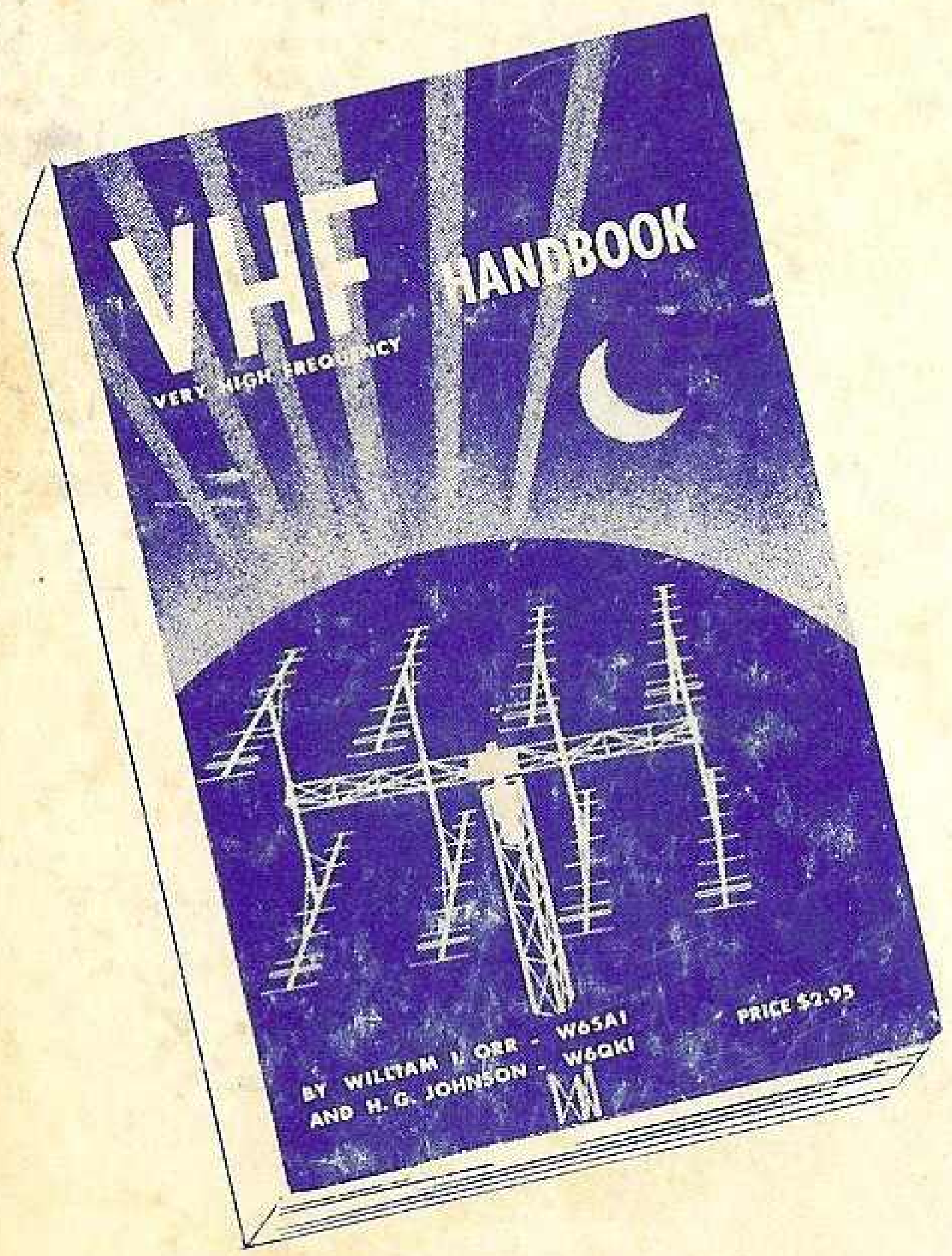

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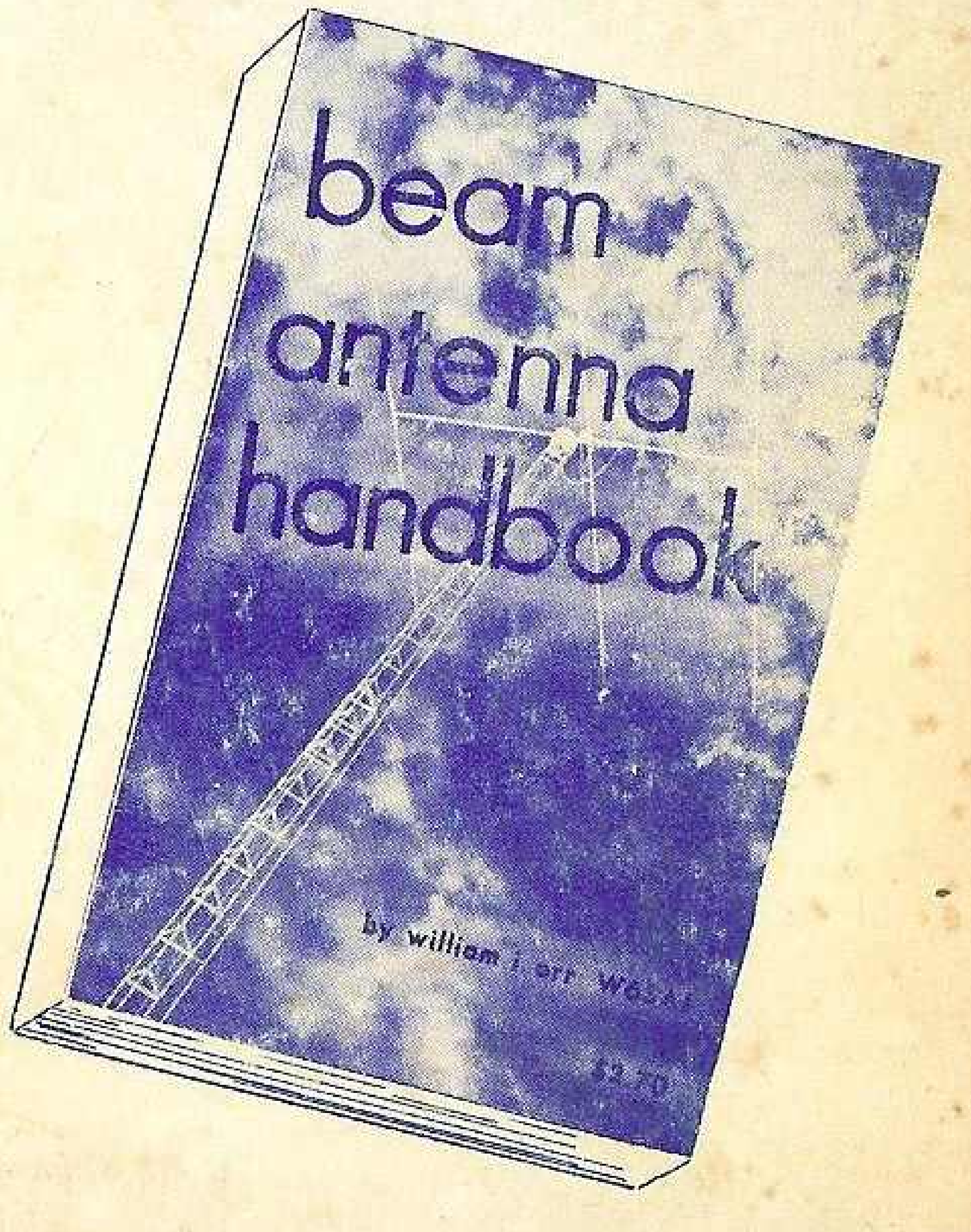

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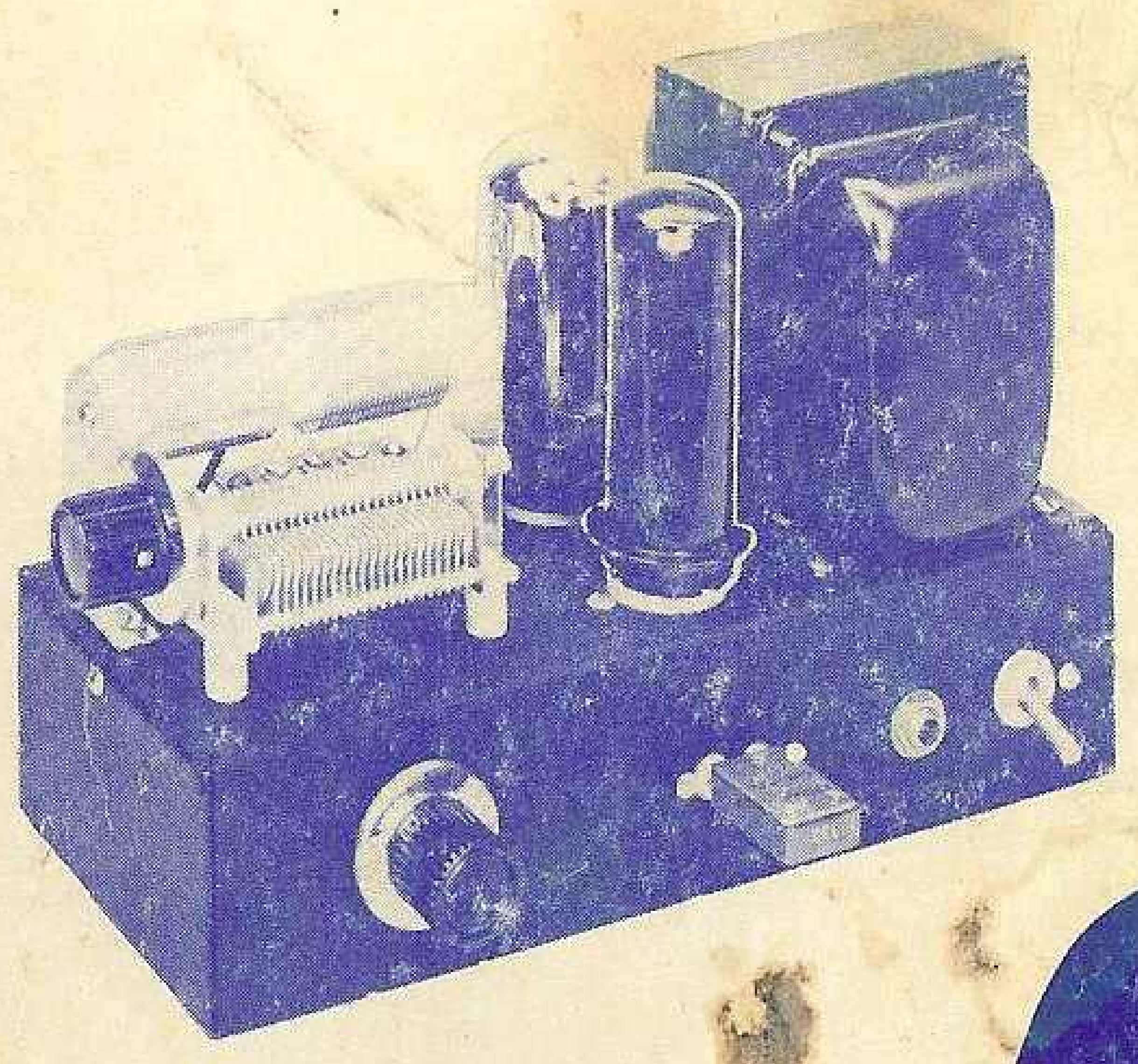
NOVICE AND TECHNICIAN HANDBOOK

William Orr, W6SAI
Donald Stoner, W6TNS



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- How to obtain your Amateur License
- How to assemble your Amateur Station
- How to get on the air

NOVICE

AND

TECHNICIAN

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FIRST EDITION

NOVICE AND TECHNICIAN HANDBOOK

TABLE OF CONTENTS

FOREWORD

Welcome to the realm of amateur radio! You will find this is a most exciting and satisfying hobby! Its popularity is well verified by the more than 200,000 licensed amateurs in all parts of the globe.

The purpose of the NOVICE AND TECHNICIAN HANDBOOK is to provide an insight into amateur radio, and to explain—in simple terms—some of the basic principles underlying radio communication. In addition, a selected group of radio transmitting and receiving equipment suited for the Novice and Technician amateur is illustrated, and detailed construction information is given. A new Handbook innovation is introduced in the form of step-by-step wiring instructions for the assembly of the equipment.

It is the hope of the authors that this Handbook will be of use to the beginning amateur, and will help him get on the air and obtain the maximum of pleasure and the minimum of headache from his station equipment.

The authors wish to thank the following individuals whose assistance and suggestions for the preparation of this Handbook were invaluable.

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P. R. Simms, WØRT (Collins Radio Co.)

Don, W6TNS   Bill W6SAI

COMPONENT NOMENCLATURE
FOR SCHEMATICS

CAPACITORS

1. VALUES BELOW 999 μμF ARE INDICATED IN UNITS. *EXAMPLE:* 250 μμF DESIGNATED AS 250
2. VALUES ABOVE 999 μμF ARE IND. IN DECIMALS. *EXAMPLE:* .0015 μF DESIGNATED AS .0015
3. ALL OTHER CAPACITOR VALUES ARE AS STATED. *EXAMPLE:* 15 μF, 0.3 μμF, ETC.
4. TYPE OF CAPACITOR IS DESIGNATED AS FOLLOWS:
   M = MICA
   BM = BUTTON MICA
   C = CERAMIC
5. VOLTAGE RATING OF CAPACITORS IS 600 VOLTS UNLESS OTHERWISE STATED.

RESISTORS

1. ALL RESISTORS 0.5 WATT COMPOSITION TYPE UNLESS OTHERWISE NOTED.
2. RESISTANCE VALUES STATED IN OHMS, THOUSAND OHMS (K), AND MEGOHMS (M)

EXAMPLE:
330 OHMS IS DESIGNATED 330
1500 OHMS IS DESIGNATED 1.5 K
1,000,000 OHMS IS DESIGNATED 1 M

CHAPTER I

The Romance of Amateur Radio

Sooner or later almost every individual is exposed to the fact that many fascinating events are taking place in the radio spectrum beyond the tuning range of the usual broadcast receiver. Upon investigation, the curious listener will find such activities as international broadcasting, radio beacons, ship to shore radio telephones, commercial radio links, police and aircraft stations, and radio amateurs *(hams)* crowding this hitherto unknown portion of the ether.

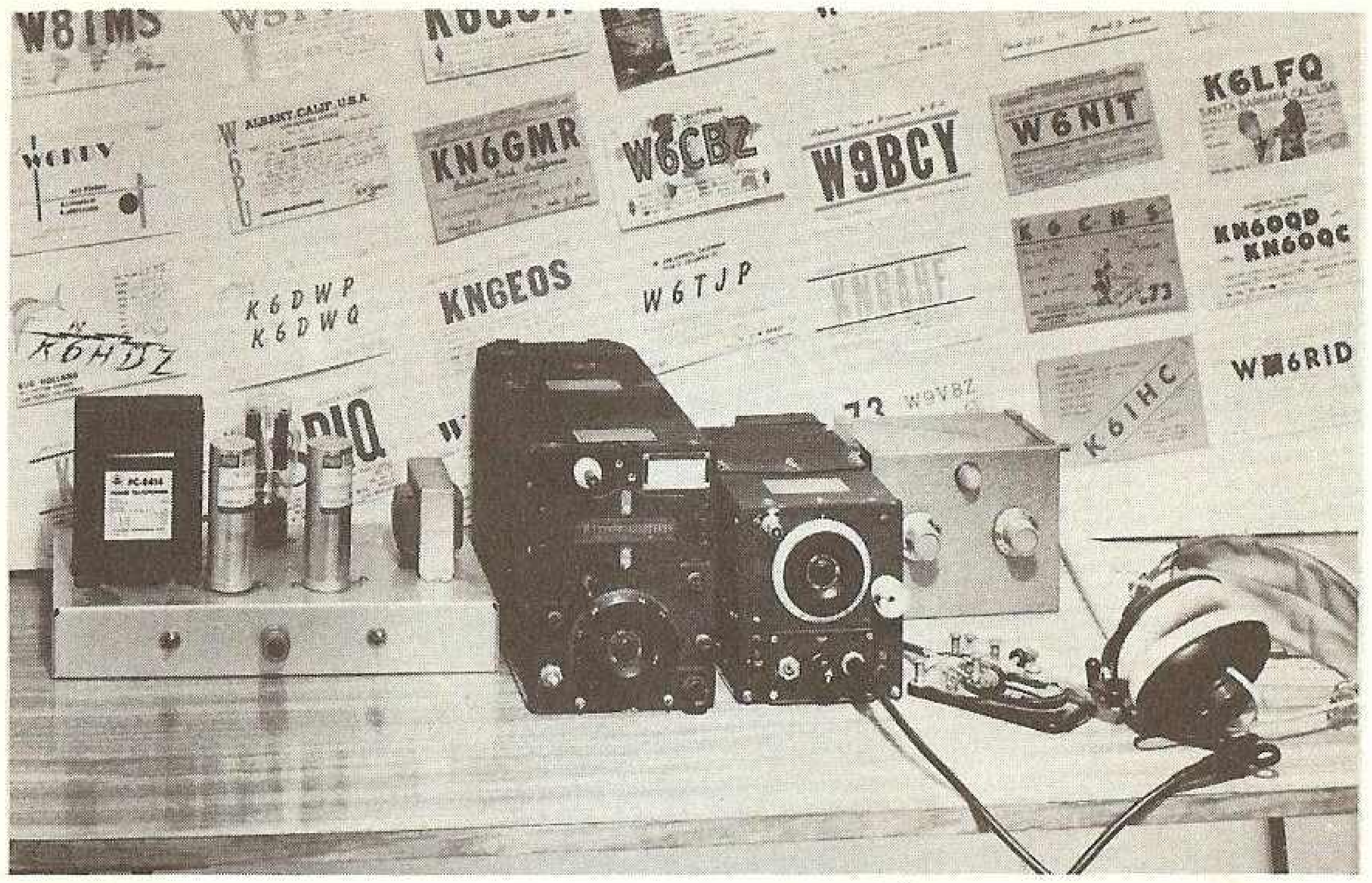
Of all these occupants of the high frequency radio spectrum, the radio amateur commands the greatest public interest. A civic servant in time of disaster, a trained technician and operator in time of war, and an experimenter in time of peace, the radio amateur enjoys the greatest scientific hobby in the world. As a training ground for industrial and military electronics, amateur radio offers the greatest possible opportunity to combine a fascinating avocation with practical experience in the art of electronics and communication. From the ranks of the radio amateurs come hundreds of ready-trained radio operators and technicians for the Armed Services, and thousands of engineers and scientists for the electronic industries and associated enterprises.

The hobby of amateur radio is as old as the art itself. Starting with a handful of bold experimenters before the first World War, the radio hams have grown to include more than 200,000 adherents, living in over 250 different countries of the globe.

What Is Amateur Radio?

Amateur radio is a hobby or avocation dealing with the art of communication by electronic means. It is recognized by practically all the countries of the globe who have formalized it in international agreements as . . . "self-training, intercommunication and technical investigations" . . . conducted by . . . "duly authorized persons interested in radio technique solely with personal aim, and without pecuniary interest." As a result of these international agreements, certain segments of the short wave radio spectrum are set aside for the use of radio amateurs.

In the United States and its possessions, the activities of the radio ham are supervised by a special branch of the government called the *Federal*



Thrills and excitement may be had from a simple "war surplus" Novice station costing less than forty dollars, assembled as described later in this Handbook.

Communications Commission. Radio amateurs licensed by this authority are responsible to it for the overall activities and conduct of their station. Certain regulations and restrictions are imposed upon the amateur by Federal Law, and specific requirements must be met by the individual desiring an amateur radio license. These regulations, restrictions and requirements are necessary to protect the great group of licensed amateurs, and to prevent the crowded short wave spectrum from degenerating into chaos.

To obtain an amateur license, the interested individual must have adequate knowledge of the rules and regulations governing amateur radio, and he must have sufficient technical knowledge to permit him to operate his equipment in the proper manner. Finally, he must be able to receive and send the International Morse Code at a prescribed rate of speed.

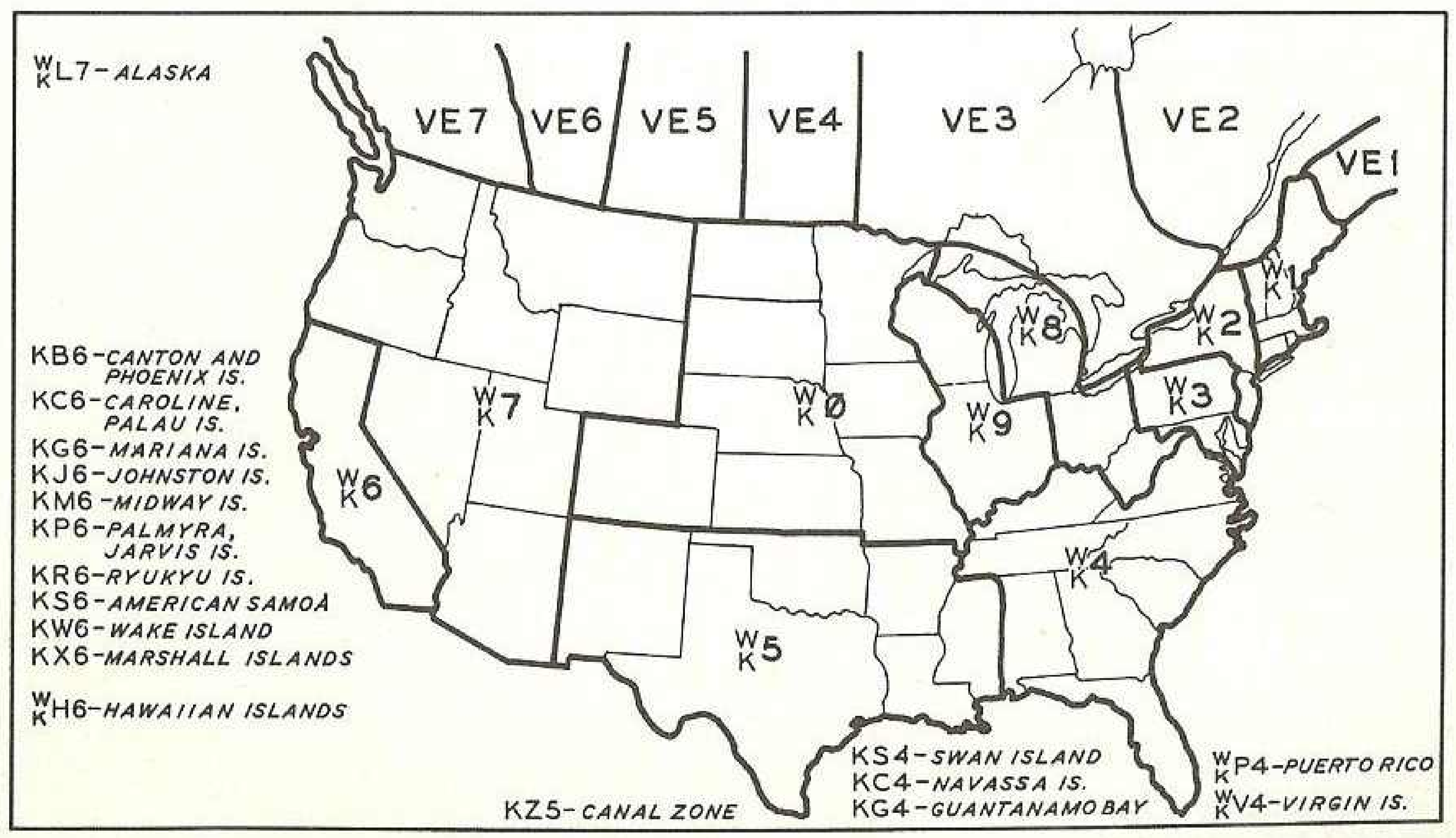
Radio amateurs as a group form a corps of trained technicians that the country may call upon in times of emergency, and who perform as civic servants in times of great need. The war record of radio amateurs in the various branches of the Armed Services, and the public service record of amateurs during hurricanes, floods and natural disasters are some of the reasons that the government is willing to reserve valuable portions of the radio frequency spectrum for the amateur. In times of war, the government may instantly move military communication circuits into amateur bands without the necessity of moving other complex services out of the desired frequency ranges. Thus, the amateur holds in trust important frequency bits that can be instantly converted to military use. Finally, the mastery of the code by the large body of radio amateurs is one of the great public services performed by these hobbyists. The trained reservoir of communication experts existing within the ranks of amateur radio is of great value to the country in times of international crisis. This fact is even recognized in many countries in which freedom of speech is curtailed.

Radio hams come from all walks of life. Well-known statesmen, movie actors, aviators, athletes, and others in the public eye are radio amateurs. Many famous scientists, doctors and industrialists are hams. School boys, housewives, grandmothers, cowboys, policemen, and teen-age "kids" are amateurs. Rich or poor, the hobby of amateur radio forges a common bond of interest between the fortunate members of this group.

What Does Ham Radio Offer You?

Amateur radio means different things to different enthusiasts. To all hams it allows an escape from the humdrum affairs of daily existence. Because of its almost magic-like capabilities it challenges the imagination, since it affords the opportunity for the ham to converse with thousands of other enthusiasts in all corners of the world. To certain amateurs the thrill of handling messages is the "heart" of ham radio. Some of these operators have organized relay chains to pass messages within the country and to overseas bases of the Armed Forces. Other amateurs are interested in long distance contacts, and revel in competing with other hams to see who can talk to the largest number of foreign countries and exotic out-of-the-way spots. There are other operators who are merely interested in good conversation or companionship, and who favor "rag chews" with local friends, and some amateurs who follow the experimental and technical phases of the hobby. This latter group uses the air as the proving ground for their experimental equipment. Other amateurs are interested in propagation techniques, and spend much time experimenting with the very short radio waves. Still others are interested in amateur television or perhaps radio-teletype.

So it can be seen that the hobby of amateur radio is really a collection of hobbies within a larger hobby, all bound together by the invisible electromagnetic waves of the radio spectrum.



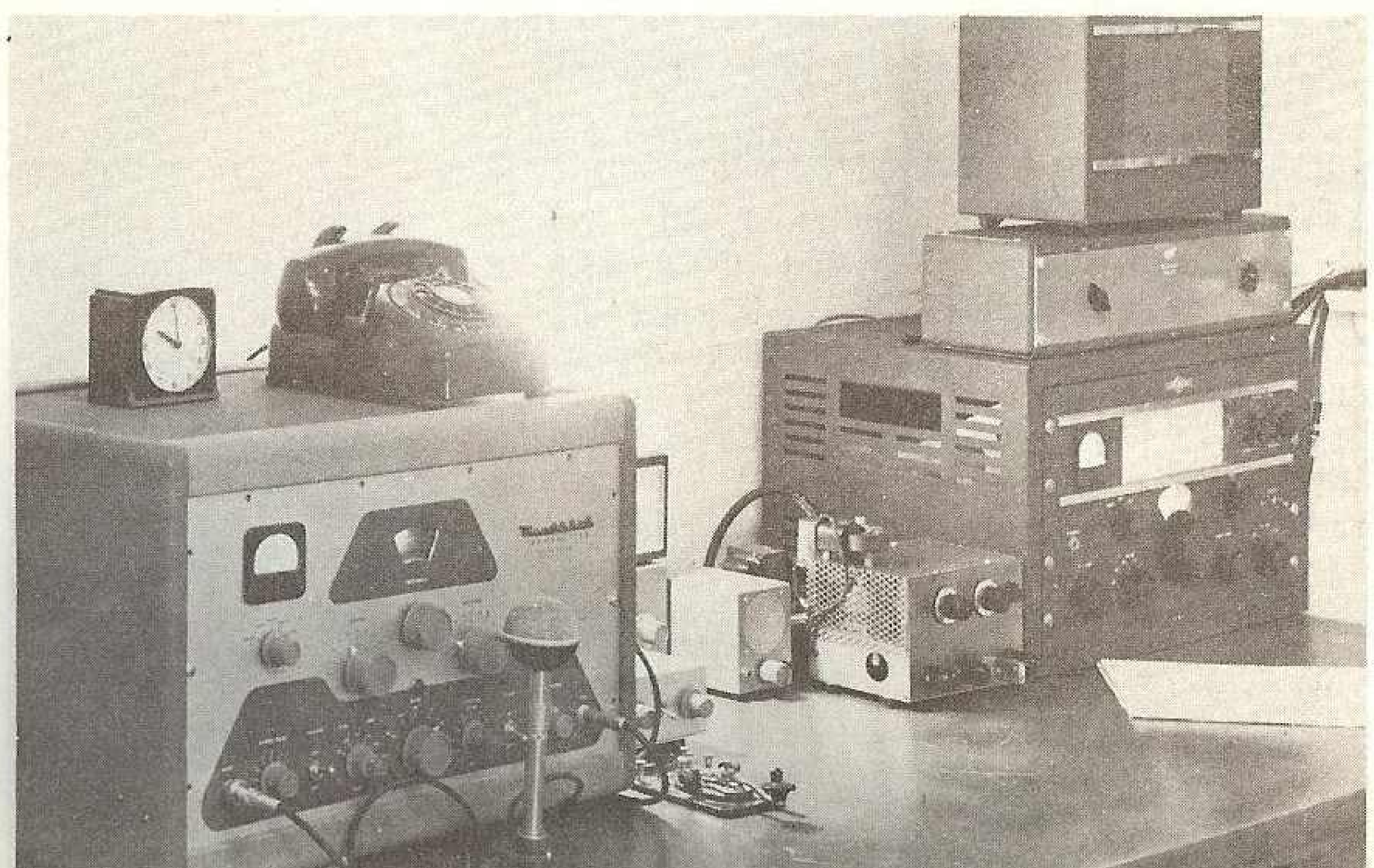
Call area map of United States and Canada, showing overseas prefixes.

Amateur Radio Communication

Radio amateurs may use various modes of communication. The most inexpensive and widely used method utilizes *c-w telegraphy,* or code. The International Morse Code is universally employed for this type of communication. Other amateurs employ voice transmission *(radiotelephony),* while others go in for more unusual means of communication, such as teletype, or television. C-w telegraphy is the most reliable of these various modes of communication under conditions of heavy interference, and it is the least expensive means of communication for the beginner, offering the greatest results for a given investment in transmitting equipment.

Since 1946, much interest has been aroused by *mobile operation* of amateur stations. A complete radio station—often of elaborate proportions—is installed in the automobile of the radio amateur, allowing two way communication while he is driving to work, or perhaps travelling on a vacation trip. A whole series of specialized radio equipment has been designed for specific mobile use by hams, and mobile interest runs high, particularly on the 10- and 80-meter bands.

Some new listeners to the amateur bands are often inclined to ask, "What do radio hams talk about? What can you say to someone whom you have never met?" The answer to this question, of course, is that the conversation of amateurs on the air is only limited by a combination of the amateur's imagination and his common sense of politeness. Discussion of radio equipment and of radio propagation conditions are always popular. The latest DX information travels rapidly via the amateur "grapevine." After close friendships have grown between amateurs, the conversation usually becomes of a more private nature. In general, such controversial subjects as politics, etc. are considered bad taste on the amateur bands, and discussions about



As the Novice becomes more experienced, his equipment becomes more expensive. Shown above is 175 watt all-band transmitter and double-conversion receiver.

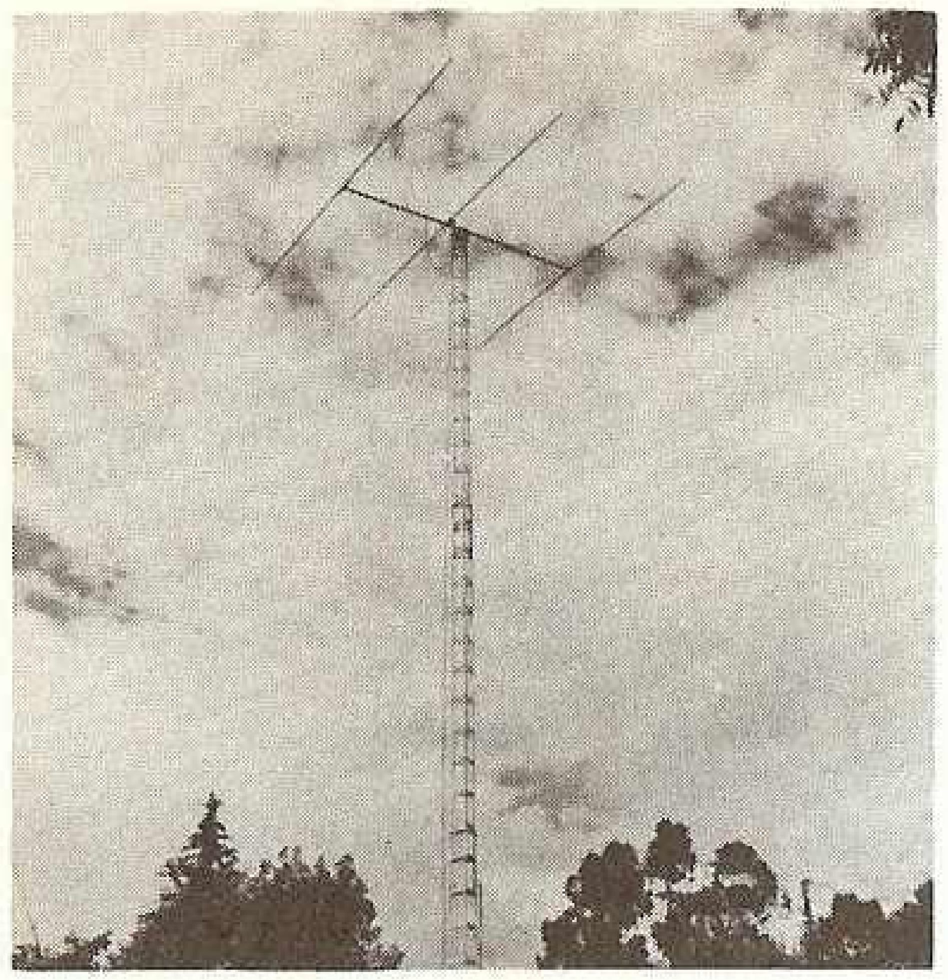
DX-thrill of a lifetime occurred in 1951 when SM5UM (left) and W6SAI (right) visited PX1YR (center), only amateur in tiny Principality of Andorra. Many amateurs enjoy thrill of DX operation during vacations to far-away countries.

such topics are rarely heard. The radio amateur must always keep in mind that his conversation is always open to any casual listener who tunes to his signal. As a result, the ham should say nothing on the air that he would not be willing to say in public.

Many amateurs have banded together for *net* operation. That is, a group of amateurs meet at regular intervals upon a chosen frequency for a "round table" contact. Some nets are employed for the handling of third party messages, others meet to exchange technical information, or merely for the exchange of pleasantries and good fellowship. Certain nets are formed to provide the newcomer to amateur radio with the opportunity to improve his code speed or operating ability, and in times of national emergency radio amateur nets provide communication and assistance to stricken areas.

Another facet of amateur radio is the participation of hundreds of hams throughout the world in the various radio contests sponsored by radio magazines and clubs. These competitions may take the form of "DX tests" in which the participants try to contact the greatest possible number of foreign countries, or perhaps contests in which a premium is placed upon operating skill. Special contests are also held for the VHF operator, and other special interest groups.

To further enhance the hobby, it is possible for the ardent amateur to win operating awards, such as the DXCC (DX Century Club) for contacting 100 different countries, the WAZ (Work All Zones) award, and the WAS (Work All States), etc. Many of the larger radio organizations throughout the world have contests and awards for radio amateurs. The station of a "contest man" is literally covered with diplomas, certificates and cups, all attesting to his skill at a certain phase of amateur radio.



The use of rotary beam antenna is common practice in the amateur bands above 40 meters. A simple rotary array can quadruple the signal of the transmitter in the desired direction, and cut down on received QRM coming from unwanted directions. Shown at left is a three element 21 mc beam.

Radio Amateur Regulations

In the United States and Possessions, the Federal Communications Commission issues amateur radio operator licenses and station licenses to duly qualified citizens. There are four classes of amateur operator licenses: 1) Novice, 2) Technician, 3) General Class, and 4) Extra Class. Each class of license has certain defined privileges and has different examination requirements. The Novice and Technician Class licenses are the most restricted in scope and are the easiest to obtain. This Handbook is mainly concerned with these two types of licenses.

Amateur Licenses

The *Novice License* may be considered to be an "apprentice" license, in that it forms an important step towards the General Class and Extra Class License. This license is non-renewable, and runs for a period of one year. It is intended to give the newcomer to the amateur game some actual "on the air" experience. Requirements for the Novice License include a basic knowledge of amateur regulations, electrical theory, and a code examination in transmission and reception at the rate of five words per minute. The holder of a Novice License is entitled to operate c-w and phone in the band segments shown in Chapter 2. The transmitter of the Novice operator is limited to a maximum input of 75 watts, and must be crystal controlled. During the year term of the Novice "ticket" the holder of such a license must qualify for a higher grade of amateur license as the Novice License becomes void at the expiration of that time, and cannot be renewed.

The *Technician License* is issued for the purpose of encouraging experimentation and developmental work on the higher frequency amateur bands. This license is renewable and the requirements include a written examination covering amateur regulations and electrical theory, and a code test at the rate of five words per minute. The written examination is comparable in scope to that given for the General Class License. The Technician License covers operation on the 50 mc amateur band, and all amateur frequencies above 220 mc.

The *General Class License* is the usual form of amateur license, allowing both phone and c-w operation on all amateur frequencies. Requirements for this class of license include a code examination in sending and receiving at a rate of thirteen words per minute, and a written examination covering amateur regulations and electrical theory.

The *Extra Class License* may be considered to be the highest grade of amateur license issued by the Federal Communications Commission. The requirements for this class license include two years amateur experience, a code examination at the rate of twenty words per minute, and a written examination covering advanced electronic theory. At present, no additional privileges are attached to this license over the usual privileges of the General Class License.

A complete outline of license requirements, examination procedure and Federal Regulations governing amateur radio will be found in the *Radio Amateur's License Manual*, published by the American Radio Relay League, West Hartford 7, Conn.

Amateur Call Letters

Amateur call letters are assigned by the FCC on an impartial basis. A typical amateur call consists of a letter, a number, and two or three letters. The letter or letters before the number designate the country in which the station is located (W or K in the case of stations located within the continental United States). The normal procedure is to issue "W" call letters in a certain area. When all available "W" calls have been issued, the letter "K" is then employed as the prefix. The numeral in the amateur call designates the area in which the station is licensed (Figure 1). The United States is divided into ten call areas, bearing the numerals 1 to 0 (zero). Following the numeral are two or three letters assigned in alphabetical sequence which individualize the amateur station. These suffix letters may begin with any letter of the alphabet except "X," an old indication of an experimental-type license which is no longer issued. In addition, certain letter combinations starting with "Q" are not employed for amateur calls, as these combinations are used in the international *Q-signal* code groups.

The Amateur Station

The amateur radio station consists of a short wave receiver and a transmitter capable of working on one or more of the amateur bands. An antenna tuned to the band in use is also required, as is an instrument for measuring and checking the frequency of the amateur transmitter. Other items of equipment may be added as the station expands. In recent years, many items of station equipment have become available in kit form, greatly simplifying the problem of home construction.

The cost of a complete amateur station depends largely upon the indulgence of the operator. For less than $25 an experienced amateur can assemble a workable station from war-surplus equipment. Some of the simpler surplus conversions suitable for the Novice and Technician are discussed later in this Handbook. If commercial equipment in kit form is purchased, the minimum cost of an amateur station may run between $60 and $400, depending upon the power level and complexity of the equipment. Additional savings may be made if a second hand receiver is procured.

As the ham operator becomes more proficient, he usually will desire more and better equipment. If money is not a retarding factor, "the sky is the limit" as extensive installations may run into the tens of thousands of dollars. The point is, however, that an inexpensive amateur station costing under one hundred dollars can certainly produce very satisfying results, and can allow contacts to be made over distances of many thousands of miles.

The ultimate key to the success of the amateur station is the antenna employed for transmission and reception. The best transmitter will produce mediocre results when attached to a poor antenna. Sufficient literature is available to allow the amateur to build a good antenna, and many fine manufactured antennas are available on the market at a modest price.

An important adjunct to the amateur station is the *harmonic filter*, which prevents spurious emissions of the transmitter from interferring with nearby television receivers of modern design. Certain manufactured transmitters and transmitter kits have interference prevention filters incorporated in the circuit. In other cases, such filters must be added to the existing equipment.

The International Morse Code

If it were not for the code, there would probably be over a million radio hams on the air in the United States! Many would-be hams gripe and grumble at the prospect of learning the code. They wish a ham "ticket" to be handed to them on a silver platter. The code, however, forms the backbone of the amateur license, and mastery of the code is one of the principal reasons that amateurs are actually allowed to occupy bands of frequencies that are ardently desired by other services. If the code test were abolished, one of the principal arguments for the existance of the amateur would vanish. The best advice to the would-be amateur is not to look upon the code as an obstacle in the path of the amateur license, but as an achievement to be won on the way to becoming a better radio ham! Listen to all

Many overseas amateurs do not enjoy radio parts, kits and equipment that is easily obtainable in W-land. Completely home built equipment is the rule, as shown in this photo of ex-FP8BX. Note the home-made coils on the transmitter at the left. Running but ten watts, FP8BX worked many DX stations in all parts of the world. What can you do with 75 watts? Try your hand at DX!

the hams operating c-w (code). Nobody is forcing them to do it. They like it! By the same token, once you have mastered the code and obtained your amateur license, do not renounce c-w operation for "easier" modes of transmission. Set your sights on a higher c-w operating goal and go after it.

All letters of the alphabet, the numerals and the important punctuation may readily be transmitted via c-w telegraphy by the use of the International Morse Code. This code is employed throughout the world, and all countries are in agreement as to the meaning of the code symbols. Certain foreign countries employing different alphabets may have their own particular code systems, but these are also based upon the International Morse system. It is mandatory for the prospective radio amateur to learn this code, and to be able to transmit and receive it at stated rates of speed in order to qualify for any grade of amateur license.

The International Morse Code is made up of three characters: the *dot*, the *dash*, and the *space*. A code chart comprising the alphabet, numerals, and punctuation is shown in Figure 2. Mastering this code has been the stumbling block to perhaps 40 percent of the eager applicants taking the amateur examination for the first time. However, study and practice will pay off, as testified by the over 150,000 radio amateurs in the United States.

How to Learn the Code

Those amateurs proficient in the use of the code are almost unanimous in the opinion that the best way to learn the code consists of memorizing the *sound* of the various characters, rather than by the appearance of the

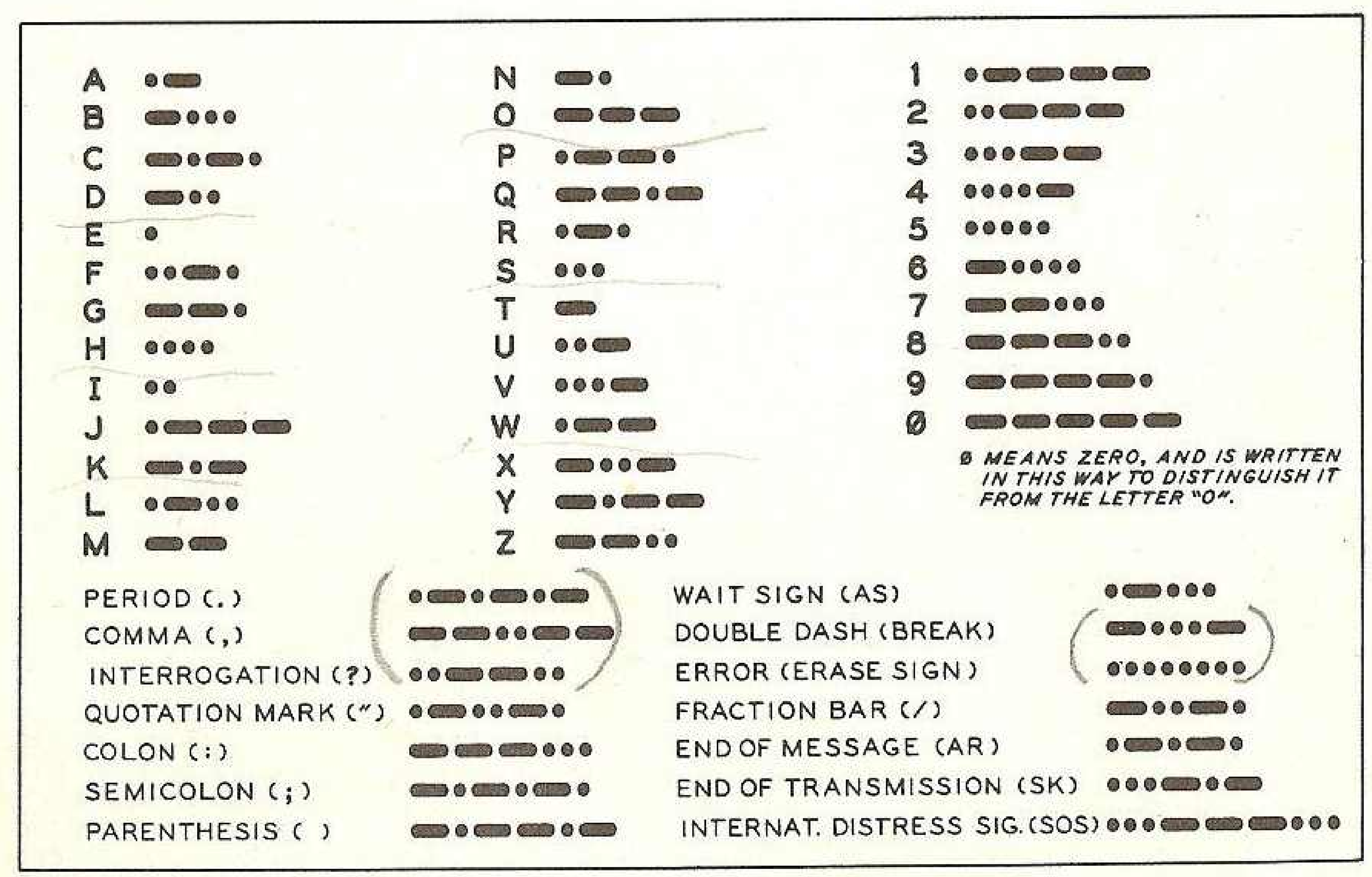


Fig. 2 First step towards the amateur "ticket" is the Morse Code, illustrated in the above table. Punctuation is not required for the Novice license. As with any skill or sport, the key to quick and successful mastery of the code is summed up in the single word: PRACTICE. If you spend an hour a day at code practice, you will be well on your way to obtaining that coveted Novice license.

dots and dashes that make up the letters. It is best to imagine the code symbols as being made up of sounds, such as one hears when listening to c-w signals on a short wave receiver. The letter A in the code, for example, is not "dot-dash," but *dit-dah.* All dots bear the resemblance to the sound *dit* and all dashes sound like *dah* when heard on a short wave receiver, a code practice oscillator, or an electric buzzer.

There are many schools of thought as to the best way of learning the code. In all cases, the first step is to completely memorize the code, so that each character can be instantly translated into *dits* and *dahs* at the drop of a hat. Take a few letters at a time and memorize them thoroughly, such as A, B, C, and D. Be sure to learn each letter by itself without having to think of the neighboring letters. When you tackle the next group of letters, continue to review all the previous letters that you have studied. A half an hour in the morning and a half an hour at night (at the minimum) will work wonders! You should keep at this practice until someone can awaken you at 3 a.m. and ask, "What is the letter Q?", and you reply "dah, dah, dit, dah!" without even opening your eyes!

A very effective method of memorizing code characters is to place each letter on a "flip card." This device is a piece of cardboard the size of a playing card, with the code symbol on one side and the equivalent letter or numeral on the other side, together with the code symbol. If a friend spends a few minutes a day with you, flashing the cards one at a time while you repeat the letter aloud for the code symbol you see on the card, you will memorize the symbols rapidly. A second deck of flash cards may be made in the reverse order, showing a letter or numeral. In this case, you write the code symbol for the letter or numeral you see. However, once the separate letters and numerals are memorized, it is still necessary to obtain actual practice in transmitting and receiving the sound of the c-w symbols. In passing, it should be noted that punctuation and numerals are not required for the Novice examination.

This is the deluxe all-band station of "Doc," W8FHY, Ishpeming, Michigan.

The code must be *thoroughly memorized* before actually starting to practice for speed. If you hesitate even slightly on any one letter, numeral, or punctuation mark, your job is not yet done! After you have thoroughly learned the whole "works," you should obtain as much practice as possible in mentally translating every word you see into the code. Whenever you read a newspaper, a book, or see a billboard or a sign, translate it into the code and "send" the message to yourself. If you can learn to "think" code for everything you read, you will soon find that it becomes remarkably easy—and fun, too!

Once you have reached this stage, the battle is more than half won! The next step is to gain practice in actually sending and receiving the code. If you are lucky enough to have a friend who is learning the code with you, the process will be much easier as you may practice sending and receiving the code with each other. As a side line, you should also practice copying code transmissions with your receiver. One of the best methods of picking up code speed is to rent or buy a tape machine that is capable of sending code at various rates of speed. The *Instructograph Co.*, 4701 Sheridan Rd., Chicago 40, Ill., rents and sells tape machines, as do other companies. The important thing to remember is that learning to send and receive code takes both *time* and *practice.* It is necessary to practice at least an hour a day, seven days a week in order to become proficient enough to really learn the code for any grade of amateur examination. This sounds hard, but it is not. The main requirement is perseverance, not skill. Keep at it, and soon you will find that you are able to actually copy code messages on the air, and that reception and translation of the magic *dits* and *dahs* will become almost second nature!

One of the best manuals for would-be hams that are working to master the code is *Learning the Radiotelegraph Code,* published by the American Radio Relay League, West Hartford 7, Conn. This booklet will not only help you to learn the code, but will also aid you in increasing your code speed in preparation for the next higher grade license examination.

CHAPTER II

Radio: What Is It?

One of the most fascinating aspects of amateur radio is the system by which radio signals are transmitted from one point to another. To speak into a microphone and to have your voice reproduced in a receiver a thousand miles away is an amazing thing, indeed.

Radio waves are but a small portion of the great family of electromagnetic radiation (Figure 1) which includes light, heat, X-rays, cosmic rays and other unknown forms of energy. Indeed, all forces in the universe are of electromagnetic origin since these forces involve matter, and all matter is composed of atoms which in turn are made of building blocks of minute electrical particles.

A simple definition of a radio wave is *electrical energy that has escaped into space.* Radio, in the overall sense, is not a *thing,* such as a chair or a house, but is a way in which things behave. Its effects can be measured and predicted, and it can be generated and put to use by man. But of the ultimate nature of the radio wave, nothing is actually known.

Electromagnetic Radiation

Every electrical circuit that carries alternating current radiates a certain amount of this energy into space in the form of electromagnetic waves. The amount of radiated energy is small in most cases unless the radiating body approaches in size an appreciable fraction of the wavelength of the alternating field. It is possible to show in a simple manner that ordinary 60 cycle alternating current is radiated a short distance from the electric light wires of your house. Take a pair of headphones and connect them to a small coil of many turns of wire. When this coil is brought near an exposed light line, a distinct 60 cycle hum will be heard in the earphones, even though they have no physical connection to the light wires. The distance from the light line that the hum may be heard is small, perhaps only a few inches or so. However, if the coil is carried beneath high tension lines it may be possible to pick up the power line hum at a distance of twenty or thirty feet from the wires. A sensitive voltmeter connected across the pickup coil would indicate the amount of radiated energy that is being "received" by this primitive "radio set." The actual amount of power radiated from a 60 cycle power line is very small, since the length of the 60 cycle wave is

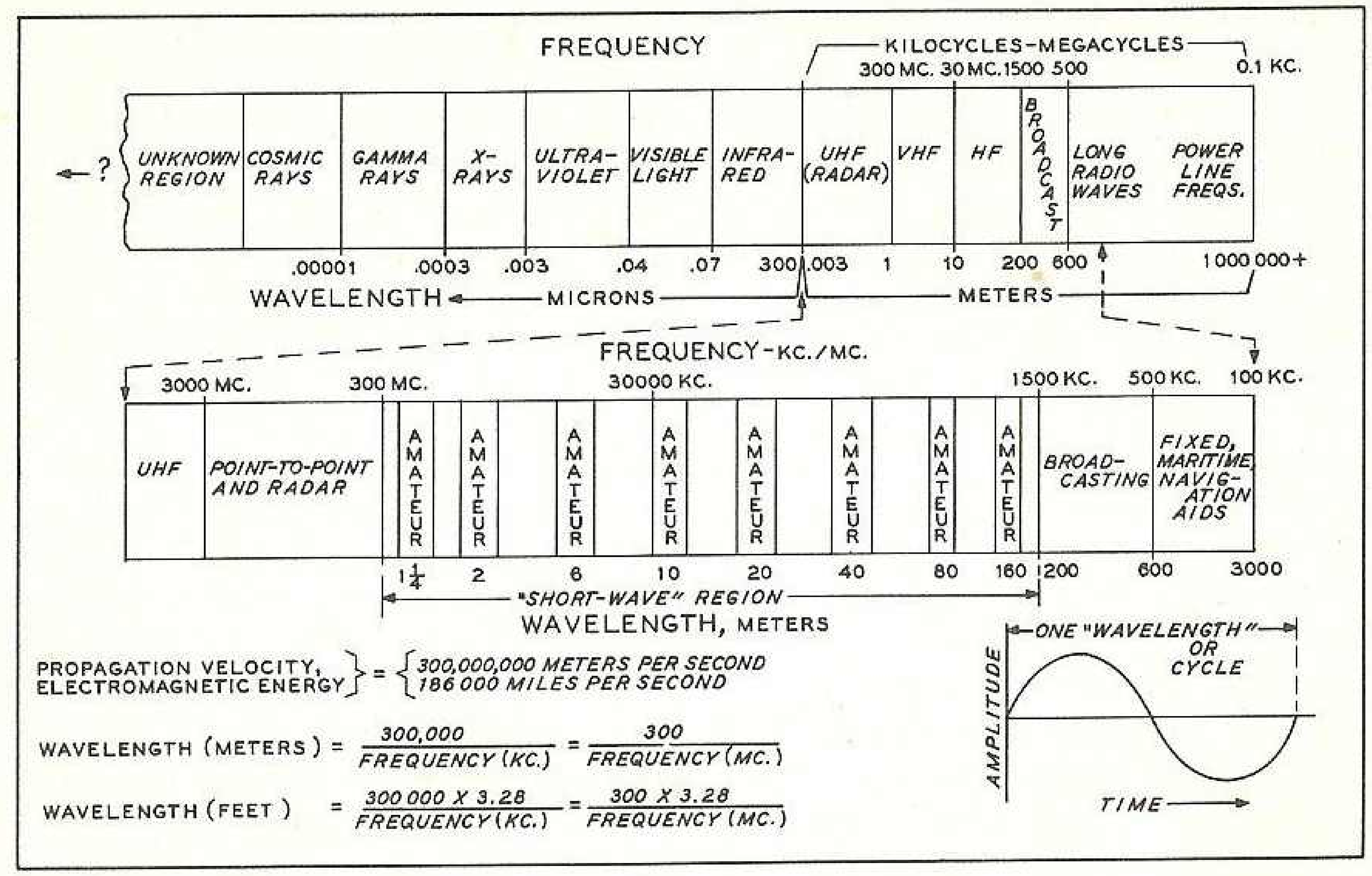


Fig. 1 The radio frequencies are but a small portion of the electromagnetic spectrum. As wavelength shortens, radio waves merge with infra-red waves.

of the order of 3100 miles, and the length of a power line is short compared to the length of the wave.

As the frequency of alternation of the current is raised and the wavelength is lowered (Figure 1) a region is reached where the invisible field becomes of some practical use for long distance communication. At a frequency of 15,000 cycles or so electromagnetic energy may be generated in an efficient manner by a special machine called an *alternator,* which is an a-c generator having many pole pieces. The 15 kc signal is radiated by huge antennas covering several square miles. It is interesting to note that at this relatively low frequency the radio wave still resembles the common 60 cycle house current in the fact that it may be generated in the same manner—by sweeping a coil through a magnetic field.

The great alternators that generated frequencies in the 15 to 100 kilocycle portion of the radio spectrum are a thing of the past, however, since the same job may be done more easily and cheaply by vacuum tubes. In passing, it might be noted that methods other than the alternator and the tube have been employed in the early days of radio to generate electromagnetic waves of low frequency. Among the most famous of these are the oscillatory spark transmitter, and the Poulsen arc.

The region between 15 kilocycles and 50,000,000 kilocycles is classified as the communication range of the electromagnetic frequency spectrum. Below 15 kilocycles, the frequencies are thought of as power line frequencies. Above 50,000,000 kc (50,000 mc) is a region wherein the electromagnetic energy begins to assume the properties we associate with light waves. Waves of 10,000,000,000 kc are commonly known as *infra-red* waves. For simplicity, the kilocycle and megacycle nomenclature are dropped in this part of the spectrum and the wave is measured in terms of *microns.* A micron is one-millionth of a meter. As the frequency is increased, the infra-red waves shorten into visible light waves, the red light being composed of the longest visible waves, and the violet light the shortest. Higher in frequency than light are the ultra-violet waves, the X-rays and the gamma rays. Highest in frequency of all of the waves known to man are those radiations known as *cosmic rays.* Undoubtedly there are radiations yet unknown that occupy the spectrum above the position of the cosmic rays.

It is interesting to speculate as to why "radio" waves are used for communication purposes out of all the enormous frequency spectrum of radiant energy. It should be noted in this regard that radiations of certain frequencies are sometimes harmful to man (X-ray and gamma rays), other frequencies are quickly absorbed by the atmosphere of the earth (infra-red waves), and others are unwieldy to radiate (power line frequencies), or hard to generate (millimeter waves). The waves most compatible to the tools of man fall in the region of the electromagnetic spectrum wherein the size of the wave is comparable in size to man himself. These waves may be easily handled, are not harmful to human life and are capable of being radiated with simple devices. It is our good fortune that a small portion of these waves are capable of being reflected from the ionosphere above the earth, permitting long distance communication across the surface of this planet.

The Radio Transmitter

The radio transmitter may be thought of as a device capable of generating energy in the communication portion of the electromagnetic spectrum. The simplest Novice transmitter employs only a single oscillator tube, with the rate, or frequency of oscillations controlled by means of a quartz crystal. A more complex transmitter may have an amplifier tube following the oscillator, building the energy up to a higher level. It should also have a means of

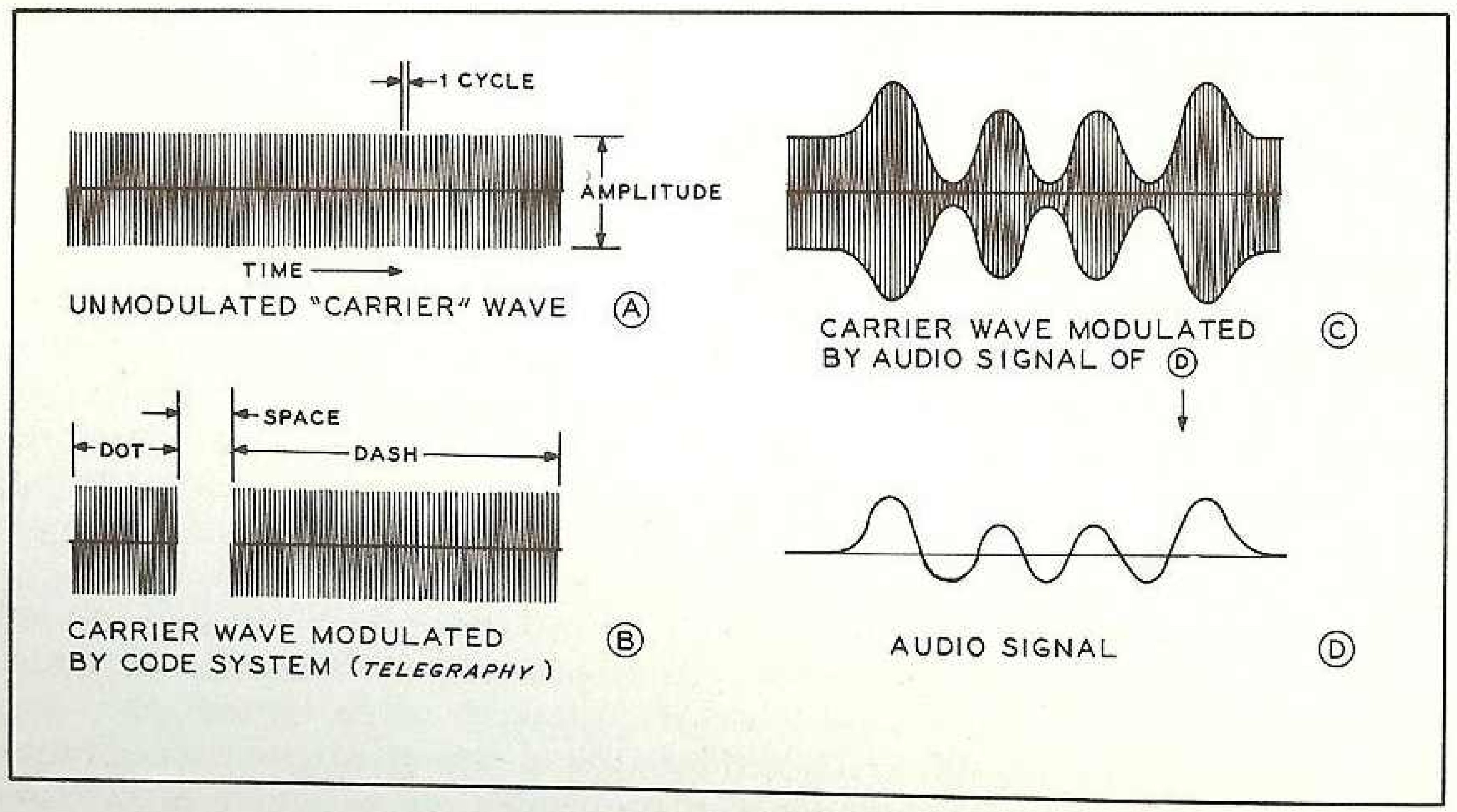


Fig. 2 Intelligence is transmitted on carrier wave by varying the amplitude. Code transmission breaks wave into "dot" and "dash" segments, while audio signal impresses its electrical equivalent upon envelope of carrier. Other forms of modulation such as frequency or pulse modulation may also be used.

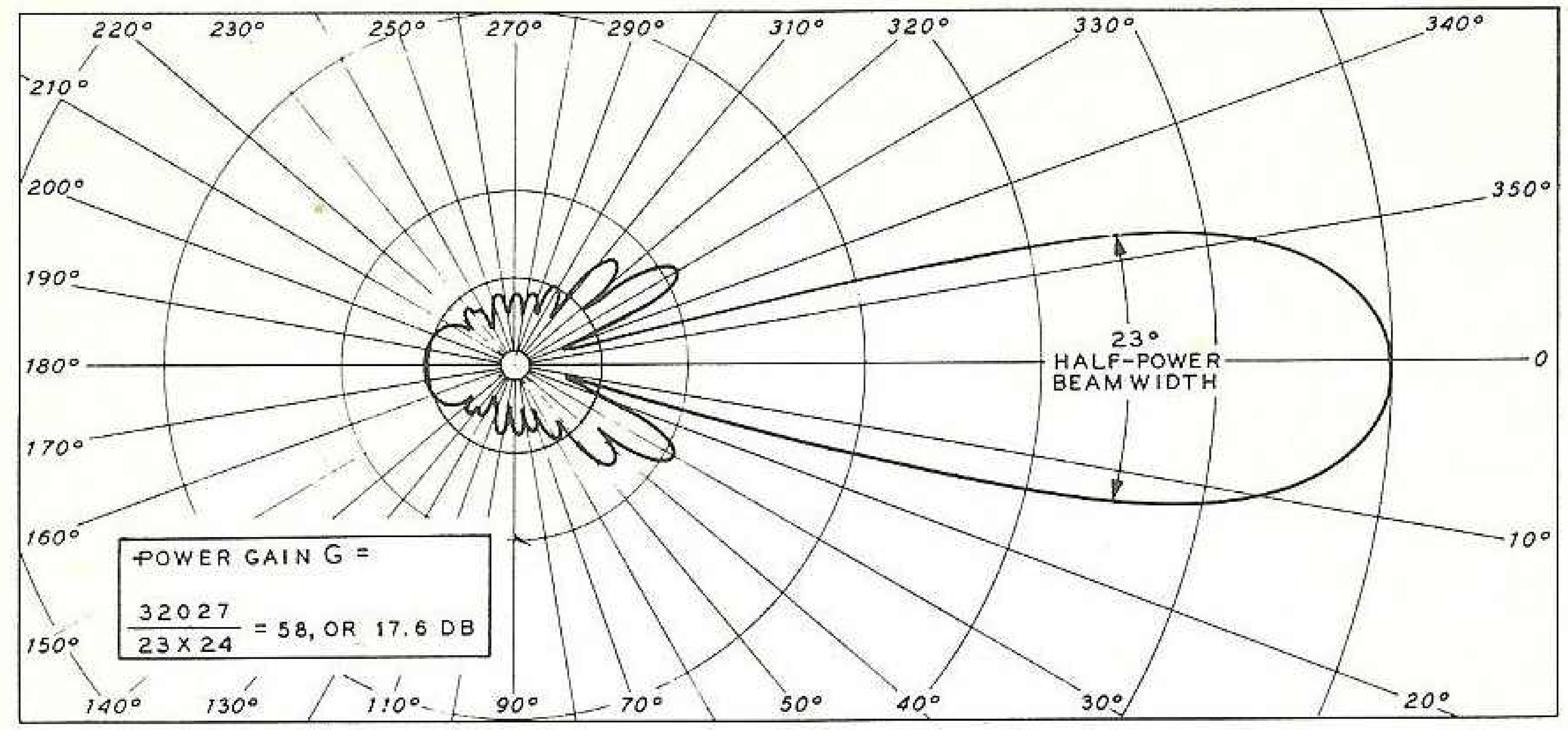


Fig. 3 A "beam antenna" concentrates the radio energy in one chosen direction, as shown in this horizontal pattern. Superimpose this plot upon a map and you will see how the radio signal may be "squirted" in the wanted direction.

varying the power output of the transmitter, plus indicating devices to tell the operator when the unit is functioning properly.

The radio energy produced by the transmitter is called the *carrier wave* as it "carries" intelligence from the transmitter to the receiver. Information may be transmitted by a radio telegraph signal by simply turning the carrier wave on and off in accordance with a pre-arranged code system. A radio telephone signal may be produced by varying the *amplitude* (strength) of the radio signal in accordance with the variations of the sound wave to be transmitted. In like fashion, a picture may be transmitted by radio by varying the amplitude of the carrier wave in proportion to the intensity of the light reflected from that part of the picture being transmitted at any given instant. Examples of several types of carrier modulation are shown in Figure 2.

The Antenna

A device that will radiate electromagnetic energy into space is called an *antenna.* For radio frequencies, the antenna is made from a metallic substance, such as copper, aluminum or steel, and may take any number of forms. The most common antenna is a piece of copper wire, usually of a specific length, related to the length of the radio wave being transmitted or received. Every type of antenna has directional characteristics by which it radiates and intercepts energy better in certain directions than in others. Only an antenna infinitely small compared to the radio wavelength may truly be thought of as non-directional. The directional effect may be used to advantage to concentrate the radio signal in a desired direction as shown in Figure 3.

It is often inconvenient to connect the antenna directly to the transmitter, therefore a "radio hose" called a *transmission line* is used to transfer the energy directly from the transmitter to the antenna. The line is designed to radiate a minimum of energy, in contrast to the antenna, which is designed for highest radiation efficiency.

Antenna Resonance

For highest efficiency, the antenna should be *resonated* (tuned) to the operating frequency of the transmitter or receiver. In this condition, the antenna will transfer or intercept a maximum of energy referred to the surrounding space. The amount of energy radiated from any antenna is proportional to the r-f current flowing in the antenna proper, so great care must be taken to see that the antenna system is designed for maximum transfer of energy from the transmitter to the antenna. A resonant antenna system is the first and most important step in this direction. Antenna resonance will be discussed in greater detail in the Antenna Chapter of this Handbook.

Wavelength and Frequency

A confusing situation exists in that any given radio signal may be described in terms of *frequency* (rate of change of alternation of the wave) or in terms of *wavelength* (physical length of one wave cycle). The radio wave (like all electromagnetic energy) travels through space at the speed of light which is about 186,000 miles per second, or 300 million meters per second. The meter is a unit of measure of the physical sciences and is approximately 3.28 feet in length. Because the radio wave occupies both time and space the wavelength and the frequency and the speed of light may all be packaged into a neat little formula that will translate wavelength into frequency and vice-versa, as shown in Figure 1.

As a quick mental exercise, let's assume a transmitter is operating on a frequency of 25,000 kilocycles (25 mc). By dividing the speed of light by the frequency, we find that the wavelength of the station is 12 meters. You will note that the conversion data of Figure 1 will work for meters and kilocycles, and meters and megacycles. Just be sure to keep track of your zeros, and all will come out well!

Radio Propagation

Although we cannot see the electromagnetic radiations leaving the transmitting antenna, instruments can measure and describe it, and theory and experiments can tell us what it does after it has left the antenna. Radio signals leaving the antenna are influenced by a number of factors, some of which may be controlled, and others which are beyond our power to control. We can control the angle and the direction taken by the signal as it escapes into space by making changes in the electrical characteristics of the antenna and by changing the height of the antenna above the surface of the ground, but after the wave has left the antenna system we are powerless to control it.

A portion of the radiated energy hugs the surface of the earth and is termed the *ground wave*. Commercial broadcasting stations make use of the ground wave, since it has proven to be a very reliable means of communicating over medium distances. Ground wave coverage in the broadcast band may range up to 500 miles, the coverage increasing as the frequency diminishes. Large portions of the earth may be covered by the ground wave at frequencies in the 100 to 200 kilocycle region. At the higher frequencies (shorter wavelengths) the ground wave diminishes, dropping to a dozen miles or so in the vicinity of 10 mc.

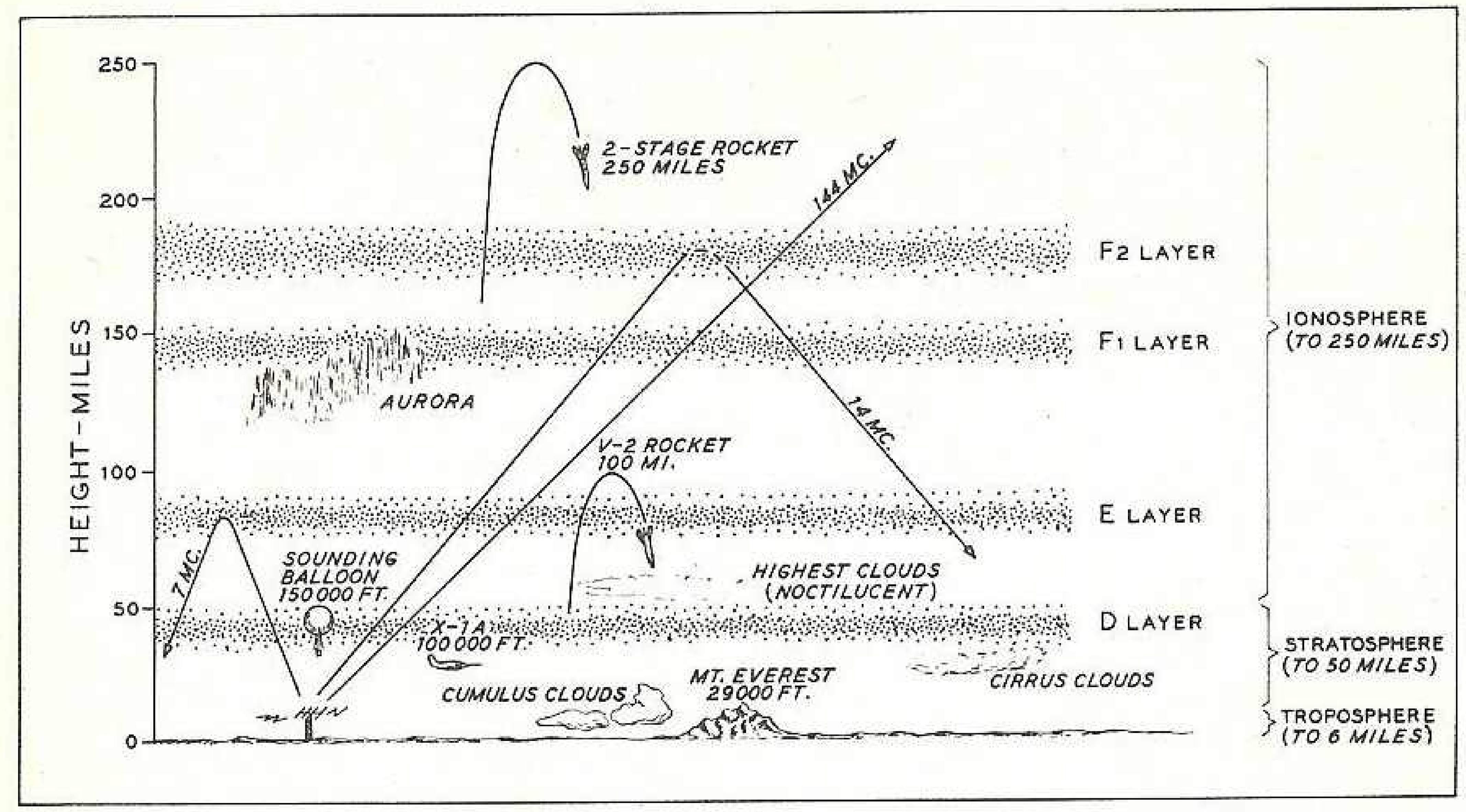


Fig. 4 The earth's atmosphere is composed of three layers, the lowest of which is the troposphere, or weather layer. The stratosphere (constant temperature zone) is next, extending to a height of about 40 miles. Above this is the ionosphere (ion layer) which is the region of reflection of radio signals. This layer is about 200 miles thick, extending to a height of approximately 250 miles.

A second portion of the radiated energy is termed the *sky wave* which increases in effectivity as the frequency of operation is increased. First noted in the early "twenties," the sky wave permits communication at great distances that are not normally reached by the high frequency ground wave. An additional characteristic of the sky wave is that it skips over the earth, jumping large areas and then showing up once more beyond the area of *skip distance.*

After a good deal of head scratching, the savants decided that the sky wave type of propagation was brought about by an area of the upper atmosphere known as the *ionosphere* (Figure 4). This interesting region hovers between 60 and 150 miles above the surface of the earth and "bounces" high frequency radio signals back to earth that would otherwise be lost in outer space. In this region of the upper atmosphere, energy from the sun strikes particles of the air and ionizes them, releasing free electrons from the particles. The blanket of electrons formed by this action has the unique ability to reflect radio signals of certain frequencies back to the surface of our planet. Radio signals aimed at this invisible mirror are reflected back to earth, many thousands of miles away from the transmitter.

The degree of ionization and the height of the ionized layer changes from day to day, and from darkness to light, and the reflective ability of the layer varies with these changes. At times the layer is in fine fettle and reflects radio signals in robust fashion, and all is well. Often, the layer goes mildly beserk from the lashings of ultraviolet radiation emanating from the sun, and radio transmission via ionospheric skip "goes to pieces." Between these two extremes radio conditions vary from day to day, and from hour to hour, to the delight or the despair of the radio ham.

The reflective ability of the ionosphere is largely a function of the frequency of the radio signal, in general being best for the higher frequencies. However, as we progress in frequency much above 30 mc, the radio signals tend to pass through the ionized layer and do not return to the earth. This is a comforting thought to those who wish to talk to the moon, but it is not much help to the amateur wishing to talk to distant points on the earth by employing the higher radio frequencies.

The highest frequency reflected back to earth between two distant points may be termed the *maximum useable frequency* (MUF) for that particular transmission path. The MUF seems to be a function of the 11 year sunspot cycle, the highest values of MUF being recorded at peaks of the cycle.

The Novice and the Ionosphere

All very interesting, but just how does this picture of the ionosphere affect the Novice or the Technician? Should they give the ionosphere more than just a passing thought? Yes sir! The ionosphere is their best friend! Some Novice bands are capable of propagating the signals great distances, others only relatively short distances. By making Mister Ionosphere work for him, the Novice or Technician can extract the fullest measure of enjoyment out of each amateur band assigned to him. Let's take the 80 meter band as an example, since this is where the fledgling Novice usually starts his ham career.

The 80 Meter Novice Band

The 80 meter Novice band occupies the frequency range of 3700 to 3750 kilocycles. During the day, the Novice operating on this band can contact stations within a radius of perhaps 150 miles or so. This distance is covered by ground wave propagation. The sky wave signal at this frequency range during the daylight hours is absorbed by the lower layers of the ionosphere, and is useless for communication purposes. The practical daylight range may further be limited by static and man-made interference, obliterating the signal of the Novice at the more distant receivers.

During the hours of the night, the ionosphere reflects the 80 meter signals to a greater degree, and communication up to 1000 or 2000 miles is common. The band is usually crowded with other Novices like yourself, and the interference between the closely packed Novice stations is a limiting factor in long distance communication.

Fig. 5 DX may be worked on the 80 meter band, but it isn't easy! Atmospheric noise and high absorption of the signal combine to restrict the range of the Novice rig.

The warm summer months bring about a very high static level on the 80 meter band, making it practically worthless except for short range contacts that are able to over-ride the static crashes. However, with the coming of the cooler fall months the static level subsides and the band reaches peak performance during the cold winter months. It is possible for Novices to work intercontinental DX on this band during the small hours of a winter morning, and many lucky embryo hams have had their first thrill of working a G (England) or perhaps a ZL (New Zealand) on the 80 meter band.

The 40 Meter Novice Band

The Novice 40 meter band occupies that part of the radio spectrum between 7150 and 7200 kilocycles. This frequency range responds to the antics of the ionosphere in much more lively a fashion than does the staid 80 meter band. Daytime conditions on this band are such that the ground wave extends for forty miles or so, and the daytime sky wave will sustain communication up to distances of four or five hundred miles. During weekdays the Novice segment of this band is not too crowded, and the static level is seldom as bad as it is on the 80 meter band. At night, when ionospheric reflection is best, contacts may be made over distances of thousands of miles. Unfortunately, this Novice section of the 40 meter band is legally used for short wave broadcasting in many parts of the world, and the low power Novice station often must compete with a 100 kilowatt short-wave broadcast station, or a high power "Iron Curtain" jamming station. These outside activities make DX contacts on the 40 meter band a real test of operating skill, to say the least. In spite of these distractions, the diligent Novice can often contact stations in many parts of the world on this band if he has a good antenna and a receiver that is capable of separating interfering stations.

Because 40 meters is a popular Novice band, you must expect it to be crowded with stations after school hours. The favorite trick of many Novices is to steal some sleep Saturday afternoon, and then to stay up to work DX stations after midnight when the band is not so crowded. As on 80 meters, the static level increases on the 40 meter band during the summer months, hampering long distance QSO's, especially during the daylight hours. However, the QRN (static) never reaches the ear-splitting level it hits on the 80 meter band.

The 40 meter band may occasionally fall prey to the obscure undulations of the ionosphere, and skip signals may drop out for a period of minutes to perhaps six or eight hours. After the ionospheric disturbance dies out, the band slowly returns to normal.

The 15 Meter Novice Band

A third Novice band that is becoming more popular is the 15 meter band. Quite a few Novices are not even aware that this band exists. It comprises a large 150 kilocycle segment, extending from 21,100 kc to 21,250 kc, and is an excellent DX band. Communication by the ground wave is limited to a dozen miles or so, but sky wave transmissions may cover the world. During daylight hours it is possible to converse with lands on the opposite side of the globe, and many Novices have contacted all continents on this band,

Fig. 6 One of the greatest thrills of amateur radio is working DX stations in all parts of the world. Many amateurs have contacted more than 200 countries.

winning the coveted WAC (Worked All Continents) award issued by the American Radio Relay League.

It is on this band that the Novice will first meet obvious instances of skip distance. He will find that it is extremely difficult to hear stations within a radius of 700 miles or so, except for short periods during the summer months. Here is an interesting situation wherein it is easier to QSO a station a great distance away than one that is relatively close by! This signal skip, of course, is caused by our friend, Mister Ionosphere, who produces a gap in the communication range on this band between the transmitter and the region wherein the signal is reflected back to earth. The effect of skip distance has been shown in Figure 4.

During the summer months the 21 mc band grows noticeably poorer, especially on east-west paths. This deterioration is caused by a drop in atmospheric ionization during the warmer months, conditions returning to normal in the early fall period.

It may seem strange that more Novices are not found on this band, but there are several reasons for this condition. First of all, some inexpensive receivers function poorly at this high frequency, lacking the sensitivity to receive all but the loudest signals on this band. In addition, some receivers are often hard to tune at the higher frequencies, and many do not have effective noise limiters. The Novice, taking a quick listen across the 21 mc band for phone signals may often hear nothing but a loud blast of automobile ignition interference and jump to the conclusion that the band is useless.

A second factor that is a deterrent to 15 meter operation is the problem of television interference (TVI). A properly designed 15 meter transmitter working in the vicinity of a television set of modern design should cause no trouble. Television interference from 80 or 40 meter operation is relatively easy to cure, but the situation begins to become marginal at 15 meters. It takes special care in transmitter design to prevent harmonics generated by the Novice transmitter from interfering with television reception in the immediate vicinity. Unfortunately, a transmitter that is "clean" harmonic-wise may still cause a form of interference to certain TV sets that are improperly shielded or that have obsolete circuitry. The addition of a high-pass antenna filter to a TV set will often eliminate the interference which may be caused by the Novice transmitter overloading the amplifying stages of the TV set with excessive 21 mc energy.

In spite of such minor headaches, the 15 meter band offers endless opportunities for the DX-minded Novice. During the next few years of high sunspot activity, this band will be active with stations throughout the world. Radio conditions will be good, and the higher frequencies will be buzzing with long distance contacts. By utilizing the 15 meter band, the Novice will be able to work his share of intercontinental DX.

The Six Meter Technician Band

The entire six meter band (50 to 54 mc) is open to Technician licensees. This band is in the twilight region between the lower frequency DX bands, and the higher frequency bands of restricted range. Exhibiting features of both parts of the spectrum, the 50 mc band may be classified as a DX band during periods of maximum solar activity. When the MUF rises above 50 mc, international contacts may be made on this band. During periods of low MUF, the 50 mc band is limited to relatively short distance QSO's, with certain exceptions.

The six meter band is located adjacent to television channel two in the

Fig. 7 The outstanding station of KH6UK, one of the country's top VHF operators. Operator "Tommy" Thomas is well-known for his contributions to amateur radio. KH6UK is active on all the VHF bands with an outstanding signal from the Pacific.

radio spectrum, and care must be taken in the design of equipment for this band to prevent spurious emanations from the transmitter from interfering with TV transmissions in the next channel. Originally, the six meter band was television channel one, which was eliminated because of the ionospheric effects upon television transmission during periods of high MUF.

From a technical standpoint, the six meter band is extremely interesting, as it will exhibit various modes of propagation from time to time. F_2-layer skip, meteor reflection, ionospheric scatter, and sporadic-E skip are some of the forms of propagation to be found on the six meter band. Under normal conditions, a range of 100 miles or so may be covered on this band, but the six meter operator must be always ready for the unexpected to happen on this unusual band. Novice operation is not allowed on the six meter band. A complete discussion of the radio propagation characteristics of this interesting amateur band, together with equipment and antennas designed for 50 mc operation is contained in the *VHF Handbook*, obtainable at your local radio distributor, or from Radio Publications, Inc., Danbury Road, Wilton, Conn. (Price: $2.95 plus 15c shipping charge.)

The Two Meter Novice Band

The remaining Novice band is the portion of the spectrum between 145 and 147 mc, commonly called the two meter band. At this frequency, the ionosphere tends to pass the radio signal into space instead of reflecting it back to earth at some distant point. Radio transmission is therefore limited to less than a few hundred miles except under unusual circumstances. Scatter transmission, air-mass boundary bending and Aurora reflection are responsible for transmission paths in excess of 1000 miles on the two meter band at irregular intervals. This is the only band wherein the Novice licensee may operate a radiotelephone transmitter. Voice operation will be discussed in greater detail later in this Handbook. The reader is again

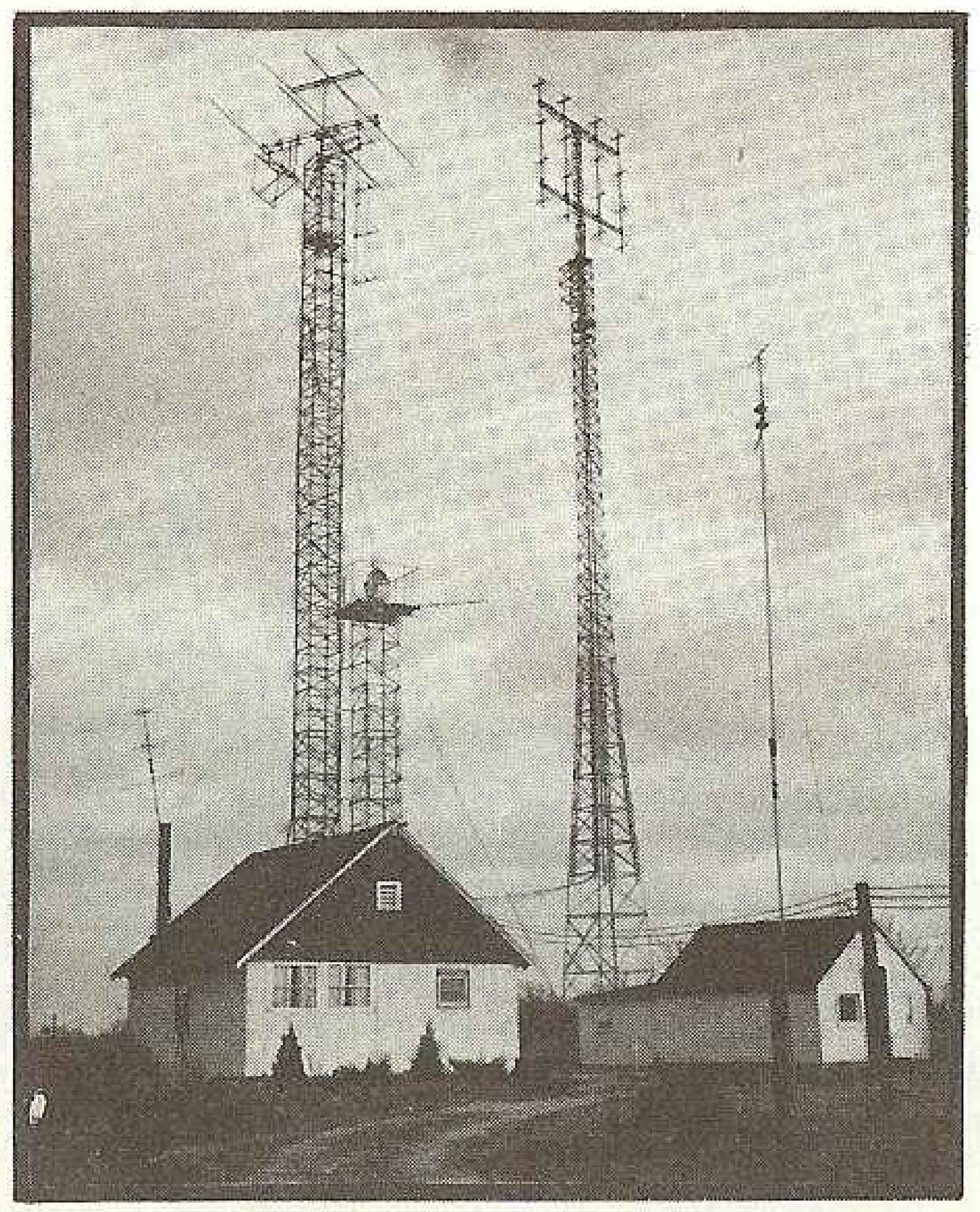


Fig. 8 Many a ham dreams of owning the "antenna farm," such as this one having the call W8IJG. City lots and building restrictions hold back many an "eager beaver" from running competition to this outstanding 'skywire' installation.

referred to the *VHF Handbook* for further information concerning the 2 meter amateur band.

The VHF Technician Bands

The Technician operator is permitted all amateur privileges in amateur bands above 220 mc. The 220-225 mc amateur band is popular in the larger cities and areas of high amateur population. Ionospheric propagation seems to be entirely absent in this frequency range, but many of the propagation phenomena noticed in the two meter region are also present on the 220 mc band. In general, transmissions are limited to less than one hundred miles on this band, except under unusual circumstances.

A limited amount of Technician activity has been noted on the 420 mc and 1215 mc amateur bands. These ranges require specialized equipment for both transmission and reception, and therefore will not be considered in this Handbook.

Radio Reception

So far we have only discussed the generation and transmission of radio signals. Let's investigate just what happens when the radio wave reaches your receiving antenna. The purpose of the receiving antenna is to extract energy from the radio signals intercepted by the antenna. The antenna will "pick up" all signals at all frequencies travelling past it, and the receiver must select the desired signal from the maze of undesired ones, amplify it, and then extract the intelligence from the signal.

The radio energy removed from the passing radio waves may be passed from the antenna to the receiver by means of a transmission line. Just as it may be difficult to locate the transmitter directly at the antenna, it may be equally difficult to locate the receiver in close proximity to the antenna. The transmission line bridges the gap between the two. Simple antennas such as a piece of random-length wire are often connected directly to the receiver, but more complex arrays require the use of some form of transmission line to pass the maximum received energy to the receiver.

Detection

The process whereby the intelligence placed upon the radio signal is removed is called *detection*, and is accomplished by rectifying the radio signal. The rectified current produced by this action is a duplicate of the electrical intelligence originally placed upon the carrier wave at the transmitter. Because the radio signal present at the antenna terminals of the receiver is very small (of the order of a few millionths of a volt) it must be increased in strength to be of much use. A powerful local broadcast station may be rectified (detected) by a simple crystal receiver and can be heard in sensitive earphones without the need of amplifying stages, but weaker, distant stations require assistance to be audible. The signals may be amplified by a radio frequency amplifier stage (r-f stage) before detection, or it may be amplified after detection by an audio amplifier stage. Finally, the useable, amplified signal is then passed on to speaker or headphones, and thence to the quivering ears of the listener.

CHAPTER III

Electronic Techniques

"Electronic techniques" cover rather a wide field. In fact, many books have been written on such subjects as how to build radio equipment, how to get it working once you have constructed it, and how to use it once you have gotten it working. This chapter attempts to sift the wheat from the chaff and presents some of the practical aspects of electronics that will be of general interest to the Novice and Technician amateurs. Much of the information contained herein is the result of practical experience, and is presented in the hope that it will save the reader the time consuming process of learning it the "hard way".

Tools

Many hams can build acceptable radio equipment, armed only with an icepick and a dull Boy Scout knife. This practice is not to be recommended. Rather, it is a wise idea to provide yourself with a good set of tools that will enable you to do the maximum amount of work with the minimum amount of effort. Here's a suggested list of basic tools used most often in building electronic equipment. Buying them one at a time will not deflate the pocket book too fast, and in a short time you will have a first class radio laboratory.

1. A *good* 100-watt soldering iron or soldering gun. The *Weller model 8100K* gun, or the *Drake #325 iron* or equivalent are recommended. The iron will cost $3.75, and the gun about $6.00.
2. Solder. A one pound spool of *rosin core* solder is recommended. Don't buy less than a pound, as solder is very expensive in small amounts. A pound roll will cost slightly over a dollar. The smart reader will read the soldering notes later in this chapter before he rushes out to buy this all-important item.
3. Six-inch long nose pliers, such as the *Kraeuter 1671*. Cheap pliers are worse than useless, so watch out for "bargains". Good long nose pliers will cost about $2.00.
4. Six-inch side cutters, such as the *Kraeuter 1830*. These cost slightly more than the pliers, and are worth their weight in gold. Don't try to do without them!
5. Screwdrivers. You need two, one with a six-inch shaft, and one with a three-inch shaft. You should make sure these tools have insulated handles, and that the tip of the blade is square and true. A suggested tool is the plastic handled *Xcelite* screwdriver, available in most radio stores. Steer away from the heavy metal-handled "automobile type" screwdriver. You're not building a tractor!

Fig. 1 The well equipped electronic workshop of W6KMK.

6. A good pair of pliers. Snoop around your automobile accessory store for well-made pliers. They should have very little side play in the joint. The *Kraeuter Grip-tite 356* or equivalent fills the bill nicely.
7. An assortment of files . . . flat, half-round and rat-tail will come in very handy. Your local five-and-dime store will probably have a fine collection for you to pour over.
8. A pistol-grip hack saw and assorted blades. Very important for chassis work!
9. A good carpenter's brace (or a sturdy hand drill) and an assortment of drills. One each 1/16", 1/8", and 1/4" will do for a starter.

This, then, is just about the absolute minimum of tools you will need to set up your shop. The next most important items to procure are a hammer, center punch, nut-driver, assorted chassis-punches, an electric hand drill, and a wire-stripper.

Tools and More Tools

The soldering iron is one of the basic tools of the trade. Contrary to popular opinion, it is not used to melt solder, rather it is used to heat the part to be soldered to the point where it will melt the solder. While the soldering iron is heavier than a gun, it will supply heat whenever you want it, after the initial warmup period. The soldering gun is lighter and consumes less power. For general use, the iron is to be preferred, although a soldering gun is a mighty handy tool to have around. Buy 'em both if your pocketbook can stand it.

Side cutters are used to cut wire, and to strip insulation off the end of the wire. Practice removing insulation off the wire with these. Soon you should be able to remove about one-half inch of insulation from the end of the wire without nicking the conductor, or cutting it in two.

After you have advanced in the fine art of electronics, you may wish to purchase other tools. By now you have found that some equipment uses foxy cross-slotted screws and bolts. A *Phillips head* screwdriver will take care of most of these in short order. You will also find that a good electric drill (in lieu of the hand drill) will save a lot of wear and tear on your frame! A three-inch vice is also a handy item to have at hand.

Test Equipment

You can't get very far without a few basic measuring devices for electrical currents and voltages. As in the case of hand tools, "you get what you pay for". If you are adept at soldering and construction, you can save a tidy sum by buying your electronic instruments in kit form, and assembling them yourself. Otherwise, you must pay more for the equivalent in finished form.

The first instrument to buy is the volt-ohmmeter which forms the backbone of your test equipment. This handy device will measure a-c and d-c voltages, direct current and resistance. A pocket-size volt-ohmmeter will cost from twenty to twenty-five dollars. In kit form, it will cost about fifteen dollars or so. A good instrument should have an insulated case, and the meter should have a zero-set adjustment. Beware of "off-brands" and "special bargains". If you stick to name brands you will not go wrong. False economy when buying test equipment is costly to the pocket book. Buy the best you can afford.

The next item of test equipment to purchase is an r-f signal generator covering the range of 200 kc to 30 mc. Several such generators are available in kit form, and may be purchased for under thirty dollars. A signal generator is useful in aligning radio receivers, and is a "must" item in a well equipped shop.

Building a Workbench

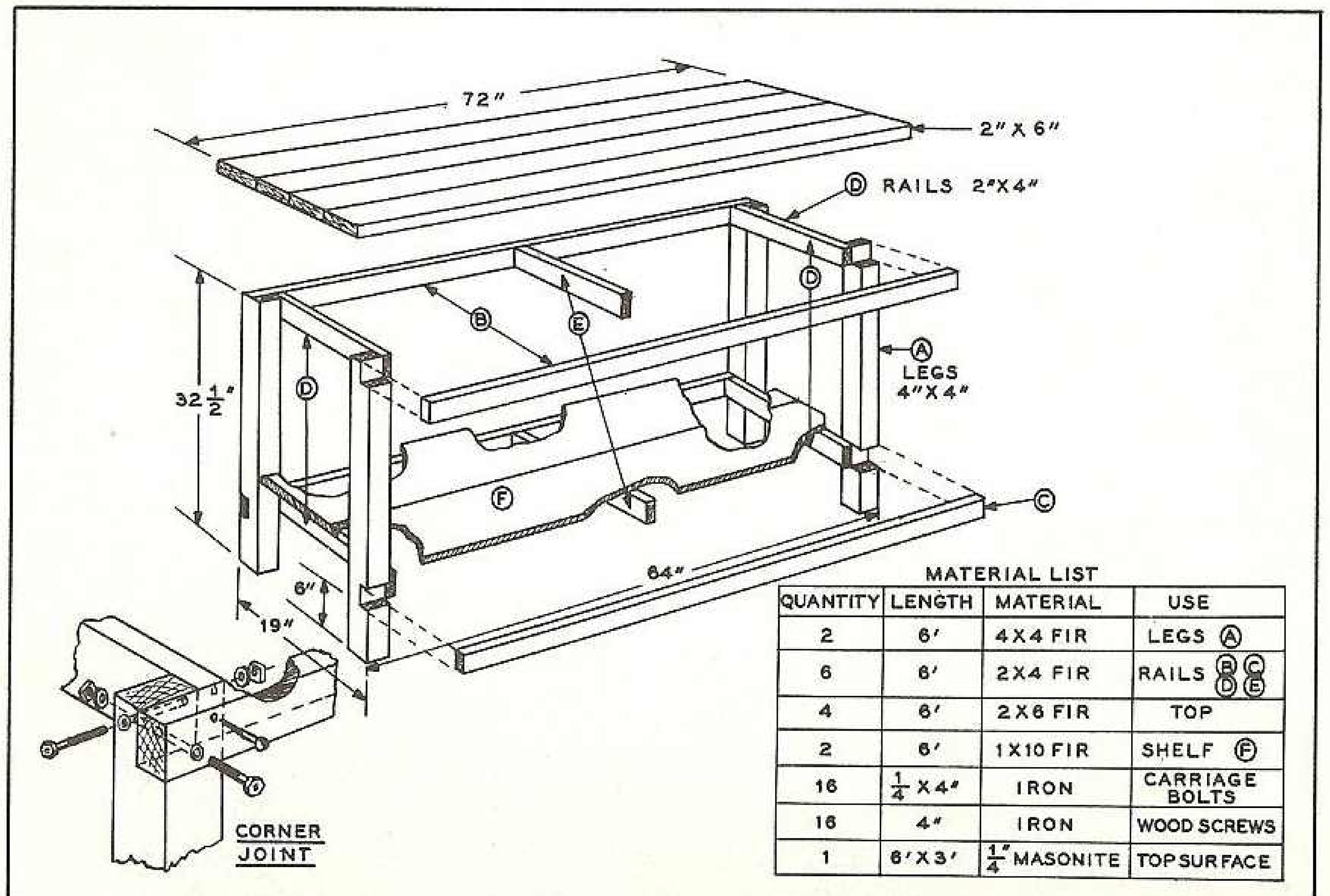
Many a worthwhile project founders after a few sessions of trying to do construction work on a wobbly card table, or on the kitchen table. A good, sturdy workbench will do much to enhance the enjoyment of your hobby. The bench should be ample in size, and sturdy enough to stand steady under heavy construction work. A good three-inch metal vise should be mounted at one end of the bench. Shown in Figure 1 are plans for a simple bench made of wood that will fill the bill. The bench is six feet long, 32 inches high and 22 inches deep. A list of materials is given in the illustration.

The legs should be cut first, each 32½ inches long, from the 4x4 stock. The top of each leg is notched to fit the 2x4 member (B). The legs are also notched four inches above the bottom end to fit the 2x4 braces (C). A wood chisel should be used for the notches. Four 64 inch pieces of 2x4 are now cut for the (B) and (C) pieces. The legs and braces are assembled, and ¼-inch holes are drilled through each end of the (B) and (C) pieces into the legs. The parts are now joined with a 4-inch wood bolt. Check with a square to make sure the joints form a true right angle.

The front and back sections are joined together with 2x4 rails (D) attached to the legs with ⅜″ carriage bolts and washers. Top rails are flush with the tops of the legs. Two additional rails (E) are placed at the center of the bench for extra strength.

The top of the bench is made of four six foot lengths of 2x6 inch material placed edge to edge so that the rear piece is flush with the rear edge of (B), while the front piece overlaps the bench frame by about two inches. The top pieces are fastened in place with 3-inch wood screws passed into the rails and the long braces (B). Countersink the holes so that the screw heads are below the surface of the bench.

As a final step, cover the top of the bench with a ¼-inch piece of tempered *Masonite*. This will provide a smooth, hard surface which will resist denting and soldering iron burns. Paint the legs and frame of the bench and you are in business!



MATERIAL LIST

QUANTITY	LENGTH	MATERIAL	USE
2	6′	4X4 FIR	LEGS Ⓐ
6	6′	2X4 FIR	RAILS Ⓑ Ⓒ Ⓓ Ⓔ
4	6′	2X6 FIR	TOP
2	6′	1X10 FIR	SHELF Ⓕ
16	¼ X 4″	IRON	CARRIAGE BOLTS
16	4″	IRON	WOOD SCREWS
1	6′ X 3′	¼″ MASONITE	TOP SURFACE

Fig. 1 You can't do good work without a heavy-duty workbench such as this!

The Color Code

The value of certain electrical components, such as resistors and capacitors is often indicated by a series of colored bands around the body of the component. For example, the value of a resistor may run from less than one ohm to several million ohms. To put the right number of zeros on the body of a ½-watt resistor (which is ⅜″ long) would be a job for a pin-head engraver. Since there seems to be a shortage of pin-head engravers, a code has been devised to indicate the significant figures of the component valve by means of various colors. This code is as important as the Morse code, and should be committed to memory. Figure 2 shows the *RTMA* (Radio and Television Manufacturer's Association) standard color code, and several other color codes which are now more or less obsolete.

In general, the code is read from left to right, with the first color band indicating the first digit of the significant figure. The second color indicates the second significant digit. The third color is the "gimmick." It indicates the *multiplier* (number of zeros following the significant figures). A black color indicates a multiplier of one, brown indicates a multiplier of ten, red one hundred, and so on. If the third band on a resistor is green (green equals five) you would instantly know there are five zeros in the value of the *multiplier*. Quick as a flash you add five zeros to the two significant figures. Let's take an example to show you just how simple (?) the system

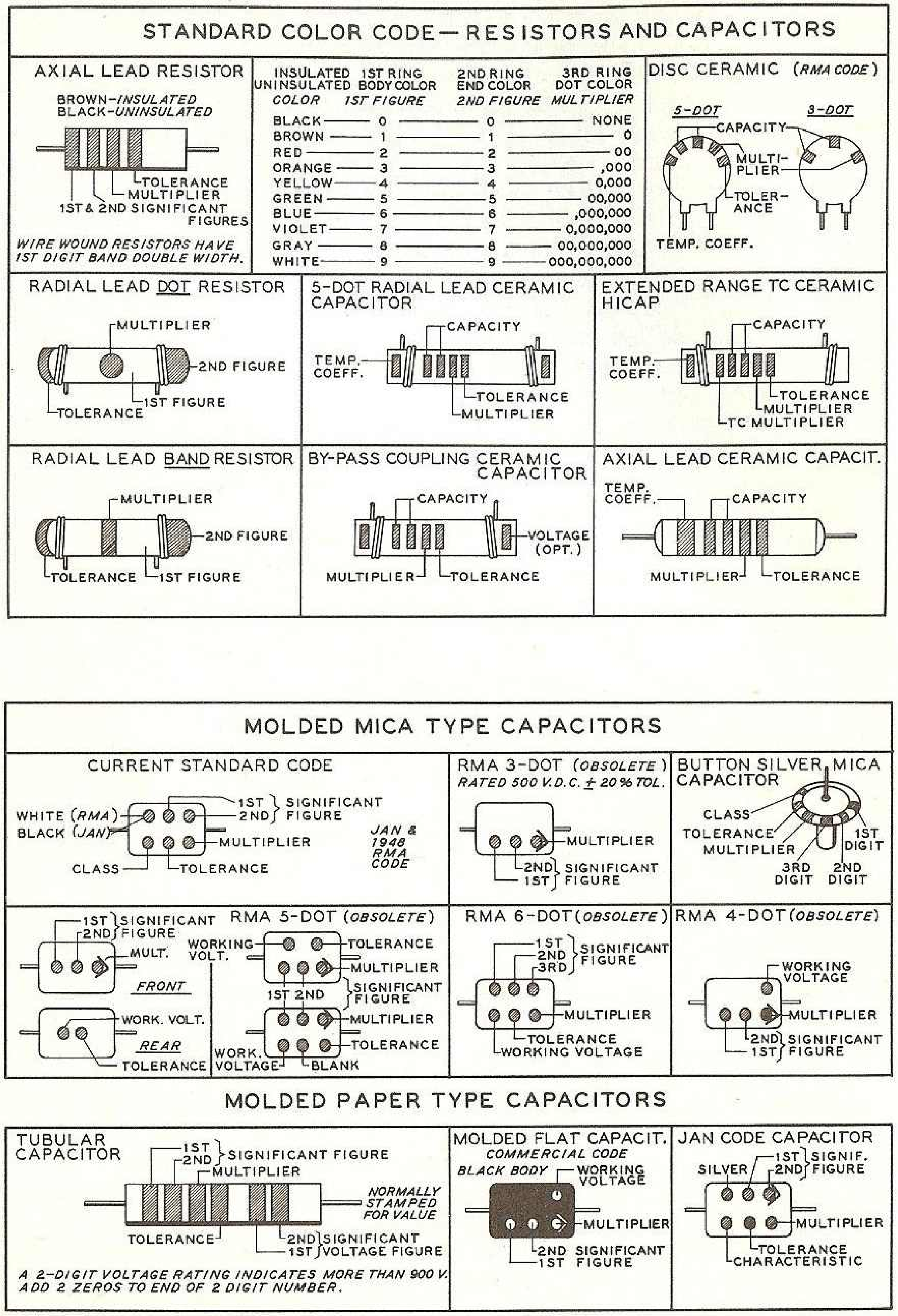


Fig. 2 A summary of the most important color codes for resistors and capacitors is given in this table. Designations of color code should be put to memory. Other radio components, such as power transformers, i-f transformers, chokes, etc., have their leads color coded for easy identification. Learn the color code as you learn the Morse Code. They both are most important!

is: You pull a resistor out of the junk box having a yellow, a violet, and a green band on it. What is its value? Yellow is four, so that is our first digit. Violet is seven, so that is our second digit. The last band is green, so our multiplier is five. Our resistor is designed by 47 followed by five zeros, or 4,700,000 ohms. A million ohms is usually referred to as *one megohm*, so we have a 4.7 megohm resistor.

Another example: Here's a resistor coded red-red-orange. Red is two, and orange indicates a multiplier of three zeros. The resistor is therefore 22,000 ohms. One thousand ohms is often referred to as *K*. So this resistor is often called *22K* in radio "lingo."

The capacitor color code works exactly the same way, except that the unit of value is the micromicrofarad, instead of the ohm. A capacitor that is coded red-red-orange is 22,000 micromicrofarads (.022 microfarads). A capacitor coded red-black-black has a value of 20 micromicrofarads.

Other information may also be conveyed by the color code, such as tolerance rating, working voltage, and temperature coefficient. Practice will enable you to thread your path through a veritable rainbow of color splotches on the tiniest of units. Study the color code chart until you become proficient at reading the values of random capacitors and resistors. You will find that you need to know this important code each time you construct a piece of electronic equipment.

Circuit Wiring

Various components making up electrical equipment are interconnected by lengths of copper wire. The wires carry the operating voltages to the circuits, and also carry the radio signal from one circuit to another. Wires have been eliminated in some of the newer construction techniques such as *printed circuits*, but amateur construction for the most part is still concerned with simple point-to-point wiring.

The Schematic Diagram

When building equipment you know *where* the wires and components connect by reference to a *schematic diagram*, and you know *how* the wires get there and the general route they follow by using a *pictorial diagram*. A schematic diagram can be considered as an "electronic blueprint" with the various components indicated by stylized symbols. These symbols are interconnected by lines representing the leads. The schematic does not indicate the location of the components, nor the wiring method. On the other hand, the pictorial diagram is like a photograph in that it shows the actual appearance of each part in relation to surrounding components, and also shows the approximate route taken by each wire to get where it is going.

The beginning amateur will probably find that a construction job is facilitated if he has a pictorial diagram to go by. All that is necessary is to make the unit under construction look exactly like the pictorial, and the chances are pretty good that it will work when completed. You don't learn anything by this process, though. It is essential that the beginner learn to read a schematic diagram because sooner or later he will find equipment that he would like to build—and there will be no pictorial diagram to go by!

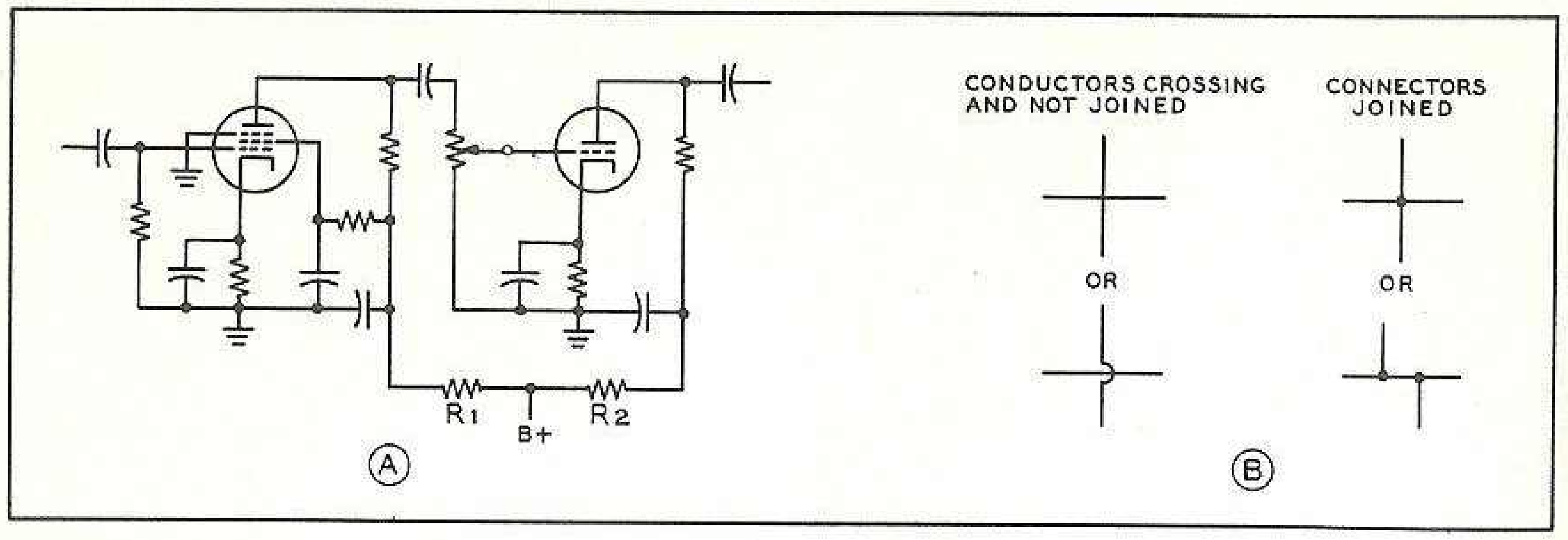


Fig. 3 The schematic diagram shows interconnections between various parts of electronic circuit, but does not show the actual placement of the parts. Different drawing techniques (B) create confusion for beginner, as it is hard to determine if crossed wires are junction (right) or merely cross-over (left).

To aid you in learning to "follow" a schematic, most of the projects in this book contain wiring instructions along with the schematic. Chassis layout drawings are also included, but pictorial diagrams are omitted.

Inside the Schematic

Let's look at Figure 3. This represents a portion of a resistance coupled amplifier, similar to the type found in almost all modern radios. The B-plus connection is drawn half-way between R1 and R2. This junction point may actually be made at *either* R1 or R2. The artist drawing the schematic puts the connection at the midpoint of the wire because that is where it looks the neatest. Experience will soon show the reader of the diagram exactly at which terminal points of the components the actual connection is made. A second point that creates confusion in the minds of the beginners is the *junction.* Because of the complexity of most schematic diagrams, it is usually necessary to draw a line crossing over another line, even though there is no electrical connection between the wires the lines represent. Some schematics use a little half-circle at the junction point to show that the wires do not actually meet. If the wires happen to join at the junction in question, a black dot is placed there. Other diagrams eliminate the half-circle and the dot, providing a spirit of excitement and allowing the reader to guess whether or not a connection was intended. A third school of thought uses the dot to indicate a connection, and the absence of a dot if no connection is intended. And so, when you "read" a schematic diagram it is necessary to establish which schematic pattern is being employed. After you have looked at a few schematics the drawing differences will be obvious to you, but that first schematic can be mighty confusing!

It is a good idea (even for the "old timer") to place a mark over each wire or symbol on the drawing as the unit is wired. In this way, the unit can be completed without leaving anything out!

The newcomer may be a little dismayed by the symbols that are used in the schematic diagrams. The symbol is a simplified representation of a component that has been agreed upon (more or less) by most radio associations and publishing houses. The symbol tells what the component is (i.e. a resistor, a capacitor, etc.) but it does not indicate the value of the component. In most cases, there will be a note beside the component indicating its value and other pertinent information. The symbols for vacuum tubes present a simplified picture of the elements of the tube and usually show the numbers that correspond to the pin connections of the tube base. Some publications prefer to label the components as R1, C2, T4, and so on, and place below the schematic a list tabulating the values of the components. By studying the various styles you will improve your ability to interpret schematics and, in turn, your knowledge of electronic techniques. In passing, it should be noted that many European countries employ symbols strikingly different than those we are used to. Shown in Figure 4 is a typical circuit, drawn in the two different styles. Compare them and note the difference in the symbols. Which system do you think is best?

How to Solder

There is nothing mysterious about soldering, but a surprisingly large number of electronics personnel do not know how to make a good solder connection. All you need is a soldering iron (or gun), solder (of the right type), and a connection to be made.

The essence of VHF construction, or any other type of construction for that matter is the mastery of proper soldering procedure. A few words on this important subject will not be amiss before descriptions of some worthwhile building projects are presented.

Proper Soldering Procedure

Correct soldering technique is extremely important. Good soldered joints are essential if the performance engineered into a piece of radio equipment is to be fully realized. If you are a beginner with no experience in soldering, a half-hour's practice with odd lengths of wire, a tube socket, and some components will be a worthwhile investment.

High quality rosin solder of the proper grade is most important. There are several different brands of solder on the market, each marked "Rosin Core Solder." Such solders consist of an alloy of tin and lead, usually in the proportion of 50:50. Minor variations exist in the mixture, such as

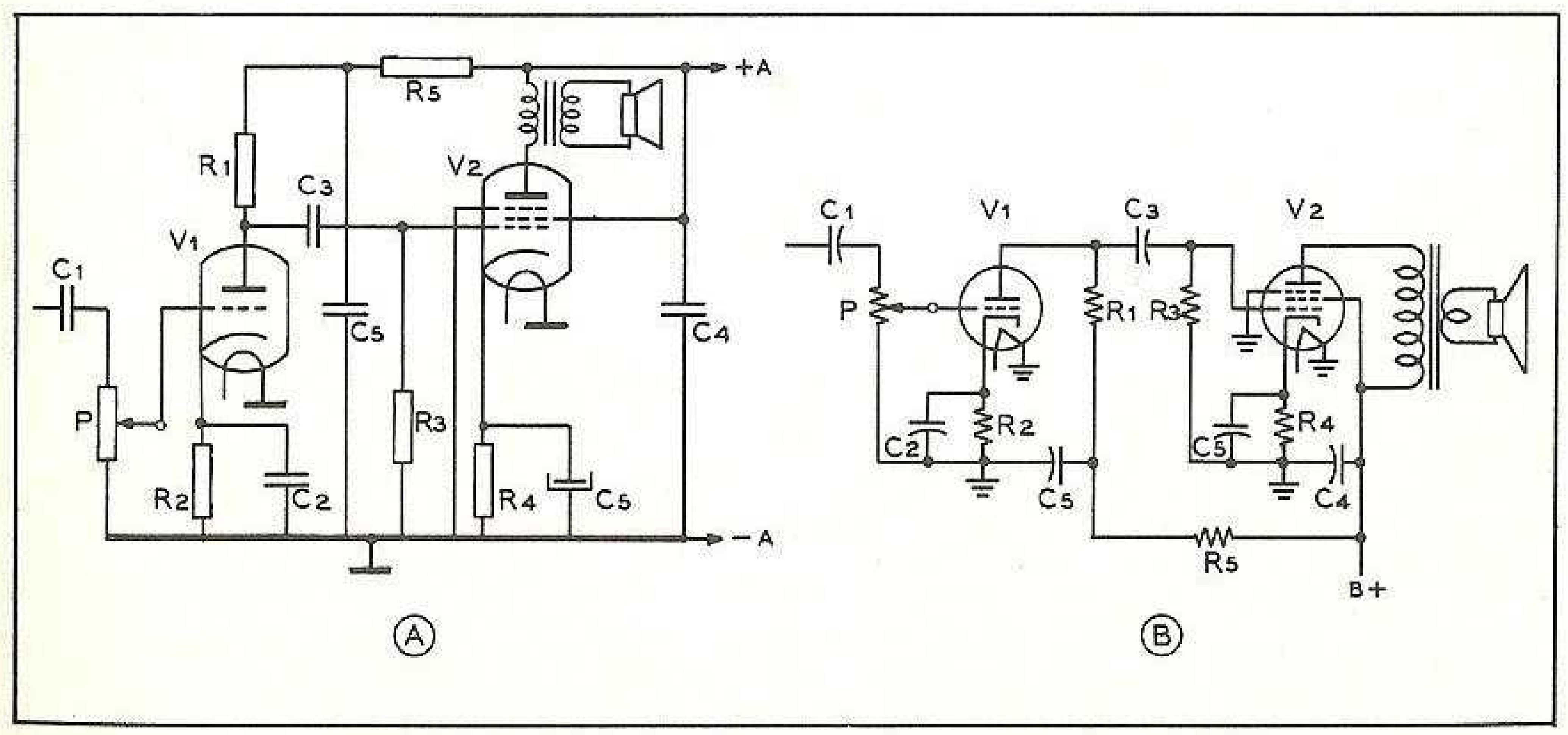


Fig. 4 Other countries have different radio symbols than those common in U.S.A.

40:60, or 45:55, etc., with the first figure indicating the tin content. Radio solders are formed with one or more holes running lengthwise through the center. These holes are filled with a rosin compound which acts as a flux or cleaning agent during the soldering operation.

No separate flux, acid, or cleaning agent of any kind should be used in radio work. Such compounds, although not always corrosive at room temperatures, will form residues when heated. The residue is deposited on surrounding surfaces and attracts moisture. The resulting compound is not only corrosive but actually destroys the insulation value of non-conductors. Dust and dirt will tend to accumulate on these surfaces and eventually will create erratic or degraded performance of the equipment.

If terminals are bright and clean and wires free of wax, frayed insulation and other foreign substances, no difficulty will be experienced in soldering. Crimp or otherwise secure the lead to the terminal so that a good connection is made without relying on solder for physical strength. To make a good solder joint, the clean tip of the soldering iron should be placed against the joint to be soldered so that the terminal is heated sufficiently to melt solder (Figure 5). The solder is then placed against both the terminal and the tip of the iron and will immediately flow out over the joint. Use only enough solder to cover wires at the junction as it is not necessary to fill the entire hole in the terminal with solder. Excess solder may flow into tube socket contacts, ruining the socket, or it may creep into switch contacts and destroy their spring action. Position the work so that gravity tends to keep the solder where you want it.

A poor solder joint will usually be indicated by its appearance. The solder will stand up in a blob on top of the connection, with no evidence of flowing out caused by actual "wetting" of the contact. A crystalline or grainy texture on the surface, caused by movement of the joint before it solidified is good evidence of a "cold" connection. In either event, reheat the joint until the solder flows smoothly over the entire junction, cooling to a smooth, bright appearance.

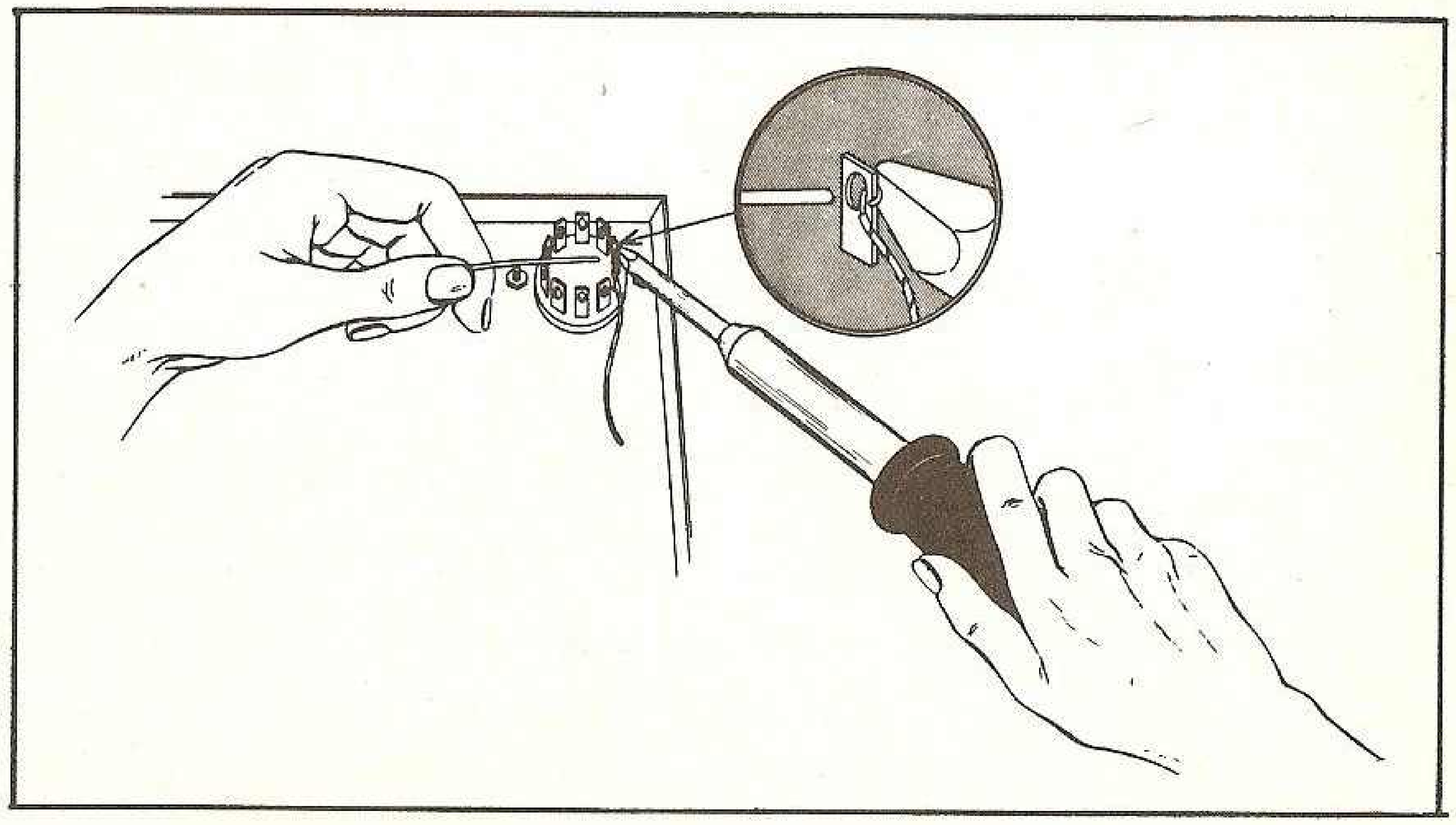


Fig. 5 Proper soldering technique is necessary for construction of equipment.

A good, clean well-tinned soldering iron is also important to obtain consistently perfect connections. For most radio work, a 60 watt iron, or the equivalent in a soldering gun is satisfactory. For tight corners, a "Pencil-type" iron is a great help. When many connections must be soldered to a copper or steel chassis, a 300 or 400 watt iron should be used to insure even heat distribution over the chassis.

Kit Construction

Building a kit lies somewhere between the practice of digging around in your junk box for enough parts to build a particular piece of gear, and going to the radio store and purchasing the ready made product. However, kit building differs from these two extremes in several important ways. Most important of all, the kit-builder is assured that if he does the job carefully, the unit will not blow up or fail to work when it is turned on. This is not always the case with "home-brew" apparatus.

When you construct a kit you are bound to learn something about the mysteries of electronics, even if it is nothing more than how to read resistor color codes, or how to solder properly (which is an art in itself). In like manner, when you purchase factory-made equipment you cannot obtain the constructional skill you attain when you "do it yourself." In this day and age it does not take any particular effort to spend money. But if you build the equipment yourself, or purchase it in kit form, you will save between 30% and 80% of the cost of the ready made unit. Naturally, the saving varies widely depending upon what you are building and what you are comparing it to. For the person with a little spare time, kits probably represent the greatest dollar value on the electronic market today.

Helpful Kit Building Information

Before attempting actual kit construction, read the assembly manual thoroughly to familiarize yourself with the general procedure and symbols used in the descriptions. Note the location of the pictorial illustrations in respect to the progress of the outlined assembly procedure. Follow all directions to the letter. In the majority of cases, failure to observe basic instruction fundamentals is responsible for inability to obtain the desired performance of the finished item. Make sure that tube sockets are properly mounted with respect to keyway or pin numbering data. Check transformer mountings to see that color coded leads will be available at the proper side of the transformer.

Make it a standard practice to use lock washers under all 6-32 and 8-32 nuts, unless soldering lugs with locking tines are used. A control lock washer should always be used between a shaft mounted control and the panel to prevent undesirable rotation of the control in the panel hole.

When following wiring procedure, make all leads short and direct. In filament circuits requiring a twisted pair of wires, allow sufficient slack in the wiring to permit the pair to be pushed against the chassis as closely as possibly thereby affording relative isolation from adjacent parts and wiring. When removing insulation from the end of hookup wire, it is seldom necessary to expose more than a quarter inch of the conductor. Excessive removal of insulation may result in short circuits to nearby wiring or terminals. In some instances, transformer leads may have a brown baked enamel coating which must be removed from the end of the wire before a connection can be made.

In mounting parts such as resistors or capacitors, trim off all excess lead length so the parts may be mounted in a direct point-to-point manner. When necessary, place insulated sleeving over exposed leads that might short to nearby wiring or the chassis.

Much of the performance of the instrument, particularly with respect to accuracy and stability depends upon the degree of workmanship used in making soldered connections. Follow the information given earlier in this chapter with respect to soldered joints. Avoid excessive use of solder and do not allow flux to form a leakage path between adjacent terminals on switch assemblies and tube sockets. Excessive heat will burn or damage the insulating material used in switch assemblies.

Shielding and TVI

Quite often the invisible *lines of force* that scatter themselves around a piece of radio gear can cause no end of trouble. Coils and transformers, in particular, are surrounded by very intense electromagnetic fields. These fields may be induced in nearby wiring, creating unwanted *feedback* voltages. As an example, if the energy in the output circuit of an amplifier stage is allowed to induce a voltage in the input circuit, a new path is created that permits the energy to "run around in circles" within the stage. Proper shielding of components and leads can cure this trouble. When you see a shield plate or a length of shielded wire used in a construction project, do not forget to include it, as it is intended to suppress an unwanted feedback path.

Television Interference

During the television "boom" of the early 1950's, the interference to TV receivers caused by amateur (and other) transmitters was such a serious problem that many hams were forced to go off the air, rather than to create ill-will in the neighborhood. In recent years, however, the problem of television interference (TVI) has been studied by both the amateurs and the television receiver manufacturers and it is no longer such a threat to amateur operation.

TVI can come about through three types of action. These are known as *TV receiver overload, transmitter fundamental radiation,* and *transmitter spurious radiation.* The usual case of TVI may be made up of any one or all of these forms of interference. Each has a similar characteristic interference pattern on the TV screen, but they can be identified by the following symptoms.

TV Receiver Overload

Receiver overload occurs when a TV set is operated near an amateur transmitter. The energy radiated by the transmitting antenna induces a strong signal into the antenna circuit of the TV set, which is unable to cope with it. Under these conditions, the neighbor's set will respond to your signal rather than to that of the TV station, and the familiar black and white bands will appear on top of their favorite program. This type of

interference is caused by proximity of the TV set to the amateur transmitter, and is not necessarily the fault of either. In the majority of cases it may be cured by inserting a *high-pass filter* in series with the antenna lead of the TV set *at the antenna terminals* of the receiver. This filter stops your signal, but allows the television signal to pass unhindered. Some of the newer TV sets have this filter incorporated in the receiver chassis. This type of interference can be recognized by the fact that it appears on every channel, and the picture contrast usually changes when the transmitter is in operation. Removing the antenna line will stop the interference.

Transmitter Fundamental Radiation

This type of interference may occur when the Novice operates on the 15 meter (21 mc) amateur band. The amateur band occupies the same frequency range as that used by the older TV sets for their amplifying circuits. If these circuits are poorly shielded, they will probably pick up your signal. This trouble is not your fault, but the result of poor or skimpy TV receiver design. This type of TVI will occur on all channels, and may occur with the TV antenna lead removed from the receiver. A high pass filter will remove your signal in some cases, but if the circuits of the TV set pick up your signal with the TV antenna disconnected, about the only thing to do is to urge the set owner to buy a modern receiver!

Another type of TVI occurs with 6 meter transmitters. This amateur band is adjacent to television channel 2 (54-60 mc). Most TV sets do not have the inherent selectivity to separate an amateur 6 meter signal from a TV station operating on channel 2. A "six-meter filter" installed in the antenna lead of the nearby TV set will often eliminate the trouble. Operating the amateur transmitter at the low frequency end of the 6 meter band will assist in reducing this type of interference.

Transmitter Spurious Radiations

This type of interference usually indicates that the transmitter is not operating properly, or that it has insufficient supression of harmonics. Spurious radiation can be recognized by the fact that it occurs on some TV channels and not on others. The transmitter may require retuning, or reneutralizing, or it may require additional filtering and harmonic supression circuits. In any case, the trouble is your fault, and it must be eliminated before you can have "peaceful coexistence" with your neighbors. Better shielding of the offending stages, and the use of a *low-pass filter* in the antenna circuit of the transmitter will usually eliminate the trouble. Modern transmitter design usually takes into account these factors, and the late model amateur transmitter is remarkably free from spurious radiations. TVI from this cause is most apparent on the high frequency (above 7 mc) bands, although parasitic (spurious) oscillations can take place in any transmitter unless steps are taken to prevent it.

CHAPTER IV

Sugar-Coated Receiver Theory

The station of the Novice is a collection of many pieces of radio equipment. Most authorities agree that the most important single piece of gear is the receiver. The receiver must be capable of amplifying the r-f voltage impressed on the antenna, detecting it, and boosting it to a level that is capable of operating the headphones or loudspeaker. When we remember that the original signal plucked out of the air is only a few millionths of a volt, this seems like a large order. There is many a slip 'twixt the cup and the lip (in this case, 'twixt the antenna and the headphones) and that is what makes one receiver function better (and sometimes cost more) than the next receiver. There are many shortcuts that the receiver manufacturer can take to reduce the cost of his receiver. Each of these shortcuts will also reduce the performance of the receiver. In general, the old axiom, "you get what you pay for" certainly applies to receivers. When buying a receiver, let your pocketbook be your guide.

Because the beginner's home made receiver is seldom satisfactory from a cost and performance standpoint, information on "rolling your own" is rather skimpy. However, do not feel that receiver construction articles should be considered a waste of time. There is a tremendous amount of satisfaction in building a receiver, turning it on, and listening to the first stations come rolling through. After you have gained greater experience, the construction of a receiver would be a good project. The knowledge gained in this manner cannot be duplicated.

Receiving Principles

The general principles of radio reception are well covered in many fine handbooks available on the market. However it is wise to examine some of the important reception techniques as they apply to short wave reception. First of all, let's have a quick look at the *tuned circuit,* the heart of the radio receiver or transmitter.

The Tuned Circuit

A combination of a coil and a capacitor has the ability to accept r-f energy of a single frequency and to reject energy of other frequencies, as shown in Figure 1. You can imagine the resonant circuit as sort of a door

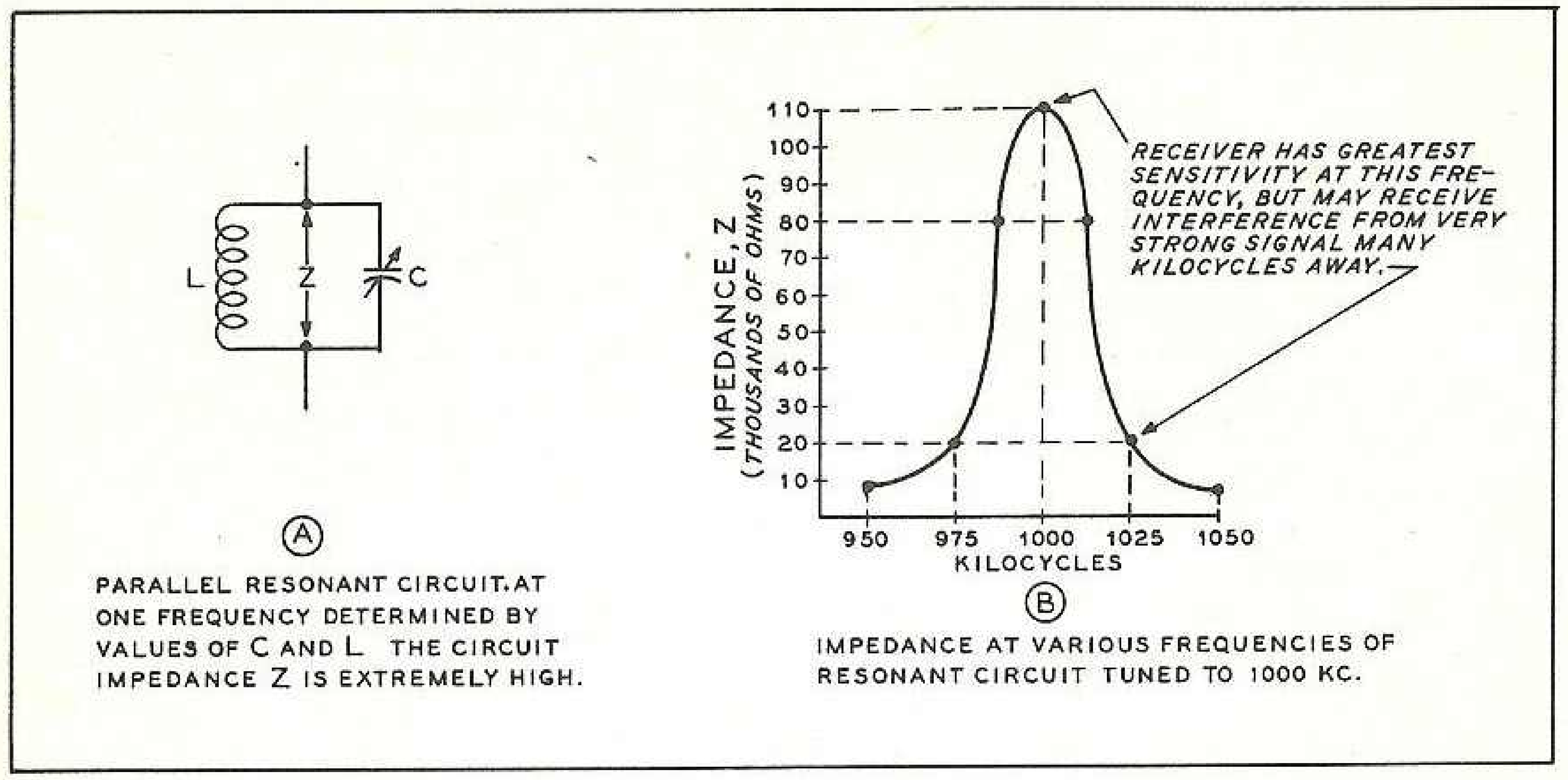


Fig. 1 The resonant tuned circuit has the ability to select radio signal of a given frequency, and to reject others at unwanted frequencies. Efficiency of rejection is determined by the "Q," or figur of merit of the circuit, and is largely determined by design and construction of the inductor (L).

keeper, who opens the door to the correct frequency, and slams it in the face of undesired frequencies. Placed between an antenna and a detector, the tuned circuit will sort out the innumerable radio signals picked up by the antenna and allow only the desired one to reach the detector of the receiver. If we should want to change the resonant frequency of the tuned circuit, it will be necessary to change the electrical value of either the coil or the capacitor. Whenever you tune your radio receiver, you are (in most cases) changing the capacity of a variable capacitor that is part of a tuned circuit of the receiver.

The rejection of a simple tuned circuit is limited, and two or three such devices are required to provide an acceptable degree of signal rejection in even the simplest short wave receiver. The excellence of a receiver is not the ability to receive signals—most any "clunker" can do that—but the ability to reject unwanted signals. It's what you *don't hear* that counts!

Detection

If we were to pass the radio signal developed in the tuned circuit to headphones we would hear nothing. The voltage in the tuned circuit is of such a high frequency that the diaphragm of the headphones could not respond to it. And even if it could, your ears cannot hear an audio frequency as high as that. It is necessary, therefore, to employ a device to extract the intelligence from the carrier wave, and to make it audible to our ears. This is the purpose of the *detector.*

A simple diode detector is shown in Figure 2. Current flows through the diode only when the plate is positive with respect to the cathode. At each positive cycle of the radio signal the diode will conduct and charge the capacitor C2. The charge on this capacitor is continually being dissipated by the diode load resistor, R1, and being replenished by the action of the diode. A state of equilibrium is established wherein the capacitor voltage varies in accord with the amplitude of the carrier wave. This voltage is a duplicate of the envelope of the carrier, and may be passed through ear-

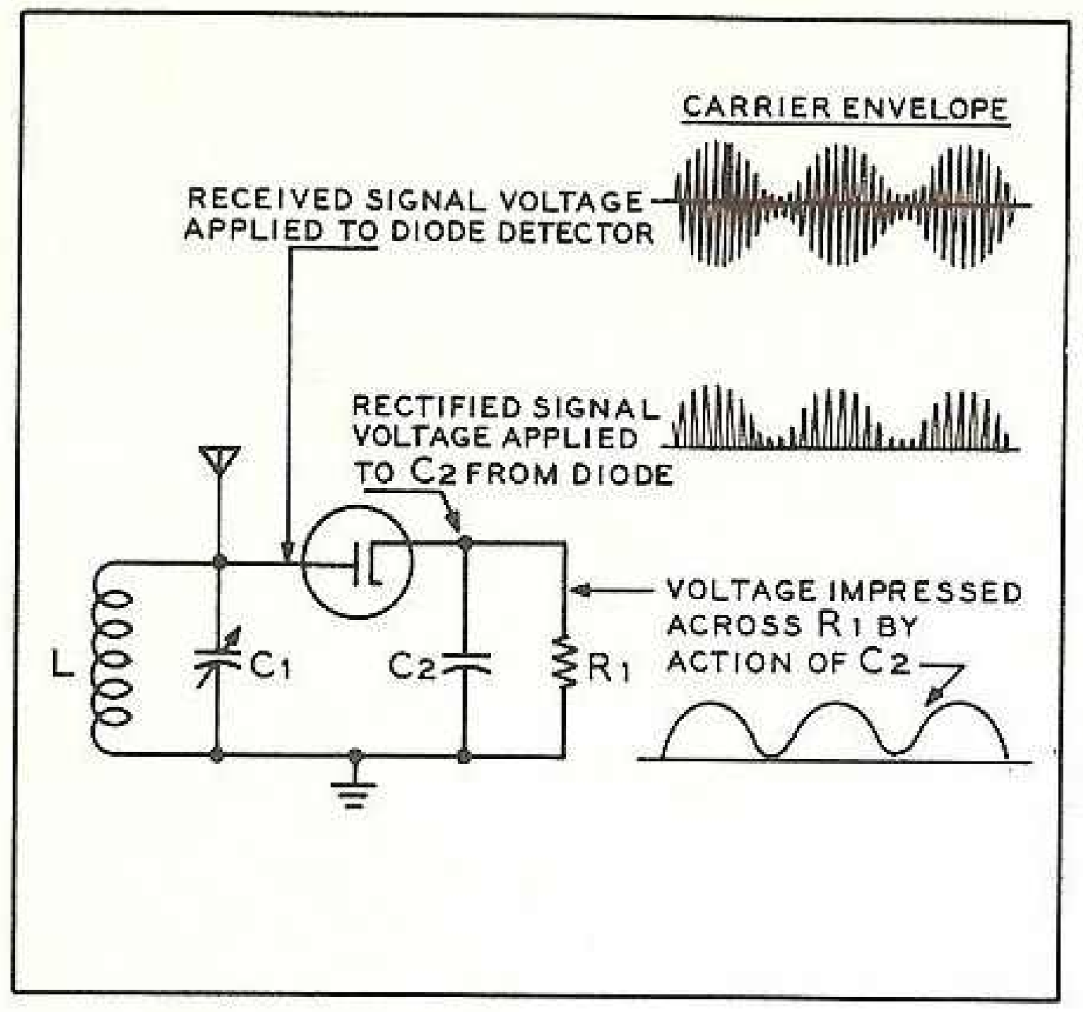


Fig. 2 The diode detector is a simple means of recovering the intelligence conveyed in the envelope of the carrier. The variations are rectified by the diode and charge capacitor C2. Indicating device across this capacitor will show variations in carrier envelope. This circuit is also called an "envelope detector."

phones to develop an audible signal. This complete process is called *detection*. Other types of detectors exist, but the simple diode is the one most commonly used for communications work.

C-W Reception

It is well to note that the diode detector is responsive to changes in the amplitude of the signal. This type of reception is useless for c-w signals because they have no amplitude changes other than when the carrier goes on and off. Unfortunately, we could not tell when it was on or off, except perhaps by noting the change in the background noise level. In order to copy c-w signals, it is necessary to generate a local carrier wave, off-set in frequency slightly from the received station. The incoming signal *beats* or *hetrodynes* with the local carrier and produces an audible beat, or whistle after detection. If the received station is on 800 kc, and the local carrier we generate is on 801 kc, the frequency difference is one kc, and we can hear a one kc tone in the headphones of the receiver tuned to the frequency. This process is called *hetrodyning* and it is accomplished automatically in a regenerative type of receiver. A communications receiver produces the audible beat note by the use of a *beat frequency oscillator*, or BFO as it is usually called.

Signal Amplification

Obviously, using nothing but a tuned circuit and a diode detector will not produce very satisfactory results. Only the loudest stations will be heard. It is essential to amplify the incoming signals to a level that can produce good headphone volume. This can be accomplished in a receiver by employing radio frequency amplifiers before the detector, or audio frequency amplifiers after the detector. One form of obsolete receiver using many r-f amplifiers was known as a TRF or *tuned radio frequency* set. All the r-f amplifiers in this type of receiver were tuned directly to the received signal. Have you seen pictures of the old radio sets having all the knobs on the panel? Well, they were TRF sets, and by modern standards were rather poor sets. Later versions had all these knobs ganged to a single shaft to simplify tuning. If you can visualize the problem in tuning all these

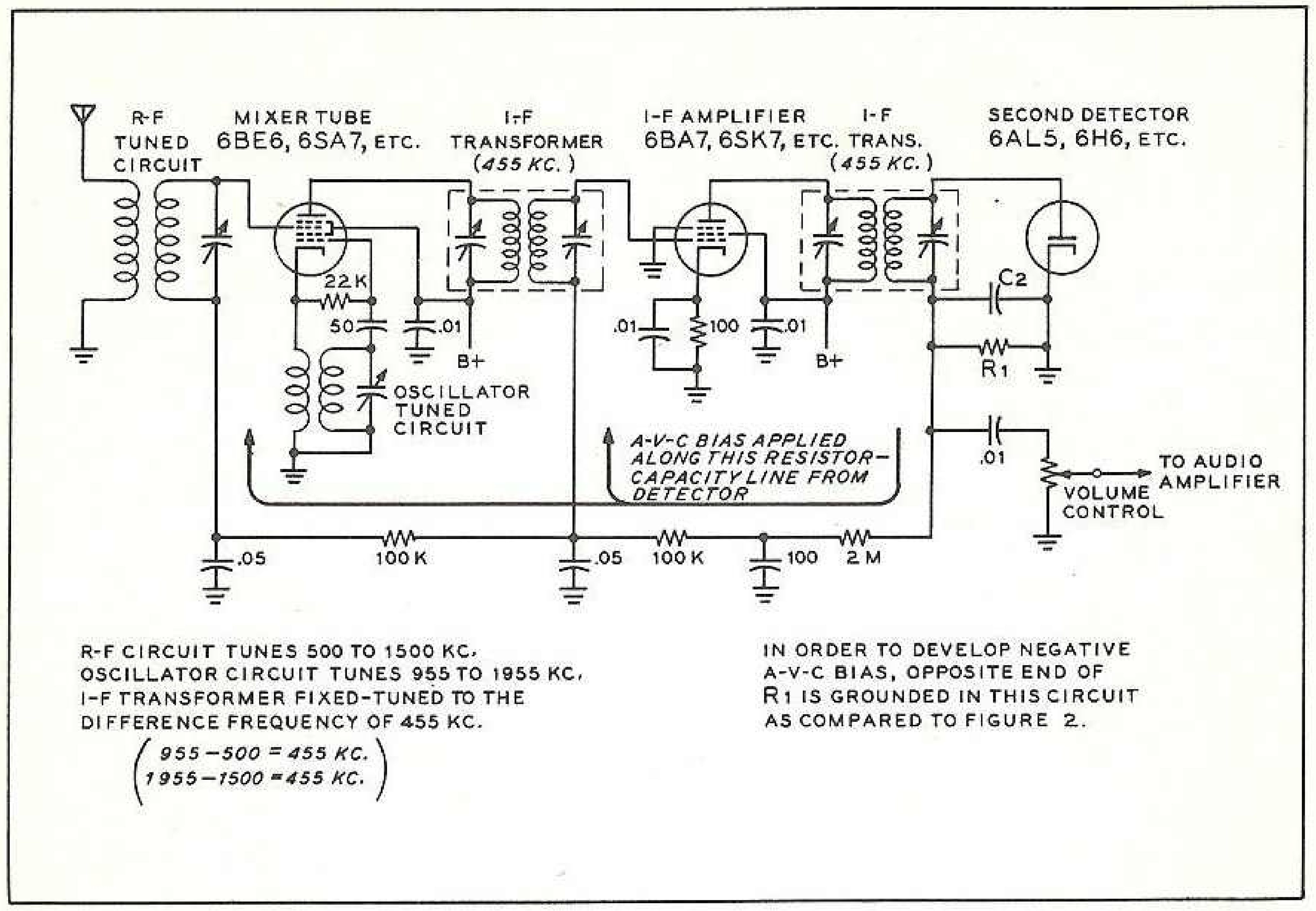


Fig. 3 The superhetrodyne receiver translates all signals to a common low frequency and amplifies them at that frequency. Since tuned circuits may be made more selective at a lower frequency, high gain and good slectivity may be obtained that would be difficult and expensive to get at the signal frequency.

circuits together perfectly across the broadcast band, you can well understand why this type of receiver was replaced with the *superhetrodyne*. Technically speaking, the TRF set was relegated to the ash-can because it was expensive to build and was not selective enough to separate loud adjacent stations.

The Superhetrodyne Receiver

The TRF set had all of its r-f amplification at the frequency of the incoming signal. This meant that when the receiver was tuned it was necessary to realign all the circuits to the new incoming frequency. Quite a job. However, suppose we could amplify all received signals in one amplifier that is tuned to a fixed frequency merely by changing all received signals to that single frequency? That would result in a much simpler receiver to build and align. That is exactly what is done in the superhetrodyne *(superhet* for short). A typical circuit for this type of receiver is shown in Figure 3.

The Converter Stage

The *converter stage* (often called a *first detector* or *mixer)* changes the frequency of the incoming signal to the frequency of the fixed-tuned intermediate frequency amplifier. A special multi-grid converter tube may be used, one portion of the tube acting as the mixing unit, and the other portion of the tube acting as the *conversion oscillator*. This low level r-f signal generated by the oscillator is combined with the received signal within the tube and the resulting signal appears at the chosen intermediate frequency.

When the dial of the superhetrodyne receiver is tuned, the conversion oscillator frequency follows the signal frequency, but always a fixed distance away in frequency. The frequency difference is equal to the frequency of the intermediate frequency amplifier, as illustrated in Figure 3. The new output frequency of the converter tube is passed through a selective transformer which rejects both the original signal and the oscillator signal and passes only the desired intermediate frequency signal. In most cases, the intermediate frequency (i-f) is in the region of 455 kc.

The I-F Amplifier

Regardless of the frequency to which the receiver is tuned, the conversion process results in a signal fixed at the intermediate frequency. It is now possible to achieve additional signal gain and selectivity through the use of i-f amplifier stages permanently tuned to the intermediate frequency. A combination of pentode tubes and high gain i-f transformers are usually used to provide signal gains of up to 10,000. In addition, the selective circuits of the i-f transformers reject signals off the resonant frequency, contributing a major portion of the selectivity of the receiver.

The Signal Detector and Audio Amplifier

The signal detector (often referred to as the *second detector)* in most communication receivers is our old friend, the diode. The circuit shown is similar to that of Figure 2, with the load resistor coupled to an extra stage of audio amplification. A volume control is also added to allow regulation of the level of the audio signal.

Automatic Volume Control

In addition to the audio intelligence appearing across the diode load resistor, R1, a negative d-c voltage is produced that is proportional to the strength of the received signal. This voltage is produced by the rectifier action of the diode detector. This d-c voltage may be applied to the input grids of the converter and i-f amplifier tubes through a suitable filter,

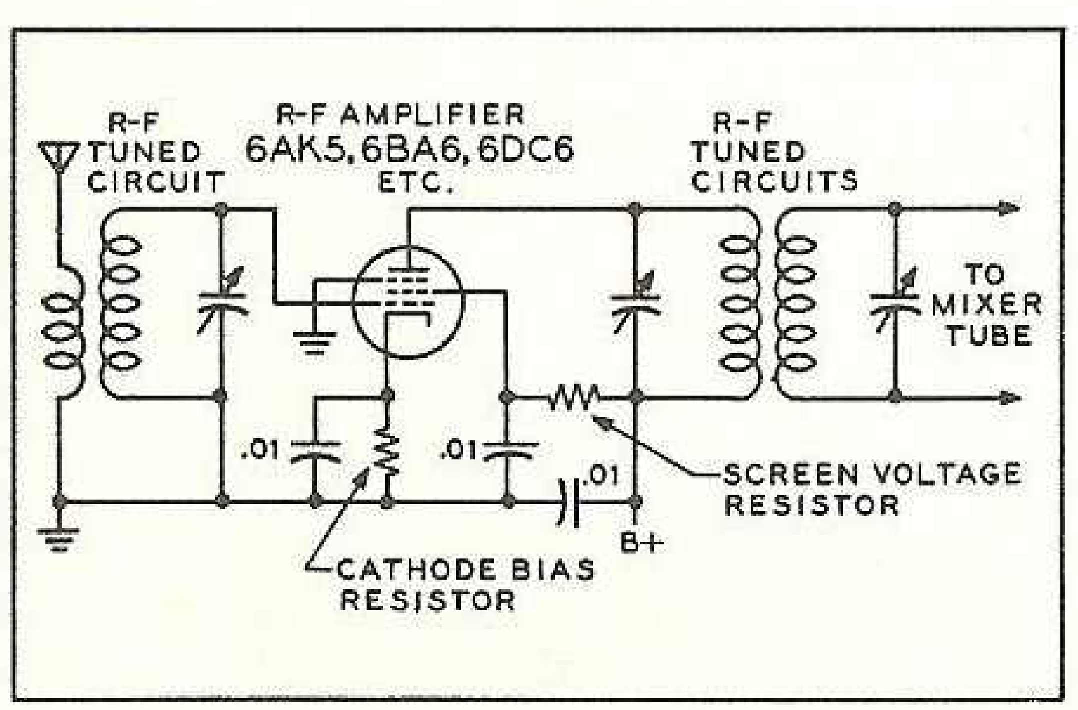


Fig. 4 Simple radio frequency amplifier placed ahead of mixer tube reduces tendency of superhetrodyne circuit to receive two frequencies at once. R-f amplifier reduces response to unwanted signal by large amount.

composed of R1 and C2. As the incoming signal becomes stronger, the voltage produced by the detector increases. The increased negative voltage on the input grids of the amplifier tubes decreases their factor of amplification, which in turn decreases the audio signal heard in the loudspeaker or headphones of the receiver. Thus, when tuning weak and strong stations, the audio volume level tends to remain constant. This *automatic volume control* (a-v-c) circuit also helps to prevent the receiver from being overloaded by extremely strong signals.

The Beat Frequency Oscillator

In most receivers, a triode tube is used as a beat-oscillator for c-w reception. Its purpose is to provide a beating signal to allow audible reception of the dots and dashes of c-w transmission. The continuous signal generated by this tube is tuned very close to the frequency of the i-f signal, and is coupled to the diode detector circuit. A b-f-o frequency of 456 kc will produce a one kc audible beat with an i-f signal on 455 kc. Because the a-v-c- circuit of the diode detector will rectify the b-f-o signal, producing a strong a-v-c voltage and a drop in receiver sensitivity whenever the b-f-o- is turned on, the a-v-c circuit is usually disconnected for c-w reception.

Auxiliary Equipment for the Communication Receiver

The superhetrodyne receiver under discussion performs in an adequate manner, but it is merely the skeleton of a communications receiver. For satisfactory short wave reception, certain other necessary items should be added to the receiver which are not absolutely required for reception in the broadcast band.

The R-F Amplifier

The main drawback of the superhetrodyne receiver is that it is capable of simultaneous reception on two different frequencies at the same time. The unwanted frequency is called the *image frequency.* Reception of the image signal may be substantially eliminated by the use of a radio frequency amplifier stage placed ahead of the converter stage of the receiver. The image frequency is displaced from the wanted frequency by twice the amount of the intermediate frequency. Thus, if we were listening to a station on 14,000 kc with a receiver having a 455 kc i-f stage, a signal on the image frequency of 14,910 could be heard in the receiver. A good r-f stage can amplify the 14,000 kc signal and reject the image signal. Many of the inexpensive short wave receivers on the market have no r-f stage for reasons of economy, and these receivers are bothered by unwanted image signals. The r-f amplifier stage also increases the overall sensitivity of the receiver to a great degree. No shortwave receiver can be called a true communications receiver unless it has a good r-f amplifier stage ahead of the first converter tube, similar to that shown in Figure 4.

The Noise Limiter

Although our typical receiver has no noise limiter, such an item is very important for good high frequency reception. Automobile ignition noise and power-line noise tend to peak in the high frequency spectrum. Short

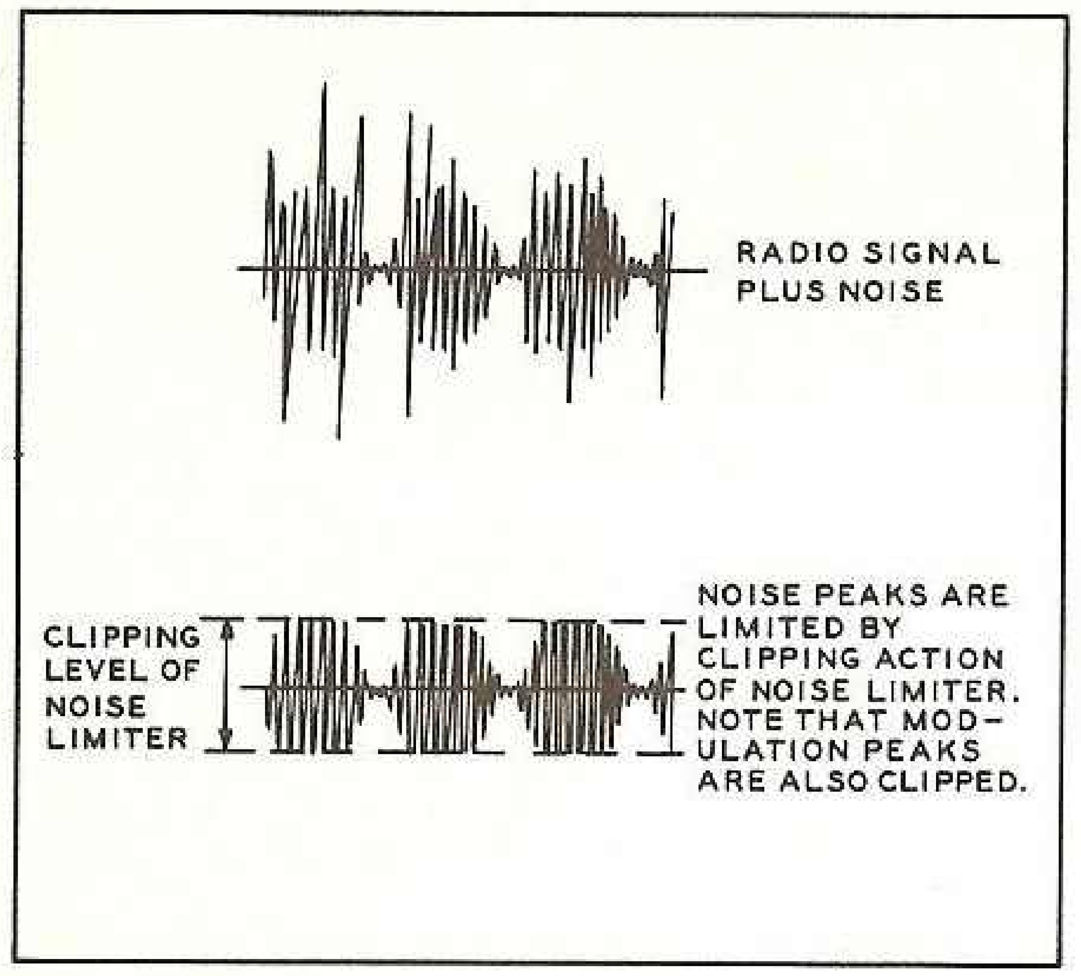


Fig. 5 Loud noise impulses tend to paralyze receiver between the pulses. A noise clipper can chop off the peaks of the noise and permit good copy of signal that is otherwise obliterated by high noise level.

wave signals, on the whole, are much weaker than broadcast signals, and they can be completely obliterated by man-made noise that does not bother the stronger broadcast signals. Figure 5 shows a combination of a radio signal and noise both before and after limiting. Note that the noise peaks have greater maximum value than the modulation impressed upon the signal. A good communication receiver will have a *noise limiter* that will short out the first audio stage whenever the noise peaks pass a certain amplitude. A "hole is punched in the signal," eliminating a large portion of the noise. In the process, some of the audio signal is usually clipped, too! That is why a noise limiter tends to introduce some audio distortion on the received signal. Even so, a good noise limiter will often make the difference between hearing a station and not being able to find it.

The Signal Strength Meter

The negative d-c voltage developed by the diode detector can also be used in another manner. If we were to connect a very sensitive d-c meter across the terminals of the diode load resistor we would have a visual indication of the strength of the incoming signals. In a communications receiver a meter that indicates signal strength is called an *S-meter,* and is calibrated in S-units. If you tell the station you are working that he is S-9,

Fig. 6 Incorporating many of the special features required for serious amateur reception is the double conversion, 12 tube National NC-300 receiver. Converters are used to extend the tuning range of the set above 420 mc.

then he has an approximate idea of the strength of his signal at your receiver. Most receivers actually measure the *effect* of the a-v-c voltage on the i-f and converter stages, rather than the a-v-c voltage itself. By using this method a less sensitive (and less expensive) meter may be employed.

Stability—Sensitivity—Selectivity

These three terms can be used to sum up the performance of any receiver. In order that you may evaluate the performance of your receiver, or one that you intend to purchase, an explanation of these terms is in order.

Stability

The electrical stability of the receiver is a function of the *thermal* stability and the *mechanical* stability. The thermal stability is a measure of the response of the receiver to changes in temperature. As the receiver warms up, the heat of the tubes and the power transformer gradually warm other components in the receiver. The tuned circuits are particularly sensitive to temperature changes. The thermal stability of the receiver is the ability of the receiver to stay tuned to a station after a short warm-up period. As the heat increases in the receiver cabinet, especially in the vicinity of the conversion oscillator, component values will change, causing the dial setting to slowly vary. This effect is known as *drift,* and can be very annoying if it is necessary to keep retuning a station for several minutes or even an hour after the receiver is first turned on. All receivers, except the most expensive have varying amounts of thermal drift, and it is well to check this drift before a new receiver is purchased.

Mechanical stability is a function of receiver design. The converter stage is especially sensitive to vibration in most receivers. Instability may be caused by loose components, poor tubes, or wires that move slightly when the receiver is vibrated. Many receivers having the speaker mounted in the case are prone to mechanical instability when the set is playing loudly. The vibrations of the speaker can lead to acoustic feedback, taking the form of a loud howl heard on strong signals. A well designed high frequency receiver will have a heavy case, with all parts firmly mounted to the chassis. Heavy leads will be employed in the r-f section of the receiver to reduce effects of mechanical vibration. Rubber shock mounts are employed in some cases to reduce vibration of the sensitive tuned circuits.

Sensitivity

Sensitivity is the ability of the receiver to receive weak stations over the inherent noise of the set. Of the three requirements for a good receiver, this one is the easiest for the manufacturer to meet. All but the most inexpensive receivers (having no r-f stage) have sufficient sensitivity and amplification to "pull in the weak ones." Generally speaking, the more tubes a receiver has, the greater gain it has. However, the amount of gain often does not really indicate just how sensitive the receiver really is. Some poor receivers having excessive gain merely amplify their own noise!

Selectivity

Selectivity is the ability of a receiver to reject unwanted stations. The true criteria of a good receiver is not what it receives, but what it rejects! This is the most critical requirement of the three, and the one where most receivers fall flat on their fuses. Because it is impossible to design a tuned circuit that will pass only one frequency, stations on either side of the wanted one will usually be heard, and will cause interference. Generally speaking again, the lower the intermediate frequency, and the more i-f stages, the better will be the selectivity of the receiver.

This brings us in round-about fashion to the last items of auxiliary equipment required in the communication receiver—devices for obtaining optimum selectivity.

Selectivity Aids for the Communication Receiver

Three items are in use today that help to obtain optimum selectivity in the communications receiver. They are the crystal filter, the Q-multiplier, and the mechanical filter. In each case, the idea is to narrow the bandwidth of the receiver, permitting the reception of only one station at a time. This function is accomplished in the fixed-tuned intermediate frequency amplifier stages.

The Crystal Filter

The crystal filter is a sharply tuned stage employing a resonant circuit made of a piece of critically ground quartz. The quartz crystal is tuned to the frequency of the i-f amplifier, and acts as a signal "gate," permitting the intermediate frequency to pass, and rejecting those frequencies on either side. The crystal filter is extremely effective for c-w reception, but does not perform nearly as well for phone reception. The crystal filter allows a high degree of rejection at *one* chosen frequency. By the use of a variable rejection control, a loud unwanted hetrodyne may be almost eliminated.

The Q-Multiplier

The Q-multiplier is a relatively new device for increasing the selectivity of a receiver. Electronically speaking, this circuit increases the "Q" (or figure of merit) of a coil in the i-f amplifier to the point where the tuned circuit employing this coil will pass only a narrow band of frequencies. This is by far the simplest and most inexpensive means that the Novice can employ to increase the selectivity of his receiver, therefore a Q-multiplier is described in detail in the chapter devoted to Novice aids. The Q-multiplier may be used for either phone or c-w reception.

The Mechanical Filter

The Collins mechanical filter employs small resonant metal discs that are tuned to the i-f frequency of the receiver. The passband of the mechanical filter is excellent, and it is by far the best (and most expensive) device for obtaining maximum receiver selectivity. The passband of this type of filter is fixed, and various models of the filter allow the use of different passbands for phone or c-w reception. Its characteristic broad flat-top and steep sided response curve make it a pleasure to copy phone or c-w even under the worst QRM conditions.

Typical of the trend to single-sideband transmission and reception is the Collins 75A–KWS-1 amateur station. Capable of 1-kilowatt peak power on the major amateur bands, the KWS-1 may be also used for c-w and a-m transmission. Many "general" class amateurs are changing to SSB operation as its advantages become more widely known and appreciated.

Converters

There is one form of "receiver" that has not yet been discussed, and that is the *converter*. A converter is a device that will extend the tuning range of a receiver. Take your home radio for example: If you desired to listen to short wave signals, you could build a converter similar to those shown in this Handbook which would extend the tuning range of the b-c set up into the short wave bands. Admittedly, the combination would not make a very good communications receiver, but it would work.

Converters are divided into two groups, tunable and fixed-tuned types. Both have decided advantages and disadvantages that make one type preferable to the other for certain applications.

Either type of converter may be used in conjunction with an inexpensive shortwave receiver to improve reception at the higher frequencies. As an example, most of the inexpensive communications receivers will not perform to a high degree on the 10 meter band (28-29.7 mc). It is possible to build a converter that will "beat" the 10 meter signals down to a lower frequency at which the receiver will be more sensitive. Converters are also used to an advantage in conjunction with an automobile receiver to facilitate mobile operation of an amateur station.

The converter, in effect, is comparable to the "front end" of a communication receiver. The receiver to which the converter is attached serves as the i-f amplifier and detector stages for the r-f circuits of the converter.

A block diagram of a typical fixed-tuned converter is shown in Figure 7A. The r-f amplifier section is adjusted so that it will amplify a band of frequencies between 50 and 54 mc. The conversion oscillator is crystal controlled at 43 mc. Note that the conversion frequency is fixed, and cannot be changed unless a new crystal is inserted in the oscillator. Any signals

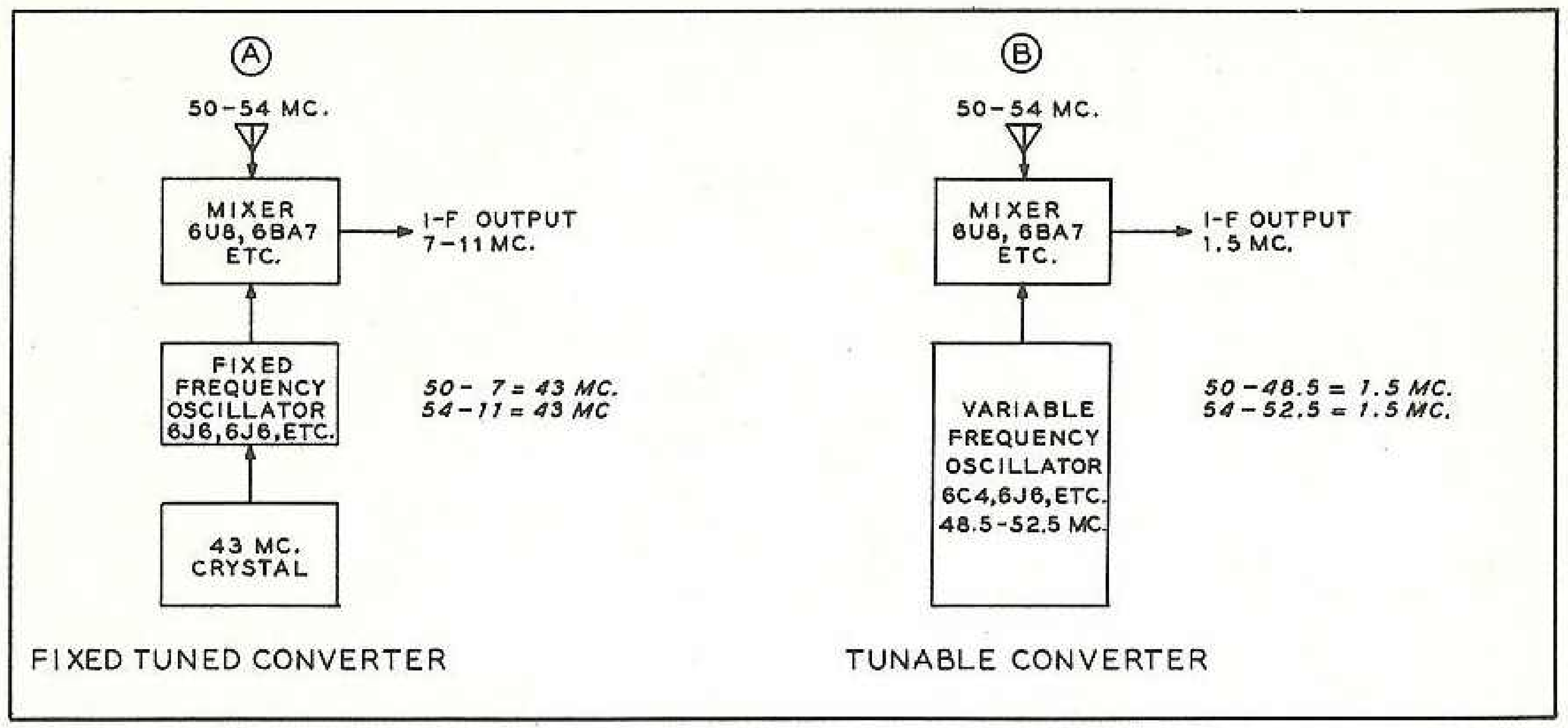


Fig. 7 Fixed tuned converter is best for VHF work where stability is desired.

in the 50-54 mc range are mixed with the 43 mc oscillator signal in the 6U8 mixer tube. The i-f frequency range for reception across the six meter band is the difference in frequency between the tuning range and the conversion oscillator frequency. In this case, the i-f range is 7 mc to 11 mc. If the converter is attached to a communication receiver capable of tuning this frequency range, signals in the 50-54 mc range may be received. Note that the r-f stage of the receiver serves as a tunable i-f stage for the converter. The converter-receiver combination actually has two i-f channels, and is called a *double conversion receiver.* With a fixed-tuned converter, all tuning is done with the main tuning dial of the receiver. The converter can be tucked out of the way and left un-attended for long periods of time. Another advantage is that the crystal controlled conversion oscillator in the converter contributes negligible drift to the 50 mc signals. On the debit side of the ledger, this type of converter has lower gain than the tunable type, because the r-f stages must be adjusted to cover the complete band of frequencies to be received. The broad-band r-f stage will sometimes let signals get through it which are unwanted. These are known as *spurious signals.* In spite of this drawback, this type of converter is unanimously favored over the tunable converter for high frequency reception.

Figure 7B shows a typical tunable converter diagram. The oscillator section of this converter, unlike the crystal controlled model, can be changed in frequency by means of the main tuning dial. When used with an automobile radio, the i-f channel of the converter is 1500 kc. The car radio is tuned to that frequency, and the conversion oscillator of the converter always operates 1500 kc away from the received signal. A fixed intermediate frequency is used, and all tuning is accomplished at the converter. This type of converter features good gain, good selectivity, and good spurious signal rejection because all the r-f tuned circuits are sharply resonant at the incoming signal frequency. The disadvantages of this type of converter are the large size (because of the bulky tuning capacitor), thermal drift (because of the heating of the oscillator components) and relatively poor mechanical stability, especially in an automobile. In most cases, it is usually not as handy to tune the converter as it would be to tune the receiver. However, this type of converter is by far the most popular type for mobile reception.

CHAPTER V

Receiver Projects You Can Build

IMPROVE YOUR RECEPTION WITH A PRESELECTOR

Here's an inexpensive gadget that will turn a DX-dud into a Band-sniffin' Bloodhound—and at a minimum price, too! A few hours work and a very few dollars will give you the best of reception in the range of 3.3 to 33.0 mc. A big signal boost in all the high frequency ham bands, and in the short wave broadcast bands! You can't work 'em if you can't hear 'em! And with this sensitive preselector you CAN hear them!

A preselector is an auxiliary r-f amplifier hiding behind a fancy name. If your receiver has a three gang tuning capacitor behind the dial, it is the proud possessor of a built-in r-f stage. If the capacitor is a two gang affair, your receiver is "barefoot" with no r-f stage at all. In either case, a preselector will do wonders for the set, particularly in the vicinity of the ten and fifteen meter amateur bands. If your receiver has no r-f stage, the preselector will make the difference between an S9 signal and no signal at all!

This midget preselector uses a single high gain 6AK5 pentode tube, and covers the complete short wave spectrum without the use of coil switching.

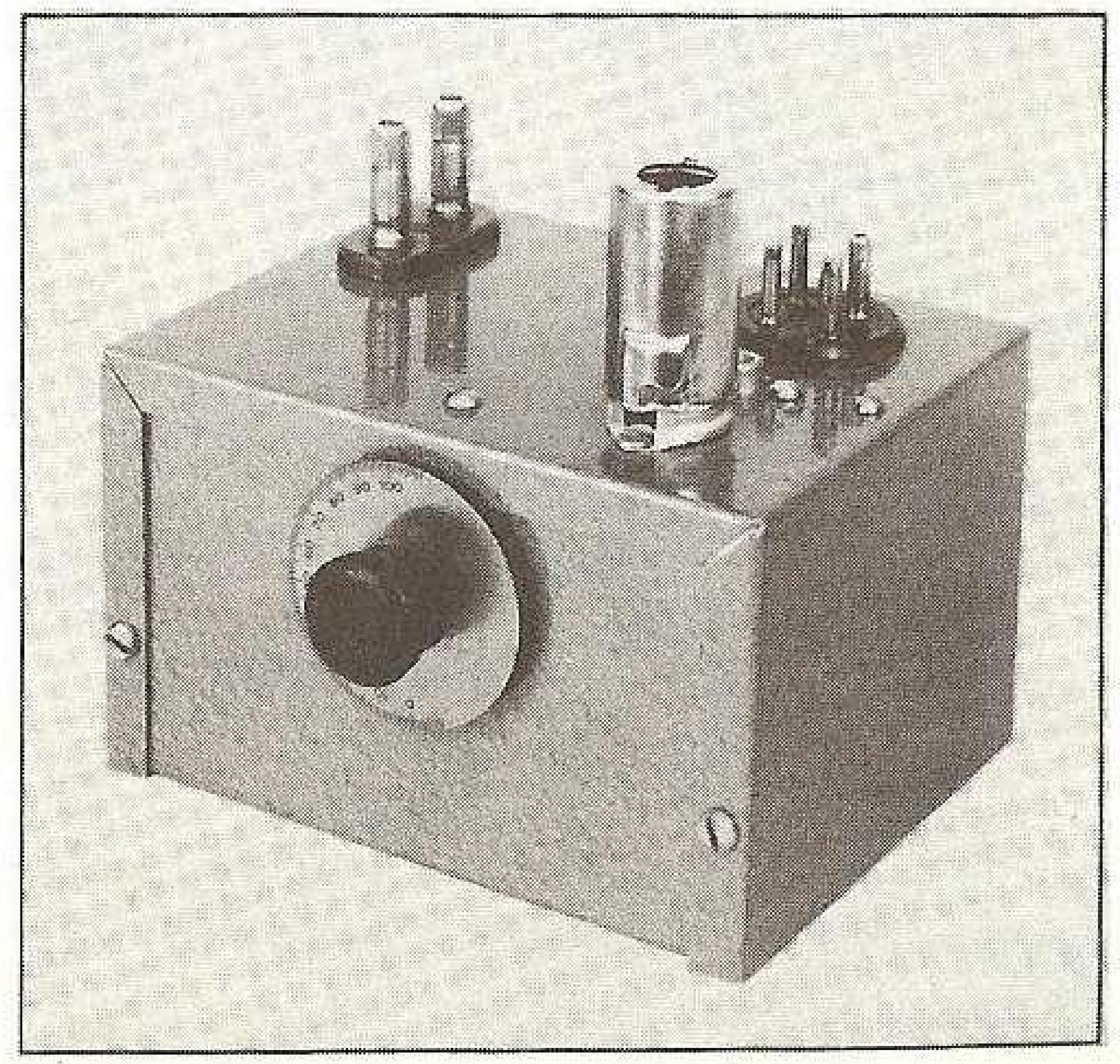


Fig. 1 The midget preselector is only 3" x 4" x 5" in size. A 6AK5 pentode tube in a unique all-band tank circuit provides maximum gain from 3.3 mc to 33 mc. Antenna terminals are at the left, and power plug and i-f output receptacles are behind the tube socket.

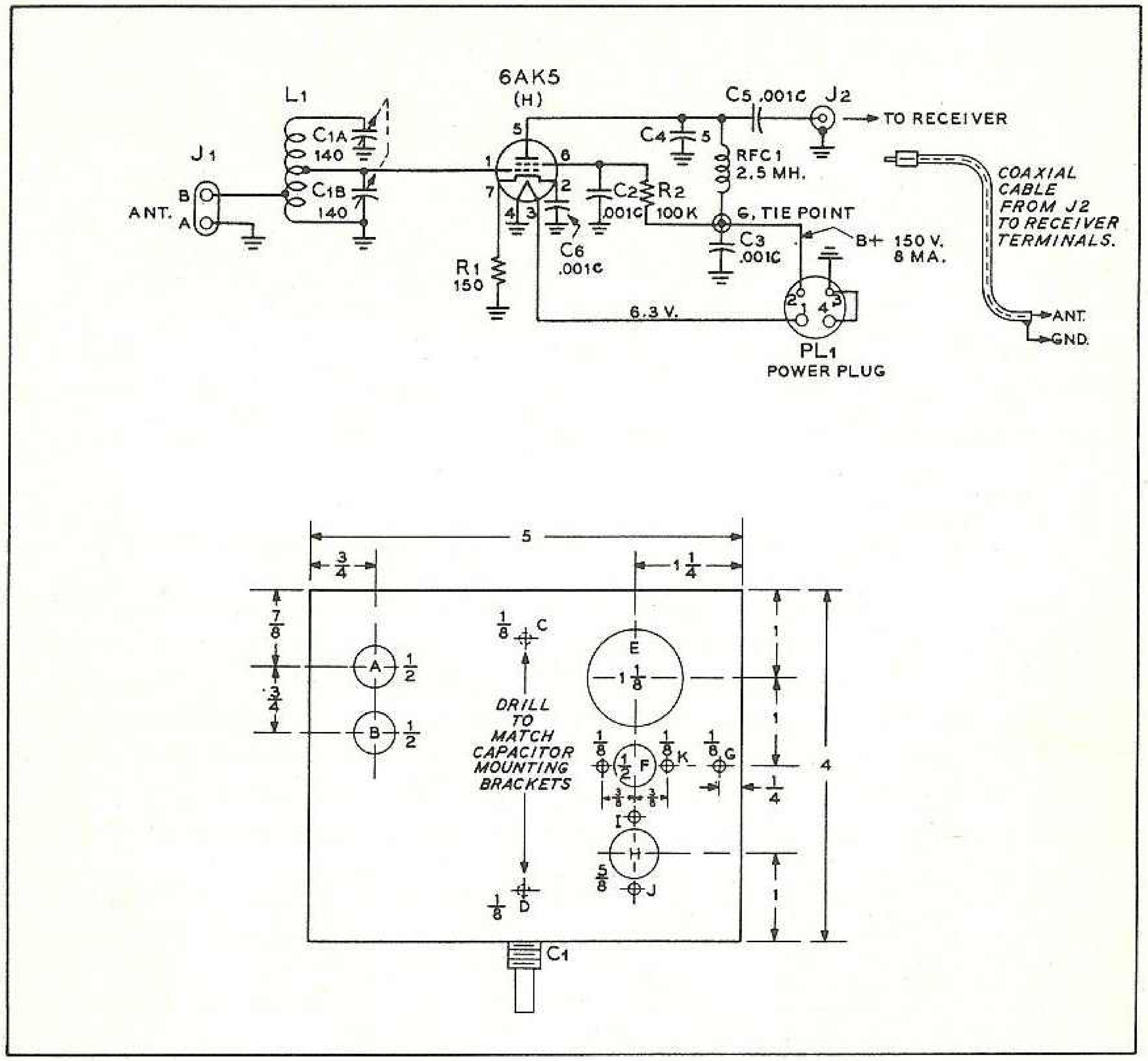


Fig. 2 The simplicity of the preselector can be seen in the above schematic.

It will work with any receiver, regardless of make or design. The preselector is powered by the low voltage supply shown in the Power Supply chapter of this Handbook, or (under certain circumstances) may obtain its power from the station receiver. A unique all-band tuned circuit covers the range of 3.3 mc to 33.0 mc, permitting the operator to merely turn the peaking control (C1) of the unit for greatest signal strength of the incoming station.

Preselector Construction

The complete preselector is constructed on the "top" of a 3" x 4" x 5" aluminum box *(Bud Minibox CU-2105)*, and is shown in Figure 1. You can get a good idea of the layout of the various components from the bottom view of Figure 3. The output connector (J2) is located directly behind the 6AK5 tube socket, with the 4 prong power input plug (PL-1) to the rear. The peaking control (C1) is mounted in the center of the chassis. A 3/8" wide slot should be carved in the front of the U-shaped part of the box to allow the shaft of the peaking capacitor to pass through the front of the box. A skirted knob is installed on the shaft of C1, hiding the slot.

The following assembly and wiring instructions are presented in a step-

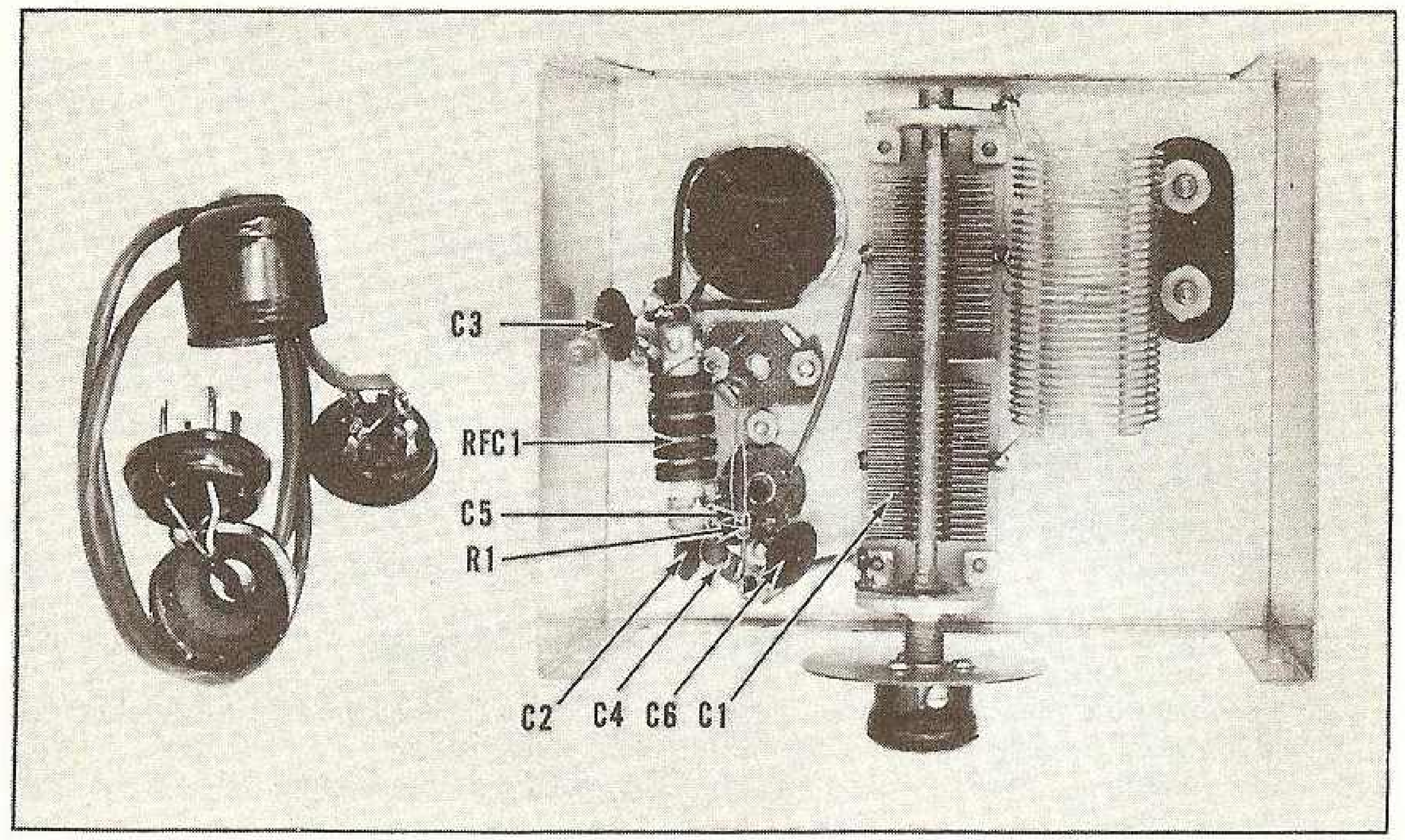


Fig. 3 The placement of the under-chassis components are shown here. Coil L1 is at the right of peaking capacitor C1, with the antenna terminals at the right of the chassis. Power cable is at left, showing wiring of plugs.

by-step sequence to enable the constructor to complete the project easily and correctly. Be sure to read each step all the way through before you start to do it. When the step is completed, check it off in the space provided.

( ) Lay out the chassis holes (Figure 2) to be drilled on the paper wrapper of the chassis. Drill the holes and remove the burrs.
( ) Mount the twin terminal binding post (J1) in holes A and B.
( ) Bolt peaking capacitor (C1) to the chassis using 6-32 bolts passed through holes C and D. The shaft of (C1) points towards front of the chassis.
( ) Mount 4 pin power plug (PL-1) in E using the socket locking ring.
( ) Mount the output connector (J2) in F. Under one of the 6-32 nuts place a ground lug, K, as indicated in Figure 2.

Parts List for Preselector

1—Dual 140 mmf. midget variable (Hammarlund HFD-140) (C1A, C1B)
4—.001 mf. 600 volt disc capacitor (Centralab DD-102) (C2, C3, C5, C6)
1—5 mmf. ceramic capacitor (Centralab DD-050) (C4)
1—Twin terminal binding post (National FWH) (J1)
1—Coaxial connector and plug (Cinch-Jones 13A and 81A) (J2)
1—Inductor (B & W 3015 or Air Dux 816T) (L1) 29 turns, 1" diam., 1 7/8" long, #14 tinned wire (see text for taps)
1—4 pin chassis mounting plug (Amphenol 86-RCP4) (PL-1)
1—150 ohm, 1/2-watt resistor (IRC BTS or BW-1/2) (R1)
1—100,000 ohm, 1/2-watt resistor (IRC BTS or BW-1/2) (R2)
1—2 1/2 mh. r-f choke (National R-100) (RFC-1)
1—Aluminum chassis-box, 3" x 4" x 5" (Bud Minibox CU-2105)
1—Tube, 6AK5 (RCA)
1—socket, small 7-pin (Amphenol 147-913) with shield
1—tie-point strip, single terminal (Cinch-Jones 51)
5—6/32 bolts and 3 nuts
2—4/40 bolts and nuts
2—ground lugs, #6
1—dial (0-100), (Johnson 116-222-1)
1—20" length coaxial cable (RG-58/U) or (RG-59/U)
2 feet of #18 flexible hookup wire

( ) Mount a single terminal phenolic tie-point under the chassis in G.
( ) Mount the 7 pin tube socket in H, using 4-40 hardware. The blank pin of the socket should face hole F. Under the socket nut near the front of the chassis install ground lug, J.
( ) Connect a wire from pin 4 of (PL-1) to pin 3 of (PL-1).
( ) Connect a wire from pin 3 of (PL-1) to ground lug K.
( ) Connect a wire from pin 2 of (PL-1) to tie-point G.
( ) Connect a wire from pin 1 of (PL-1) to pin 3 of socket (H).
( ) Connect a wire from pin 4 of socket (H) to ground lug J.
( ) Install a .001 disc ceramic capacitor (C3) between tie-point G and ground lug K.
( ) Install a 150 ohm resistor (R1) between pin 7 of tube socket (H) and ground lug J.
( ) Install a .001 disc ceramic capacitor (C6) between pin 2 of tube socket (H) and ground lug J.
( ) Install a .001 disc ceramic capacitor (C2) between pin 6 of tube socket (H) and ground lug J.
( ) Install a 5 mmf ceramic capacitor (C4) between pin 5 of tube socket (H) and ground lug J.
( ) Install a .001 disc ceramic capacitor (C5) between pin 5 of tube socket (H) and the center terminal of output connector (J2).
( ) Install a 100K resistor (R2) between tie-point G and pin 6 of tube socket (H).
( ) Install a 2.5 mh r-f choke (RFC-1) between pin 5 of socket (H) and tie-point G.
( ) Solder a lead from the front *rotor* (ground) lug of capacitor (C1) to ground lug J. Check all joints for wiring errors.
( ) Connect a wire from the *rear stator* lug of capacitor (C1B) to pin 1 of socket (H).
( ) Connect a wire from the *rear ground* lug of capacitor (C1) to terminal A of antenna terminal binding post (J1).
( ) Prepare coil (L1). Cut 29 turns of prepared coil material. Pull off and tin ½-inch of wire at each end of the coil. At the center of the coil (14½ turns from one end) solder a piece of wire 3 inches long. Push in a turn of wire on each side of this turn to facilitate soldering the connection.
( ) In the same manner, locate the fifth turn from one end of the coil and solder to it a second 3-inch length of wire.
( ) Place the coil below the chassis as shown in Figure 3. Connect the end lead of the coil *nearest* the 5 turn tap to the *rear ground* lug of peaking capacitor (C1).
( ) Connect the 5 turn tap wire to terminal B of antenna binding post (J1).
( ) Connect the center tap wire of the coil to the *rear stator* lug of peaking capacitor (C1B).
( ) Connect the remaining front lead of the coil to the *front stator* lug of peaking capacitor (C1A).
( ) Solder all connections.
( ) Prepare a 20 inch length of coaxial cable to connect the preselector to the receiver. Install a male connector *(Cinch-Jones 13A)* at one end, and unbraid and tin the other end for connection to the antenna and ground terminals of your receiver.
( ) Check all wiring connections and assemble the preselector box.

Testing the Preselector

Connect the shielded output lead of the preselector to the antenna terminals of your receiver, with the braid going to the "ground" terminal. Connect your antenna to terminal B of J1, and an external ground (if one is used) to terminal A of J1. If a doublet or other two wire antenna is used, connect the two leads to A and B, with no external ground connection. Attach the preselector to the power supply via a short length of four wire cable, and tune your receiver to the frequency you wish to receive. Turn on the preselector, and note if the tube lights. Slowly adjust the peaking control until stations are at maximum strength. If instability is noted—which is very unlikely—increase the resistance value of R1 to 300 ohms, decreasing the gain of the preselector.

Because the preselector consumes so little power it is possible to "steal" power from any communications receiver that *is not* an ac-dc set. To do this, install a 4 pin tube socket on the rear apron of the receiver. Connect pins 3 and 4 of this socket to a convenient ground point in the receiver. Connect pin 1 to the 6.3 volt filament line, and connect pin 2 to a voltage source in the receiver of approximately 150 volts. If such a point cannot be found, connect pin 2 to the B-plus point of the receiver through a 10K, 1-watt resistor. If the preselector is used with a receiver having 12 volt tubes (such as the *Heathkit type AR)* and it is desired to use the receiver to power the preselector, it is necessary to install a 50 ohm, 10-watt wire-wound resistor between pin 1 of the power socket and the 12 volt filament circuit of the receiver.

Note! When this preselector is used in conjunction with an ac-dc receiver it is important that no d-c connection exists between the chassis of the preselector and that of the ac-dc receiver in order to reduce the shock hazard. Most ac-dc sets have an isolating capacitor between the "ground" terminal and the chassis of the receiver. If this capacitor is not included in the set, or if it cannot be found, it is wise to insert a .01 ufd, 600 volt ceramic capacitor between the braid of the coaxial interconnecting cable and the "ground" terminal of the ac-dc set. This will in no way effect the operation of the preselector, yet will remove the danger of accidental shock.

A SENSITIVE SHORT WAVE CONVERTER

Too many short wave receivers, particularly the inexpensive ones, fail to "deliver the goods" on the higher frequencies. Poor sensitivity, images, and instability are some of the usual symptoms. This two tube fixed-tuned converter will convert any 2 megacycle portion of the spectrum between 12 mc and 54 mc down to an intermediate frequency range falling in the region where your receiver can get a good "bite" on the signal. If you wish to tune 6 meters, 10 meters, or some band not covered by your present receiver—this simple converter will do the job for you! Using it in conjunction with your receiver will give you all the advantages of a double conversion receiver, at a fraction of the cost! To the soldering iron!

This inexpensive fixed-tuned converter is designed primarily for first-class reception in the 6, 10, 11, 15, or 20 meter amateur bands, or the 12, 14, or 19 meter short wave broadcast bands. Any one of these bands may be covered by a single set of coils. The cost of the converter is so small that individual converters may be built for each band, if desired. The output intermediate frequency may be set for any range between 500 kilocycles and 5 megacycles. An automobile receiver may be used with the converter for mobile work, or the unit may be employed with a 3-6 mc "Command Receiver," or a simple ac-dc short wave set to form a "hot" double conversion receiver. Only 4"x2"x2" in size, this midget packs a real DX-punch!

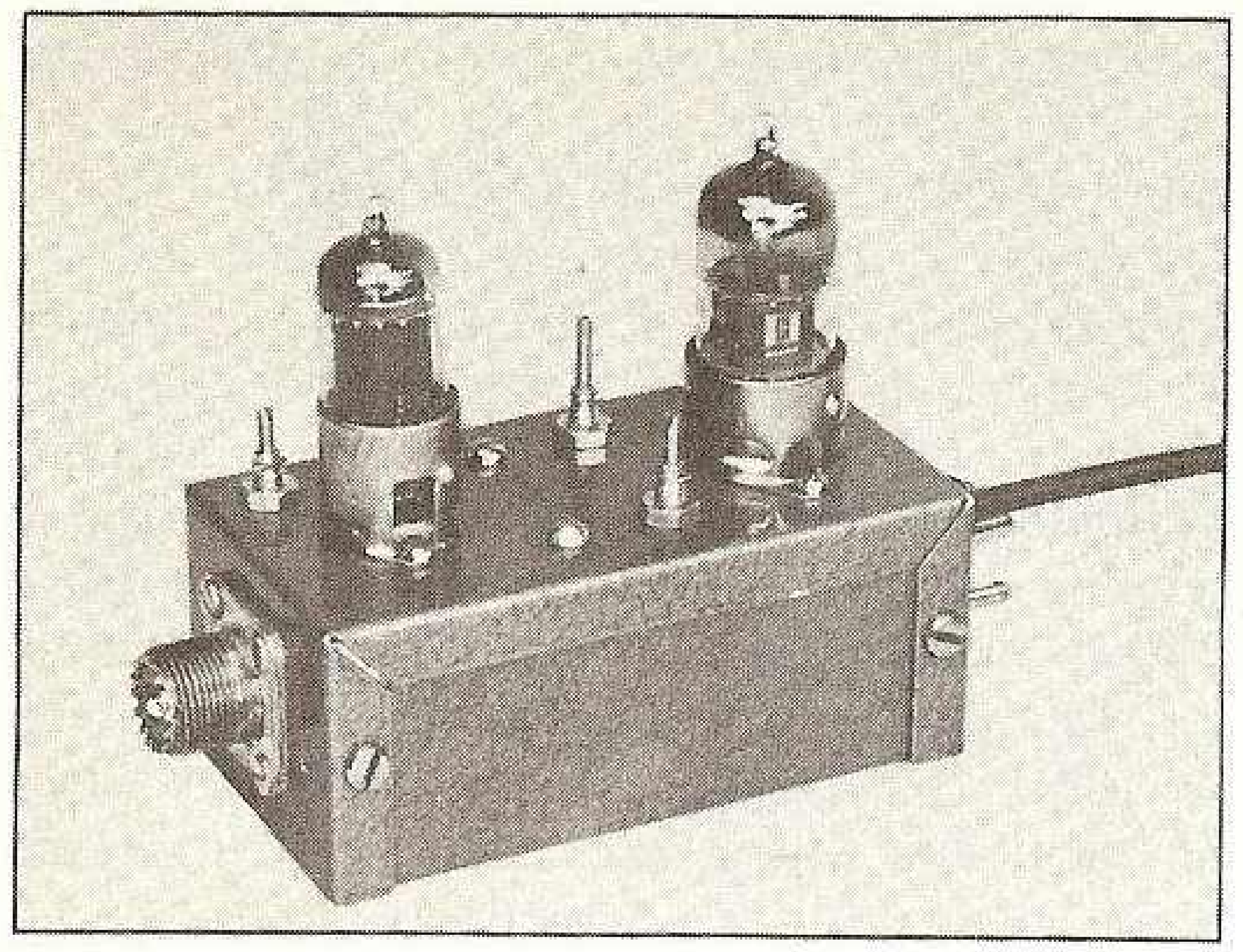


Fig. 4 This two tube converter may be used up to the six meter amateur band with any good short wave receiver. The 6BH6 r-f amplifier is at the left, and the 6U8 mixer/oscillator tube is at the right. The tuning slugs of the three inductances project through the top of the chassis box for adjustment.

The Converter Circuit

The schematic of the converter is given in Figure 5. A high gain 6BH6 tube is used as an r-f amplifier, with the grid circuit tuned to the approximate frequency of reception by L2 and C1. A dual-purpose 6U8 tube is used as a pentode mixer and a triode high frequency conversion oscillator. The frequency of the conversion oscillator is set by the inductance value of L4 and the capacity of C2 and C3. Power for the converter may be obtained from the low voltage supply shown in the Power Supply chapter of this Handbook. It is also possible to "steal" the power for the converter from the station receiver, under the conditions described for the high frequency preselector a few pages back.

Converter Construction

The converter is built upon one half of a *Bud Minibox (CU-2102)*. The general placement of parts may be seen in Figures 4 and 6. The following wiring and assembly instructions are presented in a step-by-step sequence enabling the constructor to complete the project correctly in a minimum of time. Be sure to read each step all the way through before you start to do it.

( ) Mark the chassis holes (Figure 5) on the paper wrapper of the chassis. Center-punch each hole and drill the chassis. Clean off all burrs. The bolt holes for antenna receptacle (J1) can be located by temporarily mounting the receptacle and marking the chassis through the mounting holes.
( ) Cut a shield plate from a piece of thin brass or aluminum as shown in Figure 5. Mounting holes K and L in the shield should match holes F and G of the chassis. Position the flange of the shield as shown in Figure 6. Mount the shield with 6-32 screws.
( ) Place a ground lug under nut G, and a single terminal phenolic tie-point under nut F. Tighten the nuts.
( ) Place a ¼-inch rubber grommet in hole A on rear of chassis.
( ) Mount a 4 pin male plug (PL-1) on rear apron of chassis in hole B. Place a ground lug P on mounting bolt of socket near hole A.
( ) Mount a 9 pin tube socket (6U8) in hole C, with blank pin pointed in direction of hole E. Place ground lug C under socket nut near pin 4.
( ) Wind coils (L3) and (L4) from coil table data. Mount (L3) in socket hole D, and (L4) in E. Align coil terminals towards socket (C).
( ) Mount a 7 pin tube socket (6BH6) in hole H, with blank pin positioned towards hole I.

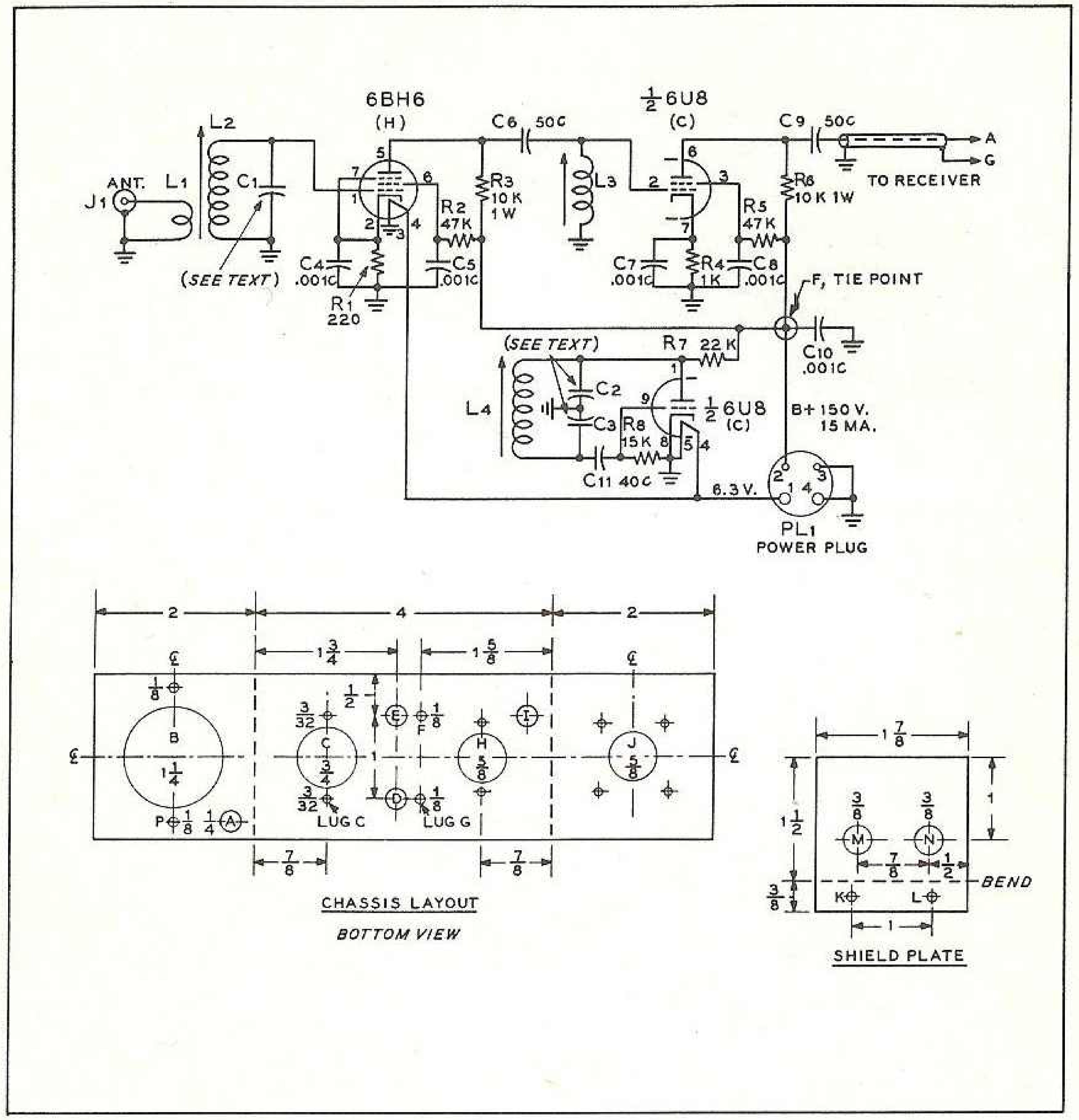


Fig. 5 Schematic of two tube amateur band converter for 20, 15, 10 or 6 meters.

( ) Mount antenna receptacle (J1) in hole J. Place a ground lug under mounting nut adjacent to socket H.
( ) Connect a wire between pin 3 of power plug (PL-1) and lug P.
( ) Connect a wire between pin 4 of (PL-1) and ground lug P.
( ) Connect a wire from pin 2 of (PL-1) to phenolic tie-point F.
( ) Connect a wire from pin 1 of (PL-1) to pin 4 of tube socket (C).
( ) Connect a wire from pin 4 of socket (C) to pin 4 of socket (H) through shield hole M.
( ) Connect a wire from pin 5 of socket (C) to ground lug C.
( ) Connect a wire from pin 3 of socket (H) to ground lug J.
( ) Connect a wire from pin 8 of socket (C) to ground lug C.
( ) Install a 15K resistor (R8) between pin 8 and pin 9 of socket (C).
( ) Twist the leads of a .001 disc ceramic capacitor (C7) and a 1K resistor (R4) together, placing the components in parallel. Connect the combination between pin 7 and pin 5 (ground) of socket (C).
( ) Install a 220 ohm resistor (R1) between pin 7 socket (H) and ground lug J.
( ) Install a .001 disc ceramic capacitor (C4) between pin 2 of socket (H) and ground lug J.
( ) Connect a short, bare wire from pin 2 of socket (H), through the hole in the center stud to pin 7.
( ) Install a .001 disc ceramic capacitor (C5) between pin 6 of socket (H)

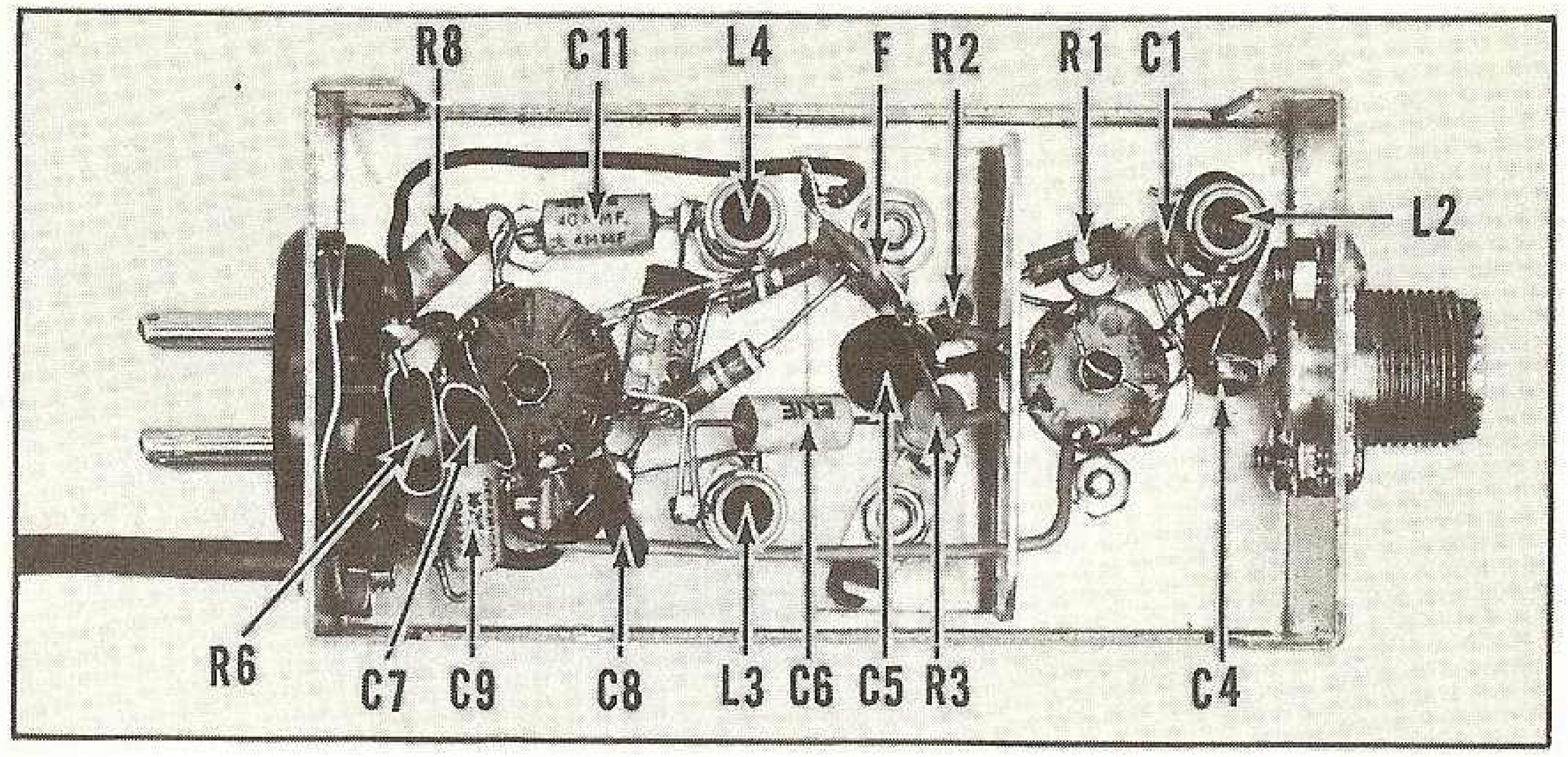


Fig. 6 Under-chassis view of converter, showing placement of major components.

and ground lug G. C5 is mounted above lug G, and the lead to pin 6 passes through the 3/8" shield hole. Place a piece of insulating sleeving over this lead so it will not short out against the shield plate.

( ) Install a .001 disc ceramic capacitor (C8) between pin 3 and pin 5 of socket (C).
( ) Install a .001 disc ceramic capacitor (C10) between the phenolic tie-point F and ground lug G.
( ) Check all the above connections and solder them.
( ) Install a 47K resistor (R5) between tie-point F and pin 3 of socket (C).
( ) Install a 10K resistor (R6) between pin 2 of (PL-1) and pin 6 of socket (C).
( ) Install a 47K resistor (R2) between tie-point F and pin 6 of socket (H). The lead of this resistor is covered with insulating sleeving and passes through hole N of the shield plate. The resistor mounts in a vertical position next to the tie-point.
( ) Install a 10K, 1-watt resistor (R3) between tie-point F and pin 5 of socket (H), in the same manner as described in the previous step.
( ) Install a 22K resistor (R7) between tie-point F and pin 1 of socket (C).
( ) Check all the above connections and solder them.
( ) Install a 50 mmf ceramic capacitor (C6) from pin 5 of socket (H) to the top lug of coil (L3). The lead from (C6) to pin 5 is insulated and passes through hole N in the shield.
( ) Connect a wire from the bottom lug of coil (L3) to ground lug C.
( ) Install a 40 mmf ceramic capacitor (C11) from the bottom lug of coil (L4) to pin 9 of socket (C).
( ) Connect capacitor (C3) (see coil table) from bottom lug of coil (L4) to ground lug C.
( ) Connect the top lug of coil (L4) to pin 1 of socket (C).

FREQUENCY	L_1	L_2	L_3	L_4	C_1	C_2 & C_3	SUGGESTED I-F RANGE (*TUNING RANGE OF RECEIVER*)	CONVERTER OSCILLATOR FREQUENCY
50-54 MC.	2 TURNS INSULATED WIRE	8 TURNS #20 E	8 TURNS #20 E	7 TURNS #20 E	NONE	50µµF	8-12 MC.	42 MC.
							3-7 MC.	47 MC.
27-30 MC. 10 METERS AND 12 METERS B-C	2 TURNS INSULATED WIRE	19 TURNS #24 E	17 TURNS #24 E	18 TURNS #28 E	NONE	100µµF	4-7 MC.	23 MC.
21-22 MC. 15 METERS AND 14 METERS B-C	2 TURNS INSULATED WIRE	20 TURNS #24 E	18 TURNS #24 E	17 TURNS #28 E	5µµF	100µµF	4-5 MC.	17 MC.
14-15 MC. 20 METERS AND 19 METERS B-C	3 TURNS INSULATED WIRE	25 TURNS #24 E	25 TURNS #28 E	18 TURNS #28 E	10µµF	100µµF	4-5 MC.	10 MC.

COILS WOUND ON CERAMIC FORM 3/8" DIA., SLUG-TUNED (*SEE PARTS LIST*)
C_1-C_3-*CENTRALAB NPO* CERAMIC CAPACITORS

( ) Connect capacitor (C2) (see coil table) between the top lug of (L4) and ground lug C.
( ) Check the above connections and solder them.
( ) Wind coil (L2) from coil table data, Figure 7. Wind a three turn link (L1) over the center of (L2). Twist the ends of the wire, and cement the winding so that it will not work loose. Nail polish will do the job.
( ) Mount coil (L2) in hole I, with coil lugs toward socket (H).
( ) Connect the bottom coil terminal of (L2) to ground lug J.
( ) Connect a wire between the top terminal of coil (L2) and pin 1 of socket (H).
( ) Connect one of the link coil leads to ground lug J, and the other lead to the center connection of receptacle (J1).
( ) Install capacitor (C1) (see coil table, Figure 7) between pin 1 of socket (H) and ground lug J.
( ) Cut a 14 inch length of coaxial cable. Strip the outer insulation off each end for two inches, and unbraid the shield at both ends. Pass one end of the cable through grommet A. Twist and ground the outer braid of the cable to lug P.
( ) Connect a 40 mmf ceramic capacitor (C9) between the inner conductor of the cable and pin 6 of socket (C).
( ) Check all connections, and solder remaining unsoldered connections.

Testing the Converter

When you are sure the wiring is correct, connect the wires of the coaxial cable to the receiver antenna terminals in place of the usual antenna. Connect the receiving antenna to the antenna receptacle (J1) of the converter. Tune the receiver to the center of the i-f range you have chosen. Apply power to the converter and note that both tubes light. By adjusting the slug of coil L4, it is possible to tune in signals if the converter is wired properly.

Pick a strong station, then turn the slugs of L2 and L3 for maximum volume. Next, adjust L4 until stations in the band that you are trying to receive are heard. As you tune L4, it will probably be necessary to readjust L2 and L3 to keep the volume up to maximum. Once the band has been located, peak L2 and L3. The band may now be tuned on the tuning dial of the station receiver, and no further adjustments of the converter controls are required.

Parts List for Converter

5—.001 mf., 600 volt disc capacitors (Centralab DD-102) (C4, C5, C7, C8, C10)
2—50 mmf. NPO ceramic capacitors (Centralab TCZ-50) (C6, C9)
1—40 mmf. NPO ceramic capacitor (Centralab TCZ-40) (C11)
1—220 ohm, ½-watt resistor (IRC type BTS, or BW-½) (R1)
2—47,000 ohm, ½-watt resistors (R2, R5)
1—10,000 ohm, ½-watt resistor (R6)
1—1,000 ohm, ½-watt resistor (R4)
1—22,000 ohm, ½-watt resistor (R7)
1—15,000 ohm, ½-watt resistor (R8)
1—10,000 ohm, 1-watt resistor (IRC type BTA, or BW-1) (R3)
1—Antenna receptacle (Amphenol SO-239) (J1)
1—4 pin male plug (Amphenol 86-RCP-4) (PL-2)
3—Coil forms, ceramic (CTC type LS-5) (L2, L3, L4)
1—Aluminum box, 4"x2"x2" (Bud CU-2102)
1—Tube, 6BH6 (RCA)
1—Tube 6U8 (RCA)
1—Socket, small 7-pin (Amphenol 147-913, with shield)
1—Socket, small 9 pin (Amphenol 59-407, with shield)
2—tie-point strips, single terminal (Cinch-Jones 51)
4—6-32 nuts and bolts
4—ground lugs, #6
8—4-40 nuts and bolts
1—14 inch length of coaxial cable (RG-58/U) or (RG-59/U)
10 feet of #18 flexible hookup wire (insulated)
Capacitors C1, C2, and C3 (see coil table)
1—piece thin brass or aluminum, 1⅞"x 1⅞" (shield plate)
1—grommet for ¼" hole

CONVERTING THE "COMMAND RECEIVER" FOR AC OPERATION

What's the most popular piece of war surplus equipment? The Command Set, of course. Once sold for a buck or two, these sensitive little receivers are still a bargain at five or six dollars. One of the best "first receivers" for the Novice, these little gems will run circles around sets costing ten or fifteen times as much. When the Novice graduates to a more exotic receiver, the Command set can still be used as an auxiliary receiver, or as a monitor. Here's the full story on just how to convert these receivers from 24 volt dc to 115 volt ac operation! Read on!

The Command Receivers are one band, six tube superhetrodyne sets, covering the following ranges: 190-550 kc (Model BC-453, R-23, or 46129) 1.5-3.0 mc (Model R-25, or 46104), 3.0-6.0 mc (Model BC-454, R-26, or 46105), 6.0-9.0 mc (Model BC-455, R-27, or 46106). The 3.0-6.0 mc version may be used for 80 meter Novice work, and the 6.0-9.0 mc version may be employed for 40 meter Novice work.

The following conversion instructions are applicable to any of the above receivers. The Navy receivers are identical to the Army (Model BC) version, with the exception that a 12SF7 tube is used as the second i-f tube, rather than a 12SK7. No matter; they both work the same. The fact that the receiver is painted black or is plain aluminum has no bearing on the performance, either.

The 80 meter or 40 meter command receivers may be used with the high frequency converter described previously, or they may be used directly "as-is." Buy a receiver that is "clean" and does not look as if it has been run over by an LST. Here's how you convert it to a good ham receiver! During the following steps it may be necessary to unscrew some of the components along the side of the receiver and lift them up to get at the connections beneath them. Do not remove any wires unless instructed to do so.

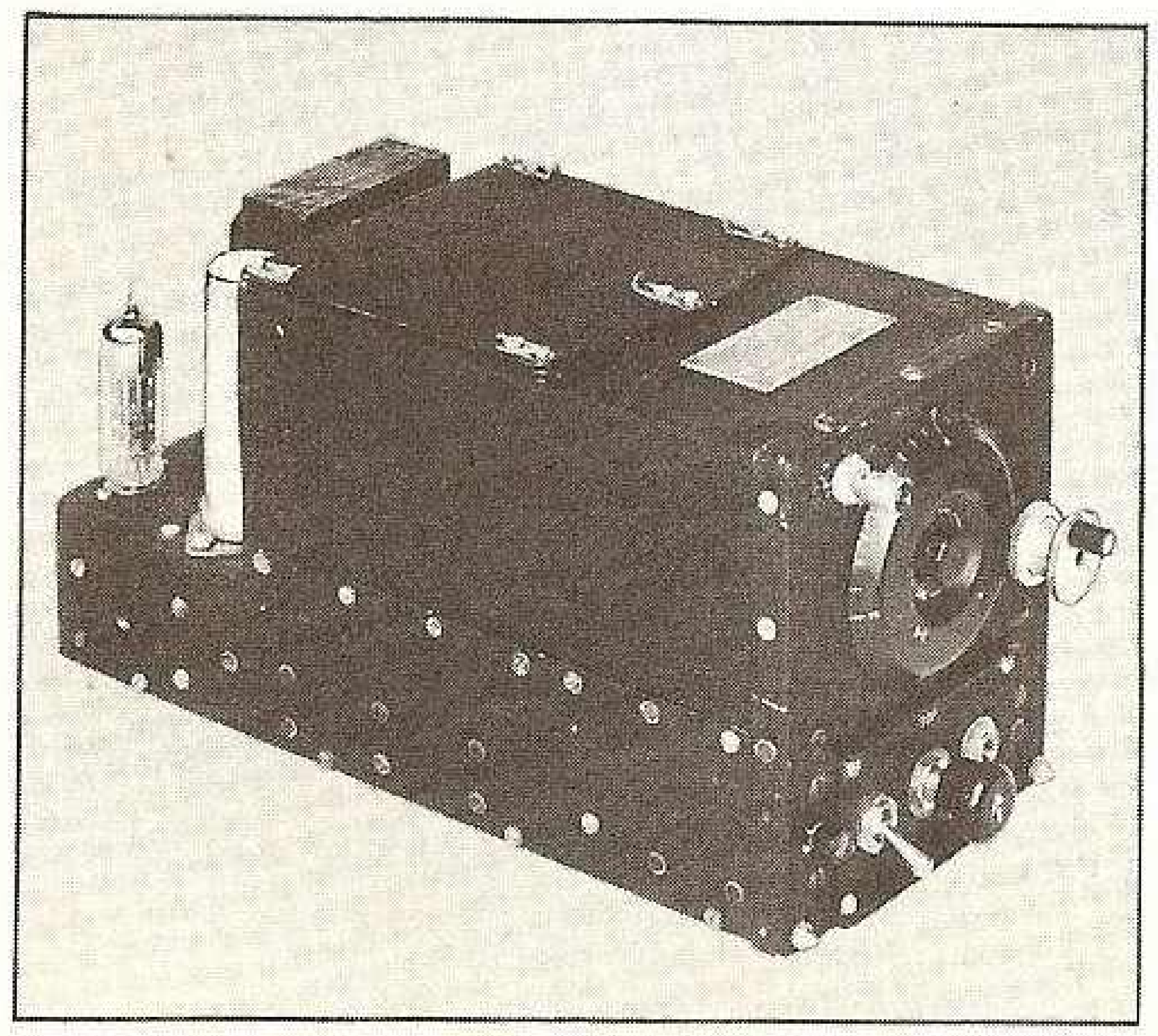


Fig. 8 When converted to a-c operation, the "Command" set makes an excellent receiver for the beginning amateur. Power supply is placed in dynamotor well of receiver, and control panel is added.

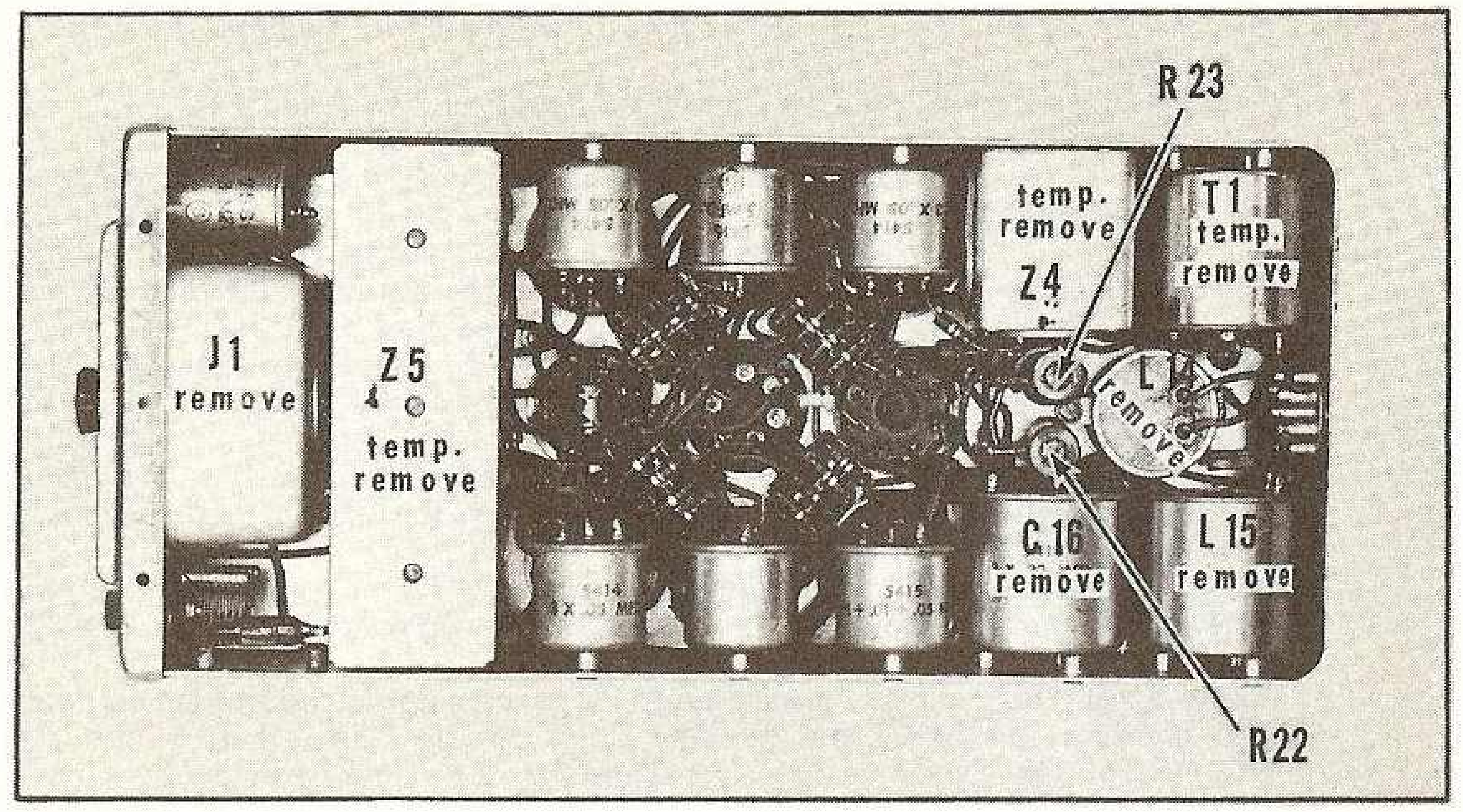


Fig. 9 Under-chassis view of unmodified "Command" set showing placement of the major components. Coil compartment Z-5 of r-f stages is at left of chassis.

( ) Remove the top and bottom covers (and dynamotor, if any) and save the screws.
( ) Temporarily remove the r-f coil assembly Z-5 (Figure 9) by removing the two side screws and pulling up on the coil box. Save the screws.
( ) Remove the front adapter assembly P-1 with the pull knob. Save the screws.
( ) Remove the front adapter assembly can J-1. Clip out the red lead connected between pin 8 (center) and the rear resistor terminal board. Discard the lead. Unsolder the rest of the wires from J-1.
( ) Clip the leads at the terminals of C-16 and discard it. Clip the white and red leads going to C-16 at their source and discard them.
( ) Clip the leads at the terminals of L-15. Remove and save it. Remove the red lead from L-15 to the 7 pin receptacle on the rear of the receiver.
( ) Clip the leads at the terminals of L-14. Discard it. Clip the white lead from L-14 to the 7 pin receptacle at the rear of the receiver.
( ) Using a screw removed in the previous step, reground the solder lug (black wire) at the screw hole of L-14 nearest the front of the chassis.
( ) Clip the wires at the terminals of dynamotor plug J-2 directly below L-14. Break out the pins of the plug and remove the plug and the aluminum mounting ring. Remove the black (ground) wire from J-2 and the red wire to mica capacitor C-31.
( ) Remove the 750 mmf capacitor C-35 and the black wire to socket J-3 on rear of chassis. (This capacitor is omitted in some receivers.)
( ) Remove the rubber dynamotor mounts. In some models these unscrew; in others, the nut must be filed off the chassis.
( ) Remove the white wire from pin 7 of socket V-4 (12K8). (The other end of this wire goes to pin 7 of socket V-5 (12SK7). Free the loose (V-4) end of this wire, and reroute it from V-5 to pin 2 of socket V-4. Solder the wire to this pin.
( ) Ground pin 7 of socket V-4 to adjacent ground lug of resistor mounting board.
( ) Locate the white wire that went to the front adapter assembly can J-1 from pin 7 of socket V-5. Pull the wire back, and reroute it to the rear of the chassis along the side wall.
( ) Remove the white wire from pin 2 of socket V-5. Ground pin 2 of V-5 to adjacent ground lug of resistor mounting board.
( ) Solder the white wire removed from socket V-5 to pin 7 of socket V-5.
( ) Remove the white wire from pin 7 of socket V-8 (12A6) and ground pin 7 to adjacent ground lug of resistor mounting board.

( ) Disconnect the other end of this white wire from pin 7 of socket V-7 (12SR7) and discard the wire.
( ) Connect a wire from pin 7 of socket V-7 to pin 2 of socket V-8.
( ) This completes the wiring of the filament circuit. All filaments are now connected in parallel. Check all joints. The following steps cover installation of the new a-c power supply.
( ) Under components Z-4 and C-16 are two mica capacitors referred to as C-29 (on the left) and C-31 (on the right, when viewed from the rear of the chassis). Temporarily lift out component T-1 so that C-31 is visible.
( ) Connect the red wire from C-31 to the bottom terminal (nearest the chassis) of resistor R-22. On the bottom terminal of R-22 is a loose red wire. Do not clip it, as it is used later.
( ) Attached to power receptacle J-3 is a green wire that runs to a resistor mounting board at the front of the receiver. Clip the wire at both ends and remove.
( ) There is a free, yellow lead coming from pin 6 of socket V-6. Splice this wire to the short, yellow wire from the junction of resistors R-22 and R-23. Tape the splice.
( ) Remove the three metal spacers atop the dynamotor compartment as they will obstruct the power transformer. They can be drilled out. Mount the *Stancor PC-8401* power transformer atop the chassis (Figure 8) over components Z-4 and T-1. It should be mounted as close to the rear of the chassis as possible so that the tube compartment cover may be replaced. Note that it is necessary to mount the transformer with three screws, because resistors R-22 and R-23 will be in the way of the fourth screw. Pass the transformer leads through the rear left hole vacated by the dynamotor mount. The hole may be enlarged with a file to prevent the leads from rubbing the chassis.
( ) In the rear of the two remaining dynamotor mount holes install a 7 pin miniature socket for the 6X4 rectifier tube.
( ) In the front dynamotor mount hole, mount the 450 volt electrolytic capacitor. It will be necessary to enlarge this hole to 1⅛" to fit the capacitor mounting plate.
( ) On the rear chassis apron below the 6X4 socket, drill a ⅜" hole and install a rubber grommet for the 115-volt line cord.
( ) Above the grommet on the inside of the chassis, mount a phenolic tie-point strip having three *ungrounded* terminals.
( ) Take the front adapter plug P-1 previously removed. Take off the aluminum cover by removing the two screws that secure the adapter socket. Drill off the pull knob and the two metal posts. This plate will be used to mount the auxiliary controls on the front panel.
( ) Looking at the front of the plate, drill out the left center hole to ½" diameter.
( ) Drill the middle hole and the right center hole to ⅜" diameter. Mount the adapter plate to the front of the receiver with 4-40 bolts and nuts.
( ) Install a SPST toggle switch (BFO switch) in the ½" hole.
( ) Install a 25K potentiometer (gain control) with auxiliary switch in the center hole.
( ) Install an open circuit earphone jack in the remaining hole.
( ) Ground connections made in the following steps are made to the ground terminal of the earphone jack. If you are not sure which terminal is grounded, use an ohmmeter and check the resistance of each terminal to ground. The grounded terminal will measure zero ohms.
( ) Connect the green lead from capacitor C-5 to the center arm of the gain control potentiometer.
( ) Connect the green lead from the front resistor mounting board to the center arm of the potentiometer. Reroute lead to reach.
( ) Connect the black lead from transformer T-1 to the ungrounded terminal of the earphone jack.
( ) Connect the red lead from the rear of the receiver to one terminal of the toggle switch. Reroute to reach.
( ) Connect the other terminal of the toggle switch to the ground lug on the earphone jack.
( ) Cut off and tape the green-yellow wire of the power transformer.
( ) Ground the red-yellow wire of the power transformer to the chassis of the receiver at the bottom end of resistor R-23.

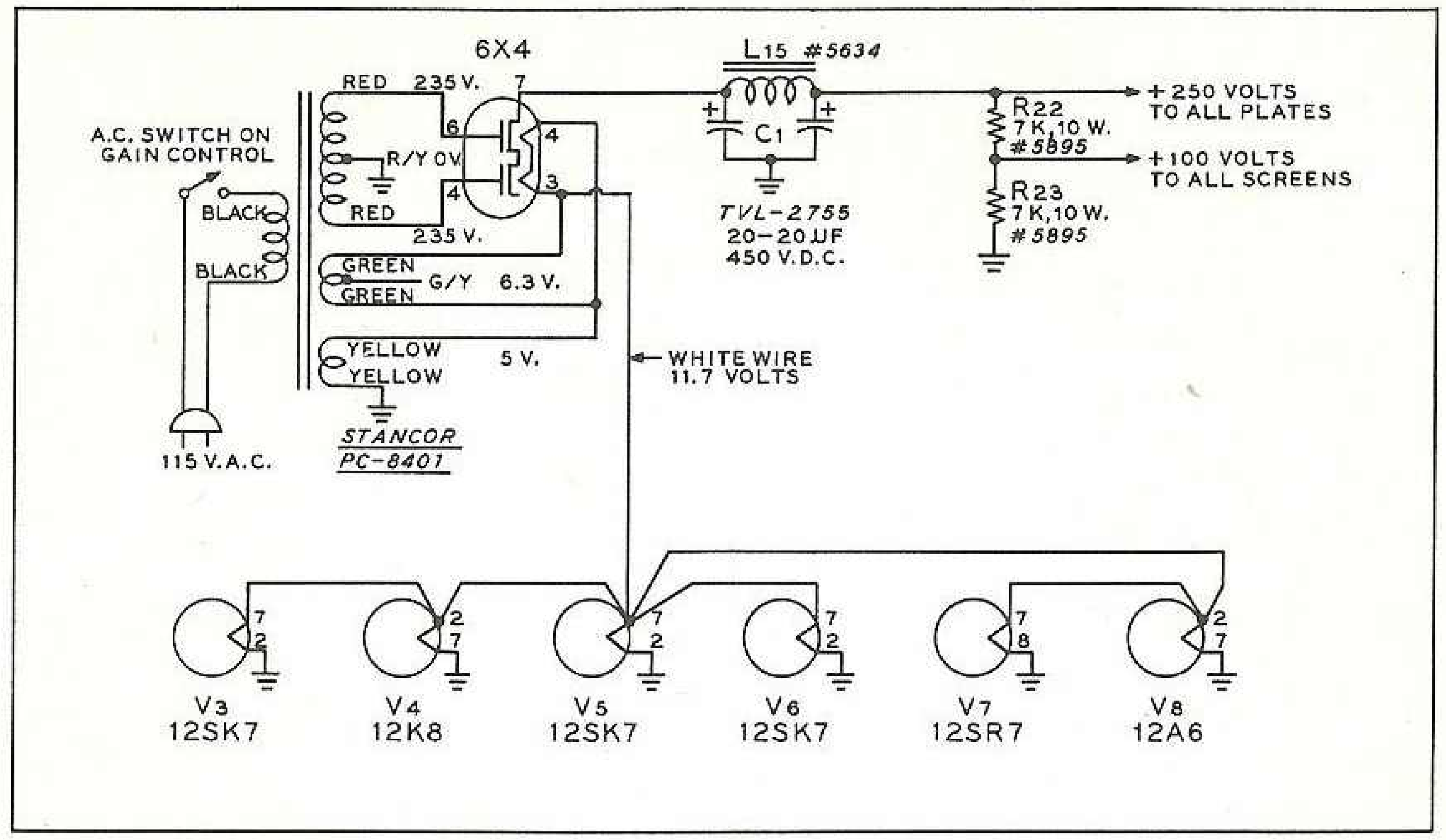


Fig. 10 Filaments of "Command" receiver are rewired in parallel to operate from seriesed 5 volt and 6.3 volt filament windings of the power transformer.

( ) Connect one of the two red leads of the power transformer to pin 1, and the other red lead to pin 6 of the 6X4 socket.
( ) Connect a yellow wire of transformer T-1 to the bottom terminal (ground) of resistor R-23.
( ) Connect the other yellow lead of T-1 to pin 4 of the 6X4 socket.
( ) Temporarily solder one of the green leads of the transformer to pin 3 of the 6X4 socket. Don't "wrap" the connection, as it may be necessary to reverse the polarity of the 6.3 volt winding later.
( ) Temporarily connect the other green transformer lead to pin 4 of the 6X4 socket.
( ) Connect the long, white wire of pin 7, socket V-5 to pin 3 of the 6X4 socket.
( ) Connect a wire from pin 7 of the 6X4 socket to one B-plus (center) terminal of the filter capacitor (C1, Figure 10). If the capacitor is mounted with a phenolic wafer, one of the shell terminals should be grounded to the receiver chassis. Trim the lugs of C1 so they do not touch L-15 when it is reinstalled.
( ) Connect two 3" wires to the two terminals of L-15.
( ) Connect the red lead from the bottom terminal of R-22 (next to the chassis) to the unwired center terminal of filter capacitor C1.
( ) Connect the red lead from capacitor C-31 to the bottom terminal of R-22.
( ) Connect the two 3" leads on L-15 to each of the center terminals of capacitor C1.
( ) Mount component L-15 in the position formerly occupied by component C-16. Check to see that the terminals of C1 do not touch the case of L-15.
( ) Connect a .01 ceramic capacitor between pin 6 and pin 1 of socket V-5 (12SK7).
( ) Locate the loose, white wire running from the front of the chassis to the rear. Connect the rear end to one of the lugs on the three terminal phenolic tie-point strip. This wire will serve as one 115-volt lead.
( ) Connect a long lead from one of the other tie-points of this strip and route it to the front of the chassis. This will serve as the other 115-volt lead.
( ) Connect the white wire to one of the switch lugs on the back of the volume control.
( ) Connect the long lead to the other switch lug on the back of the volume control.
( ) Connect one of the black power transformer leads to the tie-point terminal holding the white wire.
( ) Connect the other black power transformer lead to the remaining blank terminal of the tie-point strip.
( ) Pass a line cord through the ⅜" rubber grommet on the back of the receiver

chassis. Connect one lead to the tie-point terminal holding *only* the black transformer lead.

( ) Connect the other line cord lead to the tie-point terminal holding the new lead installed six steps before. Solder all connections. Check all wiring for shorts, opens, transpositions and accidental grounds. Remove all excess solder from beneath the chassis.

( ) Remount all components that were temporarily lifted during the conversion process. Remount coil compartment Z-5.

( ) Before "firing up" the receiver make this safety check. With an ohmmeter, check the resistance across the line plug with the potentiometer switch turned on. A reading of about 15 ohms should be obtained. Each pin should also measure infinity to the chassis. Measure the resistance to ground (chassis) from pin 7 of the 6X4 socket. It should be about 14,000 ohms after capacitor C1 is charged by the battery of the ohmmeter. If it reads lower, look for a possible short. If it reads much higher than 14,000 ohms, resistor R-22 or R-23 may be open.

( ) Connect an a-c voltmeter from pin 7 of V-5 (12SK7) to ground. Turn on the receiver. The filament voltage should measure about 11.7 volts. If it does not, turn off the receiver and reverse the green transformer leads temporarily connected to pins 3 and 4 of the 6X4 socket. When the correct voltage is obtained, solder the wires in place.

( ) Plug an earphone set in the front panel jack, connect an antenna, and turn up the volume control. Turn the dial until a station is heard. If the station has a "squeal" on it, flip the BFO toggle switch on the panel. This switch is used for copying c-w signals. A small screwdriver adjustment at the right rear of the receiver on Z-4 adjusts the pitch of the BFO.

( ) Remove the little caps atop the i-f transformers. Adjust the little slotted screws for maximum received signal strength. Replace the top and bottom covers of the receiver.

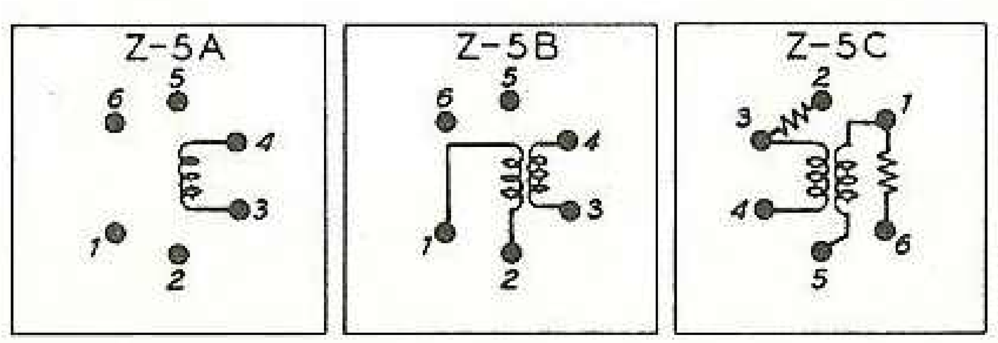
( ) If you have an amateur friend who owns an r-f signal generator, ask him to check the dial calibration for you.

( ) If you cannot purchase a tuning knob for the receiver, one can be made with a standard knob and a short length of automotive windshield wiper hose. Slip the hose over the splined tuning shaft and cement in position with nail polish. Push the knob over the section of hose and tighten in place.

COIL TABLE FOR 21 MC. CONVERSION OF COMMAND RECEIVER

ANTENNA COIL Z-5A	R-F COIL Z-5B	OSCILLATOR COIL Z-5C
8 TURNS #18 E, SPACE-WOUND TO FILL COIL. CONNECT TO PINS 4, 3. (*SEE MATCHING PINS IN COIL RECEPTACLE*)	COIL BETWEEN 3-4: REDUCE TO 8 TURNS	COIL BETWEEN 1-5: UNCHANGED
	COIL BETWEEN 1-2: 13 TURNS #18 DCC INTERWOUND WITH 8 TURN COIL.	COIL BETWEEN 3-4: 7 TURNS #18 DCC CLOSEWOUND, 1/8" FROM OTHER COIL.

BOTTOM VIEW OF COIL ASSEMBLY



OSCILLATOR TUNING RANGE FOR 21,000 – 21,450 KC.
1.5 – 3.0 MC. RECEIVER (I-F = 705 KC.) = 21,705 – 22,155 KC.
3.0 – 6.0 MC. RECEIVER (I-F = 1415 KC.) = 22,415 – 22,865 KC.

Fig. 11 "Command" receiver may be easily converted for 21 mc Novice operation by rewinding r-f and oscillator coils, as shown above. R-f and i-f tubes of the receiver are replaced with high-transconductance 12SG7 tubes for greater overall gain at the higher frequencies. Coaxial antenna input may be used.

CONVERTING THE "COMMAND RECEIVER" FOR 15 METERS

Anxious to get going on the 15 meter Novice band? Here's a red-hot receiver that you can buy for under ten bucks. For about seven dollars more you can convert it into an excellent receiver for 21 megacycles. It'll cost less if you have some of the parts in your junk box. You will be pleasantly surprised with results! You can't beat this performance at such low cost!

The 1.5-3.0 mc surplus command receiver makes a fine high frequency receiver when the following conversion is made. Either the R-25 Navy set, or the 46104 set may be used. The information will also apply to the 3.0-6.0 mc model which will work equally well, but with poorer selectivity. If a choice can be made, the lower frequency receiver of the two should be used.

The receiver should first be modified for 115-volt operation as described previously. When the receiver has been converted properly, the following steps may be taken to raise the receiver gain and to alter the tuning range.

( ) The 12SK7 i-f and r-f amplifier tubes should be replaced with 12SG7 tubes. Socket connections are the same for both tube types.

( ) A 620 ohm, ½-watt resistor should be connected from pin 3 to pin 1 of the r-f tube socket (V-3).

( ) A .001 disc ceramic capacitor should be connected between pin 3 and 2 of socket V-3.

( ) A .001 disc ceramic capacitor should be connected between pin 6 and 1 of socket V-3.

( ) A 10,000 ohm, 10 watt wire wound resistor is shunted across resistor R-22 to increase the screen voltage to about 140 volts.

( ) Remove the shield over the main tuning capacitor, C-4.

( ) Remove all but one of the rotor plates in each section of tuning capacitor C-4. Leave the slotted plate, as it can be used for alignment purposes. The extra plates may be removed by gently flexing them with a pair of long-nose pliers.

( ) Remove the r-f coil assembly Z-5. The assembly is polarized by the arrangement of the pins on the coil receptacles.

Parts List for "Command" Receiver Conversion

1—Transformer, power. 470 volts, c.t. at 50 ma (Stancor PC-8401) (T1)
1—20/20 ufd, 450 volt dual electrolytic capacitor (Sprague TVL-2755) (C1)
1—25K potentiometer, linear taper (IRC Q11-123, with type 76-1 switch)
1—Switch, SPST toggle (H&H 20994-BF)
1—Jack, earphone (Mallory A-1)
1—Tube, 6X4 (RCA)
1—Socket, 7 pin miniature (Amphenol 147-913)
1—.01 disc ceramic capacitor (Centralab DD-103)
1—Tie-point strip, three terminal (Cinch-Jones 53B)
1—Rubber grommet, ⅜" diam. (Walsco 7034F)
1—Knob, ¾" diam. (G.C. 1159)
1—Line cord and plug (Birnbach 348)

Parts List for 21 mc Conversion of "Command" Receiver

1—620 ohm, ½-watt resistor (IRC type BTS or BW-½)
1—10K, 10-watt resistor (Ohmite "Brown Devil")
2—.001 disc ceramic capacitor (Centralab DD-102)
3—Tube, 12SG7 (RCA)

( ) Remove the individual coils from the assembly, and remove the powdered iron slugs from the coils. Save the slugs.
( ) Modify the coils according to the information shown in Figure 11. The r-f coil is directly in front of socket V-3, the mixer coil is in the center, and the oscillator coil is in front of the i-f transformer. Replace the cores in the coils. Position is not critical.
( ) Replace the coils in their shield cans and resolder all leads.
( ) Place coil assembly Z-5 back in the receiver. Turn on the receiver.
( ) Hunt for the local oscillator of the command set with a nearby receiver. It should fall in the tuning range indicated in Figure 11. Adjust trimming capacitor C-9 mounted atop the main tuning capacitor C-4 to provide the correct oscillator tuning range as the main tuning dial of the receiver is tuned.
( ) Align the r-f trimming capacitors atop the main tuning capacitor C-4 for maximum signal strength of the high frequency signals. Slight adjustment of the segments of the slotted plates of the r-f stages will permit close tracking over the tuning range.
( ) If a coaxial line is to be used for the receiver, the ceramic antenna connector and its lead should be removed, and an *Amphenol 83-1R* (SO-239) coaxial receptacle substituted in its place. The following two steps must be made to the coil assembly if a coaxial antenna feed system is to be used.
( ) A two turn antenna coil should be wound over the center of the r-f coil of assembly Z-5. The ends of the winding may be attached to two of the empty pins of the coil receptacle.
( ) Before Z-5 is replaced, one of the matching antenna coil plugs on the receiver chassis should be grounded, and the other connected to the center terminal of the coaxial antenna receptacle with a short length of wire.
( ) The original dial calibrations may be blacked out with stove enamel, and new calibration marks made on a strip of heavy white paper pasted over the dial.

THE "SIMPLEX 2-6" — A CONVERTER FOR 2 AND 6 METERS

Here is the ultimate in simplicity for 2 and 6 meter reception. One tube, a few parts, and an evening's work results in a first class VHF converter that will provide many hours of enjoyable listening on these exciting amateur bands. The "Simplex 2-6" is an ideal converter for the newcomer to the VHF bands, and will provide excellent reception when used with your station receiver. Total cost of parts for converter is less than $10.00.

A great majority of VHF-minded amateurs have started their careers with a one tube tuneable converter, such as the Simplex 2-6. Using a 6J6 VHF twin triode, this simple circuit is capable of good performance in the 50 mc and 144 mc regions. For highest efficiency and greatest ease of construction separate coils are used for the two bands. It takes but a moment to unsolder one set of coils and substitute another.

The complete schematic of the S2-6 is shown in Figure 13. One section of the 6J6 is the VHF mixer, and the second section is the conversion oscillator. The output i-f range of the converter is determined by the tuning range of the high frequency oscillator. Normally a 4 mc i-f range in the vicinity of 15 mc is used for both 2 and 6 meter operation. However, if the performance of your station receiver is "not so hot" at this high frequency range, the i-f output of the converter may be set as low as 7 mc. The output circuit of the S2-6 is untuned, so changing the intermediate

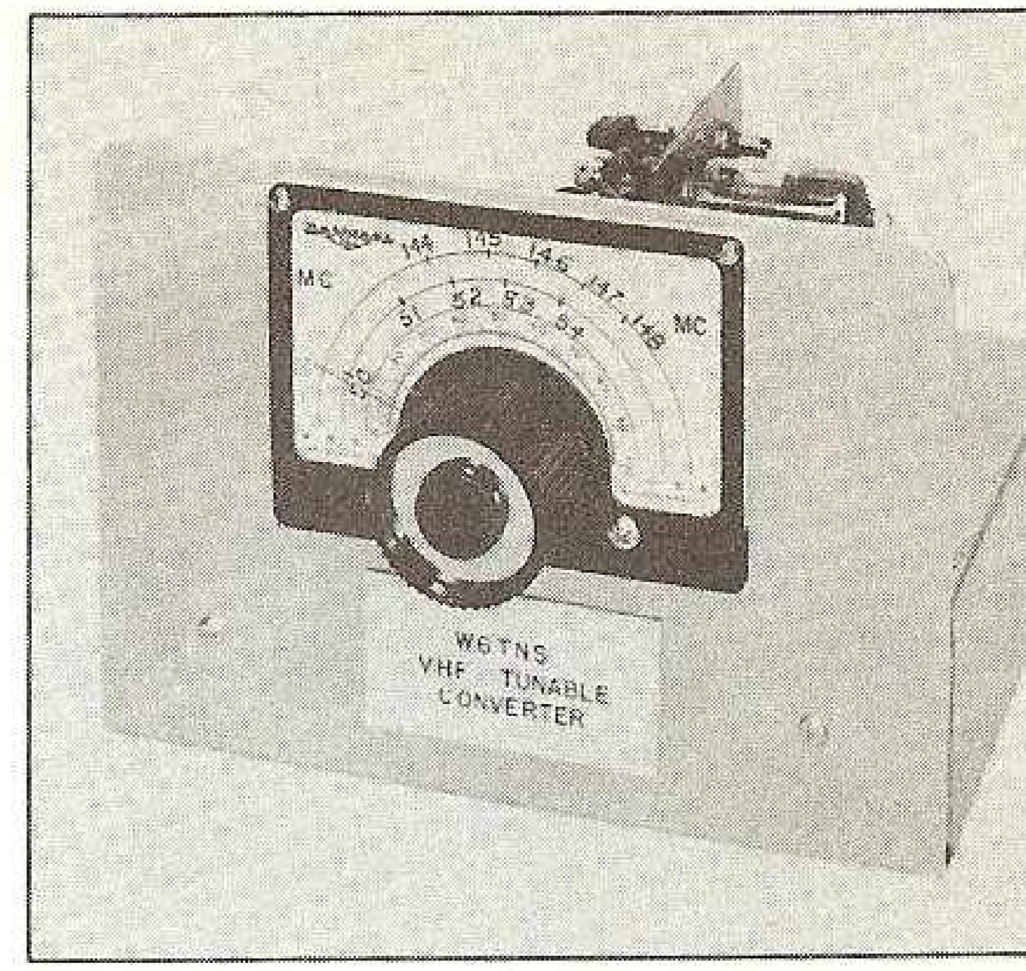


Fig. 12 This one tube converter for 50 mc and 144 mc is ideal for the Novice or Technician amateur. Only one tuning control is used, and it may be directly calibrated for both bands. The "Simplex 2-6" is easy to build and inexpensive.

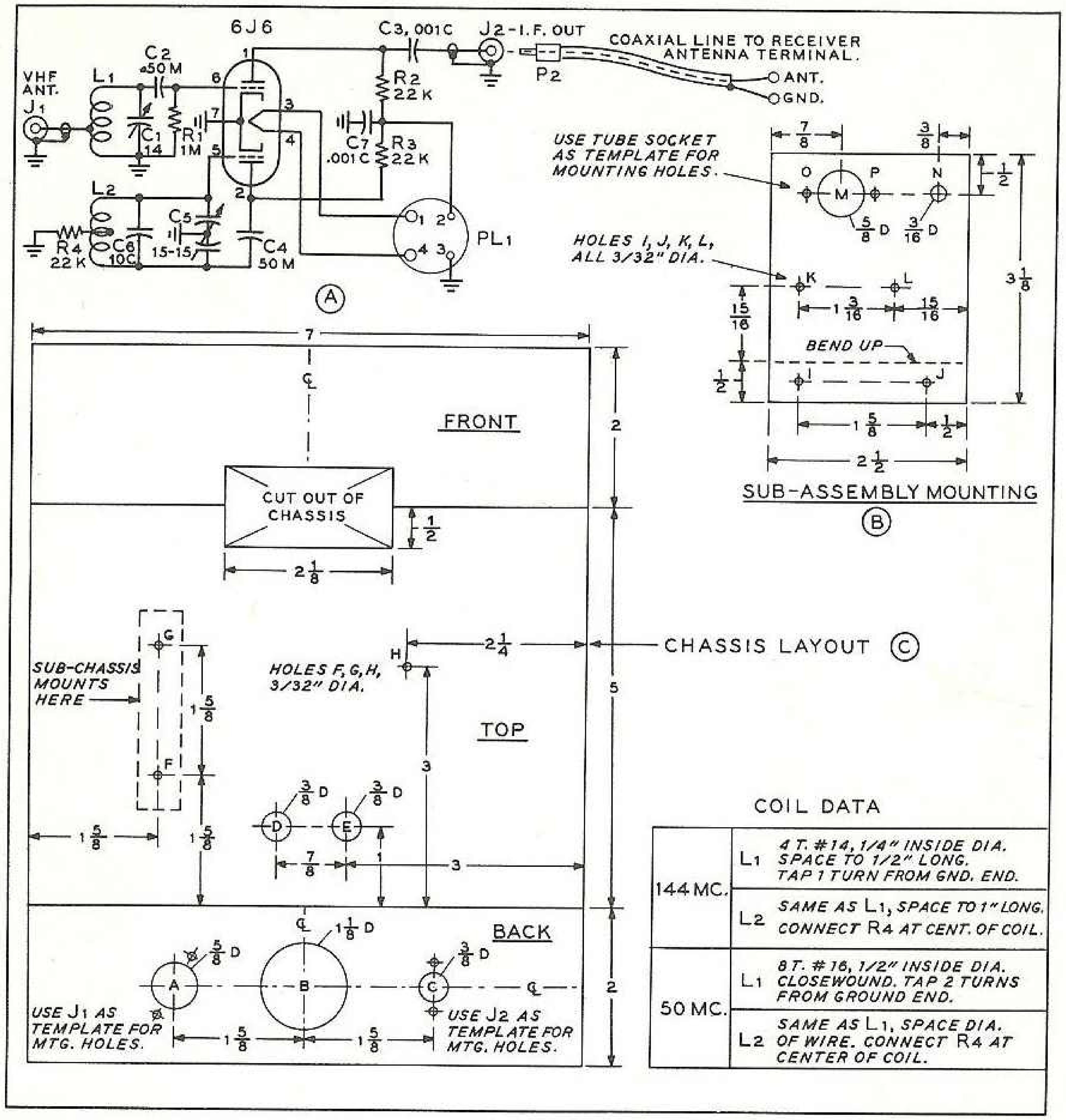
frequency is merely a matter of retuning the station receiver to the new range, and shifting the frequency of the oscillator stage of the converter. Power for the converter may be obtained from the simple supply shown in chapter 8, or it may be "stolen" from the station receiver, as explained earlier in this chapter.

Converter Construction

The "innards" of the converter are mounted upon a 2½"x2⅝" aluminum plate which is mounted atop a 5"x7"x2" aluminum chassis as shown in Figure 14. A 5"x7" aluminum panel completes the assembly. The shortest possible leads between the components are permitted by this configuration. The 6J6 tube is mounted horizontally from the small chassis-plate. Converter tuning is accomplished by a split-stator variable capacitor (C5) mounted to the chassis plate. The r-f tuning capacitor (C1) is mounted to the plate just behind the 6J6 socket. This capacitor need only be peaked for best reception at one spot in the band, and is not touched thereafter. No components are mounted beneath the main chassis, except the three receptacles which are mounted on the rear lip of the chassis.

The following wiring and assembly instructions are presented in a step-by-step sequence to enable the constructor to complete the project easily and correctly. Be sure to read each step all the way through before you start to do it. When the step is completed, check it off in the space provided.

( ) Cut the chassis-plate (B) and the panel out of an aluminum sheet. Lay out the holes on B with a pencil. Drill the holes and remove the burrs.
( ) Mount the main tuning dial to the panel, using the template supplied with the dial. The shaft hole should be centered horizontally, and the bottom of the faceplate should be 2" from the bottom of the panel.
( ) Drill the chassis (C), and cut a rectangle at the front to clear the dial mechanism. Mount the chassis, panel, and chassis-plate together using 6-32 screws, nuts, and lockwashers.
( ) Mount antenna receptacle J1 in hole A of the chassis, using 4-40 hardware. Place a ground lug under one retaining nut.
( ) Mount power plug PL-1 in hole B, using the mounting ring supplied.
( ) Mount i-f output receptacle J2 in hole C, using 4-40 hardware.
( ) Install ⅜" rubber grommets in holes D and E.
( ) Mount tuning capacitor C5 in holes K and L of the chassis-plate, using 6-32 hardware, with lockwashers between the capacitor brackets and the chassis plate. Place a ground lug beneath the rear capacitor bracket. The shaft of



144 MC.	L1	4 T. #14, 1/4" INSIDE DIA. SPACE TO 1/2" LONG. TAP 1 TURN FROM GND. END.
	L2	SAME AS L1, SPACE TO 1" LONG. CONNECT R4 AT CENT. OF COIL.
50 MC.	L1	8 T. #16, 1/2" INSIDE DIA. CLOSEWOUND. TAP 2 TURNS FROM GROUND END.
	L2	SAME AS L1, SPACE DIA. OF WIRE. CONNECT R4 AT CENTER OF COIL.

Fig. 13 Schematic diagram, parts layout, and coil table for VHF converter.

C5 passes into the dial mechanism mounted on the front panel. After setting the dial pointer to "100," mesh the capacitor plates and tighten the set-screw in the dial collar.

( ) Mount the 7 pin miniature socket in hole M of the chassis-plate, using 4-40 hardware. The blank pin faces the front of the chassis.

( ) Mount a two terminal phenolic tie-point strip (Q) in a vertical plane, using the retaining nut and bolt nearest the panel of the tube socket (hole O).

( ) Mount a grounding lug on the top of the chassis at hole H.

( ) Install r-f tuning capacitor C1 in hole N of the chassis-plate, using the collar nut. Position the capacitor as shown in Figure 17.

( ) Connect a wire from pin 1 of power receptacle PL-1, through grommet E to pin 3 of the 6J6 tube socket.

( ) Connect a wire to pin 4 of PL-1, pass it through grommet E twisting it about the lead just installed. Connect to pin 4 of the tube socket.

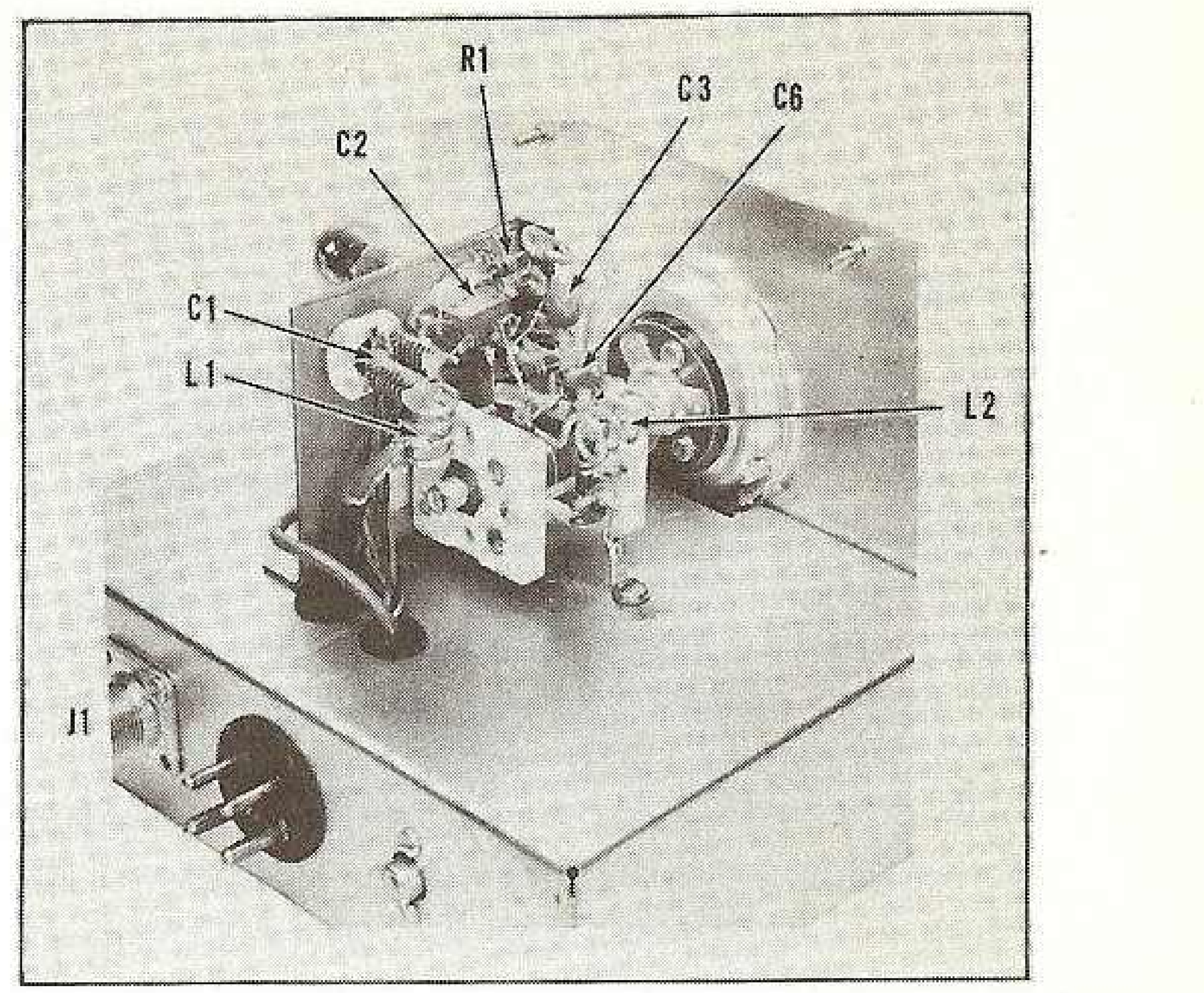
( ) Connect a wire to pin 3 of PL-1, through grommet E, past the tube socket to the center lug (ground) of tie-point strip Q.

( ) Connect a wire from pin 2 of PL-1, through grommet E, to the *lower lug* of strip Q.

( ) Bend pin 7 of the tube socket down and solder it to the socket retaining ring.

( ) Install a .001 disc ceramic capacitor (C7) between the center lug (ground) and the lower lug (B-plus) of strip Q.

Fig. 14 Placement of the major components are seen in this rear view. Most parts are mounted upon the sub-assembly plate (B) shown in Figure 13. Power plug and output receptacle (J2) are to the right of antenna receptacle J1. Front of chassis has small cut-out to clear dial mechanism.



( ) Install a 22K resistor (R2) between the lower lug of strip Q and pin 1 of the tube socket.

( ) Install a 22K resistor (R3) between the lower lug of strip Q and pin 2 of the tube socket.

( ) Install a .001 disc ceramic capacitor (C3) between pin 1 of the tube socket and the *upper lug* (i-f output) of strip Q.

( ) Install a 1 megohm resistor (R1) between pin 6 of the tube socket and the center lug (ground) of strip Q.

( ) Connect a short, bare wire between pin 5 of the tube socket and the *rear stator* terminal of tuning capacitor C5.

( ) Connect a 50 mmf silver mica capacitor (C4) between pin 2 of the tube socket and the *front stator* terminal of C2.

( ) Wind coil L2 (Figure 13) and install it between the front and rear stator terminal lugs of C5.

( ) Install a 22K resistor (R4) from the mid-point (center-tap) of coil L2 to ground lug H directly below the coil.

( ) Using a piece of #14 wire, connect the *rotor* terminal of C5 to ground lug H.

( ) Install a 50 mmf silver mica capacitor (C2) between pin 6 of the tube socket and the *stator* (ungrounded) terminal of r-f tuning capacitor C1.

( ) Wind coil L1 (Figure 13) and install it between the *stator* terminal of C1 and the ground lug mounted beneath the rear foot of tuning capacitor C5. If the coil does not reach, move the soldering lug slightly, but do not stretch or compress the coil.

( ) Install a 10 mmf tubular ceramic capacitor (C6) between the front and rear *stator* terminals of tuning capacitor C5.

( ) Prepare a 5" length of coaxial line by unbraiding 1" of shield at each end. Twist the braid. Cut off ¼" of inner insulation. leaving the center conductor exposed at each end.

( ) Connect the center conductor of the line at one end to the center pin of antenna receptacle J1.

( ) Connect the shield braid at the same end to the grounding lug under a retaining nut of J1.

( ) Route the coaxial line up through grommet D. Connect the center conductor to the tap point on L1 (see coil table). Connect the shield braid to the soldering lug under the rear mounting foot of C5.

( ) Prepare a 10" length of coaxial line in the same manner. Connect the center conductor to the center pin of i-f receptacle J2, and the shield braid to the ground lug of J2.

( ) Route the coaxial line up through grommet E, around the tube side of the chassis-plate and up to tie-point strip Q.

( ) Connect the center conductor of the coaxial line to the *upper* lug of strip Q.

( ) Connect the shield braid to the center (ground) lug of strip Q.
( ) This completes the wiring of the converter. Check all connections for rosin joints, shorts, transpositions, and accidental grounds.

Testing the Converter

With an ohmmeter, measure the resistance between pin 1 and pin 2 of the tube socket. It should be 44K. The resistance of pin 2 of the tube socket to pin 2 of PL-1 should measure 22K. Resistance of pin 2 of the tube socket to ground should be infinity. Check all wiring against Figure 13 before power is applied to the converter.

Attach the converter to a power supply, plug in the 6J6 tube, and connect the converter to the station receiver. If the receiver is an ac-dc set, connect the outer shield of the i-f cable to the "ground" of the set through a .01 ceramic capacitor to reduce shock hazard. Tune the receiver to 15 mc, and attach a VHF antenna to the input receptacle (J1) of the converter. Set C1 and C5 to mid-capacity and turn on the converter. The 6J6 should light. If a d.c. milliammeter is placed in the B-plus line (pin 2, PL-2) to the converter the indicated current should be about 6 to 8 ma. Touching pin 5 of the 6J6 with a screwdriver should cause the current to jump abruptly. If the current drain is appreciably higher than this figure, it means the oscillator section of the 6J6 is not working. Check the circuit wiring, and try another tube.

Tuning the converter should produce VHF signals. The exact calibration of the main dial may be varied by changing the spacing of turns of L2, and also by varying the station receiver above and below the i-f spot of 15 mc. Tune C1 for maximum received signal.

If a balanced 300 ohm line is to be used with the converter, receptacle J1 should be replaced with a two terminal antenna strip *(National FWH)*. The input coaxial line is discarded, and a short length of 300 ohm ribbon is run from the antenna terminals to a two turn link coil placed between the bottom turns of L1. Coupling between the link and L1 is adjusted for best signal response.

It is a simple matter to unsolder one set of coils and replace them with a different set. The dial of the converter may be calibrated for each set, as shown in the front view photograph.

Parts List for the Simplex 2-6

1—14 mmf midget variable capacitor (Johnson 15M11) (C1)
2—50 mmf silver mica capacitor (Cornell-Dubilier 22R5Q5) (C2, C4)
2—.001 disc ceramic capacitor (Centralab DD-102) (C3, C7)
1—Dual 15 mmf variable capacitor (Bud LC-1660) (C5)
1—10 mmf ceramic capacitor (Centralab NPO-TCZ) (C6)
1—1 megohm, ½-watt resistor (IRC type BTS) (R1)
3—22K, ½-watt resistors (R2, R3. R4)
1—Coaxial receptacle (Amphenol 83-1R) (J1)
1—"Phono" receptacle and plug (Cinch-Jones 81A and 81C) (J2)
1—Plug, male, 4 pin (Amphenol 86-RCP4) (PL-1)
1—7 pin socket, miniature mica-filled (Cinch-Jones 7EM)
1—Dial (National MCN)
1—Tube, 6J6 (RCA)
1—Chassis, 5"x7"x2" (Bud AC-402)
1—two lug phenolic terminal strip (Cinch-Jones 52A)
2—⅜" rubber grommets (Walsco 7034F)
Two feet of coaxial line (RG-59/U or equal), 6-32 and 4-40 hardware, #16 and #14 tinned wire. Scrap aluminum for sub-chassis and front panel.

A RED-HOT CRYSTAL CONVERTER FOR 2 AND 6 METERS

This small, stable crystal controlled converter has the ears of an Iroquois scouting party! It digs down into the external noise level and really scratches for signals. Suitable for the serious VHF operator, this 2N6 converter is highly recommended for the Novice or Technician amateur who desires nothing but the best. Complete cost of parts and tubes is less than $20.00.

The 2N6 converter is designed for maximum stability and highest sensitivity in the 50 mc and 144 mc amateur bands. Three tubes are used, as shown in the schematic of Figure 16. A dual triode 6BQ7A is employed as a Cascode r-f amplifier, inductively coupled to a triode-pentode 6U8. The pentode section of this tube is the mixer stage, and the triode section is a frequency multiplier for the conversion oscillator. A test point (J1) is provided in the grid circuit of the mixer stage to allow measurement of the level of oscillator injection. A 12AT7 double triode serves as an overtone crystal oscillator, and as a cathode follower i-f output amplifier stage. "Birdies" and spurious responses are cut to a low value by the use of a double tuned circuit (L3-L4) between the r-f stages of the converter.

The 2N6 is designed to work into any communication receiver, preferably one having a tuned r-f amplifier stage. Receivers lacking an r-f stage usually have insufficient gain for best results with this (or most any other) VHF converter. The i-f output range of the converter is a 4 megacycle range falling between 7 mc and 18 mc for 2 meter operation, and between 11 mc and 18.5 mc for 6 meter operation. Exact placement of the i-f range upon the dial of the station receiver depends upon the choice of frequency of the conversion crystal, X1. A summary of i-f tuning ranges is shown in Figure 19. For economy's sake, only one conversion crystal is used for both six and two meter operation. This is done by juggling the i-f output of the converter. For example if a 65 mc crystal is used, the i-f range for "six" is 15 mc to 11 mc, changing to 14 mc to 18 mc when the second harmonic of the crystal is used for 144 mc operation. Note that the receiver tunes "backwards" for six meter reception, that is, 50 mc appears at 15 mc on the receiver dial, and 54 mc shows up at 11 mc on the receiver dial. The authors will leave this "quirk" as an exercise for your wits without further explanation. What would the i-f tuning range be for 50 mc to 54 mc if the frequency of the conversion crystal was 39 mc?

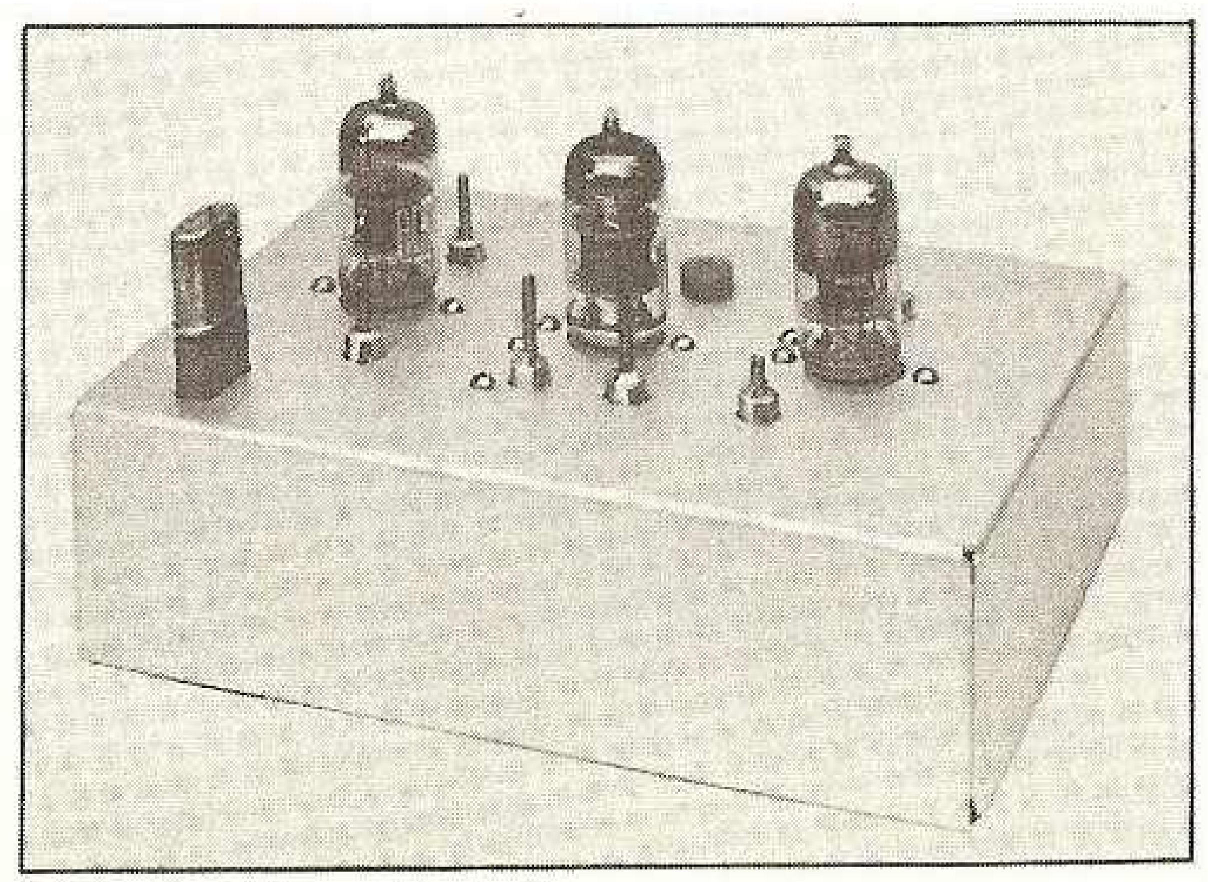


Fig. 15 Simple crystal converter will provide maximum performance on 2 and 6 meter bands. Crystal oscillator stage is at left, with 6BQ7A r-f amplifier at right.

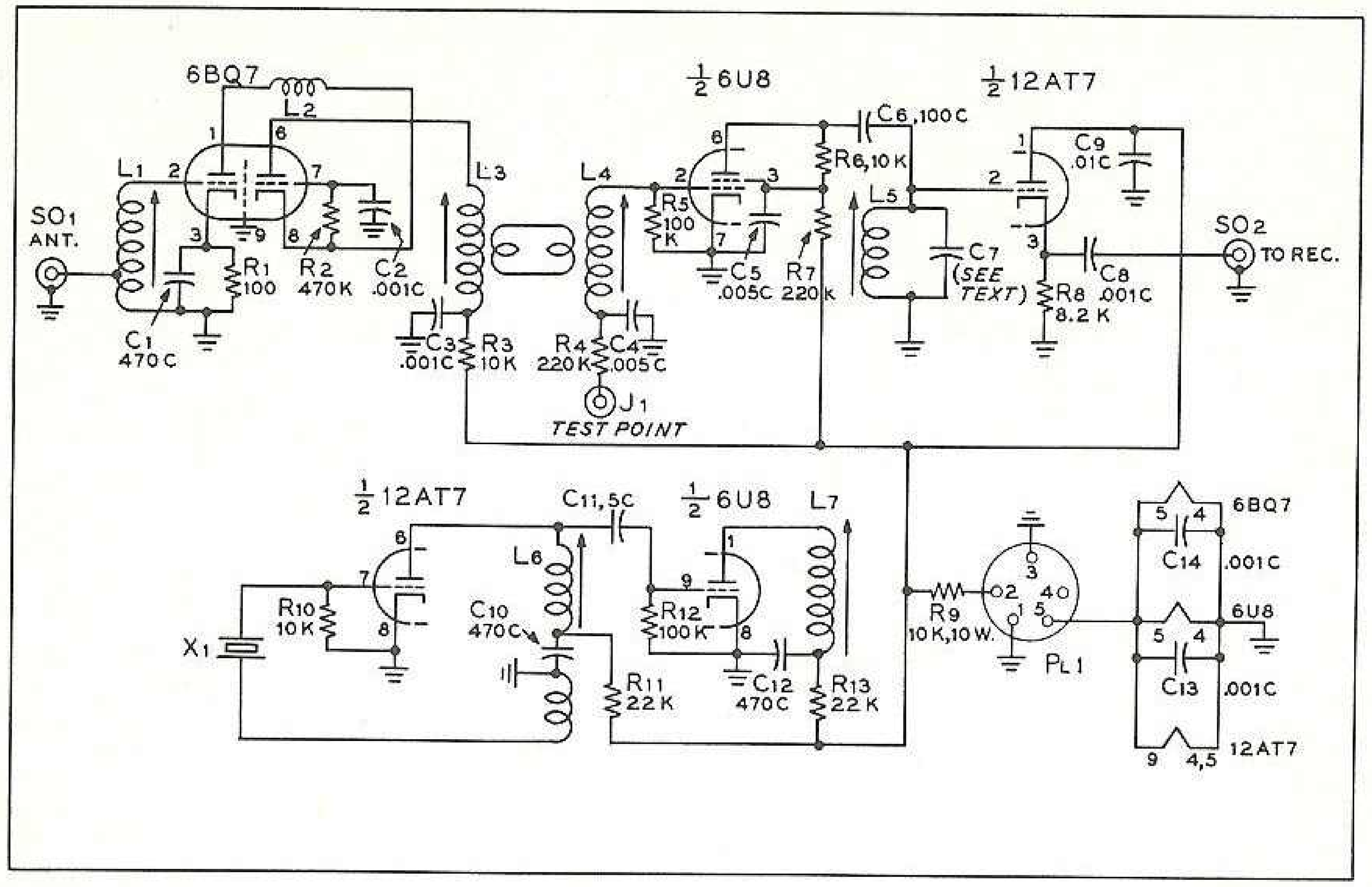


Fig. 16 Schematic diagram of 2N6 crystal-controlled VHF converter.

Converter Construction

The 2N6 converter is constructed upon a 5" x 7" x 2" aluminum chassis. The under-chassis view of Figure 18 and the layout drawing of Figure 17 should give you a pretty good idea of component placement. Notice that a small copper shield is mounted across the 6BQ7A r-f amplifier socket at the right, shielding the grid and plate coils from one another.

The construction and wiring information follows the usual step-by-step sequence, enabling the constructor to complete the project easily and correctly. The use of a small "pencil-type" soldering iron is recommended for this close work. Short, direct leads are a must! Be sure to read each step all the way through before you start to do it. Check each completed step in the space provided.

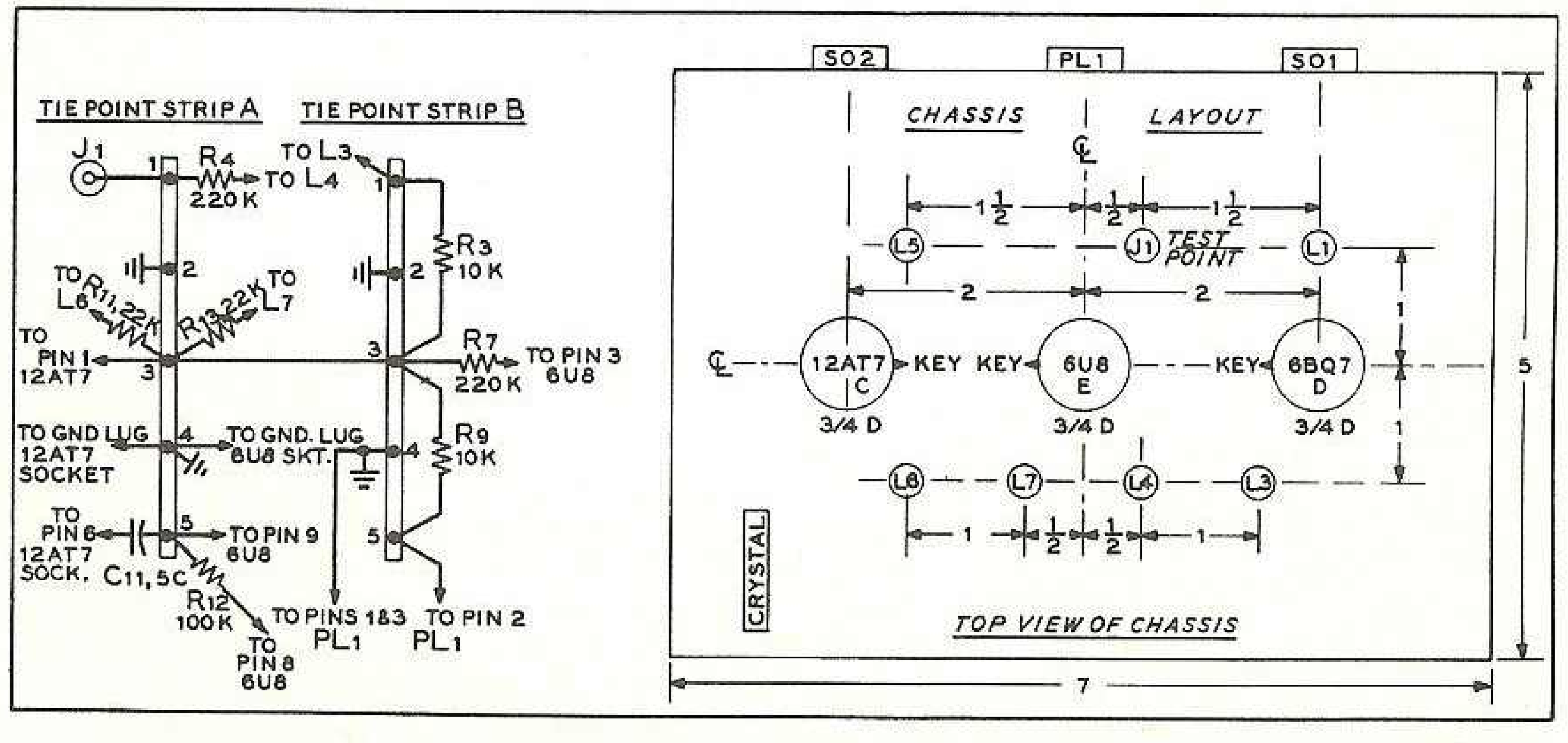


Fig. 17 Terminal strip layout and chassis drilling template for converter.

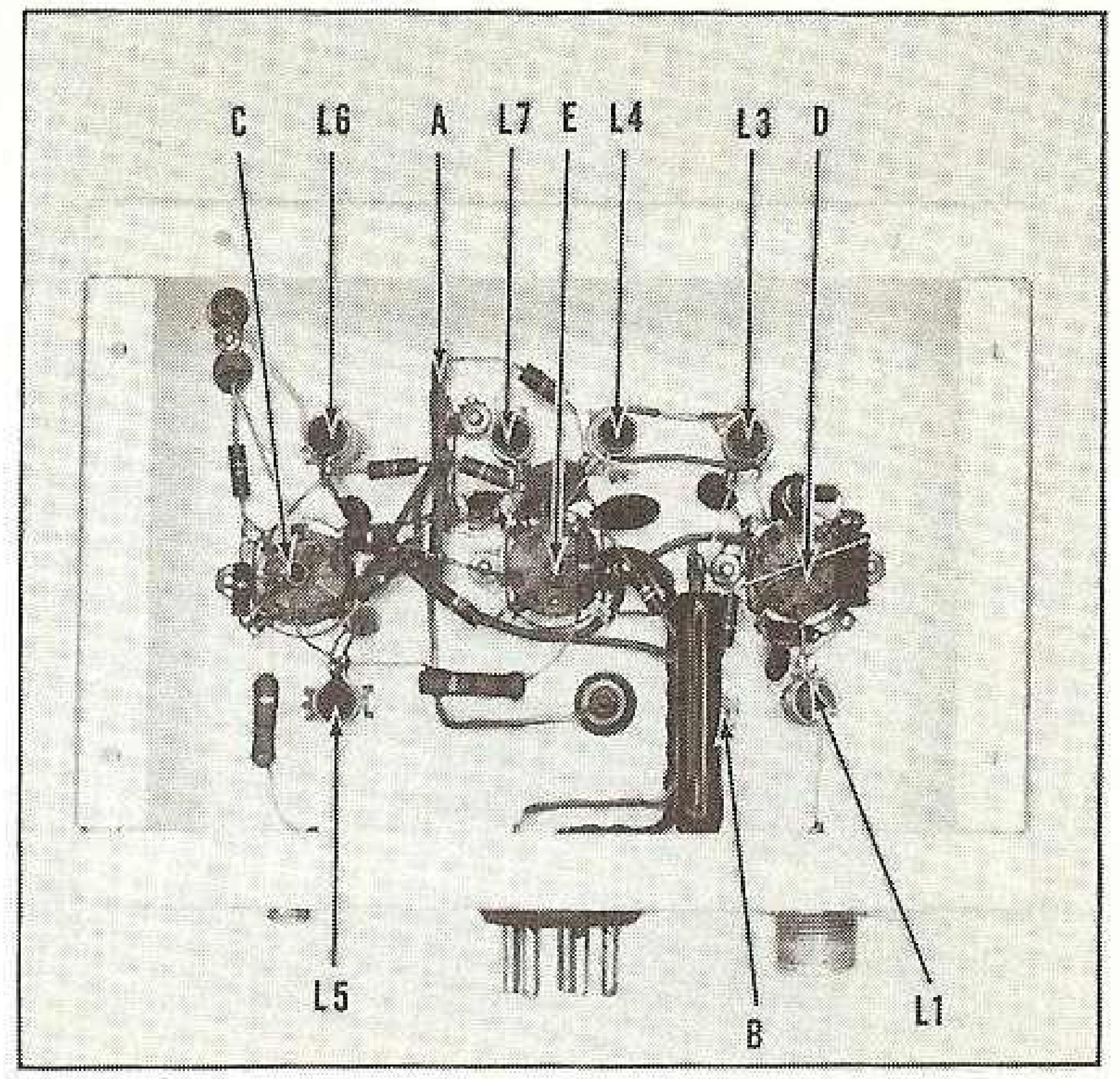


Fig. 18 Under-chassis view of 2N6 converter. Placement of major components is indicated. Crystal socket X1 is at upper left, and test point J1 is at center, below socket E. Note that all leads are short and direct. The 6BQ7A shield plate may be seen bisecting socket D.

( ) Lay out the chassis holes (Figure 17) to be drilled on the paper wrapper of the chassis. Drill the holes and remove the burrs.

( ) Mount the three nine-pin tube sockets in the holes along the center line of the chassis, using 4-40 hardware. The blank pin of the 12AT7 socket (C) and the blank pin of the middle 6U8 socket (E) face each other. The blank pin of the 6BQ7A socket (D) faces the center socket. Mark the socket designations on the underside of the chassis with a pencil. Place lockwashers under the bolt heads and *also* under the nuts to insure good grounds.

( ) Mount antenna receptacle SO1, power receptacle PL1, and i-f output receptacle SO2 on the rear apron of the chassis.

( ) Mount insulated tie-point strips A and B beneath the chassis as shown in Figure 18. Use lockwashers to insure a good ground.

( ) Mount the crystal socket X1 and the insulated test point jack, J1.

( ) Connect a wire from pin 5 of power receptacle PL1 to pin 5 of socket E.

( ) Connect a wire from pin 5 of socket E to pin 9 of socket C.

( ) Connect a wire from pin 5 of socket E to pin 5 of socket D.

( ) Ground pins 4, 5, and 8 of socket C to the socket ground lugs.

( ) Ground pins 4, 7 and 8 of socket E to the socket ground lugs.

( ) Ground pins 4 and 9 of socket D.

( ) Connect a wire from pin 1 and pin 3 of PL1 to lug 4 (ground) of strip B.

( ) Connect a wire from pin 2 of PL1 to lug 5 of tie-point strip B.

( ) Install a 10K, 10-watt resistor (R9) between lug 3 and lug 5 of tie-point strip B. Lug 3 is the common B-plus point.

( ) Install a 10K resistor (R3) between lug 3 and lug 1 of tie-point strip B.

( ) Install a 220K resistor (R7) between lug 3 of strip B and pin 3 of socket E.

( ) Connect a wire from lug 3 of strip B to lug 3 of strip A.

( ) Connect a bare, tinned wire from a ground lug of socket E, through lug 2 of strip B to a ground lug on socket D.

( ) Connect a bare, tinned wire from a ground lug of socket E, through lug 4 of strip A to a ground lug on socket C.

( ) Connect a wire from lug 1 of strip A to insulated test point jack (J1).

( ) Connect the leads of a 470 mmf ceramic capacitor (C1) and a 100 ohm resistor (R1) in parallel. Install the combination between pin 3 and an adjacent ground lug of socket D.

( ) Cut a shield for socket D from a thin piece of flashing copper (Figure 18). Solder the shield to pin 4 and pin 9, and to the center post of the socket. Solder the tabs of the shield to the socket mounting ring.

( ) Install a 470K resistor (R2) between pin 7 and pin 8 of socket D.

( ) Install a .001 ceramic capacitor (C2) between pin 7 of socket D and an adjacent ground lug.

( ) Install a .001 ceramic capacitor (C13) between pin 5 and pin 4 of socket D.

( ) Wind coil L2 and install between pin 1 and pin 8 of socket D. The coil passes around the edge of the shield plate.

( ) Install a 100K resistor (R5) between pin 2 of socket E and an adjacent ground lug.

( ) Install a .005 ceramic capacitor (C5) between pin 3 of socket E and an adjacent ground lug.

( ) Install a .001 ceramic capacitor (C14) between pin 4 and pin 5 of socket E.

( ) Install a 10K resistor (R6) between pin 3 and pin 6 of socket E.

( ) Connect a wire from pin 9 of socket E to lug 5 of strip A.

( ) Install a 100K resistor (R12) from lug 5 of strip A to pin 8 (ground) of socket E.

( ) Connect a wire from pin 7 of socket C to the nearest terminal of crystal socket X1.

( ) Install a 10K resistor (R10) between the above terminal of X1 and a ground lug of socket C.

( ) Install a 8.2K resistor (R8) between pin 3 of socket C and an adjacent ground lug.

( ) Install a .001 ceramic capacitor (C8) between pin 3 of socket C and i-f output receptacle SO2.

( ) Install a .01 ceramic capacitor (C9) between pin 1 of socket C and ground lug 4 of strip A.

( ) Connect a wire from lug 3 of strip A to pin 1 of socket C.

( ) Install a 5 mmf ceramic capacitor (C11) between pin 6 of socket C and lug 5 of strip A.

( ) Wind a set of coils for either 2 meters or 6 meters from the data of Figure 19. The link winding of L6 is added later. Mount the coils in the proper holes using lockwashers and nuts.

( ) Ground the base end (nearest the chassis) of L1 to a ground lug of socket D.

( ) Attach the tap on L1 to center terminal of antenna receptacle SO1.

( ) Attach the top end of L1 to pin 2 of socket D.

( ) Install a .001 ceramic capacitor (C3) between the base end of L3 and a ground lug of socket D.

( ) Connect a wire between the base end of L3 and lug 1 of strip B.

( ) Connect a wire between pin 6 of socket D and the top end of L3.

( ) Install a .005 ceramic capacitor (C4) between the base end of L4 and a ground lug of socket E.

( ) Install a 220K resistor (R4) between the base end of L4 and lug 1 of strip A.

( ) Connect a wire between the top end of L4 and pin 2 of socket E.

( ) Wind a loop link consisting of ½-turn about the center of L3 and L4 from a length of #20 hookup wire (see Figure 18).

( ) Connect a wire from the base end of L5 to ground lug of socket C.

( ) Install capacitor C7 (see i-f chart) across coil L5, if required.

( ) Install a 100 mmf ceramic capacitor (C6) between pin 6 of socket E and the top end of coil L5.

( ) Connect a wire between top of L5 and pin 2 of socket C.

( ) Install a 470 mmf capacitor (C10) from base end of coil L6 to ground lug of socket C.

( ) Install a 22K resistor (R11) between base end of L6 and lug 3 of strip A.

( ) Connect a wire from top of L6 to pin 6 of socket C.

( ) Install a 470 mmf capacitor (C12) from base end of coil L7 to ground lug of socket E.

( ) Install a 22K resistor (R13) from base end of L7 to lug 3 of strip A.

( ) Connect a wire from top end of L7 to pin 1 of socket E.

( ) Run a short length of insulated wire from the far terminal of crystal holder X1, wrapping it around L6 (as per coil table) to form the feedback winding. Ground the free end of the wire to a ground lug of socket C.

( ) Check the wiring carefully with Figure 16. Check for poorly soldered joints, shorts, open connections and accidental transpositions.

Testing the Converter (144 Mc)

After checking, the converter is ready for testing. Plug in all tubes and

the correct crystal. The converter should be attached to a 250 volt power supply of 40 milliamperes capacity. A 150 volt supply may be used if resistor R9 is shorted out. Turn on the converter and observe that all tubes light. A high resistance voltmeter (20,000 ohms per volt) or a 0-100 d-c microammeter is attached between test jack J1 and ground. The slug of coil L6 is tuned for an indication on the meter. This indicates that the crystal is oscillating. The crystals used in this circuit are overtone types, and require a small degree of feedback provided by the link winding on coil L6. If the link has too few turns, the crystal may not oscillate, or will act sluggish. If there are too many turns on the link, the circuit will break into self-oscillation without benefit of the controlling characteristics of the crystal. The link should never run over four turns at the most. Start with two turns, and place a 0-25 d.c. milliammeter in series with resistor R11, the B-plus decoupling resistor of the oscillator stage. When the slug of L6 is resonated, the plate current of the tube will drop sharply. A well defined indication should be noted on the meter as L6 is tuned through resonance. If the plate current varies erratically as L6 is tuned, or if double dips are noted, a turn should be removed from L6. One sure sign of too many turns on L6 is reception of numerous "birdies" as the station receiver is tuned across the intermediate frequency range of the converter.

FREQUENCY	L_1	L_2	L_3	L_4	I-F AND OSC. COILS
50 MC.	19 TURNS # 28 E. CLOSEWOUND. TAP 4 TURNS FROM GROUND END.	(SAME COIL FOR 50 AND 144 MC.) 8 TURNS # 20 E 1/8" DIA. WIND ON DOWEL ROD, CEMENT WITH NAIL POLISH AND REMOVE FROM ROD.	14 TURNS # 28 E. CLOSEWOUND. LINK: 2 TURNS # 20 INSULATED WIRE AROUND B-PLUS END.	9 TURNS # 28 E. CLOSEWOUND. SAME LINK COIL AS L_3.	L_5 – (SAME COIL FOR 50 AND 144 MC.) 20 TURNS # 26 E. CLOSEWOUND.
144 MC.	4 TURNS # 22 E. 1/4" LONG. TAP 2 TURNS FROM GROUND END.		5 TURNS # 22 E. 1/4" LONG. LINK: 1 TURN # 20 INSULATED WIRE AROUND B-PLUS END.	4 TURNS # 22 E. 1/4" LONG. SAME LINK COIL AS L_3.	L_6 – (SAME COIL FOR 50 AND 144 MC.) 8 TURNS # 26 E. CLOSE-WOUND. LINK: TWO TURNS # 20 INSULATED WIRE AROUND B-PLUS END OF L_6.

FREQUENCY	I-F RANGE	CRYSTAL (X_1)	C_7	L_7 – (USED FOR 144 MC. ONLY)
50 MC.	15 – 11 MC. L_5 PEAKS AT 14 MC.	65 MC.	40 μμF	6 TURNS # 22 E. 1/4" LONG.
	18.5 – 14.5 MC. L_5 PEAKS AT 17.5 MC.	68.5 MC.	25 μμF.	COIL FORMS – 1/4" DIA. CERAMIC SLUG-TUNED. J.W. MILLER # 4500
144 MC.	14 – 18 MC. L_5 PEAKS AT 15 MC.	65 MC. X 2	30 μμF.	CRYSTAL – INTERNATIONAL CRYSTAL CO. – OVERTONE TYPE FA9. 65 MC. OR 68.5 MC.
	7 – 11 MC. L_5 PEAKS AT 8.5 MC.	68.5 MC. X 2	100 μμF.	C_7 – CENTRALAB TYPE NPO.
6BQ7A SHIELD PLATE = 1" X 1" FLASHING COPPER. SOLDER TO PINS 4, 9, CENTER POST AND MTG. RING.				

Fig. 19 Coil table and i-f range chart for VHF crystal controlled converter. Either a 65 mc or 68.5 mc overtone crystal may be used, as desired. Coils L2, L5, L6, and L7 need not be changed between 50 mc and 144 mc operation.

Coil L7 is now peaked for a reading of 3 volts at J1, and L6 is adjusted for stable oscillator operation. The resonant frequency of L6 and L7 may be checked with a grid-dip oscillator.

The converter is now connected to the station receiver with a short length of coaxial line. A suitable VHF antenna is connected to SO1. The input circuit of the receiver is designed to be used with a 52 ohm unbalanced coaxial transmission line. If it is desired to use a 300 ohm balanced line, SO1 should be replaced with a double terminal strip, and a two turn link coil wound around the base of L1 and attached to the antenna terminals.

The station receiver is tuned to the middle of the i-f range, and L3, L4, and L5 are peaked for maximum strength of a received signal. L1 is then adjusted for best reception of a very weak signal. The station receiver is now tuned plus or minus 2 megacycles to cover the VHF amateur band to which the converter is tuned. The coils of the converter (L1, L3, and L4) may be peaked for best reception at any point in the band, although excellent results will be had across the entire band with the coils resonated near the center frequency of each band.

50 Mc Alignment

For six meter operation, the fundamental frequency of the oscillator stage is used, rather than the second harmonic. The 6U8 triode section serving as a frequency doubler must therefore be disabled, and the output of the 12AT7 crystal oscillator coupled directly to the 6U8 pentode mixer stage. Only a few small circuit changes are necessary. The 5 mmf coupling capacitor C11 is disconnected from pin 9 of the 6U8 socket (E) and connected to pin 2 of the same socket. Next, the lead from coil L7 to pin 1 of the center 6U8 socket (E) is opened and finally, the correct value of capacitor C7 is inserted across the terminals of coil L5. The proper coils (Figure 19) are placed in the circuit, and the converter is aligned as described above.

Parts List for 2N6 Converter

3—470 mmf disc ceramic capacitor (Centralab DD-471) (C1, C10, C12)
5—.001 disc ceramic capacitor (Centralab DD-102) (C2, C3, C8. C13, C14)
2—.005 disc ceramic capacitor (Centralab DD-502) (C4, C5)
1—.01 disc ceramic capacitor (Centralab DD-103) (C9)
1—100 mmf tubular ceramic capacitor (Centralab D6-101) (C6)
1—5 mmf tubular ceramic capacitor (Centralab D6-050) (C11)
1—Padding capacitor (C7) (see text)
1—100 ohm, ½-watt resistor (IRC type BTS or BW½) (R1)
1—470K, ½-watt resistor (R2)
3—10K, ½-watt resistor (R3, R6, R10)
2—220K, ½-watt resistor (R4, R7)
2—100K, ½-watt resistor (R5, R12)
1—8.2K, ½-watt resistor (R8)
1—10K, 10-watt resistor (Ohmite "Brown Devil") (R9)
2—22K, ½-watt resistor (R11, R13)
1—Crystal, 65 mc, or 68.5 mc. (International Crystal Mfg. Co. FA-9) (X1)
1—Plug, 5 pin, male (Amphenol 86-RCP5) (PL1)
1—Receptacle, coaxial (Amphenol 83-1R) (SO1)
1—Plug and socket, coaxial (Cinch-Jones P101, S101) (SO2)
1—Chassis, aluminum, 5"x7"x2" (Bud AC-402)
6—Coil forms, ceramic, slug tuned, ¼" diam. (J. W. Miller 4500) (L1, L3-L7)
3—Socket, small 9 pin (Amphenol 59-407)
1—Tube, 6BQ7A (RCA)
1—Tube, 6U8 (RCA)
1—Tube, 12AT7 (RCA)
1—Insulated tip-jack (Johnson 105-602) (J1)
2—Tie-point strips, 5 terminal (Cinch-Jones 53C)
1—Crystal socket (Cinch-Jones 2KM) (X1)
5 Feet, insulated hookup wire
Misc. 6-32 and 4-40 nuts, bolts and lockwashers

AN ANTENNA COUPLER FOR YOUR RECEIVER

The antenna coupler is normally thought of as a piece of transmitting equipment, but it can also be used to improve receiver performance. Because of the wide range of frequencies covered by the communication receiver, it is difficult to maintain a good impedance match between the receiver and a random length wire antenna over the various bands. This little coupler solves this difficulty, and the signals will literally "jump right up out of the noise" when it is in use. No tubes or batteries required, and only 8 major parts, including the case!

This simple impedance matching device will improve the performance of any communication receiver when used with a random length wire, or any antenna fed by a low impedance coaxial line. Only 4"x2"x2" in size, it is a useful piece of auxiliary equipment for any short wave enthusiast.

Coupler Construction

The schematic of the coupler is shown in Figure 21, and comprises a simple L-type network. The complete coupler is built within an aluminum box *(Bud CU-2103)*, as shown in Figures 20 and 22. The following wiring and assembly instructions are presented in a step-by-step sequence enabling the constructor to complete the project correctly in a minimum of time. Be sure to read each step all the way through before you start to do it. Solder all connections as you go along.

( ) Mark the chassis holes (Figure 21) on the paper wrapper of the box. Drill all holes and remove the burrs.
( ) Install a ground lug in hole A, using 6-32 hardware and a lock washer.
( ) Mount the tuning capacitor (C1) in hole B. with the *rotor* connection pointing toward hole A.
( ) Mount the receptacle (J1) on the back portion of the box in hole E using 6-32 hardware.
( ) Mount the ceramic feedthrough insulator in hole D.
( ) Prepare coil (L1). It is necessary to place a tap at every seventh turn on the coil. To make the taps without shorting adjacent turns, push down the wire turn on each side of the turn to be tapped, as shown in Figure 22. Do this to the turns on *each side* of every seventh turn, starting from one end of the coil.

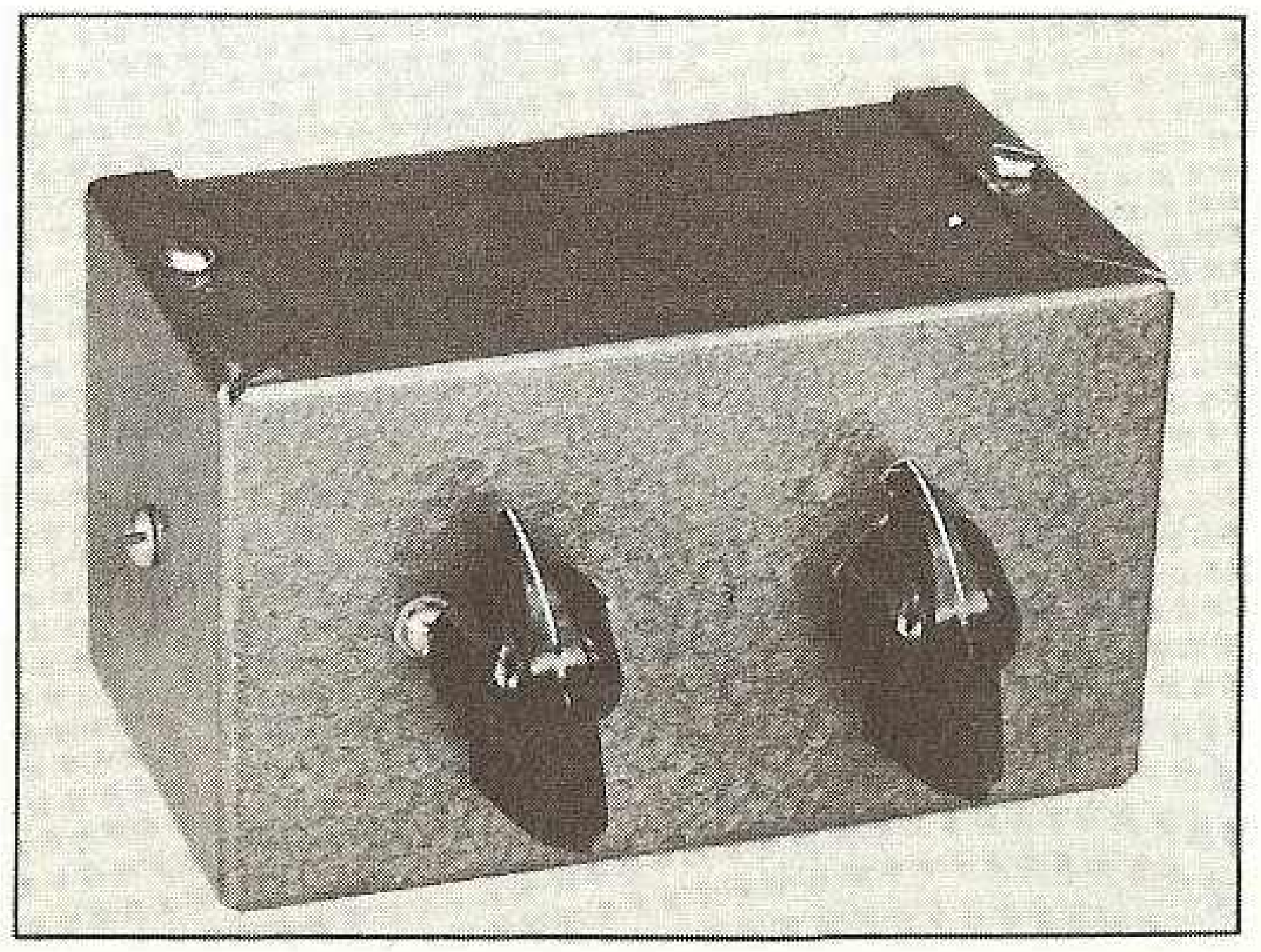


Fig. 20 Simple antenna coupler will match the antenna to your receiver. Control at left is C1, with switch S1 at right.

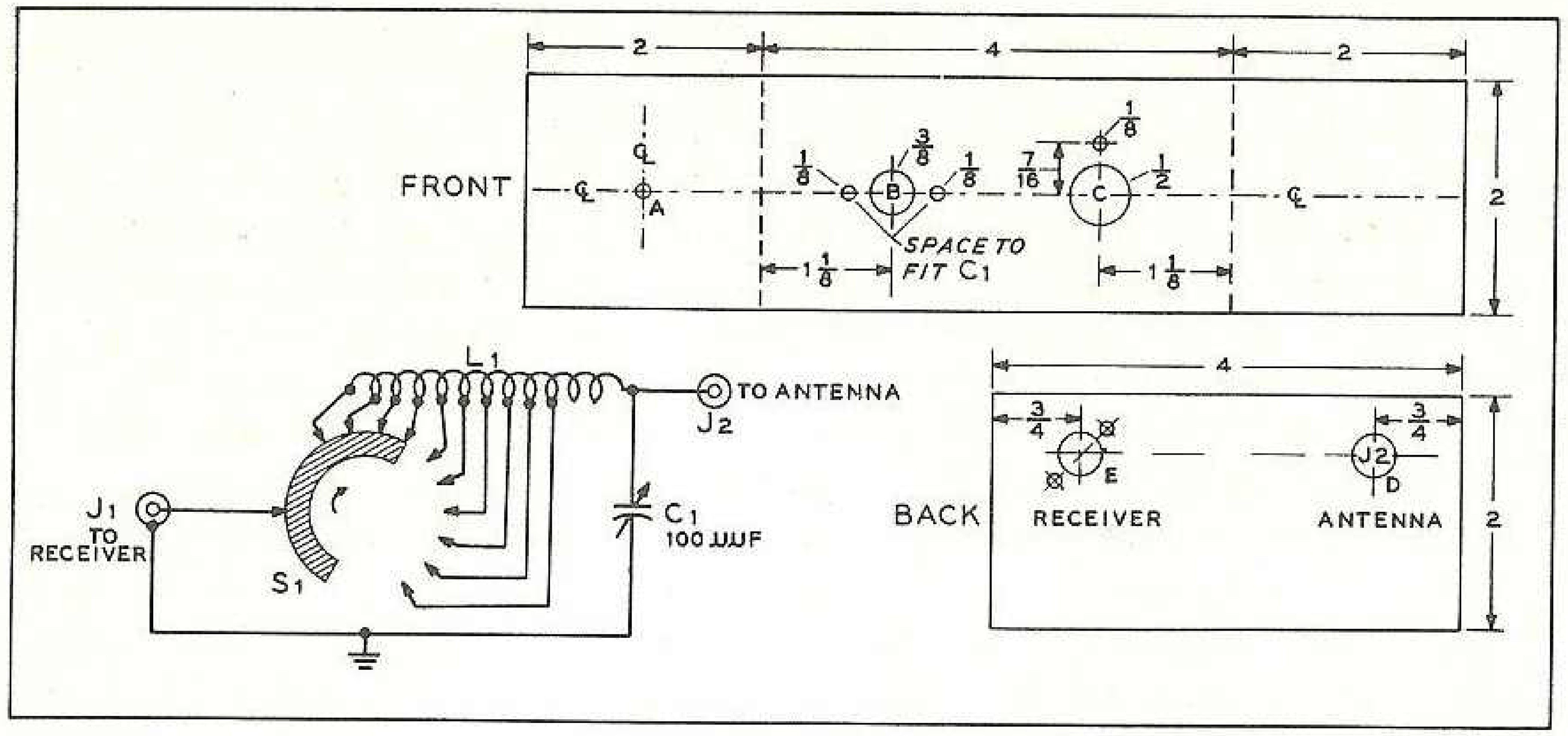


Fig. 21 Schematic diagram and chassis layout of simple antenna coupler.

( ) At each tap point, solder a 2 inch length of insulated wire. Do this carefully, preferably with a small pencil iron. Be careful not to short out any turns, and do not apply heat long enough to melt the insulating material of the coil. You should have nine taps, plus the leads at each end of the coil.
( ) Notice that switch (S1) has a set of contacts on the front, and also on the rear. The contacts on the rear (away from the panel bushing) will be wired first, in order counter-clockwise.
( ) Mount the switch in hole C. Position the switch so the guide falls in the small alignment hole in the panel.
( ) Looking at the bottom of the switch, connect the lead from the left end of the coil (not the tap) to the most counterclockwise terminal on the rear of the switch (see Figure 22).
( ) Attach a 3 inch length of wire to the *same* switch terminal, as above.
( ) Connect the first coil tap to the next clockwise switch terminal.
( ) In this manner, connect the next four taps in order to the remaining four rear terminals of the switch.
( ) Connect the sixth tap to the most counterclockwise terminal on the *front* of the switch.
( ) In this manner. connect the remaining three coil taps in order to the remaining switch terminals.
( ) This leaves only the lead at the left end of the coil free. Connect this lead to a stator terminal of capacitor (C1).
( ) Connect a 2 inch length of wire to the other stator terminal.
( ) Connect the rotor terminal of (C1) to the adjacent ground lug.

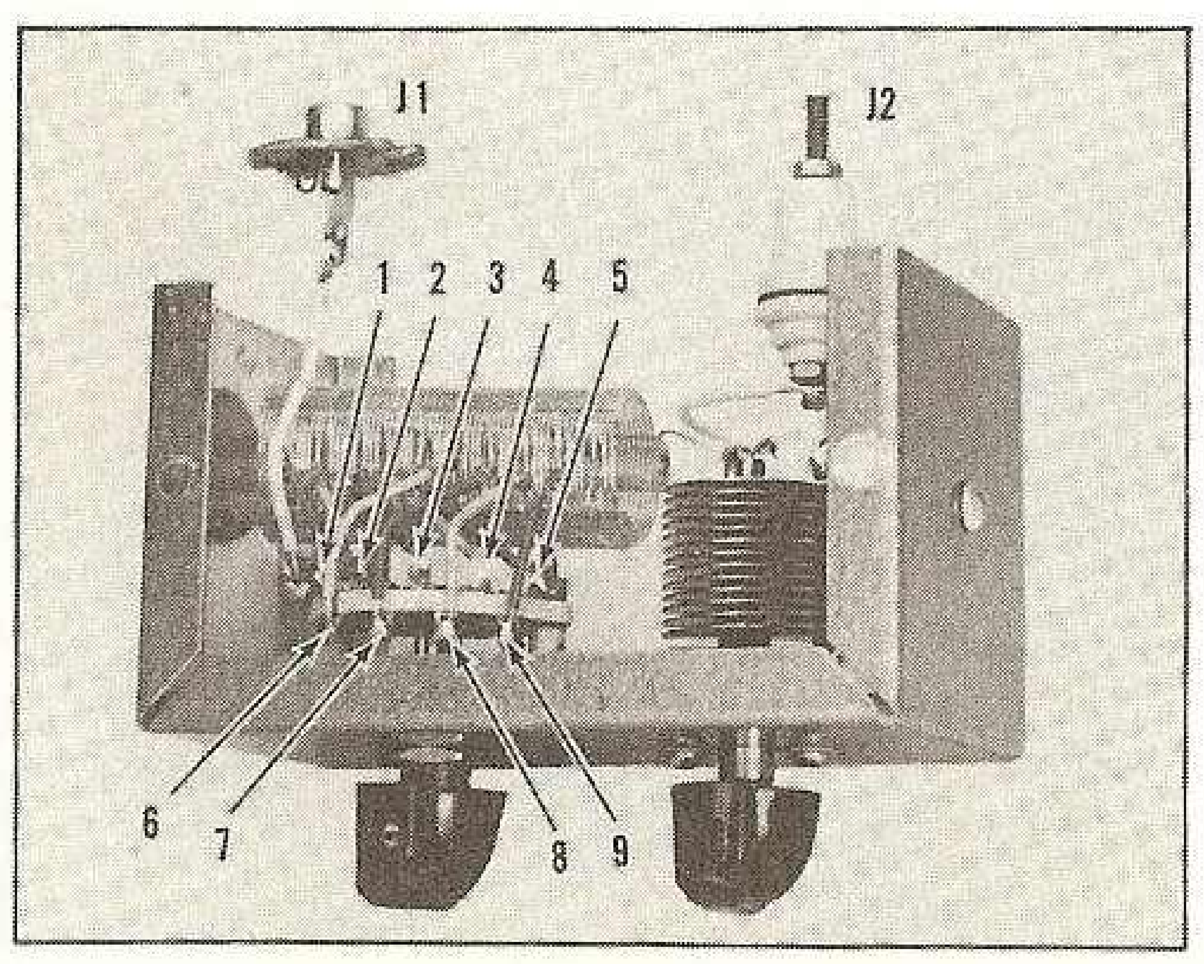


Fig. 22 Switch taps of coil L1 are seen in this view. The input and output connectors (J1 and J2) attach to the other section of the aluminum box.

( ) Connect the 3 inch lead from the terminal of switch (S1) to receptacle (J1).
( ) Connect the 2 inch lead from the stator terminal of (C1) to the ceramic feedthrough insulator.
( ) Assemble the box, and tighten the hardware on the outside of the ceramic feedthrough insulator.
( ) Prepare a 14 inch length of coaxial cable to connect the coupler to your receiver. Install the coaxial fitting at one end of the cable, and unbraid the opposite end for two inches, and tin the braid.

Using the Antenna Coupler

Plug the coaxial cable into receptacle J1, and connect the other end to the antenna and ground terminals of the receiver. The outer braid of the cable goes to "ground." (See the remarks about ac-dc receivers in the instructions for the preselector earlier in this chapter.) Attach your antenna to the ceramic feedthrough insulator. Set capacitor C1 at half capacity, and adjust switch S1 for the loudest signal. Adjust the variable capacitor C1 for maximum signal—and there you are! If you doubt the effectiveness of the antenna coupler, you can disconnect it and connect the antenna directly to the receiver. There will be a definite improvement in signal strength with the antenna coupler in use.

Parts List for Antenna Coupler

1—100 mmf. variable capacitor (E. F. Johnson 100-S8, with shaft) (C1)
1—Coaxial plug and receptacle, phono type (Cinch-Jones 13A and 18A) (J1)
1—Ceramic feedthrough insulator (E. F. Johnson 135-44) (J2)
1—Inductor, ¾" diameter, 96 turns #20, 3 inches long (B & W 3012, or Airdux 632) (L1)
1—Switch, progressively shorting, 10 position (Centralab PA-2042) (S1)
1—Box, 4"x2"x2" (Bud CU-2103)
1—14 inch length of coaxial cable (RG-58/U) or (RG-59/U)
1—pointer knob (one is furnished with S1)
Miscellaneous hardware and two feet of hookup wire

A TRANSISTORIZED Q-MULTIPLIER FOR YOUR RECEIVER

Here's a DX-Dandy that will appeal to all operators! A miniature Q-multiplier that works with any receiver having a 455 kc i-f channel! Operating from an internal battery supply that will last for years, the T-QM requires but two wires to attach it to your station receiver. Like to have some razor-sharp selectivity? The T-QM is for you! Total cost of parts is less than $9.00, including transistor and batteries! Beat the QRM with the T-QM!

The Q-multiplier is a regenerative resonant circuit capable of increasing the i-f selectivity of your receiver. Adjacent channel selectivity may be increased to a point where QRM will drop out, leaving only the signal you wish to receive in the passband of the receiver. Suitable for phone or c-w operation, this miniature transistorized unit operates in the same manner as its "tubed-up big brother." The battery drain of the transistor is so low that almost full shelf-life may be expected from the 9 volt transistor-type battery. Best of all, the T-QM may be used with ac-dc receivers, and will introduce no shock hazard.

Circuit and Construction of the T-QM

The circuit of the transistorized Q-multiplier is shown in Figure 24. A

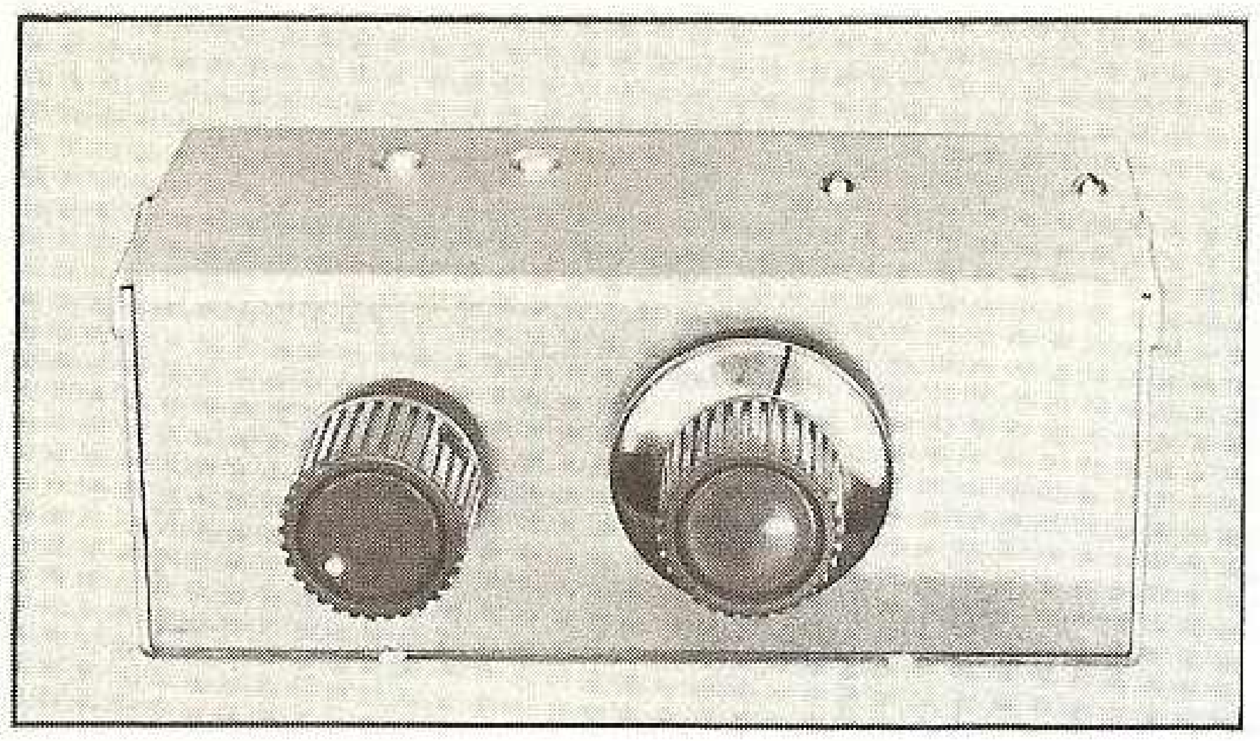


Fig. 23 The transistorized Q-multiplier works with any receiver having a 455 kc i-f amplifier. Life of the self-contained battery is extremely long, due to low current drain of transistor.

General Electric 2N170 n-p-n transistor is used in a grounded emitter configuration. The high-Q resonant circuit is composed of a "loopstick" coil (L1) and tuning capacitor C3. The gain of the Q-multiplier is adjusted by varying the base bias of the transistor by means of potentiometer R2.

The T-QM is built in a 2"x3"x5" aluminum box, as shown in Figure 23. All parts, including the battery are contained within the box. The following assembly and wiring instructions are presented in a step-by-step sequence to enable the constructor to complete the project easily and correctly. Be sure to read each step all the way through before you start to do it. When the step is completed, check it off in the space provided.

( ) Lay out the chassis holes to be drilled on the paper wrapper of the chassis. Drill the holes and remove the burrs.
( ) Mount the peaking potentiometer (R2) in hole B. Mount coil L1 in hole A.
( ) Mount the 5 terminal phenolic tie-point strip (H) in holes C and D.
( ) Mount the "phono-type" receptacle (J1) in hole G.
( ) Mount the battery (B1) with a ¼" wide strip of metal passed over it and bolted at the ends in holes E and F.
( ) Connect the negative terminal of the battery to lug 4 (see Figure 24) of strip H (ground).
( ) Connect the positive terminal of B1 to one lug of S1 on the rear of potentiometer R2.
( ) Connect the other terminal of switch S1 to lug 5 of strip H.
( ) Connect terminal C of potentiometer R2 (Figure 24) to lug 4 of strip H.

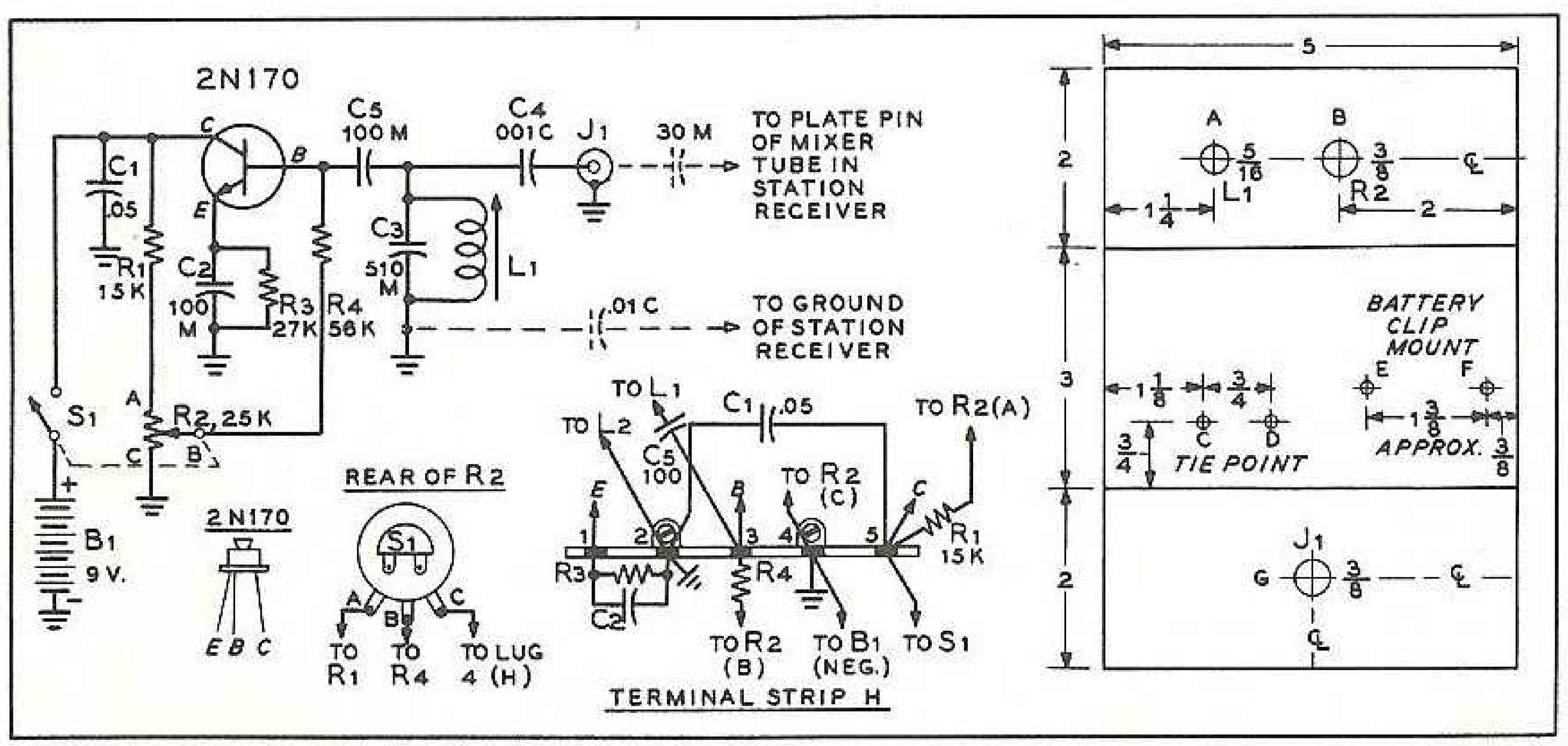
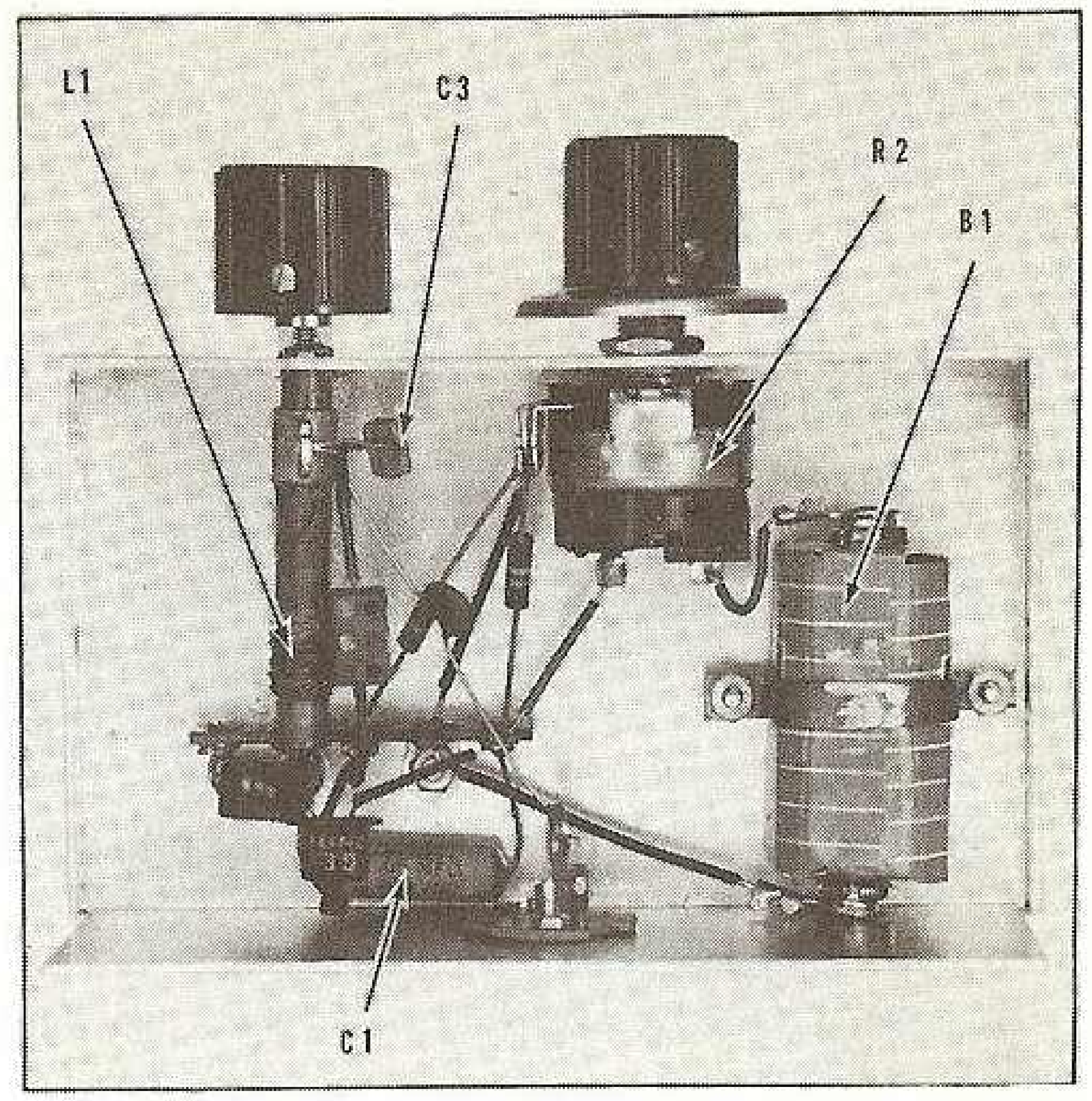


Fig. 24 Schematic of T-QM. Feedback is controlled by size of capacitor C5, which may be increased in value if greater selectivity of the T-QM is desired.

Fig. 25 Under-chassis view of T-QM. "Loopstick" coil (L1) is at left, with 2N170 transistor directly below it. 9-volt battery is mounted in clamp at right. Output receptacle (J1) is on the rear lip of chassis behind L1.



( ) Install a 56K resistor (R4) from center terminal B of R2 to lug 3 of strip H.
( ) Install a 15K resistor (R1) from terminal A of R2 to terminal 5 of strip H.
( ) Twist the leads of a 27K resistor (R3) and a 100 mmf capacitor (C2) placing the components in parallel. Connect the combination between terminals 1 and 2 of strip H.
( ) Install a wire from lug 2 of strip H to one terminal of coil L1.
( ) Install a 100 mmf capacitor (C5) between the opposite terminal of L1 and terminal 3 of strip H.
( ) Install a .001 disc ceramic capacitor (C4) from the junction of L1 and C5 to the center terminal of receptacle J1.
( ) Install a 510 mmf mica capacitor (C3) between the terminals of coil L1.
( ) Install a .05 mf paper capacitor (C1) between terminal 2 and terminal 5 of strip H.
( ) The last step is to install the transistor. During all soldering operations, grasp the transistor lead between the transistor and the point to be soldered with a pair of long nose pliers to conduct the heat away from the body of the transistor. Do not shorten the transistor leads. Employ a hot iron, and solder the leads as quickly as possible so as not to damage the transistor.
( ) Solder the *emitter* lead of the transistor to terminal 1 of strip H.
( ) Solder the *base* lead of the transistor to terminal 3 of strip H.
( ) Solder the *collector* lead of the transistor to terminal 5 of strip H. Space the leads so they do not touch each other, or the other components.
( ) This completes construction of the T-QM. Assemble the box, after checking all connections.

Connecting the T-QM to the Receiver

Two connections are made to the station receiver. A 10" length of wire is attached to a soldering lug at one end. This lug is placed beneath one of the bolts holding the box of the T-QM together. If the receiver *is not* an ac-dc set, the opposite end of this lead is grounded to the chassis of the receiver. If the receiver *is* an ac-dc set (no power transformer) the lead is connected to the ground terminal of the set through a .01, 1KV disc ceramic capacitor. This eliminates any shock hazard that might be present if the T-QM was directly connected to the receiver chassis.

A second 10" length of wire is attached to the plug of J1. This wire runs to the plate pin of the mixer tube of the receiver through a 30 mmf ceramic capacitor. If the receiver uses octal tubes, the mixer is probably a 6SA7 or perhaps a 12SA7. One lead of the 30 mmf capacitor may be soldered directly to the plate pin of the tube (pin 3) at the base of the pin. The lead of the capacitor should be covered with insulated sleeving right up to the tube pin to prevent it from shorting out to the chassis of the receiver. If a miniature tube is used as a mixer, this quick and dirty technique won't work, since it is next to impossible to solder to the pins of a miniature tube! In this case, install a coaxial receptacle (just like J1) on the back apron of the receiver, and connect a 30 mmf mica capacitor between the receptacle and the plate pin of the mixer tube. Place a matching plug on the end of the lead from the T-QM, and plug it in the receptacle. This is a good installation to use with octal tubes, too, even though soldering to the plate pin of the mixer tube is an "easy way out"!

When the T-QM is installed properly, turn it on, and turn on the receiver. Tune in a station, and rotate the potentiometer clockwise. Adjust the slug of L1 for maximum signal strength. Now, adjust the primary and secondary trimmers of the first i-f transformer in the receiver, as the T-QM tends to detune this stage a bit. Be sure the lead from J1 of the T-QM is kept at least one inch away from the chassis of the receiver. Finally, advance potentiometer R2 until the T-QM breaks into oscillation, and a howl is heard in the speaker. The point of maximum selectivity is just before the Q-multiplier breaks into oscillation. Control R2 will have to be retarded from this point to allow good phone reception.

To check operation, tune the T-QM for maximum selectivity, as indicated by a ringing sound. Then, pull the plug out of the rear jack of the receiver. Some difference!

Parts List for T-QM

1—.05 mf, 200 volt paper capacitor (Aerovox P82) (C1)
2—100 mmf mica capacitor (Aerovox K-1310) (C2, C5)
1—510 mmf silver mica capacitor (Aerovox KR-1451) (C3)
1—.001 disc ceramic capacitor (Centralab DD-102) (C4)
1—30 mmf mica capacitor (Aerovox K-1430) (see text)
1—15K, ½-watt resistor (IRC type BTS or BW-½) (R1)
1—25K potentiometer, linear taper, with SPST switch (Centralab B-26-S) (R2) and (S1)
1—27K, ½-watt resistor (R3)
1—56K, ½-watt resistor (R4)
1—NPN transistor, 2N170 (General Electric)
1—Ferrite "Loopstick" (J. W. Miller 6300) (L1)
1—Box-chassis 2"x3"x5" (LMB 136)
1—Terminal strip, 5 lug (Cinch 53C)
1—.01 ceramic capacitor (Centralab DD-103) (if receiver is ac-dc)
1—Phono jack (Cinch-Jones 81A) (J1)
1—9-volt transistor battery (RCA #VS-300) (B1)
1—Phono plug (Cinch-Jones 13A)
1—Pointer knob (Gee-lar 990-SS)
Misc 6-32 and 4-40 hardware. wire
1—Knob for ⅛" shaft (Millen A006) (for L1)

CHAPTER VI

Transmitter Theory in a Nutshell

The purpose of a radio transmitter is to take some form of intelligence (voice, music, code, or perhaps a picture) and change it into electromagnetic energy that may be propagated through space. Amateur transmitters vary in complexity from a single tube low power rig to a multi-tube single-sideband transmitter costing thousands of dollars. Since it is customary to learn to walk before you learn to run, this Handbook will deal primarily with simple transmitters especially designed for the Novice and Technician amateur. Regardless of the cost or complexity of the transmitting equipment, all such units may be broken down into fundamental "building blocks" common to all transmitters. Let's examine some of these blocks and note their application in a typical beginner's transmitter.

Transmitter Building Blocks

The fundamental parts of a simple transmitter are shown in Figure 1. The first building block is the *signal generator,* or *oscillator.* This circuit generates the radio signal at some specific frequency. In the case of the Novice, this frequency is crystal controlled. That is, the frequency is predetermined by using a mechanical resonator (quartz crystal) instead of a variable tuned circuit, such as shown in Figure 1, chapter 4. The quartz crystal has the same properties of frequency selection and rejection as does the tuned circuit—only more so! The frequency of operation is fixed by the physical dimensions of the crystal. In addition, the crystal has no knob to tweak to vary the frequency of resonance. When you use a crystal you are "rock bound" to one spot in the band. No amount of oscillator tuning will change the frequency of the stubborn crystal. An oscillator may be built which does not use a crystal, employing instead a variable resonant circuit of inductance and capacity for frequency determination. This gadget is termed a *variable frequency oscillator,* or *VFO.*

The simplest transmitter is a crystal oscillator coupled to the antenna. A rig of this type is quite limited in power output, so to achieve a huskier signal it is necessary to add an amplifier stage *(power amplifier* or *p-a)* to the oscillator, boosting the signal level ten to several hundred times. In

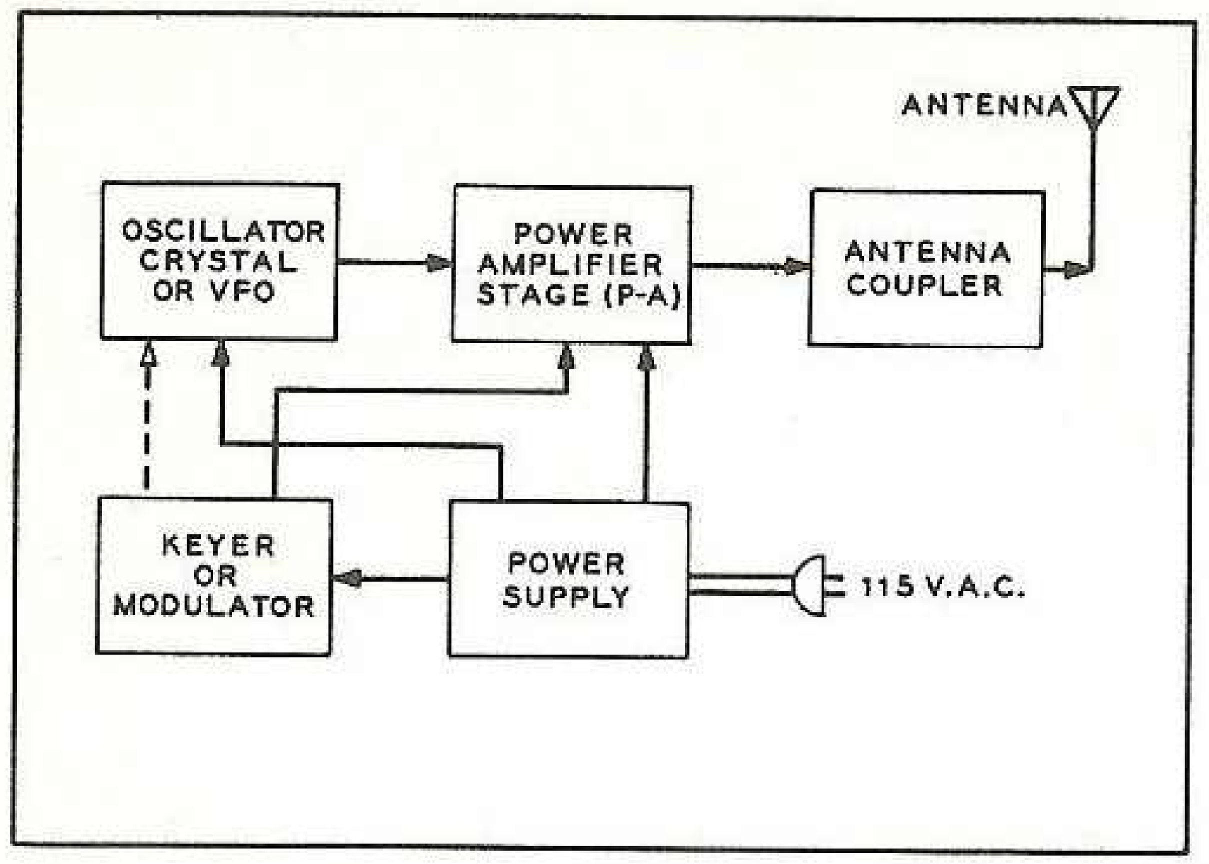


Fig. 1 Any modern transmitter is made up of five basic building blocks, discussed at length in the text.

addition the amplifier may be used to multiply the frequency of the oscillator. In this case, the amplifier is called a *doubler*, or *frequency multiplier*. A multiplication factor of three or four may be obtained in one stage, and two or more stages can be cascaded to achieve higher orders of frequency multiplication.

The next building block of the transmitter is the *antenna coupler*. The purpose of this unit is to transfer the radio energy to the antenna system in an efficient manner. There are as many forms of antenna couplers as Carter has pills, and some of the better ones are discussed in chapter 9 of this Handbook.

Another basic building bloc of the transmitter is the *keyer*, or *modulator*. This unit imposes the chosen intelligence upon the carrier wave. A simple telegraph key may be used for c-w transmission. A more complex modulator is required for phone transmission, and a whole room full of equipment is needed for radio teletype and television transmission. Various types of carrier modulation are shown in Figure 2, chapter 2.

The final building block needed to complete the transmitter is the *power supply*. Alternating current may be used for the filament circuits of the transmitter but steady, smooth direct current is required for the high voltage circuits. To obtain this voltage, d-c power supplies operating from the 50-60 cycle house line are usually employed. Examples of such supplies are shown in chapter 8.

Additional equipment is often added to the basic transmitter to simplify operation, or to make the signal more readable or sharper. Indicating devices are added to measure voltages, currents, and the operating frequency. No matter how involved the schematic of such a complex transmitter appears it may be broken down into the fundamental building blocks mentioned here. In many cases, the auxiliary circuits are more complex and more costly than the basic transmitter circuits. Practice in reading and studying transmitter schematics and unraveling the various building blocks hidden in the maze of wiring will pay big dividends in the art of understanding some of the mysterious processes involved in the transmission of radio signals.

A Complete Transmitter

Let's combine these basic building blocks into a complete, workable transmitter (Figure 2). This circuit is a simplified version of the all-band two

stage transmitter discussed in chapter 7. A study of the basic circuitry will be useful when the time comes to build the transmitter!

The Oscillator Stage

A crystal controlled oscillator, using a 6AG7 pentode tube is shown in this building block. The oscillator portion of the circuit is the grid-screen network of the tube. Oscillation may be maintained with the plate circuit of the 6AG7 tuned to some harmonic of the crystal. The stage thus acts as both a crystal oscillator and a frequency multiplier. Capacitor C2 serves as an amplitude limiting device for the oscillator circuit. Increasing the capacity will decrease the amplitude of oscillation, and the power output of the tube. Decreasing the capacity will increase the output up to a certain point, at which the circuit may become unstable, or damage to the crystal may result. Capacitor C1 serves to isolate the crystal and socket from the screen voltage of the tube which is applied through resistor R8. The screen voltage will not harm the crystal, but it might give the operator a nasty "bite" if he removed the crystal from its socket with the high voltage applied to the oscillator tube.

The plate circuit of the oscillator-amplifier tube may be tuned to the crystal frequency or to one of its harmonics. If an "80 meter" crystal is used, L1-C4 may be resonated at 80, 40 or 20 meters. It may also be tuned to 15 or 10 meters, but little power will be developed at these high orders of frequency multiplication. (An aside to the reader: "Frequency multiplication" is the same as "wavelength division." Substitute "frequency" for "wavelength" in the above remark and see.) In order to obtain a useable amount of power at these higher frequencies, it is necessary to use a crystal capable of oscillation at a higher frequency. In this case, a "40 meter" crystal (7 mc) may be used for 40, 20, or 15 meter operation. If it is desired to have 10 meter operation, the frequency multiplication is taken in two steps. The oscillator tube doubles from 7 mc to 14 mc, and the 6146 amplifier tube doubles from 14 mc to 28 mc.

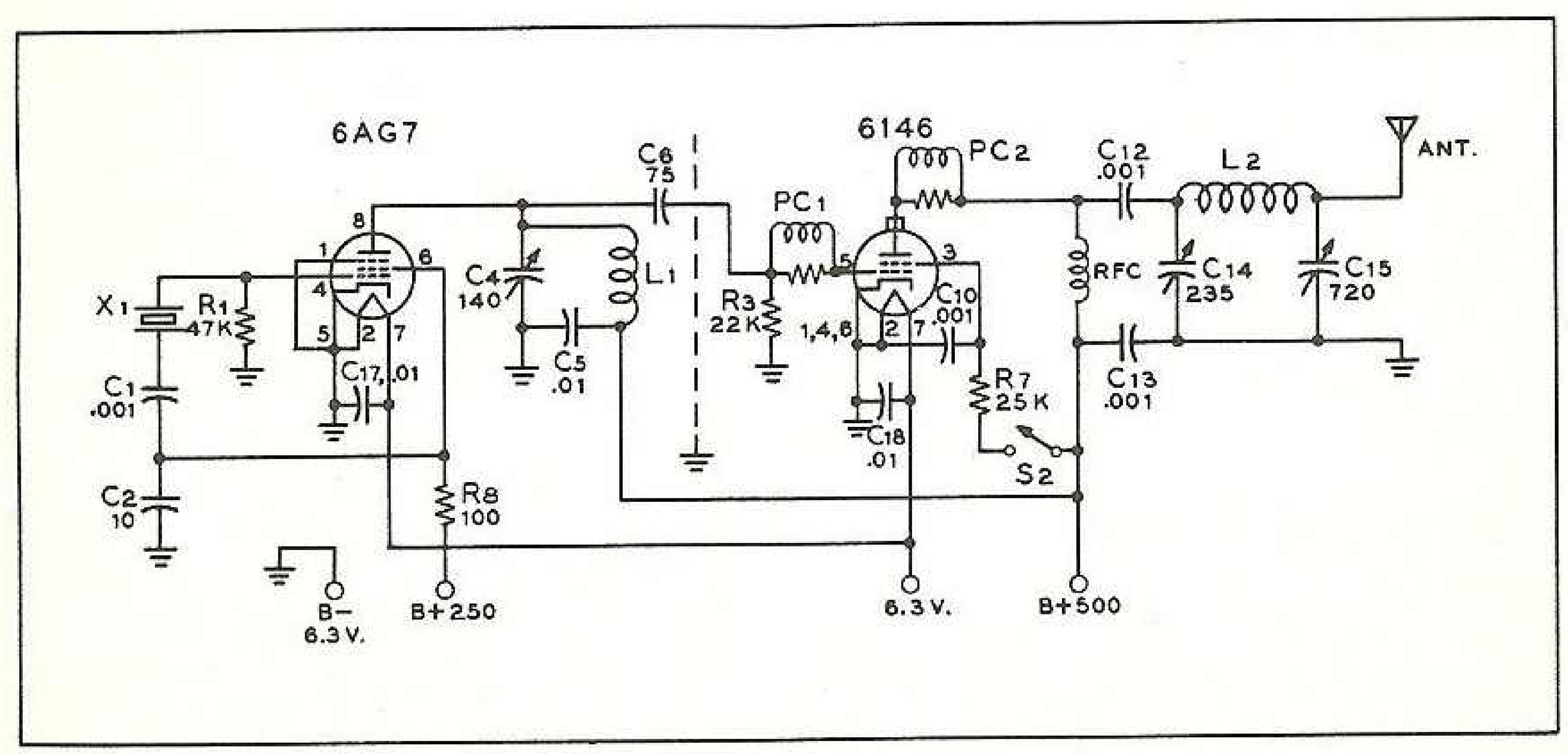


Fig. 2 A simplified diagram of the AB-60 transmitter shown in chapter 7. A 6AG7 harmonic crystal oscillator drives a 6146 amplifier-doubler stage. Good output may be obtained as high as eight times the crystal frequency. Operation of the complete circuit is covered in this chapter, as well as metering ideas.

The Power Amplifier Stage

The plate circuit of the 6AG7 oscillator-amplifier stage is capacity coupled by C6 to the grid circuit of the 6146 power amplifier. C6 prevents the plate voltage of the 6AG7 from being impressed upon the grid of the 6146, yet allows passage of the r-f voltage necessary for proper operation of the amplifier. Enough excitation is applied to the control grid of the 6146 to permit it to draw a small amount of grid current. This current, flowing through grid resistor R3 develops a *negative* operating bias at the grid of the tube. This amount of bias may be determined by Ohm's Law. If, for example, the resistor is 20,000 ohms, and the grid current flowing through it is 3 milliamperes (.003 ampere) the bias is equal to IxR (20,000 x .003), or 60 volts. This bias is entirely produced by the action of grid current, and the amplifier tube is said to be *self-biased.* That is, no external bias supply is used. If the oscillator ceases to function, the bias disappears. Loss of bias under full plate and screen voltage conditions will cause the amplifier tube to draw an excessive amount of plate current which in time may damage the tube. On the other hand, if the screen voltage is removed from the 6146, the value of maximum plate current in a state of no bias is severely limited. A screen voltage switch (S2) may be used to open the screen circuit of the amplifier stage for oscillator adjustment purposes.

To eliminate any tendency of spurious oscillation, parasitic suppressors (PC-1 and PC-2) are placed in the grid and plate leads of the amplifier tube. Almost all tubes have an intense desire to oscillate at some very high frequency when they are operated as an amplifier at a lower frequency. In many cases, these unwanted oscillations fall in or near the high frequency television channels. Suppression chokes will eliminate this intense desire! Oscillation at the operating frequency of the tube is suppressed by the shielding action of the screen grid of the tube, which is bypassed to ground by capacitor C10. In addition, a shield plate is placed between the input circuit (L1-C4) of the amplifier tube and the output circuit (C14-L2-C15) to prevent a circulation of r-f energy between these two tuned circuits. If a triode tube had been used as an amplifier instead of the 6146 tetrode, an external neutralizing circuit would have had to be added to the amplifier to prevent oscillation at the operational frequency of the stage.

Plate voltage is applied to the 6146 tube through an r-f choke (RFC-1) which serves to isolate the r-f energy in the amplifier plate circuit from the power supply components. The output circuit is coupled to the 6146 via capacitor C12 which removes the d-c plate voltage from the elements of the output circuit and from the antenna. Capacitors C5 and C13 prevent any leakage of r-f energy into the power supply leads.

The Antenna Coupler

The components C14-L2-C15 "double in brass" as a tuned plate circuit for the 6146 amplifier tube, and also as an antenna coupling device. This circuit is called a *pi-network coupler.* It is resonant at the operating frequency of the amplifier, and effects the proper impedance match between the tube and a low impedance antenna, or coaxial transmission line. In addition, this form of coupler offers considerable attenuation to harmonics of the transmitter, with consequent reduction of TVI problems. Tuning of such a network is discussed later in this chapter.

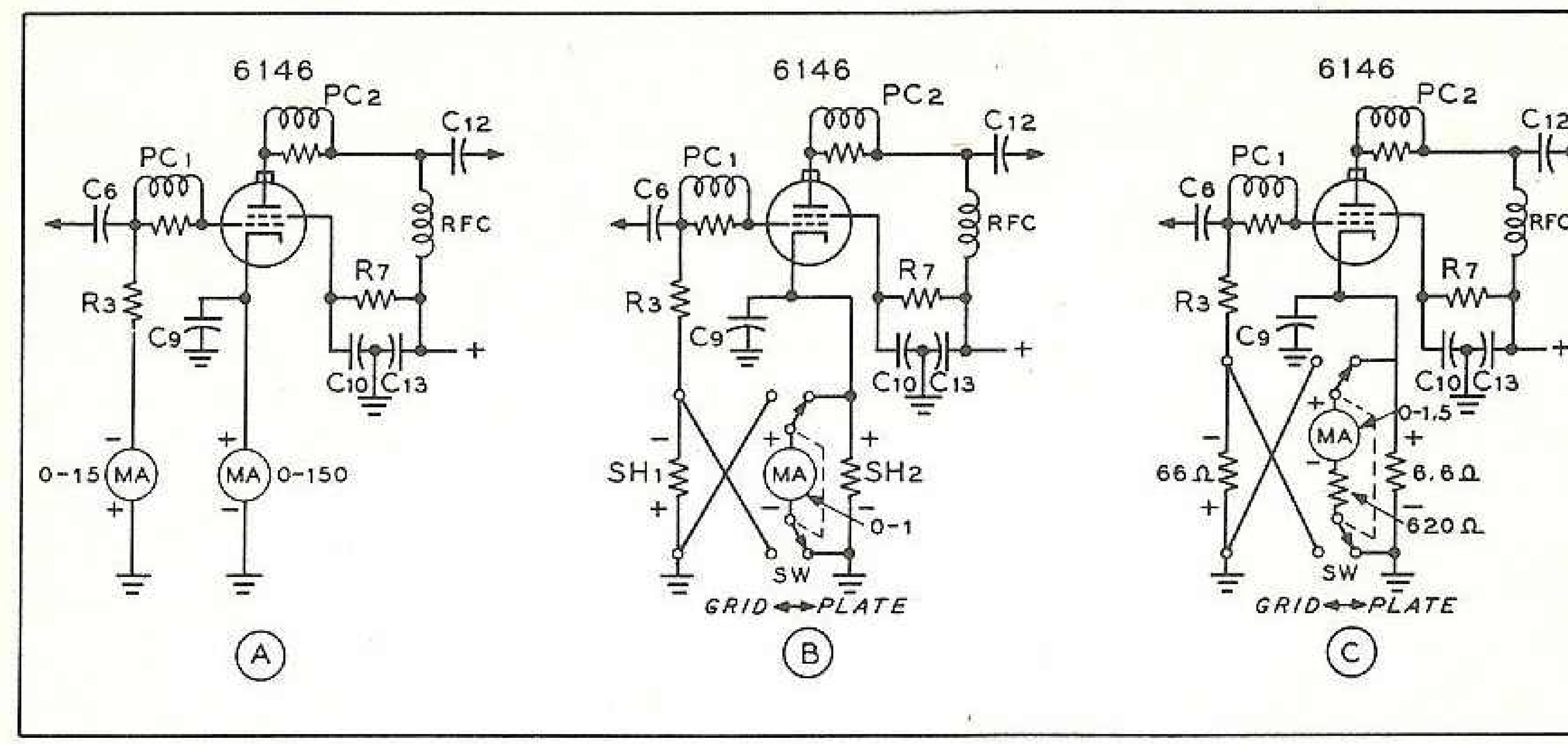


Fig. 3 By the use of a suitable switching circuit, a single 0-1.5 d-c milliammeter may be used to measure grid and plate currents of an amplifier stage.

Circuit Metering

The first additions to the basic transmitter of Figure 2 are metering circuits. Possible parameters to meter are the screen and plate currents of the oscillator, and the grid, screen and plate currents of the 6146 amplifier. The values of oscillator and amplifier screen and plate voltages are determined by power supply components, and need be checked only during the initial tuning process. Correct oscillator operation may be noted by measuring the value of grid current flowing through R3, so it is not necessary to measure the plate or screen current of the 6AG7 tube. Grid current measurement will also provide an important check on the operation of the amplifier stage.

Measurement of the 6146 amplifier plate current will permit us to figure the plate power input to the stage (the product of plate voltage times plate current *expressed in amperes).* The resonant dip in the plate current will also indicate the correctness of tuning of the amplifier plate circuit. Thus some provision must be incorporated in the transmitter to check the plate current of the 6146 amplifier. Since the plate current of the 6146 also flows through the cathode circuit, it is a good idea to place the plate current meter in the cathode lead, where the meter is at "ground potential." This removes any shock hazard present when the meter is placed in the high voltage lead. It must be noted that screen and grid currents also flow in the cathode circuit, and this extra current (about 10 milliamperes, total) must be mentally subtracted from the meter reading to obtain the true value of plate current.

Two separate meters may be used to measure the currents (Figure 3A), or a single meter placed across suitable shunts in the grid and cathode leads (Figure 3B) may be employed. The meter is switched between the shunts by a double-pole, double-throw switch. This thrifty system works fine in theory, but breaks down in practice when an attempt is made to buy meter shunts in the local radio store. The correct shunts are usually "odd-ball" values of resistance that are never carried in stock! We can be foxy, however, and get around this procurement roadblock with the neat little stunt shown in Figure 3C.

A Practical Dual Metering Circuit

The first step is to determine the full scale meter readings required in the grid and plate circuits. Let's assume that normal grid current is 3 ma, and we wish the full scale reading of the meter to be 15 ma. Let's also assume that the plate current is 120 ma, and we wish the full scale reading of the meter to be 150 ma. We will now design each meter shunt to have *one volt* drop across it at the full scale meter current values. Then we'll make our milliammeter into a voltmeter having one volt as the full scale meter reading. The meter will measure the *voltage drop* across each shunt. In each case, the shunt resistance is known, and the required current (by Ohm's Law) is directly proportional to the reading of the voltmeter. O.K.? Here we go:

First step. Determine the value of the grid circuit shunt. R=E/I=1/.015=66.6 ohms, where R is the resistance of the shunt in ohms, E is the voltage drop across the shunt, and I is full scale meter current in *amperes.*

Second Step. Determine the value of the plate circuit shunt. R=E/I=1/0.15=6.6 ohms, where R is the resistance of the shunt in ohms, E is the voltage drop across the shunt, and I is full scale meter current in *amperes.*

Voila! The grid shunt can be a 68 ohm resistor, which costs about ten cents. The plate shunt is a 6.8 ohm resistor. These common values are close enough for practical purposes. In each case five per-cent tolerance resistors should be used.

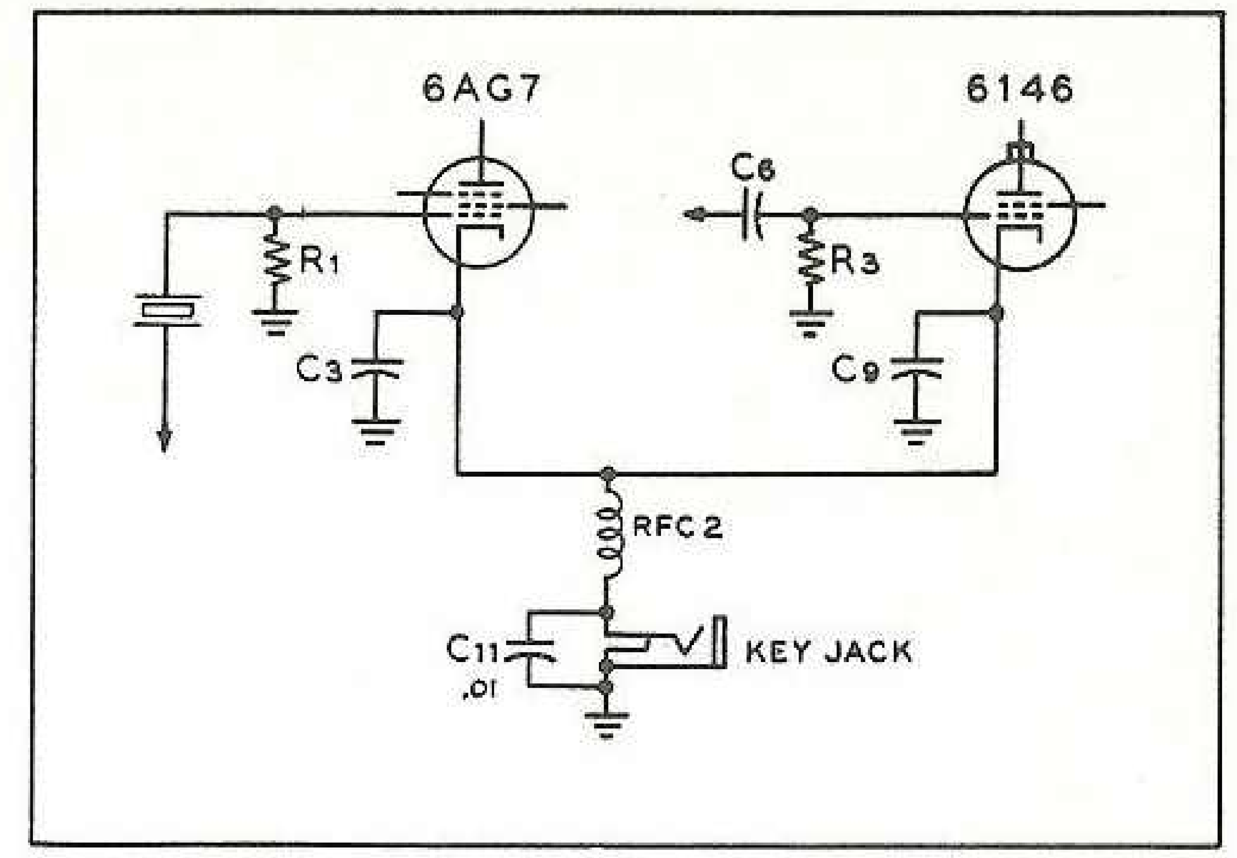
Third Step. Determine the value of the meter multiplier. For greatest accuracy, the meter should draw as little current as possible. A 0-1.5 d-c milliammeter is ideal for this circuit. The multiplier resistance required for conversion of the meter to read one volt full scale is: R=E/I=1/.0015=666 ohms, where I is the full scale meter reading in *amperes.* A ten cent 620 ohm 5% resistor may be employed.

The complete dual meter circuit is shown in Figure 3C. The operator must remember that full scale meter reading is 15 ma with the switch in the "grid" position, and 150 ma with the switch in the "plate" position. Since the meter action is linear, it is easy to interpolate lower values of meter reading. For example, 2 ma of grid current will indicate 0.2 on the meter scale, and 100 ma of plate current will indicate 100/150, or 0.66 of full scale reading.

The Keyer

At this stage of the game we have a workable transmitter. The next step is to install some form of keying circuit. All keyers act to disable one or more tubes of the transmitter, either by removing an essential voltage, or by over-riding or blocking out a control voltage. For this particular circuit, the simplest keying system to use is one that interrupts the high voltage to the tubes. The high voltage lead could be broken by a key, but that would place a lethal voltage across the key contacts. If the voltage is broken in the cathode circuit instead of the plate circuit, the blocking action of the tubes tend to reduce the voltage across the key. In addition, one side of the key is at ground potential. A suitable keying system for this transmitter is shown in Figure 4. Additional capacity is placed across the keying circuit (C11) to reduce the keying impact, or *key click* that is generated by such a simple keying system.

Fig. 4 Oscillator and amplifier may both be keyed in cathode circuit. Extra capacity is added across key (C11) to reduce key-click. R-f choke is added to keying circuit to reduce the harmonic radiation from the key leads.



The Power Supply

The remaining building block to be added to the transmitter is the power supply. Power supply theory and circuits are covered in chapter 8 of this Handbook, and a suitable supply for this transmitter is shown in the schematic in chapter 7.

Tuning the Transmitter

The average Novice transmitter has less panel controls than its companion receiver. Nevertheless, it is still as much of an "art" to tune the transmitter properly as it is to tune the receiver. Transmitter adjustments are usually quite simple *if* the operator knows just what he is doing, and he does the tuning in the correct sequence. The ultimate objective in the tuning process is to generate as much power as is possible in the transmitter and to get it into the antenna where it can do some good. All adjustments, however, must be consistent with the safety of the operator, and the maximum ratings of the transmitter components. Above all, the transmitter must not be "pushed" too hard, or a poor signal and television interference problems will develop.

Tuning the Transmitter for the First Time

Let's tune up the transmitter we have been discussing. First of all, disconnect the antenna from the station receiver and tune it to the approximate frequency of the crystal to be used in the transmitter. Plug the crystal in the transmitter, and insert a telegraph key in the jack. Be sure the transmitter power line is correctly fused. A fuse is cheap insurance if something goes wrong! Apply filament voltage to the transmitter by turning on the a-c line switch. Note if all tubes light. Set the band switch to the proper frequency range. Be sure the screen circuit to the amplifier tube is open. (Note: The version of this transmitter described in chapter 7 automatically opens the screen circuit when switch S2 is placed in the "grid" position.) After 30 seconds or so, close the key and tune C4 (oscillator tuning control) for an indication of grid current on the meter. Send a series of short dashes with the key and tune the receiver back and forth across the frequency of the crystal. The oscillator should be heard in the receiver each time the key is closed. If the oscillator is not heard, or no grid current can be observed

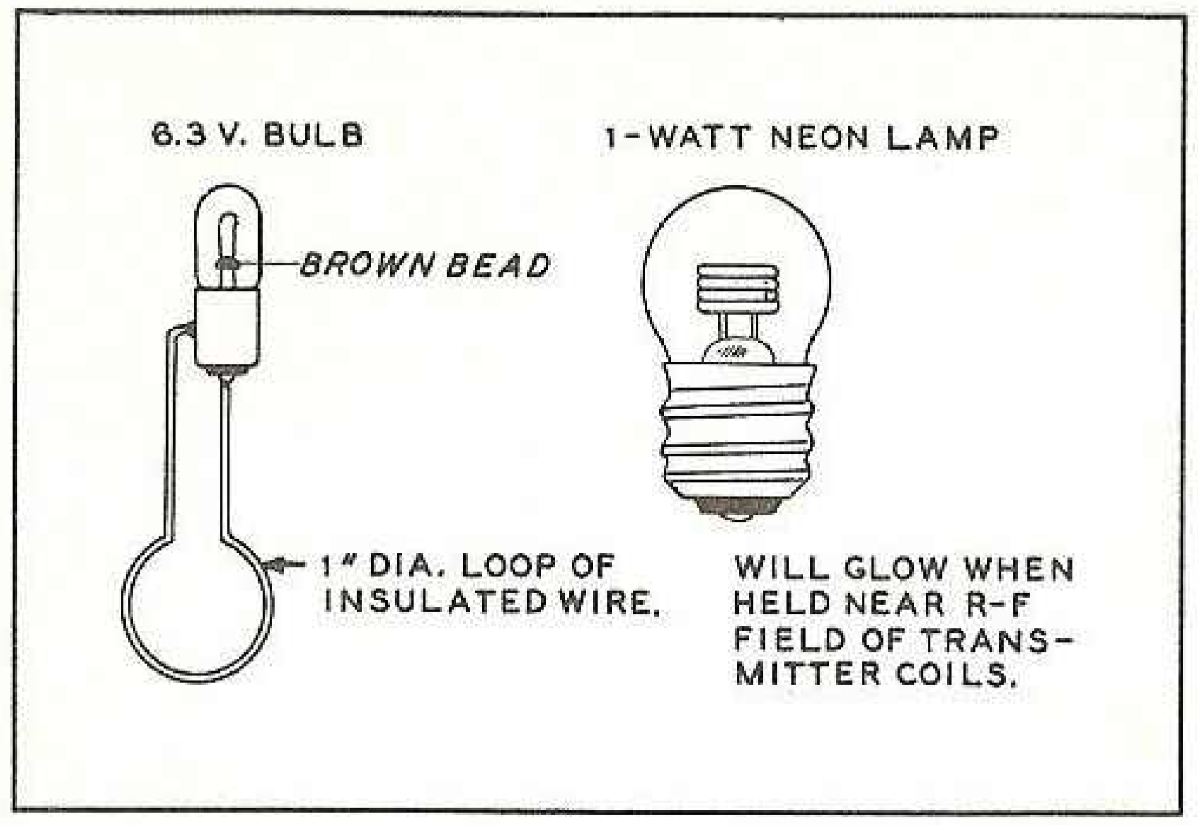


Fig. 5 Neon lamp, or flashlight bulb may be used as a simple r-f indicator. These basic instruments are helpful during preliminary tuning and adjustments.

on the meter, turn off the transmitter and check for wiring errors or defective tubes or parts.

When the crystal oscillator has been heard in the receiver and is known to be working, a neon lamp touched to the plate pin of the oscillator tube should glow brightly. *Don't* touch the plate pin yourself, or you will get a juicy shock! A flashlight bulb attached to a loop of wire (Figure 5) placed over the oscillator coil should glow, indicating the presence of r-f energy. If necessary the oscillator tuning control should be detuned slightly so as not to exceed the maximum grid current rating of the amplifier tube.

The next step is to test the power amplifier stage. Couple a 50 watt light bulb to the antenna terminals of the transmitter to serve as a dummy load. The antenna loading capacitor (C15) should be set to maximum value, and the station receiver should be tuned to the approximate operating frequency of the amplifier stage, if it happens to be different than the frequency of the crystal. The meter switch is set to the "plate" position, switching the meter to the cathode circuit of the 6146, and closing the screen circuit. Now, when the key is pressed the 6146 will go into action! Press the key, and rotate the amplifier tuning capacitor (C14). At some point, the plate current will drop in value, and the dummy load bulb will light up. The degree of brilliance of the bulb and the amount of plate current dip are a function of the setting of C15 (antenna loading control). Decreasing the capacity of C15 will increase the antenna coupling and raise the plate current value, and vice-versa. C15 should be varied bit by bit until the resonated plate current is the correct value—in this case 120 ma. After each change of C15, the amplifier tuning capacitor C14 should be retuned for minimum plate current. The transmitter may now be keyed. Keying should be clean, without noticeable clicks or chirps. A slight variation in the setting of the oscillator tuning control (C4) may improve the keying characteristic to a degree. Be sure not to overload the receiver while listening to the keying, or you cannot obtain a true idea of just how it sounds.

Before the transmitter is coupled to the antenna, it is wise to check the actual frequency of each tuned circuit to make sure that it is operating where you think it is. This may be done with a wavemeter or with the aid of a grid-dip meter. If the circuits are found to be in tune, the dial settings should be written down for future reference. A final check should be made of the power supply voltages. These should be measure and written down, so if trouble develops in the future, the correct voltages are known for comparative purposes.

CHAPTER VII

Transmitter Construction—The Easy Way

THE "LITTLE JIFFY" 15 WATT TRANSMITTER FOR 40 AND 80

Interested in a simple and reliable 1-tube beginner's transmitter? Here it is! Complete with antenna tuner and selenium-type power supply, this midget rig puts out an imposing signal for its small size and modest cost. Suitable for operation on 3.5 mc or 7 mc without the necessity of coil changing, the "Little Jiffy" 15 watt transmitter is ideally suited as a "first" transmitter for the Novice ham. Best of all, the transmitter may be built for approximately $20, including parts and the tube.

This single tube c-w transmitter is an inexpensive way to "get your feet wet" on the low frequency Novice bands. Using an inexpensive television sweep tube, this pint-sized powerhouse runs 15 watts input on either the

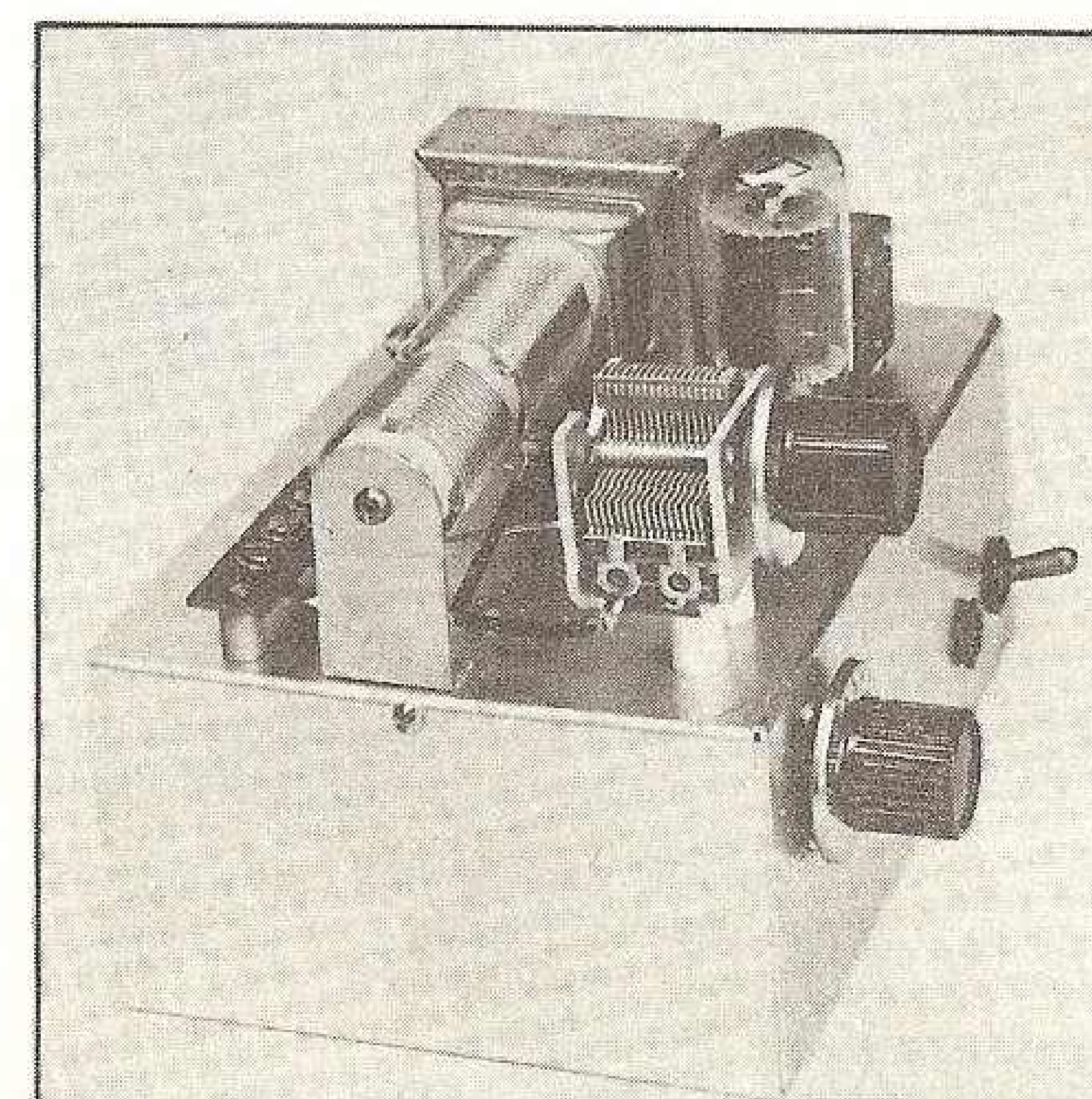


Fig. 1 The "Little Jiffy" 15-watt transmitter is only 3"x5"x 7" in size and uses a single 6AV5 tube. Antenna tuning capacitor C2 is at the right, with coils L1-L2 directly behind it. Antenna terminal strip is at far left, with power transformer T1 to the rear.

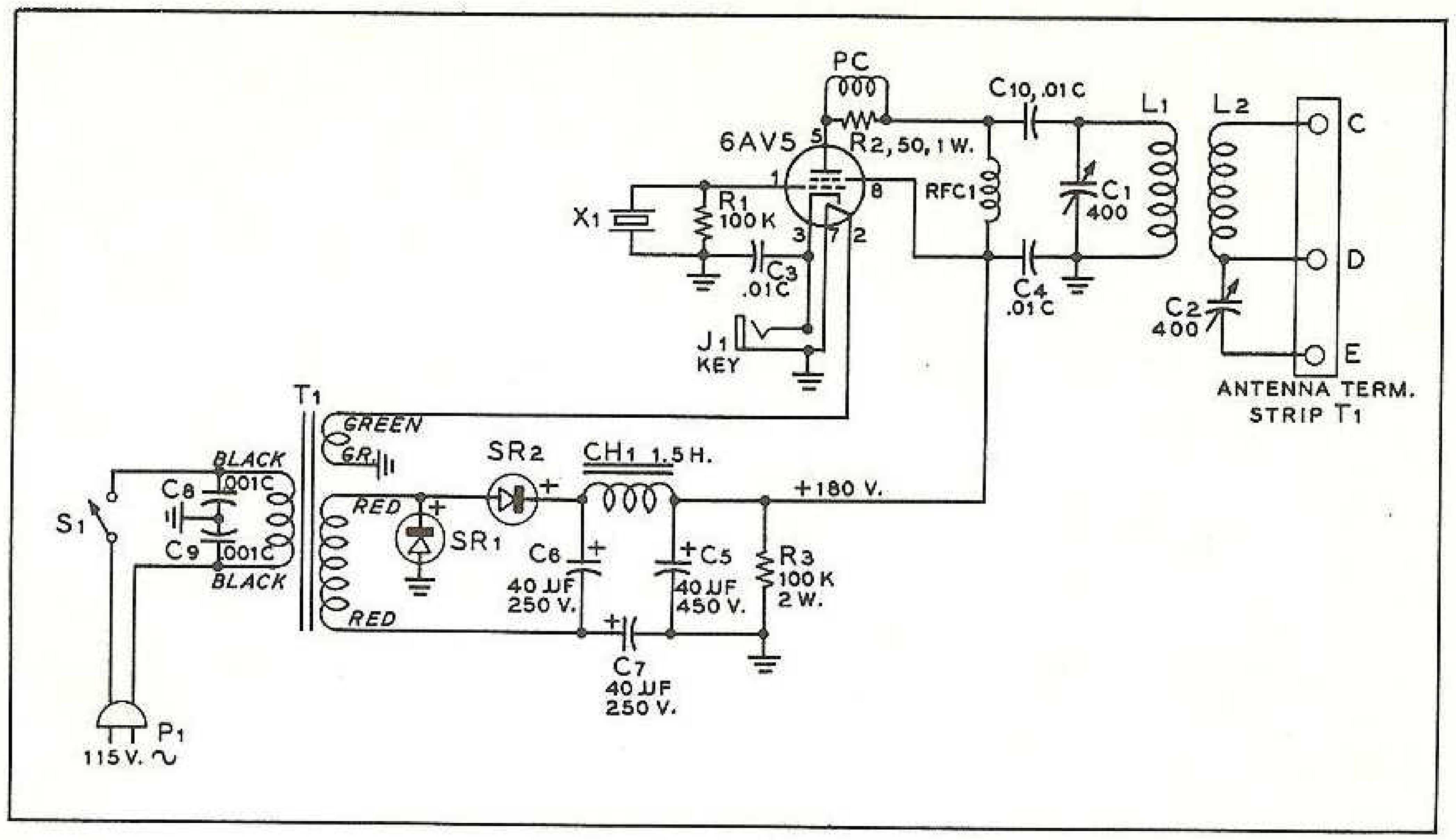


Fig. 2 Schematic of LJ-15 transmitter. Voltage-doubler power supply is used.

80 meter or 40 meter band. No coil changing is necessary when you jump from band to band. Merely plug a crystal of the correct frequency in the holder, tune up, and away-y-y you go! The simple antenna tuner permits many different types of antennas to be used with the transmitter, and at the same time reduces the possibility of harmonic radiation and the accompanying TVI problems. Don't be fooled by the 15 watt power level! This rig is capable of good, solid contacts, and makes use of every watt. It can be used long after you have obtained your "general" ticket.

Transmitter Circuit and Construction

The schematic of the LJ-15 ("Little Jiffy fifteen watter") is shown in Figure 2. A 6AV5 pentode tube is used as a crystal oscillator, with a plate circuit covering both 80 and 40 meters. A simple antenna tuner (L2-C2) allows "Zepplin" tuned feeders, a low impedance transmission line, or end fed antenna systems to be used with equal ease. Several antennas for use with this transmitter are shown in chapter 9. The power supply consists of a half-wave transformer (T1) and a voltage doubler rectifier, using two selenium rectifiers (SR1 and SR2). The supply will deliver 15 watts to an intermittent load, such as provided by c-w operation. The complete transmitter is constructed upon the "top" of an aluminum box measuring 7" x 5" x 3". Placement of the major components may be seen in Figures 1 and 4, and in the chassis drawing layout, Figure 3.

The following wiring and assembly instructions are presented in a step-by-step sequence to enable the constructor to complete the project easily and correctly. Be sure to read each step all the way through before you start to do it. When the step is completed, check it off in the space provided.

( ) Lay out the chassis holes (Figure 3) to be drilled on the paper wrapper of the chassis. Drill the holes and remove the burrs.

( ) Mount the octal socket, using 6-32 hardware. The socket key faces the crystal socket holes.

( ) Mount the crystal socket (X1), using 4-40 hardware. Place a ground lug under the retaining nut near the edge of the chassis.

( ) Place 3/8" rubber grommets in holes A, B, C, and D.

( ) Mount power transformer T1 atop the chassis using 6-32 hardware. The 115-volt leads (black) pass through hole A.

( ) Mount filter choke CH1 beneath the chassis, with the leads facing the center of the chassis.

( ) Mount the two selenium rectifiers (SR1 and SR2) to the chassis using an 8-32 bolt 2½" long. The "plus" terminal of each rectifier should face the retaining nut, and the "minus" terminals should face the chassis. The connecting lugs of the rectifiers face the center of the chassis.

( ) Mount antenna tuning capacitor C2 atop the chassis, using two 5/8" ceramic insulators and 6-32 hardware. Cut the heads off of two bolts, and thread the bolts into the insulators. The top bolts that fasten capacitor C2 to the insulators pass into two holes in the aluminum frame of C2. Place a soldering lug between the capacitor and one insulator to make a connection to the rotor. The holes in the capacitor should be threaded with a 6-32 tap. Be careful not to run the tap into the plates of the capacitor. Also make sure the mounting bolts are not too long, or they will hit the plates of C2.

( ) Mount tuning capacitor C1 to the front of the aluminum box. A cardboard template may be made to mark the location of the three mounting holes. Use 6-32 bolts cut very short.

( ) Mount key jack J1, and power switch S1 on the front panel.

( ) Mount a two terminal phenolic tie-point strip in hole K.

( ) Mount two four terminal phenolic tie-point strips (A and B) in holes E, F, G, and H on the rear of the chassis.

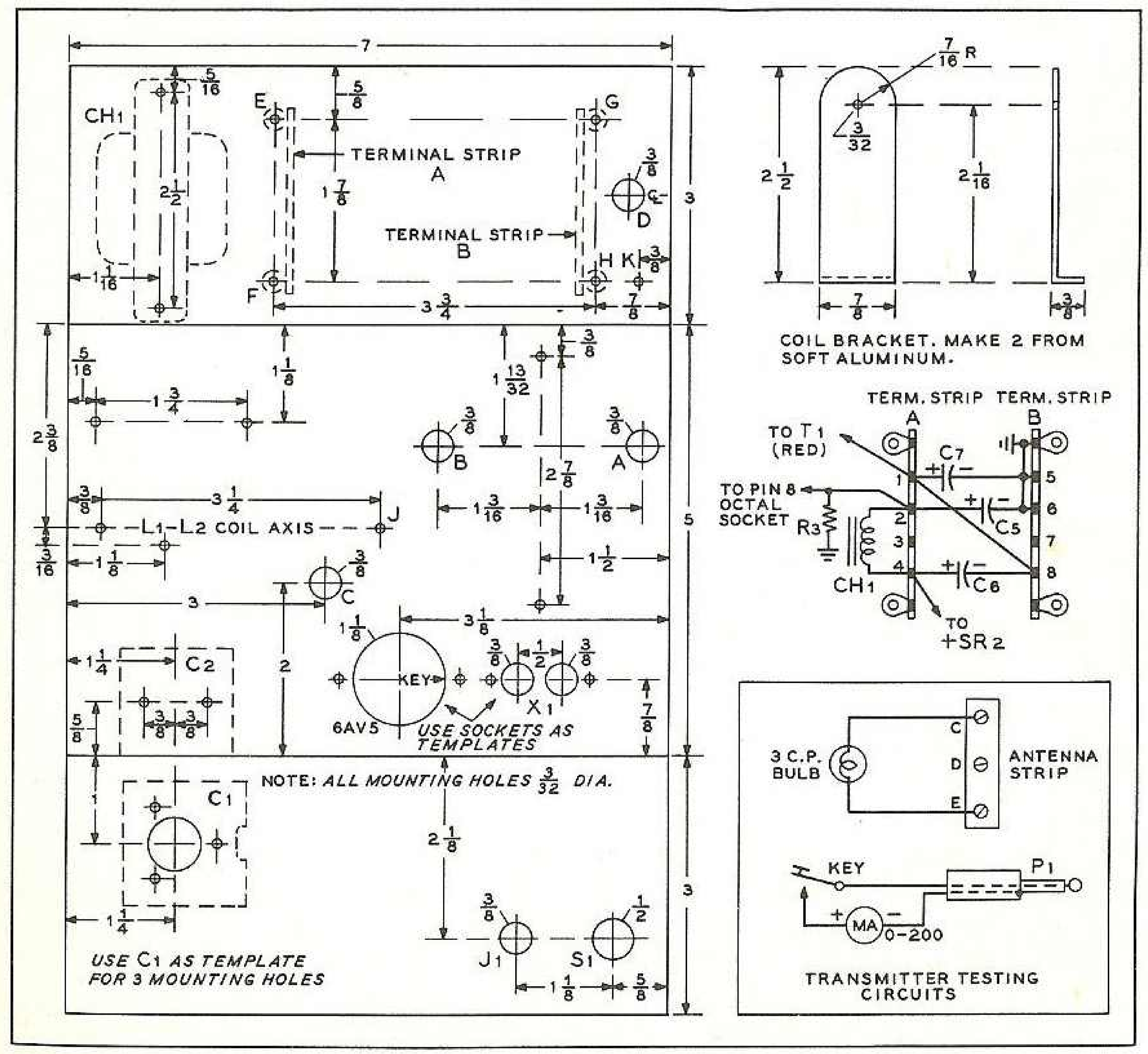


Fig. 3 Parts layout and chassis template for LJ-15 transmitter. Coil brackets for L1-L2 are shown at upper right. The test circuits are shown at the lower right.

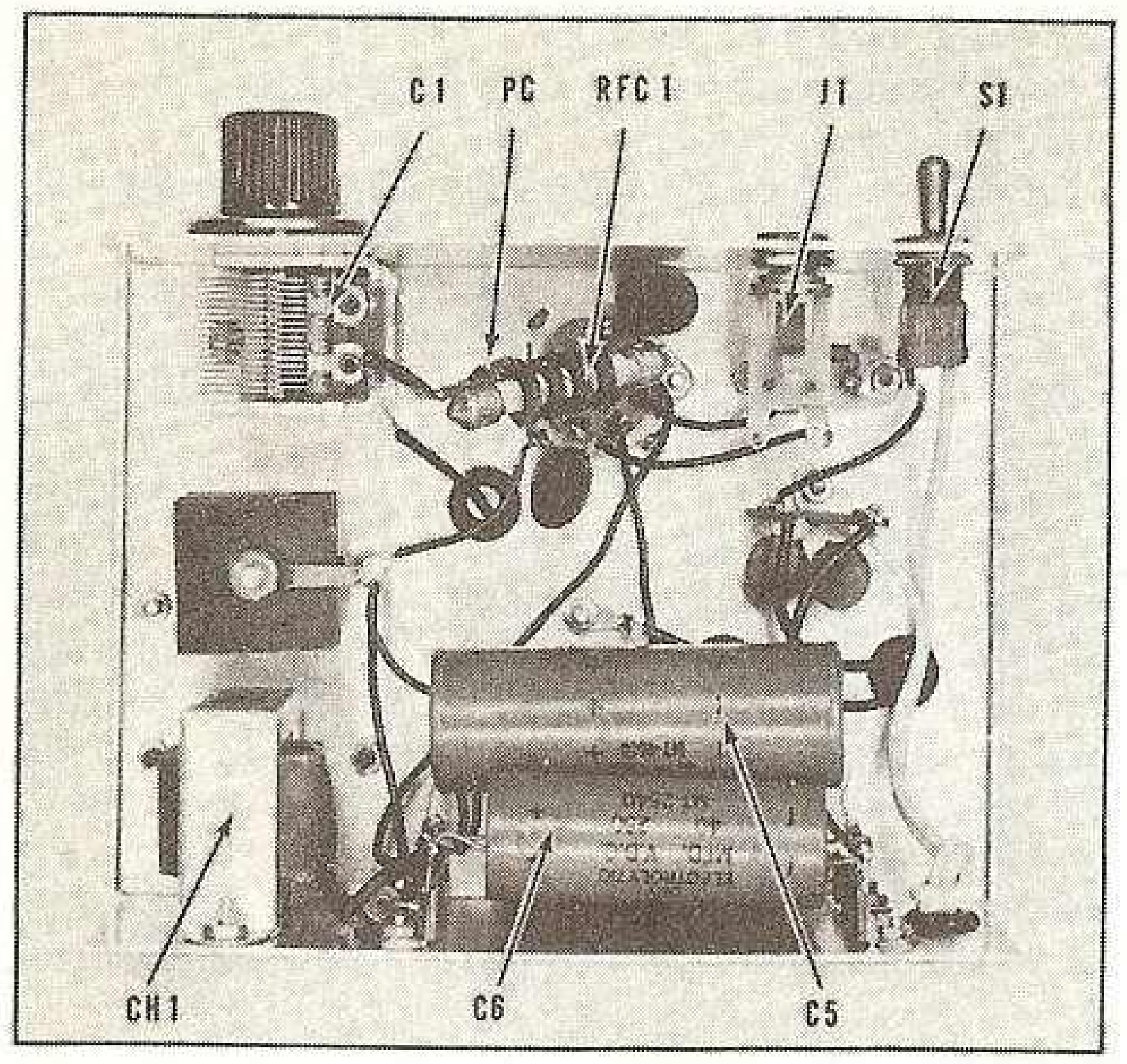


Fig. 4 Under chassis view of LJ-15 transmitter. Selenium rectifier is mounted to the chassis by long bolt. The line filter capacitors (C8, C9) are mounted to phenolic strip behind key jack, J1.

( ) Install a .01 disc ceramic capacitor (C3) between pin 3 and the adjacent ground lug of the octal socket.
( ) Install a .01 disc ceramic capacitor (C4) between pin 8 and pin 7 of the octal socket.
( ) Ground pin 7 of the octal socket to the adjacent ground lug.
( ) Install a 100 K resistor (R1) across the pins of crystal socket X1.
( ) Ground one pin of crystal socket X1 to the ground lug under the retaining nut. Connect a wire from this ground lug to pin 7 of the octal socket. phenolic tie-point (K) to the center, grounded terminal.
( ) Connect a wire from pin 1 of the octal socket to remaining pin of X1.
( ) Install a .001 ceramic capacitor (C8) from one lug of the two terminal phenolic tie-point (K) to the center, grounded terminal.
( ) Install a .001 ceramic capacitor (C9) from the other lug of tie-point strip (K) to the center, grounded terminal.
( ) Install a 40 uf electrolytic capacitor (C7) between terminals 1 (plus) and 5 (minus) of the two four terminal strips (Figure 3).
( ) Install a 40 uf electrolytic capacitor (C6) between terminals 4 (plus) and 8 (minus) of the two four terminal strips (Figure 3).
( ) Connect a lead from terminal 1 of strip A to terminal 8 of strip B (Fig. 3).
( ) Ground terminals 5 and 6 of strip B to the ground lug of the strip.
( ) Attach the black leads of filter choke CH1 to terminals 2 and 4 of strip A.
( ) Install a 40 uf 450 volt electrolytic capacitor (C5) between terminals 2 (plus) and 6 (minus) of the two capacitor terminal strips.
( ) Attach one filament lead (green) of T1 to terminal 2 of the octal socket.
( ) Attach one high voltage lead (red) of transformer T1 to terminal 1 of capacitor terminal strip A.
( ) Solder together the two center terminals of rectifiers SR1 and SR2.
( ) Attach the second high voltage lead (red) of T1 to the two center terminals of SR1 and SR2.
( ) Connect a wire from the "plus" terminal of SR2 (top) to terminal 4 of capacitor terminal strip A.
( ) Connect a wire from the "minus" terminal of SR1 to a ground lug of the octal tube socket.
( ) Connect a wire from pin 8 of the octal tube socket to terminal 2 of capacitor terminal strip A.
( ) Attach the 115 volt leads (black) of transformer T1 to each of the two tie-points of phenolic strip K.
( ) Install a 100 K, 2 watt resistor (R3) between terminal 2 of capacitor terminal strip A and the ground terminal of this strip.
( ) Cut two coil support brackets from soft aluminum (Figure 3).
( ) Cut the prepared coil material into two equal coils of 24 turns each. Pull the end wires away from the insulating material until each coil is reduced to 20 turns. Peel the turns from both ends of the coils, forming leads.

( ) Cut a 3¾" length of ⅞" diameter wooden dowel stock. Sand the ends and slide the coils onto the dowel rod. Trim the rod slightly with a knife if necessary to obtain a smooth, sliding fit.
( ) Mount the dowel rod to the aluminum support brackets with ¼" wood screws, as seen in Figure 1.
( ) Mount the coil support brackets to the chassis, using 6-32 hardware. Place a ground lug beneath the bolt head of the bracket nearest the edge of the chassis.
( ) Ground the second filament lead (green) of transformer T1 to a ground lug (J) beneath the nut of the coil bracket nearest the center of the chassis.
( ) Mount the three terminal phenolic antenna strip atop the chassis. Use ⅜" metal spacers to hold the strip above the chassis.
( ) Ground the inner-lead of coil L1 (right coil, viewed from front) to the ground lug at the outside coil bracket. Slip a section of insulating sleeving over the lead before the connection is made.
( ) Pass the opposite lead of coil L1 through chassis grommet C. Slip a section of insulating material over the lead, and connect the lead to a *stator terminal* of capacitor C1.
( ) Connect the inside lead of coil L2 (left coil, viewed from front) to terminal C of the antenna strip.
( ) Connect the outside lead of coil L2 to terminal D of the antenna strip.
( ) Connect terminal D of the antenna strip to the *rotor soldering lug* of capacitor C2.
( ) Connect terminal E of the antenna strip to the *stator terminal lug* of capacitor C2.
( ) Take a short length of remaining wire left over from one of the coils, and wind 5 turns of it around the 50 ohm resistor R2. Space the turns evenly and solder to the resistor leads. This combination forms parasitic choke PC.
( ) Attach one end of choke PC to pin 5 of the octal socket.
( ) Attach one end of a 2½ mh r-f choke (RFC-1) to pin 8 of the octal socket.
( ) Twist the free leads of choke PC and choke RFC-1 together, so that the junction lies about ½" from the *stator terminal* of capacitor C1. Cut the twisted leads short and solder.
( ) Install blocking capacitor C10 between the stator terminal of C1 and the junction of the leads of PC and RFC-1.
( ) Connect a wire between pin 3 of the octal socket and the ungrounded terminal of key jack J1.
( ) Pass the leads of a 115 volt line cord through grommet D. Tie a knot in the leads.
( ) Attach one 115 volt lead to one tie-point of phenolic strip K.
( ) Connect a wire between the other tie-point of strip K and one lug of toggle switch S1.
( ) Attach the other lead of the 155 volt cord to the other terminal of toggle switch S1.
( ) Check all the above connections for shorts, opens, transpositions, and accidental grounds.
( ) Place knobs on capacitors C1 and C2. Adjust the knobs so that they read "10" when the capacitors are fully meshed.

Transmitter Testing

When the transmitter wiring has been completed and checked, the LJ-15 is ready for testing. Insert the 6AV5 and an 80 meter crystal in their respective sockets. With an ohmmeter, measure the resistance between pin 8 of the octal socket and the chassis. After the filter capacitors of the transmitter are charged by the battery of the ohmmeter, the reading should be close to 100 K (100,000 ohms). Plug a key and a 0-200 d.c. milliammeter in the key jack (Figure 3). Connect a 3 candlepower lamp between terminals C and E of the antenna terminal strip. Set the dials of C1 and C2 to "10" (full capacity). Turn on the transmitter and observe that the tube lights. If it does not, turn off the transmitter and check the power supply and filament wiring. After the transmitter has warmed up for about a minute, close the key. A reading of about 150 milliamperes should be observed on the meter. Tune capacitor C1 for a dip in meter current to about 70 ma. This is indication that the circuit is oscillating. Decrease the capacity of antenna tuning capacitor C2 until the lamp in the antenna circuit lights. Retuning C1 and C2 will provide a plate current of about 80 to 85 milliamperes and maximum bulb brilliance. Practice tuning the transmitter for best indication of the antenna circuit lamp. Listen to the transmitter in a nearby receiver, and tune C1 and C2 for best keying characteristic. It will be found that it will be necessary to detune C1 a bit from maximum output to obtain the smoothest keying.

The antenna bulb, of course is an indication of the power output of the transmitter. Note the correlation between plate current reading, the tuning of C1 and C2 and bulb brilliance. Note also that the physical separation between L1 and L2 can be adjusted for maximum brilliance, with a plate current not exceeding 85 ma. Coupling between L1 and L2 may be varied by pushing the coils closer together with a section of wooden dowel rod. Do not touch the coils while the transmitter is operating.

The tuning capacitors should now be set at "zero" (minimum capacity) and a 7 mc crystal plugged in the holder. The key is closed, and C1 tuned for the usual plate current dip. C2 may then be tuned for maximum brilliance of the antenna bulb at a plate current of about 80-85 ma. Write down the dial settings for 7 mc and 3.5 mc. Also, experiment with the coupling between coils L1 and L2. When you are thoroughly familiar with the operation of the LJ-15, the dummy load bulb may be removed, and an antenna attached to the transmitter. Antenna tuning is covered in chapter 9 of this Handbook.

Parts List for LJ-15 Transmitter

2—Variable capacitor, 400 mmf. (Allied Radio Co., Chicago. Catalog #61-H-009) (C1, C2)
3—.01 mf. 600 volt disc capacitor (Centralab DD-103) (C3, C4, C10)
1—40 mf. 450 volt electrolytic capacitor (Sangamo MT-4540) (C5)
2—40 mf. 250 volt electrolytic capacitor (Sangamo MT-2540) (C6, C7)
2—.001 mf. 600 volt disc capacitor (Centralab DD-102) (C8, C9)
1—100,000 ohm, ½-watt resistor (IRC type BTS or BW-½) (R1)
1—50 ohm, 1-watt resistor (IRC type BTA or BW-1) (R2)
1—100,000 ohm, 2-watt resistor (IRC type BTB-2 or BW-2) (R3)
1—Transformer, 125 volts at 50 ma., 6.3 volts (Stancor PA-8421) (T1)
1—Choke, 1.5 H at 200 ma (Stancor C-2327) (CH1)
2—75 ma selenium rectifier (Federal 1003) (SR1, SR2)
1—Inductor (B&W 3015 or Air Dux 816T) (L1, L2). 20 turns #14 tinned wire, 1" diam., 1¼" long each.
1—Crystal holder (Millen 33102) (X1)
1—Open circuit jack (Mallory A-1) (J1)
1—SPST toggle switch (H&H 20994-EW) (S1)
1—Octal socket (Amphenol 168-015)
1—6AV5 tube (RCA)
1—Line cord and plug (Belden 1765B)
2—Phenolic tie-point, 4 terminal (Cinch-Jones 54A)
1—Phenolic tie-point, 2 terminal (Cinch-Jones 52A)
1—Screw-type terminal strip, 3 lugs (Cinch-Jones 17-3)
2—Ceramic insulators, ⅝" high (Johnson 135-500)
2—Metal spacers, ⅜" high
2—Knobs, National type HRS-5
1—⅞" diameter dowel rod (hardware store item)
1—Chassis box, 7"x5"x3" (LMB #145)
4—⅜" rubber grommets (Walsco 7034F)
1—3 candlepower bulb, 6 or 12 volt (Tung-sol 63 or 67)
5 feet insulated hookup wire
1 foot insulated sleeving
1—Crystal, type FT-243, 80 or 40 meter Novice band.

50 WATTS IN A SMALL PACKAGE

Here is a simple two-tube transmitter that will really punch a hole through the 80 and 40 meter QRM. Running a hefty 50 watts input, this "Small Package" costs less than $26, including all parts and tubes. No coil changing is necessary for operation on either 3.5 mc or 7.0 mc, and the transmitter incorporates a simple antenna tuner for ease of operation and TVI reduction. All in all, this is a fine rig for the Novice who wants the best for a few dollars. If you have a junk box, the cost will be less!

The two tube "Small Package" (SP-50) transmitter runs a husky 50 watts input on the two low frequency Novice bands. The wide range tank circuit (L1-C4) covers the 3.5 mc to 7.3 mc range, eliminating messy plug-in coils, and expensive band switching arrangements. The simple antenna tuner (L2-C6) allows the use of various types of antennas with the minimum of fuss and bother. In addition, this form of inductive coupling reduces bothersome TVI-producing harmonics to a minimum. Simple to build and capable of an outstanding signal, the SP-50 is an ideal transmitter for the Novice or "general" amateur.

Transmitter Circuit and Construction

The schematic of the SP-50 is shown in Figure 6. A 1614 (premium type 6L6) is used as a crystal oscillator, employing either 80 meter or 40 meter crystals. The plate circuit (L1-C4) is shunt-fed to remove the dangerous d-c plate potential from circuits that the operator might accidentally touch. The power supply consists of a 5U4-GB rectifier tube and a capacitor input filter. Screen voltage is derived from a bleeder resistor (R4-R5) placed across the output of the supply. The complete transmitter is constructed upon the top of an aluminum chassis-box measuring 10" x 4" x 2½". Placement of the major components may be seen in Figures 5 and 9, and in the chassis drawing layout of Figure 7.

The following wiring and assembly instructions are presented in a step-

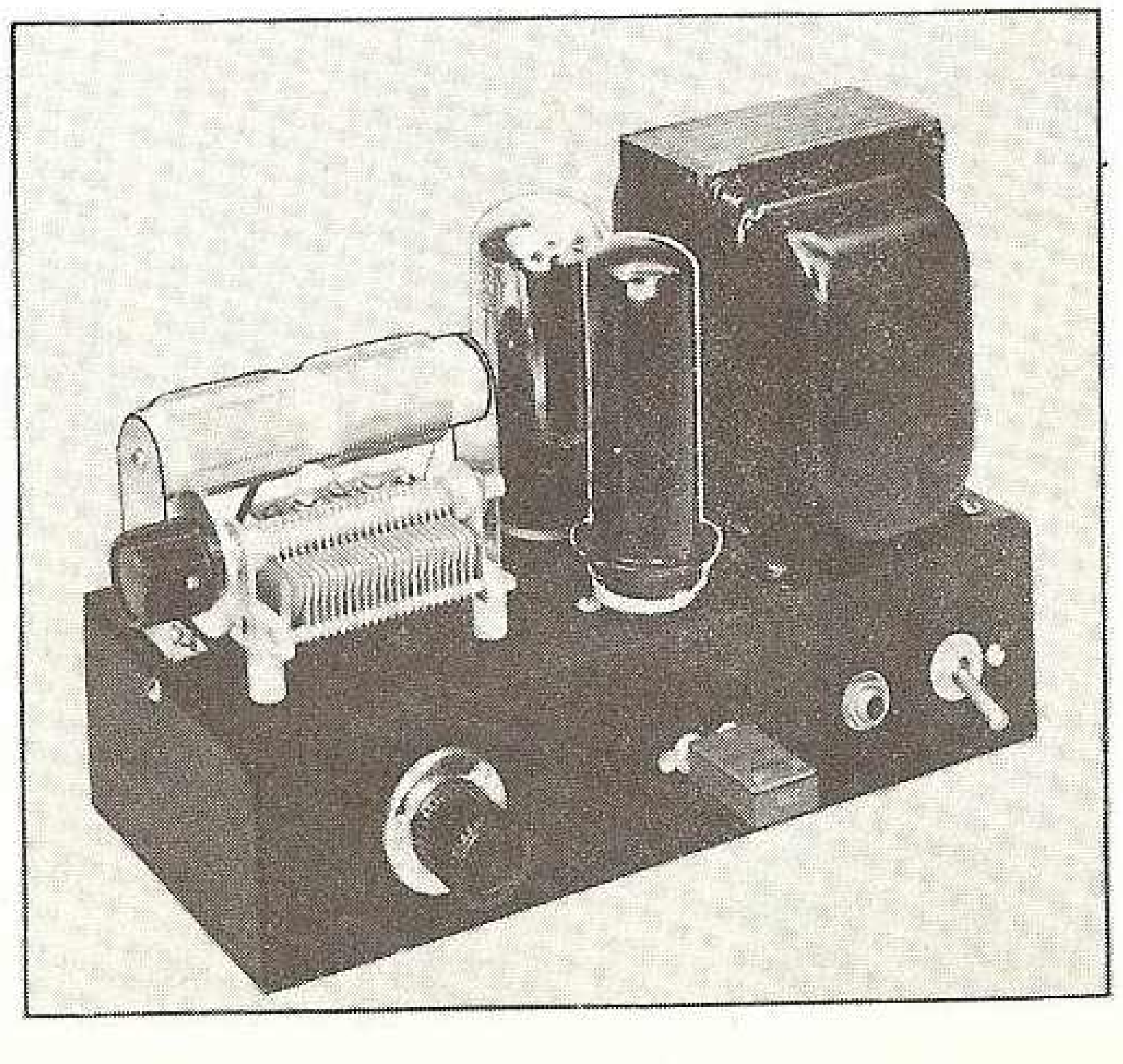


Fig. 5 The SP-50 transmitter runs 50 watts input on the 7 mc and 3.5 mc amateur bands. A 1614 pentode is used as a crystal oscillator, and a 5U4-GB serves as a high voltage rectifier. A built-in antenna tuner is a feature of the SP-50.

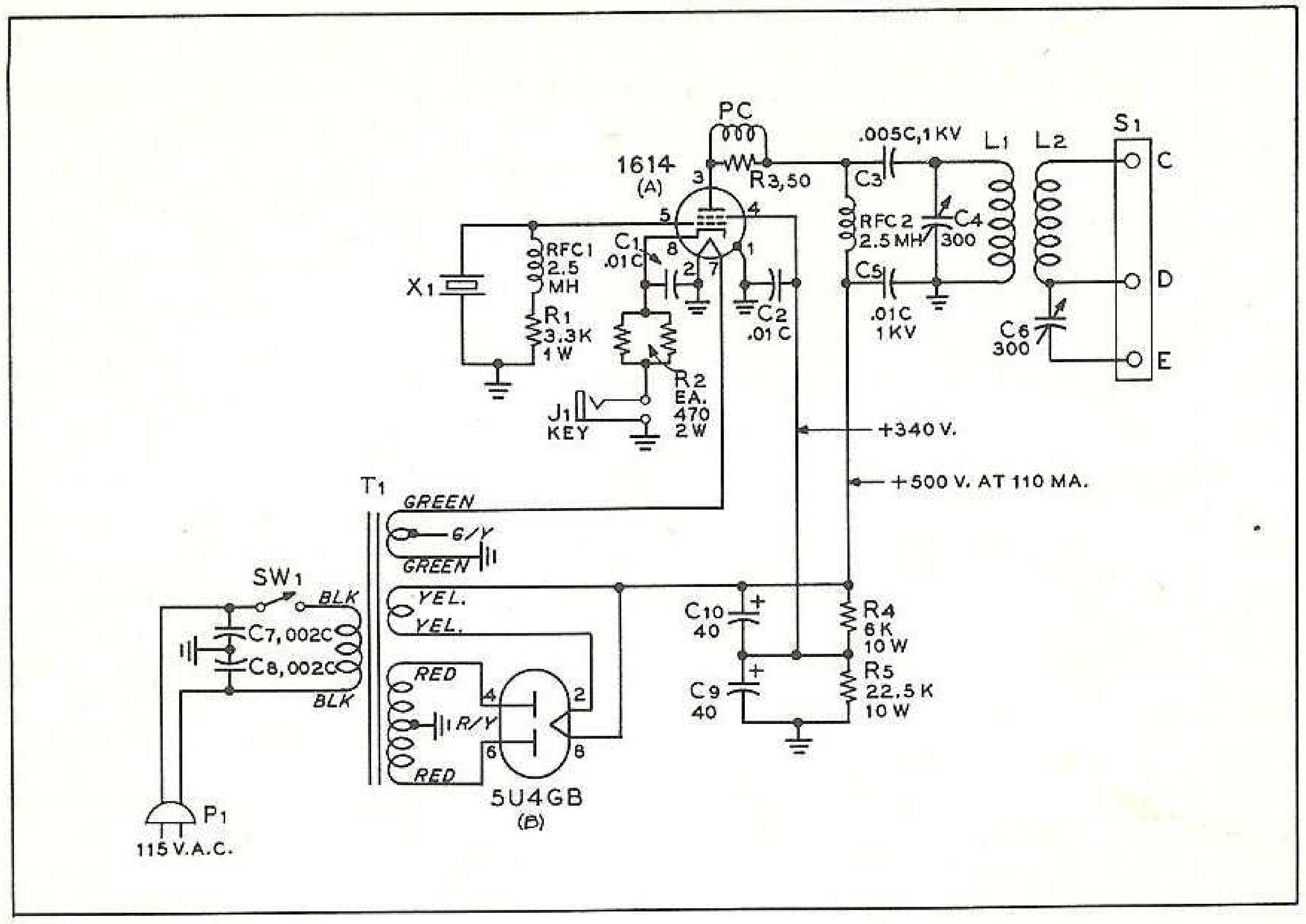
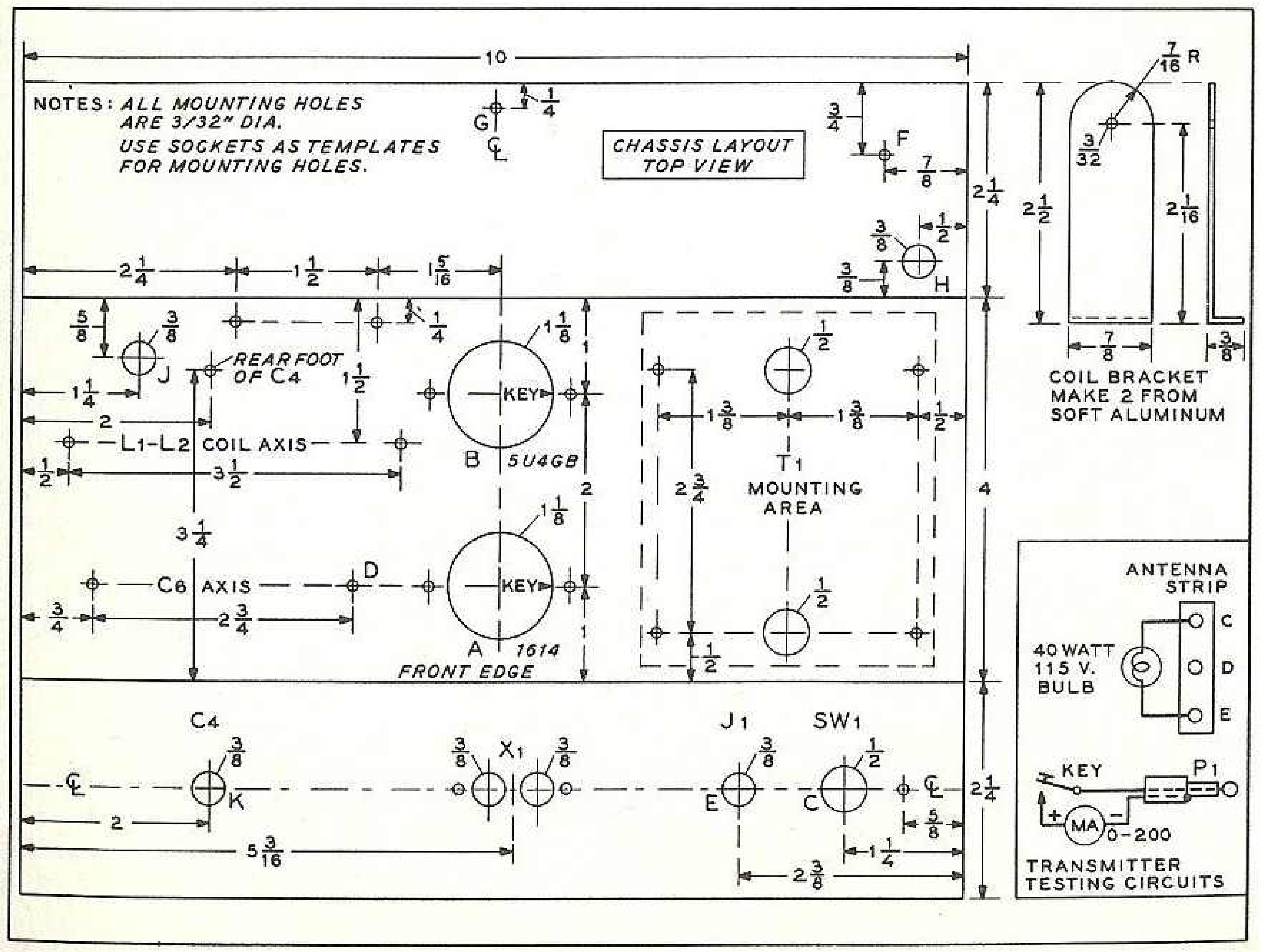


Fig. 6 Schematic of SP-50 transmitter. A small amount of grid-leak bias is provided by R1 to limit the crystal current to a safe value for 7 mc operation.

by-step sequence to enable the constructor to complete the project easily and correctly. Be sure to read each step all the way through before you start to do it. When the step is completed, check it off in the space provided.

( ) Lay out the chassis holes (Figure 7) to be drilled on the paper wrapper of the chassis. Drill the holes and remove the burrs.
( ) Mount the two octal sockets in holes A and B, using 6-32 hardware. The socket keys face towards the power transformer holes.
( ) Mount power transformer T1. The green leads pass through the chassis hole nearest the front of the chassis.
( ) Mount switch SW1 in hole C and key jack J1 in hole E on the front lip of the chassis.
( ) Mount crystal socket X1 on the front lip of the chassis, using 4-40 hardware.
( ) Mount tuning capacitor C4 to the underside of the chassis, using a 6-32 bolt through the rear mounting foot. Place a ground lug beneath the rear foot of the capacitor. Place a nut on the threaded collar, locking the capacitor firmly to the front lip of the chassis.
( ) Place a ⅜" rubber grommet in chassis holes H and J.
( ) Attach two ⅝" ceramic insulators to capacitor C6. Cut the heads from two 6-32 bolts, and thread the bolts into the insulators. Attach the capacitor to these bolts. Bolt the insulators to the chassis. Under the head of the bolt at the rear of the capacitor, place a single terminal phenolic tie-point (D) beneath the chassis.
( ) Connect one of the two red leads of transformer T1 to pin 4 of rectifier socket B.
( ) Connect the other red lead of T1 to pin 6 of socket B.
( ) Connect the red/yellow lead of T1 to a ground lug of socket B.
( ) Connect a yellow lead of T1 to pin 2 of socket B.
( ) Ground pins 1 and 2 of oscillator socket A to adjacent ground lug of the socket.
( ) Connect a green lead of transformer T1 to pin 2 of socket A.
( ) Connect the other green lead of T1 to pin 7 of socket A.

( ) Cut the green/yellow lead of T1 (6.3 volt filament center tap) to a length of 1½". (If this lead is composed of two enamel covered wires, scrape the enamel from the ends of the wires. and solder them together.) Wrap the lead with electrical tape, and tape it to the yellow leads of the transformer (Figure 8) so that it does not touch the chassis.
( ) Install a .002 ceramic capacitor (C7) between one insulated arm and the center, grounded arm of a two terminal phenolic tie-point strip.
( ) Install a second .002 ceramic capacitor (C8) between the other insulated arm, and the center, grounded arm of the same tie-point.
( ) Mount this tie-point strip in chassis hole next to the 115volt switch (SW1).
( ) Connect one black lead of transformer T1 to one terminal of switch SW1.
( ) Connect the other black lead of T1 to one of the insulated terminals of the tie-point strip adjacent to SW1.
( ) Connect one terminal of crystal socket X1 to a grounding lug of tube socket A.
( ) Connect the other terminal of X1 to pin 5 of socket A.
( ) Install a .01 ceramic capacitor (C2) between pin 1 and pin 4 of socket A.
( ) Install a .01 ceramic capacitor (C1) between pin 1 and pin 8 of socket A.
( ) Take two 470 ohm, 2-watt resistors and wire them in parallel (R2). One end of the two resistors connects to pin 8 of socket A. The opposite end connects to the ungrounded arm of key jack J1.
( ) Install a 3.3K resistor (R1) between insulated tie-point terminal (D) and a ground lug of socket A.
( ) Install a 2½ mh. r-f choke (RFC-1) between terminal D and the terminal of crystal socket X1 that is connected to pin 5 of socket A.
( ) Mount a single terminal phenolic tie-point strip in chassis hole F.
( ) Mount the 40 mf electrolytic capacitor (C10) between pin 8 of socket B and the tie-point. The "plus" terminal of C10 goes to pin 8, the "negative" terminal goes to the insulated tie-point (F). Press C10 down against the transformer leads, as C9 must fit above it.
( ) Mount the 40 mf electrolytic capacitor (C9) between a ground lug of socket B and the insulated tie-point (F). The "plus" terminal of C9 goes to the tie-point, and the "negative" terminal goes to the ground lug. Slide a length of insulating sleeving over the negative lead.



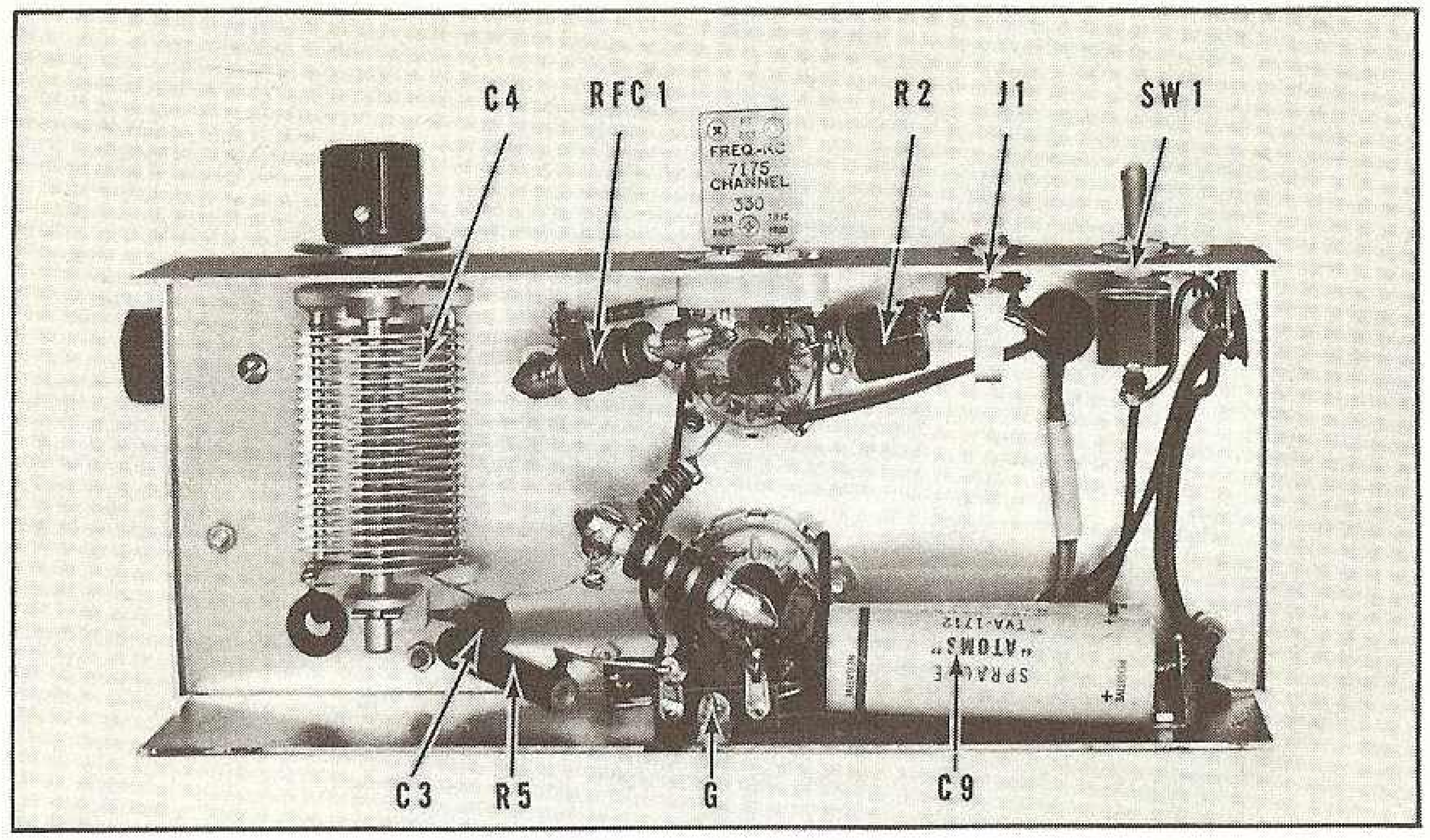


Fig. 8 Under-chassis view of SP-50 transmitter. Ceramic insulator holds one end of C3, RFC-2, and PC. Lead from C4 to coil L1 passes through grommet at lower left of tuning capacitor. Bypass capacitors C7 and C8 are mounted to insulated tie-point to the right of line switch SW1, at upper right.

( ) Install a 6K, 10-watt resistor (R4) between the insulated terminals of a two terminal phenolic tie-point strip.
( ) Mount the phenolic strip in chassis hole G, using 6-32 hardware.
( ) Connect a lead between pin 8 of socket B and tie-point terminal G nearest the electrolytic capacitors.
( ) Install a .01, 1 KV ceramic capacitor (C5) between the above tie-point terminal and the center, ground lug of the tie-point strip.
( ) Install a 22.5K 10-watt resistor (R5) between the opposite tie-point terminal of G and the ground lug mounted beneath the rear foot of capacitor C4.
( ) Connect a lead between the junction of resistors R4-R5 and the phenolic tie-point F.
( ) Connect a lead between the junction of resistors R4-R5 and pin 4 of socket A.
( ) Cut two coil brackets from soft aluminum (Figure 7).
( ) Cut the prepared coil material into two equal coils of 24 turns each. Peel the end wires away from the insulating material until each coil is reduced to 20 turns. The turns removed from each end of the coils form the leads.
( ) Cut a 4" length of ⅞" diameter wooden dowel stock. Sand the ends and slide the coils onto the rod. Shave the rod slightly with a knife if necessary to obtain a smooth, sliding fit.
( ) Mount the dowel rod to the aluminum support brackets with ½" wood screws.
( ) Mount the coil brackets to the chassis. using 6-32 hardware. Place a ground lug atop the outside coil bracket near the edge of the chassis.
( ) Ground the outside lead of coil L1 (left coil, viewed from the front) to the ground lug at the outside coil bracket.
( ) Pass the inside lead of coil L1 through grommet hole J. Slip a section of insulated sleeving over the lead, and connect the lead to the *stator terminal* of capacitor C4.
( ) Mount a ¾" ceramic insulator on the end of the bolt holding the inner coil bracket (Figure 8). Place a soldering lug atop the insulator.
( ) Install a 2½ mh. r-f choke (RFC-2) between the insulator soldering lug and the terminal of phenolic strip G holding capacitor C5 and the lead to pin 8 of socket B.

( ) Take a short portion of the wire left over from one of the coils, and wind 5 turns of it around a 50 ohm resistor (R3). Space the turns evenly and solder the ends to the resistor leads. This combination forms parasitic choke PC.
( ) Connect one lead of PC to pin 3 of socket A.
( ) Connect the opposite lead of PC to the soldering lug atop the ceramic insulator.
( ) Install a .005, 1 KV ceramic capacitor (C3) between the soldering lug atop the ceramic insulator and a *stator terminal* of capacitor C4.
( ) Pass the leads of a 115 volt line cord through grommet H. Tie a knot in the leads.
( ) Attach one lead to one terminal of the phenolic tie-point strip mounted next to SW1.
( ) Attach the other lead to the other terminal of the strip.
( ) Connect a wire from the free terminal of SW1 to the terminal of the phenolic strip that *does not* hold the black lead from transformer T1.
( ) Mount the three terminal phenolic antenna strip (S1) above the chassis directly behind coil L2. Use ⅜" metal spacers to hold the strip above the chassis.
( ) Connect the outside lead of coil L2 (right coil, viewed from front of transmitter) to terminal C of the antenna strip (S1).
( ) Connect the inside lead of coil L2 to the stator of tuning capacitor C6.
( ) Connect terminal D of the antenna strip to the stator of C6.
( ) Connect terminal E of the antenna strip to the rotor terminal of C6.
( ) Check all the above connections for shorts, opens, transpositions, and accidental grounds.
( ) Place knobs on capacitors C4 and C6. Adjust the knobs so that they read "10" when the capacitors are fully meshed.

Transmitter Testing

When the wiring of the SP-50 has been completed and checked, the transmitter is ready for testing. Insert a 1614 tube in socket A, 5U4GB tube in socket B, and an 80 meter Novice crystal in holder X1. With an ohmmeter, measure the resistance between pin 8 of socket B and the chassis. After the filter capacitors are charged by the battery of the ohmmeter, the reading should be close to 28.5K (28,500 ohms). Plug a key and a 0-200 d.c. milliammeter (Figure 7) in the key jack. Connect a 40 watt lamp bulb between terminals C and E of the antenna terminal strip. Set the dials of C4 and C6 to "10." Turn on the transmitter and observe that the filament of the rectifier tube lights. After the transmitter has warmed up for a minute or so, close the key. A reading of about 80 milliamperes should be observed on the meter. Tune C4 for a rise in plate current to about 120 ma. This is an indication that the circuit is oscillating. Decrease the capacity of antenna tuning capacitor C6 until the lamp in the antenna circuit lights. Retuning C4 and C6 will provide a plate current of 110 ma, with maximum bulb brilliance. Adjust the coupling between the coils with a wooden rod to obtain maximum output. Listen to the transmitter in a nearby receiver, and adjust C4 for best keying characteristic.

Next, remove the 80 meter crystal and plug in a 40 meter Novice crystal. Set C4 and C6 to "zero" capacity. Close the key, and tune C4 for a rise in plate current to about 120 ma. C6 may then be adjusted for maximum indication of the antenna lamp. Try for maximum brilliance at a plate current of 100-115 ma. Experiment with the coupling between L1 and L2. When you are thoroughly familiar with the tuning adjustments of the SP-50, write the dial settings down, remove the dummy load and attach an antenna to the transmitter. Antenna tuning is covered in chapter 9 of this Handbook.

Parts List, SP-50 Transmitter

2—.01 disc ceramic capacitor (Centralab DD-103) (C1, C2)
1—.005, 1KV disc ceramic capacitor (Centralab DD16-502) (C3)
2—300 mmf variable capacitor (Bud MC-1860) (C4, C6)
1—.01, 1KV disc ceramic capacitor (Centralab DD16-103) (C5).
2—.002 disc ceramic capacitor (Centralab DD-202) (C7, C8)
2—40 uf, 450 volt electrolytic capacitor (Sprague TVA-1712) (C9, C10)
1—3.3K, 1-watt resistor (IRC type BTA, or BW-1) (R1)
2—470 ohm, 2-watt resistor (IRC type BTB. or BW-2) (R2)
1—50 ohm, 1-watt resistor (R3)
1—6K, 10 watt receiver (Ohmite "Brown Devil") (R4)
1—22.5K, 10-watt resistor (R5)
2—2½ mh. r-f choke (National R-100) (RFC-1, RFC-2)
1—Inductor, 48t, 1" diam., 3" long (B&W 3015) see text (L1, L2)
1—Transformer, 880 volts c-t, 130 ma (Stancord P-6143) (T1)
1—Crystal holder (Miller 33102) (X1)
1—Jack, open circuit (Mallory A-1) (J1)
1—Switch, SPST (Carling S60A) (SW-1)
1—Screw-type terminal strip, 3 lugs (Cinch-Jones 17-3) (S1)
1—Line cord and plug (Belden 1765B)
2—Octal socket (Cinch-Jones 8JC)
1—1614 tube (RCA)
1—5U4-GB tube (RCA)
2—Phenolic tie-point, single terminal (Cinch-Jones 51A)
2—Phenolic tie-point, double terminal (Cinch-Jones 52A)
3—Ceramic insulator, ⅝" high (Johnson 135-500)
2—Metal spacers, ⅜" high
2—Knobs, National type HRS-5
1—⅞" diameter dowel rod (hardware store item)
1—Chassis box, 10" x 4" x 2½" (LMB #144)
2—⅜" rubber grommets (Walsco 7034F)
2—⅜" metal spacers
1—40 watt, 115 volt lamp bulb
5 feet insulated hookup wire
1 foot insulated sleeving

STEP-BY-STEP CONVERSION OF THE "COMMAND" TRANSMITTER

The Command transmitters are undoubtedly one of the most popular pieces of surplus equipment. Here is a simple step-by-step outline showing how one of these inexpensive rigs can be quickly converted into a first-class 75 watt VFO transmitter for 80 or 40 meter operation. TVI suppression measures are included in the design to keep your neighbors happy. The transmitters discussed herein are the BC-696 (T-19/ARC-5) covering 3 mc to 4 mc, and the BC-459 (T-22/ARC-5) covering 7 mc to 9.1 mc. The conversion information also applies to other transmitters covering the intermediate frequency ranges (4-7 mc).

Although they have different designations and frequency ranges, all the "Command"-type transmitters follow the basic circuit shown in Figure 10A. The transmitter operates at approximately 75 watts input from a power source of 600 volts at 150 ma., and 24 volts at 0.75 amperes. The tubes used in these transmitters have 12 volt filaments, and are wired in series-parallel. Since it is much easier to construct a 12 volt filament supply than a 24 volt one, the filaments are wired in parallel in this conversion.

A 1626 tube is used as a variable frequency oscillator, inductively coupled to two parallel connected 1625 tetrodes. The latter is similar to the popular 807 tube, except for a twelve volt filament and a 7-pin base. A 1629 "magic eye" tube is used in conjunction with a quartz crystal to calibrate the transmitter frequency at one point on the dial. The transmitter frequency is *not* controlled by the crystal. Both the crystal and the 1629 tube may be removed from the transmitter if desired since it works just as well without them. The oscillator and amplifier tuning capacitors are ganged to the main tuning dial for ease of operation.

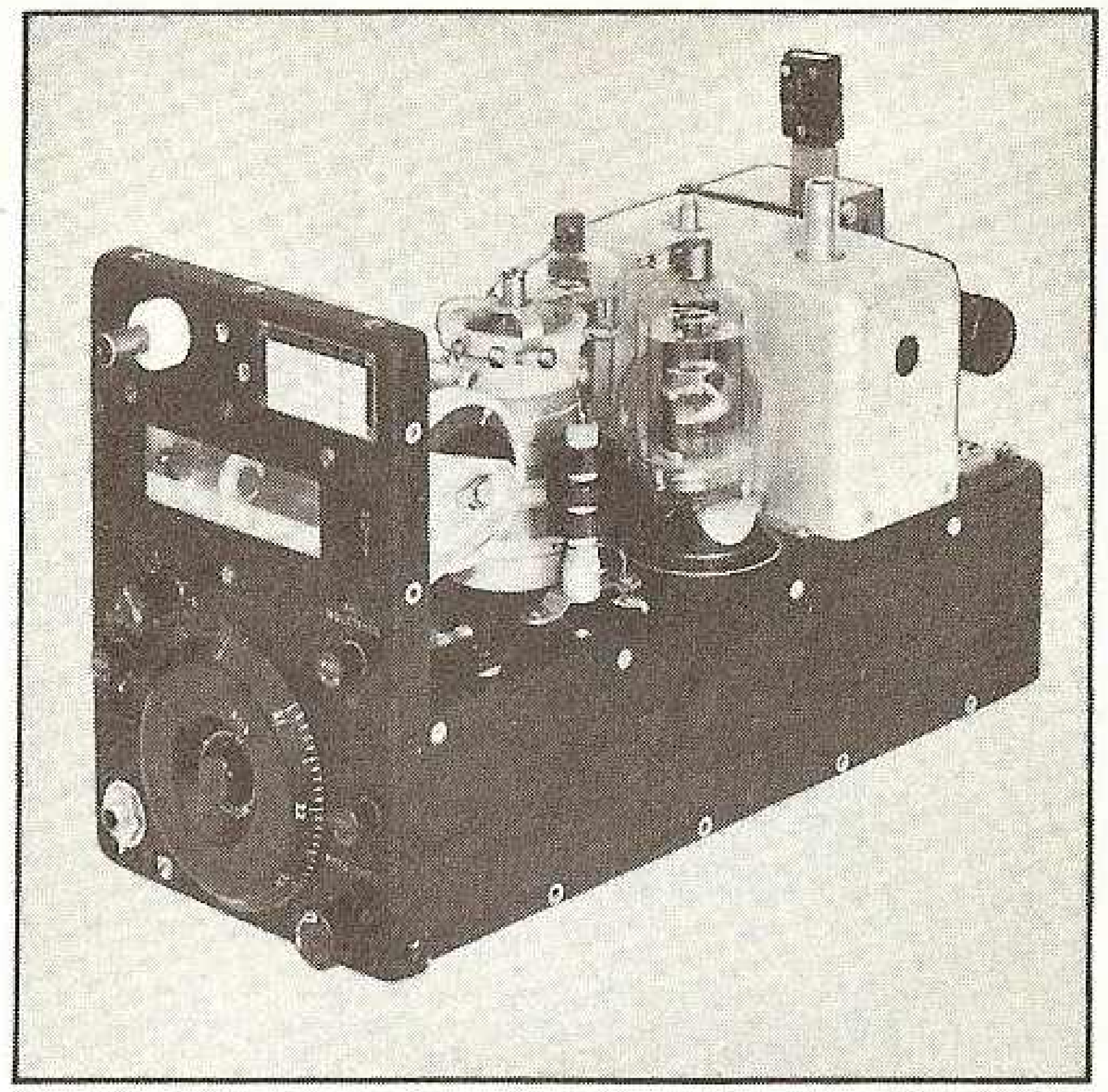


Fig. 9 Surplus "Command" transmitter makes ideal rig for the Novice. With the use of a simple adapter, the transmitter may be converted to crystal control operation. Removal of the adapter restores v-f-o operation. The complete conversion of the "Command" transmitter for a-c operation is given in the accompanying text.

The Army and Navy versions of the transmitter have minor differences in circuitry which do not affect the conversion. The power receptacle pin numbering system, however, varies slightly, as indicated in Figure 10A. Before you start the conversion, check the nameplate of the transmitter to see if you have an Army (BC-type) or a Navy (ARC-type). You can then juggle the pin numbers accordingly.

Conversion Instructions for the Command Transmitter

( ) Remove the top and bottom covers and store the tiny screws where they will not get lost.
( ) Locate pin 1 of 1625 socket #1 (see Figure 11). This pin has three white wires connected to it.
( ) Unsolder the three wires and trace out the one which goes to relay (K-53). Remove this wire.
( ) Trace out the white wire from pin 1 to relay K-54 atop the chassis. Remove this wire.
( ) Connect the remaining white wire to pin 7 of 1625 socket #2.
( ) Connect pin 1 of socket 1 to pin 7 (ground) of 1625 socket #2.
( ) Remove resistor R-71 (126 ohms) in the rear corner of the chassis by clipping the white wires and the support brackets. Remove the wires.
( ) Unsolder the remaining white wire on pin 7 of socket V-53 (1629) and connect it to pin 2 of the same socket.
( ) Connect pin 7 of tube socket V-53 to pin 1 (ground) of the same socket. The filaments of all tubes are now wired in parallel.
( ) Remove the black wire between relay K-54 (atop chassis) and pin 5 of the rear power receptacle (J-64).
( ) Remove relay K-54 (atop chassis).
( ) Remove the black wire between relay K-53 and pin 5 of the rear power receptacle.
( ) Remove the bare wire between relay K-53 and pin 6 of 1625 socket #2.
( ) Remove the 51K resistor (R-75) between pins 6 and 7 of 1625 socket #2.
( ) Ground socket pin 7 of 1625 socket #2 to the frame of the adjacent variable capacitor (C-67) with a short length of solid wire.

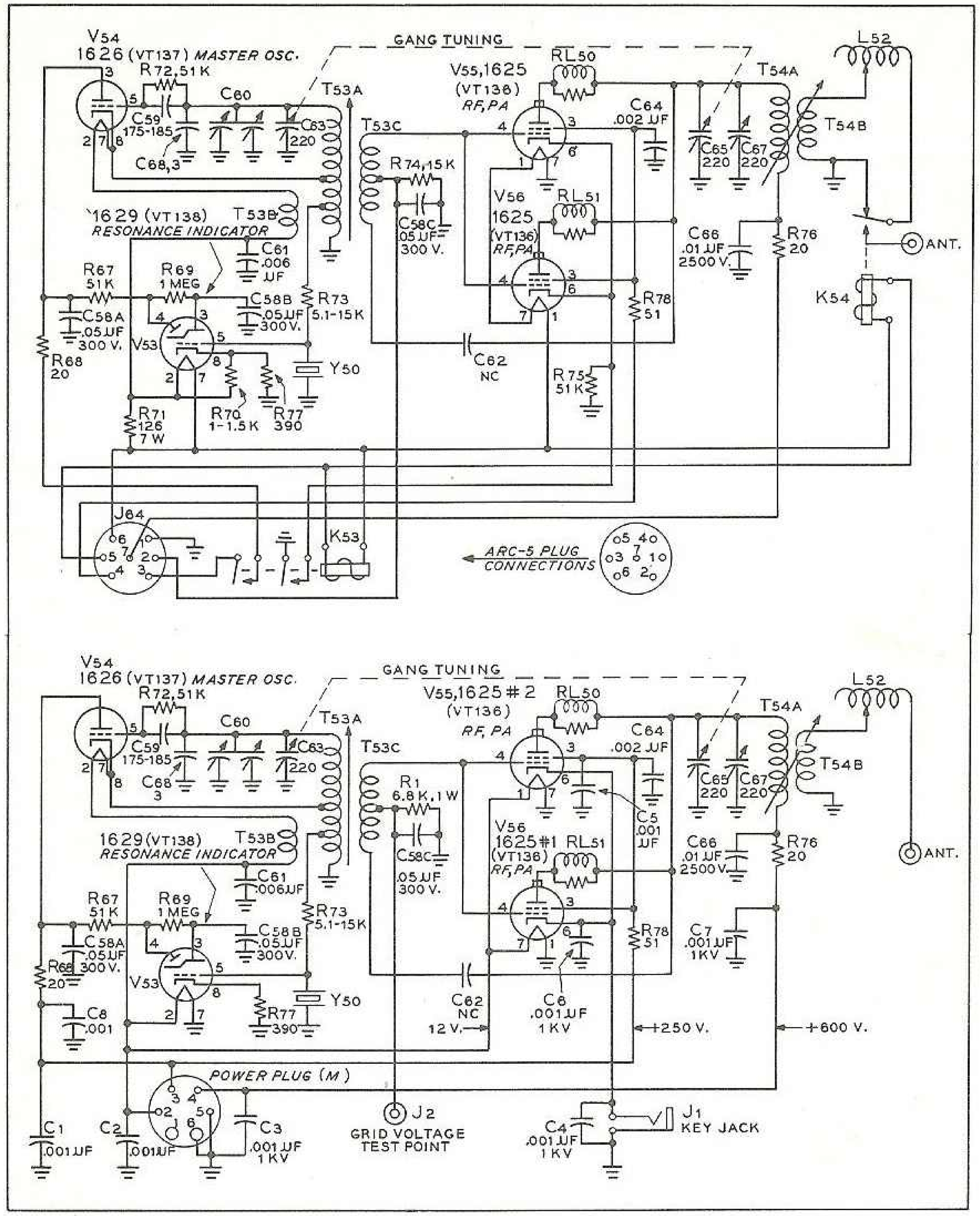


Fig. 10 Circuit of "Command" transmitter, before and after conversion.

( ) Locate the red wire that connects relay K-53 to pin 4 of socket V-54 (1626). Unsolder the relay end of this wire and connect it to pin 5 of 1625 socket #2.
( ) Install a .001 ceramic capacitor (C5) between pin 7 of 1625 socket #2 and pin 3 of the same socket.
( ) Install a .001, 1KV ceramic capacitor (C6) between pin 1 (ground) of 1625 socket #1 and pin 6 of the same socket.
( ) Remove the red lead from relay K-53 to pin 3 of rear power receptacle J-64.
( ) Remove relay K-53.
( ) Inspect all the above connections, and solder all joints.
( ) The next conversion step is to replace the rear power receptacle J-64 with a standard one. At this point, pins 3 and 5 of the rear power receptacle should be vacant.
( ) Unsolder the black wire from pin 1 of the power receptacle and label it *ground* with a small tag.

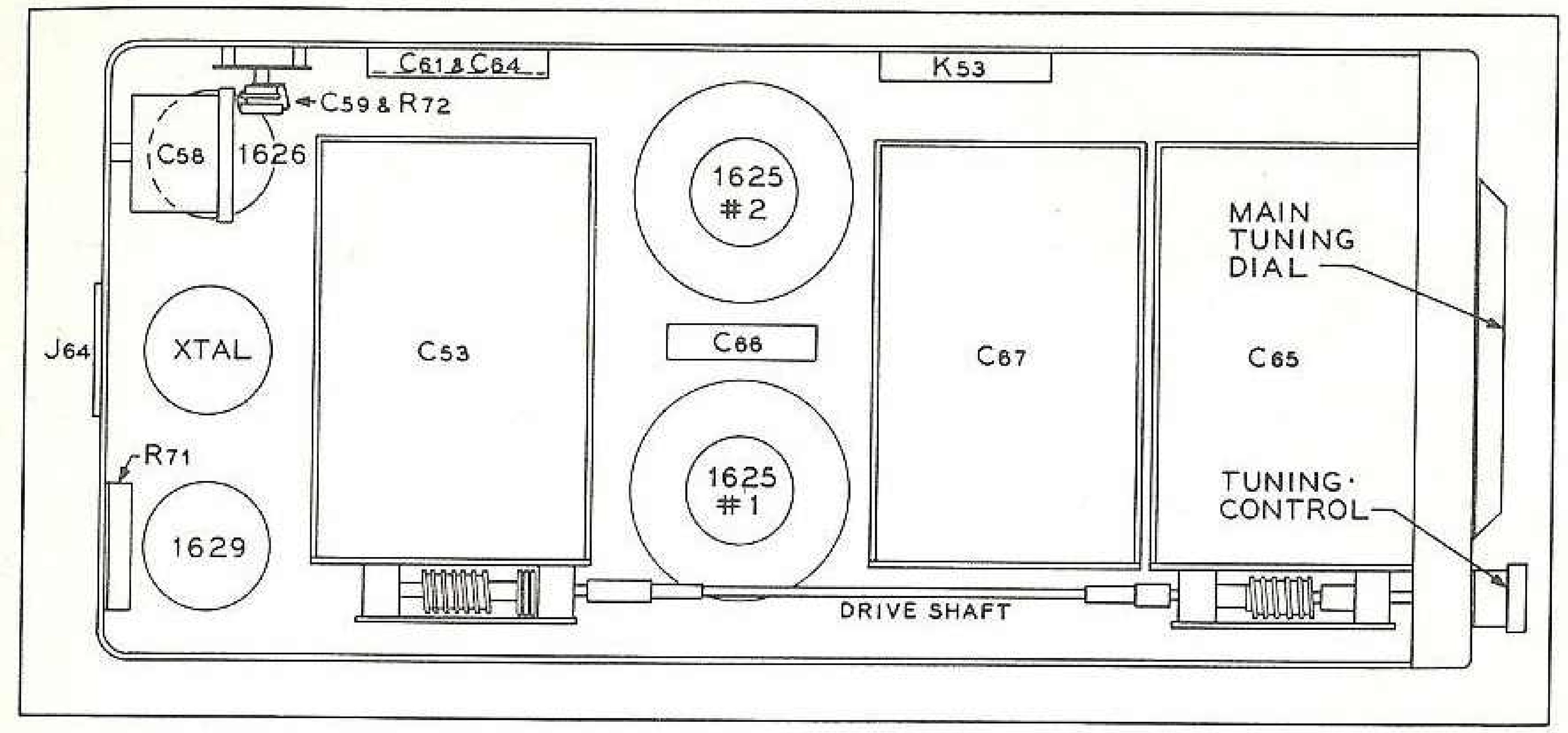


Fig. 11 Under-chassis layout of typical "Command" transmitter, showing placement of major components. Oscillator padding capacitors are atop the chassis.

( ) Remove the black wire from pin 2 and label it *bias*.
( ) Remove the yellow wire from pin 4 and label it *B-plus low*.
( ) Remove the white wire from pin 6 and label it *filament*.
( ) Remove the red/white wire from pin 7 (center) and label it *B-plus high*.
( ) Break out the mica power receptacle J-64 and enlarge the mounting hole to 1¼ inches. Install a 6 pin male power plug (M), with a ground lug under one of the 6-32 nuts used to hold the plug in place.
( ) Between this plug and capacitor C-58 (3 x .05) drill a ⅜ inch hole and install an insulated pin-jack (J2). This jack will be used to check grid current for indication of oscillator performance.
( ) Connect the black wire labeled *bias* to pin-jack J2.
( ) Connect the black wire labeled *ground* to pins 5 and 6 of the new power plug (M).
( ) Connect the yellow wire labeled *B-plus low* to pin 3 of plug (M).
( ) Connect the white wire labeled *filament* to pin 2 of plug (M).
( ) Connect the red/white wire labeled *B-plus high* to pin 4 of plug (M).
( ) Install a .001 ceramic capacitor (C2) from pin 2 of plug (M) to the adjacent ground lug.
( ) Install a .001 ceramic capacitor (C1) from pin 3 of plug (M) to the adjacent ground lug.
( ) Install a .001, IKV ceramic capacitor (C3) from pin 4 of plug (M) to the adjacent ground lug.
( ) Connect a short, bare wire from pin 5 of plug (M) to the adjacent ground lug.
( ) Solder all connections.
( ) Drill a ⅜ inch diameter hole in the front panel of the transmitter in the lower left corner (viewed from the front). Install key jack (J1) in this hole.
( ) Install a .001, 1KV ceramic capacitor (C4) between the two terminals of (J1).
( ) Connect one end of an insulated lead to pin 6 of 1625 socket #1 and the other end of the lead to the *ungrounded* lug of jack (J1).
( ) Install a .001 1KV ceramic capacitor (C7) between pin 5 and pin 1 (ground) of 1625 socket #1.
( ) Clip the leads of resistor R-74 (15K) mounted between pin 7 and pin 5 of crystal socket Y-50.
( ) Connect a 6.8K, 1-watt resistor (R1) between pin 7 and pin 5 of crystal socket Y-50.
( ) Remove R-70 (1K) between pin 2 and pin 8 of tube socket V-53 (1629).
( ) Connect a wire from pin 1 of tube socket V-54 (1626) to pin 1 (ground) of crystal socket (Y-50).
( ) Install a .001 ceramic capacitor (C8) between pin 4 and pin 1 of tube socket V-54 (1626).

( ) Connect the lead from rotary coil L-52 atop the chassis directly to the antenna terminal post.
( ) If you plan to use a coaxial feedline with the transmitter, remove the antenna terminal post and replace it with a SO-239 coaxial receptacle. Connect the lead from rotary coil L-52 to the center terminal of the receptacle.
( ) Inspect and solder all connections. Check against Figure 10B.

Testing the Transmitter

The transmitter may be powered by the High Voltage Transmitter Power Supply described in the Power Supply chapter of this Handbook. Power requirements are 540 volts at 130 milliamperes, 250 volts at 20 milliamperes, and 12 volts at 1.5 amperes. Connect the transmitter to the supply by a five wire cable. Insert the tubes in the transmitter (the 1629 "magic eye" tube and crystal may be omitted). Insert leads from a telegraph key in keying jack (J1). Connect a 0-100 d.c. voltmeter between test point jack (J2) (negative) and transmitter ground (positive). Turn on the filament switch of the supply and observe if the tube filaments light. After a three minute equipment warm-up period, turn on the plate supply switch. *Caution!* High voltage is now applied to the plate caps of the 1625 tubes and other components. Keep your "cotton pickin'" hands out of the "innards" of the transmitter! Check the "B-plus low" voltage between pin 3 of plug M and ground. It should be about 250 volts. If not, turn off the supply, discharge the filter capacitors to ground with an insulated screwdriver, reset the tap on the voltage divider in the power supply and again check the voltage.

With power applied to the transmitter (but the telegraph key open), adjust the oscillator frequency until it is within the amateur band. Observe the grid voltage at the test jack. It should be over 20 volts.

Connect a dummy antenna (such as shown in Figure 12) between the transmitter antenna terminal and chassis ground. Connect a 0-250 d.c. milliammeter in series with the key (minus terminal of the meter to ground). Momentarily apply plate power and close the key. Adjust the *Antenna Inductance* and *Antenna Loading* controls until the plate meter reads 130 milliamperes. The light bulb should glow to almost full brilliance.

Calibration of the transmitter should be checked against a frequency meter or an accurately calibrated receiver. Oscillator calibration may be varied by changing the slug of coil T-53, or the oscillator trimming capacitor, C-60. Both of these adjustments are reached through the top of the oscillator shield can.

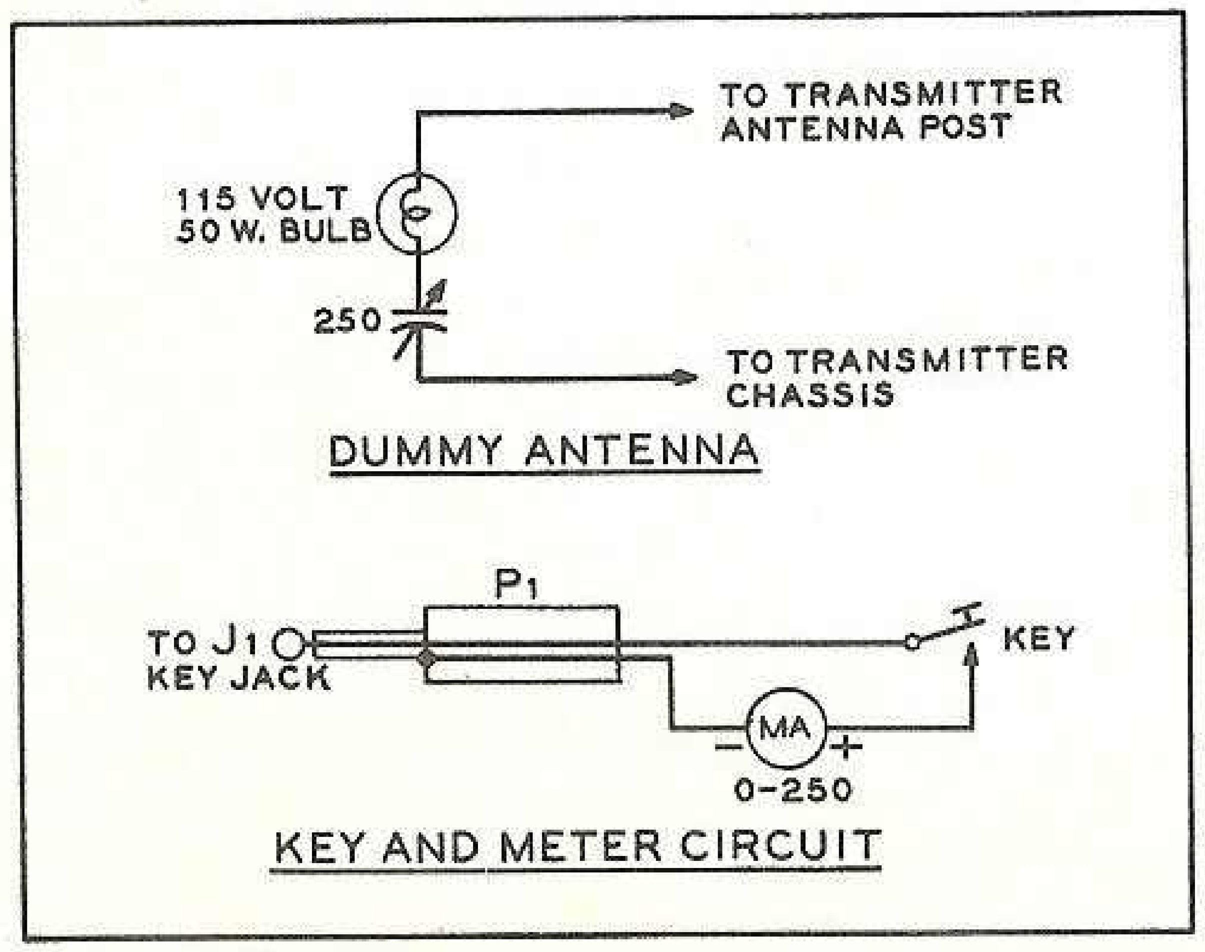


Fig. 12 A simple dummy antenna may be made from a 50-watt lamp bulb and a 250 mmf variable capacitor. This may be used with any of the "Command" transmitters. Keying circuit for the transmitters is also shown.

Using the Transmitter

The transmitter is designed to be used with a random length long wire antenna. If this type of skywire is used, a good ground should be attached to the transmitter. Antenna resonance is established with the variable loading coil, and amplifier loading is adjusted with the *Antenna Coupling* knob. If you cannot load the transmitter to 130 ma plate current, it indicates that the antenna is the wrong length. The antenna length should be changed, or else an antenna coupler should be used with the transmitter. After the transmitter is properly loaded, the shaft lock on amplifier padding capacitor C-67 should be loosened and the capacitor adjusted through the hole in the side of the case for resonant plate current dip. This insures that maximum power output will be obtained in the amateur band.

If a coaxial feed system is used with your antenna, the variable loading coil should be set to zero inductance, as it is not required.

Parts List for Command Transmitter Conversion

4—.001 mf., 600 volt disc ceramic capacitors (Centralab DD-102) (C1, C2, C5, C8)
4—.001 mf., 1600 volt disc ceramic capacitors (Centralab MD-102) (C3, C4, C6, C7)
1—6,800 ohm, 1-watt resistor (IRC type BTA or BW-1) (R1)
1—Open circuit jack (Carter J-1) (J1)
1—Insulated tip-jack (Johnson 105-602) (J2)
1—Plug, six pin, male (Amphenol 86-RCP6) (M)
1—receptacle, six pin (Amphenol 78-PFG-11)
5 feet, five wire cable

CRYSTAL CONTROL ADAPTER FOR THE "COMMAND" TRANSMITTER

The law requires that all Novice transmitters be frequency controlled by a quartz crystal. The Command transmitter may easily be converted to crystal control with the addition of this simple adapter unit. No changes need be made to the transmitter! When the General Class "ticket" arrives, the adapter may be removed, the original tubes replaced, and—presto! the Command transmitter is once again VFO controlled! Perfection!

Any Command transmitter, modified as described in the previous section may be adapted to crystal control for Novice use. The tubes and crystal are removed from the rear sockets of the transmitter, and this simple adapter is inserted into the oscillator tube socket formerly occupied by the 1626 tube (V-54). The adapter is a simple crystal oscillator using a 12A6 pentode tube. The VFO coil of the Command transmitter is now used as the plate coil of the crystal oscillator. Either 40 meter or 80 meter Novice crystals may be used with the appropriate transmitter for operation on these two Novice bands. The BC-696 (T-19/ARC-5) or the BC-457 (T-20/ARC-5) may be used for 80 meters, and the BC-459 (T-22/ARC-5) may be used for 40 meter operation.

Adapter Construction

The complete adapter is constructed in an aluminum box measuring 2¾" x 2" x 1½" *(Bud CU-2100)*, and is shown in Figure 13. You will note from the chassis layout of Figure 15 that one side of the U-shaped portion

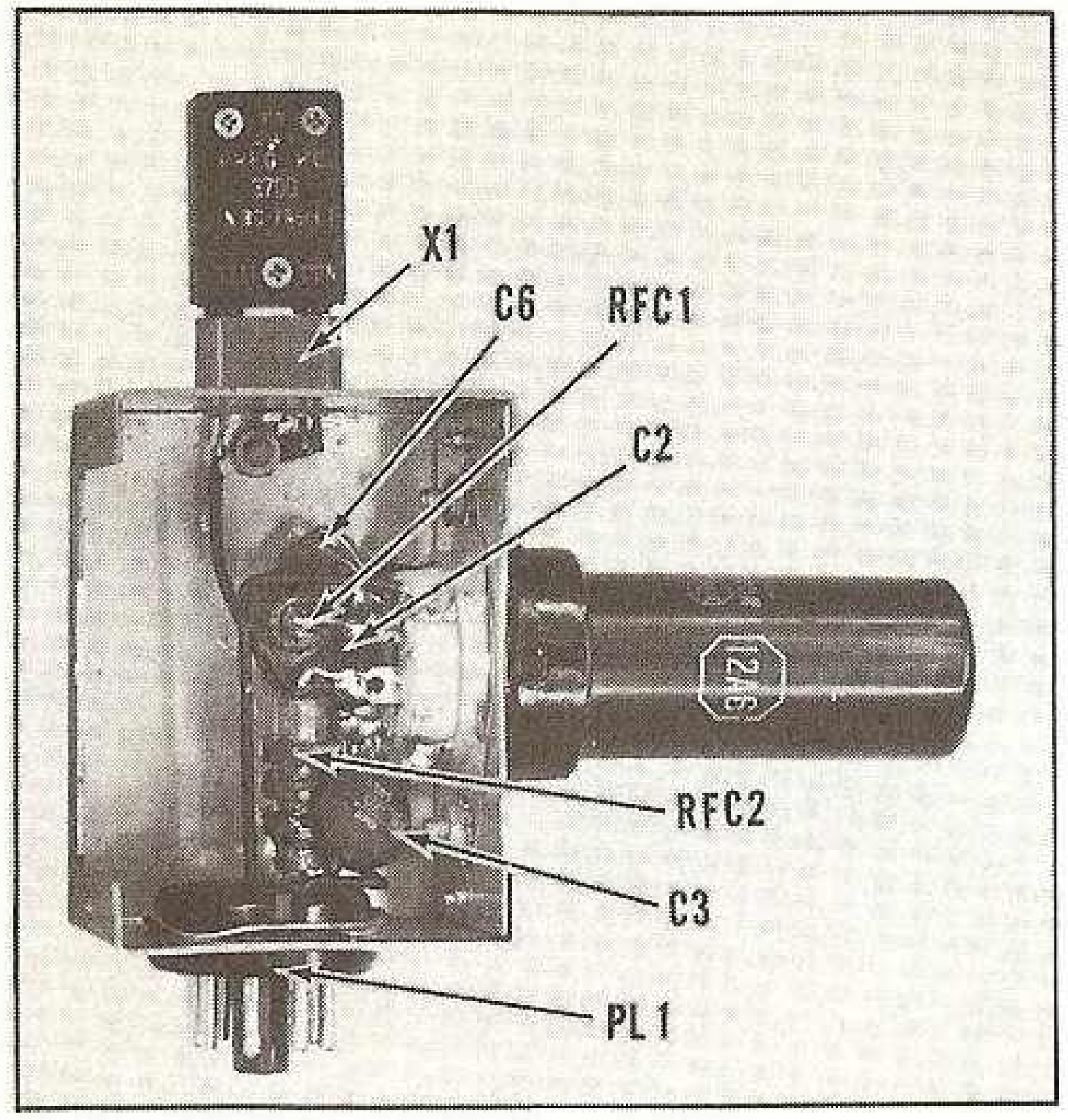


Fig. 13 Interior view of the crystal control adapter for a "Command" transmitter. The 12A6 oscillator tube mounts in a horizontal position over the unused sockets of the transmitter. Adapter plugs in 1626 oscillator socket of transmitter.

of the box is cut off, and attached to the other half of the box with self-tapping sheet metal screws. It is necessary to do this so that the 12A6 tube lays horizontally over the unused tube sockets in the rear of the Command transmitter. The crystal is mounted atop the adapter, and an octal plug is placed at the bottom. This plug makes vital connections to the circuitry of the Command set through the oscillator tube socket, as shown in Figure 14.

The following assembly and wiring instructions are presented in a step-by-step fashion to enable the constructor to complete the project easily and correctly. Be sure to read each step all the way through before you start to do it. When the step is completed, check it off in the space provided.

( ) Lay out the chassis holes (Figure 15) to be drilled on the paper wrapper of the box. Drill the holes and remove the burrs.
( ) Cut off the side of the U-shaped part of the box that contains hole E. A large pair of tin-snips will work fine. Attach this cut-off portion to the opposite part of the box, using #6 sheet metal screws, as shown in Figure 13.
( ) Mount plug (PL-1) in hole A, using the retaining ring. The key points in direction shown in Figure 15.
( ) Mount a #6 ground lug in hole B, using 6-32 hardware and a lock washer.
( ) Mount crystal socket (X-1) in hole C, using 4-40 hardware.
( ) Mount an 8 pin octal socket in hole E, using 6-32 hardware. Place lock washers under both mounting nuts.

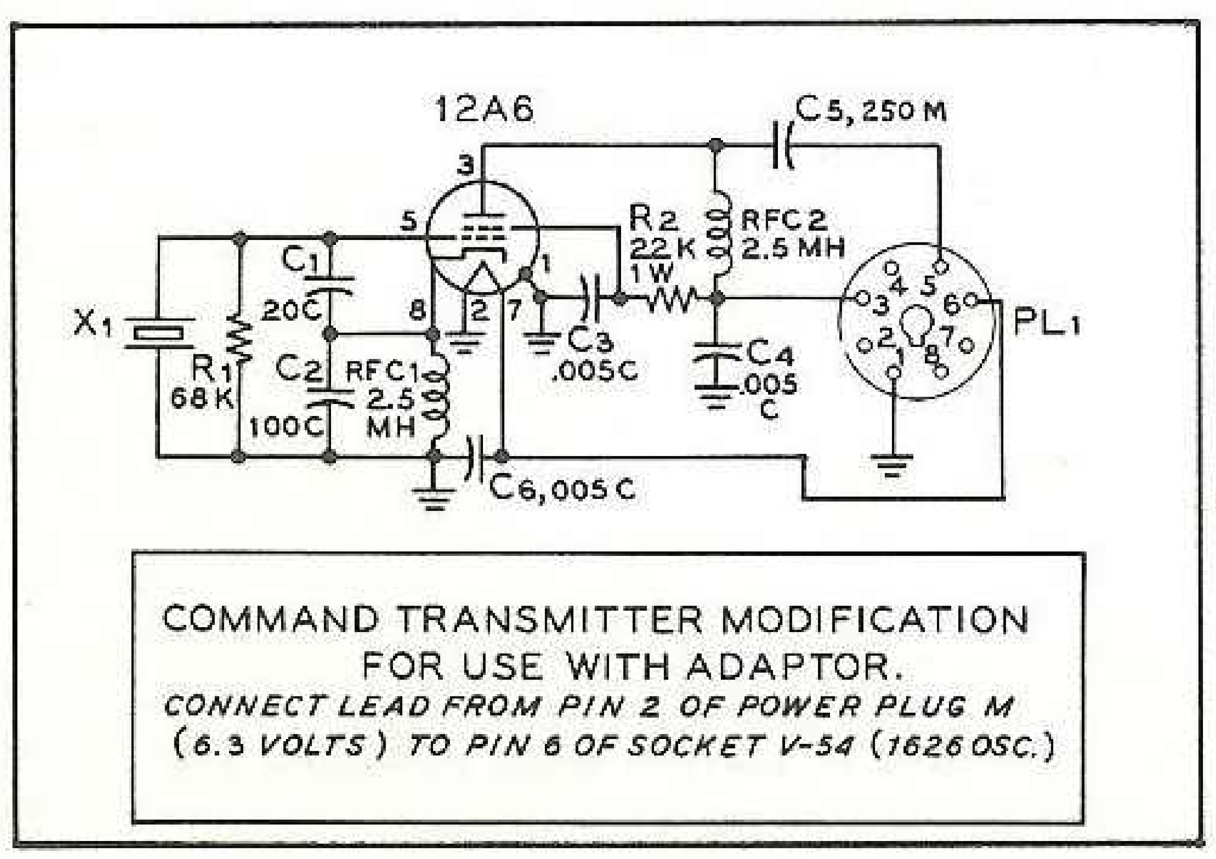


Fig. 14 Schematic of crystal control adapter. Regenerative circuit (C1, C2, RFC-1) lowers crystal current and provides better keying characteristic for crystal oscillator.

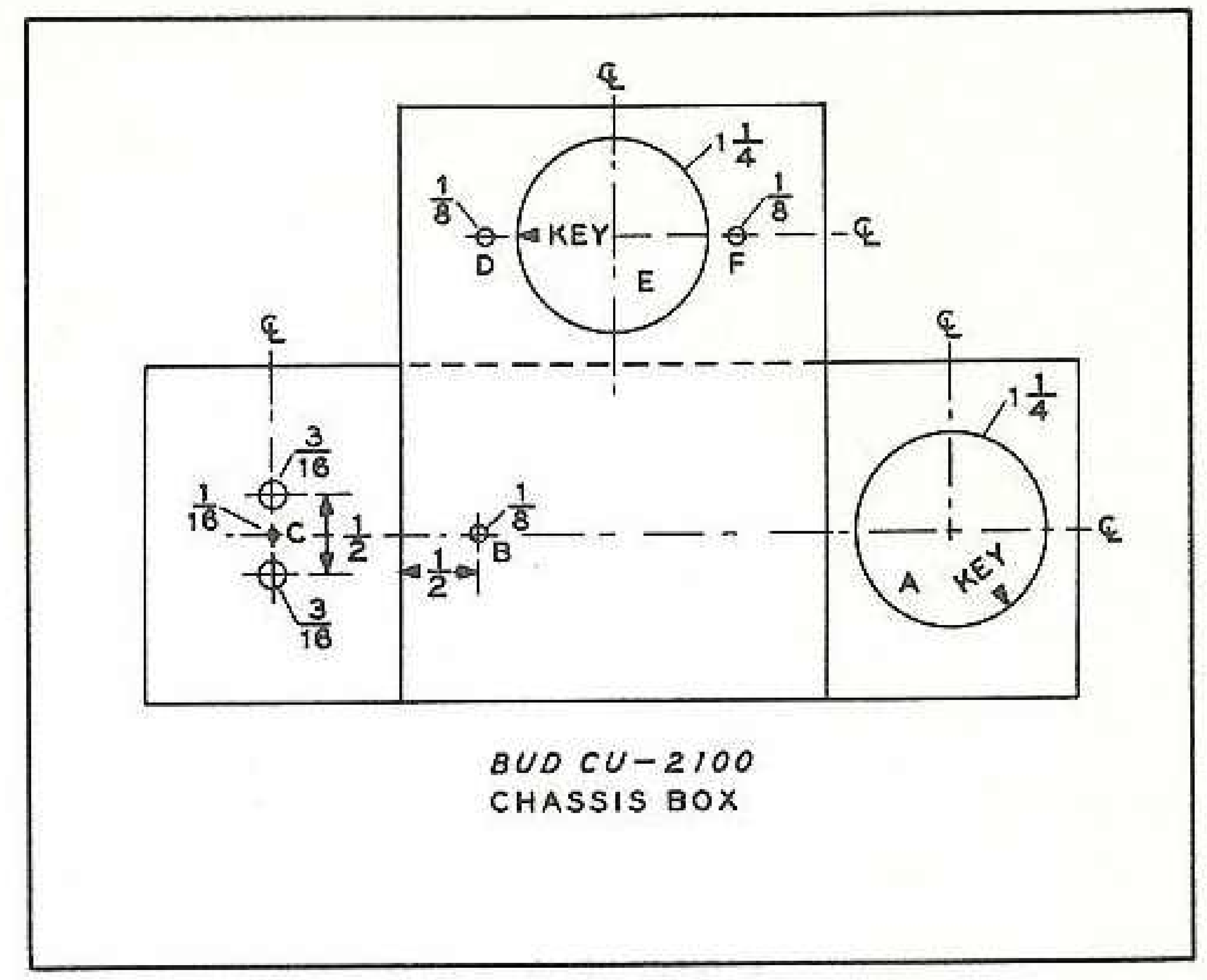


Fig. 15 Chassis layout for the adapter. One side of aluminum box is cut off and attached to the other half with sheet metal screws. Crystal receptacle is mounted on "top" of box, with octal power plug on "bottom."

( ) Connect one terminal of crystal socket (X-1) to ground lug B.
( ) Connect a wire from pin 1 of plug (PL-1) to the nearest ground lug on the mounting ring of the 8 pin octal tube socket. (Be sure pin 1 is grounded in Command Transmitter socket!)
( ) Connect a wire from ground lug B to the nearest ground lug on the mounting ring of the 8 pin octal tube socket.
( ) Connect a wire from pin 6 of plug (PL-1) to pin 7 of tube socket.
( ) Connect a wire from pin 1 and 2 of tube socket to nearest ground lug on the mounting ring of the tube socket.
( ) Install a .005 ceramic capacitor (C6) between pins 2 and 7 of the tube socket.
( ) Install a .005 ceramic capacitor (C3) between pin 4 and adjacent ground lug of the tube socket.
( ) Insert the leads of a 2.5 mh. r-f choke (RFC-2), a 27K resistor (R2), and a .005 ceramic capacitor (C4) into pin 3 of plug (PL-1).
( ) Connect the other lead of (RFC-2) to pin 3 of the tube socket.
( ) Connect the other lead of capacitor (C4) to nearest ground lug on the mounting ring of the tube socket.
( ) Connect the other lead of resistor (R2) to pin 4 of tube socket.
( ) Space components so that they do not touch. Solder all connections.
( ) Install a 250 mmf capacitor (C5) between pin 3 of the tube socket and pin 5 of plug (PL-1).
( ) Twist the leads of a 100 mmf capacitor (C2) and a 2.5 mh. r-f choke (RFC-1) together, placing the components in parallel.
( ) Connect one pair of leads to pin 8 of tube socket.
( ) Connect the other pair of leads to pin 2 (ground) of tube socket.
( ) Inspect and solder all these connections.
( ) Install a 20 mmf capacitor (C1) between pin 5 and pin 8 of tube socket.
( ) Connect a wire between pin 5 of the tube socket and the empty terminal of the crystal socket.
( ) Connect a 68K resistor (R1) across the two terminals of the crystal socket.
( ) Inspect and solder all connections. Check for shorts, and poor solder joints.
( ) Modify Command transmitter as described in Figure 14. (Connect lead from pin 2 of power receptacle M to pin 6 of 1626 oscillator socket.)

Using the Adapter

Place a Novice band crystal and a 12A6 tube in the proper adapter sockets. Insert the adapter in the oscillator socket of the transmitter. It may be necessary to rotate plug (PL-1) a bit to obtain a smooth fit. Connect a 0-250 d.c. voltmeter to the transmitter grid voltage test jack (J2). After a short warm-up period, turn on the low voltage, but leave the transmitter key open. Adjust the main tuning dial of the transmitter for maximum voltage at the test point. Connect a suitable dummy antenna (see Figure 12) to the transmitter output terminal. Loosen the shaft lock on the amplifier padding capacitor (C-67) below the chassis, and tune the amplifier stage for resonance. Adjust the antenna coupling and antenna inductance until plate current of the amplifier stage is approximately 130 milliamperes.

It will be noted that best keying characteristics occur when oscillator tuning (the main "Frequency" dial) is set to a somewhat higher frequency than that of the crystal.

For ease of adjustment, the shaft lock of amplifier padding capacitor C-67 should be removed, and a short insulated extension shaft and knob added to the capacitor. Oscillator tuning may then be done with the main tuning control of the transmitter, and amplifier tuning with the knob on C-67.

If the BC-457 (T-20/ARC-5) is used for 80 meter operation, it is necessary to increase the capacity of oscillator padding capacitor C-60 to maintain crystal oscillation. This capacitor may be reached through a hole in the top of the oscillator shield can. The oscillator shield can must be removed to release the shaft lock on this capacitor before it can be adjusted.

Parts List for Crystal Control Adapter

1—20 mmf ceramic capacitor (Centralab NPO) (C1)
1—100 mmf ceramic capacitor (Centralab NPO) (C2)
3—.005 disc ceramic capacitor (Centralab DD-502) (C3, C4, C6)
1—250 mmf ceramic capacitor (Centralab DD-251) (C5)
1—68K, ½ watt resistor (IRC type BTS or BW½) (R1)
1—22K, 1 watt resistor (IRC type BTA or BW1) (R2)
2—Choke, r-f, 2.5 mh (National R-100) (RFC1, RFC2)
1—Socket, octal (Amphenol 78-RS8)
1—Male connector, octal (Amphenol 86-CP8, with ring) (PL-1)
1—Crystal socket (Cinch-Jones 2KM) (X1)
1—Tube, 12A6 (RCA)
1—Chassis-box 2¾"x2"x1½" (Bud CU-2100)
6-32 hardware, 4-40 hardware, wire.

AN ALL-BAND 60 WATT TRANSMITTER FOR THE ADVANCED NOVICE

Here's a compact, foolproof, all purpose transmitter for the advanced Novice and General Class amateur. Capable of 60 watts input on all bands between 80 meters and 10 meters, this three tube transmitter combines ease of operation and modest cost. It may be used as a portable or standby rig when you advance to high power, or it may be used as a driver for a high power amplifier. Easily adapted to phone, the AB-60 is a good investment as a permanent piece of station equipment!

This three tube transmitter is recommended to those amateurs who have had some constructional experience. Employing a transmitting-type 6146 as an amplifier stage, the AB-60 runs 60 watts input on all bands between 3.5 mc and 29.7 mc. In addition, it may be easily adapted for phone operation, as described later. A simplified system of bandswitching is employed, and grid and cathode metering circuits are incorporated in the amplifier stage. A single-ended pi-network tank circuit is used. Ample lead filtering is designed into the transmitter to reduce TVI to a minimum. Best of all, the transmitter can be built without completely deflating your pocketbook!

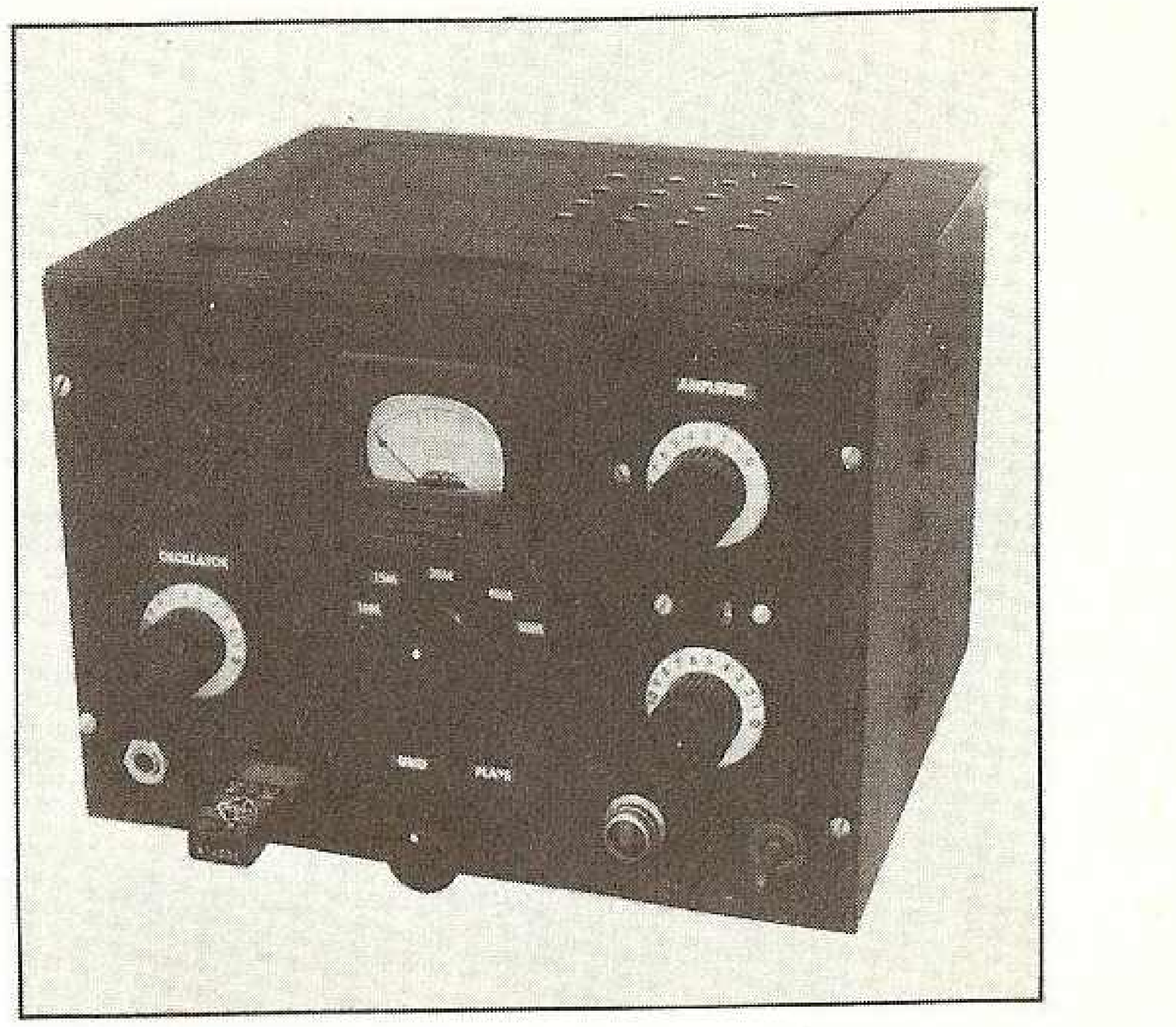


Fig. 16 This all-band transmitter measures 7" x 8" x 10" in size, including power supply. Oscillator control is at left, with bandswitch and meter switch at center. Amplifier controls are at the right, with line switch and pilot.

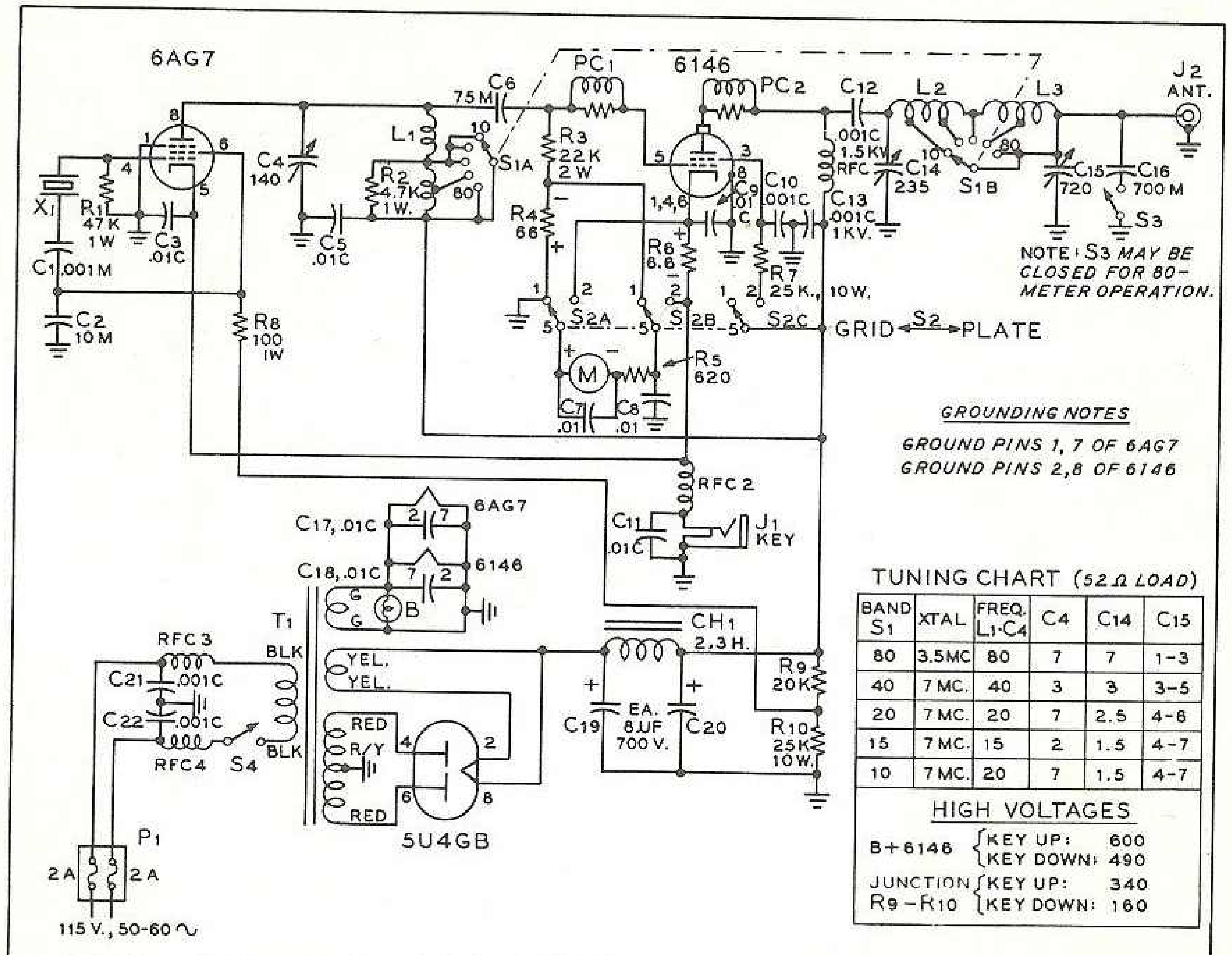
Transmitter Circuit and Construction

The schematic of the AB-60 transmitter is shown in Figure 17. A 6AG7 pentode tube is used as a grid-screen oscillator, delivering fundamental frequency output from an 80 meter crystal, and fundamental and harmonic output from a 40 meter crystal. The plate tank circuit (L1-C4) of the oscillator employs a tapped coil, and covers the range of 3.5 mc to 21 mc. A loading resistor (R2) drops the output level of the stage on the low frequency bands to prevent over-excitation of the amplifier. The 6AG7 is capacity coupled to a 6146 amplifier stage. Suppression chokes are included in the grid and plate leads of this tube to eliminate VHF parasitics. The output circuit of the amplifier is a conventional pi-network (C14-L2-C15). Extra capacity (C16) may be shunted into the loading circuit to accommodate low impedance 80 meter antennas. The cathode circuit of both the oscillator and the amplifier are keyed for c-w operation.

The high voltage supply is incorporated in the transmitter, and employs a 5U4-GB rectifier tube and a capacity input filter system. Screen voltage for the oscillator tube is obtained from a tap on the bleeder resistor network (R9-R10). The power leads and the key lead from the transmitter are filtered to reduce leakage of r-f energy into the 115-volt light line.

The complete transmitter is enclosed in a metal box measuring 10"x7"x8" in size. The transmitter chassis measure 9"x7⅜"x1½". Placement of the major components may be seen in the top and bottom photographs. A discussion of the circuitry of this transmitter is given in chapter 6 of this Handbook.

By this stage of the game, it should not be necessary for the builder to require such explicit assembly and wiring instructions as provided herein for the more simple construction items. The following instructions, therefore, indicate the proper sequence of assembly without the detailed wire-by-wire



TUNING CHART (52 Ω LOAD)

BAND S1	XTAL	FREQ. L1-C4	C4	C14	C15
80	3.5MC	80	7	7	1-3
40	7 MC.	40	3	3	3-5
20	7 MC.	20	7	2.5	4-6
15	7 MC.	15	2	1.5	4-7
10	7 MC.	20	7	1.5	4-7

HIGH VOLTAGES

B+6146	KEY UP:	600
	KEY DOWN:	490
JUNCTION R9-R10	KEY UP:	340
	KEY DOWN:	160

Fig. 17 Schematic diagram and tuning chart for AB-60 transmitter. Switch S3 is closed when low impedance 80 meter antennas are used with the transmitter.

outline. With the help of Figures 18, 20, and 21, you should have no trouble at all. Let's get to work!

( ) Lay out the major chassis holes to be drilled on the paper wrapper of the chassis. Drill the holes and remove the burrs.

( ) Drill the panel holes. If you use a drill press, cover the table of the press with a cloth, and take care not to scratch the finish of the panel.

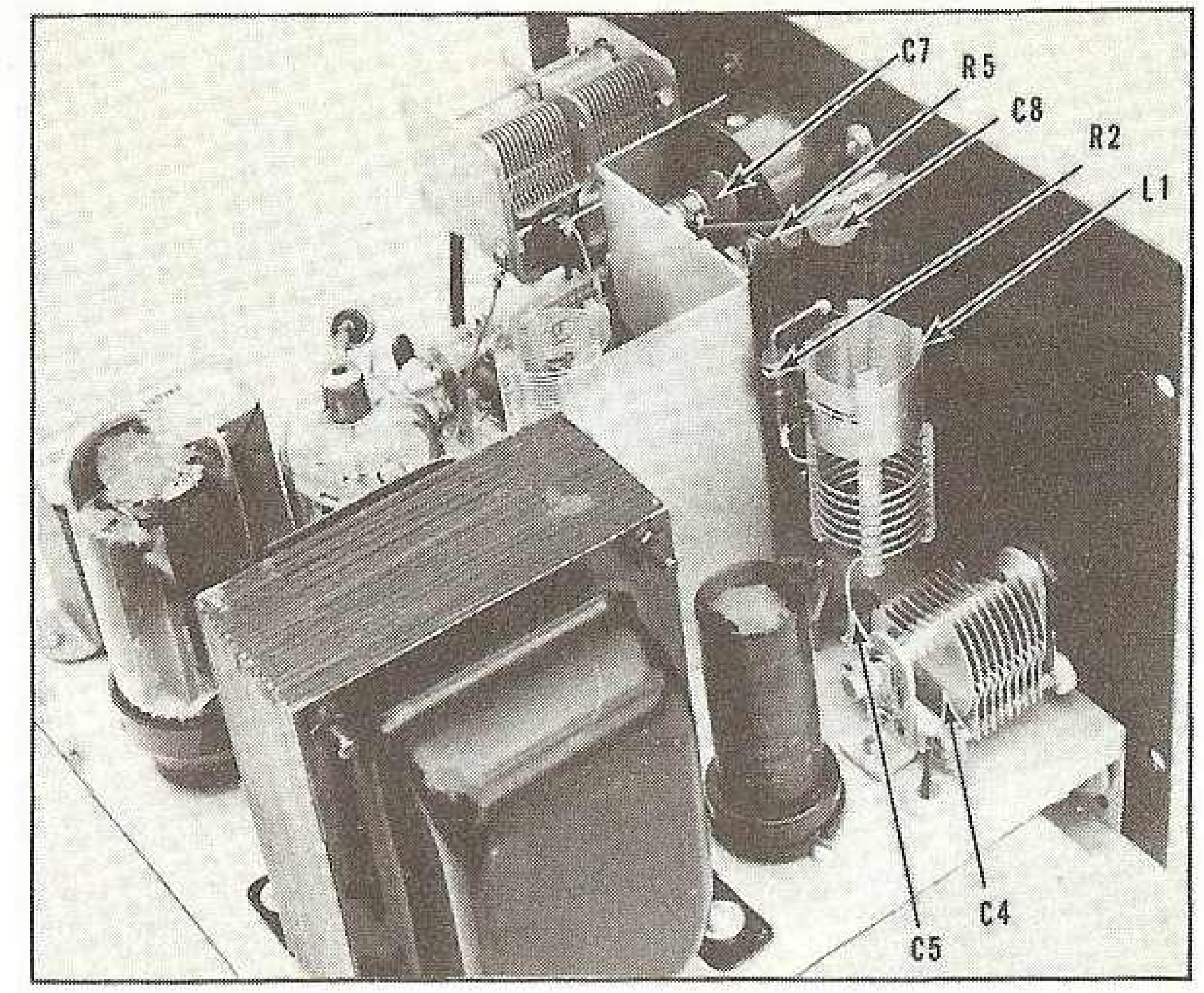
( ) The panel is mounted to the chassis by the shaft nuts of C4, C14, J1, S2, and S4. These components are mounted to the chassis. The shaft nuts of J1, S2, and S4 will space the panel away from the chassis about 1/16" or so, and a second set of locking nuts on the shafts of C4 and C14 are placed over the panel, locking it firmly to the chassis. Crystal holder X1 is attached to the panel with a 4-40 nut and bolt. Note that a small cut-out is made in the bottom lip of the chassis to clear switch S2. Your tin-snips will come in handy.

( ) After the panel and chassis are fastened together, transformer T1, choke CH1, and the tube sockets should be mounted. Observe the orientation of the socket keys (Figure 21). Place a single terminal phenolic tie-point above the chassis on the bolt holding the 6146 socket nearest CH1. Mount the various tie-points beneath the chassis, and place the ⅜" rubber grommets in the six chassis holes.

( ) The next step is to wire the transformer and choke leads to get them out of the way. The two leads of CH1 attach to the tie-point strip supporting the "plus" ends of capacitors C19 and C20.

( ) Switch S1 should now be assembled (Figure 19). A *Centralab P-121* Index Assembly is used, with a *Centralab* phenolic *type H* deck (S1A) placed directly behind the assembly mechanism. A *Centralab* ceramic *type P1-S* deck is spaced about 1" behind the H deck. Deck S1A taps various turns of the oscillator coil (L1), and deck S1B (a progressively shorting deck) shorts out segments of the amplifier coil, L2-L3.

Fig. 18 View of oscillator compartment of the AB-60 transmitter.



( ) Mount switch S1 to the panel of the transmitter. Make sure that the shaft collar of S1 makes a good ground connection to the panel, and that the panel makes a good electrical ground to the chassis. It may be necessary to scrape paint off the rear of the panel behind the controls to make an effective ground to the chassis.

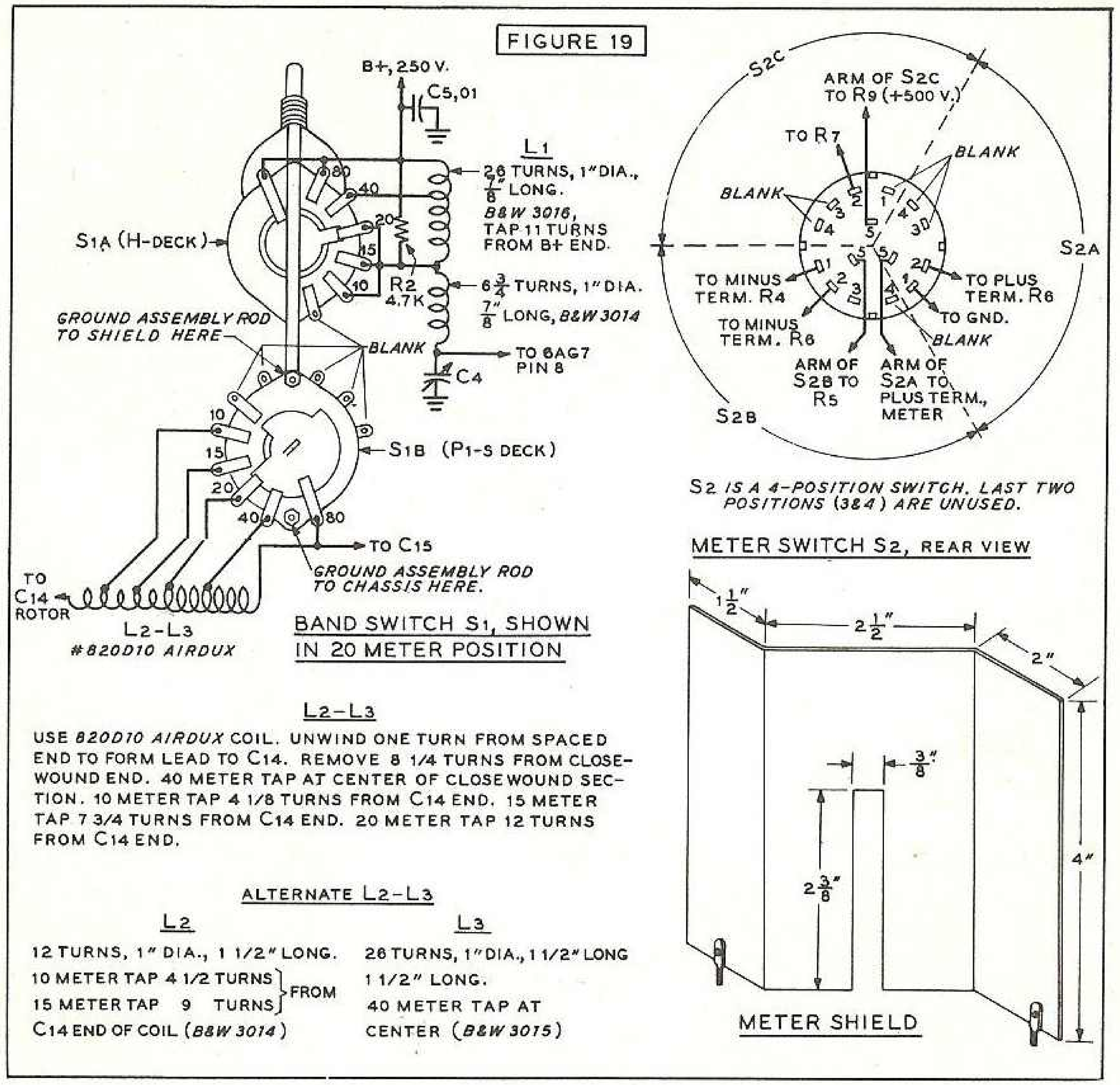
( ) Cut the interstage shield (Figure 19) from a piece of soft aluminum. This shield crosses the center of switch S1, shielding the oscillator coil from the amplifier coils. The shield is held to the chassis by two spade bolts. A slot is cut in the center portion of the shield to pass the assembly rods of S1. Before the shield is mounted in place, a soldering lug is attached to the shield just above the slot. After mounting the shield, this lug is soldered to the top assembly rod of the switch, grounding the rod to the shield. A second soldering lug is bolted to the chassis directly under the rear of S1. This is soldered to the rear end of the lower assembly rod. It is necessary to ground the assembly rods at the rear of the switch to prevent energy leak-through between the coils along the metal rods.

( ) Capacitor C15 and switch S3 are now mounted to the panel. A ground wire is attached from the rotor of C15 to the rotor of C14, providing a short, direct ground path between the two capacitors.

( ) The power supply wiring is completed next. The filament leads, C17 and C18, the pilot lamp assembly, the high voltage filter capacitors (C19, C20), and the bleeder resistors (R9, R10) should be wired. The line cord and line filter assembly (RFC-3, RFC-4, and C21, C22) are installed. The socket grounds are made to the 6AG7 and 6146 sockets. Next, the resistance to ground from the "plus" end of R9 should be checked. It should be about 45K. The tubes are now placed in their sockets and the transmitter turned on. All filaments should light, and the voltage from the "plus" end to ground of R9 should be about 600 volts.

( ) The next step is to wire the oscillator components. R1, C1, C2, C3, and R8 mount between the pins of the 6AG7 socket and the grounding lugs of the socket. The "empty" pin 3 of the oscillator socket is used as a tie-point for the "B-plus" end of resistor R8. A single terminal tie-point is mounted above the chassis between tuning capacitor C4 and the shield plate. Bypass capacitor C5 is mounted across this tie-point. The arm of S1A is wired to this tie-point.

( ) Oscillator coil L1 is now assembled. Two sections of coil material are cemented together, as shown in Figure 18. Nail polish, or *Duco* cement may be used to bind the ends of the insulating strips together. When the coil assembly has dried, taps may be made on the coil, by bending in the turns on each side of the turn to be tapped. The 4.7K load resistor (R2) is



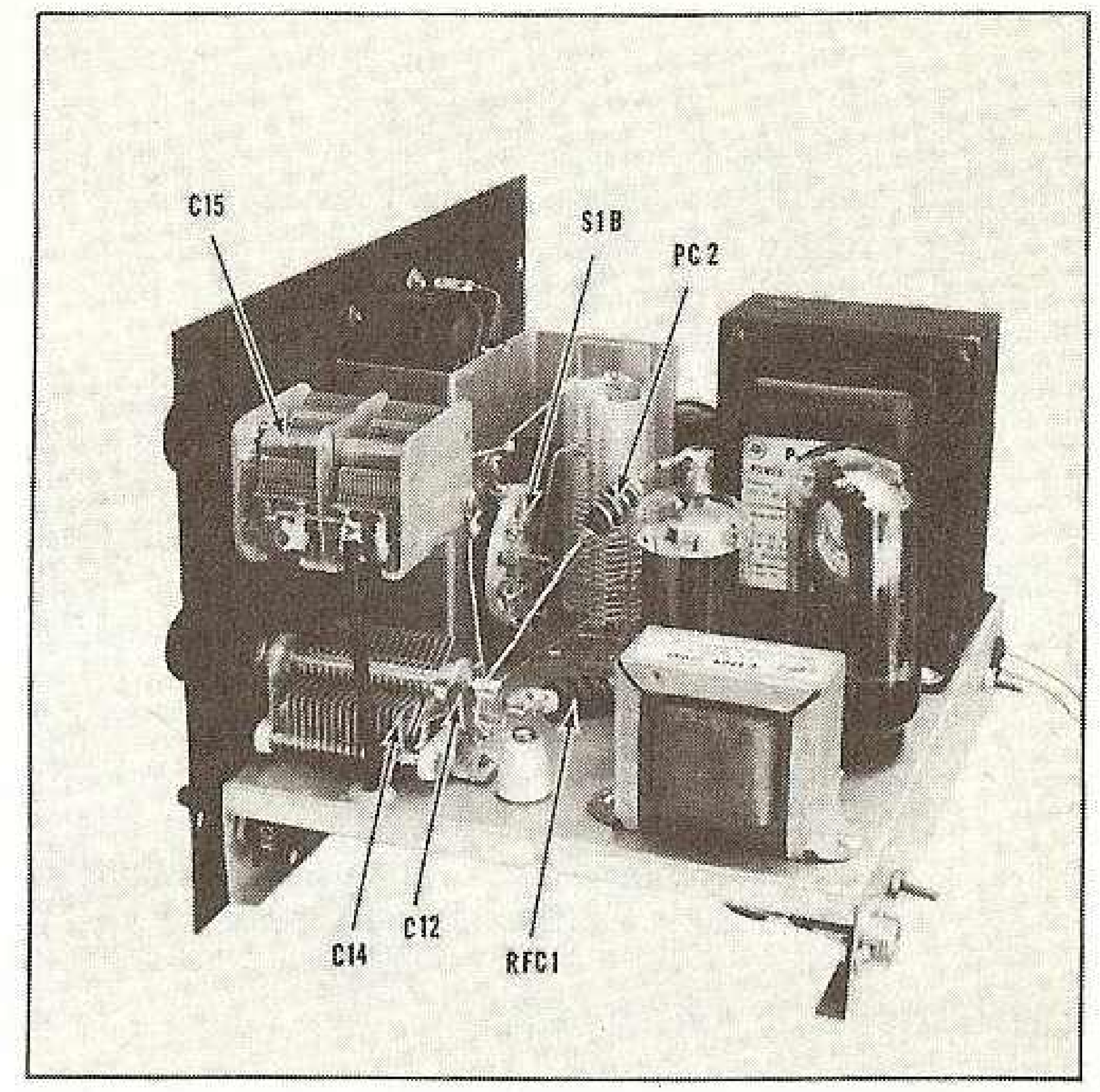
mounted in place. Leads are soldered to the arms of switch section S1A, and insulated sleeving is slid over the leads. The leads are soldered to the coil taps, holding the coil in a vertical position. The bottom coil wire attaches to the stator of tuning capacitor C4.

( ) When the oscillator wiring is finished, the plate coil assembly may be checked with the aid of a grid-dip oscillator. The bandswitch S1 should be set to each band in turn, and capacitor C4 tuned for an indication on the meter of the grid-dip oscillator held in proximity to L1. On the 28 mc position of S1, the coil assembly should resonate at 14 mc, as the 6146 stage operates as a frequency doubler from 14 mc to 28 mc.

( ) The next step is to wire the 6146 amplifier. Parasitic chokes PC-1 and PC-2 are wound as specified in the parts list. A 5/8" ceramic insulator is mounted above chassis between the 6146 tube socket and capacitor C14. This insulator supports one end of RFC-1, one terminal of capacitor C12, and the 6146 plate lead from PC-2. The B-plus end of RFC-1 is attached to the phenolic tie-point mounted at the 6146 socket bolt. Capacitor C13 is placed across the terminals of that tie-point, and spaced to clear the metal shell of the tube base. The keying circuit is wired next.

( ) The plate coil of the 6146 stage is made up of an *Air Dux 820D10* pi-network inductor. The coil is modified as described in Figure 19. In order to make coil taps without damaging adjacent turns, it is desirable to indent one turn each side of the tap. This may be done by pushing gently on the turn with the blade of a screwdriver. The wanted turn, therefore will be left projecting above the two adjacent indented turns. Attach three inch tinned leads to each tap position on the coil.

Fig. 20 Amplifier portion of transmitter, showing S1B and coil connections to L2-L3. Rear assembly rods of S1 are grounded to interstage shield and to the chassis. Lead from C15 passes through chassis to antenna receptacle J2 mounted on rear lip of chassis. Bolts mounted on rear of chassis hold rear of transmitter firmly to cabinet.



( ) An insulated jumper runs from the arm of S1B to the paralleled stators of loading capacitor C15. After this lead is in place, plate coil L2-L3 may be mounted to the chassis behind S1 by means of a ½-inch metal bracket and 4-40 hardware. The coil is positioned with the spaced end of the winding next to the chassis. The top connection of the coil attaches to the jumper going to C15. The bottom connection of L2-L3 goes to the stator of C14. Coil taps are attached to S1B as shown in Figure 19.

( ) If desired, an alternative coil may be made of two sections of *Miniductor* stock (Figure 19). Sections L2 and L3 are placed at right angles to each other across the back of S1B. Coil L3 mounts in a vertical position, and coil L2 mounts between the 20 meter tap of S1B and the stator connection of C14. Make sure that L2 and L3 do not touch each other, and see that L3 does not touch the rotary shaft of S1.

( ) Run the lead from the parallel connected stators of capacitor C15 to antenna receptacle J2, and wire capacitor C16 and switch S3. The ground connection of S3 should return to the rotor frame of loading capacitor C15.

( ) The next step is to install the 0-1.5 d.c. milliammeter (M) on the panel, and to wire the meter circuit. Capacitor C7 is placed across the meter terminals, and multiplier resistor R5 is attached between the "minus" meter terminal and a phenolic tie-point placed under a meter mounting bolt (Figure 18). Capacitor C8 is placed across the terminals of this tie-point. Switch S2 is now wired (Figure 19).

( ) All transmitter wiring should now be checked against Figure 17, preferably by another person. (It is very easy to be blind to your own wiring errors!) All tubes should be placed in their sockets. The resistance to ground of the various tube pins should be checked against the table of Figure 22.

( ) The knobs are now placed on the shafts of the transmitter controls so that they indicate "10" when the capacitors are fully meshed. Temporary panel markings may be made for the notations of S1 and S2 with pieces of paper tape affixed to the panel.

( ) The transmitter should be tested, following the procedure outlined in chapter 6. All tuning should be done with a 50-watt, 115-volt light bulb as a dummy antenna until the operator is familiar with transmitter operation. Full scale meter reading in the "grid" position is 15 ma, and grid current should be adjusted to 2.5 ma to 3 ma (.25 to .3 on the meter). Full scale "plate" current reading of the meter is 150 ma, and plate current should be adjusted to 120 ma (1.2 ma on the meter). The transmitter should never be operated without an antenna load of some kind connected to antenna receptacle J2.

( ) Lettering "decals" should now be applied to the panel to designate the controls. A *very little* lacquer thinner will cement the decal in place after it has dried.

( ) About a dozen 3/8" diameter holes should be drilled in the bottom of the cabinet to improve air circulation. The top of the cabinet should be drilled with 1/4" holes, as shown in the photograph. This improves the ventilation around the 6146 and 5U4-GB tubes.

( ) The front lips of the cabinet, and the rear lips of the panel should be scraped free of paint to make a good electrical contact between the two. A long 6-32 bolt should be fastened to the rear lip of the chassis, projecting through a matching hole drilled in the rear of the cabinet. This insures a good ground at the rear of the chassis, and reduces movement of the chassis within the cabinet. The cabinet is drilled to pass the 115-volt line cord, and the coaxial antenna plug. The transmitter is placed within the cabinet. For maximum TVI prevention, additional sheet metal screws should run through the front panel into the cabinet. The flanges of the cabinet lid should be scraped clean, and the lid fastened shut with four more sheet metal screws. In weak TV signal areas, it may be necessary to add a low-pass TV filter in the coaxial line from the transmitter to the antenna. This is usually only necessary for 28 mc operation of the transmitter.

Transmitter Operation

Tuning of the transmitter has been discussed in detail in chapter 6. As with any multi-band transmitter, it is important that the resonant circuits be tuned to the *correct* multiple of the crystal frequency for harmonic operation. In particular, the oscillator tank circuit tunes the frequency range of 12 mc to 25 mc for operation on the 20, 15, and 10 meter bands. On 20 meters, this circuit is resonated to 14 mc, and for 15 meter operation it is resonated to 21 mc. When the transmitter is used on the 10 meter band, the oscillator tank is again resonated to 14 mc. Tuning this circuit to the wrong frequency can cause the transmitter to tune erratically, and to radiate a signal on an unwanted frequency. A summary of dial settings for both the oscillator and amplifier tuned circuits is given in Figure 17. Compare your dial settings with these.

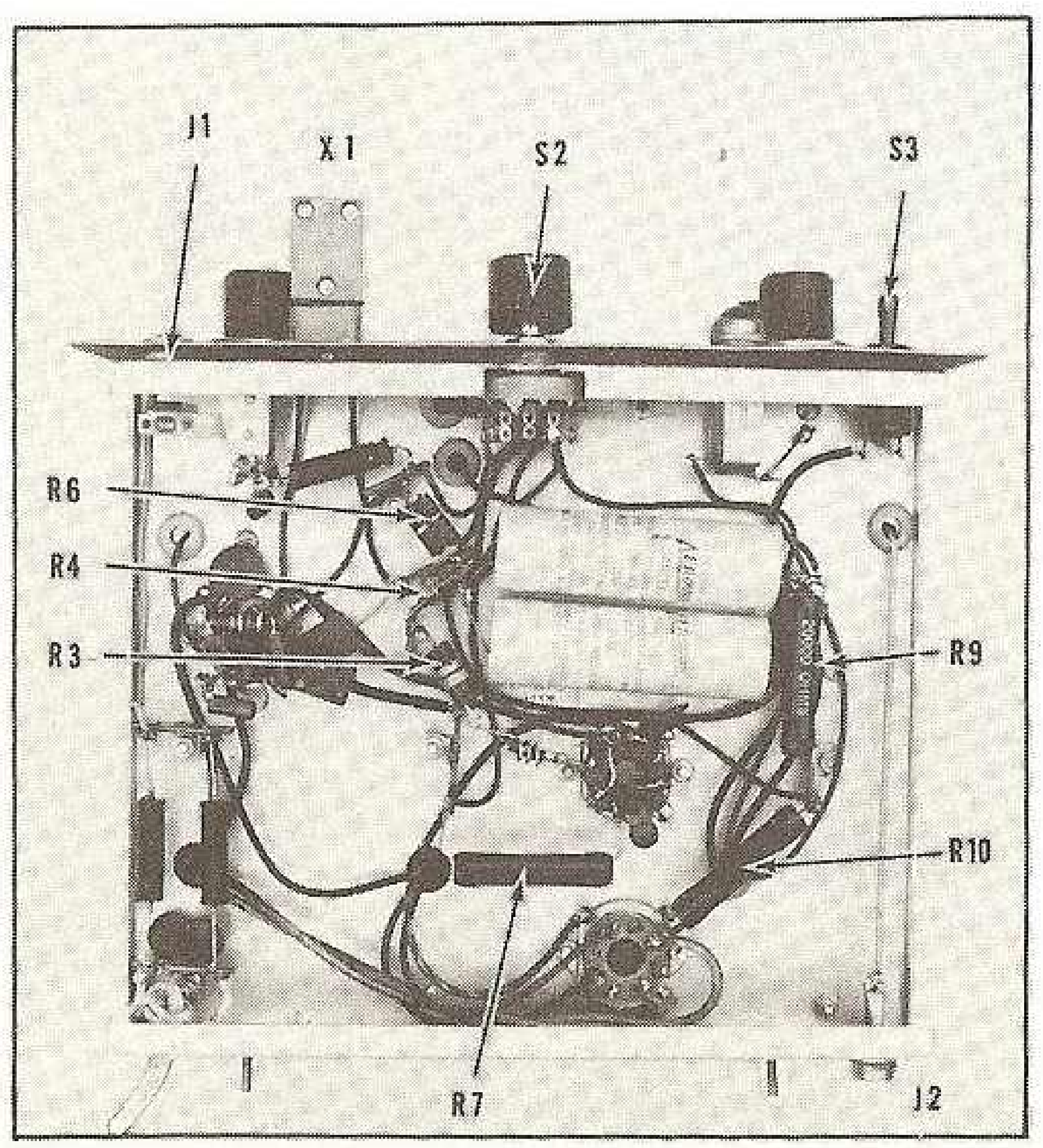


Fig. 21 Under-chassis view of AB-60 transmitter. High voltage filter capacitors are near the center of chassis, supported at right end by two terminal tie-point strip. Oscillator components are at left.

Parts List for AB-60 Transmitter

1—.001 mica capacitor (Sprague 1FM-21) (C1)
1—10 mmf ceramic capacitor (Centralab NPO) (C2)
8—.01 disc ceramic capacitor (Centralab DD-103) (C3, C5, C7-C9, C11, C17, C18)
1—140 mmf variable capacitor (Bud MC-1856) (C4)
1—75 mmf mica capacitor (Sprague 1FM-475) (C6)
3—.001 disc ceramic capacitors (Centralab DD-102) (C10, C21, C22)
2—.001, 1.5 KV disc ceramic capacitor (Centralab DD16-102) (C12, C13)
1—235 mmf variable capacitor (Bud MC-1859) (C14)
1—dual section 350 mmf variable capacitor (J. W. Miller 2112) (C15)
1—700 mmf mica capacitor (Sprague 1FM-37) (C16)
2—8 mf, 700 volt electrolytic capacitor (Aerovox PRS8-700) (C19, C20)
1—47K, 1-watt resistor (IRC type BTA, or BW-1) (R1)
1—4.7K, 1-watt resistor (R2)
1—22K, 2-watt resistor (IRC type BTB, or BW-2) (R3)
1—66 ohm, 1-watt resistor (R4)
1—620 ohm, 1-watt resistor (R5)
1—6.6 ohm, 1-watt resistor (R6)
1—25K, 10-watt wire wound resistor (Ohmite "Brown Devil") (R7)
1—100 ohm, 1-watt resistor (R8)
1—20K, 10-watt wire wound resistor (R9)
1—25K, 10-watt wire wound resistor (R10)
1—Suppressor. 3 turns #14 wire on 50 ohm, 1/2-watt resistor (PC1)
1—Suppressor. 4 turns #14 wire on 50 ohm, 2-watt resistor (PC2)
1—Oscillator inductor (see text). 6 3/4 turns, 1" diam., 7/8" long. (B & W 3014) plus 26 turns, 1" diam., 7/8" long (B & W 3016) (L1)
1—Amplifier inductor (see text). Air-Dux 820D10, 1" diam., 4" long, modified. Alternative coil: B&W 3015 and B&W 3014, modified per Figure 20. (L2-L3)
1—2 1/2 mh. r-f choke (National R-100) (RFC-1)
3—2 microhenry r-f choke (National R-60) (RFC-2, RFC-3, RFC-4)
1—Switch Assembly (Centralab P-121) (Part of S1)
1—Switch Deck (Centralab type H) S1A)
1—Switch Deck (Centralab type P-1S) (S1B)
1—Switch, 4PDT (Mallory 3234J) (S2A, S2B, S2C)
1—Switch SPST (Carling S60A) (S3)
1—Switch, toggle (H & H 20994-EW) (S4)
1—Crystal socket (Cinch-Jones 2KM) (X1)
1—Jack, closed circuit (Mallory A-2A) (J1)
1—Receptacle and plug (Cinch-Jones (P-101, S-101) (J2)
1—Meter, 0-1.5 d-c milliamperes (Triplett 227-T) (M)
1—Transformer 880 volts c-t, 130 ma (Stancor P-6143) (T1)
1—Choke, 2.3 henries at 150 ma (Stancor C-2304) (CH1)
3—Octal socket (Cinch-Jones 8JC)
1—Tube, 6AG7 (RCA)
1—Tube, 6146 (RCA)
1—Tube, 5U4-GB (RCA)
1—Pilot lamp assembly (Johnson 147-400) (B)
1—Fused line plug (El-Menco) (P1)
2—Fuses, 3AG, 2 ampere (Littelfuse)
1—Chassis, 7 3/8"x9"x1 1/2" (Bud CB-976)
1—Cabinet, 7"x10"x8" (Bud C-993)
6—Single terminal tie-point (Cinch-Jones 51)
5—Double terminal tie-point (Cinch-Jones 52A)
1—Ceramic insulator, 5/8" high (Johnson 135-500)
6—3/8" diam. rubber grommets (Walsco 7034-F)
3—Knob (National HRS-5)
2—Knob (National HR)
1—Plate clip (National 24)

PIN	1	2	3	4	5	6	7	8
6AG7	0	0.2	25K	47K	0 (1)	25K	0	45K
6146	6.6 (2)	0	70K (3)	6.6 (2)	22K	6.6 (2)	0.2	0
5U4GB	—	45K	—	90	—	90	—	45K

(1) INFINITY WHEN J1 IS OPEN.
(2) S2 IN "GRID" POSITION. INFINITY WHEN J1 IS OPEN.
(3) INFINITY WHEN S2 IN "GRID" POSITION.

Fig. 22 Resistance chart showing pin measurements of AB-60 transmitter.

A SCREEN MODULATOR FOR THE AB-60 TRANSMITTER

Do you have your "General" ticket yet? Well, then, its about time to start thinking about phone! You'll have to furnish your own "handle," but here's a simple two tube modulator that you can add to the AB-60 transmitter that will put you on phone in a jiffy! Low in cost and high in effectivity, this unit is worth its weight in rare, exotic DX QSL cards. You can build it for less than $8.00, including tubes! Have at it!

A simple and economical method of phone transmission is to employ screen modulation of a tetrode or pentode r-f amplifier. The 6146 and 807 tubes are particularly well suited to this style of modulation, and the circuit of Figure 24 may be employed with these tubes. Peak amplitude carrier output in a screen modulation system is equal to the c-w output of the stage. This is about 40 watts for the AB-60. In order to obtain maximum output consistent with the plate dissipation of the r-f tube, this modulator incorporates a carrier control system that reduces the carrier level to about 8 watts under conditions of no modulation. Under full modulation, the normal peak power is obtained.

A 6SL7 dual triode is used as a two stage resistance coupled speech amplifier, working from an inexpensive crystal microphone. The output from this tube is split into two channels, one of which drives one-half of a 6SN7 which acts as a carrier level control tube. The control tube averages the audio level in its cathode circuit as a d-c bias which is applied to the other half of the 6SN7 serving as a cathode follower. The other portion of the speech amplifier output is applied to the grid of the cathode follower and appears as a superimposed audio signal on the d-c output of the cathode follower. The combined audio and d-c output of this stage is applied to the screen of the tetrode r-f amplifier tube and results in a varying d-c screen

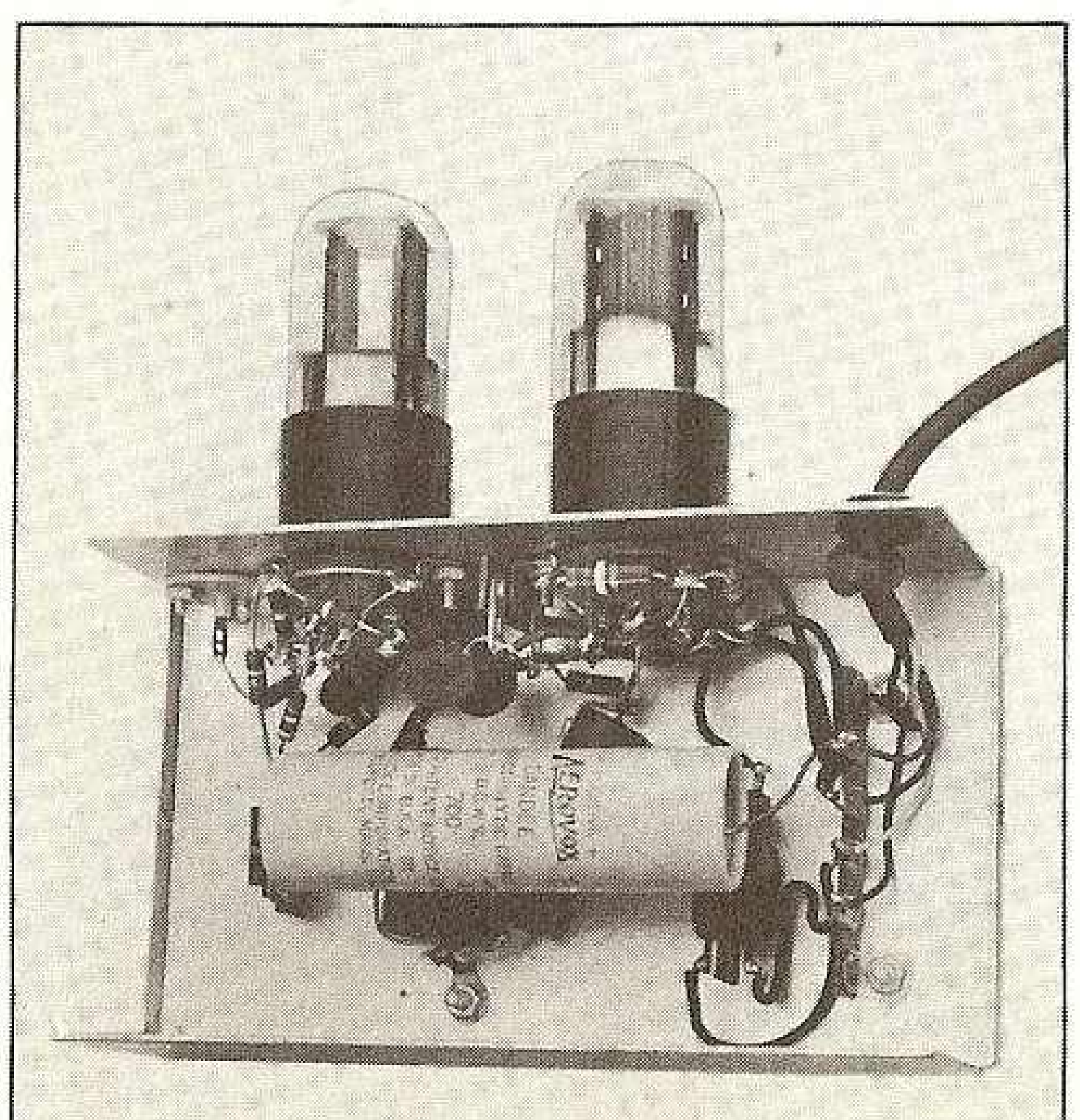
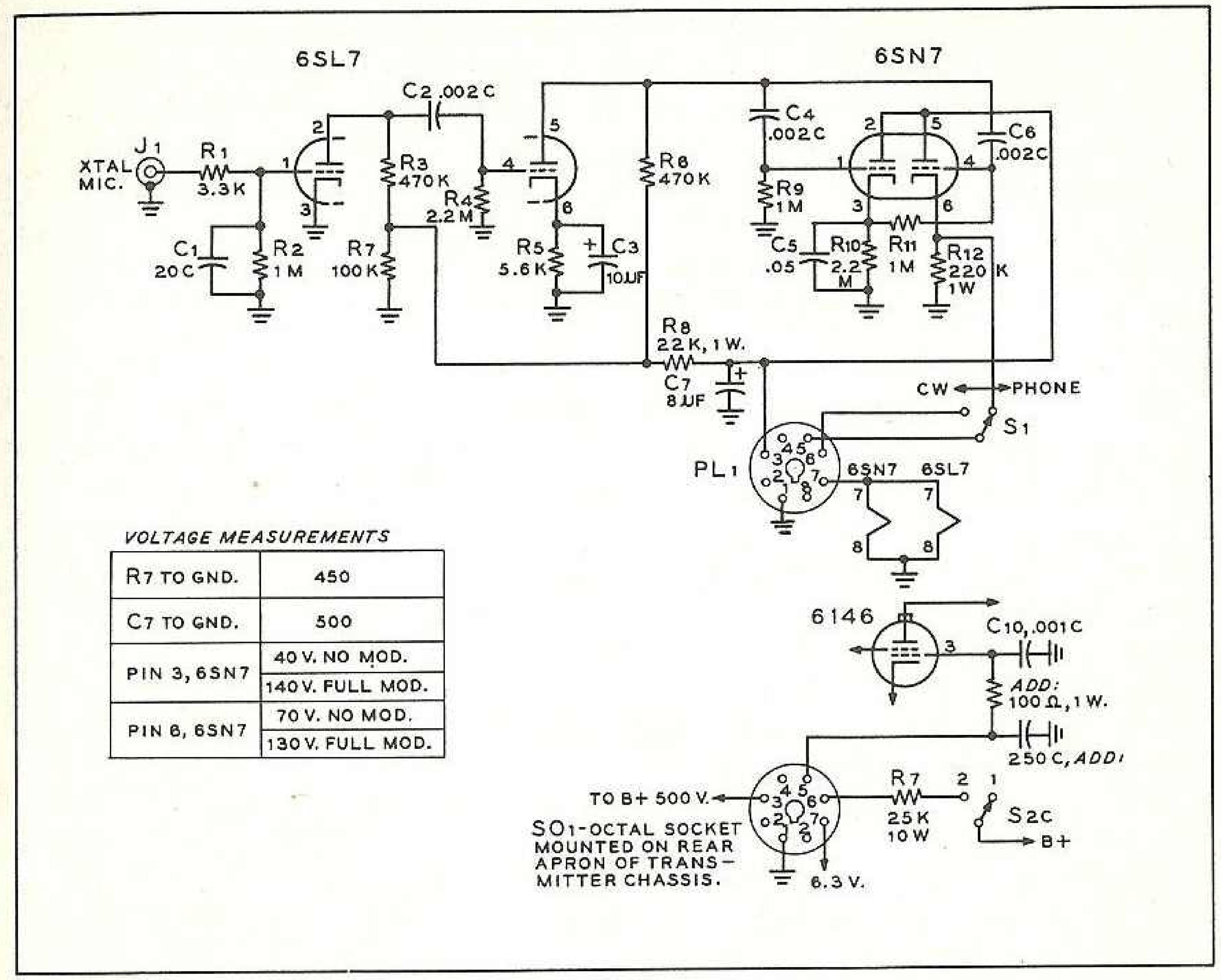


Fig. 23 **Small components of screen modulator are mounted between tube socket pins. C4 and C6 are attached to tie-point strip attached to bolt of 6SN7 socket. Switch S1 is mounted to side of case. Entire unit bolts to side of AB-60 cabinet.**



VOLTAGE MEASUREMENTS

R7 TO GND.	450	
C7 TO GND.	500	
PIN 3, 6SN7	40 V. NO MOD.	
	140 V. FULL MOD.	
PIN 8, 6SN7	70 V. NO MOD.	
	130 V. FULL MOD.	

Fig. 24 Schematic of screen modulator for AB-60 transmitter.

voltage having an audio component. The net result is a change both in r-f output and modulation level of the stage as the audio level changes. The modulator may be removed from the circuit and c-w operation restored by the *phone c-w* switch, S1.

Modulator Construction

The modulator is built within an aluminum chassis-box measuring 6" x 3½" x 2" in size (Figure 23). The modulator obtains its plate and filament power from the transmitter via a 5 wire interconnecting cable. The modulator is bolted to the left side of the AB-60 cabinet. All modulator components are mounted upon one-half of the chassis box, thus simplifying construction.

The usual step-by-step wiring instructions are omitted for this modulator, since it is felt that by the time the Novice or Technician gets to the stage of the game where he is ready for a modulator, he is also capable of wiring it up without too much coaching from the sidelines. The general assembly outline that follows, plus the diagram of Figure 24 should supply adequate assembly information. Ready to start??

( ) The chassis should be laid out and drilled, following the layout shown in Figure 23. The input circuit and 6SL7 are at the left, and the 6SN7 is to the right, with the 8 mf filter capacitor (C7) below the tube sockets.

( ) Tube sockets, microphone receptacle, switch S1 and insulated tie-points are mounted in position using 6-32 hardware. A four terminal phenolic tie-point strip is employed to terminate the wires of the power cable.

( ) Ground connections should be made to both tube sockets, and the filament circuit is wired.

( ) Resistors R2, R4, and R5 are mounted between the pins of the 6SL7 socket and adjoining socket ground lugs. Capacitors C1 and C2, and resistor R1 are mounted in place.

( ) Capacitors C4 and C6 are mounted between pin 5 of the 6SL7 socket and a two terminal tie-point strip fastened beneath the retaining nut of the 6SL7 socket. Resistors R9, R10, R11, and R12 are placed between various socket pins and socket grounding lugs.

( ) Capacitors C3 and C5 are mounted between tube socket pins and a grounding lug attached to the rear of the case, just below the 6SL7 socket.

( ) The last item to install is filter capacitor C7. The "minus" end of it is grounded at the center lug of the strip supporting R8, and the opposite end is attached to the tie-point holding the incoming B-plus lead (Figure 23).

( ) The octal plug (PL-1) is attached to the end of a 16" length of 5-wire cable. The opposite end of the cable goes to the four terminal strip mentioned above. The "ground" wire of the cable is attached to a foot of the mounting strip.

( ) When all connections are completed, the modulator should be checked against the schematic of Figure 24. Inspect the unit for rosin joints, shorts, transpositions or accidental grounds.

( ) The r-f amplifier screen circuit of the AB-60 should be modified as shown in Figure 24. An octal socket is installed on the rear apron of the transmitter chassis to supply power to the modulator, and to make the proper connections to the 6146 screen circuit.

( ) After the modifications have been completed, the modulator is bolted to the transmitter case, and plug PL-1 inserted in the power receptacle of the transmitter. The emission switch S1 of the modulator is set to *c-w.*

( ) The AB-60 is tuned up in the normal manner, and loaded to 120 ma plate current. Grid current should be about 2 ma. The c-w key of the transmitter is closed, and emission switch S-1 thrown to *phone.* Plate current of the 6146 will drop to about 45 ma. Upon speaking into the microphone, the plate current should rise to about 100 ma on voice peaks. The modulation level is regulated by varying the speaking distance from the microphone. To return to c-w emission, it is only necessary to throw S1 to the *c-w* position, and open the key. For either type of emission, all preliminary tuning adjustments should be made with S1 in the *c-w* operation.

Parts List for Screen Modulator

1—3.3K, ½-watt resistor (IRC type BW½ or BTS) (R1)
3—1 megohm, ½-watt resistor (R2, R9, R11)
2—470K, ½-watt resistor (R3, R6)
2—2.2 megohm, ½-watt resistor (R4, R10)
1—5.6K, ½-watt resistor (R5)
1—100K, ½-watt resistor (R7)
1—22K, 1-watt resistor (IRC type BTA, or BW-1) (R8)
1—220K, 1-watt resistor (R12)
1—20 mmf ceramic capacitor (Centralab TCZ-20) (C1)
3—.002 disc ceramic capacitor (Centralab DD-202) (C2, C4, C6)
1—10 mf, 25 volt electrolytic capacitor (Mallory type TC) (C3)
1—.05 mf, 400 volt paper capacitor (Mallory "Gem") (C5)
1—8 mf, 700 volt electrolytic capacitor (Aerovox PRS) (C7)
1—"Phono" type plug and receptacle (Cinch-Jones 13A, 13E) (J1)
1—SPDT toggle switch (G-C 1331)
1—Plug, male, 8 pin (Amphenol 78-PF8-11) (PL-1)
2—Sockets, octal (Cinch-Jones 8AB)
1—Tube, 6SL7 (RCA)
1—Tube, 6SN7 (RCA)
1—Chassis-box, 6"x3½"x2" (L.M.B. 138)
2—Double terminal tie-point (Cinch-Jones 52A)
1—Four terminal tie-point (Cinch-Jones 54A)
Two feet of five wire cable, misc. hardware, etc.

THE 2N6 VHF TRANSMITTER

Here's a fine little VHF transmitter for 2 and 6 meters that is inexpensive and easy to build! Using only five tubes and 8 mc "surplus" crystals the 2N6 will lay down a signal that will command attention. A simplified tuning arrangement makes use of a "magic eye" tube, in place of the more expensive tuning meter. Less than twenty-five dollars will put you on the VHF bands with this FB transmitter! Better get to work!

Activity on the Novice 2 meter band and the Technician 6 meter band is at an all-time high. This simple five tube VHF transmitter is recommended to amateurs interested in operation on these bands. Using a 5763 transmitting-type pentode in the output stage, the 2N6 will deliver a strong, well-modulated signal on either band. Interested? Well, let's look at the circuit of Figure 26.

Transmitter Circuit and Construction

A single 12AT7 double triode is employed as an overtone oscillator and frequency multiplier. Crystals in the 8 mc to 9 mc region are used for both 50 mc and 144 mc operation. The crystal oscillates on the third overtone in the 24 mc to 27 mc region. For 2 meter operation, the second section of the 12AT7 acts as a frequency tripler to 73 mc. The 5763, then operates as a frequency doubler to 146 mc. When 6 meter operation is desired, the second section of the 12AT7 is removed from the circuit, and the 5763 functions as a frequency doubler from 25 mc to 50 mc.

The plate circuit of the 5763 employs the high-efficiency *series tuned* VHF tank circuit, explained in detail in the *VHF Handbook,* published by *Radio Publications, Inc., Wilton, Conn.* The reader is referred to this text for a complete coverage of VHF operation and equipment design.

Transmitter tuning is greatly simplified by the use of a 6U5 "magic eye" tube. This tube has an illuminated target at the top which opens and closes when excited by a d-c voltage impressed upon the grid of the tube. In the 2N6 transmitter, this d-c voltage is obtained from a 1N34 crystal diode that is placed across the resonant circuits of the transmitter. When the

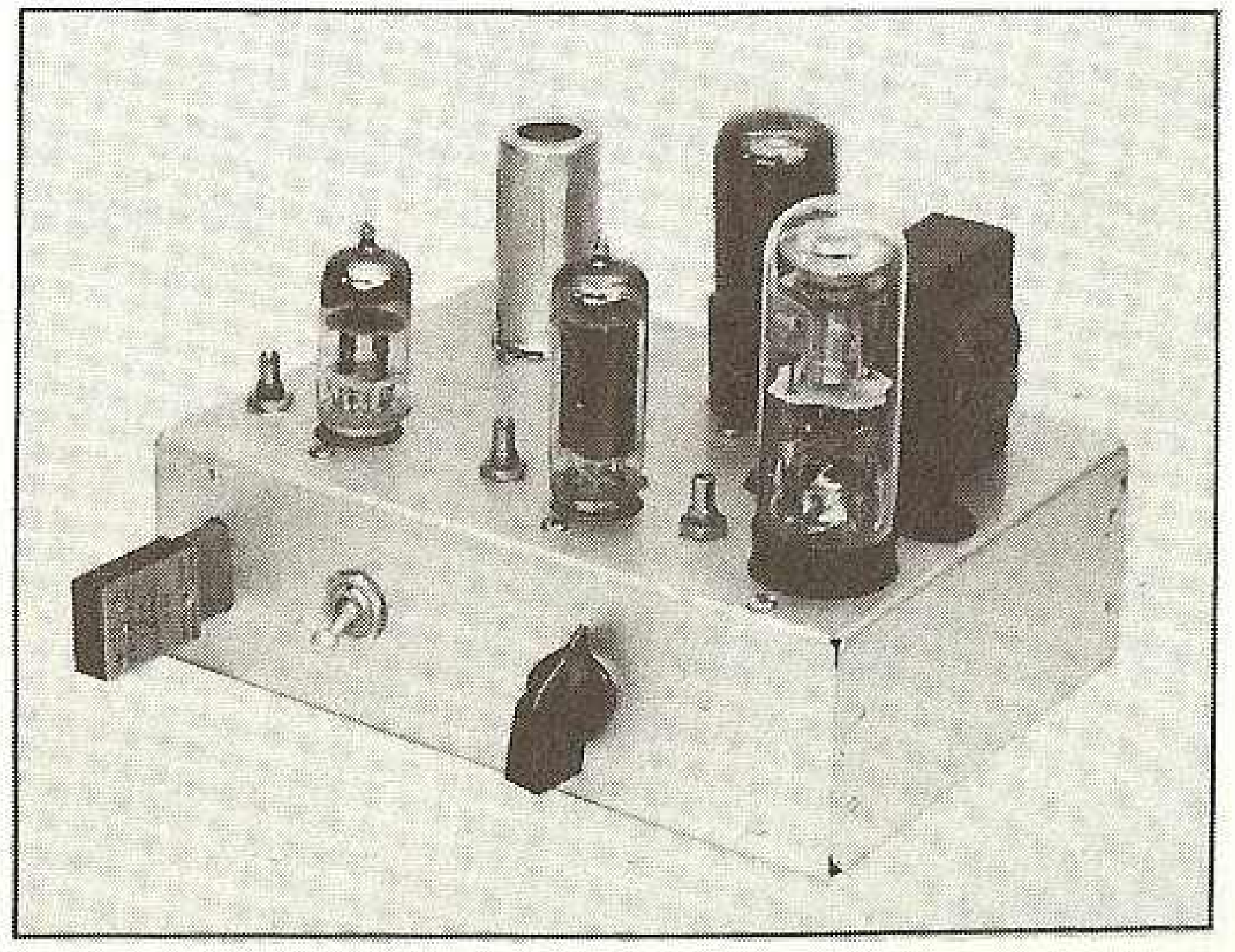


Fig. 25 The 2N6 transmitter is an ideal beginner's VHF rig. A 5763 transmitting type pentode is used in the output stage, modulated by a 6V6-GT. A 6U5 magic-eye tube (right) serves as the tuning indicator.

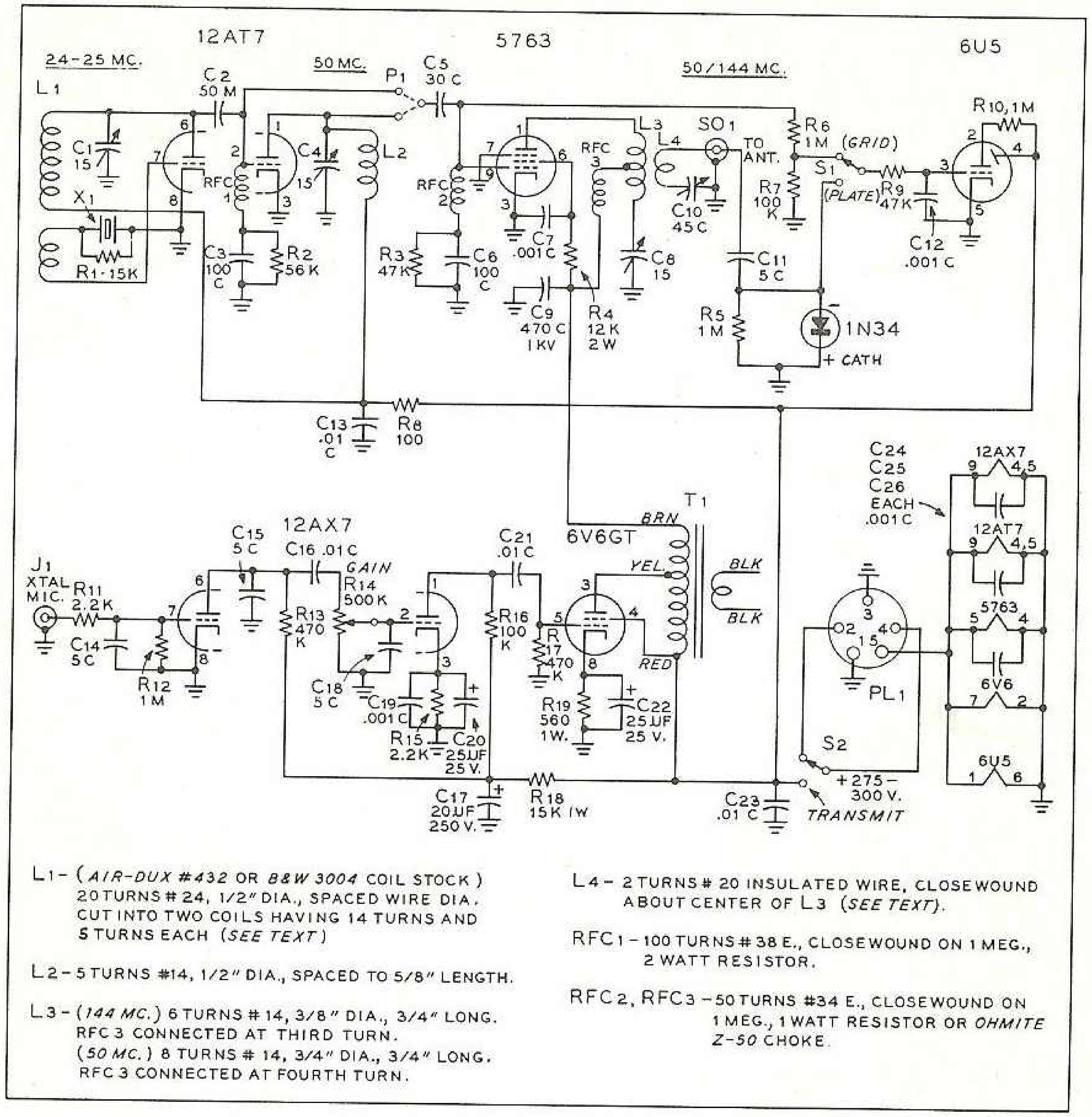


Fig. 26 Schematic of 2N6 VHF transmitter, showing "magic-eye" tuning circuit.

resonant circuit is properly tuned, the r-f voltage is rectified by the diode and applied to the 6U5 tube which blinks in appreciation! The eye-tube may be placed in either the grid circuit or the plate circuit of the 5763 output stage by means of switch S1. Oscillator output may also be observed by the eye-tube by changing terminal connection P1.

Two tubes are used in the audio section of the transmitter, which is designed to operate from an inexpensive crystal microphone. A 12AX7 dual triode serves as a two stage speech amplifier, with the gain potentiometer (R14) in the grid circuit of the second stage. A single 6V6-GT is employed as the modulator, using a tapped *Triad* modulation choke, T1, to couple the modulator to the VHF amplifier stage.

The transmitter is designed to operate with a 300 volt, 100 milliampere power supply, such as shown in chapter 8. A vibrator-type d-c power supply may be used if mobile operation of the transmitter is contemplated.

The complete transmitter is built upon an aluminum chassis 5" x 7" x 2" in size, and the layout of the major components is shown in Figure 27. The following assembly instructions, together with the bottom view of Figure 28 should suffice to put the transmitter on the air in jig-time. Grab your iron,

and let's get going. Remember—short leads are the key to success!

( ) Lay out the major chassis holes to be drilled on the paper wrapper of the chassis. Drill the holes and remove the burrs.

( ) Mount the major components on the chassis. Use 4-40 hardware and lockwashers for the miniature tube sockets. See Figure 27 for socket orientation. The 6U5 socket is recessed below the chassis in the special mounting cup. Observe the placement of tie-point strips TP-1, TP-2, and TP-3 in the bottom view of Figure 28.

( ) All filament wiring should be done first, and all required grounds made at each tube socket. Short, direct grounding leads from the socket pins to the grounding "ears" of the socket should be used. Make sure that the rotors of C1, C4, and C8 are grounded to the chassis by the capacitor mounting bolt.

( ) Coil L1 is made from a single section of miniature air inductor. A center turn is cut to make two coils, but the plastic support rods should not be cut. Separation between the coils is therefore determined by the distance left by the removal of a turn. One end of L1 is supported by TP-2, and the other end by a pin of crystal receptacle X1. The "inner" lead of the smaller coil attaches to pin 7 of the oscillator tube socket. The "inner" lead of the larger coil attaches to pin 6 of the 12AT7 socket.

( ) Bypass capacitor C13 and one end of coil L2 attach to TP-2. The other ungrounded lug of TP-2 supports RFC-1, R2, and C3. Coupling capacitor C2 mounts between pin 6 and pin 2 of the 12AT7 socket.

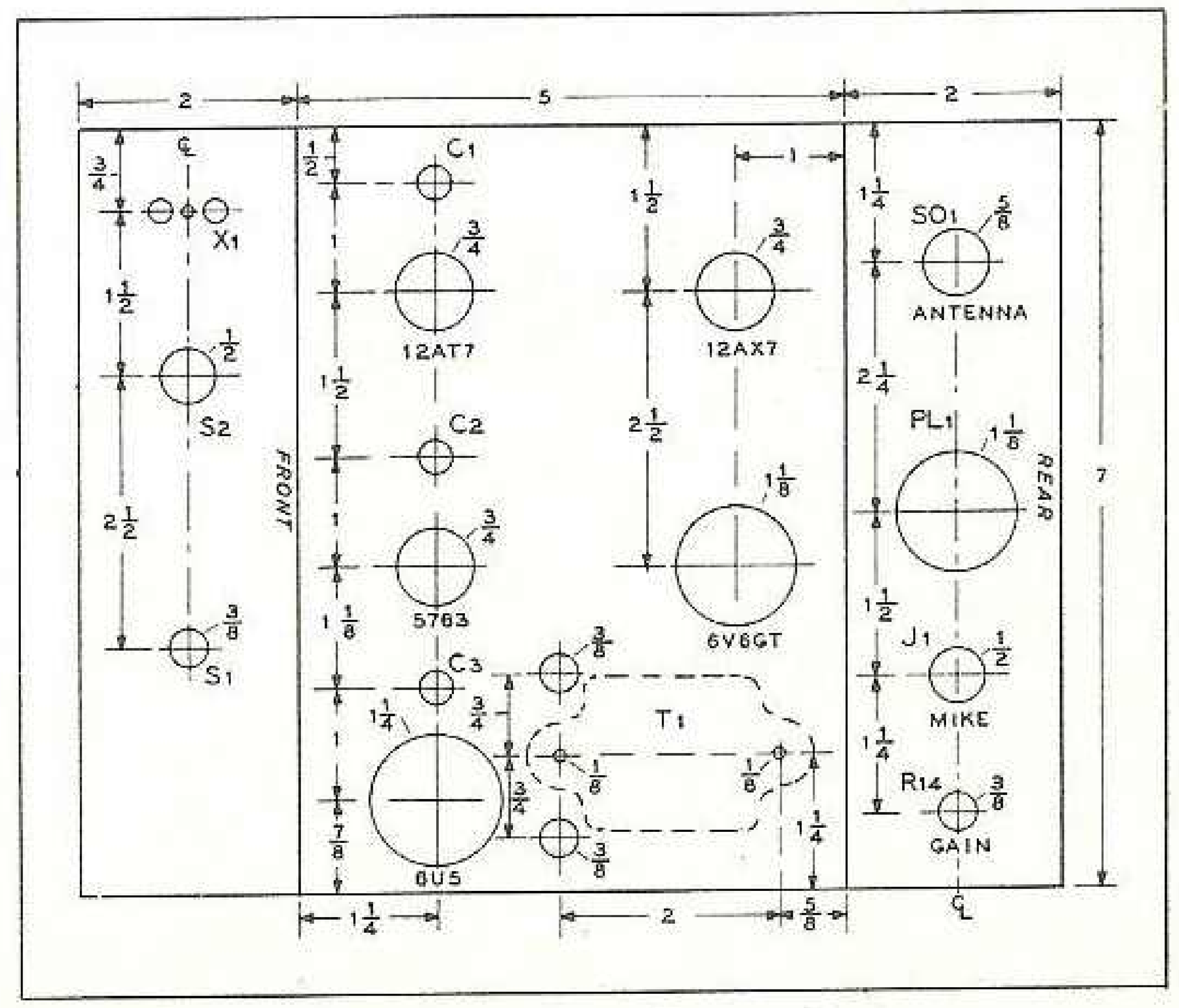
( ) A lead is run from grid pin 2 of the 12AT7 to tie-point TP-3, located near pin 9 of the 5763. For 50 mc operation, a lead of coupling capacitor C5 of the 5763 is removed from the stator terminal of C4 and attached to TP-3, eliminating the multiplier section of the 12AT7 tube.

( ) RFC-2, R3, and C6 are supported by TP-4, placed directly below the 5763 socket. Screen bypass capacitor C7 is installed between pin 6 and pin 4 (ground) of the 5763 socket.

( ) Plate coil L3 of the 5763 tube is mounted between pin 1 of the amplifier tube socket and the stator terminal of C8. RFC-3 is attached to the center of L3, and the 470 mmf plate bypass capacitor (C9) is installed between the B-plus end of the choke and an adjacent ground "ear" of the 5763 tube socket. The ceramic antenna tuning capacitor C10 is mounted to the chassis with 4-40 nuts and bolts. Small metal spacers are passed over the bolts to space C10 away from the chassis about ¼-inch. One terminal of C10 is grounded to a mounting bolt.

( ) A short length of coaxial line is run between antenna coil L4 and the antenna receptacle (SO-1) mounted on the rear of the chassis. The outer shield of this line is unbraided for about an inch at each end, and the braid is grounded to the chassis at both ends of the line.

Fig. 27 Chassis layout and drilling template for 2N6 VHF transmitter.



( ) Components R5, R6, R7, R9, and the 1N34 diode are all grouped about the terminals of switch S1. R10 and C12 mount directly on the 6U5 socket terminals.

( ) Layout of the audio section is conventional. Components are mounted between socket pins wherever possible. A two terminal tie-strip (TP-1) is mounted to one bolt of the 12AX7 socket to support R18, and the leads from R13, R16, and C17. The negative terminal of electrolytic capacitor C17 is grounded to pin 2 of the 6V6-GT socket.

Transmitter Adjustment (144 mc)

When the wiring is completed, it should be checked against Figure 26. All tubes except the 5763 should be inserted in the correct sockets, and the transmitter is connected to a 300 volt supply. An 8 mc crystal should be used. Coupling capacitor C5 should be temporarily connected to the oscillator tie-point, TP-3, and switch S1 is set to the "grid" position. Plate power should be applied to the transmitter, and capacitor C1 tuned for crystal oscillation, indicated by the closing of the eye-tube. A neon bulb held near L1 should glow when the oscillator is functioning. Coupling capacitor C5 should be removed from TP-3, and soldered to the stator of C4. Resistor R4 should be temporarily disconnected from pin 6 of the 5763 tube which is now placed in its socket. Power is applied, and C4 tuned for closing of the eye-tube. R4 is now reconnected to pin 6 of the 5763, and switch S1 set to the "plate" position. A #46 (blue bead) pilot lamp is connected to the terminals of SO-1, and the transmitter is again turned on. Capacitor C8 is tuned for resonance, indicated by the closing of the eye-tube and the glow of the pilot lamp serving as a dummy load. Loading capacitor C10 and coupling between L3 and L4 are adjusted for maximum brilliance of the bulb.

A high resistance voltmeter (20,000 ohms per volt) may be used to check the bias voltages of the transmitter. Over –50 volts of bias should be developed across resistor R2. Approximately –40 volts of bias is developed across resistor R3. Plate current of the 12AT7 tube is about 20 milliamperes, and the 5763 stage draws between 25 ma and 30 ma under full load.

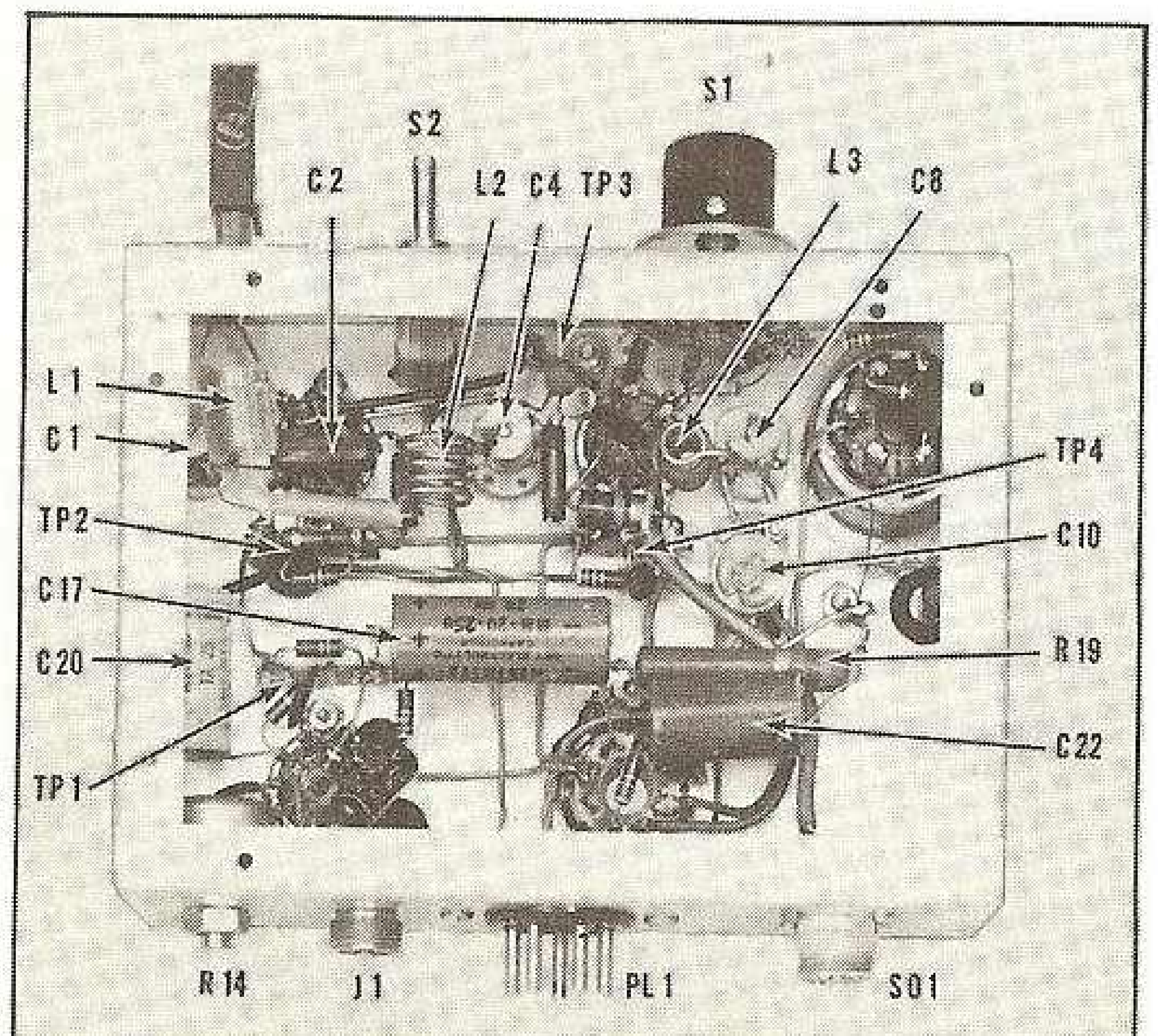


Fig. 28 Under-chassis view of 2N6 transmitter. "Magic eye" socket is at right, with the r-f amplifier plate circuit components to the left. The audio components are along the rear edge of the chassis.

A crystal microphone is now attached to the transmitter, and the gain control (R14) is advanced. Under modulation, the dummy antenna bulb should increase in brilliance. If the coupling between L3 and L4 is too tight, the lamp will dim under modulation. Adjustment of the coupling, and the setting of loading capacity C10 will eliminate this fault. When the adjustments have been completed, the transmitter may be attached to an antenna and the 5763 stage retuned slightly for optimum output. The transmitter is designed to be used with a coaxial-feed antenna system, such as the ground plane shown in chapter 9.

Transmitter Adjustment (50 mc)

It is necessary to disable the second section of the 12AT7 for 50 mc operation. To do this, coupling capacitor C5 is attached to the lead from the oscillator that terminates at P1 (tie-point TP-3). In addition, coil L2 is *removed* from the transmitter and a 50 mc coil is substituted for L3. The oscillator section of the transmitter is tuned in the normal manner, with S1 in the "grid" position. Oscillator tuning capacitor C1 should be adjusted for maximum eye-tube indication. The screen circuit of the 5763 is now closed, and S1 placed in the "plate" position. Capacitor C8 is now resonated to 50 mc, using the lamp bulb dummy load mentioned above.

Switch S2 serves as a "stand-by" switch, disconnecting the B-plus circuits of the transmitter from the power supply.

Parts List for 2N6 VHF Transmitter

3—Variable capacitor, 15 mmf. (Johnson 15M11) (C1, C4, C8)
1—50 mmf mica capacitor (Sangamo K-1450) (C2)
2—100 mmf ceramic capacitor (Centralab BC) (C3, C6)
1—30 mmf ceramic capacitor (Centralab DD-500) (C5)
8—.001 disc capacitor (Centralab DD-102) (C7, C12, C13, C19, C24-C26)
1—470 mmf ceramic capacitor, 1 KV (Centralab DD-471) (C9)
1—45 mmf ceramic variable capacitor (Centralab 822-BN) (C10)
4—5 mmf ceramic capacitor (Centralab DD-050) (C11, C14, C15, C18)
3—.01 disc capacitor (Centralab DD-103) (C16, C21, C23)
1—20 mf, 250 volt electrolytic capacitor (Sprague TVA-1508) (C17)
2—25 mf, 25 volt electrolytic capacitor (Sprague TVA-1205) (C20, C22)
1—15K, ½-watt resistor (IRC type BTS or BW-½) (R1)
1—56K, ½-watt resistor (R2)
2—47K, ½-watt resistor (R3, R9)
1—12K, 2 watt resistor (IRC type BTB or BW-2) (R4)
4—1megohm, ½-watt resistor (R5, R6, R10, R12)
2—100K, ½-watt resistor (R7, R16)
1—100 ohm, 1-watt resistor (R8)
2—2.2K, ½-watt resistor (R11, R15)
2—470K, ½-watt resistor (R13, R17)
1—500K potentiometer (Centralab B-60)
1—15K, 1-watt resistor (Centralab type BTA or BW-1) (R18)
1—560 ohm, 1-watt (R19)
1—Crystal socket (Cinch-Jones 2KM) (X1)
3—Socket, 9 pin miniature (Elco 371)
1—Socket, octal (Amphenol 78-RS-8)
1—Socket, 6 pin (Amphenol 78-S6, with 23-1S shell)
1—Plug, 5 pin (Amphenol 86-RCP5) (PL-1)
1—Microphone receptacle (Amphenol 75PC-1M) (J1)
1—Coaxial receptacle (Amphenol 83-1R) (SO-1)
1—Transformer, modulation (Triad M-4Z) (T1)
1—Switch SPST rotary (Centralab 1460) (S1)
1—Switch SPDT toggle (H&H 21350-BP) (S2)
1—Diode, 1N34 (RCA)
1—12AT7 tube (RCA)
1—12AX7 tube (RCA)
1—5763 tube (RCA)
1—6V6-GT tube (RCA)
1—Knob (National HRS-5)
1—Chassis, 5"x7"x2" (Bud AC-402)
1—Tie-point, single terminal (Cinch-Jones 51A)
3—Tie-point, double terminal (Cinch-Jones 52A)
Misc. 6-32 hardware, grommets, wire. See Figure 26 for coil and r-f choke data.

CHAPTER VIII

Power Supplies

Our friend the vacuum tube is very dependent upon a positive plate voltage for operation. In fact, up to a point, the more plate voltage that is applied to a tube, the more the filament electrons that will be attracted to the plate. Inversely, as the plate voltage is decreased, less electrons will reach the plate. If the plate voltage is bobbing up and down (as it would do if alternating current is applied to the plate of the tube) the amplification factor of the tube would vary in unison with the plate voltage. Accordingly, the level of the signal passing through the tube would go up and down, imparting an a-c hum to the signal.

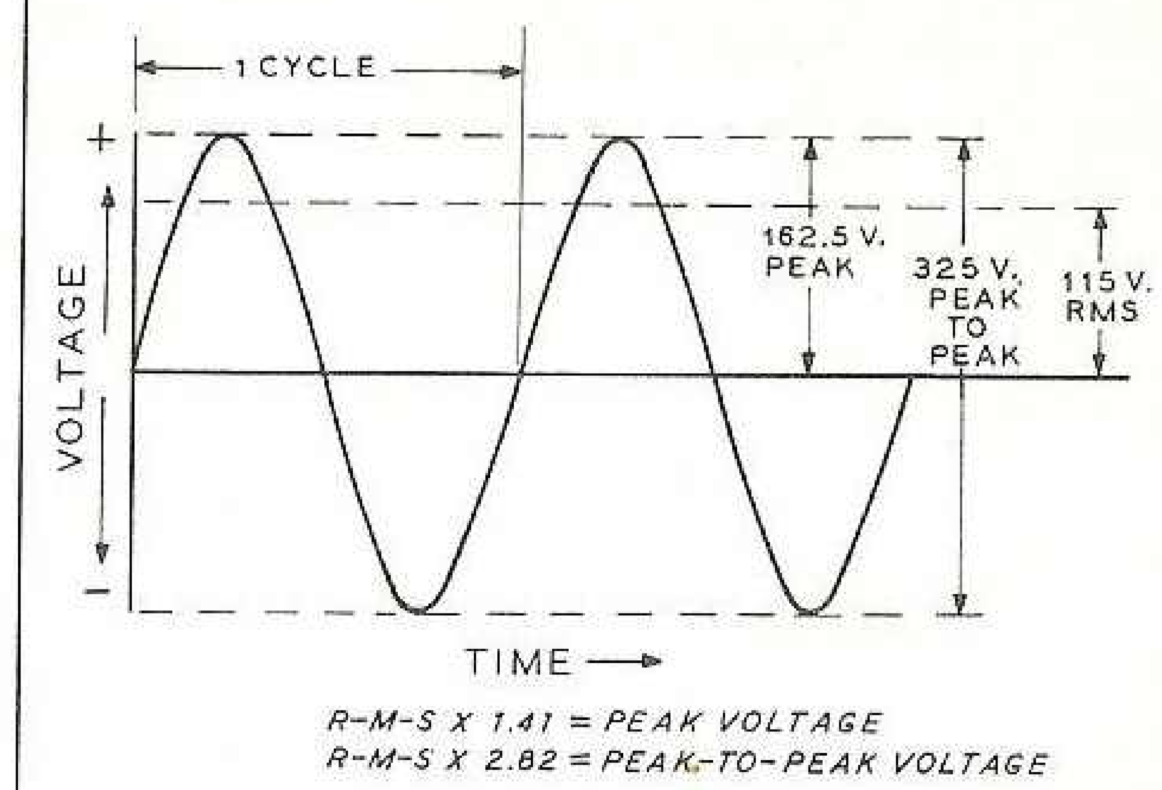
To avoid this annoying trouble, it is necessary to provide the plate of each amplifying tube with a reasonably steady source of d-c. Originally, radio used batteries to provide this steady plate potential. Grand-dad was proud of his *Radiola IIIA,* or his *Colin B. Kennedy type 220 Intermediate Wave Receiver,* and he spent countless hours fussing with his battery supply for the receiver. The filaments were lit by means of a 6-volt wet battery, and the plate voltage was supplied by a group of B-batteries, or perhaps a wet Edison cell. Along about 1926 or so, the a-c operated receiver came into general use, and the days of the acid-burned carpet were over, as the wet cell was cast into the junk heap.

Alternating Current

Most modern radio equipment makes use of *alternating current* to provide the source of direct current required for vacuum tube operation. Alternating current is interesting and useful stuff, and it would be wise to examine it for a moment before passing on to other things.

The voltage output of a simple a-c generator is essentially a *sine wave,* pictured in Figure 1. Note that the voltage rises to a positive peak, then decreases to zero, rising to an equal negative peak. The wave can be defined in terms of cycles and frequency, just as in the case of a radio wave. In the United States, power line frequencies are standardized at 60 cycles, with

Fig. 1 Alternating current may be expressed in terms of peak voltage, peak-to-peak voltage and root-mean-square (r-m-s) voltage. Average voltage of a-c is zero.



a smattering of 50 cycles in some areas, and 25 cycles in large industrial regions. In other parts of the world, 42, 16.2 cycles, and other unusual frequencies may be found.

Since the a-c wave is bobbing around at a fast rate, some value must be found whereby the effectivity of the wave may be measured. The *average value* of the wave is of no use, since there is just as much positive voltage as there is negative voltage, and the average value is therefore zero. The true value of alternating current is based upon its heating effect, and an a-c ampere is defined as that amount of current which will produce the same rate of heat in a given resistance as a d-c ampere. This value is called the *effective,* or *r-m-s* value. The relationships between the maximum (peak) and effective values of an a-c wave are given in Figure 1. The peak voltage of the 115-volt light line is in the neighborhood of 162 volts. Because 115-volts r-m-s can do the same amount of work as 115 volts d-c, this value is considered a standard measurement, and almost all a-c voltmeters, multimeters, and vacuum tube voltmeters are calibrated in r-m-s volts.

The Power Supply

Let's take a closer look at this amazing device which revolutionized the radio industry in the late "twenties." The purpose of a power supply is to provide a source of steady d-c voltage for the plate and screen circuits of radio tubes, and to supply power (almost always a-c) to energize the filaments of the tubes. A typical half-wave power supply (Figure 2) is made up of three main components: a transformer, a rectifier tube, and a filter system.

The Transformer

Even a simple receiver requires different voltages in its various circuits. The *B-plus* circuit (Plate and screen voltages) may require 100 to 300 volts at a fraction of an ampere, the filaments of the tubes may need 6.3 volts at several amperes, and the rectifier tube may require 5 volts at an ampere or two. All these voltages may be obtained from one *power transformer.* A transformer is a device for changing electrical energy from one circuit to another without a change in frequency. The transfer is usually (but not

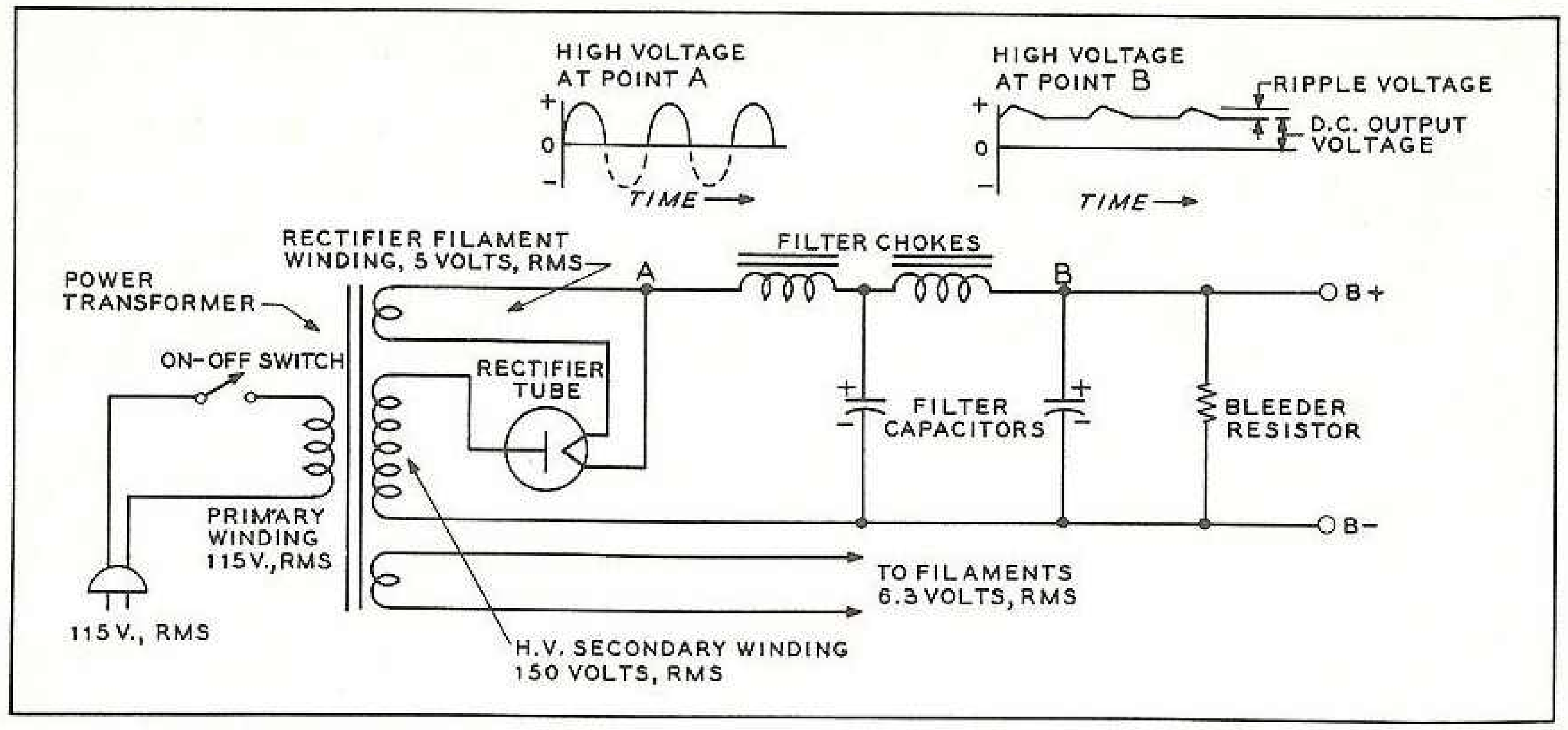


Fig. 2 Schematic diagram of a typical half-wave high voltage power supply.

always) accompanied by a change in voltage. The power transformer of Figure 2 has four separate windings on a core of iron. Electrical energy may be efficiently transferred from the *primary* winding by induction to the *secondary* windings. This action takes place within the iron core of the transformer. The ratio of secondary to primary voltage is a function of the number of turns of wire on each winding. The more turns of wire in a secondary winding in relation to the number of turns in the primary winding, the higher will be the voltage developed in that winding. If you examine a power transformer closely, you will find that the low voltage, high current filament windings are made of a few turns of heavy wire, and the high voltage, low current windings are made of many turns of light wire.

Whenever more current is drawn from a transformer winding than the wire can safely carry, the transformer will overheat, and the insulation may be damaged, ruining the unit. It should be remembered that the transformer must always be supplied with a-c. If sufficient d-c were applied to a transformer, it would overheat and eventually burn up.

The Rectifier

The transformer supplies us with various voltages at certain current ratings. It is now necessary to change the desired a-c voltages to d-c. The *rectifier circuit* accomplishes this. In effect, the rectifier is simply an electronic switch which allows current to flow in one direction, but not in the opposite direction. It is an electronic one-way street! Some natural substances such as selenium and silicon possess the unusual property of one-way passage of electrons, and *metallic rectifiers* may be made of these substances. A simple diode vacuum tube possesses the same property. Whenever the plate is positive, it will attract electrons from the filament. When the plate of the tube becomes negative with respect to the filament it will not attract the negatively charged electrons, and plate current will not flow. The positive pulses of an a-c wave may thus be simply sorted out from the negative pulses. The output of a simple *half-wave rectifier* consists of a series of positive pulses that are a duplicate of the positive half of the sine wave applied to the tube. The negative pulses are lopped off, leaving a pulsating d-c voltage at the output of the rectifier.

The Filter System

The rectifier supplies us with a pulsating d-c voltage that is still not the smooth, steady voltage that is required for proper operation of a radio receiver or transmitter. To be useable, the voltage must be *filtered*, or smoothed out. A filter system is usually composed of one or more *filter capacitors* and one or more inductances, called *filter chokes* (Figure 2).

Inexpensive filter capacitors employed in high voltage power supplies are *electrolytic capacitors*, in that the electrodes are immersed in a chemical mixture that increases the effectivity of the unit. Such capacitors are *polarized*, having a negative and a positive terminal, and must be connected into the circuit correctly, as shown. A capacitor has the ability to store electrical energy rather rapidly, and serves as a reservoir of voltage, helping to fill the voltage gaps in the pulsating voltage supplied by the rectifier tube. The larger the capacitor (rated in *micro-farads)*, the greater is the charging capacity.

The *inductor* (or *filter choke)*, on the other hand, opposes any *change* in current flowing through it, yet offers a minimum of opposition to direct current flow.

The pulsating output of the rectifier, then, charges the input filter capacitor which tends to discharge through the filter choke. The choke opposes this discharge, allowing the capacitor to regain its initial charge on the next impulse from the rectifier. The smoothed voltage passing through the filter choke charges the output filter capacitor. The residual pulsations that develop across this capacitor are termed *ripple voltage*, and are illustrated in Figure 2. The larger the filter elements, the smaller will be the ripple on the d-c output voltage of the power supply. If the ripple voltage is excessive, power supply hum will be heard in amplifiers powered by the supply, and it will be necessary to increase the capacity of either the filter capacitors or chokes. The relation between supply output voltage and the load current is termed the *voltage regulation* of the supply.

The Bleeder Resistor

The *bleeder resistor* assists in regulating the power supply output voltage. By placing a small, but permanent current drain upon the supply, the no load-full load margin is decreased, with a consequent improvement in regulation. A second major function of the bleeder is to discharge the filter capacitors when the supply is turned off. A good filter capacitor can hold a charge for several days, until it leaks off through the air, or the case of the unit. A bleeder resistor will dissipate the capacitor charge a few seconds after the power supply is turned off. It is then perfectly safe to work on the supply. A good safety precaustion is to discharge each capacitor with a heavy, well-insulated piece of wire before any work is done upon the supply.

Full-Wave Rectification

Up to this point we have discussed only half-wave rectification, which utilizes only one part of the incoming a-c cycle. Figure 3 illustrates a simple *full-wave rectifier* that works on both halves of the a-c cycle. A center-tapped high voltage winding is employed on the power transformer. The center-tap is taken as ground, and the instantaneous polarity at each end of the high voltage winding is equal and opposite. Thus, one half of the rectifier tube

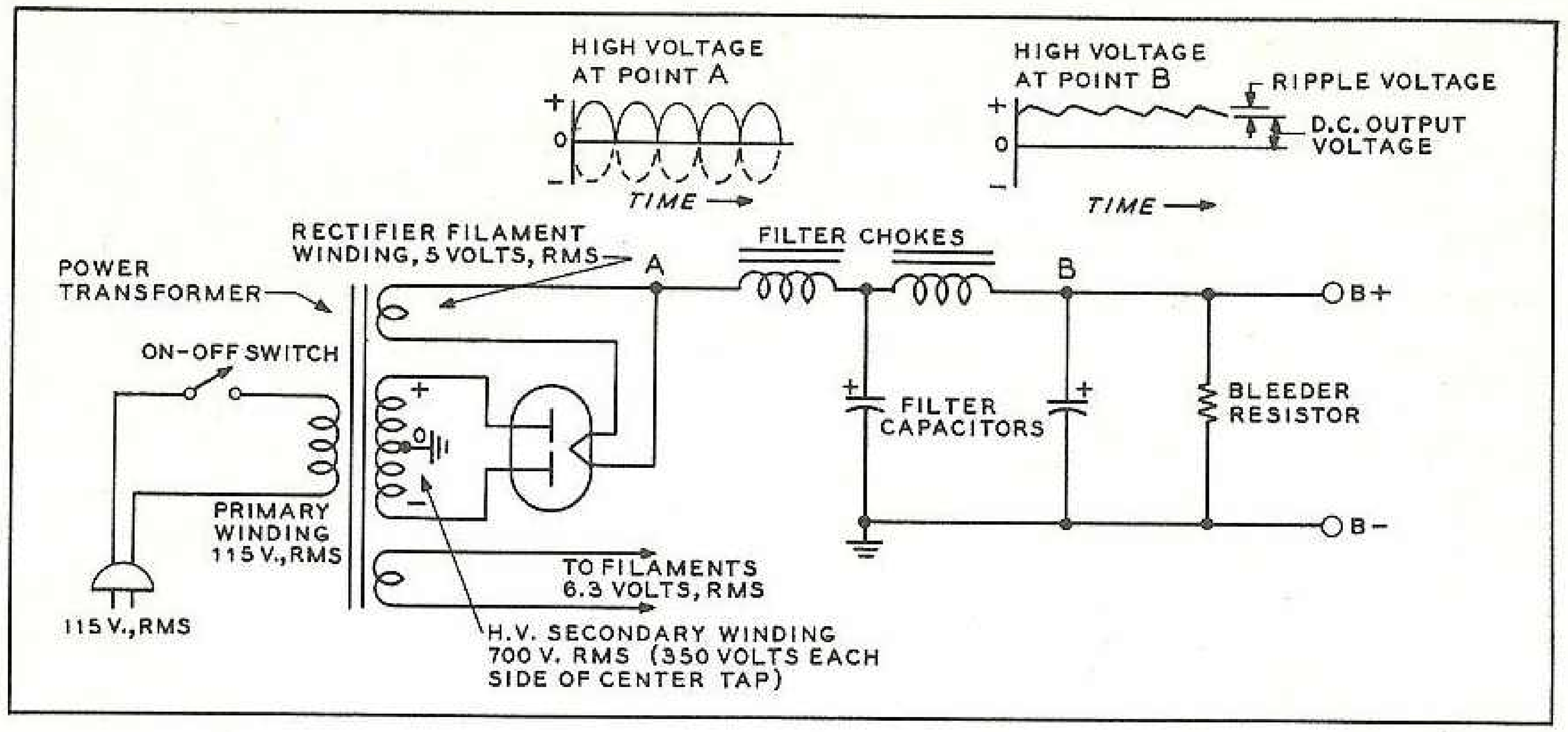


Fig. 3 Schematic diagram of a typical full-wave high voltage power supply.

conducts on each half-cycle, providing a positive voltage pulse for each half of the a-c cycle. Filtering action is much simplified with this circuit, as compared to a half-wave rectifier, as there are twice as many voltage pulses applied to the filter circuit in a given interval of time.

Power Supply Construction

The power supplies described on the following pages are examples of the types necessary to power amateur equipment. To avoid any possibility of confusion, each supply employs a different output socket and a different power cable. The various pieces of equipment that obtain power from these supplies are fitted with matching sockets, making it virtually impossible to connect a piece of equipment to the wrong power supply.

A LOW VOLTAGE POWER SUPPLY YOU CAN BUILD

(150 volts at 25 milliamperes)

The amateur can find many applications for this power supply around the ham station. It is designed to power small receivers, converters, preselectors, and items of test gear. A half-wave selenium rectifier is used, together with a capacitor input filter network. The selenium rectifier acts in the manner of a diode tube in that it permits the current in the circuit to flow in one direction only. Unlike the diode, it does not have a filament and therefore requires no extra filament winding on the power transformer.

Construction Details

The reader is referred to the Electronics Techniques chapter for the basic wiring and assembly information. The following instructions are presented in a simple, step-by-step sequence to enable the constructor to complete the project easily and correctly. Be sure to read each step all the way through before you start to do it. When the step is completed, check it off in the space provided.

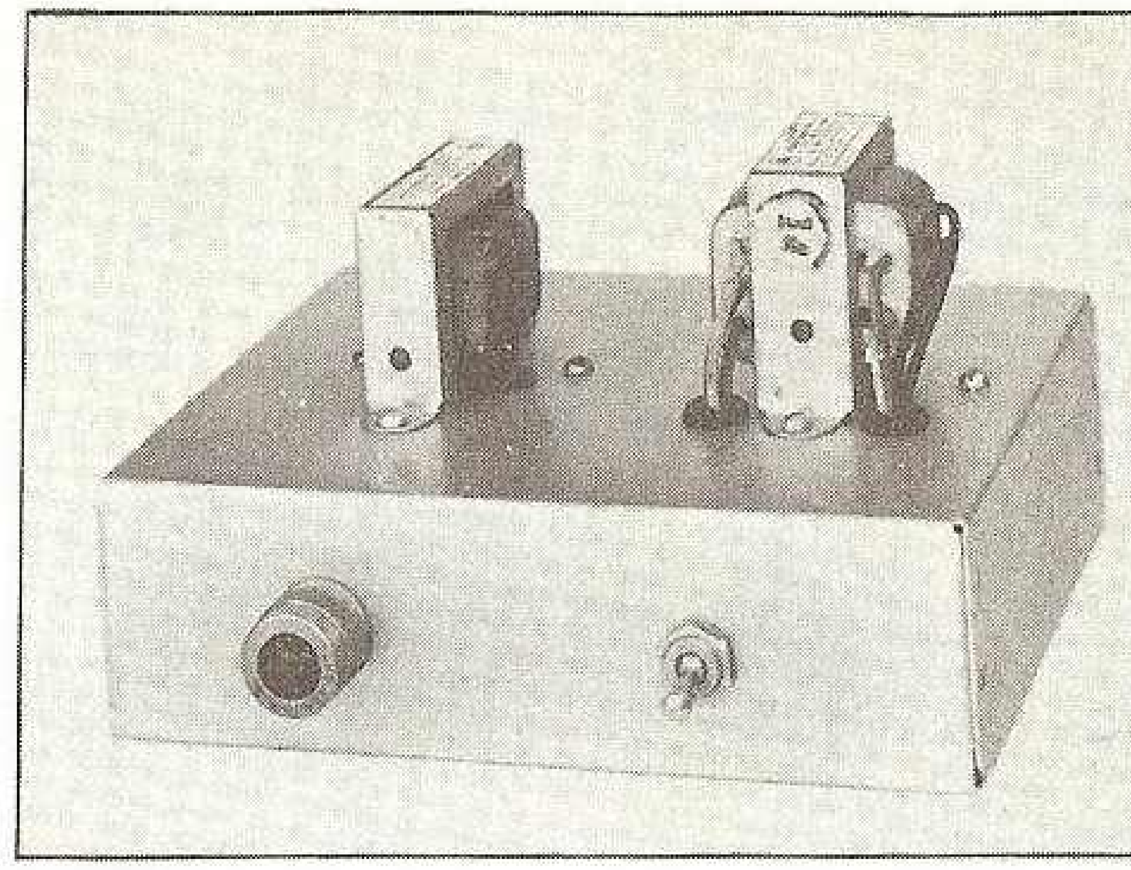


Fig. 4 This small power unit will provide 150 volts at a current drain of 25 milliamperes. Power transformer is at right, with filter choke to the left.

( ) Mark all the holes to be drilled in the chassis on the paper wrapper of the chassis, as shown in Figure 5. Drill the chassis, then remove the paper.
( ) Mount switch (S1) in hole (K). Mount pilot light assembly (P1) in hole (L). Mount fuse holder (F1) in hole (N).
( ) Mount power socket (P2) in hole (M), using 6-32 screws, nuts, and lockwashers.
( ) Insert ⅜" rubber grommets in holes (C), (D), and (O).
( ) Insert a ¼" rubber grommet in hole (G).
( ) Attach a soldering lug under the chassis at hole (A).
( ) Mount the selenium rectifier (RA) at hole (J), using a long 6-32 screw, nut, and lockwasher.
( ) Attach the filter choke (CH) at holes (H) and (I), using 6-32 screws, nuts, and lockwashers.
( ) Mount the two terminal phenolic strip (TP) at hole (F), on the underside of the chassis.
( ) Mount the power transformer (T) atop the chassis at holes (B) and (E), using 6-32 screws, nuts, and lockwashers. On the underside of the chassis at hole (B), mount the one terminal phenolic strip (TP-1).
( ) Pass the 115-volt line cord through grommet (O) on the rear apron of the chassis and connect one lead of the cord to either terminal of fuse holder (F1). Connect the other lead to one terminal of switch (S1).
( ) Run a short length of flexible, insulated wire from the other terminal of fuse holder (F1) to the insulated terminal of phenolic strip (TP-1). Connect one of the black transformer (T) leads to the insulated terminal of (TP-1).
( ) Connect the other black transformer lead to the free terminal of switch (S1).
( ) Cut off the end of the yellow lead of transformer (T) and tape it securely. This is the center-tap of the filament winding, and is not used.
( ) Connect one of the green leads of transformer (T1) to pin 1 of power socket (P2).
( ) Connect the other green lead of (T1) to pin 4 of power socket (P2).
( ) Connect the red-yellow lead of transformer (T1) to ground lug (A).
( ) Examine the selenium rectifier (RA). Note that one terminal has a "plus" sign stamped on it, and the other terminal is either marked "minus", or is left blank. For the following steps, make sure you connect the proper polarity of the rectifier, or you might damage the rectifier and the filter capacitors.
( ) Connect the red lead of transformer (T1) to the terminal of the rectifier (RA) that is marked "minus" (or has no sign at all).
( ) Connect a three inch piece of flexible, insulated wire to the "plus" terminal of rectifier (RA). The other end of this lead is connected to the tie-point of the two terminal phenolic strip (TP) that is *closest* to the rear of the chassis.
( ) Connect one of the black leads from filter choke (CH) to the above mentioned tie-point to which the flexible lead has just been attached.
( ) Connect the other black lead of filter choke (CH) to the unused, front tie-point of phenolic strip (TP). Connect a 5 inch piece of flexible, insulated wire to the same tie-point.
( ) Attach the free end of this 5 inch lead to pin 2 of the power socket (P2).

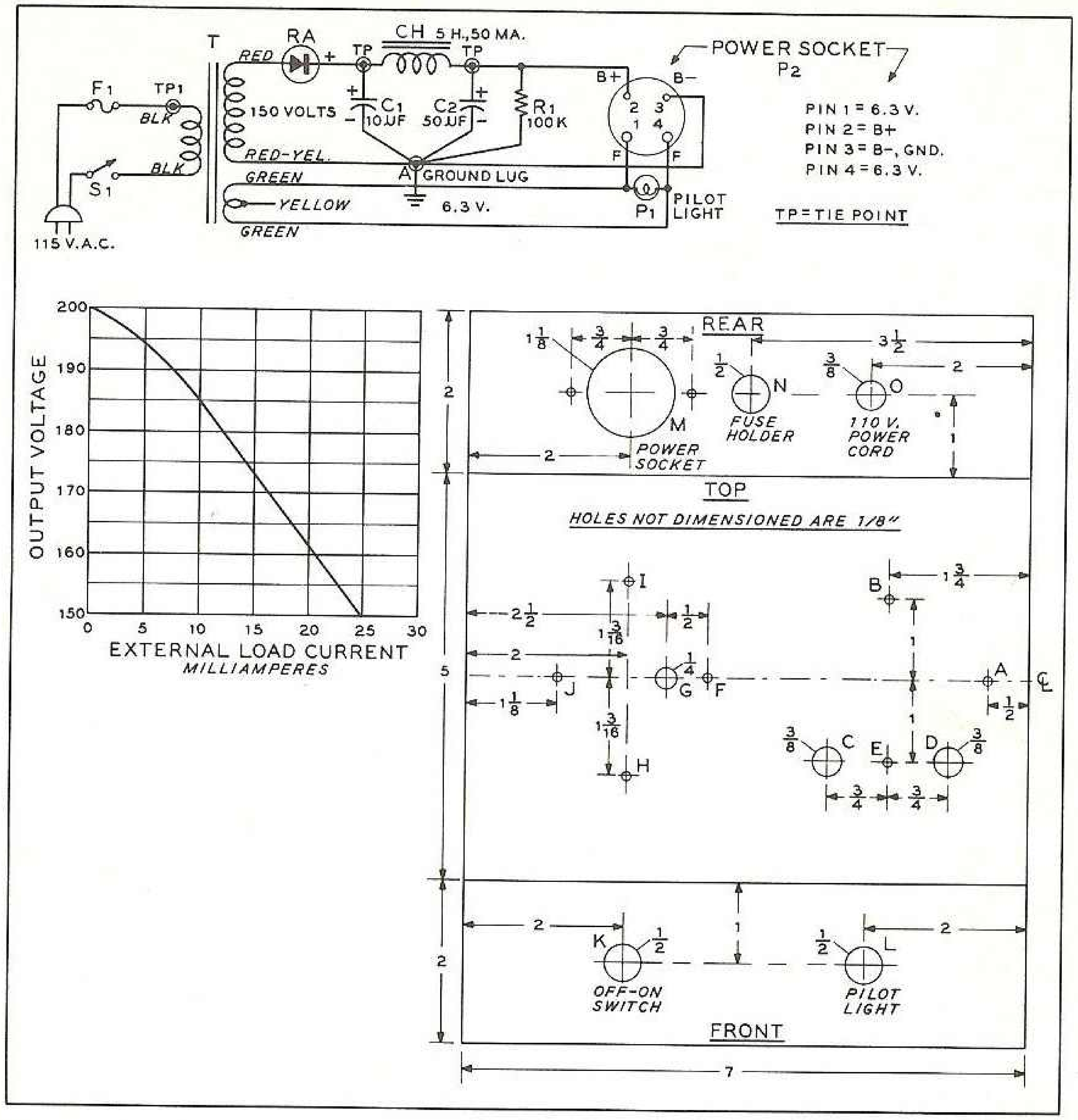
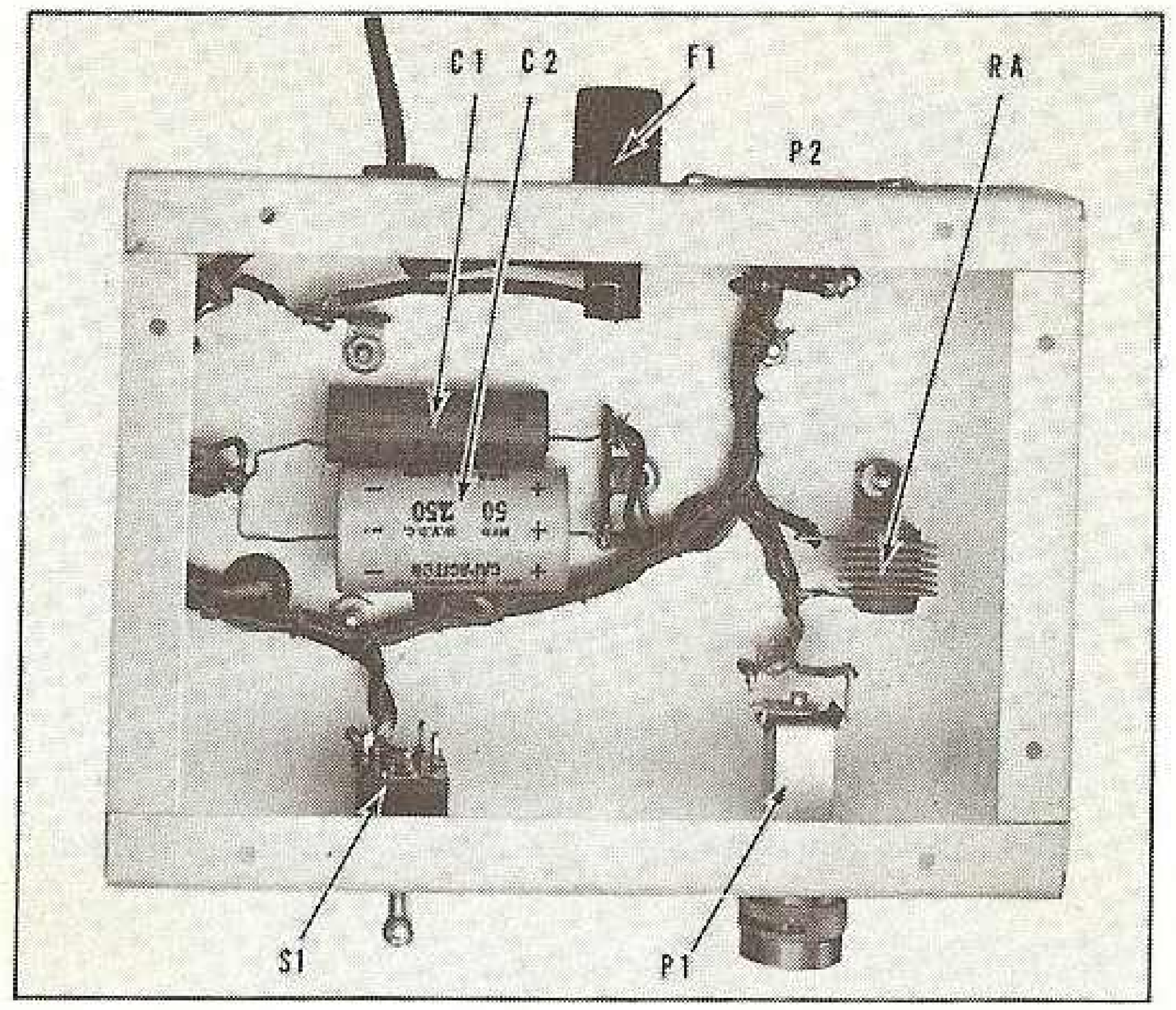


Fig. 5 Schematic, regulation curve, and chassis layout of low voltage supply.

( ) Attach an 8 inch lead to pin 3 of power socket (P2). Connect the other end of this lead to ground lug (A).
( ) Twist two 6 inch pieces of flexible wire together. At one end of the twist, connect the wires to each terminal of pilot light holder (P1).
( ) At the opposite end of the twist, connect one wire to pin 1 of power socket (P2), and the other wire to pin 4 of (P2).
( ) Connect the "plus" terminal of the 50 mf filter capacitor (C2) to the front tie-point of the phenolic strip (TP-1).
( ) Connect the "minus" terminal of capacitor (C2) to the ground lug (A).
( ) Connect the "plus" terminal of the 10 mf filter capacitor (C1) to the rear tie-point of phenolic strip (TP-1).
( ) Connect the "minus" terminal of capacitor (C1) to the ground lug (A).
( ) Connect the bleeder resistor (R) between ground lug (A) and the front tie-point of phenolic strip (TP-1).
( ) Install a 100K, 2-watt resistor (R1) between pin 2 and pin 3 of power receptacle P2.

This completes the wiring of the power supply. Check all connections against the schematic diagram of Figure 5. Inspect the wiring for shorts to ground or poor connections. Insert a 1-ampere fuse in the holder, and place a #47 pilot lamp in the lamp holder. Plug the power cord into a 115-volt, 50-60 cycle receptacle. The pilot light should light instantly, and the fuse

Fig. 6 Under-chassis view of low voltage supply, showing placement of major parts. The selenium rectifier is mounted to the chassis with a long 6-32 bolt.



should not blow out. An a-c voltmeter connected between pin 1 and pin 4 of power socket (P2) should indicate about 7 volts, a-c. A d-c voltmeter connected between pins 2 and 3 of this plug should indicate approximately 200 volts d-c. If these checks are satisfactory, your power supply is working correctly.

Parts List for Low Voltage Power Supply

1—Capacitor, electrolytic. 10 mf, 250 volt (Mallory type TC-52) (C1)
1—Capacitor, electrolytic. 50 mf, 250-volt (Mallory type TC-59) (C2)
1—Choke, filter. 5 henry at 50 ma. (Stancor C-1325) (CH)
1—Transformer, power. 150 volts at 25 ma, 6.3 volts at 0.5 ampere (Stancor P-8181) (T)
1—Rectifier, selenium. 50 ma. (Federal 1002-A) (RA)
1—Resistor, 100,000 ohms, 2-watt (IRC type BW-2) (R1)
1—Switch, SPST toggle (H&H 20994-EW) (S1)
1—Pilot lamp assembly (Drake #20) with #47 pilot lamp (P1)
1—Fuseholder (Buss HJM) with 1 ampere fuse (Buss AGX-1) (F1)
1—Socket, 4 pin (Amphenol 77-MIP4) (P2)
1—Chassis, aluminum. 5" x 7" x 2" (Bud AC-402)
1—Line cord and plug (Birnbach 816)
1—Terminal strip, single (Cinch 51) (TP-1)
1—Terminal strip, double (Cinch 52) (TP)
3—Grommet, ⅜" (General Cement 1042-E)
1—Grommet, ½" (General Cement HO30-F)
Misc. 6-32 nuts, bolts, lockwashers, soldering lug.

A MEDIUM VOLTAGE SUPPLY YOU CAN BUILD

(350 VOLTS AT 90 MILLIAMPERES)

This supply is designed to power small transmitters, receivers, and other equipment requiring medium plate voltage. In addition to the uses shown in this book, there are many applications for this power supply for conversions of war surplus equipment. In addition to the high voltage, the supply also provides 6.3 volts at 3 amperes for filament circuits.

The circuit for the supply is a standard full wave rectifier, combined with a capacitor input filter, as shown in Figure 8. A variable voltage divider is incorporated in this supply, allowing the user to obtain any intermediate voltage between zero and 350 volts. The variable voltage may be adjusted by turning off the supply, shorting the filter capacitors and adjusting the slider on R1.

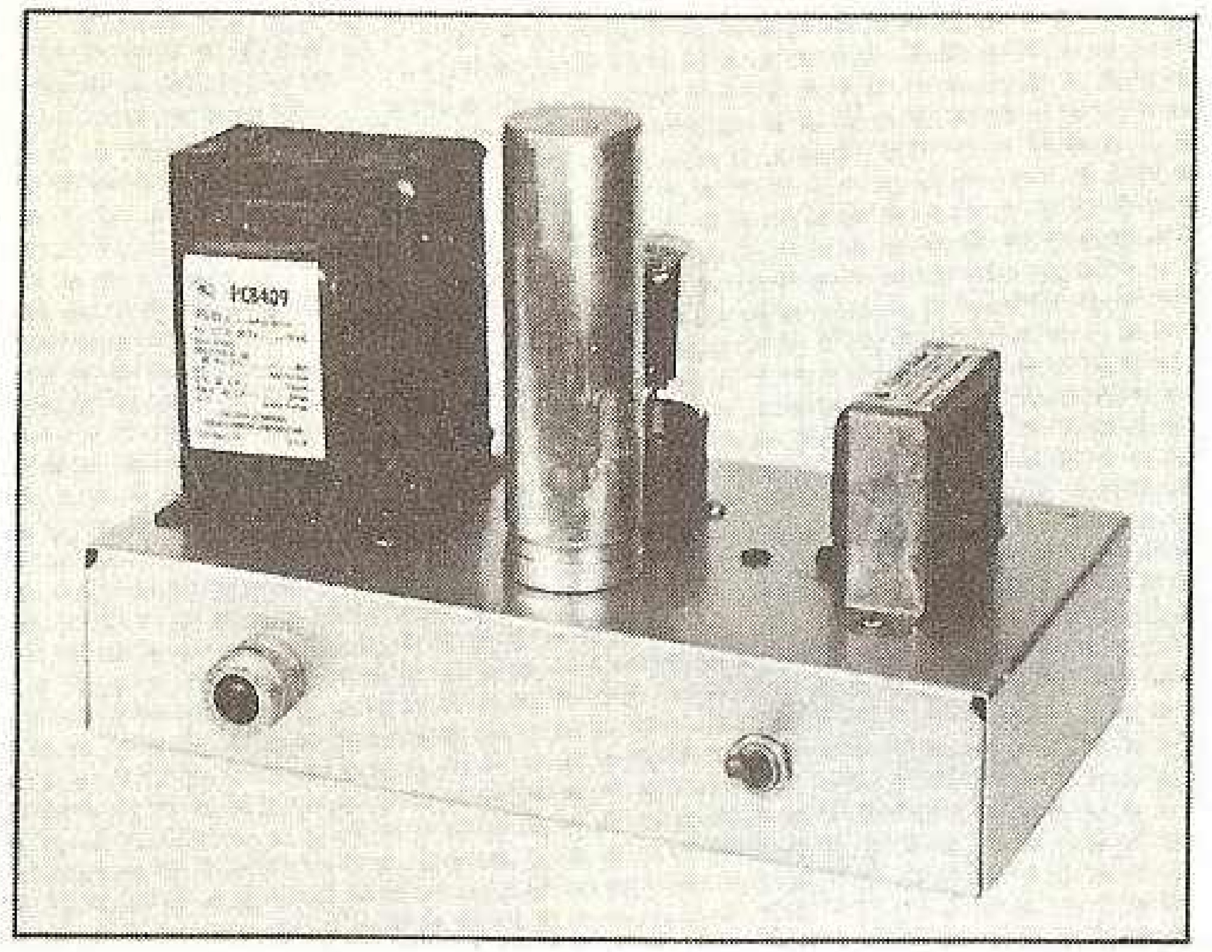


Fig. 7 350 volt power supply may be used for receivers or low power transmitters. The power transformer is at the left, with filter capacitor and rectifier tube in center. Filter choke is at right.

Construction Details

( ) Mark all the holes to be drilled in the chassis on the paper wrapper of the chassis, as shown in Figure 8. Drill the chassis, then remove the paper. It is a good idea whenever you are working on an aluminum chassis to spray the outside of the chassis with a coat of clear plastic, such as *Krylon*. An unsprayed chassis is very susceptible to the oil on hands and fingers. As a result, such an untreated chassis will become very smudged, and tend to look like the "wanted" file at an FBI office!

( ) Mount switch (S1) in hole H. Mount pilot light holder (P1) in hole G. Install fuse holder (F1) in hole (O).

( ) Mount the rectifier tube socket (X1) in hole E, using 6-32 screws, nuts, and lockwashers. Mount the filter capacitor (C1) in hole (F) by the metal mounting plate, using 6-32 screws, nuts, and lockwashers.

( ) Install a two terminal phenolic strip in hole (D). Insert a ¼" grommet in hole (C). Insert a ⅜" grommet in hole (N).

( ) Pass the insulated leads of power transformer (T) through the hole (I), and mount the transformer in place, using 6-32 screws, washers, lockwashers and nuts in holes (J), (K), (L), and (M). Place the lockwashers under the screw heads to keep them from slipping through the transformer mounting holes.

( ) Mount resistor (R1) under the chassis, using transformer bolts in holes (J) and (K). Place lockwashers and nuts atop the mounting brackets of (R1).

( ) Mount filter choke (CH) atop the chassis, using 6-32 screws, lockwashers and nuts in holes (A) and (B). Push the choke leads through grommet (C) to the under-chassis area.

( ) Mount power receptacle (P2) in chassis hole (P) using 6-32 hardware.

( ) Connect one of the black leads of transformer (T) to one terminal of switch (S1). Connect the other black lead to one terminal of fuse holder (F1).

( ) Connect one of the yellow leads of transformer (T) to pin 2 of the rectifier tube socket (X1). Connect the other yellow lead of (T) to pin 8 of socket (X1).

( ) Connect one of the red leads of transformer (T) to pin 4 of the rectifier tube socket (X1). Connect the other red lead of (T) to pin 6 of socket (X1).

( ) Connect the two green leads of transformer (T) to the two terminals of pilot light holder (P1). Attach one lead to each terminal.

( ) Twist two fourteen inch long pieces of flexible, insulated wire together. At one end of the twist, connect one lead to each side of the pilot light holder (P1).

( ) Route the twisted wires to the back of the chassis, around the transformer wires at hole (I), and along the rear of the chassis to power socket (P2). Connect one wire to pin 1 of (P2), and the other wire to pin 5 of (P2).

( ) Cut off the exposed end of the green and yellow lead of transformer (T). Tape the lead so that no short to chassis can occur.

( ) Route the red and yellow lead of transformer (T) up near the pilot lamp holder (P1), and over to a ground lug of filter capacitor (C1). Ground this lead. (Note: The three outer lugs of (C1) are the ground lugs, and the two

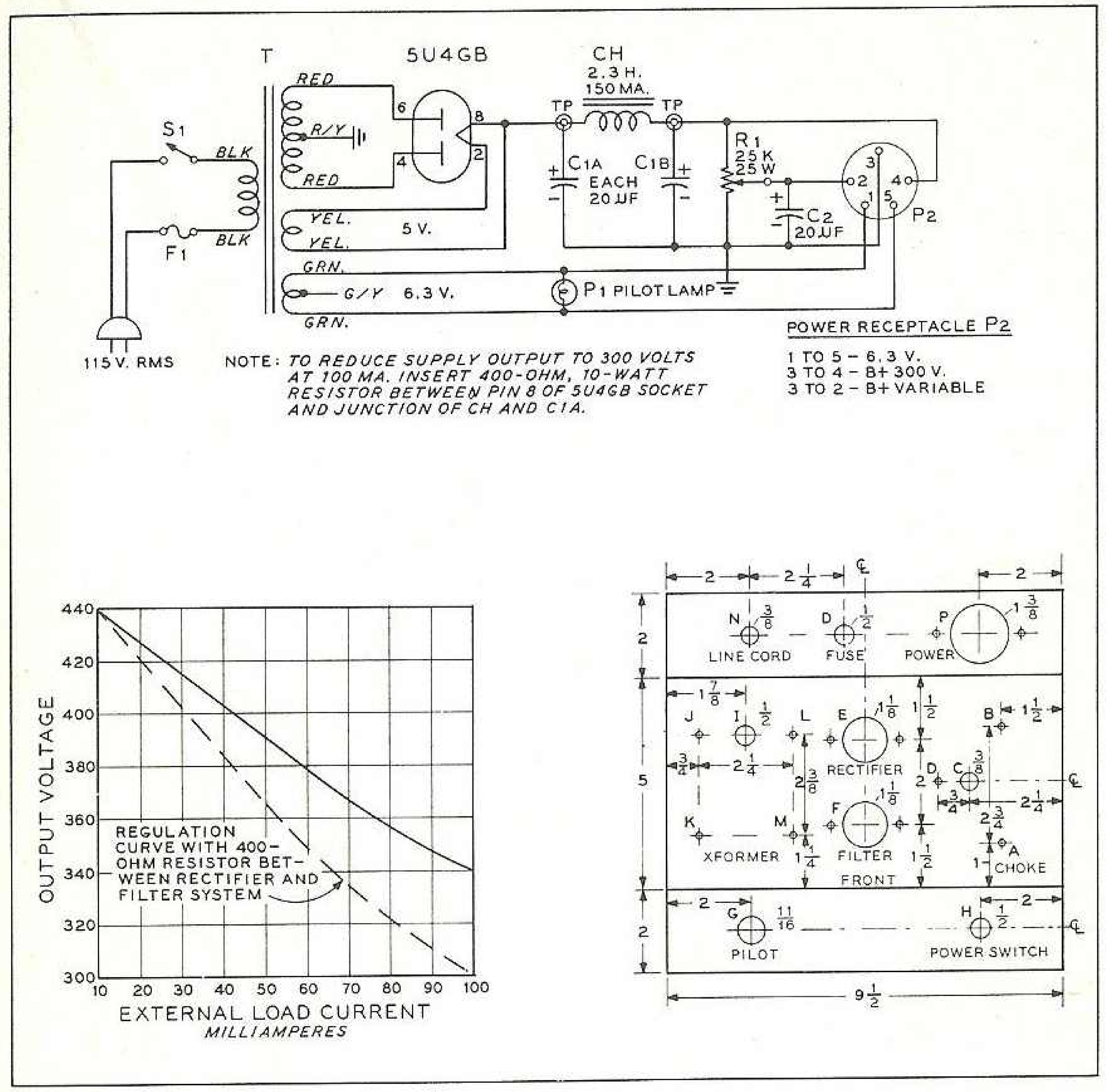


Fig. 8 Schematic, regulation curve, and chassis layout of 300 volt supply.

center lugs are the positive terminals of the dual condenser).

( ) Connect each of the two black leads of the filter choke (CH) to the two center, positive lugs of capacitor (C1), one lead to each lug.

( ) Connect a flexible, insulated wire from pin 2 of the rectifier tube socket (X1) to one positive lug of capacitor (C1, Section A).

( ) Connect a flexible, insulated wire to the remaining positive lug of capacitor (C1, Section B). Run this wire to the terminal on resistor (R1) nearest the rear of the chassis. From this same terminal on (R1), run a wire over to pin 4 on power socket (P2).

( ) Connect a wire to the terminal on resistor (R1) nearest the front of the chassis. Ground this lead to one of the ground lugs of capacitor (C1).

( ) Connect a lead to the slider of resistor (R1). Leaving a small amount of slack in the wire, connect the other end of pin 2 of power socket (P2). Carefully remove the insulating cardboard from beneath the slider of (R1), allowing the slider to contact the resistance wire. Set the slider in the center of the resistor, and gently tighten the slider set-screw.

( ) Install capacitor C2 between pin 2 of plug P2 and a ground "ear" of socket X1. The positive terminal of C2 attaches to P2.

( ) Connect a wire from pin 3 of power socket (P2) to one of the ground lugs of capacitor (C1).

( ) Pass the 115-volt line cord through grommet (N). Connect one of the wires of this cord to the empty terminal on fuse holder (F1). Connect the other wire to the empty terminal on switch (S1). Lace the wires with heavy twine.

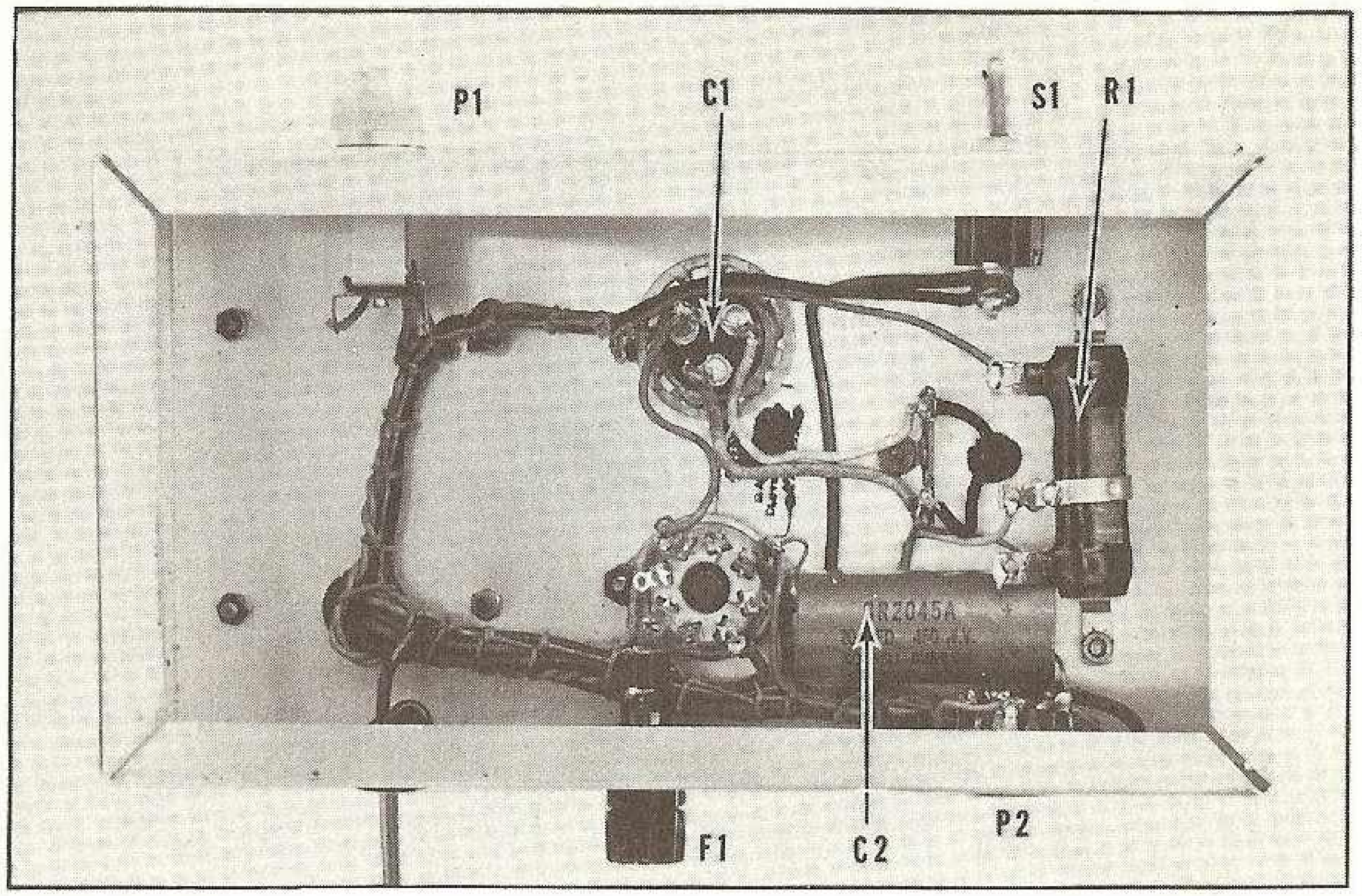


Fig. 9 Under-chassis view of medium voltage supply, showing major components.

This completes the wiring of the medium voltage supply. Check all connections against the schematic of Figure 8. Examine all soldered joints for shorts to chassis and rosin joints. Insert a fuse in the holder and a pilot lamp in the lamp holder. Plug the line cord into a 115-volt, 50-60 cycle outlet, and turn on the power supply. The pilot light should light instantly, and the fuse should not blow out. The filament of the 5Y3 tube should slowly light. Examine the long vertical plates of the tube. They should show no color. If they glow cherry red, turn off the supply and check for shorts to ground in the high voltage circuit.

An a-c voltmeter connected between pins 1 and 5 of power socket (P2) should indicate about 7 volts. A d-c voltmeter connected between pins 4 and 3 of (P2) (with the positive meter lead at pin 4) should indicate about 430 volts d-c. With the slider set in the middle of resistor (R1), a d-c voltmeter connected between pins 2 and 3 of (P2) (with the positive meter lead at pin 2) should indicate about 225 volts. If these voltages check within 10% of the indicated values, the supply is working properly.

Parts List for 350 Volt Power Supply

1—Capacitor, dual electrolytic. 20-20 mf, 450 volt (Sprague TVL-2755) (C1A, C1B)
1—Capacitor, electrolytic. 20 mf, 450 volt (Sprague TVA-1709) (C2)
1—Choke, filter. 2.3 henry at 150 ma. 60 ohms. (Stancor C-2304) (CH)
1—Transformer, power. 350-0-350 volts at 95 ma., 5 volts at 2 amperes, 6.3 volts at 3 amperes (Stancor PC-8409) (T)
1—Resistor, 25,000 ohm, 25 watt adjustable (Clarostat P-25K) (R1)
1—Switch, SPST toggle (H&H 20994-EW) (S1)
1—Socket, 5 pin (Amphenol 78RS5)) (P2)
1—Socket, 4 pin (Amphenol 77-MIP4)
1—Fuseholder (Buss HJM) with 1 ampere fuse (Buss AGX-1) (F1)
1—Pilot lamp assembly (Drake #20) with #47 pilot lamp (P1)
1—Chassis, aluminum. 5"x9½"x2" (Bud AC-403)
1—Line cord and plug (Birnbach 816)
1—Terminal strip, double (Cinch 52) (TP)
1—Tube, 5U4-GB (RCA)
2—Grommet, ⅜" (General Cement 1042-E)

A TRANSMITTER POWER SUPPLY YOU CAN BUILD

(540 VOLTS AT 200 MILLIAMPERES)

This large power supply is suitable for use with transmitters running up to 100 watts on c-w, and up to 50 watts on phone. This supply will provide more than enough power for the converted surplus "Command" transmitter that is described in chapter 6.

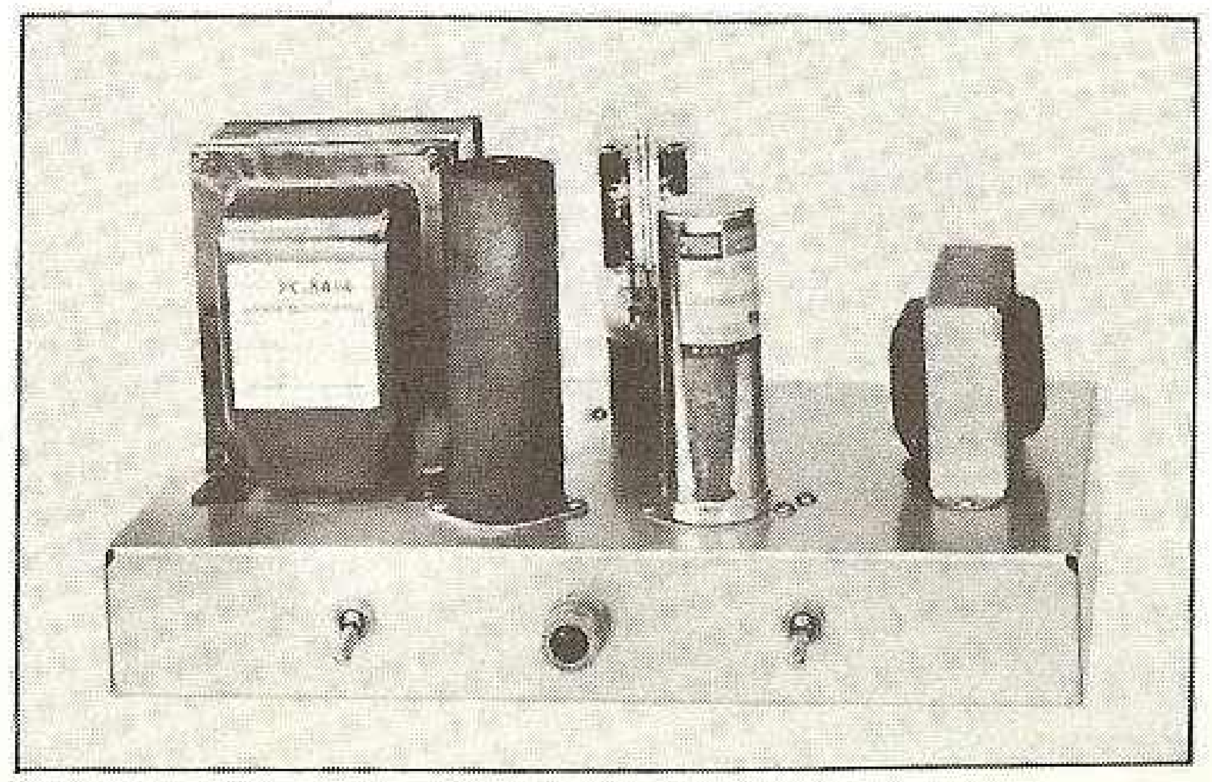
The schematic diagram of the supply, and the voltage regulation curve are shown in Figure 11, together with a complete parts list. A full wave rectifier circuit is employed, using an 83 mercury vapor rectifier tube, and a single section choke input filter system. Because the output voltage rises to approximately 580 volts with no external load, the inexpensive 450 volt filter capacitors would probably break down after a short time when employed in this fashion. However, two of these capacitors are connected in series in this supply, providing an effective voltage rating of 900 volts. The two series capacitors (C1 and C2) each have a capacity of 125 mf. When series connected, the effective capacity is 62.5 mf. The purpose of the two resistors (R1 and R2) is to equalize the voltage distribution across each of the capacitors.

Either six or twelve volts a-c filament supply may be obtained from this unit. The twelve volt source is very handy when working with war-surplus equipment having twelve volt heater tubes, such as the 1625 transmitting tetrode.

Construction Details

( ) Mark all the holes to be drilled in the chassis on the paper wrapper of the chassis, as shown in Figure 11. Drill the chassis, then remove the paper. Spray the outside of the chassis with a coat of clear *Krylon* to protect the chassis from smudges and smears.
( ) Mount switch (S1) in hole (H), with the terminals towards the top of the chassis. Mount switch (S2) in hole (J), in the same manner. Install the pilot light holder (P1) in hole (I).
( ) Mount the fuse holder (F1) in hole (R). Mount the six pin power socket (P2) in hole (Q). Mount the four pin rectifier socket (X1) in hole (G).
( ) Mount one of the 125 mf capacitors (C2), in hole (E), using a *metal* mounting ring.
( ) Mount the other 125 mf capacitor (C1) in hole (F), using a *fibre* mounting ring. Check the four mounting tabs to see that none are touching the chassis. Slide the insulating cardboard case over this capacitor, after placing a drop of cement inside the case to make sure it will not fall off the capacitor.
( ) Insert a ⅜" grommet in hole (D). Insert a second ⅜" grommet in hole (S).

Fig. 10 High voltage supply employs two low voltage filter capacitors cnnected in series. The "hot" capacitor must be insulated from the chassis, and covered for protection of the operator, as shown at right.



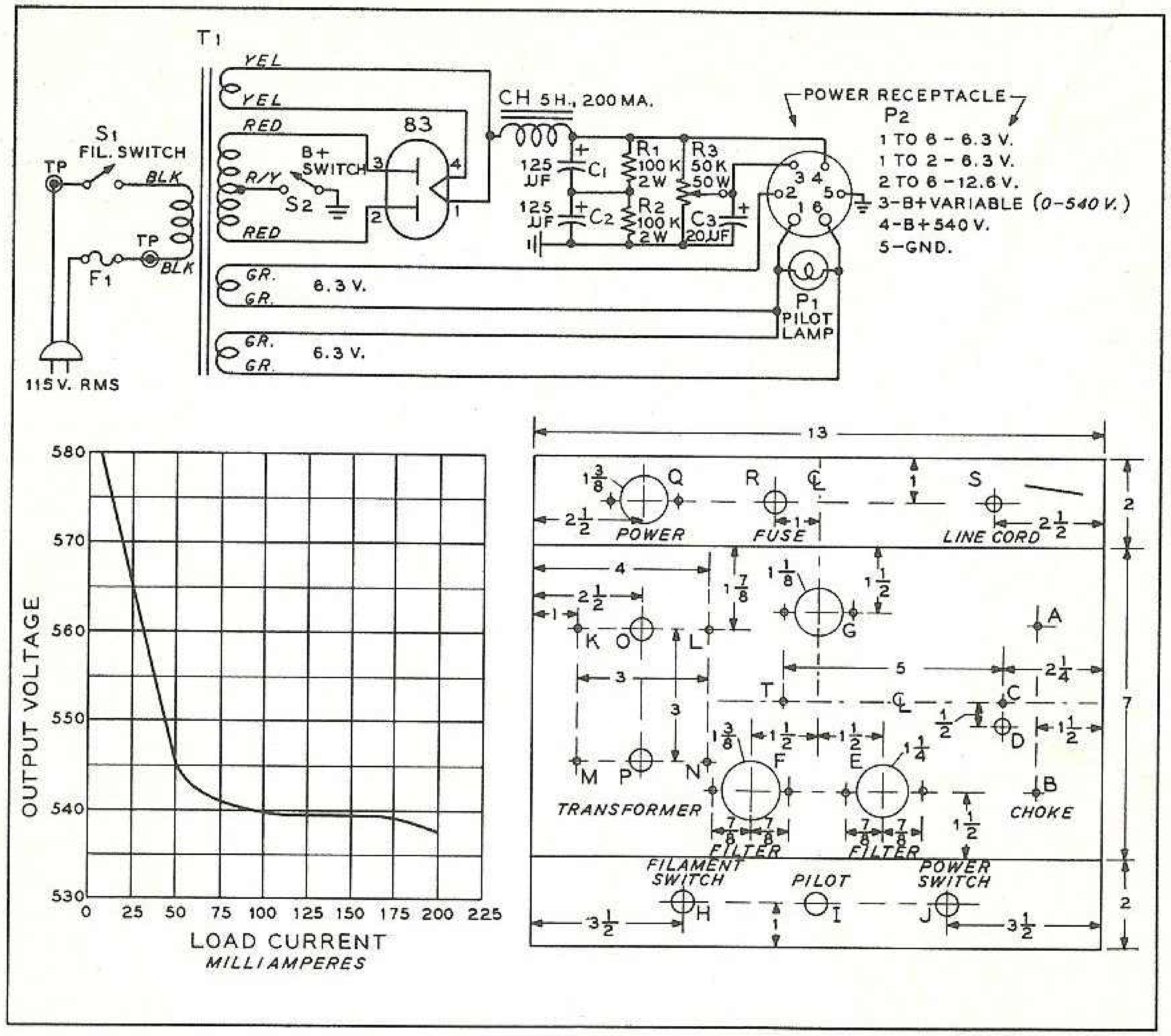


Fig. 11 Schematic, regulation curve, and chassis layout of 500 volt supply.

( ) Mount the 50,000 ohm resistor (R3) at holes (C) and (T) using 6-32 bolts, lockwashers, and nuts, and the hardware supplied with the resistor.

( ) Mount the filter choke (CH) at holes (A) and (B), and pass the leads of the choke through grommet (D).

( ) Mount the power transformer (T1) at holes (K), (L), (M) and (N). Use 6-32 screws, and ⅜" washers under the screw heads, to prevent the heads from slipping through the mounting holes of the transformer. The green and brown leads of the transformer should pass through hole (O).

( ) Attach a ground lug at transformer mounting screw (K), using a lock washer and a nut. Attach a two terminal phenolic strip at transformer mounting screw (L), using a lockwasher and a nut. Attach a ground lug at transformer mounting screw (N), using a lockwasher and a nut.

( ) Connect one of the black leads of transformer (T1) to one terminal of switch (S1).

( ) Connect the other black lead of (T1) to one terminal of phenolic strip (L). From this same lug on (L), connect a short lead to a terminal of fuse holder (F1).

( ) Connect a wire from the unused terminal of switch (S1) to the *unused* terminal on phenolic strip (L).

( ) Connect a red lead of transformer (T1) to pin 2 of rectifier tube socket (X1). Connect the other red lead of (T1) to pin 3 of socket (X1). Dress the leads away from each other at the pins of the socket, and trim any loose ends of the leads, as there is a 1200 volt potential between these wires.

( ) Connect the two yellow wires of transformer (T1) to pins 1 and 4 of socket (X1), one wire to each pin.

( ) Connect the two brown leads of transformer (T1) to pins 1 and 6 of power socket (P2).

( ) Twist together two twelve inch lengths of flexible, insulated wire. Connect

one end of the twist to pins 1 and 6 of power socket (P2), one wire to each pin.

( ) Route the twisted wires up to the front of the chassis, then over to the pilot light holder (P1). Connect one lead of the twist to each terminal of (P1).

( ) Connect one of the green leads of transformer (T1) to pin 1 of power socket (P2). Do not solder this connection, as it may be necessary to change it later. Connect the other green lead of (T1) to pin 2 of (P2) in the same manner.

( ) Connect one of the black leads of choke (CH) to pin 1 of rectifier tube socket (X1). Connect the other black lead of (CH) to the terminal of the 50,000 ohm resistor (R3) closest to grommet (D).

( ) From the abovementioned terminal of resistor (R3), connect a lead to the center terminal of resistor (R3), connect a lead to the center terminal of filter capacitor (C1), which is mounted on the fibre insulating ring.

( ) From the same terminal on resistor (R3), run a lead to pin 4 of power socket (P2).

( ) Run a wire from the center "plus" terminal of capacitor (C2)—mounted on the metal plate—to one of the four outside terminals of capacitor (C1).

( ) Connect a 100K, 2 watt resistor (R1) between the center terminal of capacitor (C1) and one of the four outside terminals. Connect a 100K, 2 watt resistor (R2) between the center terminal of capacitor (C2) and one of the four outside terminals.

( ) Connect a flexible lead from the slider arm of resistor (R3) to pin 3 of power socket (P2).

( ) Install the 20 mf capacitor (C3) between pin 3 of receptacle (P2) and the ground lug under mounting bolt M of transformer T1.

( ) Connect a lead from pin 5 of power socket (P2) to ground lug (K).

( ) Route the red-yellow lead of transformer (T1) to switch (S2). Connect this lead to one terminal of switch (S2). Connect a short lead from the other terminal of (S2) to one of the four outside lugs of capacitor (C2).

( ) Insert the 115-volt line cord through the ⅜" grommet on the rear apron of the chassis.

( ) The phenolic terminal strip (L) has a lug containing one black wire, and a lug containing two wires. Connect one wire of the line cord to the lug containing the *one black* lead from transformer (T1). Connect the other wire of the line cord to the empty terminal of fuse holder (F1).

( ) Connect a three inch piece of wire to the lug of resistor (R3) nearest the center of the chassis. Ground this lead to ground lug (N).

( ) Remove the paper cover of the resistance element of (R3). Set the slider arm to the center of the resistor, and tighten the clamp gently. Insert the fuse in the fuse holder, and a pilot lamp in the pilot lamp holder.

( ) If an ohmmeter is available, measure the resistance between pins 4 and 5 of power socket (P2). It should measure approximately 40,000 ohms, after the filter capacitors have become charged by the battery of the ohmmeter.

( ) Remove the ohmmeter, and turn on the supply by switch (S1). Make sure switch (S2) is off (open position) before (S1) is turned on. The pilot lamp should light and the fuse should not blow out. The filament of the rectifier tube should slowly light.

( ) Insert an a-c voltmeter into pins 2 and 6 of power socket (P2). A reading of approximately 13 volts should be obtained. If the reading is very close to zero volts, turn off the supply, short the filter capacitors, and *reverse* the two green leads attached to pins 1 and 2. Solder the connections. The correct reading should now be obtained between the pins.

( ) An a-c voltmeter connected between pins 1 and 2 of power plug (P2) should read approximately 7 volts. The same reading should be obtained between pins 1 and 6 of (P2).

If all the previous checks are satisfactory, you should turn on the "B-plus" switch (S2). There should be a small blue flash observable in the 83 rectifier tube, as the filter capacitors charge to full voltage. If an *intense* blue glow is noted, turn off the supply instantly and check for short circuits in the high voltage wiring.

With no load on the supply, a d-c output voltage of approximately 600 volts may be measured between pins 4 and 5 of power socket (P2). The positive meter lead goes to pin 4.

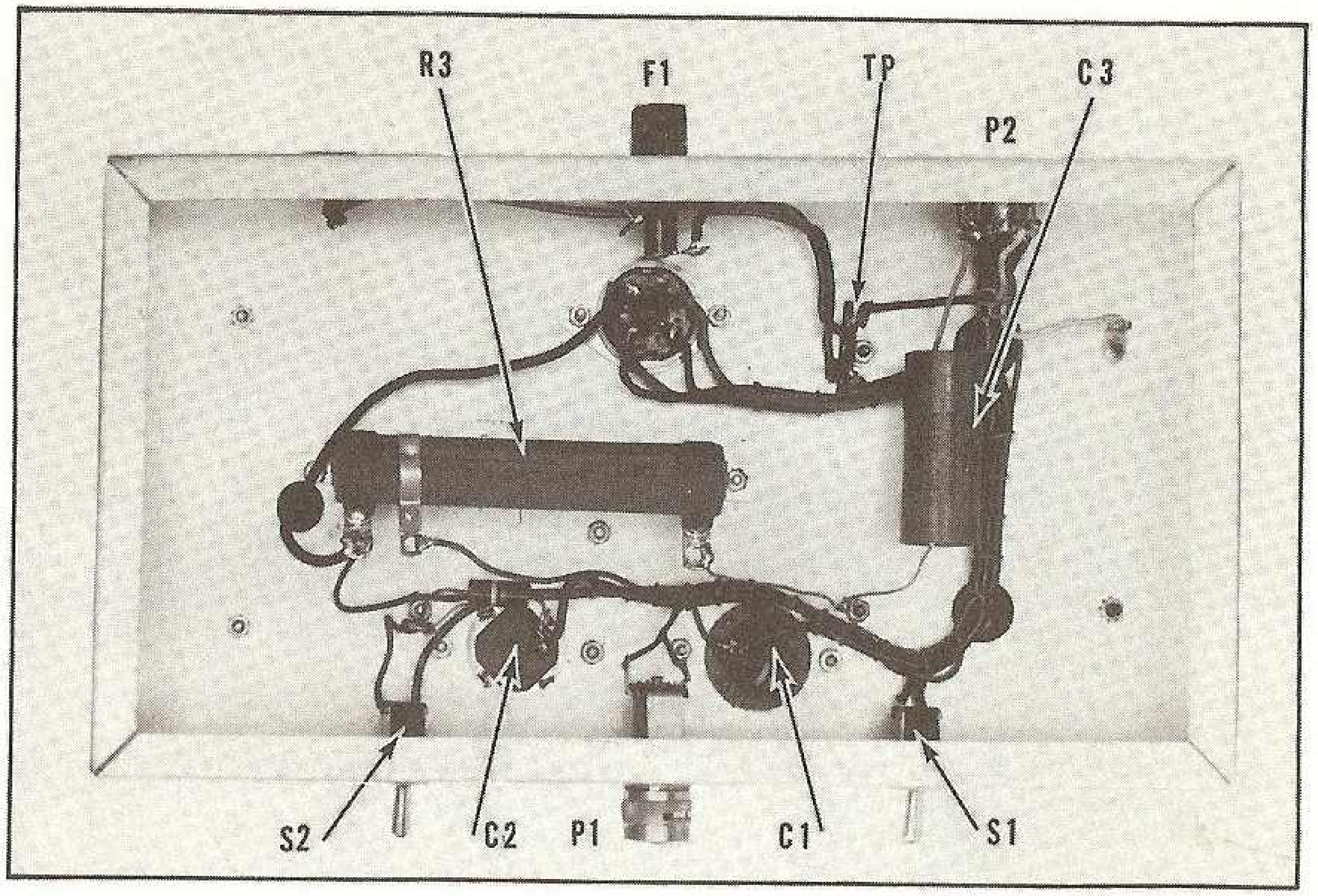


Fig. 12 Under-chassis view of 500 volt supply, showing placement of major components. For higher operating voltages, 5000 volt insulated "test lead" wire should be used for all high potential circuits. Filter capacitor should always be shorted out with piece of wire before any work is done on supply.

NOTE: Because of the high potentials developed by this supply, the constructor should use extreme care and caution when working under the chassis, or when working with other equipment connected to the supply. Adjustments to the slider of resistor (R3) should never be made unless the filter capacitors have been discharged. Another precaution is to allow the 83 rectifier tube filament about 30 seconds to warm up before switch (S2) is closed. Finally, the power supply should not be operated unless the rectifier tube is in a vertical (upright) position.

Parts List for 540 Volt Transmitter Power Supply

2—Capacitor, electrolytic. 125 mf, 450 volt (Sprague TVL-1760) (C1, C2)
1—Mounting plate for C1, fibre (Mallory BP-6)
1—Mounting plate for C2, metal (Mallory MP-6)
1—Insulated sleeve for C1 (Mallory CE-10)
1—Capacitor, electrolytic. 20 mf, 450 volt (Sprague TVA-1709) (C3)
1—Transformer, power. 600-0-600 volt at 200 ma., 5 volts at 3 amperes, 6.3 volts at 3 amperes (Stancor PC-8414) (T1)
1—Choke, filter. 5 henry at 200 ma. (Stancor C-1646) (CH)
2—Resistors, 100,000 ohm, 2-watt (IRC type BW-2) (R1, R2)
1—Resistor, 50,000 ohm, 50-watt adjustable (Clarostat K-50NA) (R3)
2—Switch, SPST toggle (H&H 20994-EW) (S1, S2)
1—Pilot lamp assembly (Drake #20) with with #47 pilot lamp (P1)
1—Socket, 6 pin (Amphenol 77-MIP6) (P2)
1—Socket, 4 pin (Amphenol 77-MIP4)
1—Fuseholder (Buss HJM) with 3 ampere fuse (Buss AGX-3) (F1)
1—Chassis, aluminum 7" x 13" x 2" (Bud AC-409)
1—Line cord and plug (Birnbach 816)
1—Terminal strip, double (Cinch 52)
1—Tube, 83 (RCA)
2—Grommets, 3/8" (General Cement 1042-E)
Misc. 6-32 nuts, bolts, lugs, lockwashers, 3/8" washers.

Power Cables

In order to transfer the various voltages from the power supplies to the associated transmitting and receiving equipment it is necessary to construct interconnecting power cables, with mating connectors. The builder may have noticed that each power supply has a different power socket so that the particular supply cannot be connected to the wrong piece of equipment. The power sockets have no exposed metal pins, and it is necessary to insert a plug into the socket, much in the manner of plugging in a radio tube, to obtain power from the socket. Accidental contact with a "hot" pin is thereby avoided.

The power cable has a plug that matches the power socket at one end, and has a *socket* at the opposite end. If a plug was used here, the pins would carry a shock hazard if the cable was plugged into the power supply. It is necessary, therefore, to mount a chassis-mounting plug on the piece of equipment to which the cable supplies power.

The cables themselves are not critical. The length may be any reasonable value, *provided* the ohmic resistance of the cable is not high enough to cause a drop in filament voltage between the power supply and the equipment. If multi-conductor cable is difficult to obtain at your local radio store, the cable may be made by braiding the required number of wires together. Number 22 wire (or larger) should be employed for high voltage leads, and Number 14 wire (or larger) should be used for filament leads. When heavy filament current is drawn through the cable, it is best to parallel two conductors for each filament lead.

The construction of the cables is simplicity in itself. Even the XYL (wife), YL (girl friend), or your sister can do it. Cut the cable to the proper length, allowing an extra four inches at each end to make the connections. Strip the ends of the wires at each end of the cable and tin each lead. Slide the little black plug caps on the cables before any connections are made to the plugs. If the cable wires are color coded, assign a color to the power plug which inserts in the socket of the supply. Start by wiring pin 1 at each end of the cable. Then, connect pin 2 at each end of the cable to a second color coded lead, and so on until all the wires have been connected to the corresponding terminals. After you have completed a cable check with an ohmmeter from pin 1 to pin 1, pin 2 to pin 2, etc. Make sure that all connections are well soldered. Snap the black cover caps on the plugs, and the cable is finished.

CHAPTER IX

Antennas: Their Care and Feeding

Probably more "hot air" has been written and spoken about the subject of antennas than about any other phase of amateur radio. Some of what you read and hear is true, and some is just wishful thinking. The "facts" and "conclusions" reached in such discussions of fancy are—as stated by *Pooh-Bah* in the *Mikado*—"merely corroborative detail, intended to give artistic verisimilitude to an otherwise bald and unconvincing narrative."

As a grip on reality, the following basic rules are presented by which all antennas must be judged. If either rule is violated, the antenna in question should be viewed with skepticism, to say the least.

Basic Antenna Rules

1. You can't get something for nothing.
2. There is no easy path to the possession of an outstanding signal.

Happily, for the amateur, the vagaries of the ionosphere are a great equalizer in regard to radio signals, and the amateur running the most power into the best antenna does not always possess the loudest signal at any given time and place. There is always a good chance for the "little guy" with low power and simple antennas. Armed with these highly important facts, the Novice can make the best possible use of his low power, and will be in an advantageous position to compete with his high powered cousins when he obtains his General "ticket" and ventures forth into the wilds of the unrestricted portions of the amateur bands.

Any antenna, whether used for transmission or reception must satisfy two basic conditions in order to approach maximum efficiency. These conditions, or requirements are:

1. The antenna must be *resonant* at or near the frequency of use.
2. The antenna must be connected to the transmitter (or receiver) in such a way so that a *maximum transfer of energy* from one to the other is accomplished.

That's all there really is to the problem! These two conditions—plus the two basic rules previously mentioned form the framework of design for all

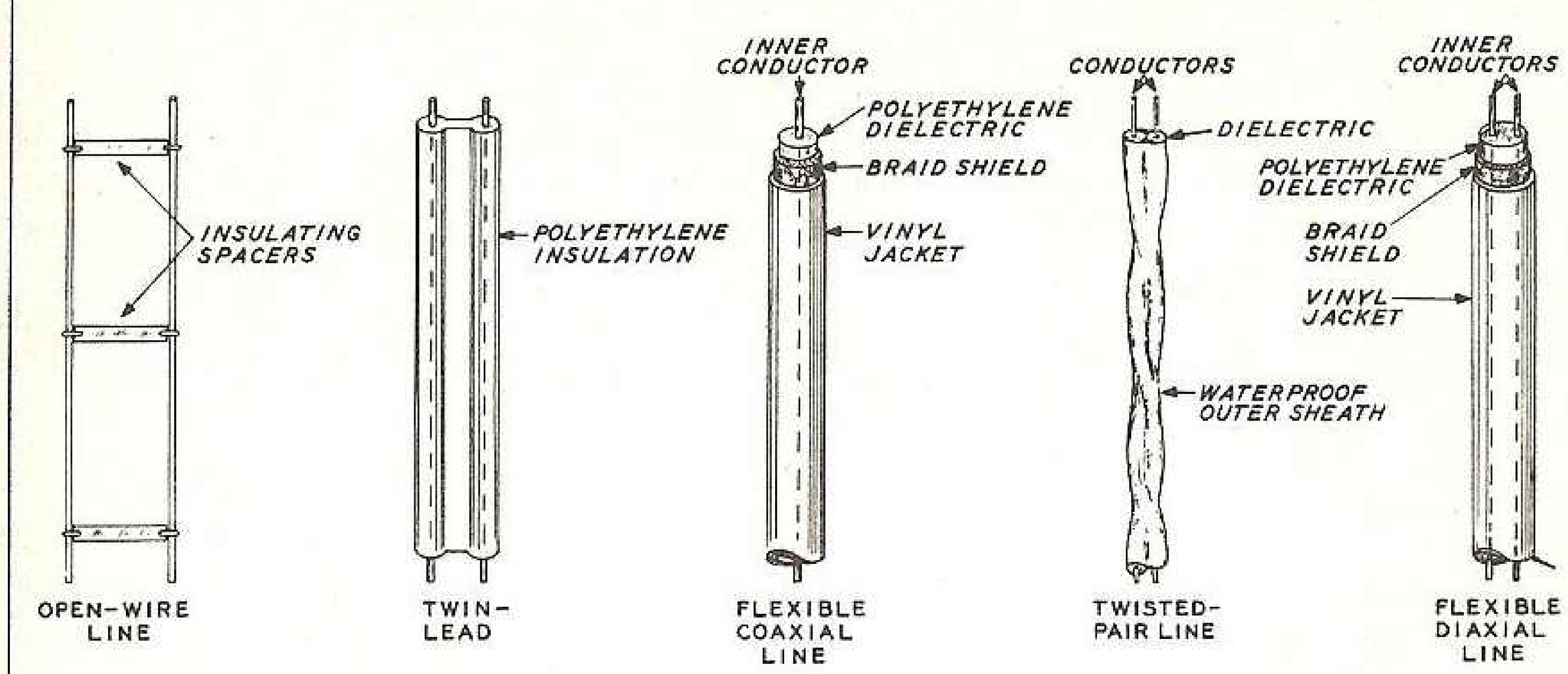


Fig. 1 Five types of transmission lines used by amateurs. The "TV-type twin lead" and shielded coaxial lines (RG-8/U and RG-59/U are the most popular.

radio antennas, regardless of their size, gain, or other exotic qualities. As a starting point, it is well to briefly examine some antenna concepts.

Antenna Resonance

For any antenna there is one frequency, called the *resonant frequency,* at which the capacitive and inductive reactances are exactly equal and neutralize each other, leaving only the radiation resistance of the antenna to oppose the flow of current in the circuit. The resonant frequency of a simple antenna is a function of its physical length. If the antenna is not the correct length for resonance at the desired frequency of operation, it can accordingly be brought into resonance by adding series inductance to equalize the capacitive reactance of an antenna that is too short, or by adding series capacitance to neutralize the inductive reactance of an antenna that is too long.

Energy Transfer to the Antenna

A resonant antenna wire suspended well in the air makes a fine antenna, but it does little good unless some means are provided to conduct the radio energy from the antenna to the receiver, or from the transmitter to the antenna. To accomplish this, a radio "hose" called a *transmission line,* or *feeder,* is used to pipe the energy back and forth between the radio equipment and the antenna. Four common types of transmission line are shown in Figure 1. Although there are physical differences between these lines, they all have the common property called the *characteristic impedance* of the line. This impedance is expressed in ohms, and is determined by the physical and electrical properties of the line, such as the size of the wire, the spacing between the conductors, and the type and amount of insulating material used. Two common impedance values of line are 52 ohms and 300 ohms. Many types of inexpensive television transmission line are available in these values, and it would be a smart move to design the antenna so that it can efficiently employ these popular line impedance values.

An impedance notation of "52 ohms" or "300 ohms" does not mean that the transmission line has a resistance equal to that value. In fact, efficient lines made of copper wire have resistance values less than one ohm or so. The characteristic impedance notation of "so-many-ohms" means that the line is designed to be used with an antenna that presents that value of *terminating resistance* or *radiation resistance* to the transmission line. To clarify these last two terms, let's look at the antenna once again.

Radiation Resistance

The radiation resistance of a dipole—or any other antenna for that matter—is expressed in ohms and may be defined as that value of resistance which, when substituted for the antenna, will dissipate in the form of heat the same amount of power as is radiated into space by the antenna. The actual value of radiation resistance is determined by the length and size of the antenna compared to the radio wave, and the proximity and character of objects located near the antenna. The radiation resistance of any antenna may be measured with appropriate instruments, and usually runs in the neighborhood of 30 to 300 ohms for simple resonant antennas usually employed by Novices and Technicians. The radiation resistance is measured at that portion of the antenna having the greatest value of current. In the case of the dipole, this is the center point of the antenna.

Standing Wave Ratio (SWR)

The *standing wave ratio* is a value that summarizes some of the other qualities of the antenna. This ratio (abbreviated *SWR)* is a measure of the mismatch between the terminating load that the antenna places across the transmission line, and the characteristic impedance of the line. If the two quantities are equal the SWR is 1/1. If the line impedance is 52 ohms, and the radiation resistance of the antenna is 70 ohms, the SWR is 70/52, or 1.35/1. If the radiation resistance of the antenna is 300 ohms, the SWR is 300/52 or 5.8/1. Everything else being equal, the efficiency of transfer of power from transmitter to antenna, and the ease of transmitter loading are both best with lowest values of SWR. With high values of SWR, tuning troubles begin and efficiency of energy transfer drops. Instruments such as the *Micromatch* and the *SWR bridge* will read the value of SWR present on the transmission line. The SWR is at a minimum when the antenna is resonant at the frequency of transmission, and the SWR value increases rapidly when the antenna is operated in an off-resonant condition.

Certain types of antennas (such as the "end fed" and the "Zepp") employ *tuned feeders* having a high value of SWR. Efficiency of the tuned feeders is acceptably high when the length of the feeder is less than one wavelength, and the feeder is kept clear of nearby metallic objects.

For a complete discussion of antennas in general and beam antennas in particular, the reader is referred to the *Beam Antenna Handbook* and the *VHF Handbook*. These references are available at your local radio supply store, or may be ordered from the publisher, *Radio Publications, Inc.*, Wilton, Conn.

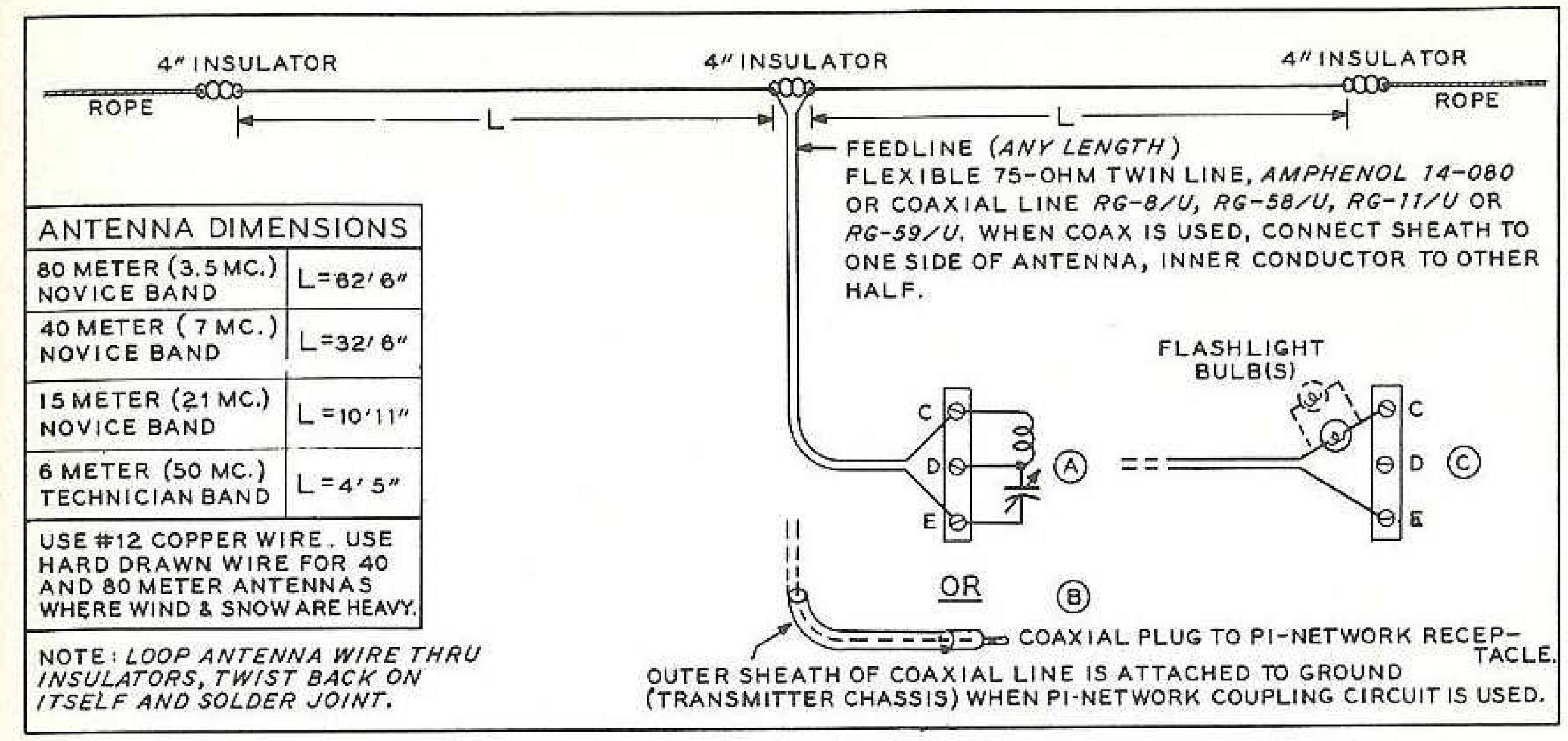


Fig. 2 The center-fed dipole (doublet) antenna is popular on all ham bands.

Practical Antennas—The Center-Fed Dipole

A center-fed antenna that is electrically one-half wavelength long is called a *dipole*. Dipole lengths for the Novice and Technician bands are shown in Figure 2. The antenna is split in the center, and each half is attached to one side of the transmission line. Such an antenna has a radiation resistance falling in the region of 35 to 75 ohms, depending upon the height of the antenna above the surface of the earth. The antenna may be efficiently fed with a random length of 72 ohm balanced transmission line as specified in Figure 2. It may also be fed with a random length of 52 ohm or 72 ohm coaxial cable. In either case, the SWR on the transmission line will be well below 2/1 in most installations. The antenna should be erected as high as possible (not less than twenty feet above the ground) and the feedline should drop vertically from the center of the antenna to a height of a few feet above the ground. It may then run horizontally along the ground at that height to the transmitter. Best results will be obtained if the antenna is forty or fifty feet high. An antenna such as this is a one-band affair, and will perform in excellent fashion on that band. One exception: the 7 mc doublet will also work fairly well on the 21 mc band. (Here is a rare instance where you get something for nothing!)

When the dipole antenna is used in conjunction with the transmitters having a built-in antenna tuning device, such as the LJ-15 and the SP-50 (Figure 2A) the twin feedline is attached to terminals C and E. Terminal D is not used. These connections result in a *series tuned* network, designed to match low impedance loads, such as presented by the dipole and feedline.

A good check of tuner and antenna performance can be obtained by inserting a 6.3 volt flashlight lamp *in series* with one wire of the feedline immediately after the tuner. A #44 lamp (0.25 ampere) may be used for low power, and a #50 (3 candlepower) lamp may be used for high power. Two bulbs may be connected in parallel to carry a high current (Figure 2C). After the antenna tuning capacitor and coil coupling are adjusted for maximum bulb brilliance, the bulb is shorted out with a short length of wire.

If a transmitter is used that employs a pi-network output circuit, the feedline should terminate in a coaxial plug, with the shield of the coaxial

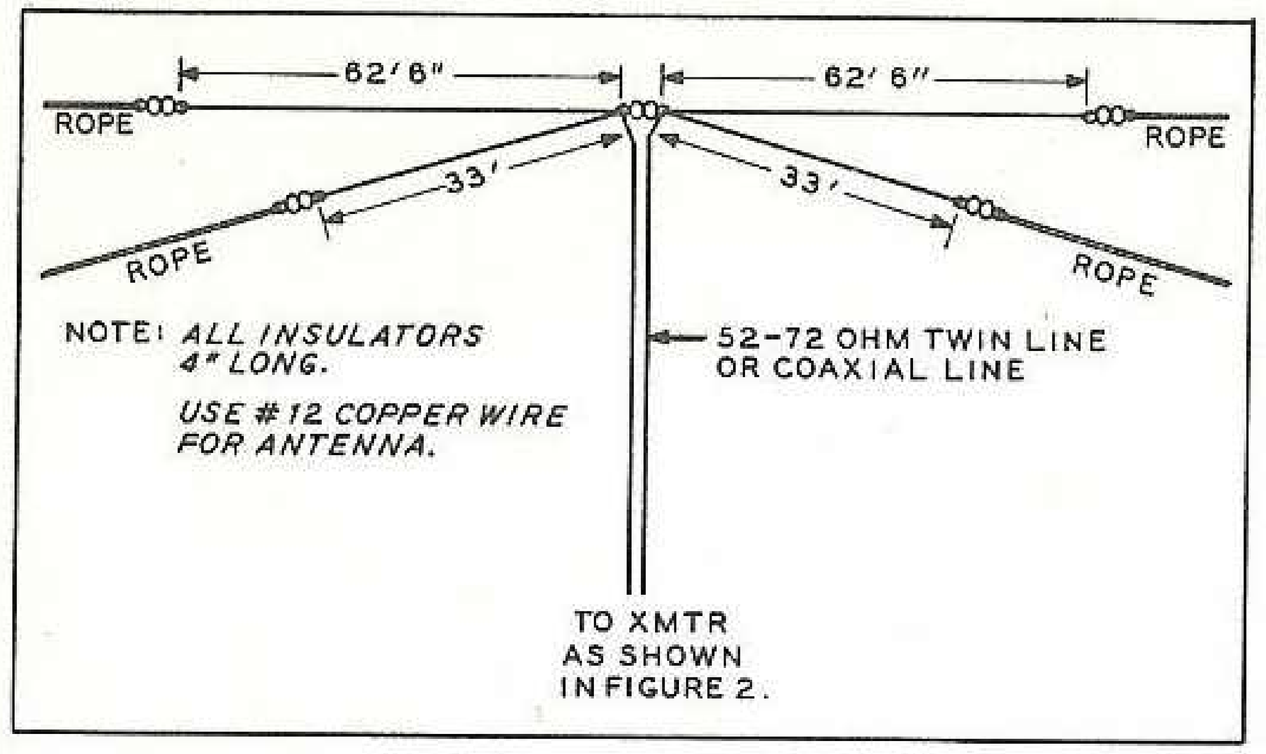


Fig. 3 Three bands may be worked with this multi-wire doublet antenna. As with any antenna of this type, care must be taken to make sure that harmonics of the transmitter are not radiated by the antenna.

line (if one is used) attached to the outer shell of the plug. If a balanced line is used, either wire may be attached to the plug shell. The use of a coaxial line is recommended for 21 mc operation, although either type of line will work equally well at lower frequencies.

The 7, 21, and 50 mc dipoles are directional at right angles to the wire. That is, the antenna should run in a North-South direction for best results in an East-West direction.

Practical Antennas—The Multi-Band Dipole

It is possible to attach two dipoles to one feedline, making a multi-band antenna that requires but one feeder system. Such an arrangement is shown in Figure 3. 80 and 40 meter dipoles are joined at the center insulator and fed in parallel from one transmission line. Either 72 ohm balanced line, or 52 ohm or 72 ohm coaxial line may be used for the feed system. Since the third harmonic of the 40 meter (7 mc) dipole falls close to the 15 meter (21 mc) amateur band, the antenna system will also function on that band. The SWR is low enough on all bands to permit proper operation of the system.

It will be found that the antenna field is best at right angles to the line of the wires on 40 and 80 meters. Thus, the antenna should be erected at right angles to the direction of desired transmission. On 15 meters, the antenna pattern is more complex due to both the principle of harmonic operation and the distorting effect of the 80 meter wires. In general, the 15 meter antenna pattern may be considered to be almost nondirectional. Indeed, the directional effect on the 40 and 80 meter bands is not too great, and more thought should be spent in the problem of getting the antenna *up in the air* than in worrying about the pattern of radiation of the antenna.

A connection is made between the two antenna wires and one leg of the feed line at each side of the center insulator. Solder all joints. The spacing between the two wires making up each half of the antenna is not critical. It may be of the order of one to three feet. The wires may run side by side, or one above each other with no difference in performance. As in the case of the center-fed dipole, the antenna should be erected in the air as high as possible. Operation of the antenna on the three Novice bands is automatic—no changes need be made in the antenna when changing the band of operation.

It should be noted that any multi-band antenna of this type is a "bear cat" at radiating transmitter harmonics—if any! So make sure your transmitter is free from harmonics. Use an antenna tuner if necessary!

ANTENNA DIMENSIONS	
80 METER (3.5 MC.) NOVICE BAND	L=61'0"
	S=62'6"
40 METER (7 MC.) NOVICE BAND	L=32'8"
	S=33'6"
15 METER (21 MC.) NOVICE BAND	L=11'0"
	S=11'3"
6 METER (50 MC.) TECHNICIAN BAND	L=4'7"
	S=4'8"
2 METER (144 MC.) NOVICE BAND	L=18.5"
	S=19"

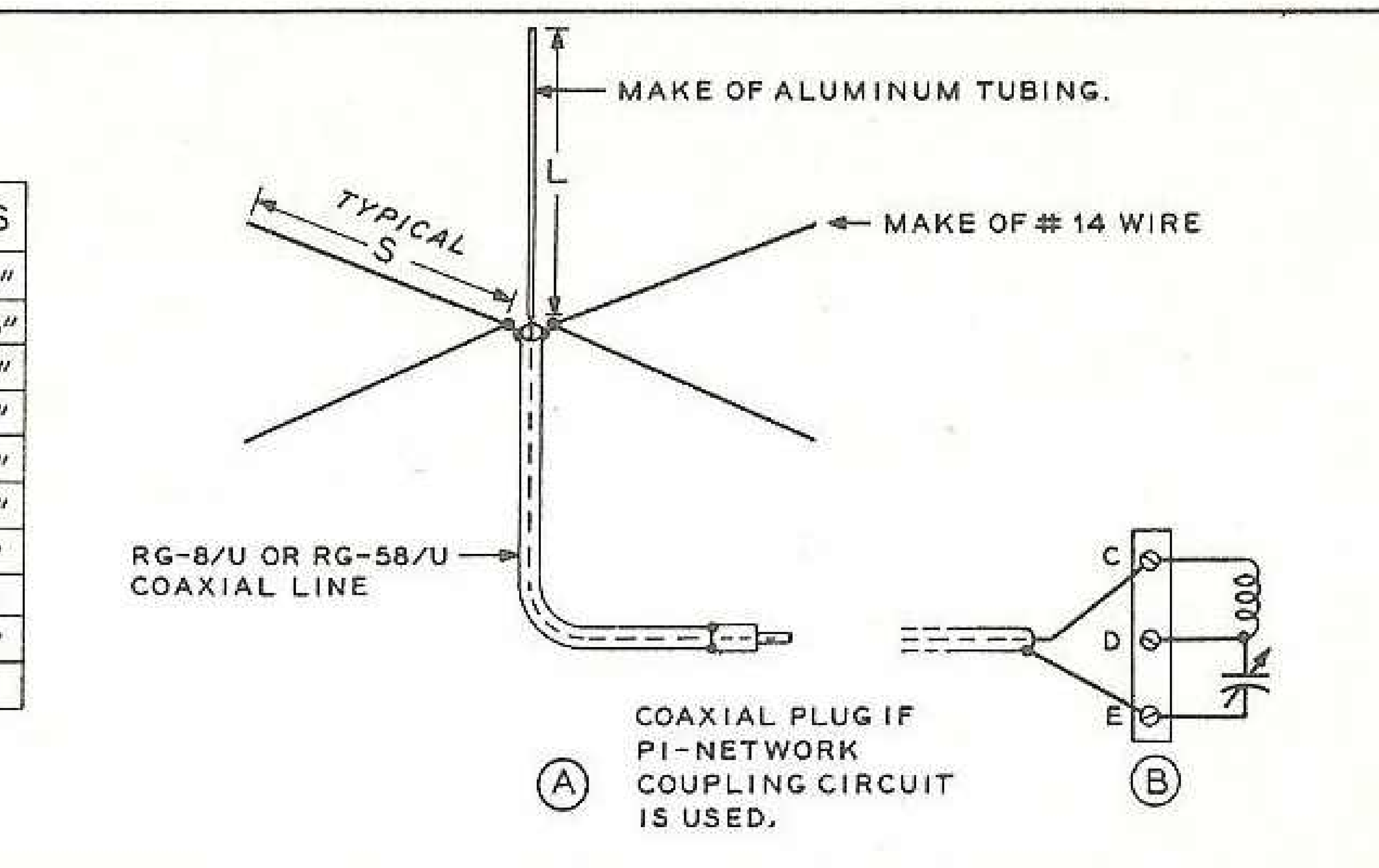


Fig. 4 The vertically polarized ground plane may be used on any band between 3.5 mc and 144 mc. For low frequency work, vertical whip may be made of wire.

Practical Antennas—The Ground Plane

The vertical ground plane is a simple structure to erect and works well. It has a nondirectional pattern and is a good antenna for the amateur who has little room to put up a relatively large dipole. Dimensions for ground plane antennas for the Novice and Technician bands are shown in Figure 4. The radiation resistance of a ground plane antenna is about 30 ohms, so it should be fed with a coaxial transmission line of 52 ohms. The outer shield of the line is attached to the radials of the antenna. These radials should run away from the base of the antenna, though it is not necessary that they travel in straight lines. The usual procedure is to weave them around the house, through fences, and through the garden to make them as unobtrusive as possible. The radials may slope down from the base of the antenna, but they should not project above the base level of the vertical section of the antenna. The ground plane is relatively unconcerned about its location. It may be strapped to a chimney or a short pole, or placed atop the garage. As with any other antenna, it should be removed as far as possible from power, telephone and utility wires. Ground planes are very popular on the bands between two and forty meters. The relatively huge size of an 80 meter ground plane limits the number in use on that band.

For the low frequency bands, the vertical section of the ground plane may be made from aluminum tubing, or galvanized steel TV mast stock. It should be guyed at a point about ⅔ of the way up from the base. The guy wires should be broken into short electrical sections by the use of "egg insulators" placed about ten feet apart along each guy wire. The six and two meter antennas may be made from a single section of ½-inch aluminum tubing. If desired, the radials may also be made of aluminum tubing.

The ground plane has a low angle of radiation, and under certain circumstances, it will be found difficult to work stations within a radius of perhaps 500 to 700 miles on the 3.5 mc and 7 mc bands, particularly during the evening hours. This effect is caused by the main lobe of the antenna skipping over these relatively close-in areas. The low angle of radiation, however, is a great help on the high frequency and VHF bands, and the antenna is an excellent performer for DX on the 21 mc and 50 mc bands. It may be used for local contacts on the 144 mc band in areas where vertical antenna polarization is used.

Practical Antennas—The Folded Marconi

A *Marconi* antenna (named after you-know-who) is one that is less than a half wavelength long. It depends upon a ground connection to supply the missing portion of the electrical length. The usual "garden variety" of Marconi has a distressingly low efficiency factor (10%-15%) as it is not easy to obtain a really *good* electrical ground connection. However, if two parallel wires are used for the Marconi antenna as shown in Figure 5, the efficiency of the antenna is boosted by a factor of four or so. This antenna may be erected in either a horizontal or vertical position, the only requirement is that one leg of the antenna be grounded at the transmitting end. A water pipe ground connection may be used. The radiation resistance of the Folded Marconi antenna is high enough so that 52 ohm coaxial cable may be used for the feedline. This antenna is a one band affair and is normally used for either 80 or 40 meter operation, depending upon the length of the parallel wires. Operation of the 40 meter antenna on the 15 meter band is not recommended. This antenna will prove to be most useful when the station is located near one end of the available antenna space, and the erection of a full-size dipole antenna is impractical.

The coaxial line may be coupled to the transmitter as shown in Figure 2A or Figure 2B. In areas of snowy or windy weather, the antenna should be made of TV ribbon having steel core wire for maximum strength. Also, if the far end of the antenna is supported by a tree, it is wise to place a spring in series with the support rope to prevent it from breaking when the tree sways in the wind. As an alternative, the rope may run over a pulley attached to the tree and the antenna may be counterweighted by a suitable weight at the far end of the rope as shown in Figure 5.

Since the entire portion of the antenna is an active radiator, care should be taken to keep it away from utility wires, phone wires, and other metallic objects. Stucco houses have a wire mesh imbedded within the walls, and the antenna should be kept clear of this type of structure, as shown.

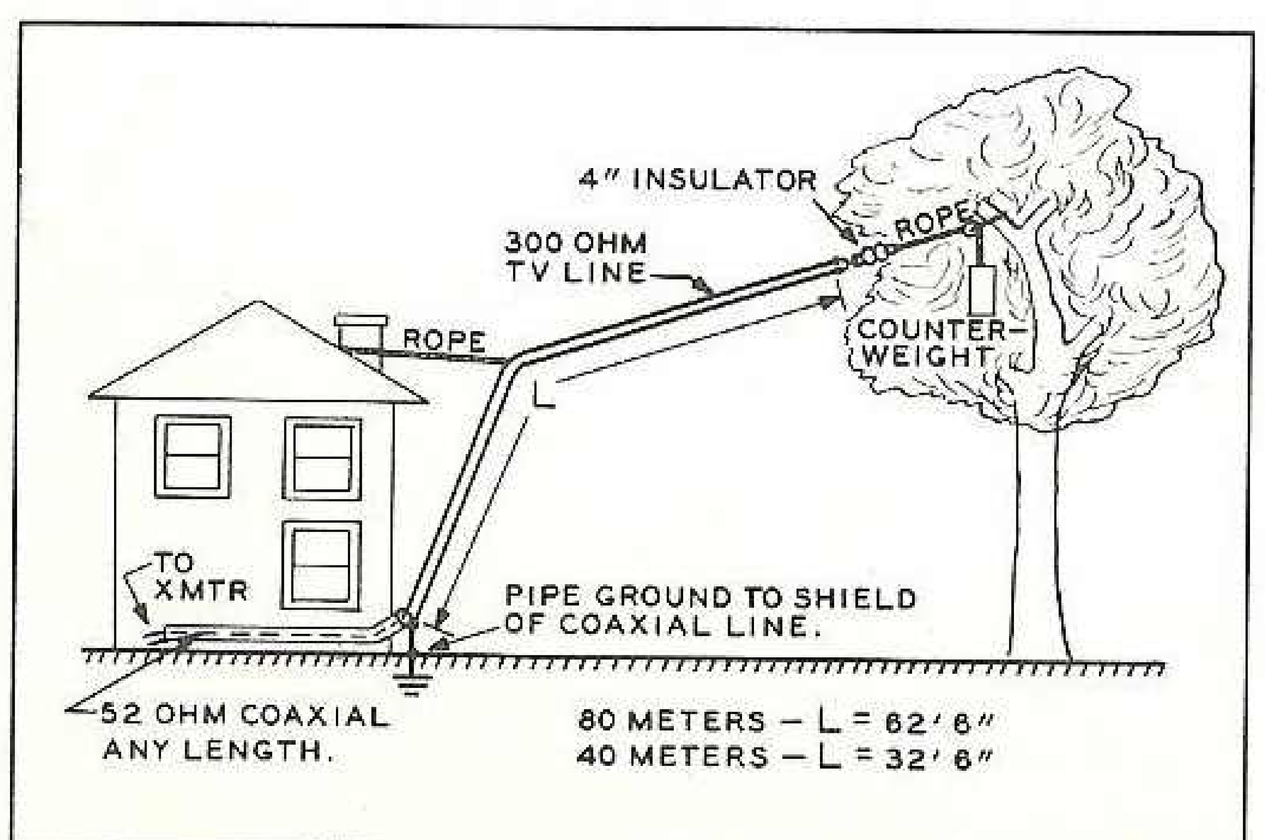
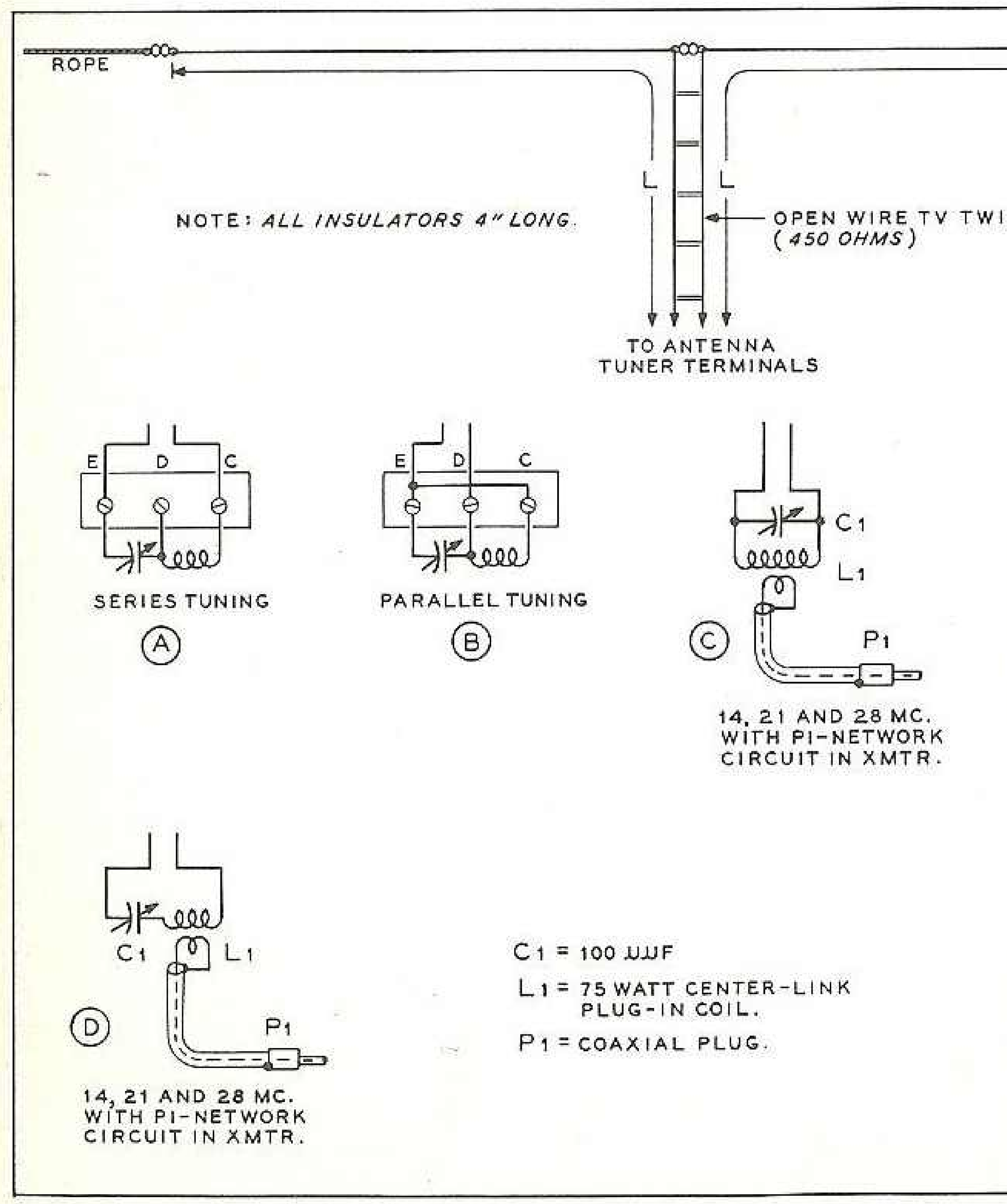


Fig. 5 Folded Marconi sky-wire is excellent antenna where amateur must contend with restricted space for his aerial. Water pipe ground may be used with antenna.

Practical Antennas—The Center-Fed "Zepp"

The *Zepplin* antenna (so named because a version of it was used on the early dirigibles) is an efficient form of multi-band antenna well suited to Novice use. In its simplest form, it is a random length of wire split at the center and fed with open-wire tuned feeders. For ease of adjustment, it is smart to adjust the length of the flat top and the length of the feeder to permit the antenna to be easily adjusted in the various amateur bands. The antenna is illustrated in Figure 6, together with a table of suggested lengths. The length L is equal to ½ the flat top plus the feedline length. One big advantage of this system is that the overall horizontal portion of the antenna need be no specific length, just as long as the two portions are of equal length. By juggling the length of the feedline and the flat top, the "Zepp" can be made to fit into almost any space. The city ham may take the 99 foot version, for example. His flat top may be two sections, each 60 feet long, fed with a twin feeder line whose overall length is 69 feet. Or (if he has a bit more room) he might make his flat top of two 80 foot sections, and his feedline will then be 59 feet long. If he is cramped for space, the 66 foot version is ideal. The flat top can be two 30 foot wires, and the feedline is then 36 feet long.

The lucky ham with plenty of room can make good use of the 128 foot



LENGTH L	BAND	COUPLING CIRCUIT
128	80	B
	40	B
	15	C
109½	80	B
	40	B
	15	B
99	80	B
	40	A
	15	D
76	80	A
	40	B
	15	C
66	80	A
	40	B
	15	C
42	80	—
	40	A
	15	C

Fig. 6 Center-fed "Zepp" antenna is well suited for general amateur use.

version. His flat top can be two 100 foot pieces of wire, with a 28 foot feedline! In all instances the "Zepp" will work well. Naturally, the longer the flat top, the "bigger the signal." Even so, a short, center-fed "Zepp" is no antenna to be brushed lightly aside when the QRM piles up.

The simple built-in antenna tuner of the LJ-15 and the SP-50 transmitters described earlier in this Handbook will work well with the "Zepp," as shown in Figures 6A and 6B. For use with the AB-60, or any transmitter having a pi-network output circuit, a simple antenna tuner such as shown in Figures 6C and 6D must be used. It may be necessary to prune the length of the feedline a foot or so to obtain optimum loading on the 21 mc band.

Antenna Tuners

It has been mentioned previously that any antenna of incorrect length may be resonated by electrical means. This opens the possibility of employing a relatively short antenna for the instances where it is impossible to erect a full size antenna. The ham living in an apartment, or trapped on a fifty foot city lot has no other choice than to use some form of shortened antenna. Such an antenna may be resonated with an *antenna tuner*.

Single Wire Antenna Tuners

One of the simplest tuners to construct is the one shown in Figure 7. This tuner is designed to match a 75 watt (or less) Novice transmitter to a random length wire on any band between 10 meters and 80 meters. The term "random length wire" means a single wire, high, and in the clear that is at least forty feet long. If 80 meter operation is not contemplated, the wire may be as short as twenty feet. For best results, however, the wire should be made as long as possible.

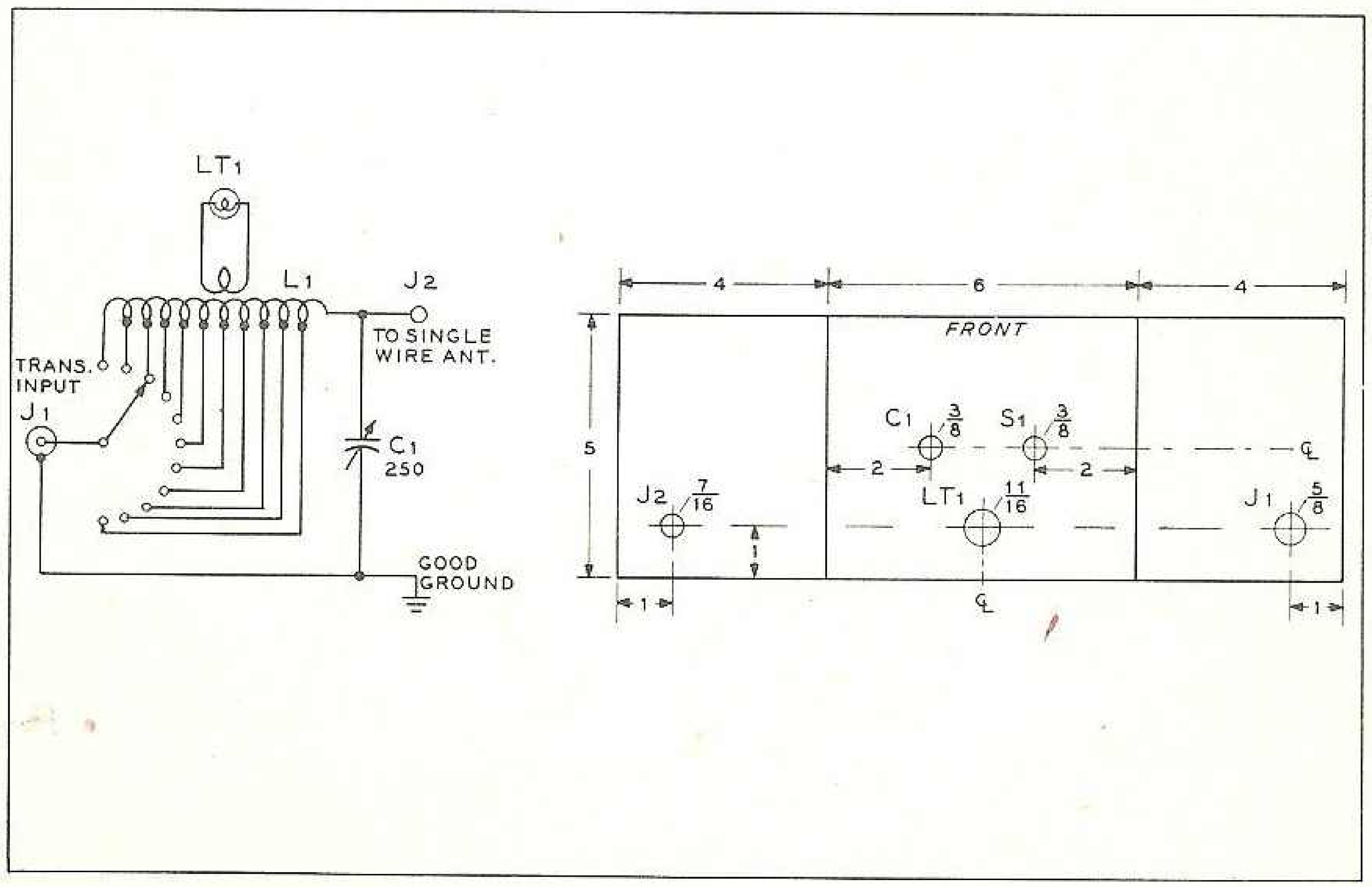


Fig. 7 Schematic of 75 watt antenna tuner suitable for 10-80 meter operation.

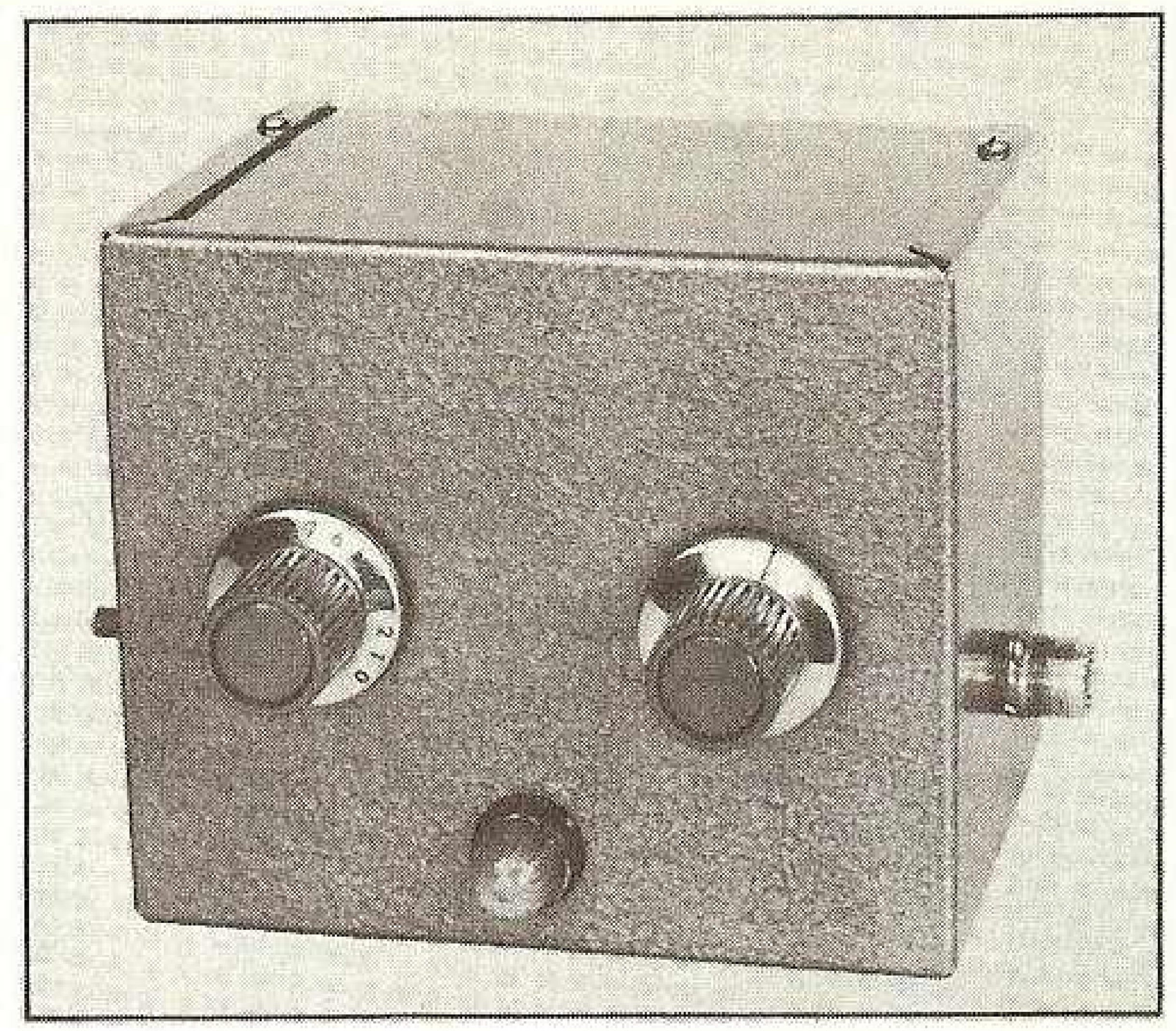


Fig. 8 Single-wire antenna tuner suitable for Novice work. The pilot lamp is inductively coupled to loading coil of unit, and indicates resonance of tuner. Inductance and capacitance should be added by adjusting tuner until maximum bulb brilliance occurs.

The tuner is a simple "L-network" built in an aluminum box measuring 3″x4″x5″ *(Bud CU-2105)*. A coaxial receptacle is mounted on one end of the box, permitting connection to be made to the transmitter via a short length of coaxial line. At the opposite end of the box is affixed a ceramic feed-thru insulator to which the antenna wire is attached. The tapped coil and rotary switch combination are mounted to the "front" of the box by the collar nut of the switch. The tuning capacitor is placed to the right of the switch and also is attached to the front panel.

Before the switch is placed in the box, the coil should be attached to the switch by the various leads. This coil is tapped at ten places. In order to do this without shorting turns, the two turns on either side of the tapped turn are depressed to allow clearance for the tap. The coil is supported from the switch by the heavy, tinned leads.

A simple water pipe ground may be used with the antenna. Every effort should be made to place the major portion of the long wire as high and as in the clear as possible. One or two mild bends in the wire to achieve this goal are permissible, but sharp bends should be avoided.

Parts List for Single Wire Antenna Tuner

1—250 mmf variable capacitor (Bud CE-2007) (C1)
1—Coil, 51 turns #20, 2″ diam., 3¼″ long. Tapped every fifth turn (Air-Dux 1616) (L1)
1—Pilot lamp receptacle (Johnson 147-406) with #47 lamp (LI-1) coupled to coil with two turn link of insulated wire.
1—Coaxial connector (Amphenol 83-1R) (J1)
1—Ceramic feedthru insulator (Johnson 135-40) (J2)
1—Switch, 1 pole, 11 position (Centralab 1402) (S1)
1—Chassis-box, 4″x5″x6″ (Bud CU-2107)
Misc. 6-32 nuts and bolts.

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