BY THE EDITORS OF RADIO

THIRTY FIVE CENTS

IN U.S.A. ELSEWHERE, FORTY CENTS

The "Radio" Amateur Newcomer's Handbook

By
The Editors of "Radio"

W. W. Smith
EDITOR-IN-CHIEF

Ray L. Dawley
TECHNICAL EDITOR

Leigh Norton
K. V. R. Lansingh

A. McMullen
W. E. McNatt

E. H. Conklin
B. A. Ontiveros

SECOND
EDITION

PUBLISHED AND DISTRIBUTED BY
RADIO, LTD.,
1300 KENWOOD ROAD, SANTA BARBARA, CALIFORNIA

35C POSTPAID IN U. S. A.; ELSEWHERE, 40C (OR EIGHT INTERNATIONAL POSTAL REPLY COUPONS)

PRINTED IN U. S. A.

OTHER PUBLICATIONS

by the Editors of "Radio"

''RADIO''

$2.50 YEARLY [10 ISSUES] IN U. S. A. AND CONTIGUOUS COUNTRIES

''RADIO'' HANDBOOK

PAPER BOUND, $1.50 IN CONTINENTAL U. S. A.; ELSEWHERE, $1.65
CLOTH BOUND, $3.00 IN CONTINENTAL U. S. A., ELSEWHERE, $3.25

RADIO TECHNICAL DIGEST

$2.50 FOR TWO YEARS [12 ISSUES] IN U. S. A. AND CONTIGUOUS COUNTRIES

''RADIO'' ANTENNA HANDBOOK

75C PER COPY IN CONTINENTAL U. S. A.; ELSEWHERE, 85C

''RADIO'' TELEPHONY HANDBOOK

75C PER COPY IN CONTINENTAL U. S. A.; ELSEWHERE, 85C

''RADIO'' NOISE REDUCTION HANDBOOK

35C PER COPY IN U. S. A.; ELSEWHERE, 40C

[SEE ADVERTISING SECTION FOR DETAILS OR SEND STAMP FOR CATALOG]

The "RADIO" AMATEUR NEWCOMER'S HANDBOOK

TABLE OF CONTENTS

Written by

The Editors of "Radio"

I. THE AMATEUR

The word *amateur* as defined by Webster is "one who cultivates an art or pursues a study from love or attachment, and without reference to gain or emolument." So it may be said that a radio amateur is one who makes radio operating a hobby. While the definition of "amateur" would seem to include shortwave listeners as radio amateurs, the term is ordinarily used to indicate specifically those possessing a government license and amateur call letters.

Raymond Scott, well known composer of a distinctive type of music and leader of the famous Scott "six man quintette," has his own amateur station, W6POJ.

The Ideal Hobby

A person should have an absorbing interest in some recreation or pastime in order to live a well-balanced life. We believe amateur radio to be one of the most fascinating of hobbies; its increasing popularity attests to this fact.

More than 50,000 licensed amateurs in the U.S.A. and many more thousands throughout the rest of the world are actively engaged in this field for purposes of experimentation, adventure, and personal enjoyment. It is interesting to consider what there is about amateur radio that captures and holds the interest of so many people throughout the world and from all walks of life, for unquestionably there is something about it which generates a lasting interest in its varied problems and activities.

Included in the international ranks of amateur radio are men and women, boys and girls. A signal heard on the short waves may be sent out by an eminent professional man, prominent movie actor, day laborer, or youngster just starting to high school. All find amateur radio an intensely fascinating hobby. It is difficult to describe the enjoyment that comes from constructing and operating one's own radio station; one must experience it in order to appreciate fully the pleasure amateur radio offers. It is an untiring thrill to contact and converse with others in distant lands by means of equipment which one has constructed himself.

Freeman Gosden, W6QUT, is probably better known as "Amos" of *Amos and Andy*.

The names of some of the more prominent radio enthusiasts are well known to most everyone: Raymond Scott, Bob Crosby, Dick Jergens, and Andy Sannella, all famous orchestra leaders; Freeman Gosden, "Amos" of *Amos and Andy;* Herbert Hoover, Jr., eminent geophysical engineer; C. R. Runyon, Jr., business executive and collaborator on developmental work on Armstrong system of frequency modulation; Wilmer Allison, world champion tennis player; and Le Roy Anspach, famous pianist.

Dr. Lee de Forest and Major Edwin H. Armstrong, famous inventors; David Sarnoff, president of the Radio Corporation, of America; and Powel Crosley, Jr., well known manufacturer and owner of WLW, are among the numerous ex-amateurs who have become so busy in the field of commercial radio that they no longer find time for amateur activity, yet still consider themselves not only as friends but "brothers" of the great fraternity of radio amateurs.

Technical Achievement

Although "hamming" generally is considered to be "only a hobby" by the general

LeRoy Anspach, W3BD, is well known to lovers of fine music. One of the country's best known concert pianists, he has appeared as soloist with the New York and Philadelphia Philharmonic Orchestras. When as a student he needed $1500 for a Steinway piano, he earned it by going to sea as a "brass pounder."

public, its history contains countless incidents of technical achievements by its members which have served to improve radio communication and broadcasting. Many of the more important advancements in the art of radio communication can be chalked up to the ingenuity of radio amateurs. Experiments conducted by inquisitive amateurs have led to important developments in the fields of electronics, television, radio therapy, sound pictures, and public address, as well as in radio communication and broadcasting.

Fellowship

Amateurs are a most hospitable and fraternal lot. Their common interest makes them "brothers under the skin" and binds them together as closely as would membership in any college fraternity, lodge, or club. When visiting a strange town an amateur naturally first will look up any friends in that town he has made over the air. But even if he is unknown to any amateurs in that town, his amateur call is an "open sesame." The local amateurs will hang out the welcome sign and greet him like a long lost brother.

It is not unusual for an amateur in one country to boast a large circle of friends, scattered throughout the world, with whom he chats nightly while seated comfortably at home. He gets to know these people intimately, many of whom he will never meet personally. Frequently he is of service to them, and they to him, in delivering messages to other people.

Amateur radio clubs have been formed in nearly all of the principal cities in the United States. The first thing a newcomer should do is to attend one of these club meetings and let the members know that he is interested in joining the ranks of radio amateurs. The veteran amateurs will be glad to lend a hand with any difficult problems you might encounter and often can give invaluable advice as a result of their own experience. Also, you will be introduced to others who have recently taken an interest in amateur radio, and will have someone with whom to study. A "study companion" is especially helpful when it comes to learning the code.

Public Service

The radio amateur, "ham" as he is often called, is of great social importance. When hurricane, flood, earthquake, or heavy ice wreaks havoc with telephone and telephone lines and the mails, the newspapers invariably follow with an account of how aid was summoned to the devastated area and communication maintained with the outside world largely through the efforts of radio amateurs. Radio amateurs are justly proud of their record of heroism and service in times of emergency.

Wilmer Allison, W5VV, started in amateur radio in 1919 and at the present time is more active on the air than ever. Allison has won various intercollegiate, American, and world championships in tennis.

Noted orchestra leader and one of the world's foremost performers on the electric guitar is Andy Sanella, often heard signing his call letters W2AD on 20 meter phone.

A typical amateur station is that of Wm. B. Fageol, Jr., W8NYD. Many amateur stations are less elaborate than this, using inexpensive equipment; some are more pretentious, using higher powered transmitters and several receivers. However, the results achieved depend more upon the antenna, location, and operator than upon the particular equipment used.

Many expeditions to remote places have kept in touch with home and business by "working" amateurs on the short waves. When Peary was at the North Pole in 1908, he was out of touch with the civilized world for an entire year. Commander MacMillan on the other hand, took along shortwave radio equipment and maintained almost unbroken communication with home. When Howard Hughes flew around the world in the summer of 1938, three U. S. amateur stations talked with his crew almost all of the way.

On previous expeditions of Admiral Byrd to the South Pole, much of the traffic, both official and personal, was handled by radio amateurs. The present expedition has a radio circuit with the U. S. Navy for handling all official traffic, but personal messages are still handled by amateur radio. Regular amateur calls have been issued to the expedition, and members may be heard in the amateur bands talking to or sending messages to the "folks back home" in the United States. Because of the importance of morale in such an expedition, the personal traffic handled by amateur radio is of no less importance than much of the "official" expedition traffic.

A Diversified Hobby

Amateur radio is a hobby with several phases. There are those who revel in long-distance contacts with amateurs in far-off lands and try to excel in number of distant stations "worked." These enthusiasts are called "dx" men.

Others make a speciality of relaying messages free of charge for people in their communities, and these fellows often perform meritorious service. Still others prefer not to specialize, but simply to "chew the rag" with any other hams who happen to be on the air.

Then, there are the experimenters, indefatigable individuals always striving for perfection. They are everlastingly building up and tearing down transmitters and receivers, deriving as much enjoyment from the construction or improvement of equipment as from its operation on the air. Whichever phase most strongly captures your fancy, you will find amateur radio an absorbing hobby.

Before you may join the others on the air, however, you must be licensed by the government to operate a transmitting station; so your first task will be to acquire sufficient knowledge to pass the test. Those who attempt to operate (on the air) *any kind of transmitting* equipment without a license are liable to fine and imprisonment.

It is not within the scope of this book to cover thoroughly the wide field of radio as a textbook might. Rather it is the aim of the authors to point out the way for you, to introduce you to the subject sufficiently well that you might carry on your study with a minimum of misdirected effort, subsequently passing your examination and becoming a full-fledged "ham" in the shortest possible time. The newcomer may elaborate upon the information given in the chapters of this book by study of corresponding chapters in the Radio Handbook.

II. HOW TO OBTAIN YOUR LICENSE

To obtain an amateur transmitting license from the U. S. government, you must be a citizen of the U. S. A., master the code, know how amateur transmitters and receivers work and how they must be adjusted, and be familiar with regulations pertaining to amateur operators and stations. An application blank for amateur radio operator and station license can be obtained from your district office of the Federal Communications Commission. (Refer to government booklet mentioned on page 59). When you have filled out this application properly, sworn to it before a notary public, and returned it to the district office, the inspector in charge will notify you of the time and place of your examination. There is no charge for an amateur operator and station license, and there are no age limits.

It is necessary that your station not be located on premises under the *control* of an alien. Remember this when determining the proposed site of your transmitter and filling out the application blanks. If you rent from an alien, the premises are under your "control" and you have nothing to worry about. However, if you merely "board" instead of rent, that does not put the premises under your control.

The examination will consist of a practical code test and a written theoretical examination. The written examination usually includes ten questions; the questions listed later in this book are typical of those asked. In the code test you will be required to send and receive messages in plain language, including figures and punctuation marks, at a speed of 13 words per minute (5 characters to the word).

If you pass both the code and written tests successfully, you will later receive a class-B license from the Commission's offices in Washington. This license, when signed by you, becomes valid. It is a combination operator and station license, one being printed on the reverse side of the other.

The station license portion will bear your call letters, which will be made up of the initial letter W or K, your call area numeral (to determine your prefix and in which U S. *call area* you are residing, refer to the map on this page), and two or three additional letters, such as W9ZZZ. The prefix W is assigned to all amateur stations within the *continental* U. S. A. and K to territories and possessions.

Do not confuse the *call areas* (1 to 9) with the *U. S. Radio Districts* (1 to 22). It is rather confusing to the newcomer because amateurs commonly refer to call areas as districts and indicate a station in, for example, the ninth call area as a "ninth district station."

The class-B operator license will authorize you to operate c.w. radiotelegraph transmitters (any licensed amateur transmitter, not just your own) in any amateur band or radiophone transmitters in the 160-, 10-, 5-, 2½-, 1¼-, and ¾-meter bands. You will not be entitled to operate phone in the select 80- and 20-meter bands until you have held your class-B license for at least one year and have successfully passed an examination for the class-A license. As this book is dedicated entirely to the newcomer, no class-A examination questions are included.

The Class-C License

If you live more than 125 miles, airline distance, from the nearest examining point maintained by the Federal Communications

Commission, you may apply for a class-C license, the examination for which is given by mail. Other persons allowed to apply for the class-C license include (1) applicants who can show a certificate from a reputable physician stating that the applicant is unable because of protracted disability to appear for examination, (2) persons stationed at a camp of the Civilian Conservation Corps, and (3) persons who are in the *regular* military or naval service of the United States at a military post or naval station.

A licensed radiotelegraph operator (other than an amateur operator who himself holds only a class-C license) or a regularly employed government radiotelegraph operator must sign the class-C applicant's blank in the presence of a notary public, attesting to the applicant's ability to send and receive the continental Morse code at the required speed of 13 words per minute. Do *not* send for class-C blanks containing the examinations and questions until you feel you are ready to take your examination, as you are not supposed to hold them indefinitely after receiving them.

Holders of class-C licenses *may* be required by the Commission to appear at an examining point for a supervised written examination and practical code test at any time during the term of their licenses. This is seldom done except where the Commission has reason to suspect that the applicant would have difficulty in passing the class-B examination. For instance, an amateur holding a class-C ticket who regularly is heard on the air with a bad note or modulation or is heard sending at 8 or 9 words a minute, should not be at all surprised to receive a notice to appear. The class-C license will be cancelled if the holder does not appear for examination when called or if he fails to pass when he does appear.

The privileges granted by the class-C license are identical with those of the class-B.

Your operator and station licenses will run concurrently, both expiring together three years from the date of issuance stated on the face of the license. Both may be renewed without examination if an application is filed at least 60 days prior to the indicated date of expiration and the applicant offers proof that he has communicated via amateur radio with three other amateur stations during the three-month period directly preceding the date of application for renewal.

You may obtain just an operator license (without the station license) if you desire; this will permit you to operate any licensed amateur station. The "station" side of the license will be left blank and you will have no call letters assigned to you. It is not possible to apply for or obtain a station license singly unless you already have an operator license.

Heavy penalties are provided for obtaining an amateur license by fraudulent means, such as by impersonating another person in an examination, copying from notes, books or the like, or misrepresenting the fact of one's U. S. citizenship. Applicants who fail to pass the examination can take it again after two months have passed from the time of the last examination.

There are so many special instances that may arise that no attempt will be made to cover every possible contingency pertaining to the application for and privileges accorded by an amateur license. If you have a special question regarding some point not covered in this book or which is not clear to you, write to the Inspector-in-Charge of your radio district. Don't guess at the proper interpretation or take somebody else's word for it; you may get in trouble.

There is one thing you should *not* write to the inspector about and that is the necessity for a license to *transmit*. A transmitter's license is absolutely necessary, regardless of power, frequency, or type of emission; there are no exceptions nor special cases.

Foreign

Prospective amateurs outside of the United States should get in touch with their national amateur society to learn about the regulations and procedure for obtaining a license before even starting construction on the transmitter, because in most countries the restrictions on transmitting amateurs are much more stringent. The part of this book pertaining to treaties, laws, and regulations of course will not apply, but the equipment shown in the construction chapter will be found highly suitable for the newcomer in *any* country. Also the chapter on elementary radio theory will be helpful, as Ohm's law is the same in any country.

III. FUNDAMENTAL THEORY

To the amateur newcomer, circuit diagrams, tube characteristic curves, and formulas first appear confusing and difficult of comprehension. However, after a short period of study, one becomes sufficiently familiar with basic concepts and fundamentals so that a quick grasp of the principles of practically all radio phenomena is made possible.

But before attempting to understand even the simpler phases of *radio* theory, one must either have or acquire a certain knowledge of elementary *electrical* theory. Inclusion of the latter in this book would necessitate a substantial increase in the number of pages and, consequently, an increased price. Inasmuch as a thorough discussion of elementary electrical theory may be found in most any high school physics book (available at public libraries) or in the RADIO HANDBOOK (a general text by the publishers of this book), its presentation here was not considered necessary. Before reading farther in this chapter, spend several evenings in conscientious study of the electrical theory chapter of any good, recently published, high school physics textbook. The following subjects should be given especial attention: conductors and insulators, the electric current, resistance, e.m.f., potential, Ohm's law, alternating current, electromagnetic effects, permeability, inductance, mutual inductance, transformers, inductive reactance, capacity and condensers, dielectric properties, capacitive reactance, rectification.

It is not necessary that these subjects be studied in the order given; the order listed is only one of many logical sequences. The arrangement given in the particular book you study is the best to follow. The advanced amateur will find useful an understanding of phase, power factor, Q, etc., but the newcomer need not concern himself with these more abstruse factors and should not do so until the simpler ones are no longer perplexing.

HOW RADIO WORKS

Radio communication is made possible by electric currents that vibrate incredibly fast, often oscillating back and forth many million times in a single second. They are essentially the same as the alternating current used for house lighting except for their tremendously higher *frequency* or rate of vibration.

How radio works is best illustrated by explaining that the effects of these high-frequency or *radio-frequency* currents are not confined to the wires in which they flow. Not only do they travel along a wire like ordinary electricity, but they give rise to *radio waves* that travel out from the wire through space in all directions with the speed of light (186,000 miles per second). If the conducting wire is insulated from the earth and is erected high above neighboring objects to afford the outgoing waves less obstruction, it is called an *antenna*.

Vacuum tubes, similar to and often identical with those used in any home radio receiver, generate the radio-frequency oscillations. They convert ordinary direct current into the high-frequency electricity necessary to produce the radio waves that go skipping through space to the far corners of the earth.

Passing radio waves will set up similar oscillations in any distant antenna upon which they impinge. Vacuum tubes may be used at such a receiving point to amplify and convert these oscillations back into direct currents to be fed into a reproducing device, such as a loudspeaker. The reproducer will, under proper operating conditions, give forth sound while direct currents are pulsating through it; however, no such pulsating direct currents can flow unless passing radio waves are *exciting* the receiving antenna.

It will be evident, then, that telegraphic communication might be carried on between any two points "connected" by radio waves by means of a predetermined system of sound signals. A code system, wherein long sounds are referred to as *dashes* and short ones as *dots*, has been accepted throughout the world as the standard scheme for radiotelegraphic communication. Combinations of dots and dashes in the Continental code (see page 14) correspond to certain letters of the alphabet.

To produce a sound of long duration (dash) at the distant receiving point, the sending apparatus is switched on just long enough to generate radio waves for the corresponding length of time. A short sound (dot) is achieved by sustaining the waves for a shorter period. The instrument by means of which the transmitter is switched on and off to produce long and short trains of waves is known as a *telegraph key* or simply a *key*.

A voice transmitter (*radiophone*) is essentially similar to a *continuous-wave* (c.w.) telegraph transmitter, except that provision is made to mix voice currents from a microphone (a refined version of the ordinary telephone transmitter unit) with the outgoing radio waves. Because the fundamental radio waves act in radiotelephony as carriers of the superimposed voice currents, they are technically termed *carrier waves*. The voice currents (audio-frequency alternating currents) are made to *modulate* the radio-frequency carrier. The process by which the voice currents and the outgoing waves are mixed is known as *modulation*.

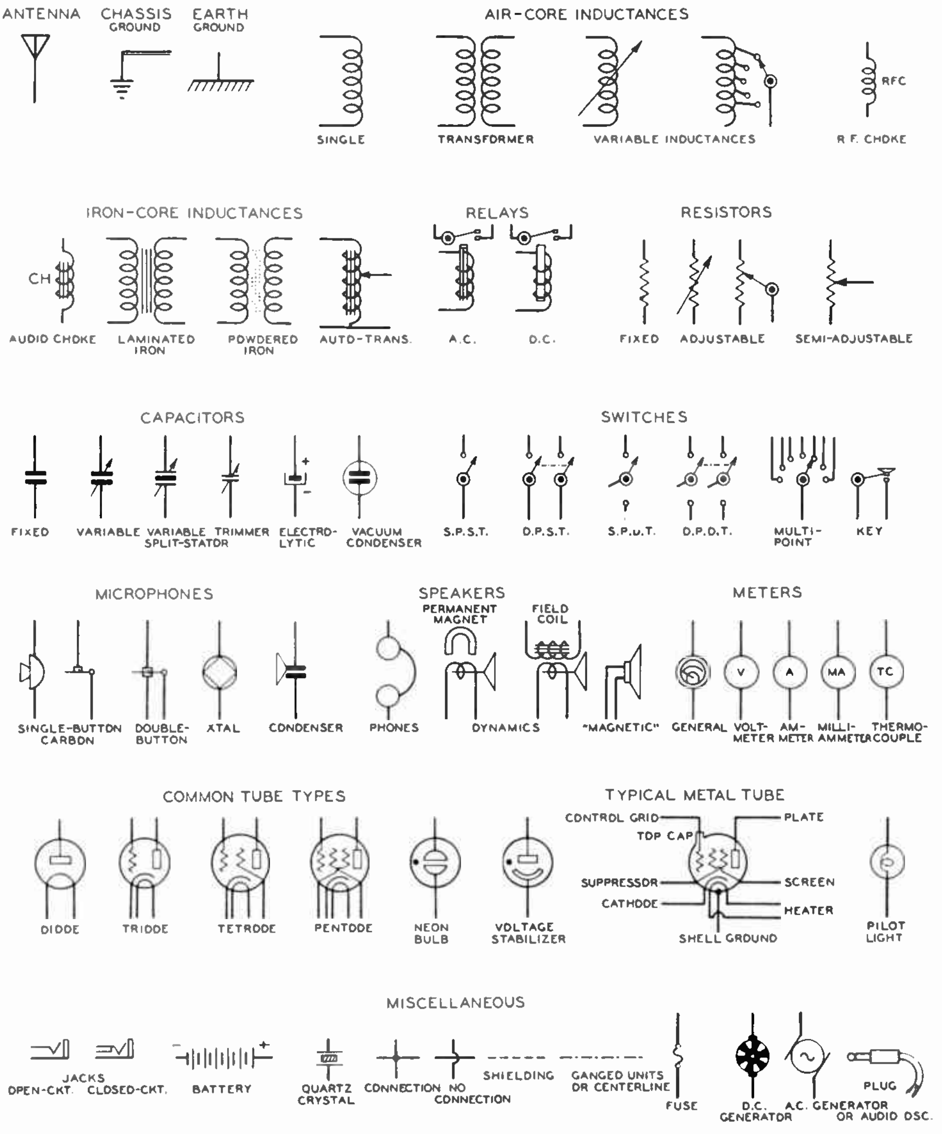
At the distant receiving point, vacuum tubes separate the voice currents from the oscillations that travel in from the receiving antenna and send them through the reproducing speaker where the original sounds impinging upon the microphone are reproduced.

Wavelength and Frequency

From certain types of antennas, radio waves may travel outward, broadcast in a manner similar and analogous to the water waves that spread out from a stone striking the surface of water. There are peaks (tops) and troughs (bottoms) in each complete wave. The distance between peaks or between troughs is the length of each single wave. In radio this distance (*wavelength*) is measured in meters, rather than in inches or feet.

It may be seen that the more rapid the rate of vibration or frequency, the more waves will be present in any given space and the more will pass any given point in a certain time; also, the shorter will be the length of each individual wave. This accounts for the fact that the "short waves" are of high frequency and vice versa.

Since the terms wavelength and frequency



SYMBOLS USED IN SCHEMATIC RADIO CIRCUIT DIAGRAMS.

are used interchangeably in radio, the reader should gain a thorough understanding of the two.

Each complete oscillation is termed one *cycle*. However, since most radio frequencies are many thousand cycles per second, a more convenient unit, the kilocycle (1000 cycles per second) has been adopted to eliminate cumbersome figures. The wavelength in meters may be obtained from the frequency in kilocycles by dividing 300,000 by the latter. Conversely, the frequency (kc.) may be determined when the wavelength is known by dividing 300,000 by the wavelength.

VACUUM TUBES

The foregoing discussion indicates the importance of the vacuum tube in both transmission and reception. The tube may well be called the heart of any radio sending or receiving set. Everyone is familiar with the exterior appearance of radio tubes. Few, however, truly know what goes on within the sealed bulb. To describe completely the working of these vacuum tubes requires more space and mathematics than can be given here. We shall discuss, therefore, only the essential theory of their operation. A more complete analysis and description will be found in the RADIO HANDBOOK.

Any radio tube consists primarily of a glass bulb or metal cylinder out of which the air has been pumped and in which are sealed a *filament* or *heater* (usually a short length or coil of fine wire) and one or more other parts. A tube is similar to an ordinary electric light bulb in that its filament is heated by currents supplied for the purpose by a battery or other generating source. The hot filament, whether in a radio tube or light bulb, pours out a cloud of *electrons*, tiny charges of negative electricity.

A large number of tubes do not depend upon the filament for the direct emission of electrons, but instead utilize a more efficient electron emitting cylinder (the *cathode* element) which is heated by an internal filament then receiving the more specific name of *heater*.

The tube differs from the light bulb in that it contains other *elements* or *electrodes* in addition to the filament. One such element, usually cylindrical in shape, completely surrounds the filament or cathode. It is constructed of metal and is termed the *plate*. Electrons from the filament or cathode are attracted to the plate with considerable velocity and in large numbers if the plate is connected to the positive terminal of a battery or other source of direct current, and the cathode is connected to the negative terminal.

It is an important fundamental fact that a stream of electrons (the *plate current*) can flow from the plate battery to the filament, across the electron-filled gap to the plate, and back to the battery, completing what is termed the *plate circuit*. If an alternating voltage is impressed upon the plate, however, electrons are attracted when the plate voltage swings in the positive direction and are repelled when it swings negative. This is because the electrons themselves carry negative charges and similar charges repel each other, while unlike ones attract.

Diodes

Thus, the simplest tube (one with only plate and a filament, or cathode, element) can be employed as a *rectifier* of alternating current, a device that changes alternating (bidirectional) current of either audio or radio frequency into unidirectional d.c.

The two-element tube or *diode* is used in modern radio transmitters and receivers principally to rectify a.c. from the power lines, which is then *filtered* to provide d.c. for the operation of other tubes. Diode *detectors* are used to some extent in combination with more complex tubes in some large receiving sets, but their use as simple detectors connected directly to the antenna has long since been abandoned because of their very low sensitivity to weak signals. Detection is the process by which the audio component is separated from the modulated radio-frequency carrier at the receiver. Detection always involves either rectification or nonlinear amplifications of an alternating current. Detection is sometimes called *demodulation*.

Triodes

Greater sensitivity, as well as some amplification of the received signal, is provided by the *triode*, or three-element tube. This type has a third element, a coil or mesh of fine wire, termed the *grid*, mounted between the filament or cathode and the plate but insulated from both. When the grid is connected to a source of alternating voltage, it acts as a sort of traffic policeman, permitting electrons from the cathode to sift through its meshes and reach the plate when the grid voltage swings positive but blocking their passage on negative halves of the cycle. Thus the grid becomes a control element, switching the plate current on or off or controlling its strength. The signal delivered by the triode is of the same frequency as that of the a.c. applied to the grid and is considerably increased in strength. *Amplification* has been obtained.

R.F. and A.F. Amplification

A signal too weak to operate a detector may be amplified beforehand by a tube placed ahead of the detector tube. This type of amplification is called *radio-frequency* amplification. Likewise, a signal delivered by the detector too weak to be heard satisfactorily in headphones or loudspeaker may be amplified by one or more other tubes connected after the detector. This process is termed *audio-frequency* amplification. A conventional radio receiver might consist of one or more radio-frequency amplifiers, a detector, and one or more audio-frequency amplifiers. A simpler set would incorporate only a detector and r.f. or a.f. amplifiers; while a very simple one, such as used by amateurs for portable use where lightness of weight and minimum bulk are essential, might consist only of a detector.

In addition to diodes and triodes there are many tubes containing additional elements which perform various electrical functions that usually provide increased sensitivity or greater amplification. Some of these, shown in picture diagram and schematic symbols on page 10, are *tetrodes*, four-element tubes in which the fourth element is a *screen grid* placed between the usual or *control* grid and plate; *pentodes*, five-element tubes containing, in addition to the screen, a *suppressor grid* between screen and plate; *pentagrid converters*, a specialized type of tube with five separate grids; *hexodes*, *heptodes*, etc. Some tubes even include more than one plate; others consist of two complete and separate tubes in one bulb.

In all types, connection to most or all internal elements is provided by wires which pass through the lower end of the sealed glass bulb or metal envelope and terminate in pins or prongs on the base mounted at the lower end of the bulb. In some transmitting tubes, leads from the elements are brought directly through the top or side of the bulb, and in numerous receiving type tubes the control-grid lead passes through the top of the tube.

TUNING

In order to eliminate the interference which would be caused by picking up more than one signal at the same time, recourse is made to the process of *tuning*. This is, in effect, simply a means of separating desired from undesired signals by setting the receiving equipment to pick up and *accept* only desired frequencies.

A simple tuner circuit comprises only a properly designed coil of wire connected to an adjustable or *variable* condenser. The setting of the condenser is the only adjustment with this arrangement and this will, with the coil characteristics, determine the frequency which will be passed through to the grid of the tube. Signals on adjacent frequencies will be attenuated and on far-removed frequencies, rejected. Complex receivers and transmitters incorporate numerous similar tuned circuits.

The ability of a receiver to tune in desired signals and discriminate against others is termed its *selectivity*. Simple receivers generally are not very selective, while complex ones usually are highly selective.

RADIATION

The radiation from an antenna consists of two components, a *sky wave* and a *ground wave* or *surface wave*. As the words indicate, the sky wave component is that part of the radiated energy which leaves the antenna at an angle above the horizon and is reflected back to earth by the *Heaviside layer*, or *ionosphere;* the ground wave is that part of the energy which is radiated parallel to the ground and travels along the surface of the earth.

As the frequency is increased, the sky wave travels farther and farther before being bent back to earth, and the ground wave is more and more rapidly attenuated. This results in a silent zone or *skip distance* on frequencies above a certain frequency. On frequencies above this critical frequency the sky wave does not return to earth until it has traveled farther than the ground wave is capable of reaching. This critical frequency changes from time to time, depending upon time of day, time of year, sunspot activity, and other factors. Usually this skip distance effect will be noticeable on the 7-Mc. and higher frequency bands at night and on the 14-Mc. and higher frequency bands in the daytime. This skip effect is greater on any frequency at night.

As the frequency is increased above 14 Mc., a point is reached between 20 and 40 Mc. (depending also upon the time of day, time of year, sunspot activity, etc.) where the skip distance is so great that the sky wave does not return to earth at all except for short periods under unusual circumstances. For this reason the amateur 28-Mc. band is useful for only local (ground wave) work during certain parts of the year.

A peculiar quality about radio waves is that as the frequency is increased above about 20 Mc., the ground wave begins to act more and more like light waves, in that the waves become less and less inclined to bend themselves over the contours of the earth but rather tend to travel in a straight line. At 56 Mc. (useful primarily for ground wave work because the sky wave very seldom returns to earth), definite "shadow effects" are noticed behind hills and large buildings. For this reason, 56-Mc. antennas are always mounted as high as possible.

Transmitting Antennas

The simplest transmitting antenna for amateur use is either a half-wave *dipole* or quarter-wave Marconi. The dipole is also called a *doublet* or *Hertz* antenna, and is an electrical half wavelength long, which is about 5 per cent shorter than a physical half wavelength due to *end effects*. Thus an 80-meter half-wave doublet is slightly less than 40 meters in length.

A half-wave doublet has high voltage at both ends and high current and a *voltage node* at the center. On the lower frequencies part of the antenna is usually brought right in to the transmitter and coupled to it. If one end is coupled to the transmitter, the dipole is *voltage fed*. If the center of the antenna is coupled to the transmitter, the dipole is *current fed*. Thus we see that the method of coupling power to the antenna will depend upon what part of the antenna is brought in to the transmitter.

The Marconi antenna is simply half a dipole (doublet) worked "against earth" to provide the missing quarter wave. In other words, the current flows into the earth instead of into another quarter-wave section. Thus we see why a good, low-resistance, earth connection is required for efficient operation of the Marconi antenna. A water-pipe makes a good ground connection for amateur work. While not quite so good a radiator as a dipole, the Marconi antenna is widely used on the 160-meter band because of space restrictions. The Marconi, being only a quarter wave long, is about 130 feet long for 160-meter operation, while a dipole for that band measures around 260 feet.

Radiating and reflecting elements can be arranged to concentrate the power of an antenna in one direction, much as a reflector is used to make a light beam. This is equivalent to increasing the transmitter power. However, to be of much use, such an antenna *array* must be arranged for rotation or else several arrays must be available to give complete coverage of all desired directions. This makes directive arrays impracticable except for the higher frequencies, as arrays for the lower frequency bands would be too cumbersome. Directive arrays are widely used on 10 and 20 meters. However, much "dx" has been worked with ordinary half-wave dipoles, and the newcomer will find that these simple antennas give good results in all directions and are easier to construct and get working properly.

The subject of antennas is a comprehensive one, and no attempt can be made in a book of this size to cover the subject thoroughly. The newcomer interested in more detailed antenna theory or construction of a more elaborate antenna than that shown in conjunction with the transmitters described in the construction chapter are advised to procure a copy of the RADIO ANTENNA HANDBOOK.

IV. LEARNING THE CODE

The applicant for an amateur license must be able to send and receive the Continental code at a speed of 13 words per minute, with an average of 5 characters to the word. Thus 65 characters must be copied consecutively without error in one minute. Similarly, 65 consecutive characters must be transmitted without error in that time.

Sending and receiving tests are both five minutes in length. If 65 consecutive characters, at the required rate, are copied correctly somewhere during the first five-minute period, the applicant may then attempt a transmission. Again, if 65 consecutive characters are sent correctly somewhere during this second period, a passing mark is received.

Failure to pass the code test results in a two-month rest period during which the applicant can improve his mastery of the code; thereafter, he may appear for another try.

Approximately 30 per cent of the amateur license applicants fail to pass the code examination. This may be attributed to several things: excitement and nervousness during the examination; a false sense of security with regard to their speed capabilities, resulting in their attempting the examination before actually being ready for it; and incorrect method of learning the code.

The first two of these reasons may be considered together, since they are somewhat related. It should be expected that nervousness and excitement—at least to some degree—will hinder the applicant's code ability. The best prevention against this is to be able to master the code at a little better than the required speed, under ordinary conditions. Then a little slowing down due to nervousness will not prove "fatal" during the strain and excitement of the examination. As to the correct method of learning the code, the following is recommended. Unfortunately, no "trick" short cut to learning the code has been found generally successful.

Memorizing the Code

Though the code itself may be memorized thoroughly in a few days of diligent application, the time required to build up speed will be entirely dependent upon individual ability and regularity of drill, and may take any length of time from a few weeks to many months.

Since code reading requires that individual letters be recognized instantly, any memorizing scheme which depends upon an orderly sequence, such as learning all "dot" letters and all "dash" letters in separate groups, is to be discouraged.

Each letter and figure must be recognized by its *sound* rather than by its appearance. Telegraphy is a system of sound communication, the same as is the spoken word. The letter A, for example, is one short and one long sound in combination, sounding like *did-dah*, and it must be remembered as such, not as *dot-dash*.

If you listen to the sound of a letter transmitted slowly by a buzzer and key in the hands of some experienced operator, you will notice how closely the dots resemble the sound *did* and the dashes *dah*.

Before beginning practice with a code-practice set, it is necessary to memorize the whole alphabet perfectly. A good plan is to study only two letters a day and to drill with those letters until they become part of your consciousness. Mentally translate each day's letters into their sound equivalent wherever they are seen: on signs, in papers—indoors and outdoors. Tackle two additional letters in the code chart each day, at the same time reviewing all of the characters already learned.

Avoid memorizing by routine. Be able to sound out any letter immediately without so much as hesitating to think about the letters preceding or following the one in question. Know C, for example, apart from the sequence A, B, C. Skip about among all of the characters learned, and before very long sufficient letters will have been acquired to enable you to spell out simple words to yourself in "*did-dahs*." This is interesting exercise, and for that reason it is good to memorize all of the vowels first, the most common letters next.

Actual code practice should start only when the entire code, including numerals and the few *commonly used* punctuation marks, have been memorized so thoroughly that any letter or figure can be sounded at a moment's notice without hesitation.

Once you have memorized the code thoroughly, you should concentrate on increas-

THE RADIOTELEGRAPH CODE

A	· —	N	— ·
B	— · · ·	O	— — —
C	— · — ·	P	· — — ·
D	— · ·	Q	— — · —
E	·	R	· — ·
F	· · — ·	S	· · ·
G	— — ·	T	—
H	· · · ·	U	· · —
I	· ·	V	· · · —
J	· — — —	W	· — —
K	— · —	X	— · · —
L	· — · ·	Y	— · — —
M	— —	Z	— — · ·

NUMERALS, PUNCTUATION MARKS, ETC.

1	· — — — —	6	— · · · ·
2	· · — — —	7	— — · · ·
3	· · · — —	8	— — — · ·
4	· · · · —	9	— — — — ·
5	· · · · ·	Ø	— — — — —

INTERNATIONAL DISTRESS SIGNAL	· · · — — — · · ·
PERIOD	· — · — · —
COMMA	— — · · — —
INTERROGATION	· · — — · ·
QUOTATION MARK	· — · · — ·
COLON	— — — · · ·
SEMICOLON	— · — · — ·
PARENTHESIS	— · — — · —
FRACTION BAR	— · · — ·
WAIT SIGN	· — · · ·
DOUBLE DASH (BREAK)	— · · · —
ERROR (ERASE) SIGN	· · · · · · · ·
END OF MESSAGE	· — · — ·
END OF TRANSMISSION	· · · — · —

The Continental code shown above is used for all radio communications. The Morse code, used for land line telegraphic communication within the U.S.A., is more complicated.

ing your *receiving* speed. True, if you practice with another newcomer who is learning the code, you will both have to do some sending. But do not attempt to practice *sending* just for the sake of increasing your sending *speed*.

When transmitting on the code practice set to your partner, so that he can get receiving practice, concentrate on the *quality* of your sending, not on your speed. Your partner will appreciate it, and he could not copy you if you "opened up" anyhow. If you want to get a reputation as having an excellent "fist" on the air, just remember that speed alone won't do the trick. Proper execution of your letters and spacing will make much more of an impression. Fortunately, as you get so that you can send evenly and accurately, your sending speed will automatically increase. Remember, try to see how *evenly* you can *send* and how *fast* you can *receive*.

Because it is comparatively easy to learn to send rapidly, especially when no particular care is given to the quality of the sending, many amateurs who have just received their licenses get on the air and send mediocre code at 20 words a minute when they can barely receive *good code* at 13. While most old timers on the air remember their own period of initiation and are only too glad to be patient and considerate if you tell them you are a beginner, the surest way to incur their scorn is to try to impress them with your "lightning sending" and then request "QRS" when they come back to you at the same speed.

Code Practice Sets

If you don't feel too foolish doing it, you can secure a measure of code practice with the help of a partner by sending "did dah" messages to each other while riding to work, eating lunch, etc. It is better, however, to use a buzzer or code practice oscillator in conjunction with a regular telegraph key.

As a good key may be considered an investment, it is wise to make a well-made key your first purchase. Regardless of what type code practice set you use, you will need a key, and later on you will need one to key your transmitter. If you get a good key to begin with, you won't have to buy another one later.

The key should be rugged and have fairly heavy contacts. Not only will the key stand up better, but such a key will contribute to the "heavy" type of sending so desirable for radio work. Morse (telegraph) operators use a "light" style of sending and can

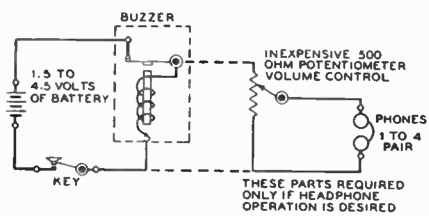


Figure 1. The simplest code practice set, a key and buzzer. The buzzer should be adjusted to give a steady, high pitched "whine." The phones and volume control may be omitted if desired.

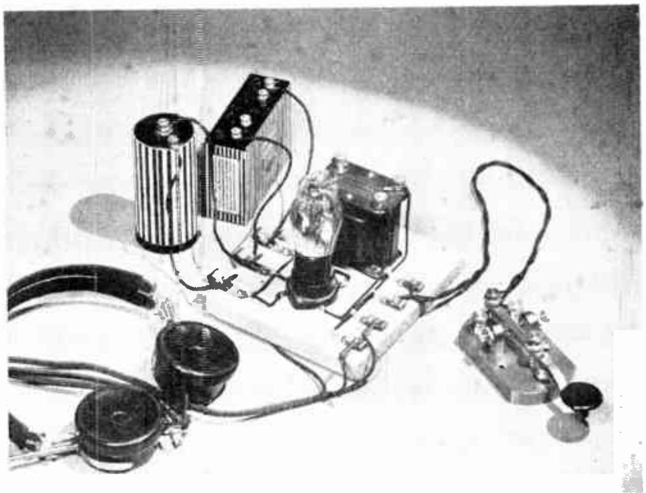


Figure 2. A battery operated code oscillator consists essentially of a tube and audio transformer. Connections are made to batteries, key, and phones by means of Fahnestock clips screwed to the baseboard.

send somewhat faster when using this light touch. But in radio work static and interference are often present, and a slightly heavier dot is desirable. If you use a husky key, you will find yourself automatically sending in this manner.

Special types of keys, especially the semi-automatic "bug" type, should be left alone by the beginner. Mastery of the standard type key should come first. The correct manner of using such a key will be discussed later.

To generate a tone simulating a code signal as heard on a receiver, either a mechanical buzzer or an audio oscillator (howler) may be used. The buzzer may be mounted on a sounding board in order to increase the fullness and volume of the tone; or it may be mounted in a cardboard box stuffed with cotton in order to silence it and the signal fed into a pair of earphones. The latter method makes it possible to practice without annoying other people as much, though the clicking of the key will no doubt still bother someone in the same room.

A buzzer-type code practice circuit is shown in figure 1. The buzzer should be of good quality or it will change tone during keying; also the contacts on a cheap buzzer will soon wear out. The volume control, however, (used only for headphone operation) may be of the least expensive type available, as it will not be subjected to constant adjustment as in a radio receiver. For maximum buzzer and battery life, use the least amount of voltage that will provide stable operation of the buzzer and sufficient volume. Some buzzers operate stably on 1½ volts, while others require more voltage.

A vacuum tube audio oscillator makes the best code practice oscillator, as there is no sound except that generated in the earphones and the note more closely resembles that of a radio signal. Such a code practice oscillator is illustrated pictorially in figure 2 and diagrammed schematically in figure 3. These parts are all screwed to a wood board and connections made to the phones and batteries by means of Fahnestock clips. A single dry cell supplies filament power and a 4½-volt C battery supplies plate voltage. Both filament and plate current are very low, and long battery life can be expected. The vacuum tube is the biggest item from the standpoint of cost, but it can later be used in a field-strength meter with the same batteries supplying power. Such a device is very handy to have around a station, as it can be used for neutralizing, checking the radiation characteristics of your antenna, etc. Such an instrument is not described in this booklet, as one is not necessary for getting on the air; but it is nice to know that when you no longer have use for a code practice oscillator and become interested in acquiring test and measuring equipment you can make use of the tube and batteries formerly used in your code practice oscillator.

A 1H4G, 30, or 1G4G may be used with the same results. The first two are 2-volt tubes, but will work satisfactorily on a 1.5-volt

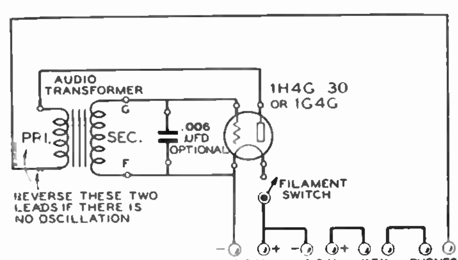


Figure 3. The simplest v.t. code practice oscillator. A dry cell and a 4½-volt C battery furnish power. Omitting the .006-μfd. condenser will result in a higher pitched note. Use the smallest, cheapest audio transformer you can find. With a good transformer it is sometimes impossible to get a sufficiently high pitched note, even by eliminating the .006-μfd. condenser.

filament battery because of the very small amount of emission required for the low value of plate current drawn. They cost less than a 1G4G. Be sure to get a socket that will accommodate the particular tube you buy.

Oddly, it is important that the audio transformer used *not* be of good quality; if it is, it may have so much inductance that it will be impossible to get a sufficiently high pitched note. If you buy a new transformer, get the smallest, cheapest one you can buy. The old transformers used in moderately priced sets of 12 years ago are fine for the purpose, and can oftentimes be picked up for a small fraction of a dollar at the "junk parts" stores. The turns ratio is not important; it may be anything between 1½/1 and 6/1.

Correct transformer polarity is necessary for oscillation. If oscillation is not obtained, reverse the two wires going to the primary terminals of the transformer.

The tone may be lowered by substituting a larger (.025-μfd.) condenser for the .006-μfd. capacitor shown in the diagram. The highest pitch that can be obtained with a given transformer will result when the condenser is left out of the circuit altogether. Lowering the plate voltage to 3 volts will also have a noticeable effect upon the pitch of the note. If the particular transformer you use does not provide a note of a pitch that suits you, the pitch can be altered in this manner.

Using a 1H4G, a standard no. 6 dry cell for filament power, and a 4½-volt C battery for plate power, the oscillator may be constructed for about $2.00 exclusive of key and earphones. The filament battery life will be about 700 hours, the plate battery life considerably more. This set has an advantage over an a.c. operated practice set in that it can be used where there is no 110-volt power available; you can take it on a Sunday picnic if you wish. Also, there is no danger of electrical shock.

Automatic Code Machines

The two practice sets just described—the buzzer and the v.t. oscillator—are of most value when you have someone with whom to practice. If you are unable to enlist a code partner and have to practice by yourself, the best way to get receiving practice is by use of a set of phonograph code practice records or a tape machine (automatic code-sending machine) with several practice tapes. The records are of use only if you have a phonograph whose turntable speed is readily adjustable. The tape machines can be rented by the month for a reasonable fee. Once you can copy close to 10 w.p.m., you can get receiving practice by listening to slow-sending amateurs on your receiver, as amateurs usually send quite slowly when working extreme dx. However, until you can copy around 10 w.p.m., your receiver isn't of much use and either another operator or a tape machine or code records are necessary for getting receiving practice after you have once memorized the code.

The student must observe the rule always to write down each letter as soon as it is received, never dots and dashes to be translated later. If the alphabet has actually been mastered beforehand, there will be no hesitation from failure to recognize *most* of the characters unless the transmission speed is too high.

Don't practice too long at one stretch; it does more harm than good. Twenty-five or thirty minutes should be the limit.

Time must not be spent trying futilely to recall a missed letter. Dismiss it and center the attention on the next letter. In order to prevent guessing and to give you equal practice on seldom-used letters such as X, Y, etc., the transmitted material should not be plain language except perhaps for a few minutes out of each practice period.

During the first practice period, the speed should be such that a substantially solid copy can be made of the entire transmission without strain. Then, in the next period, the speed should be increased slightly to a point where all of the characters can be caught only through conscious effort. When the student becomes proficient at this new speed, another slight increase may be made, progressing in this manner until a speed of about 16 words per minute is attained. The margin of 3 w.p.m. is recommended to overcome the possible excitement factor at examination time. Then when you take the test you don't have to worry about excitement or an "off day."

The speed must not be increased to a new level until the student finally makes solid copy for a 5-minute period at the old level. How frequently increases of speed can be made depends upon individual ability and the number of practice hours. Each increase is apt to prove decidedly disconcerting, but keep in mind the statement by

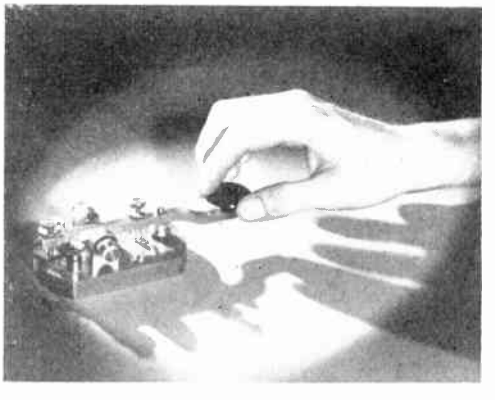


Figure 4. Correct position of the fingers when working a telegraph key. The hand should rest lightly on the key. The wrist is used merely as a fulcrum, the fingers to hold the knob and act as a cushion. A "wrist motion" is used in sending, but it is the muscles of the forearm that provide the power.

Dr. G. T. Buswell, "You are never learning when you're comfortable."

Using a Key

See figure 4 for the proper position of the hand, fingers, and wrist when manipulating the telegraph key. The forearm rests naturally on the desk. The knob of the key is grasped lightly with the thumb along the edge and the index and third fingers resting on the top towards the front edge. The hand moves with a free up and down motion, the wrist acting as a fulcrum. The power comes entirely from the arm muscles. The third and index fingers will bend *slightly* during sending, but not because of conscious effort to manipulate the finger muscles. Keep your finger muscles just tight enough to act as a "cushion" for the arm motion and let the slight movement of the fingers take care of itself.

The key spring is adjusted to the individual wrist and should be neither stiff nor "sloppy." Use a moderately stiff tension at first and gradually lighten it as you get more proficient. The separation between the contacts must be the proper amount for the desired speed, being about 1/16 inch for slow speeds and corresponding closer together (about 1/32 inch) for faster speeds. Avoid extremes in either direction. It is preferable that the key be placed far enough from the edge of the table (about 18 inches) that the elbow can rest on the table.

The characters must be properly spaced and timed with the dot as the yardstick. A standard dash is three times as long as a dot. The spacing between parts of the same letter is equal to one dot; between letters, three dots; between words, five dots.

This does *not* apply when sending slower than about 10 words per minute for the benefit of someone learning the code and desiring receiving practice. When sending at say 5 w.p.m., the individual letters should be made the same as though the sending rate were about 10 w.p.m. except that the spacing *between letters* and *between words* is greatly exaggerated. The reason for this is obvious. The letter L, for instance, will sound exactly the same at 10 w.p.m. as at 5 w.p.m., and when the speed is increased above 5 w.p.m., the student will not have to become familiar with a new sound (faster combination of dots and dashes). He will merely have to learn the identifying of the *same* sounds without taking so long to do so.

It has been found that it does not aid a student to identify a letter by sending the individual components of the letter at a speed corresponding to less than 10 words per minute. By sending the letter moderately fast, a longer space can be left between letters for a given code speed, giving the student more time to identify the letter.

When two co-learners have memorized the code and are ready to start sending to each other for practice, it is a good idea to enlist the aid of an experienced operator for the first practice session in order to get an idea of what properly formed letters sound like.

When you are practicing with another beginner, don't gloat because you seem to be learning to receive faster than he. It may mean that his *sending* is better than yours. Remember that the quality of sending affects the maximum copying speed of a beginner by as much as 100 per cent. In fact, if your sending is bad enough, a newcomer won't be able to read it at all, even though an old timer may be able to get the general drift of what you are trying to send. A good test for any "fist" is to try it on someone who is just getting to the "13 per" stage.

If You Have Trouble

While there is no justification for the contention sometimes made that "some people just can't learn the code," there is no denying that it is more difficult for some people than others. It is not a matter of intelligence; so don't feel ashamed if you seem to experience a little more than the usual difficulty in learning the code. Your reaction time may be a little slower, your coordination not quite so good. If this is the case, remember that you can *still learn the code.* You may never learn to send and receive at 40 w.p.m., but you can learn to send and receive 13 w.p.m. if you have patience and if you refuse to be discouraged by the fact that others seem to pick it up much more rapidly.

While the slow learner can ultimately get his 13 per by following the same learning method if he has *perseverance*, the following system of auxiliary practice will oftentimes prove of great aid in increasing one's speed when progress by the usual method of practice seems to have reached a temporary standstill. All that is required is the usual key-buzzer headset outfit, plus an extra operator who has a good "fist."

Suppose we call the fellow at the key the teacher and the other member of the crew the student. The student will read from a duplicate newspaper the *same text the operator is sending.*

The teacher is to start sending at a rate just slower than the student's top speed, judged by his last test. This will allow the student to follow accurately each letter as it is transmitted. After a warming-up period of about one minute, the sending speed is to be increased gradually but steadily and continued for a period of about five minutes. An equal rest period is beneficial before the second session. Speed for the second period should be started at half way between the original starting speed and the speed used at the end of the first period. Follow the same procedure for the second and third practice periods.

At the end of the third *reading* practice period, start copying immediately, using the *same text as before,* as a speed just above the student's previous copying ability. It will be found that one session of the *reading* practice will for the time being increase the student's *copying* ability from 10 to 20 per cent. The teacher should watch the student and not increase the sending speed too much above the copying ability of the student, as this brings about a condition of confusion and is more injurious than beneficial.

Code Classes

A certain number of altruistic amateurs send code practice on schedule once or twice each week, and excellent practice can be obtained after you have built or constructed your receiver by taking advantage of these sessions. Call letters, time schedules, and frequency in kilocycles of the stations currently sending code practice can be obtained by writing the American Radio Relay League, West Hartford, Conn. Enclose a stamped, self-addressed envelope.

If you live in a large city, the chances are that at least one of the radio clubs or amateur parts stores conducts a free code class. If you inquire around a bit, you can usually discover how to get in on these practice sessions.

V. THE AMATEUR BANDS

Although an amateur station may be operated in any of the shortwave bands set aside for such use, almost every operator acquires a distinct preference for certain bands. Each band offers some distinct feature which may appeal to one man but fall short of interesting another.

The long-distance fan is apt to make the 20-meter (14 Mc) band his pet, because 20-meter signals have a way of skipping over nearby places and landing many hundreds of miles away. The 160- and 5-meter bands appeal to local *ragchewers* who like to communicate in and around their own towns. And so on for the other bands.

The operator's preference between phone and c.w. telegraphy also enters into the picture. C.w. operation is permitted in any band, while voice transmission is allowed only in certain ones. The new operator holding a class-B license may operate phone transmitters only in the ¾-, 1¼-, 2½-, 5-, 10- and 160-meter bands. A class-A license, for which the operator may be examined only after he possesses one year's experience, is required for phone operation in the 20- and 80-meter bands.

A listing is made here of the amateur bands and their characteristics, for the benefit of the newcomer. For the fullest enjoyment of the hobby, the editors recommend that eventually *all* of the bands between 10 and 160 meters be employed. Most amateur receivers cover from 10 to 160 meters, and a little additional design and labor in the building of a transmitter will insure all-band transmission. The newcomer, however, will find it easier to get his transmitter working well on just one or two bands.

160 Meters

1715 to 2000 kc.* Unrestricted phone from 1800 to 2000 kc. Very popular for local ragchews and occasional work up to a few hundred miles. Although 160-meter communication over fair distances (500 miles) is rather common, long-distance communication is not regularly accomplished in this band.

80 Meters

3500 to 4000 kc. Phone restricted to holders of class-A licenses, 3900 to 4000 kc. Night transcontinental c.w. communication possible with low or medium power except during part of summer. Night skip-distance effect noticeable during the winter months.

40 Meters

7000 to 7300 kc. C.w. only. Good for long-distance communication (500-12,000 miles) at night the year round. Night skip-distance effects very pronounced. "Moderate" dx (500-800 miles) is often possible during day, especially in winter.

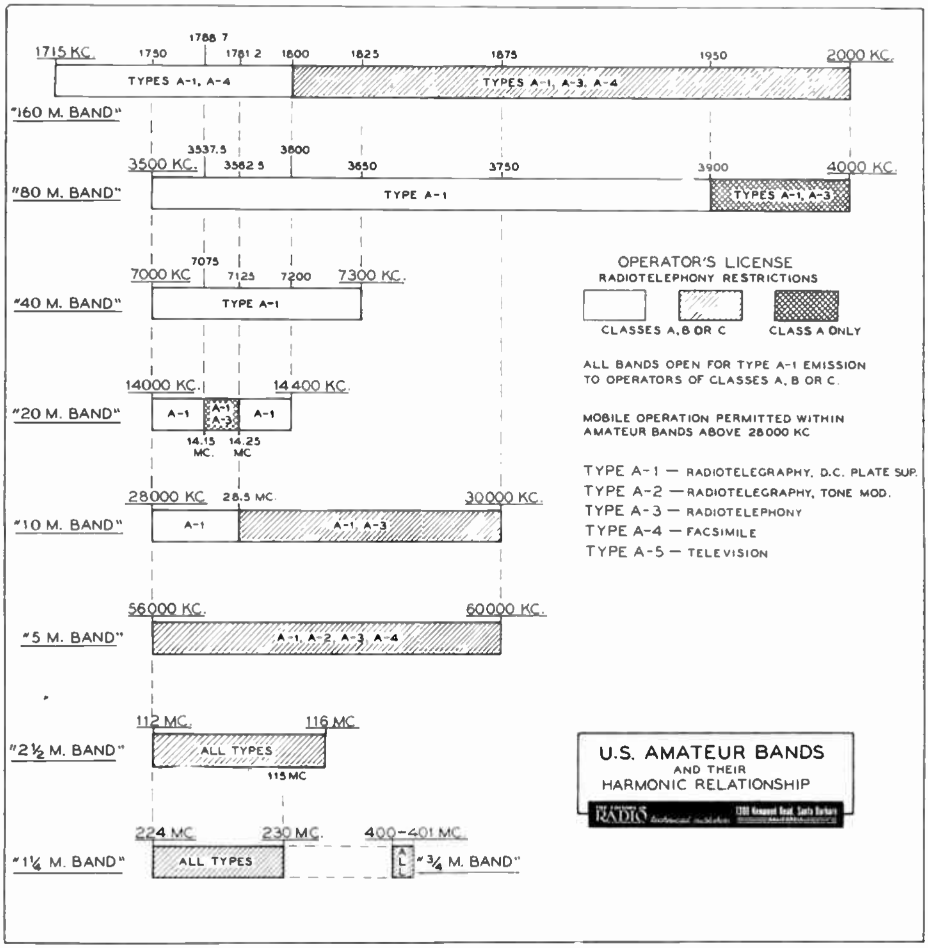
20 Meters

14,000 to 14,400 kc. Phone restricted to holders of class-A licenses, 14-150-14,250 kc. This band has the reputation of being the best daylight long-distance band, its good features usually lasting well into the evening. Has very pronounced skip-distance effects, making it hard for 20-meter operators to talk with nearby points (closer than 500 miles but beyond the "ground wave"). The skip distance increases after sunset.

10 Meters

28,000 to 30,000 kc. Unrestricted phone from 28,500 to 30,000 kc. May be used for mobile transmitters. Erratic and subject to sudden fluctuations. At various times during the year extremely long distances (1000-12,000 miles) can be covered by 10-meter signals, making this band comparable to 20 meters at these times. At all other times, only local contacts are reliable. Seasonal effect

* Subject to change to 1750 to 2050 kc. in accordance with the 1937 Havana conference.



LIMITS OF AMATEUR BANDS.

The limits and existence of certain of the amateur bands are subject to change or cancellation at any time, and newcomers should check before going on the air to make sure of the validity of this chart, which is correct at the time of this writing. While the chance of immediate change or cancellation is remote, it is nevertheless a possibility that must be recognized.

makes this band best for dx work in spring and fall. Extreme dx can often be worked at these times with but a few watts, especially when a good antenna system is used.

5 Meters

56,000 to 60,000 kc. Unrestricted phone throughout entire band. Generally speaking, this is a "local" band, the signals normally being received only slightly beyond the limit of the eyesight. However, extreme distances (1000-1500 miles) have been covered on a few days during the year due to unusual fluctuations in the ionosphere. Some amateurs consistently cover good distances (50-75 miles) by using directive antenna arrays on 5 meters.

2½ Meters

112-116 Mc. Unrestricted phone throughout band. Regulations pertaining to quality of signal not so stringent as on lower frequencies. Somewhat similar to 56 Mc. for local work; never any sky wave communication. Very simple and inexpensive equipment can be used on this band; hence it is suitable for mobile work by the newcomer. Limits of band subject to change by F.C.C. at any time.

Microwaves

224-230 Mc. and 400-401 Mc. Still highly experimental. Special equipment is necessary on these bands. Limits of these bands subject to change by F.C.C. at any time.

VI. OPERATING PROCEDURE

Radio stations originate and answer calls, carry on communication, and sign off in a prescribed standard fashion. Brevity is the keynote of the scheme. Operating procedure is standard throughout the world and the present system is the result of international agreement.

To call or reply in the accepted manner, like sending the code well, distinguishes the finished operator. "Lids" (slipshod operators) invariably deviate from the rules, making their calls or replies too lengthy, creating needless interference with other stations, or shortening them at the expense of easy identification.

An unduly long call is tiring to the operator at the receiving end and, in many instances, defeats its purpose. Too short a call usually represents so much wasted effort, unless you are right on one edge of a band.

The newcomer must be prepared to state in the license examination the manner in which calls of various kinds are made and answered, and it behooves him to put these rules into practice as soon as he embarks upon his amateur career. The following paragraphs outline accepted operating procedure. The overline (¯) indicates that the two letters are sent as one character.

Calling a Station, C.W.

To call another station known to be listening at the time, the standard procedure is to transmit the call letters of that station 3 times, the letters DE (meaning *from*) and your own call letters 3 times. Repeat this series 3 times and conclude with $\overline{\text{AR}}$ (the international end of message signal).

Example: W1ABC keeps an engagement (schedule) to call W9XYZ.
He calls thus:
W9XYZ W9XYZ W9XYZ DE
W1ABC W1ABC W1ABC
(sent 3 times)

$\overline{\text{AR}}$

While the foregoing is the accepted procedure, many good operators shorten their own signature to once except at the conclusion of the call, such as:

W9XYZ W9XYZ W9XYZ DE W1ABC
(sent 2 times)
W9XYZ W9XYZ W9XYZ DE W1ABC
W1ABC W1ABC
(sent 1 time)

Answering a Call, C.W.

To reply to a calling station, transmit the call letters of the calling station 3 times, the letter group DE, and your own call letters 3 times. Go ahead with the transmission, giving the operator a signal strength report, and conclude with $\overline{\text{AR}}$ K. (K is the international signal for *go ahead.*)

Example: W9XYZ acknowledges the call from W1ABC.
He responds thus:
W1ABC W1ABC W1ABC DE
W9XYZ W9XYZ W9XYZ
(text of your conversation)

$\overline{\text{AR}}$ K

At the start of each succeeding transmission, after communication has been definitely established, each station transmits the call letters of the other station *one* time, the signal DE, and his own call letters *once,* following with the letter group BK (international break signal) and going ahead with the conversation.

Each operator, when he has said all he intends to say in one transmission, concludes with the signal group $\overline{\text{AR}}$ K (in effect, *this is the end of this part of the conversation; I will now wait for you to talk. Go ahead.*) $\overline{\text{AR}}$ K is necessary at the end of each transmission, although the entire communication between two stations may last through many such single transmissions.

R·S·T REPORTING SYSTEM

READABILITY

1. Unreadable.
2. Barely Readable—Occasional words Distinguishable.
3. Readable with Considerable Difficulty.
4. Readable with Practically No Difficulty.
5. Perfectly Readable.

SIGNAL STRENGTH

1. Faint—Signals Barely Perceptible.
2. Very Weak Signals.
3. Weak Signals.
4. Fair Signals.
5. Fairly Good Signals.
6. Good Signals.
7. Moderately Strong Signals.
8. Strong Signals.
9. Extremely Strong Signals.

TONE

1. Extremely Rough, Hissing Note.
2. Very rough A.C. Note—No Trace of Musicality.
3. Rough, Low-Pitched A.C. Note—Slightly Musical.
4. Rather Rough A.C. Note—Moderately Musical.
5. Musically Modulated Note.
6. Modulated Note—Slight Trace of whistle.
7. Near D.C. Note—Smooth Ripple.
8. Good D.C. Note—Just Trace of Ripple.
9. Purest D.C. Note.

If the Note Appears to Be Crystal Controlled, Simply Add an X After the Appropriate Number.

The CQ Signal

When your station has no definite engagement (schedule) with another, you may send out a general call inviting conversation with *any* station that cares to answer. The international signal for this purpose is the letter group CQ. The general call is made in the following manner:

CQ CQ CQ DE W1ABC W1ABC W1ABC
(sent 3 times)
K

Note that in the case of a CQ call the AR is omitted, only K being used.

After calling CQ, tune your receiver through the entire band to ascertain if there are any stations calling you. If several stations are calling you, your choice will be a matter of your own preference. You will probably select the most distant station or the one with which you have not had the pleasure of a contact. Do not wait too long before coming back to a station that has answered your CQ, or the operator may think his call unsuccessful and tune off your frequency before you come back to him.

When answering a CQ originated by another station, call in the regular fashion described earlier.

Unduly long CQ calls, particularly those in which the operator sends long lines of CQ's before he signs his call letters, are trying on the patience of any receiving operator, newcomer or old-timer. This, of all calls, should be made as briefly as possible. It is better practice to use the standard *three-and-three* system between numerous listening periods than to transmit one long CQ call.

Directional CQ

When calling CQ, the operator may designate the stations with which contact is particularly desired in terms of country, state, city, direction, call area, etc. This character of call is termed the *directional CQ.*

The directional CQ is sent out in the same manner as the regular call, the only difference being that the direction, city, or other qualifications is attached to each CQ letter group:

CQ W9 CQ W9 CQ W9 DE W1ABC
W1ABC W1ABC etc.
(indicating that W1ABC prefers to talk with any station in the ninth U.S. call area)

Or:

CQ NY CQ NY CQ NY DE W1ABC
W1ABC W1ABC etc.
(indicating that W1ABC desires contact with any station in New York and usually indicating traffic [third party messages] for that city)

Each country having amateur stations has a characteristic *international prefix* used as the initial letters (or letter) of all of its call letters. The prefix for the United States is the letter W. All amateur calls on the mainland of the United States have W as the initial letter. An international prefix attached to a directional CQ (as the call area signal and city name were used above) designates the country with which the calling station desires contact.

Signing Off

When the entire communication period has been concluded, the last transmission should be terminated with the letter groups AR SK followed by your own call letters sent *once* for identification. The group SK (meaning *end of work*) should be used only to indicate the actual termination of *all* communication with a particular station. It is the international signing-off signal that says to the operator at the other end, *This is all I have. I am through with the conversation. I have nothing further.*

The other station will then make its final transmission (if it has further information for you) and will conclude with AR SK and his call letters sent once.

If a station has sent you the signal SK and you have nothing further for him, acknowledge by transmitting his call letters once, DE, your own call letters once, and AR SK.

Remember that you *must* identify your station at the end of each transmission and at least once each 10 minutes during any transmission of more than 10 minutes duration, except as noted in sec. 12.83 of amateur radio rules and regulations by the Federal Communications Commission.

Test Signals

It is one of the rules of good operating never to make tests on transmitting equipment over the air unless absolutely necessary. The regular antenna should be disconnected and a *dummy antenna* connected to its place.

A simple dummy antenna might consist only of an ordinary electric light bulb sufficiently high in wattage to stand the normal power output of the transmitter. The lamp is inductively coupled to the output tank coil by means of 4 to 20 turns of insulated wire connected in series with the bulb. The best number of turns will vary somewhat with frequency.

Should it be necessary, however, to make tests over the air, all such transmissions must be identified in the proper manner by the call letters of the testing station. The letter V is the international test signal and is sent in the identifying transmission in the following manner:

V V V DE W1ABC W1ABC W1ABC

Tests on the air should be made as short as is practicable and with due regard to the interference they are apt to cause to communications between other stations.

LIST OF "Q" SIGNALS MOST USED BY AMATEURS

THE FOLLOWING LIST DOES NOT INCLUDE THOSE "Q" SIGNALS WHICH ARE USED MORE OFTEN IN SERVICES OTHER THAN AMATEUR.

ABBRE-VIATION	QUESTION	ANSWER
QRG	Will you tell me my exact frequency (wavelength) in kc/s (or m)?	Your exact frequency (wavelength) is .... kc/s (or ....m).
QRI	Is my note good?	Your note varies (or is bad).
QRJ	Are you receiving me badly? Are my signals weak?	I can not receive you. Your signals are too weak.
QRK	Are you receiving me well? Are my signals good?	I receive you well. Your signals are good.
QRL	Are you busy?	I am busy. Or, (I am busy with ....). Please do not interfere.
QRM	Are you being interfered with?	I am being interfered with.
QRN	Are you troubled by atmospherics?	I am troubled by atmospherics.
QRO	Shall I increase power?	Increase power.
QRP	Shall I decrease power?	Decrease power.
QRQ	Shall I send faster?	Send faster (.............. words per minute).
QRR	....	Amateur "SOS" or distress call (U.S.A.) Use only in serious emergency.
QRS	Shall I send more slowly?	Send more slowly (.......... words per minute).
QRT	Shall I stop sending?	Stop sending.
QRU	Have you anything for me?	I have nothing for you.
QRV	Are you ready?	I am ready.
QRX	Shall I wait? When will you call me again?	Wait until I have finished communicating with .... I will call you immediately (or at .... o'clock).
QRZ	By whom am I being called?	You are being called by ....
QSA	What is the strength of my signals (1 to 5)?	The strength of your signals is .... (1 to 5).
QSB	Does the strength of my signals vary?	The strength of your signal varies.
QSK	Shall I continue with the transmission of all my traffic; I can hear you through my signals?	Continue with the transmission of all your traffic. I will interrupt you if necessary.
QSL	Can you give me acknowledgment of receipt?	I give you acknowledgment of receipt. (Will send QSL card).
QSO	Can you communicate with .... directly (or through the intermediary of ....)?	I can communicate with .... directly (or through the intermediary of ....).
QSP	Will you relay to .... free of charge?	I will relay to .... free of charge.
QSX	Will you listen for .... (call sign) on .... kc/s (or .... meters)?	I am listening for .... (call sign) on ....kc/s (or ....meters).
QSY	Shall I send on ....kc/s (or ....m) without changing the type of wave?	Send on ....kc/s (or ....m) without changing the type of wave.
QSZ	Shall I send each word or group twice?	Send each word or group twice.
QTA	Shall I cancel telegram No. .... as if it had not been sent?	Cancel telegram No. .... as if it had not been sent.
QTC	How many telegrams have you to send?	I have .... telegrams for you or for .....
QTH	What is your position in latitude and longitude (or by any other way of showing it)?	My position is .... latitude .... longitude (or by any other way of showing it).

Signal of Acknowledgment

The letter R is the international signal of acknowledgement and should be used only to indicate perfect understanding of an *entire* message. It means in effect OK.

To follow the signal R by a list of items misunderstood is exceedingly bad form, since this procedure would mean literally "OK (which in itself means *everything received all right*) but the following items are not OK."

Q Signals

The condensed list of international abbreviations printed on this page is very useful to the radiotelegraph operator. These three-letter groups simplify radio communication to a large extent, since they embrace much of the intelligence ordinarily exchanged by amateur radio stations. The newcomer should make these Q signals a part of his radio vocabulary and use them steadily.

Ham Abbreviations

Amateurs use a large number of abbreviations of their own. These have become more or less standardized among the amateurs speaking the same language. They are usually nothing more than contractions of regular words, or in some cases combinations of numerals and words, when the names of numerals are phonetically equivalent to certain words. Such abbreviations, like the Q signals, save the c.w. operator considerable time.

A list of the more popular amateur abbreviations is given on page 23.

Repeating

When poor receiving conditions, such as fading, weak signals, or high noise level make 100 per cent reception difficult or impossible, it is perfectly in order to request a station to repeat each letter or each word, as the receiving operator desires.

The transmitting operator should never take the initiative to repeat. Do this only when specifically requested to by the receiving operator.

Calling a Station, Radiophone

Voice communication is more flexible and offers a greater opportunity for originality in calling and answering stations. It is not necessary to use abbreviations; in fact, it seems rather pointless to speak telegraphic abbreviations with the full faculty of speech at one's disposal.

There is no set formula. The editors can only advise the newcomer to the phone ranks to avoid the stilted, affected and worn-out expressions he might hear. To speak clearly and distinctly, enunciating and pronouncing correctly, and "being yourself" are the virtues of the finished phone operator. In radiophone practice, of course, as in c.w., long calls are indicative of poor operating ability.

A good radiophone call might take the following suggested shape:

W1ABC calling W9XYZ Hello W9XYZ W9XYZ W9XYZ W1ABC calling.
(speak three times)
W9XYZ at (or *in*) Chicago, W1 A, Adams B, Boston C, Chicago; W1ABC at (or *in*) Boston calling and standing by. Go ahead.

The names are used after the letters for identification. Many letters, like B, C, D, E, P, etc., sound alike over the air. So do A, J, K, and H. The words are from the Western Union word list (see page 24).

It is not necessary so to identify the call letters of the called station. The other fellow will recognize his own call much more readily than he will yours. It is familiar to him.

Answering a Station, Radiophone

It is not necessary to make a prolonged answer to a radiophone call. W9XYZ would answer W1ABC's call simply by saying something of this sort:

W1ABC at Boston, this is W9XYZ.

W1ABC is already tuned to W9XYZ's frequency and will not be compelled to tune all through the band to find him; hence a prolonged call is pointless. After the brief acknowledgment, W9XYZ goes ahead with the conversation.

Signing Off, Radiophone

Radiophone stations signing off simply state that fact.

Good night, old man. W9XYZ is signing off with W1ABC and standing by for acknowledgment.

W1ABC then makes his final transmission (if he has anything further to say) and signs off in the same fashion.

At the final sign-off, either station may say instead of "now waiting for an acknowledgment," "now standing by for any other station." The latter statement is the equivalent of sending out a CQ, and the receiver should then be tuned through the band to locate any resulting calls. The practice of calling a station that has just signed

ABBREVIATIONS COMMONLY USED BY AMATEURS

SHORT	FULL	SHORT	FULL	SHORT	FULL
ABT	About	GN	Good Night	RCD	Received
AGN	Again	GG	Going	RCVR	Receiver
AHD	Ahead	GT	Got—Get	RI	Radio Inspector
ANI	Any	GND	Ground	SA	Say
APRX	Approximately	HI (HA)	Laughter	SEZ	Says
BC	Broadcast	HM	Him	SM	Some
BD	Bad	HR	Here—Hear	SW	Short-Wave
B4	Before	HV	Have	SIG	Signal
BI	By	HW	How	SKED	Schedule
BK	Break	IC	I See	TFC	Traffic
BN	Been	ICW	Interrupted	TK	Take
BT	But		Continuous Wave	TKS	Thanks
BCUZ	Because	K	Go Ahead	TMW	Tomorrow
BTWN	Between	LID	Poor Operator	TNK	Think
BIZ	Business	LIL	Little	TNX	Thanks
C	See (Yes)	LFT	Left	TR	There
CLR	Clear	LSTN	Listen	TT	That
CN	Can	LTR	Letter	TX	Transmitter
CNT	Can't	MA	Milliampere	U	You
CK	Check	MC	Megacycle	UD	You Would
CKT	Circuit	MG	Motor Generator	UL	You Will
CMG	Coming	MI	My	UR	Your
CUD	Could	MIKE	Microphone	VB	Very bad
CW	Continuous Wave	MK	Make	VT	Vacuum Tube
CUL	See You Later	MO	More	VY	Very
CUM	Come	MSG	Message	WA	Word After
CUAGN	See You Again	MT	Empty	WB	Word Before
DE	From	ND	Nothing Doing	WD	Would
DA	Day	NG	No Good	WF	Word Following
DNT	Don't, Didn't	NIL	Nothing	WK	Work
DH	Deadhead	NM	No More	WL	Will—Would
DC	Direct Current	NR	Number	WN	When
DX	Long Distance	NW	Now	WT	What
ES	And	OB	Old Boy	WX	Weather
EZ	Easy	OL	Old Lady	X	Interference
FB	Fine Business	OM	Old Man	XMTR	Transmitter
FM	From	OP	Operator	YF	Wife
FR	For	OT	Old Top—Timer	YL	Young Lady
FREQ	Frequency	OW	Old Woman	YR	Your
GA	Go Ahead	PLS	Please	30	Finish—End
GB	Good-Bye	PSE	Please	73	Best Regards
GM	Good Morning	PX	Press	88	Love and Kisses
		R	OK		

off from another is quite common on phone.

Phone duplex, in which both stations let both receivers and transmitters run continuously and conversation is carried on much the same as on a telephone, is now prohibited by sec. 12.134 of the F.C.C. rules and regulations. At the time of this writing, the ban applies to *all bands*, though it is expected that the regulation will be amended so as to permit the practice on frequencies above 60 Mc. Inquire of your radio inspector to see if the regulation has yet been amended.

Message Handling

Some hams take pride in relaying free radiograms. As an amateur station operator you may originate such messages for yourself or persons in your community, sending them directly to their points of destination or passing them along over the air to another station to be relayed along to the addressees, or you may yourself participate in the relaying of messages given you by other stations.

You may be requested to copy radiograms for relay or for delivery in your own town. This is a phase of ham radio in which you are not compelled to participate unless your fancy so dictates. However, if you do accept messages, remember that some of them might be important, though seeming trivial to you. *All* of them are important to somebody. Therefore, do not allow your own procrastination to interfere with this service ham radio offers the public at no cost. It is far better to refuse to take messages than to accept them and leave them on your operating table until they grow stale. You should also bear in mind that accepting any kind of remuneration, either direct or indirect, for handling a message makes you subject to severe penalties.

QRR

The signal QRR is the official land distress call used by amateur stations in extreme emergencies, such as during times when telephone and telegraph service has been interrupted by flood, hurricane, fire, and the like and the country's amateur stations are an important communication link between communities.

The signal QRR has the same serious significance on the amateur frequencies that SOS has in marine radio. It indicates that the station is calling from a stricken zone or that there is serious trouble at the station.

All stations hearing the distress signal must immediately curtail all transmissions while the call is being transmitted and determine at once if they can be of assistance. All stations are of potential help when another calls QRR. When the calling station signs and stands by for reply, it may be called by stations wishing to determine their value as helpers. The emergency station will then select from those calling the one which in its estimation can be of greatest service, and may designate that several others stand by pending call.

The emergency call is sent in the manner prescribed for calling stations, except that the letters QRR are substituted for the call letters of the called station:

QRR QRR QRR DE W1ABC W1ABC W1ABC
(sent as many times as the calling station deems necessary)

$\overline{\text{AR}}$

When emergency traffic is being cleared on any amateur band, all other amateur communications must cease until such time as a broadcast is sent out by the emergency station or participating stations to the effect that the condition has been relieved and that ordinary amateur work may be resumed. Refer to sec. 12.155 of the F.C.C. rules and regulations for further details relating to operation during emergencies.

The amateur has rendered service of untold value during all of the recent major emergencies, floods, high winds, and other catastrophes. Order in the ranks has been largely a matter of self-government. Do not argue with stations handling emergency traffic when they request you to leave the air. Their business is of vital importance. Obstinacy will be dangerous not only to the stubborn operator who feels that the air is free to use, but will likewise interfere with a splendid public service.

Portable Operation

Portable operation of an amateur station is permissible as stipulated under sec. 12.91 92-93 of the F.C.C. rules and regulations. As the wording is such that there would be no difficulty in interpreting these clauses correctly, no further comment will be made. Remember to take your combined license with you on your trip. If your home station is to be operated by another amateur while you are away, have a photostat made of just your station license and post the photostat in the operating room.

Logs

The government requires that every station keep an accurate log of all transmissions. This record may be called for at any time by your local radio inspector or by the Federal Communications Commission and it is a misdemeanor punishable by possible

WESTERN UNION WORD LIST

A—Adams	J—John	R—Robert
B—Boston	K—King	S—Sugar
C—Chicago	L—Lincoln	T—Thomas
D—Denver	M—Mary	U—Union
E—Edward	N—New York	V—Victor
F—Frank	O—Ocean	W—William
G—George	P—Peter	X—X-ray
H—Henry	Q—Queen	Y—Young
I—Ida		Z—Zero

fine and/or suspension of your license not to have observed this regulation.

Amateur logs must show:

1. The date and time of each transmission.
2. The name of the licensed operator on duty and whether telegraphy or radiophone was used.
3. The call letters of the station called.
4. The input power to the final amplifier of the transmitter (or to the oscillator if the transmitter consists only of an oscillator stage.)
5. The frequency band used.
6. If the station is portable, the exact location of the transmitter at the time of the transmission.
7. The messages handled. If these are in regular message form, a copy of each must be entered in the log or kept on file for at least one year.

Checking Apparatus

Remember that an accurate frequency meter or equivalent measuring device must be a part of every amateur station. Every phone station must have a means for visual checking of overmodulation. Refer to sec. 12.133 and sec. 12.135 of the F.C.C. regulations.

Broadcast Interference

Amateur stations frequently cause interference to broadcast reception, particularly to home sets in their own neighborhoods. This may be due to transmitter troubles, faulty design of the broadcast receivers, and other causes.

Whichever the cause, the amateur operator had best eliminate the interference immediately upon learning of the trouble. He may install appropriate wavetraps in the receivers to eliminate his signals, change the direction of his transmitting antenna, etc. If the receiver can be shown to be at fault or if it is not of modern design, the amateur is not *compelled* to fix the receiver or install a wavetrap; it is up to the owner of the receiver in this case. However, most amateurs have discovered it is best to "lean over backwards" to avoid serious trouble with complaining broadcast listeners, rather than try to prove to the F.C.C. that it is the fault of the particular receiver and not your transmitter which is at fault.

The commission will require you to silence your transmitter between the hours of 8 and 10:30 p.m. local time and on Sundays from 10:30 a.m. to 1 p.m. local time if you cause "general interference to receivers of modern design." (Refer to sec. 12.151 and following.)

Operating Hints

After the other station has concluded a transmission, do not "come back" so soon that the other fellow has not had sufficient time to turn on his receiver. By the same token, do not return to transmitting or tune to another frequency if the other fellow is not heard immediately. Give him ample time to get his transmitter running.

When you answer a CQ, remember that the other fellow is tuning across the entire band for calls. Do not sign off before he has had ample time to reach your spot on his receiver dial. It is not necessary to make a long call. Send the standard "three-and-three," but call slowly.

Use long calls only in emergencies when you are certain of poor receiving conditions at the other end or when you learn definitely that your signal is weak or fading at a distant point. Remember too that your signal may be in a fade-out at the time that you sign your call letters and $\overline{\text{AR}}$ K. In such a case, give the other fellow a chance to decide that you have actually stopped to listen.

Keep your transmissions clean. The law specifically forbids the transmission of profane or obscene language. Keep your transmissions free of anything of this sort. Remember that the air is not a place for two-sided jokes. Respect the unseen listener. Likewise the air is not the place for personal matters, such as grudge fights, allusions to persons who might be listening in at the time, and other such unnecessary material. Be your own censor.

Don't send the code too rapidly. The other fellow might give you more than you can swallow. If you must show off, show how *even* and *accurate* your stuff is, rather than how *fast* your fist is. It will build you a far better reputation.

Amateur stations are not allowed to broadcast news, music, entertainment, and the like. This is the right of the standard broadcast stations. The latter are not permitted to carry on the two-way communication for which you are licensed. Do not allow sharpsters to talk you into the idea of using your station for broadcasting purposes; you will be inviting prosecution by the government.

Amateur stations are not for hire. You may perform a great service to some individual in the community by relaying radiograms for him, but you must accept no remuneration for that service. The law states in certain terms that amateur stations may not accept any material compensation "direct or indirect, paid or promised."

Do not engage in operation not authorized by your class of license. If you hold a class-B or class-C ticket, you must not operate phone in the 80- and 20-meter bands.

Have your operator license on your person when you operate another ham's station and enforce this rule at your own station. Visits from the radio inspector are unannounced and can prove very embarrassing if you are without your license. Refuse non-licensed persons the right to operate your station. "Operate" does not mean merely to talk over a phone transmitter, but to be in charge of the operation of the transmitter.

While a war is in progress, be scrupulously careful that in the course of your conversation you do not divulge any information that might have the slightest military significance, and do not attempt to converse with amateurs in belligerent countries even if their government permits them to remain on the air. The safest thing to do, especially for phone amateurs, is to refrain from discussing any subject even remotely connected with the war.

When retuning or adjusting your transmitter, be extremely careful of the high voltage danger. Remember that just one slip might be fatal.

VII. BUILDING A STATION

GENERAL

Some readers will be interested primarily in getting on the air and working other stations, and will have no desire to construct their own apparatus. For those who are not technically inclined, manufacturers offer complete transmitters and receivers, ready to go. For those who are just "luke warm" about the construction part of amateur radio, and those who do not want to invest in the tools necessary to construct a transmitter or receiver from "scratch," kits of parts are offered. The complete unit can be assembled with nothing more than a wrench and screwdriver, and there is nothing left to do but wire it according to directions furnished with the kit.

A large number of newcomers will prefer to build their equipment from the ground up, particularly the transmitter. Probably the largest number of amateurs fall in that group which purchases a receiver ready built but constructs its own transmitting apparatus. The main reason for this is that it is usually possible to purchase a receiver for no more than the component parts would cost.

The Receiver

A good communications type superheterodyne having 6 tubes and covering from 550 kc. to over 30,000 kc. can be purchased for as little as $30 complete with integral power pack and speaker. The parts in one of these sets, if purchased separately, would come to at least that amount. Therefore the only point in building a small superheterodyne is to gain experience. An inexpensive three-tube superheterodyne giving excellent results is described for those interested in building such a receiver. A superheterodyne, even the simplest type, is a little too complicated for the newcomer to tackle as his first try at receiver construction, and for this reason a regenerative (autodyne) receiver is recommended as the first project.

A simple regenerative receiver can be built for very little money and it is advisable for every newcomer to construct such a receiver for the experience gained. While such a receiver is not particularly selective with regard to loud local signals and will not give any too satisfactory results on weak or fading phone signals, it is nevertheless very sensitive and makes a good c.w. receiver when there is not excessive interference from several nearby transmitters.

Many amateurs will not be satisfied for long with a simple regenerative receiver, and still others will purchase an elaborate factory built job in the first place. But a small receiver of this type, using 6-volt tubes and a B battery for plate power, makes an excellent portable or emergency receiver. Thus (in view of the small cost) the construction of such a receiver is usually justified whether you expect to be permanently satisfied with its performance as a regular station receiver or not.

If you have a suitable broadcast receiver, the cheapest method of obtaining superheterodyne operation is to build a simple, all-band *converter* and combined beat oscillator. Such a device, while more complicated than an autodyne receiver, is much simpler to build than a superheterodyne. One is described later in this chapter.

Phone - C.W.

After you have had a chance to listen around the amateur bands for a while, you should be able to determine whether you are interested primarily in c.w. (code), in telephony, or if you are equally interested in both. Even if you discover a preference for telephony, we suggest that you first build a simple c.w. transmitter and get some operating experience. A c.w. transmitter is easier to get going, and it is much simpler to get a phone transmitter adjusted correctly after you have become somewhat familiar with the operation of a c.w. transmitter.

If you use crystal control and a well filtered plate supply, it is not easy to get a "pink ticket" with a c.w. rig, but the adjustment of a phone transmitter is much more complicated, and an improperly adjusted phone transmitter can and usually does create bad interference. For this reason, familiarity with a c.w. transmitter is advisable before attempting phone operation. There is also the likelihood that if you don't get on c.w. first and thus get some practice and give your code a chance to "sink in," it will be quickly forgotten, and the time you spent so diligently in studying for the code examination will be largely wasted.

However, even though we advise against it, some amateurs do get on phone as soon as they get their license and never again touch a key. So if you consider the code only a necessary evil in getting a license in order to get on phone, there is nothing to prevent your making your initial bow over the air by means of a microphone rather than a key. We would like to point out, however, that a c.w. transmitter of a given power output is considerably cheaper to construct, and that the same power will transmit over a greater distance on c.w. than on phone.

Your Transmitter

Described later in this chapter is a 15-watt c.w. transmitter that can be built for about $25, and a 15-watt phone transmitter that can be built for about $40. If both units are desired, some saving can be realized, as there is no need for duplication in the power supply, the T-21 tube, and several other items which can be interchanged. If the c.w. set is built and it is later decided to convert it into the phone transmitter, it can be done for about $20. These prices are only approximate, as the exact cost will depend upon the quality of parts purchased, the number of usable components salvageable from old b.c. sets, and other factors.

The code transmitter is designed to work on the 40- and 80-meter (7 Mc. and 3.5 Mc.) bands. By confining operation to two bands, the design is greatly simplified and the cost minimized. The 80-meter band is perhaps the best band for the newcomer seeking code practice and operating experience. For a fling at dx, the 40-meter band offers excellent possibilities for low power work at night if one stays up till most of the operators of the high powered stations in that part of the country have gone to bed. The 20-meter (14 Mc.) band is no place for a 15-watt rig in the U. S. A., as the band is so crowded with signals from 1 kw. transmitters feeding high-gain directive antenna arrays that the low powered signal is covered with several layers of QRM most of the time. If you resided in some elusive "dx" country, amateurs might fight to dig your signal out of the QRM; but W signals are a dime a dozen and the other fellow will prefer to pick out a loud signal he can copy with little trouble from "QRM." With your 15 watts the best bet is to get on 40 or 80 (preferably the latter) where QRM and competition from kilowatt rigs are less severe.

The phone transmitter is designed specifically for 160-meter operation, as this is the best all around phone band for the holder of a class B or C ticket. A 10-meter phone transmitter is more expensive to construct and more difficult to get going, and much of the time the band is useless for working distances over 15 or 20 miles. After a newcomer has been on 160 meters a while and some experience is gained, he then can worry about getting on 10-meter phone.

The newcomer interested in portable mobile work or only in local phone ragchews will find the 2½-meter transceiver described here to be the logical answer. Requirements regarding the character of emitted signal are not especially stringent on this band, and simple, inexpensive equipment will suffice.

Checking Equipment

The F.C.C. requires that the frequency of your transmitter be checked from time to time and always after any tuning adjustments have been made. The measurement must be made by means independent of the frequency control of the transmitter and the apparatus used must be sufficiently accurate to assure operation within the band. (See Sec. 12.135.)

While a good quality crystal is usually insurance that the frequency of the emitted wave is the same as that stamped on the crystal holder, in many transmitters it is possible that the oscillator or one of the amplifier stages is producing self-excited oscillations, and that the emitted wave is out of the band. It also sometimes happens, though rarely with good crystals, that a crystal has a second, spurious frequency slightly removed from the main frequency; under certain conditions of tuning the crystal will oscillate on the second frequency, which may be out of the band. Thus we see the justification for this F.C.C. ruling.

Unless we are trying to work right on the edge of a band, an extremely high degree of accuracy is not required in the measuring instrument. Thus, if it is used properly, our receiver can be used for the purpose of checking the transmitter frequency. In its essential form a frequency meter consists of a calibrated oscillator. Whether we use a regenerative "blooper" or a superheterodyne we have an oscillator and means for calibration. The only important thing to observe when using the receiver for a frequency spotting device is to remove the antenna, as the latter not only will affect the calibration but feed so much energy to the receiver from the nearby transmitter that the receiver will be "blocked" over a good portion of the dial.

With a superheterodyne it is possible to determine your exact position in the band with respect to other signals by clipping a jumper from the control grid of the first detector (mixer) to ground (chassis). This will reduce the strength of your own signal so that it will approximate that of other signals without affecting the oscillator (main tuning) dial reading.

The receiver can also be used as a monitor to determine the character of the emitted signal by removing the antenna, shorting it to ground, or otherwise reducing the input to the receiver the same as is done for frequency spotting. If there is still too much input for getting a good beat note for c.w., it is possible to monitor the signal for purity of note and freedom of keying chirps by tuning the receiver to an image or to the second harmonic or to ½ frequency.

If you go on phone, some means must be taken to insure that the transmitter is not modulated in excess of its modulation capability. (See Sec. 12.133.) In most instances this will call for a check with a sine wave generator and oscilloscope to determine the maximum modulation capability of the transmitter, and then some type of visual indicator that will show when the modulation percentage exceeds that amount, even though it be only on peaks of short duration. Some amateur transmitters have a modulation capability of only 50 or 60 per cent, and are being overmodulated when the percentage modulation exceeds this amount. Don't get the idea that overmodulation always means "over 100 per cent." Only a perfectly designed and adjusted transmitter has 100 per cent mean modulation capability.

Tools

To construct the various apparatus described in this book, only a few shop tools are required, these being of the "hand tool" variety which may be purchased quite inexpensively at Woolworth's. The larger holes in the metal panels and chassis will be punched to your specifications by any metal shop for a small charge. Wherever practicable, wood or Masonite panels and chassis have been substituted for metal to minimize the number of holes that need be punched or drilled through metal.

Should it turn out that you get an especial "kick" out of construction work and contemplate considerable construction, you will then be justified in purchasing better grade tools in a more extensive assortment. But to begin with, the following will suffice.

- 75- or 100-watt electric soldering iron.
- Rosin core solder, ½ lb. roll.
- Pr. diagonals (cutting pliers).
- Pr. regular pliers.
- Medium size screwdriver.
- Small size screwdriver, sewing machine size.
- Ice pick (to scribe metal and start wood screws).
- Hand drill ("eggbeater" type), 3/16" chuck.
- Half dozen assorted twist drills for above, preferably nos. 10, 18, 28, 33, and 42.
- Small bottle clear lacquer or coil dope.
- Center punch.
- Small hammer.
- Roll of pushback hook up wire.
- Hacksaw or fine tooth "keyhole" saw.
- Medium-coarse file (8 or 10 inch).

Soldering

The important thing to remember in regard to soldering is to have the tip of the iron clean and the *joint* both clean and *hot*. Be sure to use *rosin core* solder. The solder should be applied to the *joint*, not to the iron. If the iron will not heat the joint sufficiently for the solder to melt and flow into it, a heavier or hotter iron will be required. An excellent technique is to apply the iron to the bottom side of the joint and the solder to the top of the joint; when the joint becomes sufficiently hot, the solder will flow into it.

When joining wires, approved practice calls for a mechanically sound joint before the solder is applied. The solder should not be depended upon to provide mechanical strength. This is a good idea in any case, is absolutely necessary in the case of mobile and other apparatus subject to mechanical vibration.

When the tip of the soldering iron becomes pitted, it should be filed clean (while hot) with a file and retinned before it has time to become discolored.

●

SIMPLE TWO TUBE AUTODYNE

A simple yet inexpensive and versatile receiver is illustrated in figures one to five. The receiver gives good earphone volume on all signals, and with a good antenna is capable of bringing in extreme "dx" under favorable conditions. Because only one tuned circuit is used, the selectivity is not especially high, and there will be trouble from broad tuning if any powerful stations are nearby. Also, the receiver does not work especially well on 10 meters and does not give as good reception of phone signals as does a superheterodyne. But even so, the receiver will provide surprisingly good results, particularly on

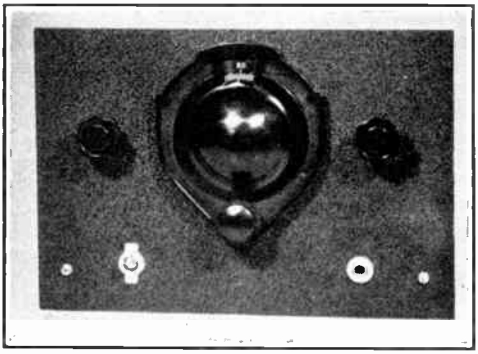


Figure 1. Simple two-tube autodyne receiver. This receiver is inexpensive to build, and has excellent weak-signal response. While not as selective as more elaborate receivers, it makes a good set for the newcomer's first receiver.

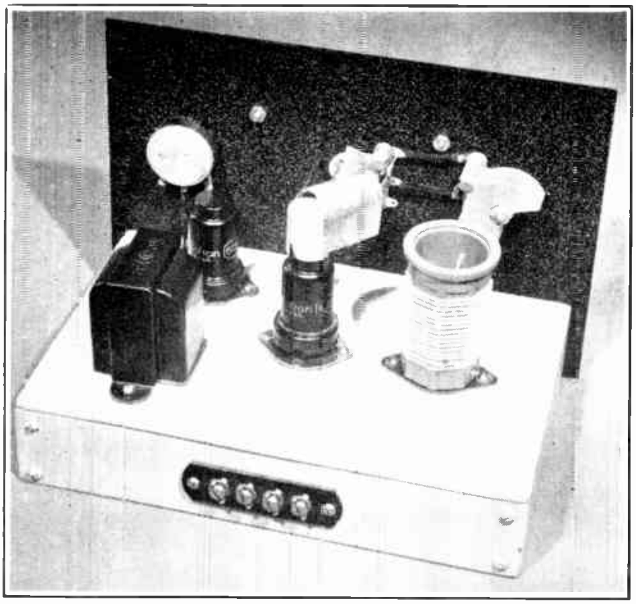


Figure 2. Back view of the two-tube autodyne. The chassis is made of wood and Masonite wall board. The "shield hat" for the grid leak and condenser hide most of the main tuning condenser.

c.w., and especially when the cost and ease of construction are considered.

The receiver uses 6.3-volt tubes, which may be supplied heater power from either a small 6.3 volt filament transformer or a regular 6-volt auto battery. For regular home use a transformer is recommended, but the provision for use with a battery permits semi-portable operation. This makes the receiver a good one for a beginner, as it can be used as a portable or emergency receiver later on should one decide to build or buy a more elaborate receiver.

Plate voltage is supplied from a standard, medium-duty 45-volt B battery. Such a battery, costing only a little over a dollar, will last over a year with normal use, as the B current drain of the receiver is only a few milliamperes. This voltage is sufficient for good performance of the receiver. In fact, when wired as shown in the diagram, the receiver should not be used with higher plate voltage, because the screen potentiometer is across the full plate voltage, and also because the 1¼-volt bias on the 6C5 is not sufficient for higher plate voltage.

The receiver can be built for about $12, including B battery and midget filament transformer, provided inexpensive components are chosen.

While the receiver will operate on 10 meters and a 10-meter coil is included in the coil table, the receiver is designed primarily for 20-, 40-, and 80-meter operation. No provision was made for 160-meter operation, as the receiver does not have sufficient selectivity for phone operation on this band.

For 20-, 40-, and 80-meter operation the receiver compares favorably with the most expensive when it comes to picking up weak, distant stations, especially on c.w. However, loud local signals have a tendency to block it, and therefore more trouble will be experienced with QRM than with a superheterodyne.

The chassis consists of a 6 x 9 inch Masonite "presdwood" top and 1¾-inch back of the same material. These are fastened to two pieces of wood which form the sides of the chassis. The wooden sides are 1¾ inch high, ¾ inch thick, and are 6 inches long, *including* the Masonite back. The whole thing is held together with wood screws as may be seen in figures two and five, and a 7-inch by 11-inch metal front panel is attached to the chassis by means of wood screws sunk in the wooden end pieces of the chassis.

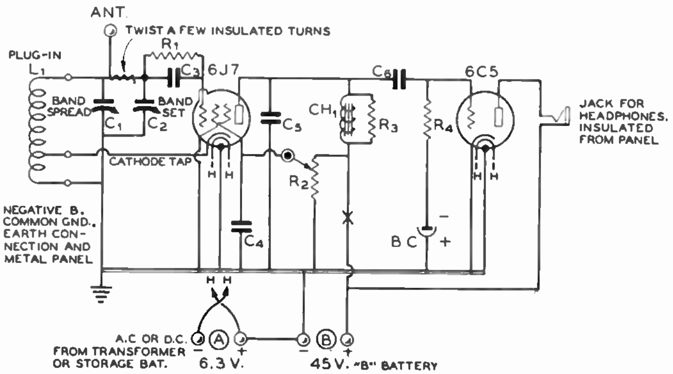
The wafer sockets are mounted on *top* of the chassis. This is clearly illustrated in the photographs. Correct connection of the socket terminals can be assured by referring to the socket connection chart at the end of this chapter.

Winding the Coils

Winding the coils is not difficult, though it will require considerably more time if one has never tackled such a job before.

It makes no difference in which direction the coils are wound, just so the entire winding is wound in the same direction. Be sure to wind all coils the same, except for the number of turns; that is, the connections should be the same for all coils. This will insure that the cathode tap is closest the ground end of the coil. A simple way to keep the connections straight is to use the "cathode" prong of the 5-prong coil socket for the cathode tap on the coil and the "grid" prong for the grid tap.

FIGURE 3. WIRING DIAGRAM OF TWO-TUBE AUTODYNE.



C_1—15-μμfd midget variable
C_2—100-μμfd. midget variable
C_3—100-μμfd. smallest size mica condenser
C_4—0.25-μfd. tubular, 400 v.
C_5—.0005-μfd. midget mica
C_6—.01-μfd. tubular, 400 v.
R_1—3 meg., ½ watt
R_2—50,000 ohm pot.
R_3—0.25 meg., ½ watt
R_4—0.5 meg., ½ watt
BC—1¼-volt bias cell
CH_1—300 or more hy., 5 ma.
L_1—See coil table

Other parts required.

- Two fiber type octal wafer sockets.
- One 5-prong wafer socket.
- One 7 x 10 inch metal front panel.
- Wood, Masonite "Presdwood" and wood screws for chassis.
- One dozen ½ in. 6/32 round head machine screws with nuts.
- Grid clip and shield cap for detector tube.
- One foot of no. 14 or no. 12 tinned wire (bus wire).
- Vernier tuning dial.
- Two tuning knobs.
- Toggle switch to kill B plus (at point "X").
- Binding post strip or Fahnestock clips.
- Phone jack and fiber insulating washers.
- Coil forms (1½ in., 5 prong) coil wire (¼ lb. no. 22 d.c.c.)
- Filament supply (storage battery or 6.3 v. transformer).
- One medium duty 45-volt B battery.
- Pr. headphones (magnetic type).

The grid connection should be made to the *top* of the coil form rather than the bottom. The various prongs and terminals for a five-prong tube and socket can be identified by referring to the type 76 tube in the socket chart at the end of this chapter. Any one of the three remaining prongs may be used for the ground connection, just so the socket and all coils are wired to correspond.

When tapping the 80-meter coil for the cathode tap, be sure that the exposed connection where the tap is soldered does not short out against adjacent turns. This may happen if the cotton covering is frayed on these turns when the tap is being made. Separate the adjacent turns until you are sure they do not touch the exposed tap, and then put on a drop of clear lacquer or coil dope. The turns of the space wound coils may be held firmly in place after they are aligned by applying a small amount of lacquer or "dope" in three narrow "ribs" along the length of the winding.

If you have difficulty in getting the solder to stick to the tips of the prongs on the coil forms, the inside of the tips can be shined up sufficiently to permit a good soldered connection to the end of each prong simply by inserting a ⅛-inch drill in each prong and giving it a few turns with the hand drill. Avoid too large a "blob" of solder on the tips of the prongs, as it will be impossible to insert the coil in the socket.

COIL TABLE
For Two-Tube Autodyne

All coils wound with no. 22. d.c.c. on standard 1½-inch forms

80 M.
29 turns close wound; cathode tap 1½ turns from ground

40 M.
16 turns spaced 1¾ inches; cathode tap 1½ turns from ground

20 M.
7 turns spaced 1¼ inches; cathode tap 1½ turns from ground

10 M.
4 turns spaced 1¼ inches; cathode tap 1 turn from ground

Wiring

Schematic diagrams never give a true picture of the wiring. For instance, in figure three the top end of R_4 is shown connected to the wire joining C_6 and the 6C5 tube. Actually the resistor connection would probably be made to the socket terminal.

The front panel should be grounded. This is automatically taken care of when the tuning condensers are mounted directly on the metal panel, as the rotors of the two condensers are at ground potential. Be sure the

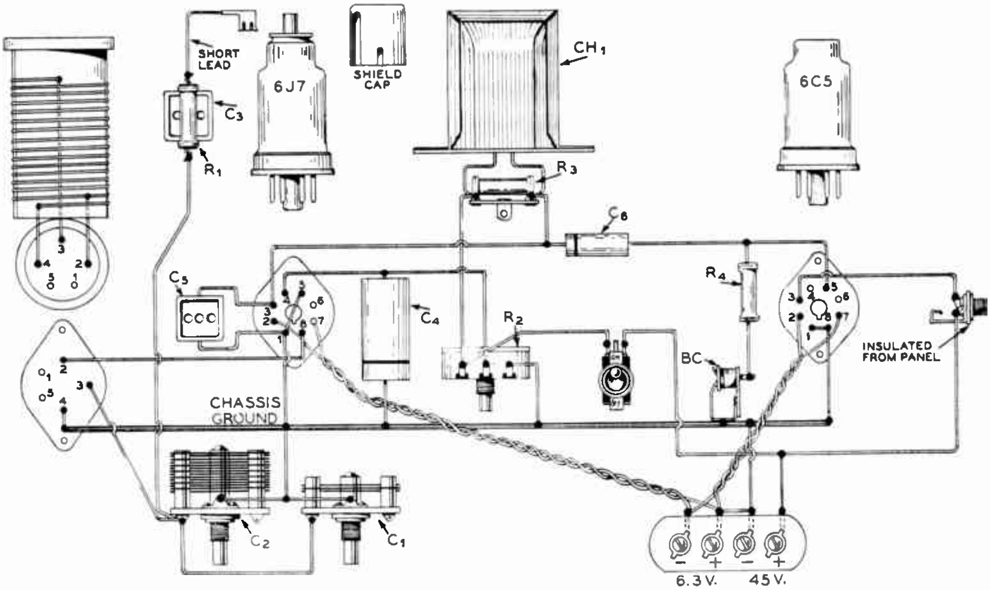


Figure 4. Unless you are thoroughly familiar with the various schematic symbols, this pictorial diagram will speed up the wiring job. Keep in mind that bottom views of the sockets are shown except for the coil schematic in the upper left.

phone jack is well insulated from the panel or it will short the battery, ruining it in short order. It is safer and easier to mount the jack on the rear of the chassis, but not so convenient in this position.

A *ground bus* consisting of sufficient tinned bus wire (no. 14 tinned wire) to reach from the cathode terminal on the 6SJ7 socket to the cathode terminal of the 6C5 should be the first wire to be soldered, as all ground connections are made to this *common ground* wire.

The leads to L_1, C_1, C_2, C_3, R_1, and to the cathode and control grid of the 6J7 should be made as short and direct as possible. The length of other leads is not especially important. The heater wires should preferably be twisted together, in order to minimize hum.

Be sure to pole the bias cell right. The outside of the holder or cell is negative, the spring connector to the carbon is positive. The latter should be grounded. From figure 3 it appears that the outside shell is grounded which would be incorrect; however this is due to the fact that it is customary to draw the negative terminal of any cell as the shorter bar. Just observe the plus and minus signs and you won't go wrong.

A small penlight cell may be substituted for the bias cell if desired. The outside shell of the cell is negative, the same as for the bias cell. The penlight cell may be mounted in any position, but will last only a year or two. The bias cell will last several years.

As is true with any grid leak type detector, the grid lead (including the grid leak and condenser) must be shielded thoroughly in order to avoid bad hum pickup, commonly known as "grid hum." This is accomplished effectively by soldering the grid leak and grid condenser (both of the smallest physical size procurable) directly to the grid clip and shielding the whole business by means of a "hat" consisting of a regular metal tube grid shield cap to which is soldered a rectangular piece of tin or galvanized iron as shown in the illustration. The latter measures about 1½ by 3 inches and is bent in the form of a "U," then soldered to the grid clip shield. Care must be taken that the shield does not short out against any of the connecting leads.

The antenna may consist of a 50 to 150 foot length of wire as high and in clear as possible. It is capacity coupled to the receiver by means of a few turns of insulated wire around the grid lead. A small 3-30 μμfd. compression type mica trimmer may be substituted as a variable coupling condenser if desired.

Just enough coupling capacity should be used to give good signal strength. Too much antenna coupling will result in broad tuning and possible "dead spots" on the tuning dial where the receiver cannot be made to oscillate.

Tuning

When tuning the receiver for the first time,

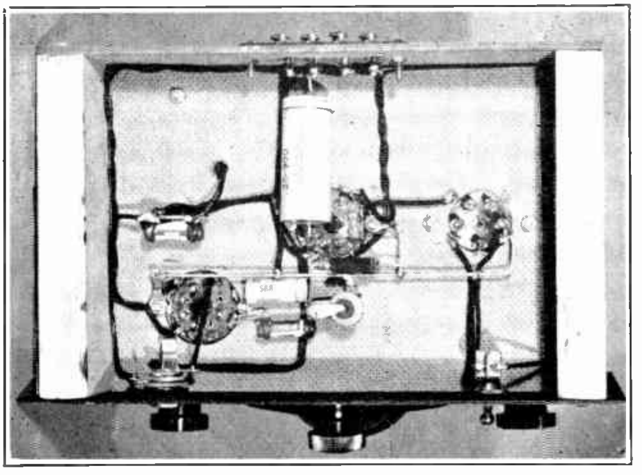


Figure 5. Under-chassis view of two-tube autodyne. The construction of the chassis and placement of components is clearly illustrated. If desired the phone jack may be mounted on the back of the chassis.

it will be necessary to do the preliminary tuning with the bandset condenser instead of the main tuning dial in order to locate the various amateur bands. Some of the coils will hit two bands; the correct band on these coils is that which conforms with the coil table.

Phone signals are received with the regeneration control just below the point of oscillation. The point of oscillation readily can be identified by advancing the regeneration control until a slight "plop" is heard. With the control advanced beyond this point, a faint hiss will be heard and stations will appear as whistles when the dial is tuned across the band. This is the adjustment for receiving c.w. (code) signals.

Maximum sensitivity on c.w. signals will occur when the regeneration control is advanced just barely enough to enable the receiver to oscillate. There will be less tendency for the receiver to block on stong signals, however, if the regeneration control is advanced considerably beyond the point where the receiver goes into oscillation.

After the correct position of the bandset condenser (C_2) is determined for a given band, a scratch or mark is made on the back rotor plate to enable one to adjust the bandset condenser for any band simply by observing the marks on the bandset condenser.

Because of the low plate voltage and loose antenna coupling this receiver does not radiate to an objectionable degree when in an oscillating condition, and therefore will not annoy nearby amateurs listening on the same band.

Connections for filament and plate power are made by means of a terminal strip which is mounted over a hole cut in the back of the chassis. If you do not have the proper tools for cutting out a long, rectangular hole, four separate holes about ⅜ inch in diameter will take the terminal screws and lugs. If desired, the terminal strip can be replaced by four Fahnestock clips screwed directly to the back of the chassis.

The phone jack is shown mounted on the front panel, along with a toggle switch in the B plus lead. If mounted on the metal front panel, the phone jack must be insulated from the panel by means of fiber washers to prevent shorting the plate voltage. The jack could just as well be mounted on the back of the chassis, in which case it would not require insulating washers.

The screen potentiometer is across the B battery and draws a small amount of current even with the filaments turned off; hence it is necessary to provide a switch in the B plus lead. This is indicated by an "X" in the diagram. The heaters are turned off by turning off the 110-volt supply to the filament transformer.

SHORTWAVE CONVERTER

Any standard broadcast receiver having 6.3-volt tubes in a superheterodyne circuit and *not* of the "a.c.-d.c." type can be used with the simple converter shown in figures six to ten to make a highly effective shortwave superheterodyne for amateur work. Most modern receivers (except the very least expensive ones) are of the superheterodyne type.

The simplest way to determine if the set is of the a.c.-d.c. type is to look on the bottom of the set or on the rear of the chassis for the specifications label. If there is no indication as to which type the receiver is, look for a power transformer. (A power transformer can be distinguished from audio transformers and filter chokes because the power transformer will get warm after the set has been turned on for a time.) If the set has a power transformer it is not of the a.c.-d.c. (transformerless) type and is suitable for use with the converter.

The receiver is tuned to a frequency just above 1500 kilocycles and used as an intermediate frequency amplifier, second detector, and audio system. The converter is nothing but a high frequency mixer and oscillator, or "front end" of a shortwave superheterodyne.

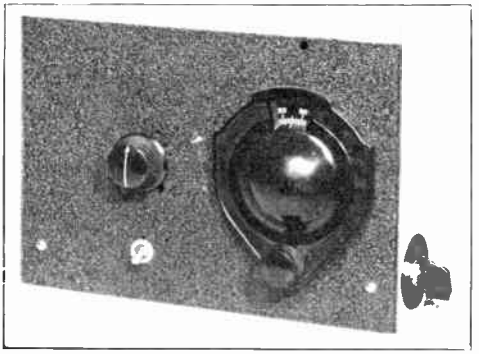


Figure 6. Front view of the simple converter. The main tuning dial tunes the bandspread condenser C_3. The knob to the left tunes C_1, the detector resonating condenser. The bandset condenser, C_2, is placed around on one side of the chassis as shown. It is adjusted only when changing bands. It should have a calibrated scale. Note that the black, crackle-finished metal panel is fastened to the chassis by means of only two bolts.

To receive code signals a beat oscillator is required. In the usual amateur or communications superheterodyne this is simply a stable oscillator working 1 or 2 kc. off the intermediate frequency of the c.w. signal it is desired to receive. This will produce an audible heterodyne or beat note. Because no standard broadcast receiver (even those including one or more shortwave bands) comes equipped with a beat oscillator, it is necessary to include one in the converter in order to receive c.w. signals.

Some of the "all wave" broadcast receivers of the better type have good sensitivity on the shortwave bands,—as good, in fact, as that of the lower priced communications receivers. However, these "all wave" broadcast receivers seldom have "band spread" and the amateur bands are jammed into a few divisions on the dial. Not only is tuning difficult, but these receivers are like regular broadcast receivers in that they are designed only for the reception of voice and music, and have no beat oscillator for c.w. telegraphy reception.

The converter described here can be constructed for about ten dollars and is recommended to anyone with a good a.c superheterodyne broadcast receiver, regardless of whether the broadcast receiver already covers the short waves.

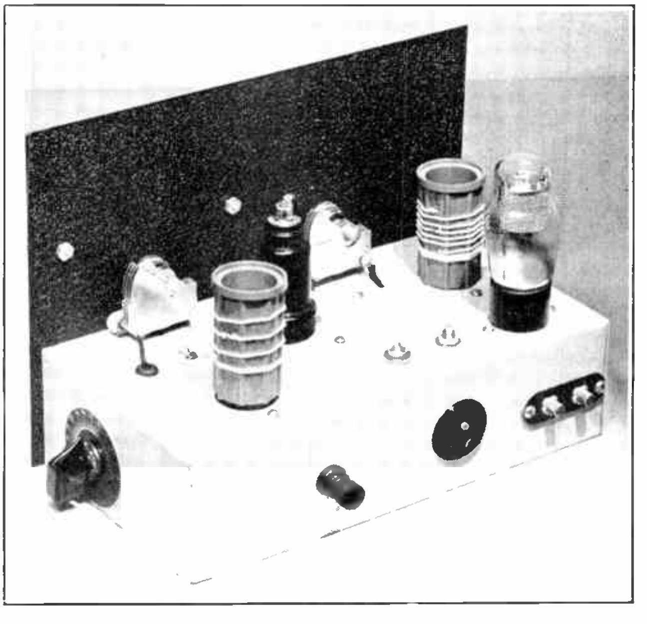
Construction

The converter is built on a 5 x 9½ x 2½ inch metal chassis to which is fastened a 7 x 10 inch metal front panel. Both these items are stock sizes and can be purchased at most any large radio parts store.

The larger holes (for sockets, etc.) can be cut or punched out by most any sheet metal shop for a small charge, and unless the constructor contemplates the building of considerable additional apparatus, this is to be advised. A good circle cutter or set of socket punches represents an investment equal to the cost of having holes punched in several small chassis of this type. Some radio stores in the large cities specialize in chassis drilling and punching, and these will usually do the job even more cheaply than a regular sheet metal shop.

After purchasing all the required parts (refer to buyer's guide at end of book for part numbers), place them in their proper positions on the chassis and panel (as deter-

Figure 7. Rear view of shortwave converter. The placement of parts above the chassis is clearly illustrated in this photograph. In this view C_3 and L_2 are to the left, C_1 and L_1 to the right. A glass 6C5 (6C5G) was used; either metal or glass type will work equally well. The adjusting screws of the two mica trimmers may be seen projecting out of the chassis to the left of the 6C5-G. C_9 is to the left, C_{10} to the right in this view. On the back drop of the chassis are, left to right: insulated binding post for connection to antenna post of broadcast set, socket connection for power cable to broadcast set, and terminals for doublet or antenna and ground for converter.



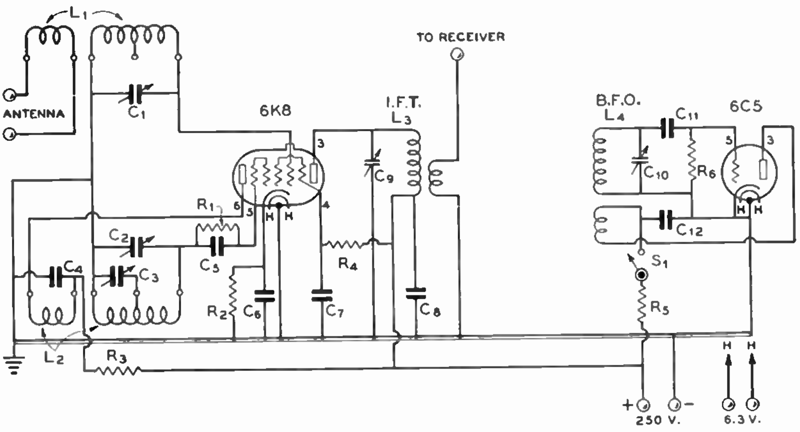


Figure 8. Schematic wiring diagram of the converter.

L_1—Plug in detector coil (see coil table)

L_2—Plug in oscillator coil (see coil table)

L_3—Midget, unshielded broadcast band antenna coil

L_4—Unshielded superheterodyne broadcast band oscillator coil designed for 456 or 465 kc. i.f.

C_1—50-μμfd. inexpensive midget variable condenser

C_2—140-μμfd. midget variable condenser

C_3—50-μμfd. inexpensive midget variable condenser

C_4—.002-μfd. paper tubular fixed condenser

C_5—.0001-μfd. midget mica fixed condenser

C_6—.01-μfd. paper tubular fixed condenser

C_7—.01-μfd. paper tubular fixed condenser

C_8—.01-μfd. paper tubular fixed condenser

C_9—25-100-μμfd. compression type mica trimmer

C_{10}—75-225-μμfd. compression type mica trimmer

C_{11}—.0001-μfd. tubular paper fixed condenser

C_{12}—.01-μfd. paper tubular fixed condenser

Note: All tubular condensers are 400 volt rating.

R_1—50,000 ohms, 1 watt insulated resistor

R_2—300 ohms, 1 watt insulated resistor

R_3—40,000 ohms, 1 watt insulated resistor

R_4—40,000 ohms, 1 watt insulated resistor

R_5—100,000 ohms to 1 megohm, 1 watt insulated resistor (see text)

S_1—Radio toggle switch

Other parts required.

5 x 9½ x 2½ inch metal chassis (unpainted).
7 x 10 inch metal panel (gray or black crackle finish).
Four 1½ inch 5-prong coil forms.
Two 1¼ inch 5-prong coil forms.
Two octal wafer sockets.
Two 5-prong wafer sockets.
One 4-prong protruding wafer socket and male connector (for power connections).
One vernier tuning dial.
One round tuning knob.
One small bar knob and 0-100 scale.
One two-post terminal strip.
One insulated binding post.
One doz. ⅜ inch 6-32 round head screws with nuts.
Two doz. radio solder lugs.
Hookup wire.
No. 24 enam. and no. 22 d.c.c. wire for coils.
50-μμfd. midget mica condenser (to pad 160M. det. coil).
Grid clip for 6K8.
Four feet of 4-wire cable for power connections.

mined by referring to figures seven and ten) and mark where the various holes must be drilled or punched.

When all holes are punched, the parts should be mounted as illustrated. They are all mounted directly on the metal chassis or panel. When screwing down the wafer sockets, put a solder lug under each nut on the under side of the chassis. These lugs can be used for chassis grounding points; when a ground is indicated in the diagram, just run a wire to the nearest of these grounding lugs. The various resistors and by-pass condensers are supported by their connecting leads, and therefore can be ignored when mounting the parts preparatory to wiring.

If you are not familiar with schematic radio symbols and wiring procedure, the job can be done most easily by referring to the pictorial wiring diagram, figure nine. The leads to the various grids of the 6K8 should be made as short as possible. Other leads are not so important, though they should not be made needlessly long.

When wiring in the two trimmer condensers, make sure you do not get them reversed, as they are of considerably different capacity. Also observe that the top or movable plate of each trimmer makes contact both to the adjusting screw and to the frame, the latter making contact to the metal chassis. Therefore be sure that you use the lug terminal on the *top* or *movable* plate for the *ground* connection on each trimmer; if you ground the lug on the bottom or stationary plate you will simply short out the trimmer condenser. If the metal frame of the trimmer makes good contact to the chassis and the trimmers

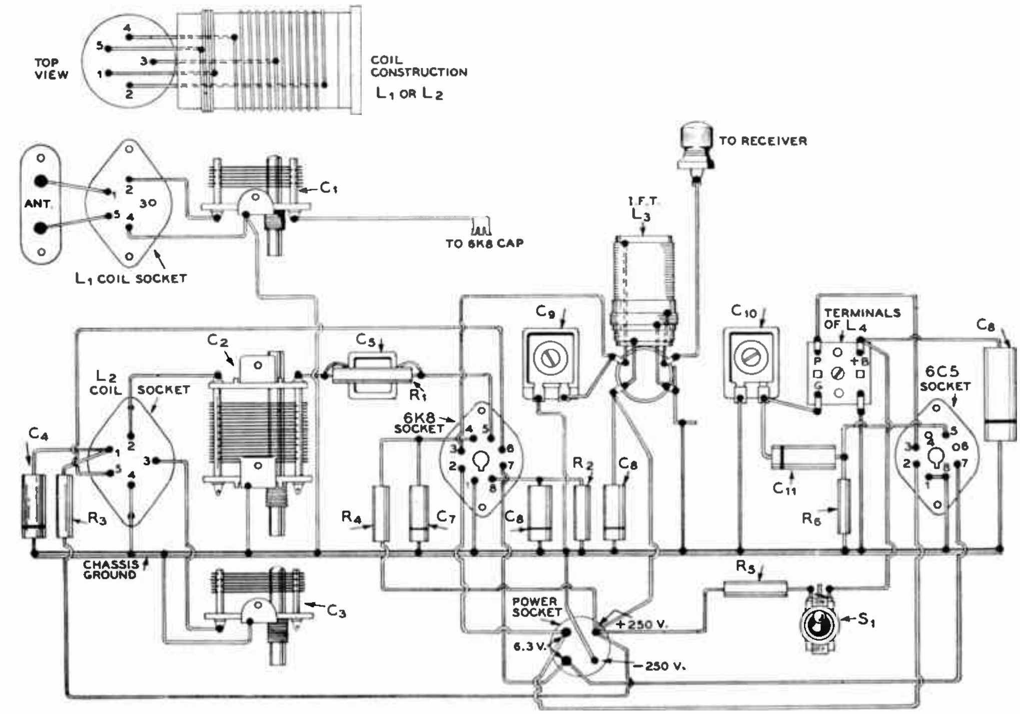


Figure 9. Pictorial wiring diagram of the converter unit. Socket connections are bottom view.

are of the same make as the ones illustrated, it will not be absolutely necessary to run a lead from the lug on the movable plate to ground. Just to be safe, however, it is advisable to run a wire from the movable plate to ground as illustrated in the pictorial diagram.

When you have finished the wiring job, go over the whole set carefully, checking a wire at a time, to make sure you did not make an error. If possible, have an experienced amateur check the wiring for you. If you trace the wires in on the pictorial wiring diagram in colored pencil as you solder them in, there is less likelihood of a mistake.

The Coils

A minimum number of coils is required for all-band operation (10 to 160 meters) because the oscillator coil for each band serves as the detector coil for the next higher frequency band, the tickler serving as the antenna winding. Thus all coils except the 160-meter detector and 10-meter oscillator coils do double duty.

If you have never tried your hand at winding plug-in coils, it is suggested that you read the coil winding data given on page 29 for the simple autodyne receiver. These instructions, coupled with the data given in the coil table for the converter, should enable one to wind the coils with little difficulty.

The converter can be used to receive crystal controlled 56-Mc. signals from local stations putting in a good signal by using the second harmonic of the oscillator. This is done as follows:

Using no. 14 enameled or the pushback hook-up wire used for wiring the converter, wind 8 turns on a pencil and leave a one-inch lead at either end of the coil. Such a coil is illustrated in figure eleven. To one end of the coil solder a 6K8 grid clip. Solder the other end to a lug placed under one of the bolts holding the 6K8 socket.

With the 10-meter coils in place, it is only necessary to pull off the regular grid clip and substitute the one connected to the 5-meter coil in order to receive 5-meter signals. The turns on the small coil should be squeezed in and out until maximum signal strength is obtained on signals in the middle part of the 56-Mc. band.

It should be borne in mind that this method of 56-Mc. operation is a makeshift and that while it will give good results on signals of good strength, it is not satisfactory for reception of very weak signals.

All coils other than the 160-meter detector coil are wound just alike except for number and spacing of turns. Both sections of each coil should be wound in the same direction, and correct polarity observed. If connections to or direction of winding of one of the windings is reversed, that particular coil will work satisfactorily in L_1 coil socket but will not

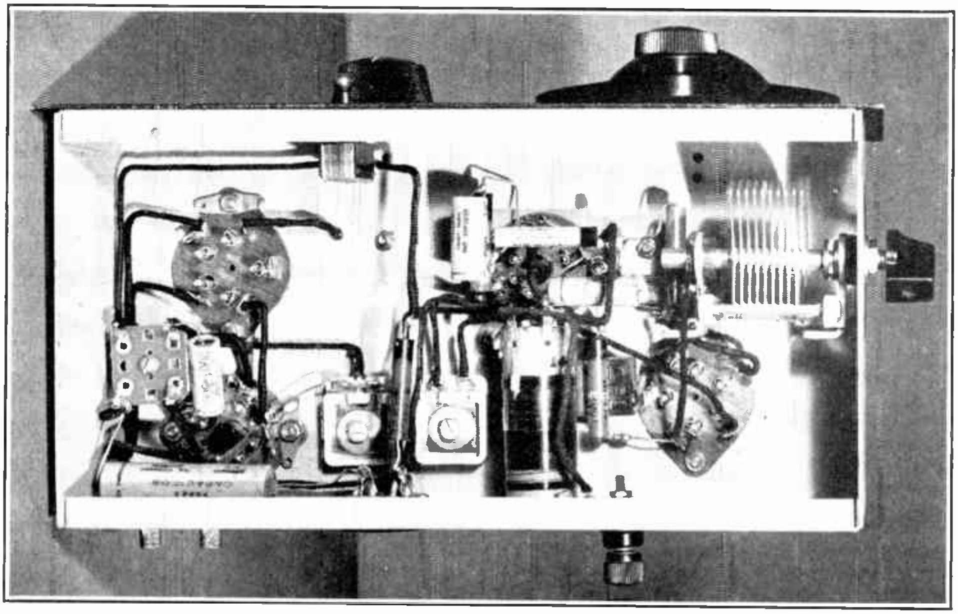


Figure 10. Under Chassis View of the Converter Unit. To the extreme left is the beat oscillator coil. In the center are the two mica trimmers, C_{10} to the left and C_9 to the right. To the right of the trimmers is the output coupling coil IFT. The bandset condenser C_2 is to the extreme right. Resistors and bypass condensers are placed wherever convenient and supported by their leads.

work in L_2 coil socket, as the high-frequency oscillator will not oscillate.

On the 160-meter detector coil the bandspread tap is omitted and a 50-$\mu\mu$fd. midget mica fixed condenser is soldered across the main (grid) winding and stuffed down inside the coil form.

Connections to Receivers

The converter requires 6.3 volts a.c. at 0.6 amp. and between 200 and 300 volts d.c. at about 8 ma. The power pack of most any broadcast receiver will handle this slight additional load without overheating.

Power connections are made by means of a four wire cable. The converter end of the power cable terminates in a four-prong male plug, which is plugged into the power socket on the rear of the converter chassis. The other end of the cabie is run inside the receiver chassis and the leads soldered permanently to the various voltage sources. The two heater leads are soldered across the heater terminals of the socket of any of the 6.3-volt tubes in the receiver (assuming the receiver is not of the "transformerless" power pack type.) The negative B lead (B minus) is soldered to any point on the receiver chassis. The positive B lead can usually be taken most handily from one of the following points at full d.c. potential but not having a.c. or r.f. on them: 1) positive side of the last filter condenser; 2) screen prong on the socket for the audio power tube (or one of the power tubes if push pull) if it is a *pentode* or *tetrode*; 3) B plus terminal on the speaker output transformer (this is the primary terminal that does *not* go to the plate of the audio power tube).

Most receivers incorporating 6.3-volt tubes and not of the "a.c.-d.c." type use one or two of the following pentodes or tetrodes in the output stages: 42, 6F6, 6V6, 6L6, 41, or 6K6. If the letter "G" appears at the end of the number it merely indicates the tube is of the glass type instead of metal. With any of these tubes having 8 prongs it is necessary only to solder a wire to socket terminal number 4 to get the positive B voltage; with those having 6 prongs, solder a wire to socket terminal number 3. Refer to the socket chart at the end of this chapter for data on numbering of prongs.

The converter should preferably be placed close to the broadcast receiver, in order to minimize the length of the r.f. lead feeding the receiver input. Be sure the ground terminal on the "antenna-ground" posts of the broadcast receiver (if the receiver has a ground terminal) is connected to the chassis. This is usually already done, but just to make sure it is a good idea to ground it to the chassis externally with a short piece of wire. The lead from the converter marked "to receiver" should connect to the antenna post. This lead should be kept short as possible.

Antenna

Most any type of antenna may be used with the converter, though a tuned antenna, such as a doublet cut for the band of operation, will give best results. If a single wire antenna is used against ground, one terminal

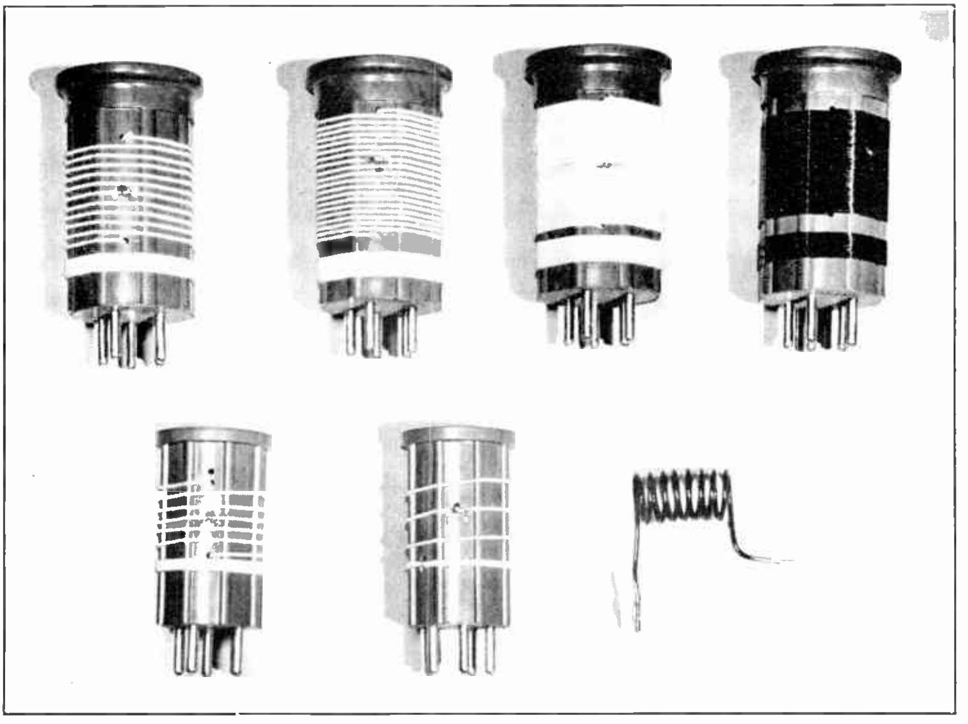


Figure. 11. Plug-in coils for the converter. Starting in the upper right and continuing counter-clockwise around to the lower right we have the 160 meter detector coil, the 160-80 meter coil, the 80-40 meter coil, the 40-20 meter coil, the 20-10 meter coil, the 10-meter oscillator coil and the 5-meter detector coil. Four of the coils do double duty, serving as oscillator coil on one band and detector coil on the next higher frequency band. The turns of the space wound coils are held in place with clear lacquer or coil dope.

connects to the antenna and the other to ground. In the case of a two-wire system (such as a feed line) no ground is used. If an external ground is not handy, satisfactory results can usually be obtained with a single wire antenna simply by connecting one terminal to the chassis and the other to the antenna.

Tuning

After the tubes have had time to reach operating temperature, tune the broadcast set to a "clear" spot around 1530 kc. With the b.f.o. switch S_1 turned off, adjust the bandset condenser C_2 until any kind of signal is heard. With a small screwdriver, adjust trimmer C_9 for maximum signal strength. This can best be done on a very weak signal. If you cannot find a signal sufficiently weak, remove the antenna from the converter while peaking up C_9. Do not touch any exposed wires or parts with the bare hands when the power is on.

The i.f. is now aligned, and need not be touched again if the broadcast set is always preset to *exactly the same spot on the dial* when the converter is to be used.

For a given band, the bandset condenser C_2 is adjusted so that the band is centered on the tuning dial, C_3. Note this setting of C_2 and always set this condenser to the same dial reading whenever plugging in the coils for that band. All tuning is done with C_3 (the station selector) and C_1 (the "resonator" which peaks up the signal strength). Condenser C_1 is also used as a volume control. It should always be detuned (when it is necessary to reduce signal strength) on the side which does not result in a change in the pitch of a received c.w. signal.

To receive c.w. signals, tune in on any band a *phone* signal that has *no other signals within about 30 kilocycles* on either side. Then turn on the beat oscillator (S_1) and vary the adjusting screw on C_{10} (the trimmer nearest the 6C5 tube) until a beat note is heard. Adjust the trimmer to exact zero beat. Henceforth to receive c.w. signals it is only necessary to turn on S_1, the beat oscillator switch.

The strength of the beat is governed by the amount of plate voltage applied to the beat oscillator, which is determined by the value of the resistor R_5. If the beat note is too strong (resistor R_5 too low in value) the response to weak c.w. signals will not be good. If the beat note is too weak, then strong signals will tend to block and there will be an "a.v.c. action" during keying, the background noise coming up annoyingly between dots and dashes.

A good value to try initially is 250,000 ohms. If the beat note appears too strong, substitute a 1-megohm resistor. If it appears too weak, substitute a 100,000-ohm resistor. If the resistor is made too high in value there will not be sufficient voltage on the beat oscillator to sustain oscillation. One megohm is about the highest value of resistor that will still permit oscillation.

On certain bands the gain and sensitivity are better with the h.f. oscillator on one side of the detector than on the other. The receiver will work with the oscillator either *higher or lower* by the i.f. frequency than the received signal. On the higher frequency bands the bandset condenser tunes over a wide enough band of frequencies that it hits both sides. This means that on these bands there are *two* settings of C_2 which will hit the band.

The only band on which images (spurious signals) might be bothersome is the 10-meter band. In most cases objectionable images can be eliminated without serious loss in signal strength by shifting the h.f. oscillator to the other side by means of the band set condenser. If you hear a commercial station in the 10- or 20-meter amateur band, it is probably an image, and if interfering with reception of a signal you wish to hear can be eliminated as noted above.

COIL TABLE
For All Band Converter

160-M. Det.

58 turns no. 24 enam. close wound on 1½ in. form, shunted with 50 μμfd. midget mica fixed condenser placed inside form. Ant. coil 14 turns close wound at ground and spaced ¼ in. from grid winding.

160-M. Osc.—80-M. Det.

42 turns no. 22 d.c.c. close wound on 1½ in. form. Bandspread tap 20 turns from ground end. Tickler 9 turns close wound, spaced 1/16 in. from main winding.

80-M. Osc.—40-M. Det.

20 turns no. 22 d.c.c. spaced to 1½ in. on 1½ in. form. Bandspread tap 12 turns from ground end. Tickler 8 turns close wound, spaced ⅛ in. from main winding.

40-M. Osc.—20-M. Det.

11 turns no. 22 d.c.c. spaced to 1¼ in. on 1½ in. form. Bandspread tap 5 turns from ground end. Tickler 6 turns close wound, spaced ⅛ in. from main winding.

20-M. Osc.—10-M. Det.

5½ turns no. 22 d.c.c. spaced to 1 in. on 1¼ in. form. Bandspread tap 3 turns from ground end. Tickler 2 turns close wound, spaced 1/16 in. from main winding.

10-M. Osc.

3 turns no. 22 d.c.c. spaced to 1 in. on 1¼ in. form. Bandspread tap 1½ turns from ground end. Tickler 2 turns close wound, spaced 1/16 in. from main winding.

Tickler is always at ground end of main coil. Note that two highest frequency coils are on 1¼ in. forms, rest 1½ in. Tickler polarity must be correct or mixer will not work.

SIMPLEST C.W. TRANSMITTER

Illustrated in figures twelve and thirteen is the simplest practical transmitter for fixed-station use. It uses only one tube and one crystal, and with four easily wound coils provides about 15 watts output on 80 meters and approximately 12 watts on 40. With few exceptions, the parts are all inexpensive standard receiver items. Under favorable conditions it is possible to work stations 2 or 3 thousand miles away with this transmitter.

The unit operates as a regenerative crystal oscillator of the harmonic type on 40 meters and as a straight tetrode crystal oscillator on 80 meters. The change from one form of oscillator to the other is taken care of automatically when the coils are changed, as a result of the jumper in the 80-meter coil.

Construction

The whole transmitter is built on a 9½ by 6½ by 1 inch thick wooden baseboard to which is mounted a 10½ by 6½ inch "presdwood" front panel.

Baseboard-mounting type bakelite sockets are used for both the tube and the coils. Five-prong sockets are used for the coils and a six-prong one for the tube. Another five-prong socket of the same type is placed directly behind the tube and used to mount the crystal.

The panel supports the two midget "tank" condensers, C_1 and C_6, and the 0-100 ma. meter. A small through-type insulator directly above the antenna-tuning condenser is used for an antenna terminal.

The two Fahnestock clips at the right rear of the baseboard are used for key connections. A small four terminal strip at the left rear of the baseboard provides a convenient method

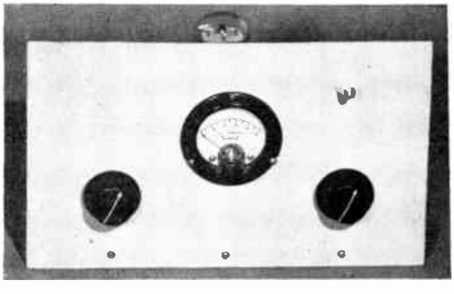


Figure 12. The front panel of the 15-watt 40-80 meter transmitter. The plate condenser is tuned by the knob to the left, the antenna condenser by the knob to the right. The feed-through insulator (upper right) serves as the antenna terminal.

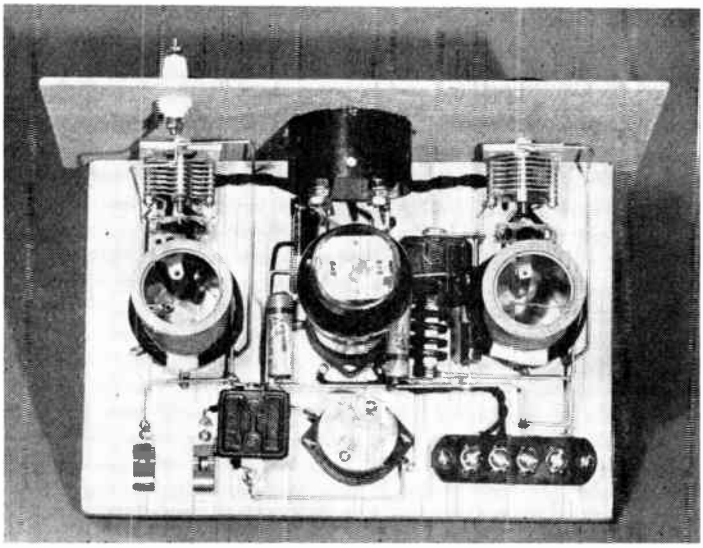


Figure 13. Showing layout of parts in the C. W. Transmitter. The antenna coil and tuning condenser are to the left, the plate coil and tuning condenser to the right. The crystal fits a 5-prong tube socket.

of making heater and plate voltage connections to the power supply. The only other components mounted on either the panel or base are two two-terminal tie points. These are screwed to the baseboard, one between each coil and condenser. They are used to support the coupling links, which will be described later.

Wiring

With the exception of the coupling link, the heater leads, and one of the meter leads, all wiring is done with no. 14 bus-bar. This heavy wire allows the various fixed condensers and resistors to be supported directly from the wiring. All wiring is above the baseboard; no wires are run underneath as is sometimes done in this type of construction.

A single piece of bus-bar along the back of the baseboard between the tube and the crystal and connected to one of the power supply terminals at one end and to one of the key terminals at the other is used for a *common ground* lead. All of the ground connections shown on the diagram are made to this lead, which in turn should be connected to a water-pipe or other good external ground.

Socket connections for the T-21 given in the tube base chart at the end of this chapter are *bottom* views, and as you are wiring from the *top*, you must keep your wits about you to avoid a mistake. The pictorial diagram, figure fifteen, shows top views of the sockets.

As may be seen from the diagram, there is a link around each coil. These links couple the plate coil to the simple antenna-matching circuit. The link around the plate coil is three turns of push-back wire, while the one around the antenna coil is three turns of the same type of wire. The links are each 1¾ inches in diameter and are permanently connected in the transmitter. They are supported by the tie-points previously mentioned. Two small pieces of tape wrapped around each link coil serve to hold the turns together.

The link around the plate coil should be placed at such a height above the socket that when the plate coil is plugged in, the link is around the bottom portion of the coil. The bottom of the plate coil should be the end which is connected through C_3 to ground on 40 meters and, by means of the jumper, directly to ground on 80 meters.

The link coil around the antenna coil should be positioned so that it falls at the *center* of the *antenna coil*. About six inches of twisted push-back wire is used as a coupling line between the two coils. The twisted line is connected to tie-points at each end of the line.

The leads to the key may be any length. A 0.02-μfd. condenser, C_7 is connected directly *across the key*. This condenser is used to minimize key clicks and is most effective when placed right at the key rather than in the transmitter. Be sure the *frame* of the key connects to the grounded key terminal and not the terminal that goes to the meter.

Coils

The jumper on the 80-meter coil allows the transmitter to work as a conventional tetrode oscillator on 80 meters and as a regenerative oscillator on 40 meters.

The antenna coil connections are the same for both bands. If the socket connections are made as shown in the diagram, the two ends of the coils are connected to the cathode and plate prongs and the center tap to the grid prong.

For some general hints on coil winding, refer to the coil winding data given for the simple autodyne receiver, page 29.

A suitable power supply and two-band an-

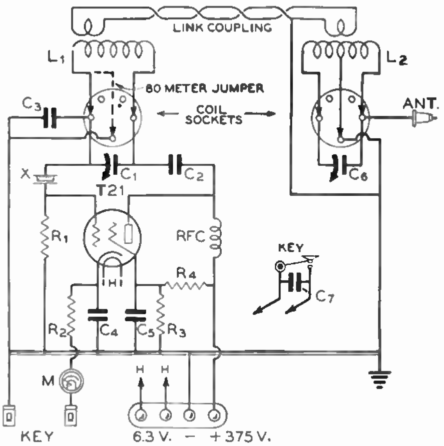


Figure 14. The r.f. portion of the transmitter.

C_1—50-μμfd. midget variable
C_2—.01-μfd. mica
C_3—.0005-μfd. mica
C_4, C_5—.01-μfd. 600-volt tubular
C_6—50-μμfd. midget variable
C_7—.02-μfd. 600-volt tubular
R_1—100,000 ohms, 1 watt
R_2—400 ohms, 10 watts
R_3—20,000 ohms, 10 watts
R_4—5000 ohms, 10 watts
RFC—2.5-m.h., 125-ma. choke
X—80-meter X or AT cut crystal
L_1, L_2—See coil table
M—0-100 milliamperes

Other parts required.

Wood for baseboard and Masonite for panel.
¼ lb. spool no. 20 d.c.c. wire for coils.
6 ft. no. 14 tinned bus wire.
6 ft. pushback hookup wire.
Binding post strip or sufficient Fahnestock clips.
3 base-mounting 5-prong sockets.
1 base-mounting 6-prong socket.
4 standard 1½ in. dia. 5-prong coil forms.
Small feed-through insulator.
Two tuning knobs.
Assorted small round-head wood screws, ½ to 1 inch long.
Two dual-terminal tie points.
One 6.3 volt 150 ma. dial lamp (type 40 or 40-A).

tenna for use with this transmitter are described later in this chapter. The following explanation of the tuning procedure assumes that this type of voltage-fed antenna is used.

80-Meter Tuning Procedure

Place 80-meter coils *correctly* in the plate and antenna sockets and close the switch on the power supply, permitting the T21 cathode to warm up. After a period of a half minute or so, close the key.

The antenna condenser should be set at minimum capacity and the plate condenser at maximum. Start tuning the plate condenser toward minimum capacity, watching the cathode meter. As the condenser is tuned, there will be no change in current until the circuit is tuned to the crystal frequency. At this point the current will take a sudden drop, indicating that the crystal is oscillating. Tune the condenser slightly toward minimum capacity from the point where the crystal started oscillating. The plate condenser should now be left at this setting and attention transferred to the antenna-tuning condenser.

Keeping one eye on the plate meter and one on the dial light in series with the antenna, start tuning the antenna condenser toward maximum capacity. As the capacity of this condenser is increased, the plate current should gradually increase and the dial light start to glow. Adjust the antenna-tuning condenser for maximum brilliance of the light. If the cathode current should take a sudden jump and the dial light go out, it is an indication that the oscillator has been pulled out of oscillation and the *plate* condenser should be turned further toward minimum capacity until the plate current again makes a sudden jump upward or downward, indicating that oscillation has begun again.

If it is impossible to restore oscillation after the antenna circuit is tuned, the link coupling between the plate and antenna coils must be loosened. This is done by pushing the link around the *plate coil* down farther away from the coil. The link around the *antenna* coil should never be touched; it should always be around the *center* of the antenna coil. Be sure to turn off the power supply before making coupling adjustments.

When the transmitter is properly adjusted it should be possible to tune the antenna coupling circuit through resonance without pulling the oscillator out of oscillation. The dial light should increase in brilliance as the antenna circuit is tuned up to resonance and then decrease as it is detuned on the other side.

When this condition is obtained, remove the dial lamp from the antenna and make the antenna connection directly to the antenna post. Then, without touching the antenna-tuning condenser, turn the plate condenser toward maximum capacity until the point of maximum capacity at which the circuit will still oscillate is found. The final adjustment of the plate condenser should be made while listening to the signal from the transmitter in

COIL TABLE

Band	Plate Coil	Antenna Coil
80	41 turns, close-wound	50 turns, center-tapped, close-wound.
40	21 turns, spaced to a length of two inches	26 turns, center-tapped, spaced to a length of two inches

All coils wound with no. 20 double-cotton-covered wire on 1½" dia. forms.

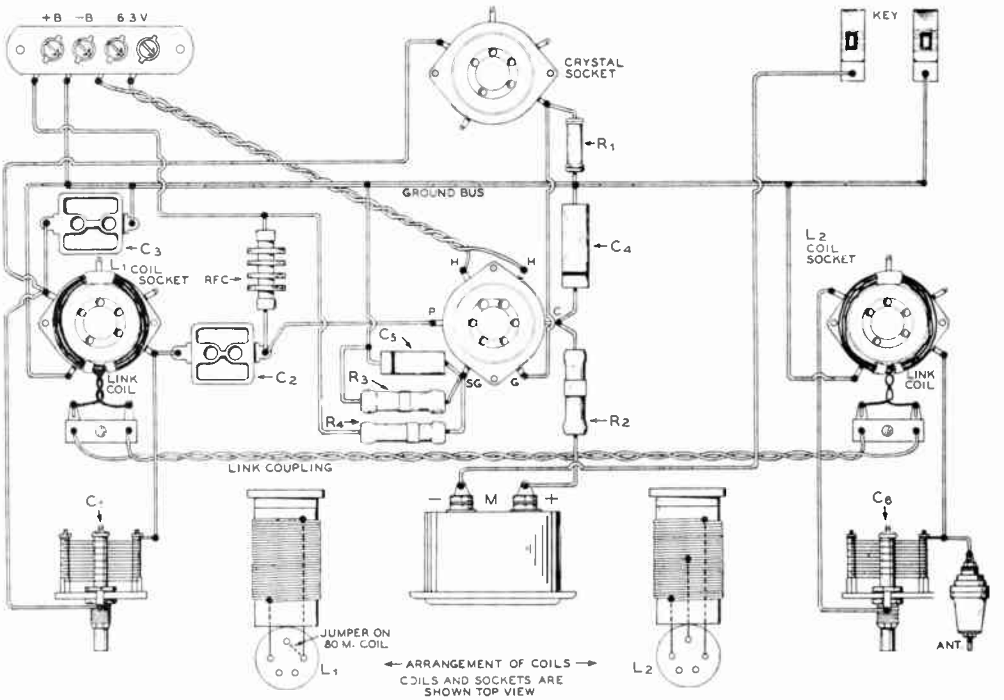


Figure 15. Pictorial wiring diagram of the simple c.w. transmitter. Sockets are top view. In hooking up the key, the frame of the key should connect to the ground bus. The small fixed condenser connected directly across the key terminals is not shown in this diagram.

the receiver. The condenser should be set at the furthest point toward maximum capacity at which the keying is clean and distinct without chirps or lag.

The farther down the plate coil the coupling link is placed, the looser the coupling to the antenna circuit. If the coupling is too tight, the oscillator won't oscillate or the note will be chirpy. If the coupling is too loose, the full power will not be delivered to the antenna.

The coupling should be adjusted by varying the position of the *plate coil coupling link*, never by detuning the antenna condenser. The latter should always be tuned to resonance. If it cannot be tuned to resonance without the transmitter's going out of oscillation or developing keying chirps, the coupling is too tight.

If the dial lamp in the antenna lead does not give sufficient indication to be observed handily, a 2-v, 60-ma. bulb may be substituted. The 6.3-v. 150-ma. type may be purchased under the following type numbers: 40, 40-A, and S-47. The 2-v. 60-ma. type is known as the type 48 or 49, depending upon the type of base.

Do not use a 60-ma. lamp unless you are unable to get a satisfactory indication on a 150-ma. bulb. The maximum antenna current will be low at this point (a current "node") and will vary somewhat in different antenna installations, due to a difference in radiation resistance. The latter depends upon height of the antenna above ground, etc.

40-Meter Tuning Procedure

On 40 meters the tuning is somewhat simpler, because the transmitter acts as a regenerative harmonic oscillator and will oscillate and key cleanly regardless of how heavily the plate circuit is loaded. Therefore it is necessary only to tune for greatest output, without regard to keying chirps or non-oscillation.

On 40 meters, with the antenna circuit uncoupled or detuned, the cathode current will "dip" about 20 ma. when the plate condenser is tuned through resonance. Resonance is obtained when the condenser is tuned to the "bottom of the dip." Keep increasing the antenna coupling and readjusting the antenna condenser to resonance until the meter shows a dip of only 3 to 5 ma. as the plate condenser is tuned through resonance. This adjustment corresponds to maximum output. The flashlight bulb is not necessary for tuning up on 40 meters, but is somewhat of a help because maximum indication will be obtained with the adjustments just described.

With the *power supply specified*, the cathode current will run around 70 ma. on 80 meters and about 75 ma. on 40 meters. These are typical readings obtained under correct operating conditions. However, one should not assume that the rig is tuned up correctly just because these meter readings are obtained, or incorrectly because it is 5 ma. lower or higher than these values. The procedure described should be followed religiously and the final value of cathode current obtained be considered *merely a check* on the *procedure*.

If you do not yet have your license, you must test your transmitter on a *dummy antenna*. This is simply a resistive load which dissipates the r.f. output of the transmitter. A suitable dummy load for this transmitter can be constructed by soldering a 10-watt Mazda lamp to a pickup coil consisting of about 10 turns of pushback hookup wire scramble wound 2¼ inches in diameter and held together with adhesive tape. The pickup coil is held over the plate coil and the coupling adjusted until the lamp lights to about normal brilliancy when the plate condenser is properly tuned. If the coupling is too tight, the keying will not be clean on 80 meters, as the resistance of the lamp is so low when cold (the resistance increases with the temperature of the filament) that it will keep the oscillator from starting readily when tight coupling is used. On 40 meters the loading has little effect on the keying, because when working on the second harmonic of the crystal it is impossible to make the crystal stop oscillating by using too heavy coupling.

Danger

The danger of shock has been minimized in this transmitter by incorporating a front panel in preference to usual "breadboard" construction, and using a circuit which puts neither the meter, coils, nor condenser shafts at positive potential. While the voltage and current delivered by the power supply used in conjunction with this transmitter are not high enough to be considered lethal under ordinary conditions, electrocution *is* possible. For this reason the beginner should learn to show a wholesome respect for high voltages without first having to get "bit" a few times. Keep in mind that sometimes the first time is the last.

●

20-WATT 160-METER RADIOTELEPHONE

The radiophone transmitter illustrated in figures sixteen to nineteen has a consistent nighttime range of several hundred miles when a good antenna is used, and a daytime range of about 50 miles. Because the transmitter has been designed specifically for use on one band, the cost is surprisingly low for a radiophone transmitter of this power. A simple yet efficient circuit makes it easy to build and tune up, and therefore an ideally suited phone transmitter for the newcomer.

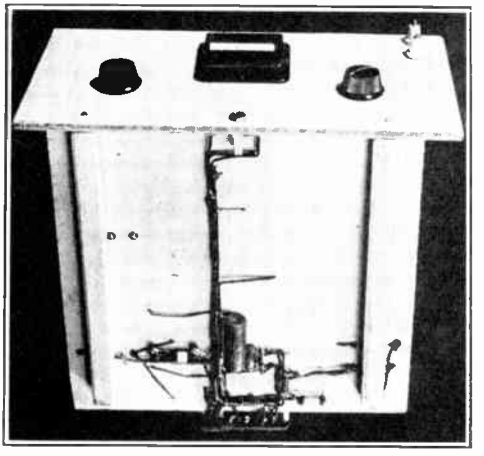


Figure 16. Showing front and under side of the phone transmitter. The antenna and ground terminals may be seen in the upper right corner of the front panel, the phone jack directly under the meter. Nearly all d.c. and a.f. leads are run under the chassis.

Construction

The transmitter is constructed on a wood front panel and a wood subpanel or baseboard. The front panel is of ⅜ inch plywood, 7 x 14 inches. The subpanel is of the same material and measures 12 x 12 inches. Two pieces of ⅞ x ⅞ inch wood, each measuring 11 inches long, support the subpanel as in figure 18, thus permitting some of the wiring and certain of the small components such as resistors to be placed below the subpanel. The appearance of the panel and chassis can be enhanced by the application of a coat of grey lacquer.

A saving of about $4.00 can be made if you can pick up two old broadcast condensers having suitable capacity for use at C_5 and C_7. The spacing of C_7 need not be as great as that of C_5 and most any condenser will do, but the 365-$\mu\mu$fd. variable condensers used in today's broadcast receivers do not have sufficient plate spacing for use at C_5. The best bet is to try to procure at least one condenser from an old broadcast receiver of the vintage 1927-1931. Such condensers usually have much wider plate spacing than those used today, and they can often be picked up for a song at junk parts stores or from radio servicemen or stores having a supply of ancient receivers in various stages of decay. Any condenser having about .02-inch or greater plate spacing will usually suffice at C_7, but the condenser at C_5 should have .03-inch air gap. A spark plug thickness gauge can be used to measure the air gap on any old condensers you are in doubt about. A dime that has been worn smooth is about .03 inch thick.

If you are unable to procure two salvaged broadcast receiver condensers that are suitable, you will have to buy them new. Con-

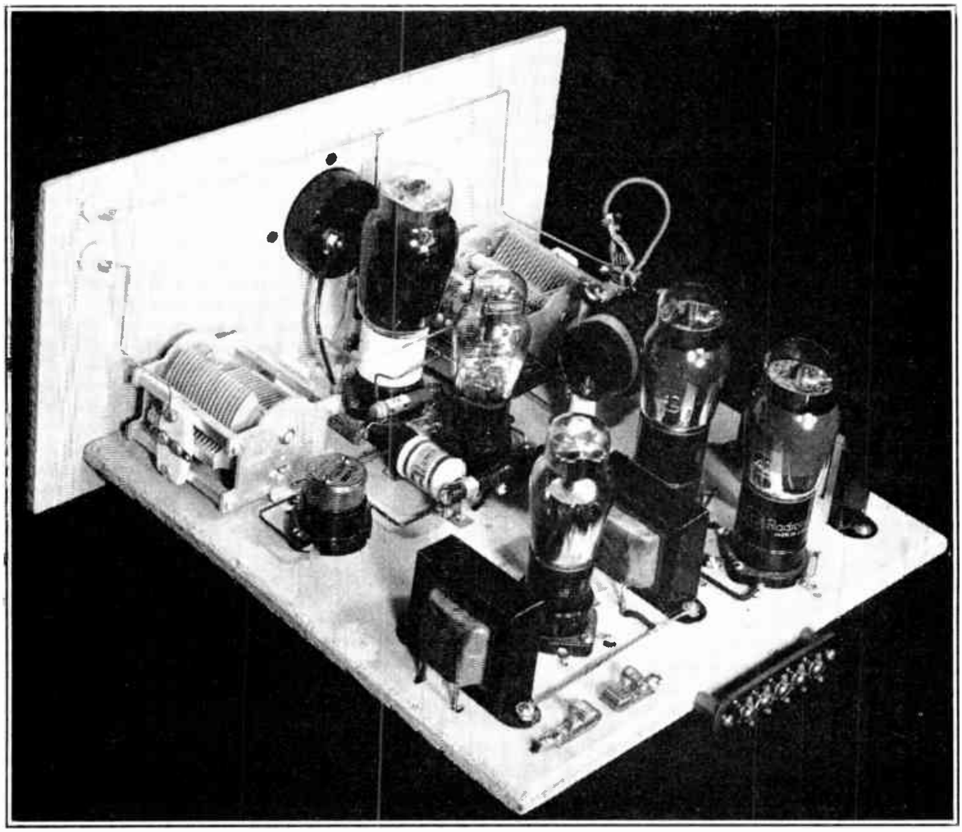


Figure 17. Illustrating correct placement of components. The two Fahnestock clips on the rear of the chassis are for leads to the microphone battery. Other connections are made to the terminal strip on the rear edge. The tank coil is mounted directly behind the plate tuning condenser to the right of the 76 oscillator in this view.

densers with .03 in air gap in 365 $\mu\mu$fd. capacity are manufactured by Cardwell, Hammarlund, and others.

The proper arrangement of parts may be seen in figure seventeen. The r.f. components are mounted towards the front of the chassis and the audio components towards the rear. All r.f. grounds are made to a common ground bus, as indicated in the wiring diagram. Heater and plate supply leads are run underneath the chassis; likewise are all a.f. leads. The r.f. leads are all made above the chassis. The ground bus need not be connected to an external ground. The only external ground connection is that made to the ground terminal of the antenna system. The antenna and ground terminals are placed on the front panel in the upper right hand corner.

When mounting T_1 and T_2, place a solder lug under one of the mounting screws on each in order to make a connection to the ground bus. This grounds the shell on each of these transformers. The shell of T_3 may be left ungrounded.

Transformers

The microphone transformer, T_1 is a standard item made by practically all manufacturers and no particular care need be taken in its selection. The interstage transformer, T_2, and the output transformer, T_3, must meet certain requirements, however. The interstage transformer, T_2, should be of the type designed to couple a type 76, 56, 6J5, 6N7, 6C5, or similar triode to class AB grids such as 45's, 2A5's, 42's, 6F6's, etc. Such transformers have a step-down ratio (primary to ½ secondary) of about 2/1. This means that the ratio of *total* primary to *total* secondary is about 1/1. Such transformers are usually designated as *driver* transformers. An ordinary push-pull interstage transformer will not do, as these transformers usually have a step-up ratio, which in this case is unsuitable.

The output or modulation transformer, T_3, should permit the modulators to work into a plate-to-plate load of somewhere between 7500 and 10,000 ohms. The plate-to-

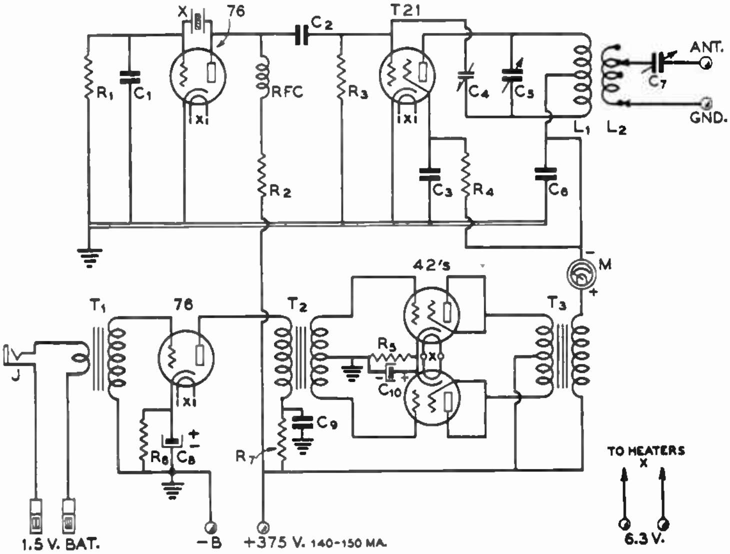


Figure 18. Schematic wiring diagram of the 20 watt 160 meter phone.

C_1—.0001-μfd. midget mica fixed condenser
C_2—.0001-μfd. midget mica fixed condenser
C_3—.002-μfd. midget mica fixed condenser
C_4—3-30-μfd. mica compression trimmer with adjusting screw removed
C_5—350 to 375-μfd. max. capacity variable condenser, .03 inch air gap (see text)
C_6—.004-μfd. 1000 volt test fixed mica condenser
C_7—350 to 375-μfd. max. capacity variable condenser, .02 inch or greater air gap (see text)
C_8—10-μfd. 25 volt electrolytic condenser (observe polarity)
C_9—0.25-μfd. 400 volt paper tubular fixed condenser
C_{10}—10-μfd. 50 volt electrolytic condenser (observe polarity)
R_1—25,000 ohm 1 watt carbon resistor
R_2—15,000 ohm 10 watt wire wound resistor
R_3—50,000 ohm 2 watt carbon resistor
R_4—15,000 ohm 10 watt wire wound resistor
R_5—750 ohm 10 watt wire wound resistor
R_6—2000 ohm 1 watt carbon resistor
R_7—25,000 ohm 1 watt carbon resistor
RFC—8 mh. radio frequency choke
X—160 meter crystal, between 1800 and 2000 kc.
M—0-100 ma. bakelite cased millammeter
T_1—Single button microphone transformer; microphone to single grid.
T_2—Driver transformer for 56, 76, 6C5, 6J5, etc. plate to push-pull 45, 42 triode, 6F6 triode, etc. class AB grids. (see text)
T_3—Class B or class AB modulation transformer for 53, 6A6, 6N7, etc. to class C load. (see text)
J—Open circuit jack for microphone.
L_1—Plate coil (see text)
L_2—Antenna pickup coil (see text)

Other parts required.

Plywood for panel and subpanel.
Wood runners to support subpanel.
3 five-prong base mounting sockets.
3 six-prong base mounting sockets.
Terminal strip or sufficient Fahnestock clips for external connections.
2 small tuning knobs.
2 small feedthrough insulators.
2 small size battery clips, copper.
1 piece 1½ inch diameter bakelite tubing 3 inches long.
2 medium-small standoff insulators to support plate coil.
2 pillar type standoff insulators to terminate antenna coil.
15 ft. no. 18 d.c.c. wire for plate coil.
10 ft. no. 14 tinned or bare copper wire, for r.f. leads.
15 ft. no. 20 solid pushback hookup wire, 1000 volt test insulation, for antenna coil and a.f. and d.c. leads.
Misc. small round head wood screws, ½ to 1 inch long.
Single-button telephone microphone (Western Electric or Automatic Electric).
1½ volt dry cell or flashlight cell for microphone voltage.
Cord and phone plug for microphone.
1 Flashlight bulb or small dial light bulb.

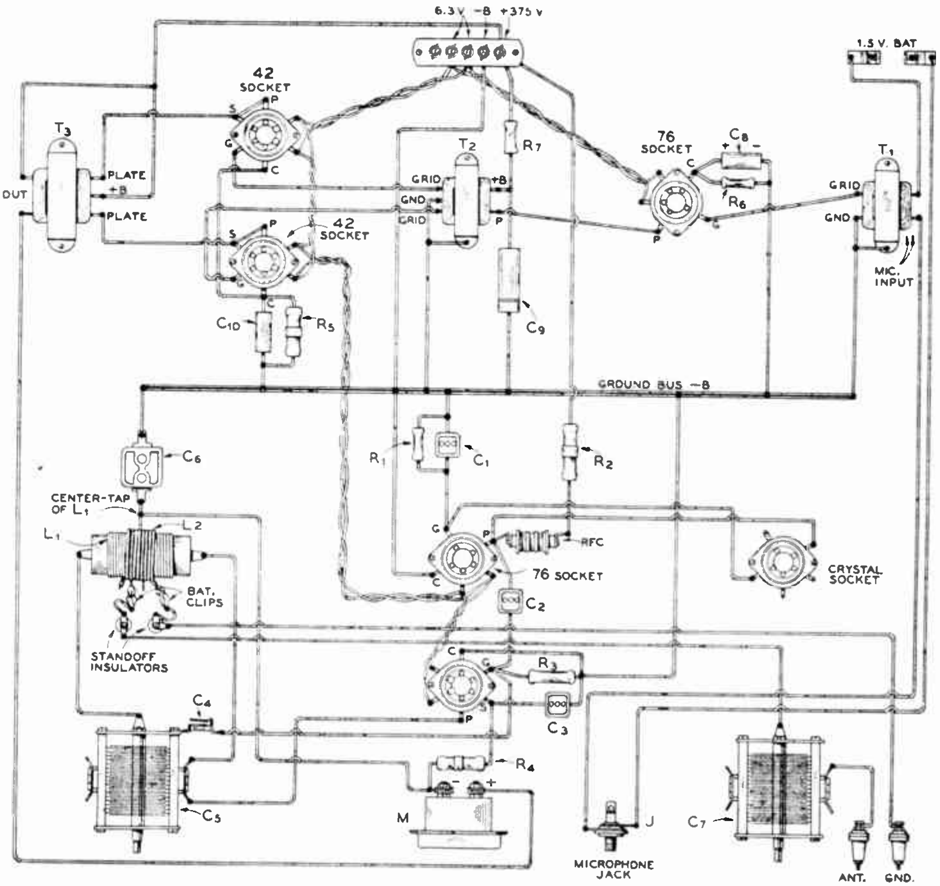


Figure 19. Pictorial wiring diagram of the 20-watt radiophone.

plate load is not extremely critical, but best results will be obtained with a load impedance between these limits. A modulation transformer designed for coupling a 6A6, 53, 6N7, etc. into a 4000, 4500 or 5000 ohm load will serve the purpose nicely. Such transformers have a 10,000 ohm primary and a secondary tapped at 4000, 4500 or 5000 ohms. Suitable transformers are the Kenyon KR53M, the Stancor A-3845, and the Thordarson T-17M59.

The plate coil, L_1, consists of 40 turns of no. 18 d.c.c. closewound on a piece of bakelite tubing 1½ inches in diameter and 3 inches long. The winding covers just over 2 inches of the length of the form, leaving approximately ½ inch at either end for mounting the coil on standoff insulators. The coil is tapped at the exact center, which means you should bring out a tap at the 20th turn as you wind the coil.

The antenna coupling coil, L_2, is constructed as follows: First wrap three or four thicknesses of ordinary writing paper over L_1, holding it in place with gummed paper. The writing paper should first be cut into strips the width of the plate winding, or about 2 inches wide.

Now wind directly over the center portion of the coil 9 turns of pushback hookup wire, tapped at the 2d and 5th turns. The coil form is then mounted on the baseboard with two standoff insulators and the ends of L_2 are fastened to terminals or solder lugs on two more standoff insulators placed beside the coil. Connections are made to the antenna coil by means of two small copper clips, commonly called "peewee battery clips". One clip fastens by means of a piece of flexible wire to the ground terminal on the front panel and the other clip fastens to the rotor of the antenna tuning condenser, C_7. Antenna coupling is varied by adjusting the position of the clips. If the taps are made as indicated, it is possible to include 2, 3, 4, 5, 7, or 9 turns between the two clips. Only those turns between the two clips are effective; hence the antenna coupling can be varied in small steps until the correct amount of coupling is obtained.

Microphone

The best inexpensive microphone is a late type telephone microphone. The Western Electric (Graybar Electric) type F-1 and the Automatic Electric type 35A7 can be purchased through the regular outlets of these companies and provide excellent quality at low cost. These microphones should not be confused with the cheap or older type telephone microphones which give the voice an unpleasant, resonant "ring". A regular handset type holder may be purchased for the microphone or a suitable holder may be improvised. The difficulty with the latter is in making contact to the microphone "button", as it is not permissible to solder directly to the microphone button. The heat required for soldering will damage the button permanently. A spring pressure contact must be made to the "button" or center terminal of the W.E. type F1.

The microphone is plugged into a microphone jack on the front panel by means of an ordinary phone plug and jack. Removing the plug automatically removes the battery voltage from the microphone. If you remember to pull the microphone plug each time you are through with the transmitter for the evening, an ordinary number 6 dry cell will give several months of service.

If two dry cells in series are used for microphone voltage, the microphone will have greater "pickup", permitting you to talk farther from the microphone. However, microphone hiss and room echo will be more noticeable, and the battery life will be shorter because of the greater current drawn by the microphone at 3 volts.

Tuning

The power supply and antenna system for this transmitter are discussed later in this chapter. The following tuning procedure should be employed after a suitable power supply and antenna system have been connected to the transmitter and the clips have not yet been connected to the antenna coupling coil.

No tuning of the crystal oscillator is required. With any good crystal the 76 will oscillate and furnish excitation to the T-21. Throw on the plate voltage after the heaters have had time to reach operating temperature, and quickly rotate the tuning condenser C for minimum plate current as read on the milliammeter. A pronounced "dip" should be obtained, indicating resonance.

Turn off the plate voltage and clip across 2 turns of the antenna coil. Apply plate voltage and slowly rotate the antenna condenser C_7. At antenna resonance the plate current will go up. Resonance of C_5 is indicated by minimum plate current, while resonance of C_7 is indicated by maximum plate current. These two adjustments interlock slightly; so the two tuning adjustments have to be made together. After tuning C_7, go back and touch up C_5.

For maximum output in the antenna, the antenna coupling should be increased until the plate current dips only about 5 ma. when C_5 is tuned through resonance after C_7 has been tuned to resonance. The antenna coupling is increased by increasing the number of turns between the two clips on the antenna coil; if the plate current dips much more than 5 ma. when C_5 is tuned through resonance, then the coupling should be increased. If it dips less than 5 ma. when C_5 is tuned through resonance, then the coupling is too tight and the clips should be readjusted to include a smaller number of turns.

An 8-inch piece of insulated wire is formed into the shape of a one-turn loop and the ends soldered to a small panel or dial light bulb. A hitch is taken in the ground lead to the transmitter to form a one-turn loop of about the same size. Bring the dial light pickup loop towards the hitch in the ground lead, and, being careful not to get too much coupling and burn out the bulb, adjust the position of the two until the lamp glows at about half normal brilliancy. The two loops can be fastened in this position by means of string or adhesive tape. The bulb serves as an antenna resonance indicator, and, in conjunction with the plate meter, as a modulation indicator.

For the initial adjustment, condenser C_7 was resonated by means of the plate current meter, but after the indicator bulb is in use the antenna condenser can be resonated by tuning it for greatest brilliancy of the bulb.

The F.C.C. regulations require that means be employed to insure that the transmitter is not modulated in excess of its *modulation capability* or in any case in excess of 100 per cent. Ordinarily this indicates the necessity for auxiliary apparatus consisting of some type of modulation indicator, such as an oscilloscope, etc. In the case of this particular transmitter, however, *provided the transmitter is built exactly as described, with no modifications or alterations*, the modulation percentage can be kept within the legal limits by observing the simple precautions to be described. This method is recommended only with this particular transmitter, and it is satisfactory because of the factors taken into consideration in the design of the transmitter and because there are so few tuning adjustments to be made. For one thing, the transmitter has been designed so that it is impossible to modulate in excess of 100 per cent without readily apparent distortion of the speech taking place.

To keep the cost down, no "gain" (volume) control is provided in the speech system. To vary the gain, talk in your normal voice and adjust the distance between your lips and the microphone until the correct degree of modulation is obtained. This is determined as follows:

After the transmitter has been tuned up as described, adjust the distance from your lips to the microphone until there is an oc-

casional flicker of the flashlight bulb as you talk but *no movement whatsoever* of the plate current meter. A check on the quality of speech should show good voice quality. Under these conditions the modulation percentage will not be in excess of the legal limits.

Not only is it inadvisable to attempt to increase the percentage of modulation beyond this point because of the chance of getting a citation from the F.C.C., but there is absolutely nothing to be gained, as the voice quality will be impaired and you actually won't "get through" as well as with the recommended amount of modulation.

After you have the transmitter working satisfactorily, and are in communication with a local amateur who can give you an accurate report on your quality, sharpness of signal, etc., the following check should be made: Reverse the two leads to the microphone and see if there is any noticeable difference in the signal. Occasionally it will be found that the microphone will work better connected one way than the other, permitting better modulation and at the same time a sharper signal.

Warning

Before touching any components of the transmitter, such as crystal, antenna clips, etc., *be sure the power supply is turned off.* The plate voltage used in this transmitter is high enough to be dangerous. A good practice to follow is to remove the power supply rectifier tube before changing crystals or making antenna coupling adjustments. With the rectifier tube in one hand you know there can be no plate voltage on the transmitter.

●

112 MC. TRANSCEIVER

A simple transmitter, suitable for use on 2½ meters, consists of an oscillator modulated by a single-tube audio stage. Likewise a simple superregenerative receiver consists simply of an oscillator and audio stage. It is apparent that by incorporating a suitable switching arrangement, one piece of apparatus can be used both to transmit and receive, most of the components doing double duty.

Such a device, which in reality is a combined transmitter-receiver, is commonly called a *transceiver*. The 112-Mc. transceiver illustrated provides the cheapest mobile operation. The range will be from 5 to 25 miles, depending upon the location. The range is not over a few miles in mobile work, unless the car is atop a high hill. This is covered in more detail in the discussion of antenna systems later in this chapter.

Construction

The r.f. portion should be arranged exactly as shown. This includes the 76 socket, the tuning condenser, grid coupling condenser, r.f. chokes, and tank coil. The oscillator circuit is quite simple, but unless constructed

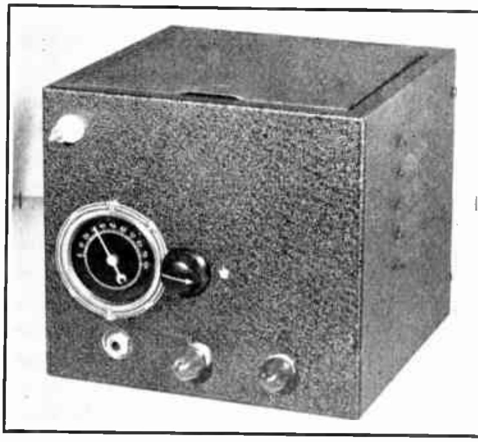


Figure 20. This compact 112-Mc. transceiver provides the least expensive form of mobile operation.

exactly as shown there is a possibility that difficulty will be encountered.

The 76 socket, which must have either ceramic or other h.f. type low loss insulation, should be of the type that has the terminals extending straight out the base as an extension of the jaws that hold the tube prongs. This results in shorter leads to the coil, as the length of the socket terminals has to be taken into consideration at this high frequency, and it is important to provide as short a path as possible from the grid and plate prongs of the tube to the tuning condenser and coil.

The 76 (5-prong) socket is mounted vertically, raised up off the chassis a half inch or so by means of angle brackets, so that shorter connections may be made to the tuning condenser. The socket is oriented so that the grid (isolated) pin is at the top.

The tuning condenser, a ceramic insulated midget having but two plates, is mounted on the chassis by means of a mounting bracket designed for use with this type midget condenser and available as an accessory. The bracket is fastened to the ceramic portion of the condenser, thus permitting both rotor and stator to "float." There should be no more metal making connection to either side of the condenser than absolutely necessary. This explains the insulated coupling connecting to the tuning condenser shaft. It should preferably have ceramic insulation.

The coil consists of three turns of no. 14 enameled wire, ½ inch in diameter and spaced to approximately 1 inch. This coil is mounted directly on the condenser, with as short leads as possible. Because a small difference in the coil dimensions or length of grid and plate leads has such an effect upon the frequency, it may be necessary to "prune" the coil a bit to hit the 112-Mc. band.

The grid condenser should be of the midget mica type, the smallest available (in physical size). This should connect from the grid terminal on the socket to the *rotor* terminal

C—Dual 8-µfd. electolytic, 450 volt
C_1 — 10-µµfd. midget, ceramic insulation. Remove 1 rotor plate
C_2—100-µµfd. midget mica (smallest physical size)
C_3—0.25-µfd. tubular, 400 volt
C_4—.002-µfd. tubular, 400 volt
C_5—10-µfd. electrolytic, 25 volt
C_6—0.25-µfd. tubular, 400 volt
C_7—.01-µfd. tubular, 400 volt
L_1—See text
R_1—100,000 ohms, 1 watt
R_2 — 100,000-ohm pot.
R_3—250,000 ohms, ½ watt
R_4—500 ohms, 2 watts
R_5—1 meg., 1 watt
R_6—15,000 ohms, 1 watt
RFC—U.h.f. radio frequency chokes

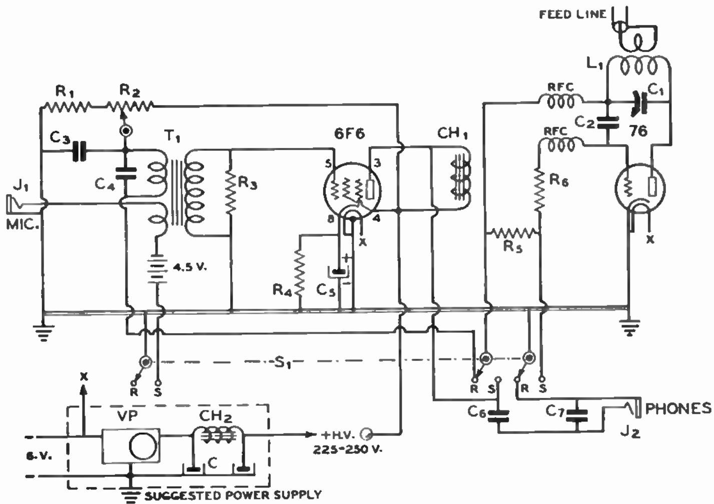


Figure 21. General wiring diagram of the 112-MC. transceiver.

S_1—3-pole 2-throw rotary switch, shorting type
CH_1, CH_2—10 hy. or more, 75 ma.
VP—200-volt 100-ma. "vibrapak" with synchronous rectifier.
T_1—Midget "transceiver" transformer, plate and s.b. mike to grid
J_1, J_2—Open circuit jacks

Other Parts Required.

Tubes
Chassis, panel, and cabinet.
Single button microphone (preferably W.E. type F1).
Pr. radio headphones.
Vernier tuning dial.
Two small knobs.
4½ volt microphone battery.
1 octal base socket.
1 socket for power connections, 4 pr.
1 ceramic or polystyrene 5 pr. socket.
1 shaft coupling, ceramic insulation.
Short piece of ¼ in. rod for extension to tuning dial.
Bracket and small standoff insulator for mounting tuning condenser.
2 angle brackets for mounting 76 socket.
Misc. 6-32 nuts and bolts, solder lugs, hookup wire, etc.

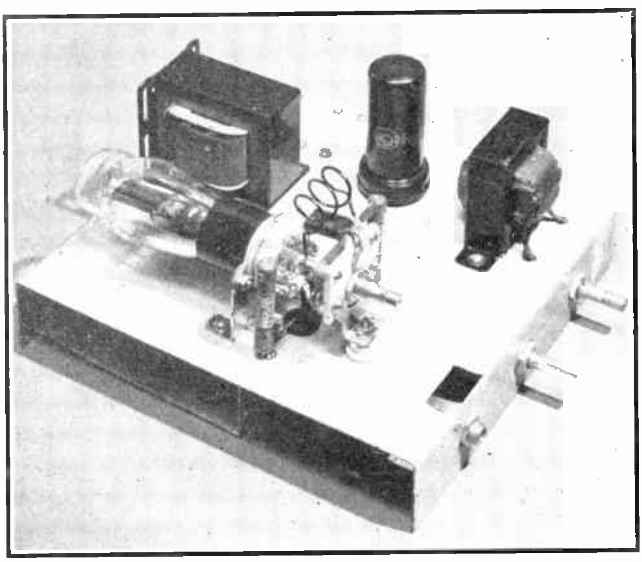


Figure 22. Interior view showing construction of 112-Mc. transceiver. The parts in the foreground should be placed and wired exactly as explained in the text. This includes tube socket, r.f. chokes, tuning condenser, grid condenser, and coil. The tuning condenser should be driven by a ceramic insulated shaft coupling.

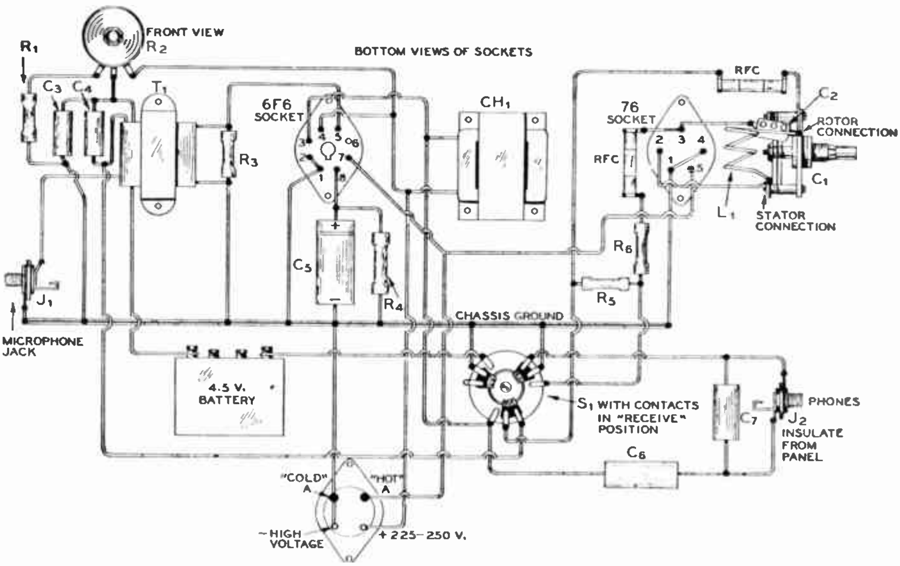


Figure 23. Pictorial wiring diagram of the 112-Mc. transceiver.

on the tuning condenser. The grid condenser may be seen just under the coil. The plate terminal on the socket should go directly to the closest stator lug on the tuning condenser.

The "hot" end of each r.f. choke should be connected with as short a lead as possible, one to each side of the grid coupling condenser. These r.f. chokes should be the special u.h.f. type, as regular r.f. chokes, even the high-frequency type, have too much distributed capacity for effective operation at 112 Mc.

The cathode of the 76 is grounded to a lug under the closest of the two screws which fasten the socket to the two brackets. The heater wires and the wires to the bottom of the r.f. chokes come up through a hole in the chassis midway between the tuning condenser and socket. The balance of the wiring is all below deck, and as it carries only d.c. and high level a.f. no care need be taken to obtain short leads. Cabling the wire with waxed cord as shown in the bottom view of the chassis is not necessary but makes a workmanlike job.

The size of the cabinet is not important just so long as it is sufficiently large to hold all the components without crowding, the one illustrated being approximately 7 inches on a side.

Power Supply

The transceiver power supply should deliver between 225 and 250 volts under load. If the voltage is greater than 250, the 76 will run too hot and draw more than the maximum advisable plate current when transmitting. If the voltage is less than about 225 volts, the tube cannot be made to superregenerate in the "receive" position when normal antenna loading is used. The drain on the power pack at 225-250 volts is around 42 ma. when receiving and approximately 65 ma. when transmitting.

Probably the most practical and least expensive source of high voltage is a 200-volt 100-ma. self-rectifying "vibrapack," such as designated in the diagram. On the highest voltage tap these packs will deliver approximately 225 volts at 65 ma. (transmitting condition) and nearly 250 volts at 42 ma. (receiving condition).

As the vibrapack is used both when transmitting and receiving, a single husky switch can be used to apply battery voltage to both the pack and tube heaters. Wire at least as heavy as no. 12 should be used between the vibrapack and the "A hot," as it will draw between 4 and 5 amperes and even a slight drop in voltage will result in considerable reduction in the maximum plate voltage available for the transceiver.

Antenna

A recommended antenna for mobile work is described later in this chapter. The antenna feed line is coupled to the transceiver coil by means of one or two turns of insulated solid hookup wire shoved down against or straddling the center turn of the three-turn coil. It should be shoved down until the transceiver will no longer superregenerate over the whole band when the regeneration control is full on, superregeneration being indicated by a fairly loud hiss or rushing noise in the phones when the send-receive switch is on "receive." Back off the coupling just enough to permit superregeneration over the whole band and then leave the coupling alone until such time as you make any changes in the antenna or feed line.

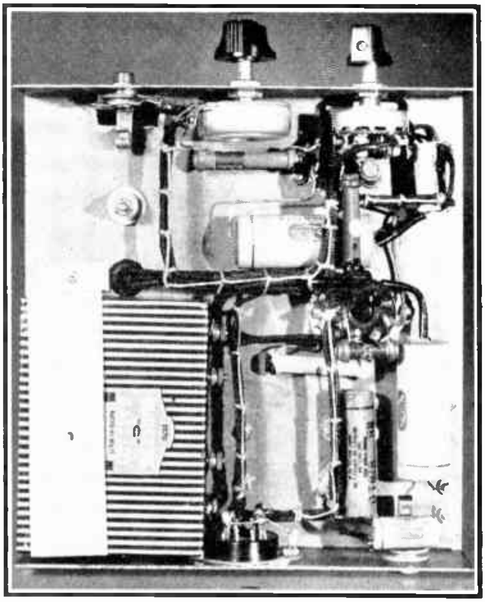


Figure 24. Under chassis view of the transceiver. Exact placement of these parts and length of leads between them is not important. All grounds are made to the nearest convenient point on the chassis.

Operation

The gain of the modulator is such that with an ordinary telephone microphone of the "F" type one should talk directly into the microphone in a normal tone of voice. Talking too loudly will result in overmodulation and consequent distortion, while talking too far from the microphone will reduce the transmitting range.

When not using the transceiver be sure either to throw the send-receive switch to "receive" or pull the microphone plug. Otherwise the microphone will be drawing current and running down the microphone battery needlessly.

The drain of the microphone is low enough that many hours of transmission can be had from one battery, but there is no point in leaving it on when the transceiver is not in use.

●

SIMPLEST SUPERHETERODYNE

If you have constructed some of the previously described apparatus and have thereby gained some practical experience, and have spent a reasonable amount of time in study of more advanced texts (such as the RADIO HANDBOOK, etc.), then you will be able to gain further practical experience from the construction of the three-tube superheterodyne to be described.

This receiver is not recommended as the first project for a newcomer. While it is about the simplest superheterodyne that can be built, it is still somewhat complicated for the newcomer to tackle without previous experience. Because it is described for construction by the more advanced newcomer, no pictorial wiring diagram is given. If you cannot wire the set from the schematic diagram alone, the chances are that you are not yet ready to tackle the construction job and would probably have difficulty in getting the receiver to work anyhow.

The cost of the receiver, less cabinet and power supply but including tubes and a 5 or 6 inch "replacement type" dynamic speaker, will run just over $15. Either of the two power supplies shown later in this chapter will be satisfactory for use with the receiver. If a suitable switching arrangement is employed, the same power supply as used for the transmitter may be used for the receiver. A heavy-duty, house-type porcelain toggle switch (s.p.d.t.) can be used for throwing the voltage from transmitter to receiver and vice versa, provided sufficient respect for the voltage involved is shown by incorporation of heavily insulated wire. As the power packs described both have sufficiently heavy filament windings, the additional drain of the receiver heaters can be tolerated and all heaters (both receiver and transmitter) can be left running continuously.

If a power pack is to be constructed specifically for use with the receiver, the 75 ma. model is to be recommended from the standpoint of economy. The receiver actually draws only 50 ma. at the specified voltage.

This receiver has practically all the advantages of sets having many more tubes. It has excellent image rejection, selectivity and sensitivity, and drives either phones or a dynamic loudspeaker to good volume.

A 6K8 converter directly feeds a regenerative second detector operating just above 1500 kc. The latter is impedance coupled to a beam tetrode audio tube. The plate current and audio power output are too great for a pair of phones; so the phones are connected in the screen circuit.

Good selectivity and sensitivity are obtained on phone by running up the regeneration on the second detector right to the edge of oscillation. By advancing the regeneration control still farther the second detector will oscillate, thus providing autodyne reception of code signals. The regeneration also acts as a sensitivity control to prevent blocking by very loud local signals. To keep loud phone signals from blocking, the regeneration is decreased way below the edge of oscillation. To keep loud c.w. signals from blocking, the regeneration control is advanced full on.

The 6K8 converter is conventional and no special precautions need be taken with this stage except to keep the first detector leads as short as possible in order to obtain maximum performance on 10 meters. A minimum number of coils is required for all-band operation (10 to 160 meters) because the oscillator coil for each band serves as the detector coil for the next higher frequency

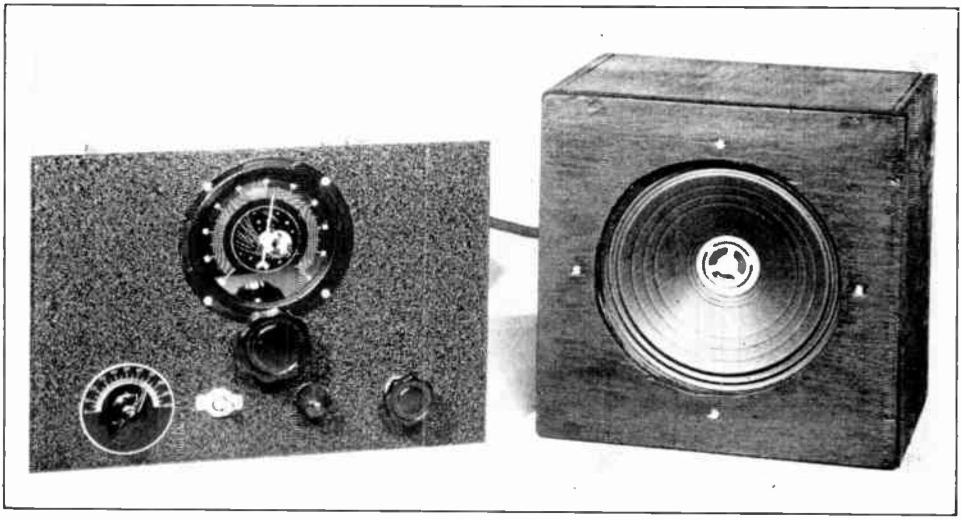


FIGURE 25. SIMPLE YET EFFICIENT THREE TUBE SUPERHETERODYNE. The bandset condenser is to the left, the detector "resonating" condenser to the right. The latter makes an effective volume control. The small knob operates the regeneration potentiometer.

band, the tickler serving as the antenna winding. Thus all coils except the 160-meter detector and a 10-meter oscillator coil do double duty.

The set is built on a metal chassis measuring 2½ inches by 6 inches by 8 inches. This supports a 7-inch by 10-inch front panel. The chassis need not be this exact size so long as it is 2½ inches deep and a front panel is chosen which is at least as wide as the chassis.

The correct placement of components may be determined by referring to the illustrations.

In order to obtain regeneration in the grid leak type second detector, a tickler coil is added to the i.f. transformer. Inspection of figure 27 will show that the second detector then resembles the common "autodyne" grid leak detector with regeneration control.

For maximum performance, the detector should go into oscillation when the screen voltage is about 35 volts. This is accomplished by using as a tickler 3 turns of no. 22 d.c.c. wound around the dowel of the i.f. transformer, right against the grid winding. Few tickler turns are required, as there is no antenna to load the detector, and therefore it goes into oscillation with but little feedback.

To wind the tickler, simply remove the shield from the i.f. transformer and using a foot length of the same d.c.c. used to wind the plug in coils, wrap three turns around the dowel as closely as possible to the grid winding. Then twist the two leads together to keep the turns in place and replace the shield. The polarity of the tickler must be correct for regeneration; if oscillation is not obtained, reverse the two tickler leads.

It is important that care be taken with the grid leak, grid condenser, and grid lead of the 6SJ7; otherwise there will be "grid hum." The outside foil of the tubular grid condenser should go to the i.f. grid coil and *not* to the grid of the tube. Connection to the grid pin of the 6SJ7 socket should be kept as short as possible—not over a half inch, and both grid leak and grid condenser should be kept at least a half inch from other wiring. In some cases it may be necessary to shield the grid leak and condenser with a small piece of grounded tin in order to eliminate grid hum completely.

The phone jack is a special type, commonly called a two-circuit "filament lighting" jack. It is connected so that when the phones are inserted they not only are connected in the screen circuit in such a way that no d.c. flows through the phones, but the speaker transformer is shorted out in order to silence the speaker. Switching the plate of the 6V6 directly to B plus also improves the quality in the phones slightly.

Either a two-wire feeder or a single-wire antenna worked against ground can be used. For doublet input, connect to the two antenna coil terminals. For Marconi input, ground one terminal and connect the antenna to the other.

Adjusting the mica trimmer on the grid coil of the i.f.t. changes the i.f. frequency. The trimmer on the plate coil should always be resonated for maximum signal strength. It need not be touched after the initial adjustment unless the grid trimmer is changed. The i.f. frequency should be adjusted to about 1550 kc. and then a check made to make sure it is not right on some nearby police or high fidelity broadcast station.

The only band on which images might be

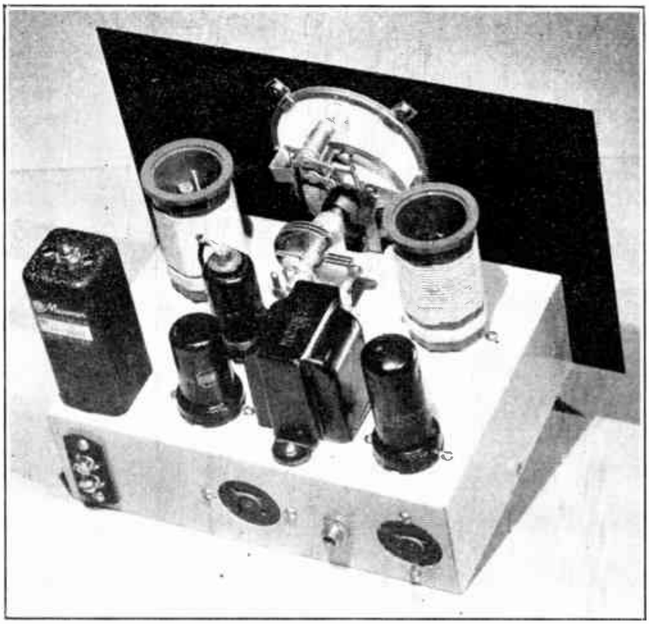


FIGURE 26. REAR VIEW OF THE RECEIVER. The detector coil is to the left, directly above the detector tuning condenser, and the oscillator coil is to the right. Antenna terminals, power socket, speaker plug socket, and earphone jack may be seen on the back of the chassis.

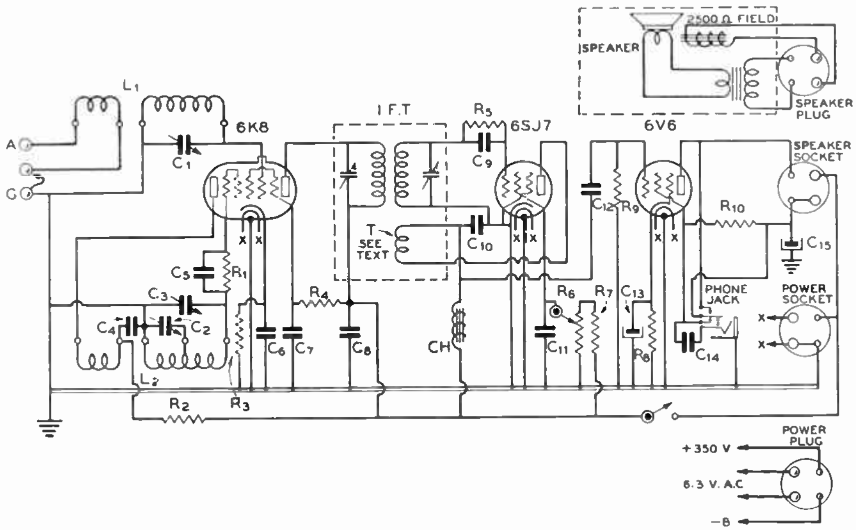


FIGURE 27. SCHEMATIC WIRING DIAGRAM OF THE RECEIVER. Tube socket connections are given in the illustration at the end of this chapter.

C_1, C_2—50-μμfd. midget variable, semi-circular plate type

C_3—140 or 150-μμfd. midget variable, semi-circular plate type.

C_4, C_8, C_{11}, C_{14}—0.1-μfd. tubular, 400 v.

C_5, C_6—.0001-μfd. tubular, 600 v.

C_9, C_7, C_{12}—.01-μfd. tubular, 600 v.

C_{10}—.001-μfd. tubular, 600 v.

C_{13}—25-μfd. 25 v. electrolytic

C_{11}—4-μfd. 450 v. midget tubular electrolytic

R_1, R_2—50,000 ohms, 1½ watts

R_3—300 ohms, 1 watt

R_4—40,000 ohms, 1½ watt

R_5—5 meg. insulated ½ watt resistor

R_6—100,000 ohm potentiometer

R_7—100,000 ohms, 1½ watt

R_8—400 ohms, 10 watts

R_9—500,000 ohms, ½ watt

R_{10}—10,000 ohms, 10 watts

IFT—1500 kc. replacement type i.f. trans. (see text for tickler data)

CH—High impedance audio choke, 500 or more hy.

Phone Jack—Two circuit "filament lighting" type bothersome is the 10-meter band. In most cases objectionable images can be eliminated without serious loss in signal strength by shifting the h.f. oscillator to the other side by means of the band set condenser. The receiver will work with the oscillator either *higher or lower* by the i.f. frequency than the received signal. On the higher frequency bands the bandset condenser tunes over a wide enough band of frequencies that it hits both sides.

On certain bands the gain and sensitivity are better with the h.f. oscillator on one side of the detector than on the other. Some experimenting with the bandset condenser should be made on those bands where it is possible to hit both the high and low side with the bandset condenser.

Coils

As the oscillator-mixer (front end) portion of the receiver is the same as for the h.f. converter unit previously described, the same coils are used. For coil data refer to the coil table on page 38, and to that portion of the text covering the winding of the coils.

Speaker

The speaker need not be an expensive one. but it should have a 2500-ohm field and be designed to work from a single pentode such as a 42, 6F6, 6V6, etc. A 5 or 6 inch "replacement type" dynamic can be purchased for less than two dollars. It should either be mounted on a flat baffle at least 2 feet in either direction, or mounted in a small box that has been constructed for it as shown in figure 25. A coat of black paint enhances the appearance of the box, which is constructed of plywood, fastened together with brads and glue. The back of the box may either be closed or left open.

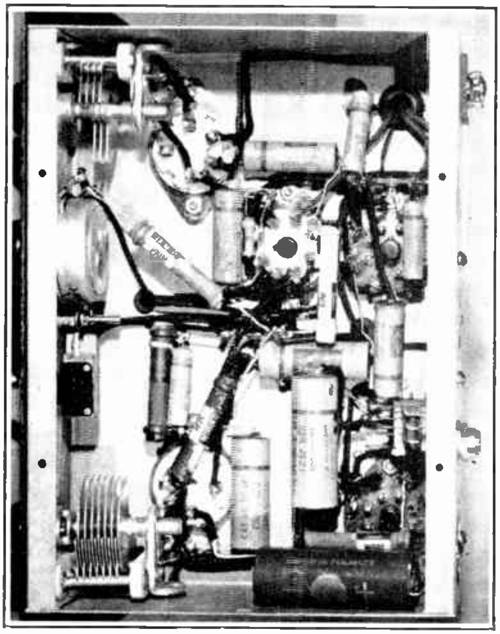


FIGURE 28. UNDER CHASSIS VIEW OF THE RECEIVER. Not much room to spare, but all components fit without crowding. The phone jack is mounted directly on the rear drop of the metal chassis; because of the method of connection, no insulating washers are required.

POWER SUPPLIES

To supply plate and filament or heater voltages to the tubes in a transmitter, a source of high voltage d.c. and a source of low voltage a.c. is required. In low voltage power supplies (under 400 volts), a single transformer ordinarily is used to supply heater voltage, filament voltage for the rectifier plates, and high voltage a.c. to the rectifier plates.

For a low power transmitter, a power pack of the same type as commonly used in radio receivers may be employed; the use of receiver-type components keeps the cost down.

The power supply circuit shown in figure 29 is practically standard for low voltage power packs used for receivers, speech amplifiers and modulators, low power transmitters, etc. Sometimes a "bleeder" resistor is placed across the high voltage output terminals, but because of the inherent leakage resistance of electrolytic type filter condensers, a bleeder is not really necessary in this type of power supply, and therefore none is shown in the diagram.

Because of the "condenser input" circuit, the output voltage will depend to a considerable extent upon the amount of current being drawn, and at low values of current drain the output voltage will rise to a value considerably higher than the r.m.s. voltage each side of the transformer center tap, the voltage finally going up to 1.4 times the r.m.s. voltage at no load.

A power supply having this characteristic is said to have rather poor *voltage regulation*, but for practically all low voltage applications and for use with the transmitters described in this book, the voltage regulation of this type of pack is sufficiently good. The use of a low resistance rectifier tube and low resistance filter choke keeps the voltage regulation from being bad enough to be a serious item. The power transformer should not be rated at more than 350 volts each side of center tap or the filter condensers will be subjected to excessive voltage when the load is removed from the power pack.

The nominal rating of 375 volts output applies to the voltage delivered under normal load when used with the equipment described in this book.

For the c.w. transmitter, less current is required than for the phone transmitter; therefore a transmitter and filter choke having a lower current capacity may be used for the c.w. transmitter if desired, with a small saving in cost.

A power supply of this type may be con-

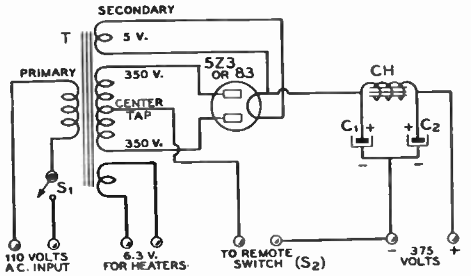


Figure 29. Standard power supply diagram. The same circuit is used for both the c.w. transmitter and phone transmitter, though lower current components may be used for the c.w. transmitter if desired, as indicated below.

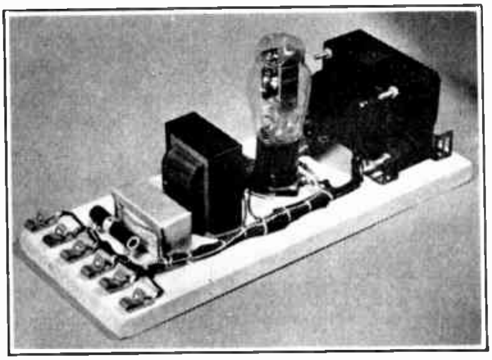


Figure 30. Typical power supply using circuit of figure 31. Fahnestock clips are screwed to the wood baseboard for terminals. Dry wood is a good insulator.

150 Ma. supply for phone transmitter or c.w. transmitter.

T—B.c.l. power transformer, 350 v. each side c.t., 145 or 150 ma., 5 v. 3 amp.; and 6.3 volt winding for heaters.
CH—8 hy. 150 ma., not over 200 ohms.
Rectifier—Type 83

70 Ma. supply for c.w. transmitter (will stand 90 ma. with keying).

T—B.c.l. power transformer, 350 v. each side c.t., 70 ma.; 5 v. 3 amp.; and 6.3 volt winding for heaters.
CH—10 hy. 75 ma., not over 300 ohms.
Rectifier—Type 5Z3 or 83

Common Components

C_1, C_2—Dual 8-μfd. electrolytic condenser, 450 volts, 525 volts peak. (Two 8-μfd. condensers in a single container.)
S_1—Regular a.c. toggle switch.
S_2—Regular house type a.c. toggle switch. May be placed on operating desk and wires run to power supply.

structed either on a wood baseboard or a metal chassis. The placement of parts is not particularly important so long as the electrolytic condenser is not exposed to high temperature, which is unlikely unless it is mounted right up against the rectifier tube. The length of the various connecting wires is not important, though the leads carrying the positive high voltage should have good insulation, such as the better grade of push-back hookup wire.

When a single transformer is used to supply both plate and heater voltages, some provision must be made whereby the plate voltage can be turned off without killing the heater voltage. If this were not done it would be necessary to wait for the heaters to reach operating temperature each time the plate voltage was turned off and on. Switch S_2 is used for turning the plate voltage off and on without killing the primary voltage to the transformer. The switch should be of the type used in house wiring, rated at 5 amp. at 250 volts. The contacts will spark considerably and the small toggle switches commonly used in radio work are not suitable.

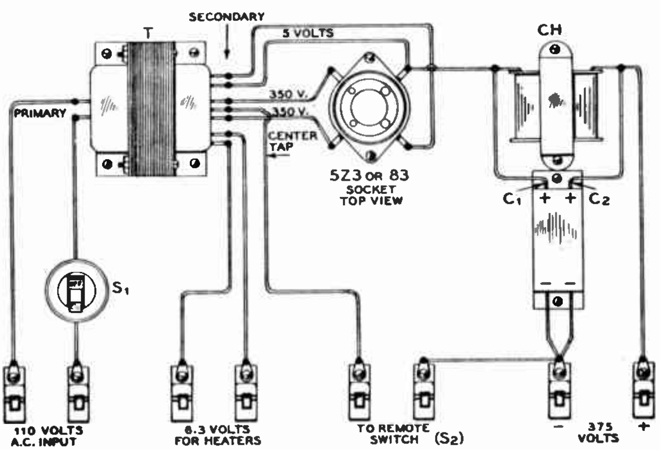


Figure 31. Pictorial wiring diagram, showing connections of power supply components. Some transformers and chokes have lug terminals, some have flexible wire leads. If the primary winding has a tap for low and high primary voltages, be sure not to connect the primary voltage to the two taps instead of to the common lead and one tap. Connecting to the two taps will immediately ruin the transformer. If your primary voltage is usually under 110 volts, use the low tap; if it is normally over 110 volts, use the high tap. Most power transformers of this size have no primary tap.

If an 83 rectifier is used, it is preferable to open S_2 before turning on S_1 and then wait 10 or 15 seconds before closing S_2. This will prevent flashing of the mercury within the tube. After the 83 rectifier filament is once warm, S_2 may be turned on and off without flashing of the tube.

Wire not smaller than no. 16 should be used for heater connections between the power pack and tubes being supplied, and the connections should not be over 4 or 5 feet long; otherwise there will be excessive voltage drop and the heaters of the tubes will not receive full rated voltage.

As the plate current is so small (in amperes), the size wire is not important in the case of the high voltage connections to the power supply, but the insulation should be adequate. This applies especially to the positive high voltage lead.

The power supply should be placed where it is impossible for anyone (including children and pets) to come in accidental contact with any of the wires, terminals, or components, as the voltage is sufficiently high to be dangerous.

DANGER—HIGH VOLTAGE

The high voltage power supplies even in a low-power transmitter are potentially lethal. They are also potential fire hazards.

Not only should your transmitter installation be so arranged to minimize the danger of accidental shock for your own safety, but also because "haywire" installations that do not pass the underwriters' rules will invalidate your fire insurance.

Some of the most important things to remember in regard to the high voltage danger are the following:

Don't touch any transmitter components without first turning off all switches. If you do insist on making coupling adjustments, etc., with the transmitter on (very bad practice), keep ONE HAND BEHIND YOU.

Do not work on the high-voltage circuits or make adjustments where it is necessary to reach inside the transmitter UNLESS SOMEONE ELSE IS PRESENT. Ninety per cent of the deaths due to electrocution could have been prevented if someone had been present to kill the high voltage or remove the victim and to call the doctor and administer first aid before he arrived.

High-voltage gear should be so fixed that small children cannot manipulate the switches or come in contact with any of the wires or components; keep the radio room or gear under lock and key if necessary.

Familiarize yourself with the latest approved methods of first aid treatment for electrical shock. It may enable you to save a life some time.

Don't attempt to hurry too much if a companion comes in contact with high voltage and cannot extricate himself. Act quickly but do not act without deliberation or you may be in as bad a fix as the person you are trying to help. Do not touch the victim with your bare hands if things are wet. Otherwise, it is safe to grab him by a loose fold of clothing to pull him free, first making sure that you are well-insulated from anything grounded. Turning off the voltage is simpler, when possible. However, do not waste precious moments dashing around trying to discover how to open the circuit. If you do not already know, try to remove the victim if it can be done safely.

A main primary switch at the entrance to the radio room, killing all primary circuits, will reduce the fire hazard and help your peace of mind, provided you make it an iron-clad rule always to throw the switch when leaving the room.

Beware of strange equipment. It may contain unconventional wiring or circuits. Do not take for granted that it is wired the way you would do it.

There is no danger so long as you are always careful and don't take unnecessary risks; but the minute you are careless your life may be in danger, just as in driving an automobile or any one of a hundred other activities.

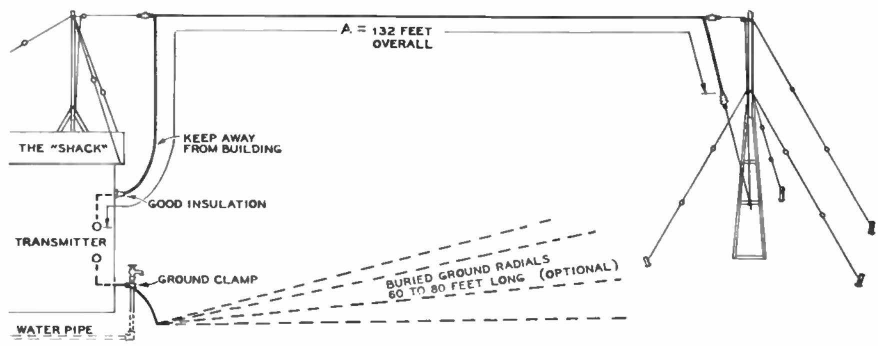


Figure 32. Efficient antenna system for use on 160, 80, and 40 meters. If only 40 and 80 meter operation are contemplated, or if several waterpipes run underground in th vicinity of the horizontal portion of the antenna as would be the case with a lawn sprinkler system, the radials will not be required.

THE ANTENNA

The antenna is one of the most important items in an amateur station. A low power transmitter with a good antenna will "get out" much better than a high power transmitter working into a poor antenna.

Many amateurs spend several hundred dollars on their antenna system, and in the case of a medium or high power transmitter the expense is justified. In the case of a low power transmitter, however, it would be cheaper to raise the power and use a moderately priced antenna system than to put practically all of the money into the antenna system. Therefore we want a good, efficient, all-around antenna system for our low power transmitter, but one not costing much. True, we could put up a better antenna if we could spend a hundred dollars or so, but it is possible to put up a good antenna for but a few dollars, one that will permit you to get out well even with low power.

160, 80, 40 Meter Antenna System

An antenna consisting of a single 132-foot wire, as high and as much in the clear as possible, can be used with excellent success for general coverage on 160, 80, and 40 meters. This means that the antenna may be used with either the 80- and 40-meter c.w. transmitter or the 160-meter phone transmitter previously described in this chapter.

The antenna is shown in figure 32. If it is impossible to run the antenna the full length in a horizontal span, the far end may be bent down as shown in the illustration, with no impairment of the radiating efficiency. For best results on 160 meters, both poles should be at least 40 feet high, though the antenna will still work well on 40 and 80 meters if only 20 or 25 feet high. If surrounding trees, buildings, etc., tend to "hem in" the antenna, greater height will result in more of an improvement than when the antenna is erected over a vacant lot with no trees or buildings in the immediate vicinity.

The antenna is used as a quarter-wave Marconi on 160 meters, as an end-fed half wave dipole on 80 meters, and as an end-fed full wave antenna on 40 meters. On 160 meters the voltage will be high at the far end of the antenna, low at the transmitter end. On 80 meters the voltage will be high on both ends, low in the center. On 40 meters the voltage will be high at both ends and in the exact center, the voltage nodes occurring midway between the center and either end. Thus it may be seen that good though not elaborate insulation is required at all points. Ordinary receiving type glass or porcelain insulators can be used to support the antenna, either one or two insulators being sufficient at each point of support.

The lead in, which is actually part of the antenna and radiates just like the rest, should be kept away from the building by at least a foot or two except where it enters the operating room. A regular porcelain type lead-in insulator or bushing (Johnson) can be used for bringing the antenna into the operating room. Insulation inside the operating room is not as important, because wood is a pretty good insulator when dry.

Either No. 12 or No. 14 hard drawn copper wire may be used for the radiator, and galvanized wire for the pole guys. The guys should preferably be broken up every 10 feet or so with small "egg" type strain insulators (Johnson 32). The antenna proper should be between 130 and 135 feet overall from the far end right down to the antenna terminal on the transmitter.

If operation only on 40 and 80 meters is contemplated, a low resistance ground connection is not important. The closest waterpipe will do nicely. The ground lead need not be insulated; it can be the same No. 12 or No. 14 used for the antenna. A ten cent ground clamp will provide a convenient and effective connection to the pipe.

On 160 meters a good ground system is of considerable importance, because heavy current will be flowing in the ground lead and any resistance in the ground connection will represent wasted power. If the water system is extensive (in other words, if there are a number of water pipes running around under the antenna), the ground may have sufficiently low resistance. However, if the soil is dry and there are but one or two water pipes running under the antenna, then a system of radials as illustrated in figure 32 will greatly improve the radiating properties of the antenna. The radials are of No. 14 bare copper wire, and are buried from 3 to 12 inches under the surface of the earth. From 3 to 6 radials are run fanwise under the horizontal portion of the antenna and all connected to the waterpipe ground.

Any splices or connections in the radials below the surface of the soil should be soldered, because of the corrosive action of damp soil.

The ground lead from the transmitter should be kept as short as possible for best 160-meter operation. Locate the closest point where a waterpipe (not a gas pipe) enters the ground and attach the ground clamp just above the surface of the soil. Then run the ground lead as directly as possible to the transmitter. Simply attaching to the closest waterpipe handy is not recommended for 160-meter operation, because the pipe may run some distance under the house before it enters the ground.

The tuning procedure and method of varying coupling has already been covered under the description of the two transmitters in this chapter.

Receiving Antenna

Oftentimes the same antenna is used for both transmitting and receiving, especially when a feed line is used to couple the transmitter to the antenna. Either a switch or relay is used to throw the antenna from transmitter to receiver.

With the antenna described here, however, the antenna itself is brought right in to the transmitter, and it is preferable to use the antenna only for transmitting. A separate antenna 50 to 75 feet long can be used for the receiver. The receiving antenna should not be run any closer to the transmitting antenna than can be avoided. If possible, the receiving antenna should be run in the opposite direction.

If a relay or switch is used to switch the transmitting antenna, the relay or switch should have low losses and be placed so that the length of the lead from the antenna lead-in bushing to the transmitter is as short as possible. If a relay is used, it should be of the type designed for r.f. use. If a manually operated s.p.d.t. switch is used, it should have low r.f. losses. A porcelain s.p.d.t. house type (110 v.) toggle switch (Woolworth's) will be satisfactory, as these switches have low resistance and good r.f. insulation.

2½-Meter Mobile Antenna

A highly efficient 2½-meter mobile antenna recommended for use with the transceiver

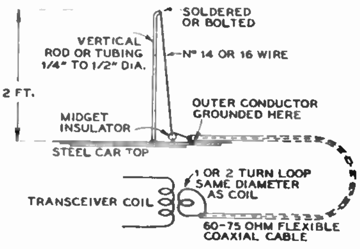


Figure 33. This 2½-meter mobile antenna is a very effective radiator. It is mounted just over the center of the windshield.

of figures 20-24 is shown in figure 33. It consists of a piece of tubing or rod between ¼ and ½ inch diameter exactly 2 feet long, mounted vertically just above the center of the windshield atop the car, in about the same position as the auto radio antenna on some of the recent model Ford V-8 cars.

The bottom of the rod or tubing is bolted, welded, or otherwise fastened to the metal portion of the car. The tip of the rod is bent slightly so that when the parallel wire is fastened as shown in the illustration, the wire is held away from the rod sufficiently that it will not whip against the rod as a result of wind or vibration. The wire is anchored by means of a midget insulator, and pulled taut enough that the rod or tubing section bends slightly. Keeping the wire under slight tension will aid in preventing the wire from whipping against the grounded rod or tubing, which would cause the antenna to work erratically.

Bassett type BCF-64-200 concentric cable is used for connecting the antenna to the transceiver. This flexible, rubber-covered cable is inexpensive and makes an ideal method of feeding the antenna. The cable may be run down one side of the windshield or down the center dividing molding of a divided windshield. It may be bent, run around corners, against the metal car body, or most anywhere without increasing the losses. This type of cable is not as efficient as the more expensive type of co-axial cable costing between 30 and 60 cents a foot, but because the length of cable required is so small (assuming the transceiver is mounted in the glove compartment or under the dash) the losses in the line are not serious. This cable costs about 5 cents per foot.

The manufacturer's type numbers of the exact parts used in the construction of equipment in this chapter may be found in the "Buyer's Guide" at the end of the book. Other makes may be substituted if of good quality and the electrical specifications are exactly the same.

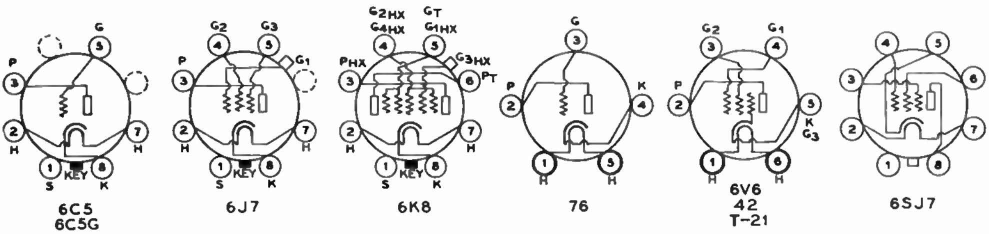


Figure 34. Bottom views of socket connections for various tubes used in apparatus described in this chapter. It is standard practice among manufacturers to show bottom views instead of top views, hence when wiring sockets mounted above a chassis or baseboard, it is necessary to pay careful attention in order to avoid errors. Octal (8 prong) sockets of the wafer type are available with the pins numbered from 1 to 8. This simplifies wiring and reduces the chance for error.

The co-axial cable can be brought into the car by drilling a hole of suitable size and using a soft rubber grommet. It is important that the grommet fits the hole with a squeeze fit and the grommet hugs the cable tightly. Under these conditions no water will leak in. The hole can always be plugged up with body solder if you wish to sell the car and someone objects to the hole. The grommet should first be placed in the hole, then the cable pulled through after first being moistened with water to provide lubrication and make the job easier.

At the antenna end the outside conductor of the co-axial cable is soldered to the base of the vertical rod and the inner conductor is soldered to the bottom of the vertical wire where it fastens to the midget insulator. This insulator may be a ½ inch dia. composition button similar to that on your coat sleeve, or a small piece of Lucite or Victron drilled with two holes about a half inch apart.

This antenna is the most effective 2½-meter antenna that can be mounted on an auto without going to considerable expense and labor.

VIII. REGULATIONS

Before attempting to take the amateur examination, the reader should have a thorough knowledge of the regulations affecting amateur operators and stations. While "memorizing" procedure is not to be recommended when preparing for the *technical* portion of the amateur examination, the best way to prepare for the questions pertaining to regulations is to memorize those portions of the communications law which apply to amateur radio and also memorize the United States amateur regulations. They do *not* necessarily have to be memorized *verbatim*, but the applicant must have at his command *all of the information contained therein*.

It is important that the reader clearly understand the distinction between violations of the basic Communications Act of 1934 and violations of the rules and regulations set up under the basic act by the Federal Communications Commission. The former constitutes the more serious offense, and anyone is liable, whether he be an amateur or not. The difficulty some applicants experience with certain questions is in deciding whether a certain offense is a violation of the basic act or a violation of rules set up by our F.C.C. under the act. A study of those questions and answers in chapter nine pertaining to penalties should dispel any confusion over this point.

Copies of the Communications Act of 1934 as Amended are obtainable from the U. S. Government Printing Office. However, as the act contains much material not of interest to radio amateurs and because the price is 15 cents, the pertinent extracts are printed here.

It is not necessary to learn the list of U. S. Radio Districts and other material given in the appendix; this is included merely for reference.

Only the following portions of the Communications Act of 1934 need be studied. The rest of the Act has no direct bearing upon amateur radio.

PERTINENT EXTRACTS FROM THE COMMUNICATIONS LAW (Communications Act of 1934)

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. For the purpose of regulating interstate and foreign commerce in communication by wire and radio so as to make available, so far as possible, to all the people of the United States

The amateur regulations are not included because of frequent minor changes and because they are obtainable free of charge in pamphlet form from the U. S. Government Printing Office. Just drop a postcard to the Superintendent of Documents, Government Printing Office, Washington, D. C. and request that they send you the F.C.C. Rules Governing Amateur Radio Operators and Stations. The pamphlet also contains, in the appendix, a list of the examining points, the radio districts, and the call areas.

By writing for the amateur regulations you are assured that the regulations as given are exactly as in effect. In preparing for an examination, one naturally wants to be sure the regulations he is studying are the ones currently in effect.

a rapid, efficient, nation-wide, and world-wide wire and radio communication service with adequate facilities at reasonable charges, for the purpose of the national defense, for the purpose of promoting safety of life and property through the use of wire and radio communication, and for the purpose of securing a more effective execution of this policy by centralizing authority heretofore granted by law to several agencies and by granting additional authority with respect to interstate and foreign commerce in wire and radio communication, there is hereby created a commission to be known as the "Federal Communications Commission," which shall be constituted as hereinafter provided, and which shall execute and enforce the provisions of this Act.

SEC. 2. (a) The provisions of this Act shall apply to all interstate and foreign communication by wire or radio and all interstate and foreign transmission of energy by radio, which originates and/or is received within the United States, and to all persons engaged within the United States in such communication or such transmission of energy by radio, and to the licensing and regulating of all radio stations as hereinafter provided; but it shall not apply to persons engaged in wire or radio communication or transmission in the Philippine Islands or the Canal Zone, or to wire or radio communication or transmission wholly within the Philippine Islands or the Canal Zone. . . .

SEC. 4 (a) The Federal Communications Commission (in this Act referred to as the "Commission") shall be composed of seven commissioners appointed by the President, by and with the advice and consent of the Senate, one of whom the President shall designate as chairman. . . .

SECTION 301. It is the purpose of this Act, among other things, to maintain the control of the United States over all the channels of interstate and foreign radio transmission; and to provide for the use of such channels, but not the ownership thereof, by persons for limited periods of time, under licenses granted by Federal authority, and no such license shall be construed to create any right, beyond the terms, conditions, and periods of the license. No person shall use or operate any apparatus for the transmission of energy or communications or signals by radio (a) from one place in any Territory or possession of the United States or in the District of Columbia to another place in the same Territory, possession, or District; or (b) from any State, Territory, or possession of the United States, or from the District of Columbia to any other State, Territory, or possession of the United States; or (c) from any place in any State, Territory, or possession of the United States, or in the District of Columbia, to any place in any foreign country or to any vessel; or (d) within any State when the effects of such use extend beyond the borders of said State, or when interference is caused by such use or operation with the transmission of such energy, communications, or signals from within said State to any place beyond its borders, or from any place beyond its borders to any place within said State, or with the transmission or reception of such energy, communications, or signals from and/or to places beyond the borders of said State; or (e) upon any vessel or aircraft of the United States; or (f) upon any other mobile stations within the jurisdiction of the United States, except under and in accordance with this Act and with a license in that behalf granted under the provisions of this Act.

SEC. 303. Except as otherwise provided in this Act, the Commission from time to time, as public convenience, interest, or necessity requires, shall—

(a) Classify radio stations;

(b) Prescribe the nature of the service to be rendered by each class of licensed stations and each station within any class;

(c) Assign bands of frequencies to the various classes of stations, and assign frequencies for each individual station and determine the power which each station shall use and the time during which it may operate;

(d) Determine the location of classes of stations or individual stations;

(e) Regulate the kind of apparatus to be used with respect to its external effects and the purity and sharpness of the emissions from each station and from the apparatus therein;

(f) Make such regulations not inconsistent with law as it may deem necessary to prevent interference between stations and to carry out the provisions of this Act: *Provided, however,* That changes in the frequencies, authorized power, or in the times of operation of any station, shall not be made without the consent of the station licensee unless, after a public hearing, the Commission shall determine that such changes will promote public convenience or interest or will serve public necessity, or the provisions of this Act will be more fully complied with;

(g) Study new uses for radio, provide for experimental uses of frequencies, and generally encourage the larger and more effective use of radio in the public interest; . . .

(j) Have authority to make general rules and regulations requiring stations to keep such records of programs, transmissions of energy, communications, or signals as it may deem desirable; . . .

(l) Have authority to prescribe the qualifications of station operators, to classify them according to the duties to be performed, to fix the forms of such licenses, and to issue them to such citizens of the United States as the Commission finds qualified;

(m) (1) Have authority to suspend the license of any operator upon proof sufficient to satisfy the Commission that the licensee—(A) has violated any provision of any Act, treaty, or convention binding on the United States, which the Commission is authorized to administer, or any regulation made by the Commission under any such Act, treaty, or convention; or (B) has failed to carry out a lawful order of the master or person lawfully in charge of the ship or aircraft on which he is employed; or (C) has willfully damaged or permitted radio apparatus or installations to be damaged; or (D) has transmitted superfluous radio communications or signals or communications containing profane or obscene words, language, or meaning, or has knowingly transmitted—

(1) false or deceptive signals or communications; or

(2) a call signal or letter which has not been assigned by proper authority to the station he is operating; or (E) has willfully or maliciously interfered with any other radio communications or signals; or (F) has obtained or attempted to obtain, or has assisted another to obtain or attempt to obtain, an operator's license by fraudulent means.

(2) No order of suspension of any operator's license shall take effect until fifteen days' notice in writing thereof, stating the cause for the proposed suspension, has been given to the operator licensee who may make written application to the Commission at any time within said fifteen days for a hearing upon such order. The notice

to the operator licensee shall not be effective until actually received by him, and from that time he shall have fifteen days in which to mail the said application. In the event that physical conditions prevent mailing of the application at the expiration of the fifteen-day period, the application shall then be mailed as soon as possible thereafter, accompanied by a satisfactory explanation of the delay. Upon receipt by the Commission of such application for hearing, said order of suspension shall be held in abeyance until the conclusion of the hearing which shall be conducted under such rules as the Commission may prescribe. Upon the conclusion of said hearing the Commission may affirm, modify, or revoke said order of suspension.

(n) Have authority to inspect all radio installations associated with stations required to be licensed by any Act or which are subject to the provisions of any Act, treaty, or convention binding on the United States, to ascertain whether in construction, installation, and operation they conform to the requirements of the rules and regulations of the Commission, the provisions of any Act, the terms of any treaty or convention binding on the United States, and the conditions of the license or other instrument of authorization under which they are constructed, installed, or operated.

(o) Have authority to designate call letters of all stations;

(p) Have authority to cause to be published such call letters and such other announcements and data as in the judgment of the Commission may be required for the efficient operation of radio stations subject to the jurisdiction of the United States and for the proper enforcement of this Act; . . .

(q) Have authority to require the painting and/or illumination of radio towers if and when in its judgment such towers constitute, or there is a reasonable possibility that they may constitute, a menace to air navigation.

(r) Make such rules and regulations and prescribe such restrictions and conditions, not inconsistent with law, as may be necessary to carry out the provisions of this Act, or any international radio or wire communications treaty or convention insofar as it relates to the use of radio, to which the United States is or may hereafter become a party

SEC. 309. (a) If upon examination of any application for a station license or for renewal or modification of a station license the Commission shall determine that public interest, convenience, or necessity would be served by the granting thereof, it shall authorize the issuance, renewal, or modification thereof in accordance with said finding. In the event the Commission upon examination of any such application does not reach such decision with respect thereto, it shall notify the applicant thereof, shall fix and give notice of a time and place for hearing thereon, and shall afford such applicant an opportunity to be heard under such rules and regulations as it may prescribe.

SEC. 318. The actual operation of all transmitting apparatus in any radio station for which a station license is required by this Act shall be carried on only by a person holding an operator's license issued hereunder. No person shall operate any such apparatus in such station except under and in accordance with an operator's license issued to him by the Commission.

SEC. 321. . . . (b) All radio stations, including Government stations and stations on board foreign vessels when within the territorial waters of the United States, shall give absolute priority to radio communications or signals relating to ships in distress; shall cease all sending on frequencies which will interfere with hearing a radio communication or signal of distress, and, except when engaged in answering or aiding the ship in distress, shall refrain from sending any radio communications or signals until there is assurance that no interference will be caused with the radio communications or signals relating thereto, and shall assist the vessel in distress, so far as possible, by complying with its instructions.

SEC. 324. In all circumstances, except in case of radio communications or signals relating to vessels in distress, all radio stations, including those owned and operated by the United States, shall use the minimum amount of power necessary to carry out the communication desired.

SEC. 325. (a) No person within the jurisdiction of the United States shall knowingly utter or transmit, or cause to be uttered or transmitted, any false or fraudulent signal of distress, or communication relating thereto, nor shall any broadcasting station rebroadcast the program or any part thereof of another broadcasting station without the express authority of the originating station. . . .

SEC. 326. Nothing in this Act shall be understood or construed to give the Commission the power of censorship over the radio communications or signals transmitted by any radio station, and no regulation or condition shall be promulgated or fixed by the Commission which shall interfere with the right of free speech by means of radio communication. No person within the jurisdiction of the United States shall utter any obscene, indecent, or profane language by means of radio communication.

SEC. 501. Any person who willfully and knowingly does or causes or suffers to be done any act, matter, or thing, in this Act prohibited or declared to be unlawful, or who willfully and knowingly omits or fails to do any act, matter, or thing in this Act required to be done, or willingly and knowingly causes or suffers such omission or failure, shall, upon conviction thereof, be punished for such offense, for which no penalty (other than a forfeiture) is provided herein, by a fine of not more than $10,000 or by imprisonment for a term of not more than two years or both.

SEC. 502. Any person who willfully and knowingly violates any rule, regulation, restriction, or condition made or imposed by the Commission under authority of this Act, or any rule, regulation, restriction, or condition made or imposed by any international radio or wire communications treaty or convention, or regulations annexed thereto, to which the United States is or may hereafter become a party, shall, in addition to any other penalties provided by law, be punished, upon conviction thereof, by a fine of not more than $500 for each and every day during which such offense occurs.

SEC. 605. No person receiving or assisting in receiving, or transmitting, or assisting in transmitting, any interstate or foreign communication by wire or radio shall divulge or publish the existence, contents, substance, purport, effect, or meaning thereof, except through authorized channels of transmission or reception, to any person other than the addressee, his agent, or attorney, or to a person employed or authorized to forward such communication to its destination, or to proper accounting or distributing officers of the various communicating centers over which the communication may be passed, or to the master of a ship under whom he is serving, or in response to a subpoena issued by a court of competent jurisdiction, or on demand of other lawful authority; and no person not being authorized by the sender shall intercept any communication and divulge or publish the existence, contents, substance, purport, effect, or meaning of such interpreted communication to any person; and no person not being entitled thereto shall receive or assist in receiving any interstate or foreign communication by wire or radio and use the same or any information therein contained for his own benefit or for the benefit of any other not entitled thereto; and no person having received such intercepted communication or having become acquainted with the contents, substance, purport, effect, or meaning of the same or any part thereof, knowing that such information was so obtained, shall divulge or publish the existence, contents, substance, purport, effect, or meaning of the same or any part thereof, or use the same or any information therein contained for his own benefit or for the benefit of another not entitled thereto: *Provided*, That this section shall not apply to the receiving, divulging, publishing, or utilizing the contents of any radio communication broadcast, or transmitted by amateurs or others for the use of the general public or relating to ships in distress.

SEC. 606. . . . (c) Upon proclamation by the

President that there exists war or a threat of war or a state of public peril or disaster or other national emergency, or in order to preserve the neutrality of the United States, the President may suspend or amend, for such time as he may see fit, the rules and regulations applicable to any or all stations within the jurisdiction of the United States as prescribed by the Commission, and may cause the closing of any station for radio communication and the removal therefrom of its apparatus and equipment, or he may authorize the use or control of any such station and/or its apparatus and equipment by any department of the Government under such regulations as he may prescribe, upon just compensation to the owners.

IX. TYPICAL EXAMINATION QUESTIONS AND THEIR ANSWERS

The Federal Communications Commission has prepared a reservoir of some several hundred questions for the amateur examination. After you have successfully passed your code test, a group of these questions will be selected from the reservoir and you must make a grade of 75 per cent or higher; otherwise you must wait at least two months from the date of the examination and attempt the examination again.

The questions are changed from time to time to keep pace with revisions in the regulations and with technical progress. However, the applicant can be sure of receiving one question from each of the following ten general classes: Transmitter Theory; Transmitter Practice; Radiotelephony; Power Supplies; Frequency Measurement; Treaty and Laws; F.C.C. Regulations, Bands; F.C.C. Regulations, Part I; F.C.C. Regulations, Part II; Penalties.

The questions given in this chapter are typical of those asked in the examination, and the answers are generally representative of what the F.C.C. expects. The answers given here are not *necessarily* the *only* correct answers, especially as regards the technical questions. Neither do we guarantee that all of the answers given would command a "100% correct" grading from the Commission, because on some questions it may be a matter of opinion as to whether a certain answer is 100% correct or just "substantially correct." You may be assured, however, that if you can answer all of the questions given here and have a pretty good idea as to why each answer is correct, you need have no fear of failing to make a passing grade.

If you have difficulty in understanding why the answer to a particular technical question is correct, more study of the theory applying to that question is indicated. A more comprehensive treatment of elementary electricity and radio theory than is given in this booklet may be found in the RADIO HANDBOOK. Most city libraries have this book, and it is available from most large radio parts stores.

> The FCC cannot answer inquiries from candidates who have taken an examination as to what grade they made, or what was the matter with their answers if they did not pass. The large number of candidates makes this impossible.

Transmitter Theory

1. Draw a simple schematic circuit diagram showing a self-excited vacuum tube oscillator using a single tube, and briefly explain its operation.

A series fed Hartley oscillator circuit is shown in figure 1. Alternating current is applied to the heater of the tube, causing it to become heated to such an extent that the cathode or emitter of the tube is raised to such a temperature that it will emit an ample supply of electrons. When a supply of high voltage is applied to the terminals "B" positive and negative, the first surge of current from the cathode to the plate due to the applied plate potential passes through the turns on the coil L from the tap to the plate of the tube. This surge of current causes an electromagnetic field to be set up in the vicinity of the coil which, in turn, causes a voltage to be induced in the portion of the coil from the tap to the grid end. This induced grid voltage acts to increase the original change in plate current. The coil and condenser C have a *resonant* frequency, the same as a pendulum, spring, or vibrating reed. This initial surge sets the tank circuit in oscillation, each oscillation occurring at greater amplitude due to the amplifying properties of the tube, until the circuit losses and any external load cause a state of equilibrium to be reached. The frequency of oscillation is determined primarily by the resonant frequency of the coil-condenser combination LC, although variations in plate voltage, filament voltage and loading can change the frequency of oscillation by an amount determined by the design of the oscillator. On part of each cycle the grid swings positive with respect to the cathode. The grid is maintained at a proper average negative potential (bias) with respect to the filament by the action of its rectified d.c. grid current passing through the grid leak R. The grid condenser C_2 serves to isolate the grid as far as direct current is concerned but at the same time to couple the radio frequency excitation voltage from the tank circuit to this element.

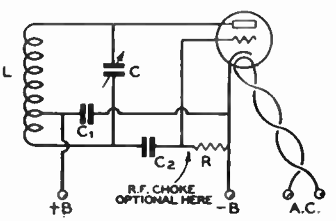


Figure 1.

2. Draw a simple schematic circuit diagram showing a self-excited vacuum tube oscillator using two vacuum tubes in push-pull arrangement, and briefly explain its operation.

A push-pull tuned-plate tuned-grid oscillator is shown in figure 2. When the cathodes of the two tubes are heated to operating temperature and positive voltage is applied to the plates, there is a current flow from the cathodes to the plates. The grid coil, L_1, is tuned by condenser C_1 approximately to the same frequency as the plate tank L_2C_2. Any minute disturbance within either of the tubes will cause the plate voltage at that tube to change a small amount and, due to the coupling of the tuned circuit, will

CORNELL-

DYKANOL TRANSMITTING CAPACITORS—Type TJU

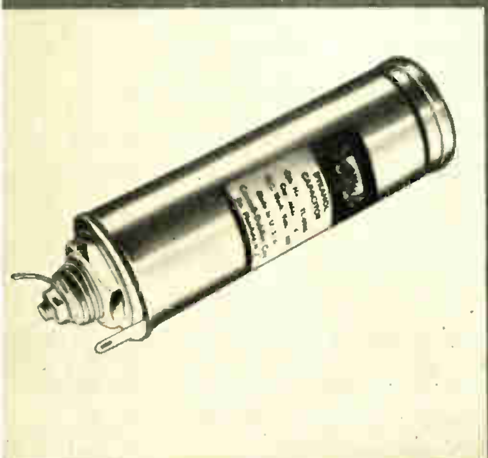
C-D Dykanol Transmitting Filter Capacitors Type TJU are without doubt the most dependable units offered to the radio trade—amateur, broadcast and commercial. Beautifully designed, compact, light-weight, safely rated, furnished with universal mounting clamp, well-insulated terminals, fireproof. These are the capacitors which practically every broadcast and government station in the world uses with such marked success. STANDARD EQUIPMENT WITH TENS OF THOUSANDS OF AMATEURS. FULLY GUARANTEED.

CAT. NO.	Capacity Mfd.	Working Voltage	Net Price
TJU- 6020	2	600 volts D.C.	$2.55
TJU- 6040	4	600 volts D.C.	3.30
TJU-10020	2	1000 volts D.C.	3.00
TJU-10040	4	1000 volts D.C.	3.75
TJU-15020	2	1500 volts D.C.	3.75
TJU-15040	4	1500 volts D.C.	5.10
TJU-20020	2	2000 volts D.C.	3.90
TJU-20040	4	2000 volts D.C.	5.40
TJU-30020	2	3000 volts D.C.	9.00
TJU-30040	4	3000 volts D.C.	13.20

CYLINDRICAL CAN CAPACITORS—Type TQ

Cornell-Dubilier Type TQ Dykanol Capacitors, in cylindical aluminum containers are provided with two insulated terminals and universal mounting bracket for mounting the unit in any position with terminals either above or below a subpanel assembly. These units are designed primarily for filter circuits in amateur, low-power broadcast and commercial transmitters. They are also adapted for high-power, high-fidelity public address systems and portable power amplifiers.

CAT. NO.	Capacity Mfd.	Working Voltage	Net Price
TQ- 6020	2	600 volts D.C.	$1.95
TQ- 6040	4	600 volts D.C.	2.70
TQ-10010	1	1000 volts D.C.	1.65
TQ-10020	2	1000 volts D.C.	2.25
TQ-10040	4	1000 volts D.C.	2.85
TQ-15010	1	1500 volts D.C.	2.10
TQ-15020	2	1500 volts D.C.	2.85
TQ-20010	1	2000 volts D.C.	2.70
TQ-20020	2	2000 volts D.C.	3.00



DYKANOL FILTER CAPACITORS—Type TLA

Solving the need for a compact high-voltage filter capacitor to use with high-fidelity P. A. amplifiers, power supplies for short-wave portable transmitters and transceivers, Type TLA Dykanol Filter Units in cylindrical aluminum containers are ideal in every respect. One terminal is well insulated, the other being the metal can itself. Substantially made, will withstand transient voltages as well as high-peak voltage surges. Designed to operate for continuous, full-load duty.

CAT. NO.	Capacity Mfd.	Working Voltage	Net Price
TLA- 6020	2	600 volts D.C.	$1.65
TLA- 6040	4	600 volts D.C.	2.25
TLA-10020	2	1000 volts D.C.	1.95

X-MITTING C

DUBILIER

MICA X-MITTING-RECEIVING CAPACITORS— Type 4 and Type 9

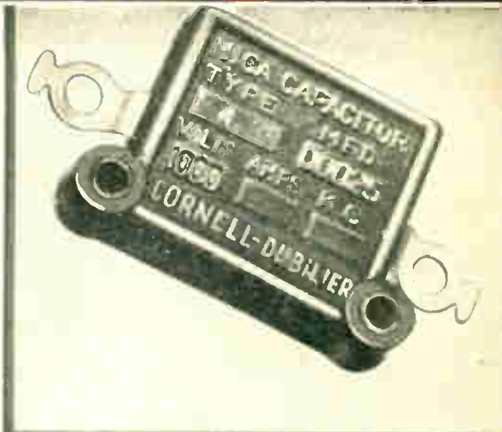
For radio frequency bypass high voltage D. C. blocking, low power tank capacitors, padders, coupling functions, audio and video purposes. Finest quality India ruby mica—select foil and the exclusive C-D stack assembly. Safe, dependable voltage ratings. Hermetically encased in rich brown bakelite, beautifully moulded.

TYPE 4

CAT. NO.	Capacity Mfd.	Test Voltage	New Price	CAT. NO.	Capacity Mfd.	Test Voltage	Net Price
4-14050	.00005	1000 volts D.C.	$0.30	4-22050	.005	2500 volts D.C.	1.05
4-13010	.0001	1000 volts D.C.	.30	4-21010	.01	2500 volts D.C.	1.68
4-12010	.001	1000 volts D.C.	.30	4-54050	.00005	5000 volts D.C.	.54
4-12060	.006	1000 volts D.C.	.51	4-53025	.00025	5000 volts D.C.	.63
4-11010	.01	1000 volts D.C.	.69	4-53050	.0005	5000 volts D.C.	.75
4-11020	.02	1000 volts D.C.	.93	4-52010	.001	5000 volts D.C.	.90
4-24050	.00005	2500 volts D.C.	.42	4-52020	.002	5000 volts D.C.	1.35
4-22010	.001	2500 volts D.C.	.54	4-52050	.005	5000 volts D.C.	2.10
4-22020	.002	2500 volts D.C.	.61				

TYPE 9

9-14050	.00005	1000 volts D.C.	$0.36	9-23050	.0005	2500 volts D.C.	.43
9-13025	.00025	1000 volts D.C.	.36	9-22010	.001	2500 volts D.C.	.54
9-12010	.001	1000 volts D.C.	.36	9-22020	.002	2500 volts D.C.	.81
9-12020	.002	1000 volts D.C.	.39	9-21010	.01	2500 volts D.C.	1.68
9-12050	.005	1000 volts D.C.	.51	9-54050	.00005	5000 volts D.C.	.54
9-12060	.006	1000 volts D.C.	.60	9-53025	.00025	5000 volts D.C.	.63
9-11010	.01	1000 volts D.C.	.84	9-52010	.001	5000 volts D.C.	.90
9-11050	.05	1000 volts D.C.	2.31	9-52020	.002	5000 volts D.C.	1.35
9-24050	.00005	2500 volts D.C.	.43	9-52050	.005	5000 volts D.C.	2.04
9-23010	.0001	2500 volts D.C.	.42	9-51010	.01	5000 volts D.C.	2.46
9-23025	.00025	2500 volts D.C.	.42				



AMATEUR MICA X-MITTING CAPACITORS—Type 86

C-D Type 86 Mica Capacitors in dehydrated porcelain cases have been designed for amateur radio communication, 'fone, CW and ICW, for plate blocking, grid, buffer, tank, and antenna coupling purposes. Widely imitated, copied, but never duplicated, these patented-construction units are serving in thousands of "ham" rigs with greatest efficiency.

CAT. NO.	Capacity Mfd.	Maximum D.C. Voltage	Net Price
31A -86	.0001	12,500	$2.25
325A-86	.00025	12,500	2.25
35A -86	.0005	12,500	2.55
35C -86	.0005	7,000	2.25
21A -86	.001	12,500	3.00
21C -86	.001	7,000	2.55
215A-86	.0015	12,500	3.30
22A -86	.002	12,500	3.90
22C -86	.002	7,000	3.15
25B -86	.005	10,000	5.70
11C -86	.01	7,000	5.70

For complete listing and description of Cornell-Dubilier, Capacitors, Capacitor Test Instruments and Quietone Interference Filters send for Catalog No. 1754, Cornell-Dubilier Electric Corp., So. Plainfield, New Jersey.

CAPACITORS

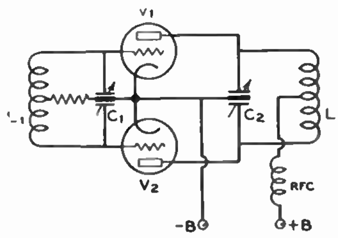


Figure 2.

cause the plate voltage of the opposite tube to change a small amount in the *opposite* direction. This small change in potential will be coupled back through the plate-to-grid capacity within each tube to the grid of that tube. The resonant grid coil offers high impedance to r.f. voltage of the frequency determined by the plate tank, and a voltage which tends to aid the original change in plate current will be developed upon the grid of each tube due to electrostatic feed-back within each tube. This process continues, due to the amplifying action of the tube, until steady-state oscillation is developed. The amplitude of oscillation is determined by grid-bias loss and loss due to external load. Grid bias is developed across the resistor R due to the rectified grid current of the two tubes. No grid condenser is required because both ends of the grid leak are at zero r.f. potential; the r.f. current flows from one grid to the other rather than to ground.

3. Draw a simple schematic circuit diagram showing a satisfactory method of coupling the output of a transmitter to an antenna system, and briefly explain its operation.

A link-coupled circuit for coupling the output of the transmitter to the antenna circuit is shown in figure 3. One end of the link is wound around the center of the plate coil of the final amplifier, where it has a current induced in it due to the magnetic field existing in the vicinity of this coil. The other end of the link is wound around the antenna coupling coil. Due to the current flowing in the link a field is set up at the antenna-coil end of the circuit. When the antenna circuit is tuned to resonance with the frequency of the transmitter, an amount of energy is coupled from the transmitter to the antenna circuit which is a function of the coupling at each end of the link and also the loading of the feeders or antenna. The untuned feeders to the antenna system are then tapped onto the antenna coil an equal number of turns each side of the grounded center until the proper amount of loading of the transmitter is obtained. Because of the selectivity of the resonant antenna tank circuit, harmonics are greatly attenuated.

4. Draw a simple schematic circuit diagram showing series plate feed to a vacuum tube oscillator, and briefly explain its operation.

The oscillators illustrated in both figure 1 and figure 2 employ series plate feed. When series plate feed is employed in an oscillator or an amplifier the direct current plate supply to the plate of the tube is connected to a point of low or zero r.f. potential on the plate coil, and the d.c. plate current flows through the plate coil. An r.f. choke is not always necessary with series plate feed.

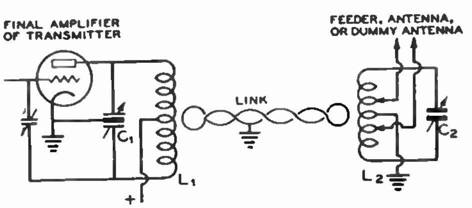


Figure 3.

5. Draw a simple schematic circuit diagram showing shunt plate feed to a vacuum tube oscillator, and briefly explain its operation.

A modification of the Hartley oscillator of figure 1 for shunt plate feed is shown in figure 4. In this case the direct current plate power to the plate of the oscillator tube is fed through an r.f. choke, RFC, which has a high impedance to the frequency of oscillation of the tube. The blocking condenser C serves to couple the r.f. energy between the tank circuit and the plate of the tube while at the same time isolating the d.c. voltage of the plate supply from the tank coil. As the latter is at filament potential, there would be a direct short across the power supply if the blocking condenser were not used.

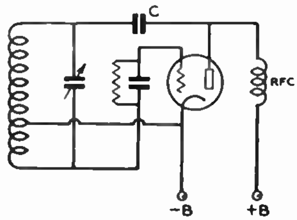


Figure 4.

6. Draw a simple schematic circuit diagram showing grid-return connection to the center tap of the filament transformer, and briefly explain its operation.

The effective (average) potential of the filament of a filamentary type tube with respect to the grid and plate is the same as the potential at the exact center of the filament. When using alternating current to heat the filament of the tube, there will be a small a.c. voltage impressed upon the grid if the grid return is made to one side of the filament. The grid return cannot very well be connected to the mid point on the filament of the tube, but the same effect may be accomplished by connecting it to a center tap on the filament winding of the filament heating transformer, as the mid point of the filament winding is always at the same potential as the mid point of the filament (figure 5). Under these conditions there can be no a.c. modulation impressed upon the grid by the a.c. filament supply. Because the filament winding does not offer a low impedance path for r.f. currents flowing to the filament, the two halves are bypassed with condensers.

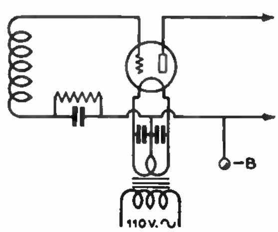


Figure 5.

EXTRA

Special offer to new subscribers. 5 big issues of "RADIO" for $1.00! (U. S. A. only)

Amateur News

Send Stamp for Free Catalog of Publications by the Editors of RADIO

THE WORLDWIDE AUTHORITY OF AMATEUR AND SHORTWAVE RADIO

RADIOMEN THE WORLD OVER PREFER "RADIO"

After twenty-three years of authoritative, accurate and reliable service to radiomen, "Radio" magazine is today the acknowledged world-wide technical authority of amateur, shortwave, and experimental endeavor.

"Radio"

Here is a magazine written by practical engineers and active amateurs of many years experience. Its profusely illustrated pages sparkle with easy-to-understand, unbiased and authoritative information that you will enjoy!

CONTAINS DOZENS OF OUTSTANDING ARTICLES

Dozens of articles by such great technical writers as W. W. Smith, W6BCX; Ray L. Dawley, W6DHG; Leigh Norton, W6-CEM. Outstanding features such as "U. H. F." by E. H. Conklin, W9BNX — and several departments including Herb Becker's famous "DX and Overseas News." As "Radio" pays for accepted technical and constructional material, it publishes the "cream of the crop" from outside authors.

YEARLY SUBSCRIPTION RATES ARE LOW!

The yearly subscription rate to "Radio" is only $2.50 in U. S. A., Canada, Newfoundland, Cuba and Mexico. Other Pan-American countries and Spain—$3.00. Elsewhere $3.50.

DON'T DELAY—SUBSCRIBE TODAY!

THE EDITORS OF RADIO *technical publishers*

1300 Kenwood Road, Santa Barbara
CALIFORNIA

7. Draw a simple schematic circuit diagram showing grid-return connection to the electrical center of the filament circuit where the filament heating transformer has no center tap, and briefly explain its operation.

A center tap on a filament transformer may be simulated by connecting across the filament leads as in figure 6 a resistor, usually 10 to 50 ohms, having a tap at its exact electrical center.

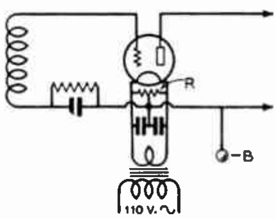


Figure 6.

The resistance is high enough that the filament voltage does not cause heavy current to flow through the resistor, yet low enough that there will not be an appreciable voltage drop as a result of plate current flowing through it. The tap is at the same potential as the mid point of the filament regardless of whether d.c. or a.c. is applied to the filament, and therefore no a.c. voltage will be impressed upon the grid when the grid return is made to the mid point of the filament resistor as shown in figure 6.

8. Draw a simple schematic circuit diagram showing the employment of a grid leak bias on a simple vacuum tube oscillator, and briefly explain its operation.

The circuit is given in figure 1. The radio frequency voltage on the grid causes the grid to swing positive with respect to the cathode over part of each r.f. cycle. When the grid is swung positive, electrons are attracted to it and the only way they can get back to the cathode is through the resistor R, because no d.c. can flow through C_2. The steady flow of rectified grid current through R causes a d.c. potential to be developed across R, the voltage being equal to the current in amperes times the resistance in ohms. The current through R will always be in such a direction that the grid is biased negative with respect to the cathode.

9. Draw a simple schematic circuit diagram showing a method for measuring the plate power input to a vacuum tube oscillator, and briefly explain its operation.

The diagram of figure 7 shows how a voltmeter and milliammeter are connected so as to measure the power input to a vacuum tube oscillator. The product of the voltage and the current in amperes gives the plate input in watts. The milliammeter reading must be divided by 1000 to give the current in amperes. Placing the milliammeter in the negative lead minimizes the danger of shock, but is not practicable where the power supply feeds more than one stage.

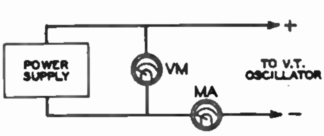


Figure 7.

10. Draw a simple schematic circuit diagram showing a method of preventing key clicks when keying a simple vacuum tube oscillator, and briefly explain its operation.

The Hartley oscillator shown in figure 8 is keyed in the center tap, with the grid return made to the negative high voltage side of the key. This method of keying effectively breaks the negative high voltage yet produces very little spark at the key due to the grid blocking effect when the grid leak is returned to negative B instead of to the filament center tap.

To prevent the remaining small spark from being radiated to nearby receivers and to introduce a small amount of lag in the keying circuit in order to avoid keying impacts due to too sudden application and cessation of power to the oscillator, a key thump filter consisting of L, R, and C is incorporated as shown in the diagram. The self-inductance of the choke L causes it to oppose any change in current, and when the key is closed it takes a very small fraction of a second for the plate current to reach its full value. This permits the oscillator to break into oscillation at a relatively low plate voltage and build up to full strength instead of starting out instantly at full amplitude. This prevents shock excitation of the antenna.

When the key is opened, the reverse is true; the energy stored in L permits the current to die out instead of ceasing abruptly. The energy stored in L will tend to make an arc at the key contacts when the key is opened; this is absorbed by the condenser C. The series resistor R prevents the energy absorbed by C from being dissipated too rapidly when the key is closed again.

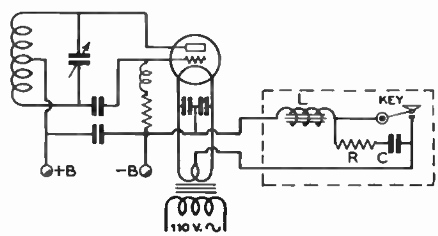


Figure 8.

If L, R, and C are proportioned correctly, there will be no objectionable keying tails, thumps, or arcing at the key.

11. Draw a simple schematic circuit diagram showing electro-magnetic feedback in a simple vacuum tube oscillator, and briefly explain its operation.

The Hartley oscillator shown in figure 1 utilizes electromagnetic feedback to obtain regeneration. Refer to the answer for question 1.

12. Draw a simple schematic circuit diagram showing a filter for preventing keying clicks or thumps, and briefly explain its operation.

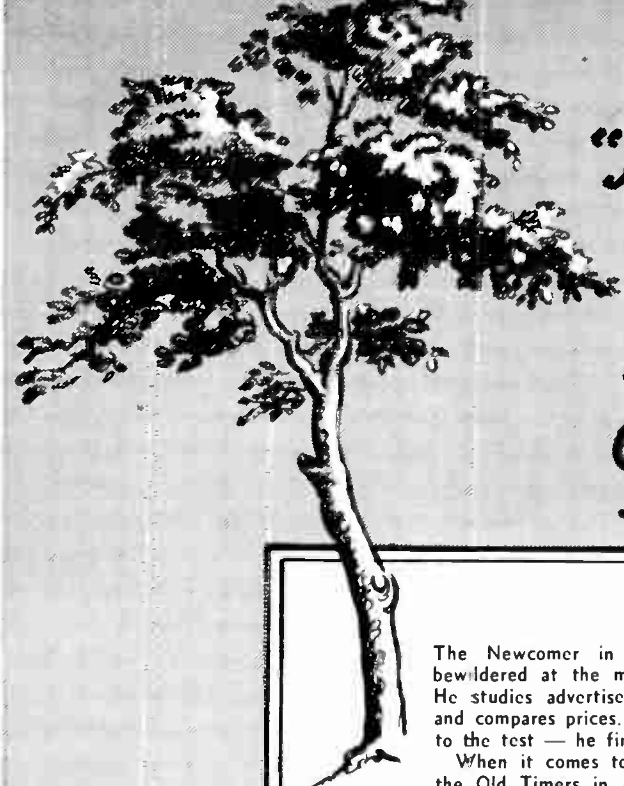
The portion of figure 8 included in the dotted enclosure constitutes a key click filter. Refer to the answer for question 10.

13. Draw a simple schematic circuit diagram showing a tuned-grid-tuned-plate vacuum tube oscillator, and briefly explain its operation.

The push-pull oscillator of figure 2 and described in answer 2 is a tuned-grid-tuned-plate oscillator.

14. Draw a simple schematic circuit diagram showing electromagnetic coupling between two tuned circuits to transfer energy from one to the other, and briefly explain its operation.

Refer to question 3 and figure 2. Power is transferred from the plate circuit of the amplifier to the antenna circuit by magnetic coupling.



"As the Twig is Bent So the Tree Inclines"

The Newcomer in Amateur Radio is often amazed and bewildered at the many conflicting claims of manufacturers. He studies advertisements and catalogs. He checks ratings and compares prices. When he buys — and puts the product to the test — he finds where he has made the error.

When it comes to transformers — Don't be misled! Ask the Old Timers in Amateur Radio; check to ascertain what transformers are specified in such outstanding equipment as The Hallicrafters, Temco, Browning, R.E.L., Harvey, etc. Ask yourself why it is that every leading Arctic, Antarctic, and Tropical Expedition in the past 10 years has depended upon KENYON for reliable performance!

Early in your career in Amateur Radio determine to *Start right* — and you'll be right for life. You'll soon learn that the lowest price does not always determine the best value — but that despite price — KENYON *always* DELIVERS VALUE!

START *RIGHT* with transformers that never grow obsolete.

KEN-O-TAP MODULATION TRANSFORMERS
ANY TUBE TO ANY LOAD. NEVER OBSOLETE

CLASS "C"

TYPE	AUDIO OUTPUT	LOAD	NET
T-489	15 watts	30 watts	2.40
T-493	40 watts	80 watts	3.60
T-494	75 watts	150 watts	5.40
T-495	125 watts	250 watts	12.00

AMATEUR PLATE TRANSFORMERS

TYPE	D. C. VOLTS	D. C. MILLS	NET
T-668	500/750	300	5.85
T-669	1000/1250	300	9.60
T-670	1500/1750/2000	300	12.90

FREE Catalog Now Ready . . . Get yours at once. Our Hammanual is ready — Send 10c to cover cost of handling and mailing.

(If Your Jobber Cannot Supply—Transformers Will Be Mailed Prepaid Anywhere in the U.S.A. at Amateur Net Prices.)

KENYON TRANSFORMER CO., Inc.

840 BARRY ST., NEW YORK, N. Y.

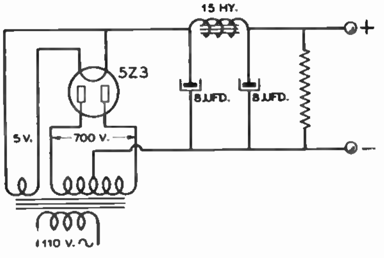
Export Department: 25 Warren St., New York, N. Y.

15. Draw a simple schematic circuit diagram showing a dummy or phantom (non-radiating) antenna, coupled to a transmitter output for testing purposes, and briefly explain its operation.

The circuit is shown in figure 3. A non-inductive resistor such as a lamp bulb of suitable wattage rating is connected an equal number of turns each side of the center tap of L_2. The more turns the resistor is clipped across, the greater will be the loading on the amplifier. The loading can also be varied by adjusting the coupling of the link circuit. Thus the resistor simulates a regular antenna load, yet does not radiate appreciably.

16. Draw a simple schematic circuit diagram showing a satisfactory rectifier-filter power supply, and briefly explain its operation.

A small power supply is diagrammed in figure 9. The power transformer has two secondaries, one a 5-volt winding to heat the filament of the rectifier tube, and a high voltage, center tapped winding which makes each plate of the rectifier



tube alternately positive with respect to the filament. When either of the plates is positive (which would occur 120 times a second with 60 cycle supply) current flows between the filament and that plate, the voltage drop being very low.

Thus there is impressed upon the filter a voltage varying in amplitude but constant in polarity, because the rectifier passes current only in one direction (electrons cannot flow from the plate to filament).

The filter possesses a time lag and is capable of storing energy. The condensers resist any change in voltage and the iron core choke resists any change in the strength of the current. Because of these characteristics of the filter, the pulsating output of the rectifier is ironed out into almost pure direct current, having an almost imperceptible ripple voltage superimposed upon it. The bleeder resistor across the filter output stabilizes the load on the power supply and speeds up the discharge of the filter condensers when the external load is removed and the supply is turned off.

Transmitter Practice

1. Explain why a high ratio of capacity to inductance in the tank circuit of a self-excited transmitter improves frequency stability.

There are two reasons why a high ratio of capacity to inductance in an oscillator tank will improve its stability. First, the high value of tank capacity reduces the percentage variation in total circuit capacity which can be caused by variations in tube interelectrode capacities due to heating in the tube. Second the sharpness of resonance or Q of the oscillator tank is primarily determined by the capacity-to-inductance ratio in the circuit. A high capacity-to-inductance ratio gives a high circuit Q and makes the frequency of the oscillator less dependent upon plate voltage, oscillator loading, and variations in electrical constants within the tube.

2. What precautions must be taken in the adjustment of a vacuum tube transmitter to prevent the emission of harmonics?

The output tank circuit in the transmitter should have high enough capacity-to-inductance ratio that the circuit Q will be satisfactory for the plate voltage-to-plate current ratio on the amplifier. Coupling to the antenna circuit should be relatively loose and neither bias nor excitation should be greater than required for good efficiency.

3. Explain how you would determine whether your transmitter was radiating harmonics.

The most satisfactory method of determining for sure whether or not your transmitter is radiating harmonics is to enlist the aid of another amateur a mile or so from your location and have him listen over the range above your transmitter frequency. Especial attention should be given to the frequency which is three times the output frequency of the transmitter. A well shielded receiver or monitor with a small antenna may be used at a distance of a few blocks to make the check if the aid of another amateur is not available.

4. Explain how keying clicks may be eliminated, stating what auxiliary apparatus is required and how it is adjusted.

Key clicks may be eliminated when keying the center tap of an oscillator or an amplifier through the use of a properly adjusted key-click filter. This filter may consist of a variable-gap choke of about 5 henries placed in series with the keying circuit, and a condenser of from 0.1 to 0.5 µfd. with a variable resistor of about 500 ohms in series placed across the contacts of the key. The air gap of the choke and the resistance of the variable resistor are varied for minimum arcing at the key contacts and least key thump without putting excessive "tails" on the characters.

5. What might happen to change the frequency of a transmitter since it was last operated, and how would you detect such a change before again engaging in radio communication?

If the transmitter is crystal controlled, it is possible that the crystal may have ceased oscillation, may have shifted to another peak, or may have drifted outside the band due to a change in temperature. Also, it might be possible that the adjustment of a neutralizing condenser had been touched, allowing one of the stages of the transmitter to self-oscillate. If the transmitter is self-excited it is possible that the adjustment of the frequency determining circuit had been shifted accidentally, that a coil or condenser had been damaged mechanically, or that the characteristics of a tube had changed. Such a change could be detected by checking the frequency of the transmitter with a frequency meter.

6. Suppose your self-excited transmitter erratically shifts frequency during operation. Name at least three possible causes.

Erratic frequency shift in a self-excited transmitter could be caused by a defective power supply, a faulty oscillator tube, a loose connection in the wiring of the oscillator circuit, a defective component, or a disturbance in the antenna system which would be coupled back into the transmitter.

7. Describe a method of voltage feed to a Hertz antenna.

A common method of voltage feeding a Hertz antenna is by means of a two-wire tuned transmission line commonly called a zeppelin feeder. At the upper extremity of the feeder one side is connected to the end of the antenna, the other side of the feeder is left to float free. The transmitter end of the feeders terminates in a tuning condenser and coil, the coil of which is inductively coupled to the output tank of the transmitter.

Another method of voltage feeding a Hertz antenna is through a coil-condenser circuit which is parallel resonant to the operating frequency and which is coupled to the output of the transmitter. Either one side or the center of the

BEFORE BUILDING *(or rebuilding)* YOUR RIG

Maximum Efficiency and Flexibility in any circuit

SEE THESE JOHNSON UNITS!

A Message to the Newcomer

At no time in your experience as a radio amateur is the choice of your equipment so important as the first outfit you assemble. It MUST have good parts to give you good results — and that means JOHNSON parts, known all over the world for recognized high quality. Ask your Jobber (or write to us) for catalog 966KN, showing condensers, Inductors, Tube Sockets, Insulators, Plugs and Jacks, "Q" Antenna, and general antenna materials.

★ *We'll gladly help you with your problems, too, if you'll write us.*

JOHNSON CONDENSERS

Known for their fine precision workmanship and superior materials, Johnson Condensers are chosen everywhere by exacting buyers because they meet requirements in every respect. Hundreds are used daily in commercial and amateur transmitters, diathermy equipment, etc. There is a Johnson size and type no matter what you need from the tiny Type J (small enough to fit inside Johnson Tube Socket Inductor) to the big Type C available in spacings to handle more than a full kilowatt.

JOHNSON INDUCTORS

Many new improvements feature Johnson Inductors such as low loss, heat and moisture proof high grade porcelain forms, integral coupling coil for feeding both high and low impedance lines, and proper inductance to insure minimum harmonic output. Two sizes are available rated at 1,000 watts and 350 watts input respectively. Also Tube Socket types for exciter and low power amplifier stages rated at 100 watts input.

E. F. JOHNSON CO.

WASECA, MINNESOTA

EXPORT: 25 WARREN ST., NEW YORK, N. Y.

"MANUFACTURERS OF RADIO TRANSMITTING EQUIPMENT"

tuned coil is grounded and the antenna is connected to a high potential point on the coil.

8. What are the advantages of an oscillator-amplifier type transmitter over a self-excited oscillator?

The frequency stability of an oscillator-amplifier transmitter is very much better than that of a self-excited transmitter since all the conditions which affect the amplifier such as antenna swinging, plate-voltage changes due to keying or power supply ripple, and heavy loading are isolated from the oscillator, which is the frequency determining portion of the transmitter. An amplifier may be operated at higher efficiency and at greater input than an oscillator. An amplifier may be keyed or modulated without causing bad chirps or frequency modulation.

9. If you were operating on 3700 kc. and received notice that you were interfering with commercial service on 11,100 kc. what trouble in your transmitter would it indicate, and what would you do about it?

11,100 is the third harmonic of 3700 kc.; hence it would indicate that the transmitter was radiating a strong third harmonic. The capacity-to-inductance ratio in the output tank circuit should be increased, antenna coupling should be loosened, and preferably an antenna coupling system should be installed which discriminates against harmonics. Excitation and grid bias to the final amplifier could be decreased, an antenna which discriminates against odd harmonics could be installed or a trap tuned to the third harmonic could be inserted in the feeder system.

10. Describe, giving dimensions, a suitable antenna system for operation in the amateur band in which you are chiefly interested.

The answer to this question will vary with the individual preferences of the individual taking the examination. Many excellent antenna systems are described in the RADIO HANDBOOK. The antenna system which is finally decided upon should be described in a manner similar to the following sample answers:

(A) The antenna system will consist of a 130-foot horizontal wire the extremity of which is brought in to the transmitter. On 160 meters the wire will be series tuned as a Marconi against a ground system consisting of a buried metal plate and a series of ground radials. On 80-meter c.w. it will be operated as an end-fed Hertz to be voltage fed by a tuned tank inductively coupled to the transmitter. On the higher frequency bands it will be harmonically operated as a long wire to be voltage fed by a tuning system similar to that used on the 80-meter band.

(B) The antenna system for use on the 28-Mc. phone band will consist of a three-element close-spaced rotary array incorporating a parasitically excited director and reflector. The reflector will be spaced 0.15 wavelength behind the driven element and the director 0.1 wavelength in front of the driven element. The reflector is approximately 5% longer than an electrical 0.5 wavelength and the director is approximately 4% shorter. The driven element is very close to a half wave long and will be excited by a low-impedance transmission line fanned out to a delta at the radiator. The exact lengths of the parasitically excited elements will be determined by cut and try with the aid of a field strength meter.

11. What are the advantages of keying an amplifier stage of an oscillator-amplifier type transmitter?

By keying an amplifier stage of an oscillator-amplifier transmitter all the disturbances due to the antenna circuit, to keying, and to the varying load on the power supply of the amplifier are isolated from the frequency determining portion of the transmitter. Greatly improved stability of the frequency of the transmitter is the result. Keying chirps and instability are greatly reduced.

12. What method could be used to prevent your transmitter feeding radio-frequency energy back into the power lines?

If a single-wire feeder is used the ground return of the transmitter should run through a short and direct lead to a good ground. R.f. chokes wound of heavy conductor may be placed in series with the power line leads to the transmitter. It may or may not be necessary also to use a pair of by-pass condensers from each side of the power line to ground. An electrostatic shield between the primary and secondary of the power transformer may be of assistance. The antenna system should preferably be removed as far as possible from the vicinity of power lines and fed with a balanced two-wire transmission line.

13. What are the advantages and disadvantages of: (A) A crystal-controlled transmitter; (B) A self-excited transmitter?

The advantages of a crystal-controlled transmitter are its much greater and more reliable frequency stability, the ability of such a transmitter to be keyed or modulated without any tendency toward keying chirps or frequency modulation, and the relative insensitiveness of such a transmitter to small misadjustments. A crystal-controlled amplifier stage may be operated at considerably higher efficiency and power output than a self-excited oscillator using the same tube.

On the other hand the crystal-controlled transmitter almost invariably will require a greater outlay for components. The self-excited transmitter allows greater flexibility with regard to frequency.

With recent improvements in the stability of self-excited oscillators operating at low power levels, such oscillators are becoming popular for the controlling of high-power transmitters. The ability of such a transmitter to transmit on any frequency within an amateur band with near crystal stability gives such a transmitter many advantages of both the crystal-controlled and high-power oscillator types.

14. If the frequency of your transmitter varies when the apparatus is jarred or vibrated, what should be done? Enumerate possible causes.

If the frequency of the transmitter varies when it is jarred or vibrated it is an indication that the constants of some of the components vary under such vibration or that there is a loose connection in the transmitter. In a crystal-controlled transmitter the most likely cause is a faulty crystal or crystal holder. In a transmitter employing a self-excited oscillator, either with or without amplifiers, possible causes are: defective oscillator tube in which the elements can vibrate; oscillator coil not firmly supported; loose plates in the oscillator tank condenser; any wiring in the tuning circuit or output circuit of the oscillator or following stage which vibrates when the transmitter is jarred or any wire or piece of metal within the field of the oscillator coil which is capable of vibration.

Mounting a self-excited oscillator on sponge rubber will minimize vibration of tube elements and tuning condenser plates.

15. Describe how you would connect a wave trap to a broadcast receiver in order to eliminate interference from your transmitter.

A simple wave trap consisting of a parallel resonant circuit may be connected in series with the broadcast receiver antenna as in figure 10 in order to reduce interference from amateur transmitters. The wave trap is tuned to the

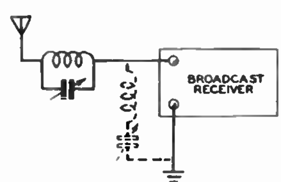


Figure 10

transmitter frequency and connected in series with the broadcast antenna as close to the receiver as possible. If interference is still experienced, a series-resonant trap (consisting of a coil and tuning condenser in series) can be connected between the antenna and ground binding posts on the receiver, thus providing an effective short to ground for what remains of the interfering signal.

16. What effect has a swinging antenna upon the frequency and the power output of a transmitter: (A) Of the oscillator-amplifier type? (B) Of the simple self-excited oscillator type?

(A) A swinging antenna may cause both the power output and frequency of an oscillator-amplifier type of transmitter to vary if no buffer stage is used between the oscillator and amplifier, but seldom to an objectionable degree. When a buffer stage is used and the amplifier is properly neutralized, however, the output may vary but the frequency will not.

(B) A swinging antenna usually causes both the frequency and power output of a self-excited oscillator type of transmitter to vary to an objectionable degree. The frequency variation is due to the changes in antenna characteristics as it swings. As the antenna acts not only as a load but as a coupled resonant circuit, any change in the resonant frequency of the antenna will affect both the frequency and loading of a self-excited oscillator to which the antenna is coupled.

Radiotelephony

1. What is frequency modulation and what undesirable effect does it produce or create?

Frequency modulation is variation of the carrier *frequency* at an audio frequency rate. With carrier *amplitude* modulation (the system of modulation generally used by amateurs) the carrier should be absolutely constant in frequency during modulation.

Even a small degree of frequency modulation is undesirable in an amplitude modulated phone transmitter because the band of frequencies occupied by a phone signal is greater when frequency modulation is present. In addition, the combination of both frequency modulation and amplitude modulation can generate spurious frequencies far removed from the carrier frequency, and thus cause bad interference.

2. Why do not amateur regulations permit radiotelephony by modulating a self-excited oscillator?

Amplitude modulation of a self-excited oscillator results in an objectionable degree of frequency modulation, as it is impossible to vary either the plate voltage or grid bias of a self-excited oscillator without varying the frequency appreciably.

3. What is overmodulation and what undesirable effects does it produce?

Overmodulation is modulation of a transmitter in excess of its modulation capability. The maximum modulation capability of a transmitter is that percentage of modulation (always less than 100 per cent) which cannot be exceeded without bad distortion or unsymmetrical modulation being present. Any such distortion results in a broad signal, even though the distortion may not be sufficient to impair the intelligibility.

4. Why must a transmitter intended to be modulated for radiotelephony be so arranged that the modulation cannot affect the carrier frequency?

Because if the oscillator is not sufficiently isolated or stabilized that the modulation cannot affect the oscillator frequency, there will be frequency modulation present, and a broad signal will be radiated.

5. In radiotelephony, what is a modulator?

A modulator is a device which superimposes an audio frequency signal upon a radio frequency carrier. This can be accomplished by varying the amplitude of the carrier in accordance with the amplitude and frequency of the voice or sound to be transmitted.

6. In radiotelephony, what is a speech amplifier?

A speech amplifier is a voice-frequency vacuum tube amplifier consisting of one or more stages. It builds up the feeble impulses of the microphone to a magnitude sufficient to excite the modulator.

7. What device is used to convert sound waves into electrical variations for radiotelephony? Describe its operation.

A microphone converts sound waves into electrical vibrations. It usually has a diaphragm, which does one of the following: Varies a resistance in accordance with the sound waves (carbon microphone). Varies the capacitance between itself and a stationary plate (condenser microphone). Drives a coil suspended in a magnetic field, thus generating a voltage (dynamic microphone). Distorts the shape of a small Rochelle salts crystal, thus generating a voltage between two faces of the crystal (crystal microphone).

8. Why cannot the carrier frequency of a radiotelephone station be set as close to the edge of an amateur band as in the case of a radiotelegraph station?

A radiotelephone signal does not occupy a single frequency but rather occupies a band of frequencies when modulated, due to the generation of sidebands. These sideband frequencies must not fall outside an amateur telephony band, and they must be taken into consideration when setting the carrier near the edge of the band.

9. What determines how close to the limits of the band the carrier frequency of a radiotelephone transmitter may be set and why?

The highest frequency to be transmitted determines the maximum width of the sidebands, therefore the carrier should be set inside the edge of the band by at *least* the highest audio frequency to be transmitted.

10. In radiotelephony, what is modulation?

In radiotelephony, modulation *usually* consists of varying the amplitude of a radio frequency carrier in exact accordance with the amplitude and frequency of an audible sound or sounds to be transmitted.

11. What undesirable effects are created by excessive speech amplification in radiotelephony?

Excessive speech amplification will result in modulation at a percentage in excess of the modulation capability of the transmitter.

12. In radiotelephony, what is meant by the carrier?

The carrier wave is the steady, radio frequency wave with which the voice frequencies are mixed to produce the modulation sidebands. It is the carrier wave which beats against the sidebands to produce an audio signal in the detector of a radio receiver.

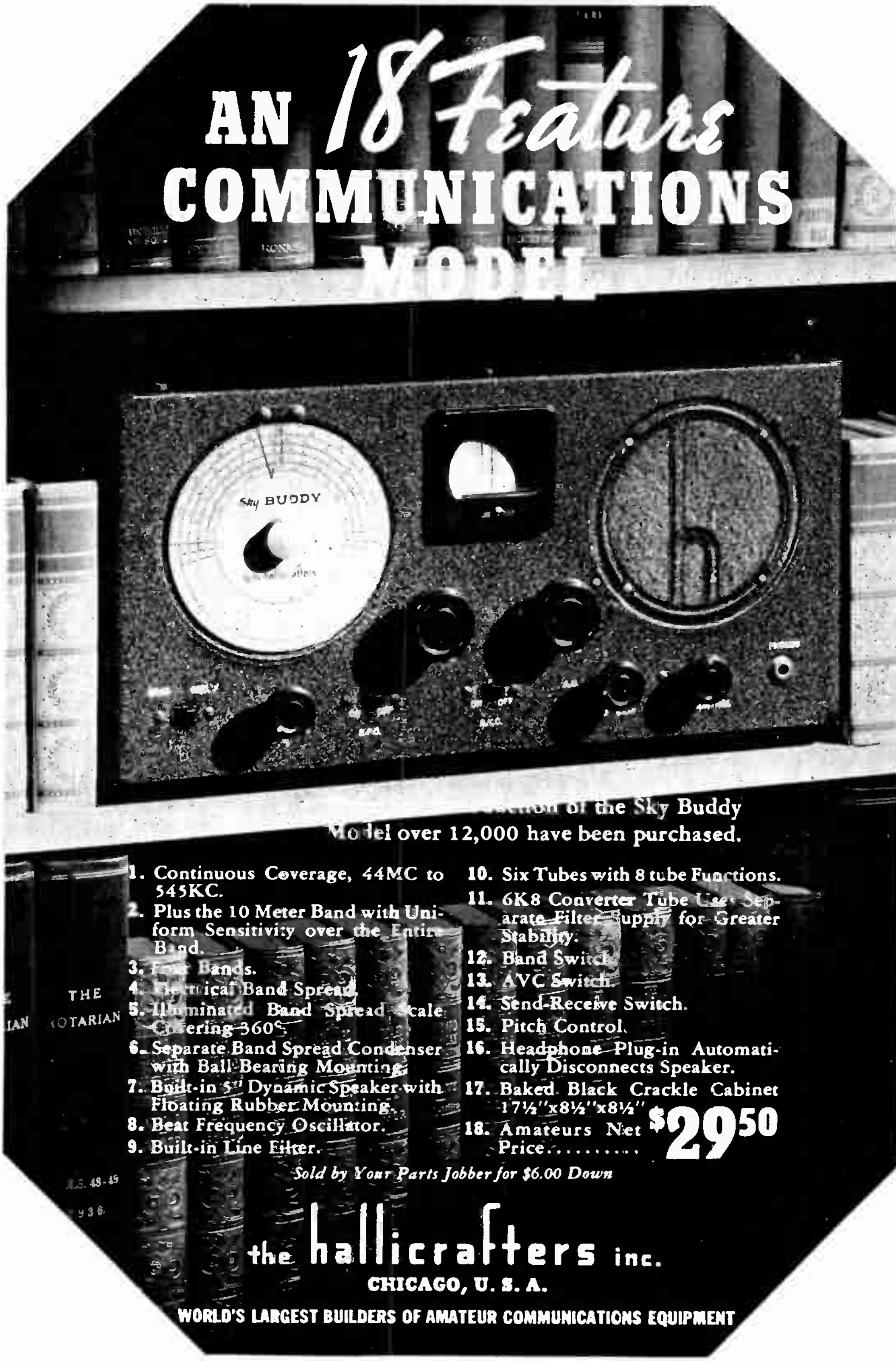
13. In radiotelephony, what is a gain control?

A gain control is a device for varying the amplification of a speech amplifier. It is usually a potentiometer connected in the grid circuit of one of the first speech amplifier tubes.

14. What causes frequency modulation in radiotelephony, and how can it be prevented?

Frequency modulation results when the operation of the modulator reacts upon the frequency of the oscillator, either through the plate supply, variation in grid impedance of the following stage, or by inductive coupling of the oscillator to the modulated stage. It can be prevented by using a shielded crystal oscillator, one or more buffer stages, and connection of the oscillator to a power supply that feeds neither modulator nor modulated stage.

15. Name two basically different systems of modulation in common use.


AN 18 Feature
COMMUNICATIONS
MODEL
Sky BUDDY
of the Sky Buddy
Model over 12,000 have been purchased.
1. Continuous Coverage, 44MC to 545KC.
2. Plus the 10 Meter Band with Uniform Sensitivity over the Entire Band.
3. Four Bands.
4. Electrical Band Spread.
5. Illuminated Band Spread Scale Covering 360°.
6. Separate Band Spread Condenser with Ball Bearing Mounting.
7. Built-in 5" Dynamic Speaker with Floating Rubber Mounting.
8. Beat Frequency Oscillator.
9. Built-in Line Filter.
10. Six Tubes with 8 tube Functions.
11. 6K8 Converter Tube Uses Separate Filter Supply for Greater Stability.
12. Band Switch.
13. AVC Switch.
14. Send-Receive Switch.
15. Pitch Control.
16. Headphone Plug-in Automatically Disconnects Speaker.
17. Baked Black Crackle Cabinet 17½"x8½"x8½"
18. Amateurs Net Price.......... $29.50
Sold by Your Parts Jobber for $6.00 Down
the hallicrafters inc.
CHICAGO, U. S. A.
WORLD'S LARGEST BUILDERS OF AMATEUR COMMUNICATIONS EQUIPMENT

Two popular systems of amplitude modulation are grid modulation and plate modulation.

16. In radiotelephony, what are sidebands?

Sidebands are actually heterodynes between the carrier frequency and the modulation frequencies; therefore they are radio frequencies equal numerically to the carrier frequency plus and minus the modulation frequencies, and their amplitude is in proportion to that of the modulation frequencies.

Power Supply

1. The amateur regulations require that the plate power supply on every tube of a transmitter operating on frequencies below 60,000 kc. must be filtered direct current. Explain why this practice minimizes frequency modulation and prevents the emission of broad signals.

(It is highly important that the applicant be thoroughly familiar with the reasons for adequately filtered power supply.)

A certain percentage of ripple in the plate voltage to either an oscillator or amplifier stage feeding an antenna will result in the same percentage amplitude modulation of the carrier frequency, thus causing the generation of sidebands and a broader signal than a pure, unmodulated carrier produces.

If there is ripple in the plate voltage to an oscillator, especially if it is of the self-excited type, there will not only be amplitude modulation of the oscillator but considerable frequency modulation as well. While successive amplifier and doubler stages supplied with pure d.c. may wipe out slight amplitude modulation of the oscillator in a multi-stage transmitter, the frequency modulation will not be reduced; on the contrary, the frequency modulation will actually be increased when frequency multipliers are used, the frequency modulation being increased directly as the degree of frequency multiplication.

While either amplitude modulation or frequency modulation will increase the number of kilocycles occupied by a signal appreciably, a combination of the two kinds of modulation will greatly increase the broadness of the signal. Hence pure, direct current should be used on all stages of the transmitter.

2. What is meant by the voltage regulation of a power supply?

Voltage regulation of a power supply is a measure of its ability to maintain constant output voltage from no-load to full-load conditions. Quantitatively, voltage regulation is usually expressed as the drop in output voltage between no load and full load expressed as a percentage of the no-load voltage.

$$\text{Regulation } (\%) = \frac{\text{Voltage Drop}}{\text{No-Load Voltage}} \times 100$$

3. What effect will poor voltage regulation in a power supply have on a keyed oscillator?

Due to the drop in voltage when the key is closed, a poorly regulated power supply will usually cause a keyed oscillator to shift frequency under keying or "chirp" as the filter condensers charge up to no-load voltage when the key is up and then discharge to full-load voltage when the key is closed.

4. Explain briefly the function of a filter in a power supply.

The filter in a power supply is used to smooth out the irregularities or "ripple" in the rectified alternating current, thus delivering a pure, unvarying voltage to the load circuit.

5. What is the effect of an inadequate power supply filter?

In a rectifier type power supply, inadequate filter causes the output voltage to pulsate at a frequency depending upon the type of rectifier used and the power-line frequency. When this poorly filtered voltage is applied to an oscillator plate circuit, it will cause both frequency modulation and amplitude modulation.

6. Why is it desirable to have separate transformers for plate power and filament heating purposes?

Separate transformers for plate power and filament heating purposes are desirable to help maintain the filament voltage at a constant value under variations in plate load, and to permit turning off of the plate supply by means of a switch in the transformer primary without killing the filament voltage.

7. Why is a filter necessary on a direct current generator used as a power supply?

On frequencies lower than 60,000 kc. a filter is necessary on a direct-current generator to remove the commutator ripple. Commutator ripple is caused by the rapid making and breaking of the load circuit as the commutator segments revolve under the brushes.

8. How may radio-frequency currents be kept out of the power supply?

Radio-frequency currents may be kept out of the power supply by the use of radio-frequency chokes in series with plate voltage leads to the radio-frequency section of the transmitter, and by-passing such leads to ground by means of mica condensers of suitable capacity. Where radio-frequency currents are induced in the a.c. power lines by the transmitting antenna they may be kept from the power supply by radio-frequency chokes and by-pass condensers in the a.c. leads to the power supply.

9. What is the difference between a full-wave and half-wave rectifier?

The difference between half-wave and full-wave rectifiers is that a half-wave rectifier utilizes only one rectifier element and rectifies only one half of the a.c. cycle, while a full-wave rectifier uses two rectifier elements to rectify both halves of the a.c. cycle. A full-wave rectifier supplies twice as many pulses per second to the filter, for a given supply frequency, and therefore is easier to filter and provides better voltage regulation.

10. Name three methods of obtaining direct-current plate supply.

Some methods of obtaining direct-current plate supply are: (1) Dry-cell or storage batteries; (2) Direct-current generator and commutator filter; (3) A.c. supply plus electronic or chemical rectifier, and adequate filter; (4) A.c. supply plus synchronous rotary or vibrator rectifier, and adequate filter system.

11. How may plate voltage from a common source be applied to two or more circuits requiring different operating voltages?

Plate supply from a common source may be applied to two or more circuits requiring different operating voltages through the use of a voltage dropping resistor. The voltage drop across a series resistor may be calculated by Ohm's Law:

E = IR or, Voltage drop = current, in amperes, flowing through resistor × resistance in ohms

12. How may it be determined whether a power supply is actually delivering direct current substantially free from ripple?

This check should always be made with the power supply delivering normal current, as the filtering ability of a power supply filter depends upon the current being drawn.

If the power supply is used to supply a transmitter, a check can be made on the quality of the emitted note by means of a suitable monitor. If there is no noticeable ripple or a.c. modulation in the note, the power supply is delivering sufficiently pure direct current.

A comparative check on the ripple of a power supply under load can be made by inserting in the negative lead between the power supply and the load a small filter choke (approximately 5 henries) capable of carrying the full current and placing across the choke a pair of earphones or

1940 "RADIO" HANDBOOK
JUST PUBLISHED !

ORDER YOUR COPY FROM YOUR
FAVORITE DEALER -
OR DIRECT FROM US !

MEMORANDA

RADIO
Handbook

SIXTH EDITION

a magnetic speaker in series with a half microfarad 200-volt condenser. The hum as heard in the speaker or phones will be in proportion to the power supply ripple. In a very well filtered power supply the hum will be practically inaudible when this test is made.

13. When more plate current is drawn through the filter choke than it was designed to handle, what is the effect on the inductance of the filter choke and on the filter action?

When a filter choke is overloaded by drawing more current through it than it was designed to handle, the inductance of the choke is reduced greatly due to saturation of the core. In effect, this is equivalent to using a choke with much less inductance, resulting in less filtering action.

14. With a.c. filament supply, why is a filament center-tap connection usually provided for the transmitting tube plate-and-grid-return circuits?

With a.c. filament supply a filament center-tap connection is usually provided for the grid and plate return circuits to prevent the alternating voltage from being impressed on the grid and plate circuits. The object of the center-tap connection is to bring the grid and plate return circuits to a point equal to the average filament potential within the tube.

15. Under what circumstances may an alternating current generator, of say 500 cycles, be legally used to supply power for an amateur transmitter?

Alternating-current generators may be legally used to supply power to amateur transmitters on amateur frequencies above 60,000 kc. They may also be used on any lower amateur frequency if the output is rectified and adequately filtered.

16. Explain how a monitoring oscillator is used in checking the quality of the emitted signal.

The signal in a monitoring oscillator simulates that heard in a receiver at a distant point. Thus a direct indication of how the signal sounds on the air may be obtained, and checks made for frequency modulation, power supply ripple, keying chirps, and general stability. For checking the voice quality of a radiophone transmitter, a non-oscillating monitor is required.

17. What would be the effect on the emitted signal of attempting to key the transmitter if the key is placed between the power source and an adequate filter?

Placing the key between the power source and an adequate filter would result in the keying being indistinct. This is due to the power-storage characteristic of the filter, thus preventing clean cut keying due to the excessive lag and keying "tails," the latter taking the form of chirps in the case of a self-excited oscillator.

Frequency Measurement

1. Explain how you would determine whether the frequency of your transmitter is withtn an amateur band.

There are several ways of determining whether the frequency of a transmitter is within an amateur band. If a well-shielded and calibrated receiver capable of giving a beat note with the transmitter is available, it is only necessary to remove the antenna from the receiver and tune it to zero beat with the transmitter. It is then possible to determine whether the transmitter is in an amateur band or not by referring to the receiver dial. This method is suitable only for frequencies well within the band, however, where inaccuracies in the receiver calibration could not result in unintentional out-of-band operation, and only with receivers which do not change calibration when the antenna is removed.

If the receiver is not well shielded enough to allow a beat note to be obtained with the transmitter signal, an oscillating monitor may be used in conjunction with a calibrated receiver. This method requires that the monitor be tuned to zero beat with the transmitter signal and the transmitter then shut off. Next, the signal from the monitor should be tuned in on the receiver to exact zero beat and the frequency of the signal from the monitor (which is the same as that of the transmitter) checked against the receiver calibration to determine if it is within an amateur band.

However, the best method of determining whether the transmitter frequency is within an amateur band is to measure the transmitter frequency with an accurate, calibrated heterodyne frequency meter. The procedure for making the frequency measurement is as follows: (1) Tune in the signal from the transmitter on an oscillating monitor and adjust the monitor to zero beat and then turn off the transmitter. (2) Tune in the signal from the monitor on the receiver and adjust the receiver to zero beat. (3) Without changing the tuning of the receiver and with the beat oscillator turned off (or with the detector adjusted so that it is not oscillating in the case of an autodyne type receiver), adjust the frequency meter so that it is tuned to the same frequency as the monitor by zero beating the signal from the frequency meter with that from the monitor in the receiver. (4) From the calibration of the frequency meter it may then be determined (within the limit of accuracy of the frequency meter) whether the transmitter is within an amateur band.

If the receiver is well shielded and the signal from the frequency meter is quite strong, the first step in the above process may be eliminated. That is, the signal from the *transmitter*, instead of that from the monitor, may be tuned in on the receiver and the frequency meter set to zero beat directly with the transmitter.

2. How may a monitor be used to determine that your transmitter is adjusted to operate within an amateur band?

The method of using the monitor to determine if the frequency of a transmitter is within an amateur band will be found in the second paragraph of the answer to question no. 1.

3. Why is it necessary to check frequently the B battery voltage of a calibrated frequency-monitoring oscillator?

As the calibration of most frequency-monitoring oscillators is dependent upon the B voltage, this voltage should be checked whenever frequency measurements are to be made to ascertain that it remains at or close to the value at which the frequency-monitoring oscillator was calibrated.

4. What valuable uses has a monitoring oscillator in an amateur station?

Some valuable uses of a monitoring oscillator are: (1) to check the purity of an emitted signal from a radiotelephone or radiotelegraph transmitter; (2) to check for frequency modulation in a radiotelephone transmitter; (3) to check for frequency shift (chirp) under keying in a radiotelegraph transmitter; (4) to check for harmonics, parasitics or other spurious radiation from radiotelephone or radiotelegraph transmitters; (5) to serve as a keying monitor with a radiotelegraph transmitter; (6) to assist in measuring the transmitter frequency when used with a calibrated heterodyne frequency meter.

5. What is a heterodyne frequency meter?

A heterodyne frequency meter is essentially a highly stable, calibrated low-power vacuum-tube oscillator. For amateur use the oscillator usually covers one of the lower frequency amateur bands. It is used to heterodyne signals from a transmitter or monitor for the purpose of determining their frequency.

6. How would you measure your transmitter frequency with a heterodyne frequency meter?

The answer to this question will be found in the last two paragraphs of the answer to question no. 1.

7. How would you adjust your transmitter to a particular desired frequency in an amateur band with the aid of a heterodyne frequency meter?

To adjust the transmitter to a particular desired frequency in an amateur band with the aid of a heterodyne frequency meter, the frequency meter should first be set to the desired frequency by reference to the calibration chart. The monitor should next be adjusted to zero beat with the frequency meter, and the transmitter frequency shifted slowly until it is at zero beat with the monitor. A dummy antenna should be used on the transmitter during the time its frequency is being shifted so as not to cause unnecessary interference. In the case of an m.o.p.a. transmitter the antenna or plate voltage can be removed from the amplifier.

8. How would you calibrate a heterodyne frequency meter from received radio signals of known frequency?

To calibrate a heterodyne frequency meter from received signals of known frequency the receiver is first tuned to zero beat with the known frequency. Then the beat oscillator is turned off or, with an autodyne type receiver, the regeneration is reduced until the receiver is no longer oscillating. Next, using the heterodyne frequency meter as a beat oscillator, it is tuned precisely to zero beat with the calibration signal in the receiver. Note and record the dial reading of the frequency meter. When several such calibration points have been noted, a calibration curve may be drawn on a large sheet of cross-section paper.

9. Why must the calibration of a frequency meter be frequently verified?

The calibration of a frequency meter must be verified frequently because the frequency at which the circuit oscillates varies as the constants of the parts used in its construction change with age. As these constants change it is necessary to make such corrections in the calibration chart as may be indicated by the check.

10. If you had a frequency meter with a possible error of 0.5 per cent, what is the lowest frequency in the 14,000-kc. amateur band to which you could safely set your transmitter, and why?

The lowest frequency in the 14,000-kc. amateur band to which an amateur transmitter could be set by a frequency meter having a possible error of 0.5% is approximately 14,070 kc. This is so because 0.5% of 14,000 kc. is 70 kc. and, as the low-frequency end of this band is at 14,000 kc., the transmitter must be set at 14,000 plus 70, or 14,070 kc., to make sure it is in the band. More accurately, $X - .005X = 14{,}000$ or $X = 14{,}070.35$ kc.

11. In operating your frequency meter what is the effect upon frequency when the tuning condenser capacity is increased, and why?

When the capacity of the tuning condenser in the frequency meter is increased the frequency is lowered, as the frequency of a resonant circuit varies inversely as the square root of the tank capacity.

12. How would you determine whether your transmitter was radiating harmonics or spurious frequencies outside the amateur bands?

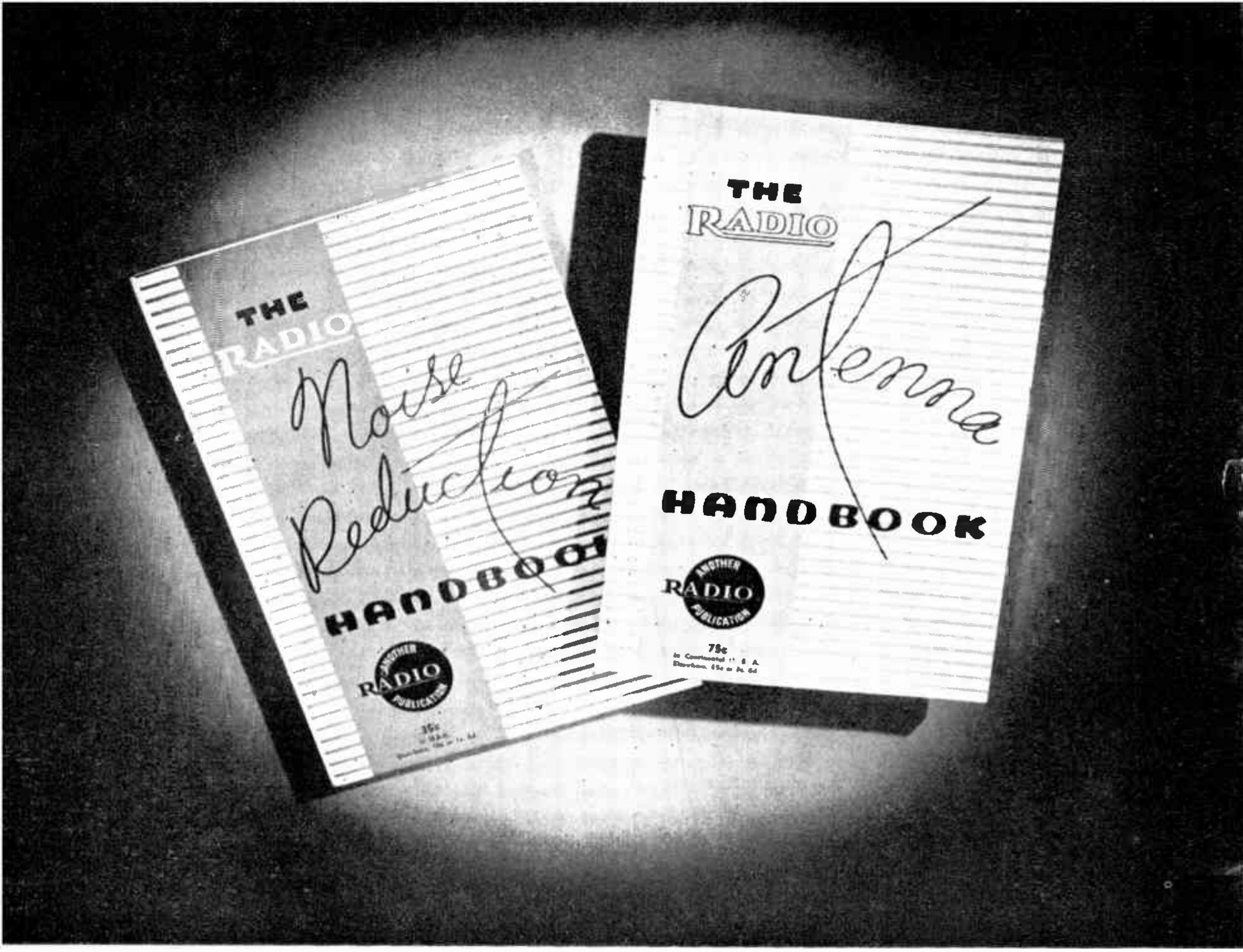
Whether or not the transmitter is radiating harmonics or spurious frequencies may be determined by listening for spurious radiations or harmonics on a well-shielded receiver or oscillating monitor. Nearby amateurs can be enlisted to check for undesirable radiations.

13. If your frequency meter is accurate to two (2) kc. when set to 1750 kc., what is its error in kc. when set to 3500 kc.?

Since the error of a frequency meter is proportional to the frequency at which it is used, a frequency meter having an error of 2 kc. at 1750 kc. would have an error twice as great, or 4 kc., at 3500 kc.

14. Explain how a heterodyne frequency meter calibrated for the 1715-2000 kc. band may be used to adjust a transmitter for operation within the band 3500-4000 kc.?

The second harmonic of a frequency meter calibrated for 1750-2000 kc. may be used to adjust a transmitter for operation within the 3500-4000 kc. band. With the exception that the second harmonic of the frequency meter is used and that the indicated frequency from the calibration of the frequency meter is multiplied by two, the procedure is the same as given under questions


THE RADIO
Noise Reduction
HANDBOOK
ANOTHER RADIO PUBLICATION
35c
THE RADIO
Antenna
HANDBOOK
ANOTHER RADIO PUBLICATION
75c

no. 1 and 7, depending upon whether it is desired to determine the transmitter frequency or to set it to a certain predetermined frequency.

15. Why do most heterodyne frequency meters require "warming up" before they may be used for frequency measuring?

Most heterodyne frequency meters must be warmed up before using because the calibration is affected by temperature. This is due to the fact that the capacity and inductance values of the various components in the frequency determining circuits change with temperature. The change in interelectrode capacity of the oscillator tube is usually the cause of the greatest "drift" during the warm-up period.

16. Why does an absorption type frequency meter give different readings when located at different distances from the transmitter?

An absorption type frequency meter gives different readings when located at different distances from the transmitter because the meter depends for its operation upon the absorption of a small amount of power from the tank circuit whose frequency is to be measured. As the resonant frequency of each of two coupled circuits changes somewhat with different degrees of coupling, the calibration of the absorption meter will change at different distances from the transmitter tank. If the meter is coupled to the tank of a self-excited oscillator, the frequency of the transmitter will also be affected by the mutual coupling of the two circuits.

Treaty and Laws

1. Why do amateur station calls in the United States and possessions begin with the letter W or K?

Each nation assigns calls to stations under its jurisdiction in accordance with a table set up according to international agreement under treaty or convention. According to this agreement, the United States is allocated all calls beginning with the letters W, K, and N. Our government has decreed that all amateur calls within the boundaries of the United States proper shall use the prefix W; U. S. amateur calls outside of the continental United States shall use the prefix K. (No nation is issued prefixes beginning with Q, since combinations beginning with Q are used for international signaling purposes. With this exception, calls are internationally assigned from CAA to ZZZ.)

2. What are the International Regulations relative to the maintenance of constant frequency and purity of signals?

The signals emitted by a transmitter must be as constant in frequency and as pure as the state of the art permits. Their radiation must contain the practical minimum amount of emission not essential to the type of communication carried on.

3. What is the Federal Communications Commission?

The Federal Communications Commission is the body of seven commissioners, appointed by the president, who are the regulating and licensing authority on matters dealing with radio and wire communications under the jurisdiction of the United States. Included in its duties are the classification of radio stations; the assignment of frequencies or wavelengths; the prescription of the nature of service to be rendered; the determination of the power, operating hours, and location of each class of station; and the issuance of licenses.

4. What class of radio communication holds precedence over all others?

Distress signals and/or distress communications hold precedence over all other classes of communications.

5. What is the law in regard to the amount of power to be used to communicate over a given distance?

The minimum amount of power enabling satisfactory communication to be carried on must be used at all times except in the case of distress signals or distress traffic.

6. What is the law regarding the transmission of false or fraudulent distress communications?

No person shall transmit any false or fradulent distress communications.

7. What is the law regarding willful or malicious interference with: (A) Distress messages? (B) Other radio communications?

No person shall willfully or maliciously interfere with any type of radio communications.

8. What is the law regarding the transmission of obscene or profane language?

No person shall utter any obscene or profane language by means of radio communications.

9. Name three Q signals from the International List of Abbreviations and give their meanings.

QRM? Are you being interfered with?
QRM. I am being interfered with.
QRT? Shall I stop sending?
QRT. Stop sending.
QRI? Is my note good?
QRI. Your note varies.
(Other Q signals are given on page 22)

10. What are the meanings of SOS, QRT, QRM, Mayday, CQ?

SOS is the international radiotelegraph signal of distress.

QRT means, "Stop sending."

QRM means, "You are being interfered with."

MAYDAY is the international radiotelephone signal of distress. (From the French *M'aidez*, meaning "Help me.")

CQ is the general inquiry call. When an answer is expected from any station within hearing range, it is terminated by the letter K. If it is used as the preface to a transmission to which no reply is expected, the letter K is omitted.

11. What is the law regarding the secrecy of radio communications?

Neither the contents nor meaning of a specifically addressed message may be divulged to anyone other than the addressee or his authorized agent, except through authorized channels of communication to a person employed or authorized to forward the message to its destination, or on demand of a competent court or other lawful authority. Neither shall a message be intercepted and divulged to the addressee without authority of the sender, nor shall anyone use any information contained in an addressed message for his own benefit or the benefit of another not entitled thereto. (Refer to section 605, page 60.)

12. What radio communications are not subject to the secrecy provisions of the Communications Act of 1934?

The secrecy provisions do not apply either to distress traffic or information which has been broadcast for public use.

13. Why does the Communications Act of 1934 require a station license even though the transmitting range of the station is extremely limited?

Interstate broadcasting falls under the jurisdiction of the Federal Government, and even a very low power station is capable of interfering with reception of out-of-state signals on receivers nearby. Therefore *all* radio transmission, regardless of power, comes under federal jurisdiction.

14. What does the Communications Act of 1934 provide in regard to the control of radio stations during a national emergency?

During any national emergency the president is empowered to either suspend or amend the rules and regulations applicable to any and all classes of stations, and may confiscate or order dismantled the equipment of any station. In case the equipment is appropriated for government use, the owner will be justly compensated.

15. What are the International Regulations concerning unnecessary signals or messages?

The transmission of unnecessary signals or messages is forbidden all classes of stations.

16. What type of communications may be exchanged between amateur stations of different countries?

Amateurs in different countries must confine their remarks to those of such a nature that their importance would not justify sending them by public communications facilities were they not sent by amateur radio. Third party traffic is prohibited unless special arrangements have been made between the two governments.

Regulations, Bands

1. State the frequency limits of at least four of the bands of frequencies assigned to radio amateurs.

It is strongly advised that the applicant familiarize himself with the frequency limits of *all* the amateur bands. They are as follows:

1715 to 2000 kc.[1]
3500 to 4000 kc.
7000 to 7300 kc.
14,000 to 14,400 kc.
28,000 to 30,000 kc.
56,000 to 60,000 kc.
112,000 to 116,000 kc.*
224,000 to 230,000 kc.*
400,000 to 401,000 kc.

[1]Subject to change to 1750-2050 kc. in accordance with Havana agreement.

2. In what bands of frequencies may every amateur engage in radiotelephony?

The following bands are open to telephony to all amateurs:

1800 to 2000 kc.
28,500 to 30,000 kc.
56,000 to 60,000 kc.
112,000 to 116,000 kc.*
224,000 to 230,000 kc.*
400,000 to 401,000 kc.

3. What bands of frequencies are available for radiotelephony by specially qualified amateurs only?

Only specially qualified amateurs are permitted to operate in the following bands:

3900 to 4000 kc.
14,150 to 14,250 kc.

4. In what bands of frequencies may tone-modulated radio-telegraphy (Type A-2 emission) be employed?

A-2 emission may be employed only in the following bands:

56-60 Mc.
112-116* Mc.
224-230* Mc.
400-401 Mc.

(Note: Permission to use A-2 emission on the band 56-60 Mc. appears to apply only to tone modulation applied by a modulator, as pure d.c. plate supply is required on this band.)

5. In what bands of frequencies is filtered direct current plate supply required?

Filtered direct current is required on all amateur frequencies below 60 Mc.

6. What types of emission may be employed in the amateur band 56,000-60,000 kc.?

Type A-1 (pure d.c. telegraphy), type A-2 (tone modulated telegraphy), type A-3 (radiotelephony), and facsimile transmission are permitted on the 56-60 Mc. band.

7. Which of the five following frequencies have their second harmonic in the amateur band which begins at 7000 Kc.: 3495, 3525, 3600, 3645, 3655?

3525 kc., 3600 kc., and 3545 kc.

* The Commission reserves the right to cancel or change these frequencies without advance hearing or notice.

8. What type or types of emission may be employed in the amateur band 7000-7300 kc.?

Only type A-1 (pure d.c. telegraphy).

9. In what portion of the amateur band 28,000-30,000 kc. may radiotelephony be used?

Between 28,500 kc. and 30,000 kc.

10. Why may not a 3700-kc. crystal be used in a transmitter which doubles frequency for operation in the amateur band beginning at 7000 kc.?

Because the second harmonic of 3700 kc. is 7400 kc., which is outside the 7000-7300 kc. band.

11. What types of emission may be employed in the: (A) 3500-3900 kc. band? (B) 3900-4000 kc. band?

(A) Only type A-1, pure d.c. telegraphy. (B) Type A-1 telegraphy and, to holders of class A licenses, type A-3 radiotelephony.

12. What portion of the amateur frequency band 1715-2000 kc. is open to: (A) Radiotelegraphy? (B) Radiotelephony?

(A) The entire band. (B) 1800 to 2000 kc.

13. May radiotelephony be engaged in the amateur frequency band: (A) 56,000-60,000 kc.? (B) 28,000-30,000 kc.?

(A) Yes. (B) Only in the portion between 28,500 kc. and 30,000 kc.

14. Explain whether the frequency band 14,150-14,250 kc. is available for unrestricted amateur radiotelephony?

Unrestricted radiotelephony would mean that the band is open to holders of all types of amateur license, which is not true. It is open only to those who possess a class A operator license.

15. In what frequency bands may an amateur operate a portable mobile station?

On all amateur frequencies above 28,000 kc.

16. Under what condition may radiotelephony be employed in the frequency bands: (A) 3900-4000 kc.? (B) 14,150-14,250 kc.?

(A) and (B): These bands may be used for radiotelephony only when the station is licensed to an operator holding a class A license and when an operator holding a class A license is present.

Regulations, Part I

1. What is the maximum power permitted an amateur station and where is it measured?

A maximum plate input power of one kilowatt to the stage feeding the antenna is permitted, whether it be an oscillator or a radio frequency power amplifier. The plate input power is determined by multiplying the plate current (in amperes) by the plate voltage.

2. Under what circumstances may an amateur station be required to observe a silent period?

When the operation of the station causes general interference to the reception of broadcast programs by receivers of modern design.

3. What restriction in operation is put upon amateur stations which interfere generally with broadcast reception on receivers of modern design?

Such amateur stations shall not operate upon such frequencies as cause this interference between the hours of 8 p.m. and 10:30 p.m. local time and also on Sunday between 10:30 a.m. and 1 p.m. The amateur may be advised as to such interference by receipt of a first notice from the commission.

In the event a second notice is received from the Commission within a year, the evening quiet period begins at 6 p.m.

In case a third notice is received within a year, the station must remain quiet from 8 a.m. till midnight, local time, on such frequencies as cause interference.

4. May amateur stations broadcast entertainment?

No.

5. (A) May an amateur radiotelephone station transmit music? (B) Under what circumstances may an amateur radiotelephone station transmit tone modulated signals?

(A) No. (B) For short tests in conjunction with the development of radiotelephone transmitters, single audio tones may be transmitted.

6. What is a radio amateur?

A radio amateur is a duly authorized person interested in radio technique solely with a personal aim and without pecuniary interest.

7. What notice must be given prior to the operation of an amateur portable station?

No notice need be given when portable operation is confined to amateur frequencies above 28,000 kc. When portable operation on frequencies below 28,000 kc. is contemplated, advance notice in writing must be sent to the inspector in charge of the district in which portable operation is to take place. The notice should give the station call, name of licensee, date of proposed operation, and locations of proposed operation as specifically as possible. Such operation should not exceed one month unless further notice is given to the inspector in charge, nor exceed four consecutive months at the same location.

8. (A) Is the keeping of a station log compulsory? (B) Is the licensee obliged to make it available to authorized government representatives upon demand?

(A) Yes. (B) Yes.

9. How often must an amateur station sign its call?

At the end of each transmission (except for intermediate break-in transmissions of less than one minute's duration) and at least once every ten minutes of operation.

10. How long before expiration of an amateur license must application for a renewal be filed and with whom?

At least 60 days before expiration of the license, application for renewal must be filed with the Federal Communications Commission at Washington, D. C.

11. Explain the difference between a portable and a mobile station.

A portable station is one that is so constructed that it can easily be carried about, and is moved from time to time but not operated while in motion.

A mobile station is a portable station that is so designed as to permit operation while in motion.

12. (A) Who may manipulate the key of an amateur radiotelegraph station? (B) Who may transmit by voice over an amateur radiotelephone station and under what circumstances?

(A) Any licensed amateur operator of any class. (B) Any person may speak over an amateur radiotelephone station so long as he complies with regulations regarding profane language, etc., and so long as a duly licensed amateur operator (class A for class A operation) is in charge of the operation of the transmitter.

13. Under what circumstances may an amateur station communicate with other than an amateur station?

Amateurs may communicate with government or commercial stations in emergencies or for testing purposes. In addition, they may communicate with expeditions and other services which are specially authorized to communicate with amateurs.

14. What restrictions exist against accepting pay for services performed by an amateur station?

Amateurs are forbidden to accept remuneration of any kind, either directly or indirectly, for services they perform.

15. (A) May other than citizens of the United States obtain an amateur station license? (B) May other than citizens of the United States obtain an amateur operator's license? (C) What restriction is there as to the nationality of the person who controls the premises upon which an amateur station is located?

(A) No. (B) No. (C) A station license will not be issued if the premises on which the proposed station is to be located are controlled by an alien.

16. Why do the amateur regulations require the transmitter to be loosely coupled to the antenna system?

In order to minimize shock excitation of the antenna and to reduce harmonics. In the case of a self-excited oscillator feeding an antenna, the stability will be improved with loose coupling.

Regulations, Part II

1. Is it permissible to operate an amateur station by some form of automatic transmitter without a licensed operator present at the transmitter? Explain.

Though it is permissible to use an automatic transmitter, a licensed operator must be present.

2. What are the hours during which an amateur station must not be operated on interferring frequencies when it has been directed to observe quiet hours?

For the first notice, quiet hours must be observed between 8 p.m. and 10:30 p.m. local time and from 10:30 a.m. till 1 p.m. on Sundays.

3. What identifying signal, in addition to its call, must be transmitted by a portable amateur radiotelegraph station?

The fraction bar (DN) followed by the number of the amateur call area in which the station is located must be used as a suffix to the regular station call.

4. What identifying announcement, in addition to its call, must be transmitted by a portable amateur radiotelephone station?

Following the call an announcement similar to the following should be made: " . . . portable station operating in the blank call area."

5. What data must be recorded in the operating log of an amateur station?

The log must contain the following data for every transmission: date and time of transmission, type of emission, station called, plate input power to the stage feeding the antenna message traffic handled if any, frequency band used, and signature of the operator, together with the signatures of any other persons talking over a radiotelephone transmitter. In the case of portable or mobile operation, the location at each transmission must be given.

6. How long may a portable amateur station remain in operation at any one location without giving further notice to the inspector in charge of that district?

One month.

7. Is it permissible for you to permit the operation of your amateur radiotelegraph station by a person holding only a commercial radiotelegraph operator's license?

No.

8. For what purposes may the call signal CQ be used?

It may be used as a general inquiry call, in which case the call letters of the calling station are followed by the letter K. It may also be used to preface general broadcasts to which no reply is expected.

9. If you speak the language of a foreign country and were in radio communication with an amateur in that country, would it be permissible for you to employ that foreign language for the communication?

Yes.

10. (A) What international signal denotes the end of a message? (B) What international signal denotes the end of a communication between two stations? (C) What does the letter "K" at the end of a call indicate?

(A) AR. (B) SK. (C) "I am through with this transmission and shall listen for you; go ahead."

11. Amateur stations are limited to a specified maximum input power. Where is this power measured?

In the plate circuit of the stage feeding the antenna, whether it be an oscillator or a radio frequency power amplifier.

12. As an amateur operator what would you do if you heard a ship transmitting a distress signal?

Listen to see if the ship received an answer or there were indication that the message had been picked up by government or commercial stations. If no one appeared to have picked up the distress signals, or if the distress call were very short and there were a likelihood that the signal might pass unnoticed by regular government or commercial services, I would immediately forward the information via land phone to the nearest government or commercial station. I would not transmit with my own station if there were even a remote possibility that I might interfere with the distress call or with any subsequent traffic related to the disaster.

13. Under what circumstances may an amateur station be operated on a mobile unit?

On frequencies above 28,000 kc.

14. What is an amateur portable-mobile station?

An amateur portable-mobile station is a portable station that is capable of being moved from one mobile unit to another and is so moved from one vehicle or boat to another from time to time.

The unit is used either when the vehicle is moving or when it is stationary; in the former case it is classified as a mobile station and in the latter case a portable station.

15. If you wish to maintain a "portable" amateur station and a "fixed" amateur station at the same time and therefore require a second license, (A) Will photostat copies of the station license serve for additional stations? (B) Is a photostat copy of the operator license acceptable for the operation of any station?

(A) Yes. (B) No.

16. (A) What is meant by Type A-1 emission? (B) What is meant by Type A-2 emission? (C) What is meant by Type A-3 emission? (D) What is meant by Type A-4 emission?

(A) Telegraphy with pure continuous waves. (B) Tone modulated telegraphy. (C) Telephony. (D) Facsimile. (A-0 emission consists of pure carrier impulses for remote control; A-5 is television.)

Penalties

1. What penalty may be imposed for a violation of any provision of the Communications Act of 1934?

A maximum fine of $10,000 and two years imprisonment for each offense. If an amateur, the offender may lose both station and operator licenses.

2. What penalty may be imposed for the violation of any regulations of the Federal Communications Commission?

A fine not to exceed $500 for each day for each offense. If an amateur, the offender may lose both station and operator licenses for an indefinite period.

3. What penalty may be imposed upon the licensee of a licensed amateur station if he permits the operation of his station by an unauthorized person?

This is a violation of the basic Communications Act. Refer to answer to question 1.

4. What penalty may be imposed for operating a licensed amateur station without an amateur operator's license?

Both the unlicensed person operating the station and the holder of the station license are subject to the penalties set forth in the answer to question 1.

5. What penalty may be imposed for transmitting profane or obscene language?

Refer to question 1.

6. What penalty may be imposed for divulging the contents of radiocommunications to unauthorized persons?

Refer to question 1.

7. What penalty may be imposed for failing to keep a log of station operation?

This is a violation of the regulations of the F.C.C. Refer to question 2.

8. What penalty may be imposed for maliciously interfering with the transmission of: (A) A distress message? (B) Other radio communications?

(A) Refer to question 1. (B) Suspension of operator license.

9. What penalty may be imposed upon a licensed amateur operator who signs a false station call?

Refer to question 1.

10. What penalty may be imposed for transmitting a false or fraudulent distress call?

Refer to question 1.

11. What penalty may be imposed upon an amateur licensee for operating on a frequency outside of an authorized amateur band?

Refer to question 1.

12. What penalty may be imposed upon an amateur licensee for operating his station with an inadequately filtered power supply?

Refer to question 2.

13. What penalty may be imposed upon an amateur licensee who willfully fails to observe quiet hours when required to maintain them?

Refer to question 2.

14. What penalty may be imposed on an amateur licensee for operating a radiotelephone station on the band 3900-4000 kc. without holding an operator's license which authorizes unlimited phone operation?

Refer to question 2.

15. What penalty may be imposed upon an amateur licensee who operates a portable station without previously having notified the inspector of the time and place of the contemplated operation?

Refer to question 2.

16. What penalty may be imposed upon an amateur licensee who accepts material compensation for any services rendered by his station?

Refer to question 2.

BUYER'S GUIDE

MAKE AND TYPE NUMBERS OF THE PARTICULAR COMPONENTS USED IN THE LABORATORY MODELS OF EQUIPMENT DESCRIBED IN CHAPTER 7.

Two-Tube Autodyne
Page 30

C_1—Hammarlund SM-15
C_2—Hammarlund SM-100
C_3, C_5—Solar type MT
C_4, C_6—Solar "Sealdtite"
R_1—Centralab 710
R_2—Centralab "Radiohm"
R_3, R_4—Centralab 514
BC—Mallory 1.25 v.
CH_1—Stancor type C-2300
Panel—Bud PS1201
Tuning dial—Bud D-103B

Shortwave Converter
Page 34

L_3—Meissner type 14-1006
L_4—Meissner type 14-4034
C_1, C_3—Bud type 148
C_2—Bud type 906
C_9—Meissner type 22-7002
C_{10}—Meissner type 22-7003
Panel—Bud 1201
Chassis—Bud 644
Tuning dial—Bud 103-D

15-Watt C.W. Transmitter
Page 40

C_1, C_6—Cardwell ZR-50 AS
C_2, C_3—Aerovox 1450
C_4, C_5, C_7—Aerovox 684
R_1—Centralab 516
R_2, R_3, R_4—Ohmite Brown Devil
RFC—Bud 920
X—Bliley LD2
Coil forms—Hammarlund XP-53
Tube—Taylor T21
Feedthrough insulator—Johnson type 44
M—Triplett 221
Sockets—Bud S-265 and S-266

20-Watt Radiophone
Page 44

R_1, R_6, R_7—Centralab 514
R_2, R_4, R_5—Ohmite "Brown Devil"
R_3—Centralab 516
RFC—Hammarlund CH-8
M—Triplett 326
C_1, C_2, C_3—Cornell Dubilier 1-W and 5-W
C_4—Mallory-Yaxley CT959
C_6—Cornell Dubilier type 4
C_8—Cornell Dubilier type BR-102-A
C_9—Cornell Dubilier type DT-4P5
J—Mallory-Yaxley A-1
T_1—Kenyon KSMG
T_2—Kenyon KR45
T_3—Kenyon KR53M
Crystal-Bliley BC-3
Standoff insulators—Johnson

112-Mc. Transceiver
Page 48

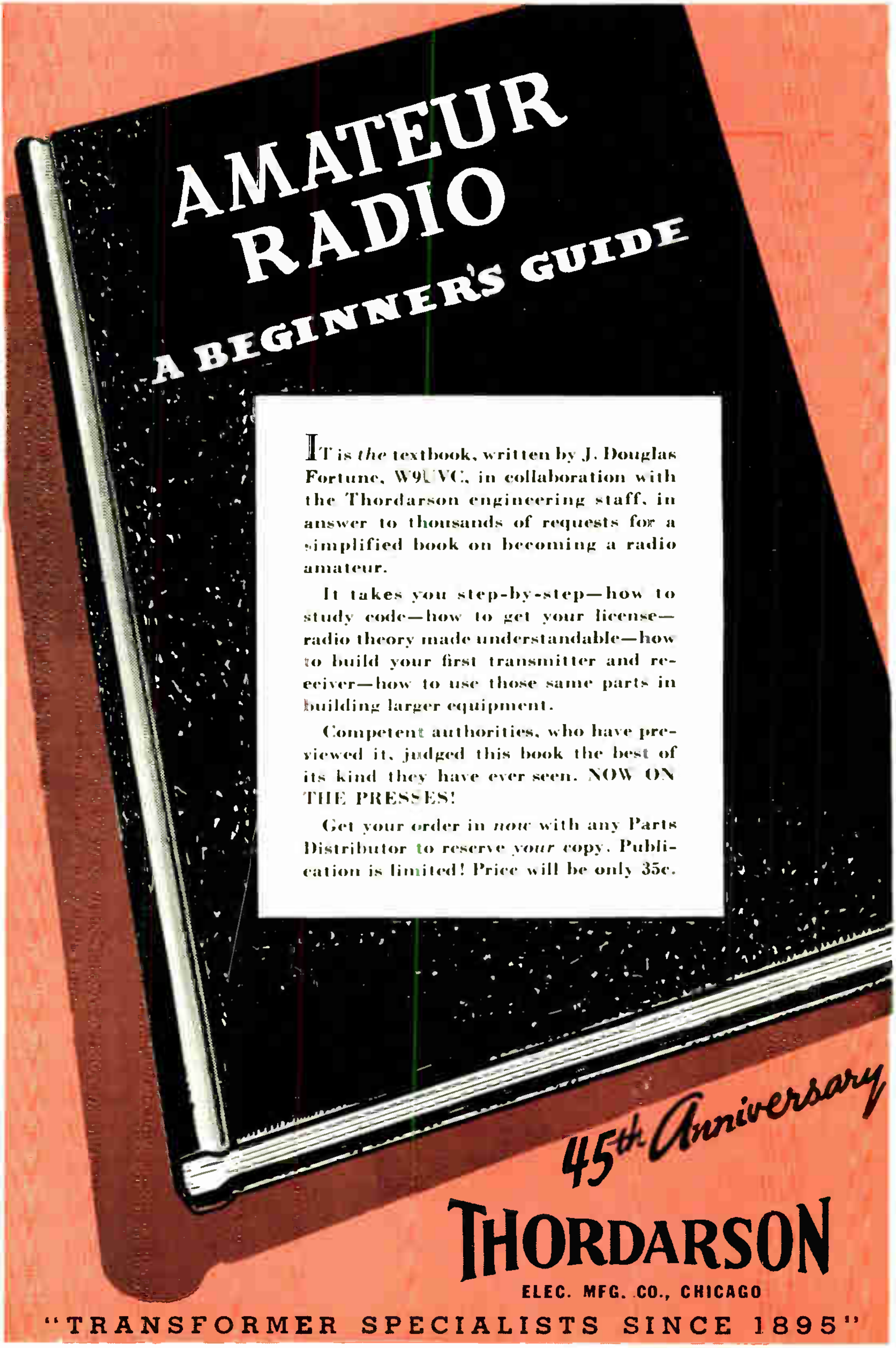
C_1—Cardwell ZR-10-AS with mounting bracket
C_2—Solar type MT
C_3, C_6—Solar type S-0256
C_4—Solar type S-0212
C_5—Solar type DT-879
C_7—Solar type S-0219
C_8—Solar type DJ-364
R_1, R_4, R_5, R_6—Centralab 516
R_2—Mallory Yaxley "Universal"
R_3—Centralab 514
RFC—Ohmite type Z1
S_1—Mallory Yaxley 3142-J
CH_1, CH_2—Thordarson T-43C92
T_1—Thordarson T-72A59
J_1, J_2—Mallory Yaxley type A-1
VP—Mallory Yaxley type VP-551
Cabinet—Bud type 870
Knobs—Bud
Shaft coupling—Cardwell type A.
Dial—Crowe 180
Tubes—RCA

3-Tube Superhet
Page 52

C_1, C_2—Bud MC1853 or Hammarlund MC-50-S
C_3—Bud MC1857 or Hammarlund MC-140-S
C_5, C_9—Cornell-Dubilier DT-4T1
C_4, C_8, C_{11}, C_{14}—Cornell-Dubilier DT-4P1
C_6, C_7, C_{12}—Cornell-Dubilier DT-4S1
C_{10}—Cornell-Dubilier DT-4D1
C_{13}—Cornell-Dubilier BR-252
C_{15}—Cornell-Dubilier EDJ-9040
R_1, R_2, R_4, R_7, R_9—Centralab 516
R_3, R_5—Centralab 514
R_6—Yaxley L
R_8, R_{10}—Ohmite Brown Devil
IFT—Meissner 16-8092
CH—Stancor C-2300
J—Mallory-Yaxley 705
Dial—Crowe 123M

Standard 375-Volt Power Pack
Page 54

T—Thordarson T-70R62 (145 ma.) or T-13R12 (70 ma.)
CH—Thordarson T-13C30 (150 ma.) or T-43C92 (75 ma.)
C_1, C_2—Single Cornell Dubilier type JRC-588


AMATEUR RADIO
A BEGINNER'S GUIDE
IT is *the* textbook, written by J. Douglas Fortune, W9UVC, in collaboration with the Thordarson engineering staff, in answer to thousands of requests for a simplified book on becoming a radio amateur.
It takes you step-by-step—how to study code—how to get your license—radio theory made understandable—how to build your first transmitter and receiver—how to use those same parts in building larger equipment.
Competent authorities, who have previewed it, judged this book the best of its kind they have ever seen. NOW ON THE PRESSES!
Get your order in *now* with any Parts Distributor to reserve *your* copy. Publication is limited! Price will be only 35c.
45th Anniversary
THORDARSON
ELEC. MFG. CO., CHICAGO
"TRANSFORMER SPECIALISTS SINCE 1895"