No. 199

getting started in amateur radio

by Julius Berens
W2PIK

a RIDER publication

getting started in AMATEUR RADIO

$2.40

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JOHN F. RIDER

PUBLISHER, INC.

116 WEST 14TH STREET

NEW YORK 11, N. Y.

Library of Congress Catalog Card Number 57-11292

Printed in the United States of America

PREFACE

Getting Started in Amateur Radio is written for people who are interested in becoming licensed radio amateurs, also known as hams. Since amateur radio has a widespread appeal to people with and without a knowledge of basic electronics and radio theory, all material is presented in a manner that should be readily understandable to everyone, regardless of technical background.

This book describes the various classes of ham licenses and their privileges, and leads the reader through every step necessary to obtain a ham license. Chapters 1 and 2 explain what ham radio is and how best to learn the International Morse Code. Chapters 3 and 5 give concise explanations of the basic electronics and radio theory that all hams must understand. Chapters 4 and 6 contain "Study Questions" with detailed answers, which should help the reader to a better understanding of radio theory and its application to ham operations. To help prepare the reader for the license examinations, required by the Federal Communications Commission (FCC), Chapters 4 and 6 also contain actual sample examinations. Many of the study questions for the license examinations were selected from a list specifically prepared for the author by the FCC.

The last chapter of this book contains extracts of all the FCC rules and regulations that must be understood in order to pass the license examinations and to operate a ham station.

The author would like to dedicate this book to his wife, Irma, and to all persons like her who are sincerely interested in ham radio. The

author would also like to thank his brother Jack, W2MDL, for his help; L. Stewart, W1YGH, for an excellent job of checking the technical accuracy of the book, and Stuart B. Flexner for his editing and help in preparing the final manuscript.

Plainview, N. Y.
May 1957

JULIUS BERENS
W2PIK

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Chapter 1: INTRODUCTION

What is Amateur Radio?

Amateur radio is a means of noncommercial radio communication between licensed individuals using licensed equipment.

Hams. Licensed amateur radio operators are called *hams.* The licensing of the ham and his equipment is controlled by the FCC (Federal Communications Commission). Chapter 7 gives the FCC requirements and licensing procedure.

If the communication is by voice transmission, the individuals doing the communicating need not necessarily be licensed, but the radio equipment must be turned on and off by a properly licensed operator, and someone with the proper license must always be in charge while the station is on the air. In addition to being permitted to operate his own station, the licensed amateur may operate those of other hams, providing the stations are within the class of his own license.

To be licensed to operate a station, the ham must pass a test in operating practices (Chap. 2) and radio theory (Chaps. 3 and 5). Thus the word "amateur," when applied to ham radio operators, means only noncommercial; their activities are in no way "amateurish." Rather, they strive to be as professional in their operations as possible, and are very proud of this fact. Many major advances in communications and in electronics engineering have stemmed from their activities.

Ham stations are the licensed amateur radio stations operated by hams. The radio equipment consists of simple components for receiving and sending messages. Although the units can be bought, most hams assemble their own. The messages can be either radiotelephone (voice) or radiotelegraph (often called cw, for continuous wave, the dots and dashes of the International Morse Code).

Amateur stations may be operated from any location, including home, car, boat, etc., but they must be used solely for personal satisfaction, not for commercial purposes.

Amateur radio is open to any interested and qualified citizen of the United States, regardless of age or sex. Thus any citizen is eligible for an amateur operator and station license, if he or she meets the requirements of the FCC.

Many people are hams because they are interested in learning about electronics and radio communications; others are interested in building electronic equipment. Still others are primarily concerned with learning Morse Code, or with relaying messages in civilian defense and emergency networks. Many people find amateur radio useful and educational, but to most hams, operation of a station is fun in itself, offering satisfying and varied experiences that make ham radio one of the most perfect of hobbies.

Some hams are interested mainly in talking with friends and making new friends in different geographical areas. While operating a station, hams talk to people in many places, "traveling" by code key and headphone. Through common interests with fellow amateurs, they can also join in country-wide activities and enlarge their social interests. Some hams specialize in communicating with foreign countries, which also offers an opportunity to learn (or to improve their knowledge of) foreign languages.

Thus, there are many reasons to be a ham. Remember also that amateur radio is an inexpensive hobby; much of the enjoyment consists of making and improving your own equipment. A ham can also devote as much or as little time to his station as he wishes, and can enjoy it at any time of the day or night. Although code transmitting speed and radio practices keep improving with experience, a knowledge of the contents of this book and of the FCC requirements is all that is needed to get full satisfaction from an amateur station.

History

The early history of amateur radio runs parallel to the history of commercial wireless code communication. A short time after Marconi proved that wireless telegraphy was practical, amateurs were attempting to duplicate his feat.

Amateur radio began when people started using wireless telegraphy as a means of private communication. At first only very short distances were involved; long distance communications required the use of relay stations. Ham stations were joined in relays to send communications throughout the country, achieving long distance communications by a cooperative effort.

By 1912 so many government services, commercial stations, and amateurs were on the air that laws and regulations were passed, assigning specific frequencies to the various groups. Radio amateurs were assigned all frequencies above 1500 kc. (At that time, no one thought that frequencies higher than this could be useful.) The early history of ham radio ended when the United States entered World War I; many radio amateurs were drafted, and all amateur radio operation suspended.

Growth of Ham Radio

Immediately after World War I, ham radio gained an immense popularity. The war had stimulated the development of new communications techniques, and the potentialities of the vacuum tube were just being realized. Amateurs took advantage of these new developments, and soon 1500 kc was found to be only the beginning of a new and potentially valuable frequency range.

In December 1921, the ARRL (American Radio Relay League) conducted a series of tests, during which various United States amateur stations were heard in Europe. In 1922 additional tests were performed, and over 300 United States calls were received by European amateurs. In November 1923, after much testing with various frequencies and power, two-way communication was performed for the first time between hams of the United States and France. Amateur cooperation with explorers' expeditions started in 1923, when an ARRL ham member accompanied an expedition to the Arctic. The early 1920's saw the use of radio communications above 1500 kc and the beginning of the short wave era.

Commercial communications services from many countries started to use these new frequencies, and chaos soon threatened. Finally, it again became necessary to regulate radio communications so that commercial radio stations, ham stations, wireless services, Coast Guard and ship transmitters, and many other radio communications from all over the world would not interfere with each other. In the 1930's a series of international and national conferences were held to allocate the available frequencies; the radio amateurs successfully fought for and obtained many frequency bands above 1500 kc for their exclusive use.

In the period before World War II, amateur radio accomplished the miracle of contacting countries all over the world. During this time, amateurs sought the development of equipment permitting the use of higher radio frequencies, while continually improving their own equipment and techniques. When World War II started, all amateur operations were again suspended.

Since the end of World War II, hams have been evolving new methods and improving old methods of receiving and transmitting. The latest receivers have performance features never before envisioned. The transistor seems to offer a complete new field for communications study. Improved types of antennas are being developed that may in the near future outdate present antenna systems, and improved types of transmitting tubes and new developments in components will result in more efficient operation with fewer parts, less bulk, and less cost.

Types of Licenses

Table 1-1 shows the different classes of amateur licenses, with a brief summary of the requirements, privileges, and duration of each class.

The Novice Class license offers most beginners the ideal means of starting in ham radio. The purpose of this license is to permit beginners to acquire a year of practical operating and technical experience, as an aid in qualifying for higher privileges. Since the license is good for only 1 year, and is not renewable, the year should be used to prepare for the General Class license. To encourage beginners, the test for the Novice license is extremely simple, consisting only of a code test of 5 words per minute and an examination on elementary radio law and FCC regulations.

The Technician Class license is intended primarily for persons interested in the technical and experimental aspects of radio. Since an amateur radio license is necessary to operate all forms of radio controlled models, this license is for those hobbyists interested in radio control of model airplanes, boats, and cars. The license examination is taken by mail only, and requires a code speed of 5 words per minute. The written portion on theory and regulations is identical to that required for the General Class license. The term of this license is for 5 years; it may be renewed upon proof of operating activity.

The General Class license is the license most commonly held by hams. The requirements are more stringent than those of the Novice Class, requiring a 13 word per minute code test and a written examination on basic amateur practice, radio theory and general amateur regulations. The examination must be taken in person before an FCC representative. (Conditions that could justify an exemption from the personal examination include physical disabilities preventing travel, or living more than 75 miles from the nearest FCC examination point; see Rule 12.21(d) in Part II of Chap. 7.) A licensee is allowed full amateur privileges of operating any amateur station at any amateur frequency,

TABLE 1-1

AMATEUR OPERATOR LICENSES

Class	*Requirements*	*Privileges*	*Term*
Novice (by mail only).	Elementary theory and regulations. A code test of 5 words per minute.	cw (continuous wave code) 3700-3750 kc 7150-7200 kc 21,100-21,250 kc Phone/cw: 145-147 mc crystal controlled, 75-watt max. input.	1 Year (non renewable)
Technician (by mail only).	General theory and regulations. A code test of 5 words per minute.	All amateur privileges in the frequency band 50 to 54 mc and all frequency bands above 220 mc.	5 Years (renewable)
General (in person) and Conditional (by mail).	General theory and basic amateur practice. A code test of 13 words per minute.	All amateur privileges.	5 Years (renewable)
Advanced (in person).	Not available to new applicants.	All amateur privileges.	5 Years (renewable)
Amateur Extra* (in person).	General theory and regulations, plus special tests on advanced techniques. A code test of 20 words per minute.	All amateur privileges.	5 Years (renewable)

* Special waivers for previous amateurs.

with any authorized type of emission. In addition, the licensee (if over 21 years of age) is permitted to conduct and supervise the code test and written examination for the Novice, Technician, and Conditional Classes, which are given by mail only.

The Conditional Class license examination and privileges are identical to those of the General Class, except that the Conditional license examination is taken by mail only.

The Advanced Class license is not available to new applicants, since it is an equivalent license for hams presently holding a type of license called "Class A," now no longer issued. The Advanced Class license authorizes the same privileges as the General Class license.

The Amateur Extra Class license is the highest grade of amateur license. While no additional privileges are attached to it, the licensees are issued a special diploma-type certificate. The basic requirement for this license is the prior possession of any amateur license, except the Novice or Technician Classes, for 2 years. In addition, the license examination, which must be taken in person, includes a 20-word-per-minute code test and a written examination on advanced radio techniques.

Types of Operation

Hams have a choice of two types of operation: cw (code) or radiotelephone (voice). In code communication the International Morse Code is used; in this system each letter of the alphabet, each numeral, and each punctuation mark is assigned a code symbol composed of dots and dashes.

The ham uses a code *key* to send each code symbol, spelling out the message letter by letter. The average ham can send at a speed of 30 words per minute. Chapter 2 explains International Morse Code in detail, teaches the code, and gives instructions on using the code key. Code operation is used by many hams, because of the relative simplicity of the code equipment, its comparatively low cost, and excellent results it gives in long distance communications. Besides these advantages, many hams prefer code for the pure fun of sending and receiving Morse Code.

In voice communication, the ham speaks into a microphone in a normal conversational manner. This radiotelephone method of operation also allows his friends or family to speak over the ham station. A voice station is more complicated than a code station, with a consequent increase in cost, and is usually inferior to a code station in obtaining long distance results. However, most voice stations also include a cw section.

For normal close range communications, voice is usually used; for long range communications, code is preferred.

Getting Started

Although this book refers specifically to the Novice and General Classes, the Technician and Conditional Class requirements are almost identical to those of the Novice and General Classes, as explained previously. If a General Class license is desired immediately, without the intermediate step of a Novice Class license, it may be obtained. However, all the material required for the Novice Class license (covered in Chap. 3) should be read and understood.

It is strongly recommended that you build your station while learning; this will give actual experience with the materials being studied. However, do *not* test or use the station (do not send any signals) until after you have received your license.

The FCC limits the power of a Novice Class station to 75 watts. This power will limit the distance normally covered to a few hundred miles, although unusual atmospheric conditions have been known to permit communications over thousands of miles.

When you have read this book and are ready to take your license examination, notify your nearest FCC field office. (See the list in Part III of Chap. 7.) The FCC will mail you all the necessary forms and notify you of any other details.

Chapter 2: THE CODE AND THE CODE KEY

The Code

In amateur radio the term *code* always refers to the International Morse Code, used in amateur communications throughout the world. Each letter of the alphabet, each numeral, and each punctuation mark is assigned a code symbol composed of a dot (called a *dit*), a dash (called a *dah*), or a combination of them. The dits and dahs are formed by a code key connected to the transmitter.

Many hams operate as code stations for the enjoyment of using code, but more practically, code equipment is relatively simple and inexpensive. Furthermore, most hams specializing in long-distance communications prefer code to voice since, for equal-powered stations, code can be heard and understood at a much greater distance.

Many code stations can use the same amount of space (frequency bandwidth) as one voice station. For example, 50 code stations could operate in the channel occupied by one a-m voice station, and many hundreds of code stations could use the space occupied by one television channel. This factor is important in the allocation of radio space. To provide maximum use from its allotted frequencies, the FCC has set up amateur frequency bands where only specified types of operation (code, voice, etc.) are permitted. To insure that all hams are versatile, all FCC license examinations include a code requirement. Although a code test must be passed for all licenses, it is not necessary to operate an amateur station as a code station.

It is not necessary to decide on a choice between code or voice transmission at this point. You must learn the code to obtain a license, and probably will want to build the simpler, less expensive code station first. After proficiency has been obtained in operating a code station, and while you are enjoying using the station, voice transmission may be added if desired.

Whether or not you intend to operate a code station indefinitely, the code must be learned as a new skill. Learn to handle a code key and to send code to the best of your ability.

The Code Chart

The International Morse Code is a language made up of short and long sounds. The short sounds are called *dits* (dots) and the long sounds are called *dahs* (dashes). Different combinations of these dits and dahs are assigned to the 26 letters of the alphabet, the 10 numerals, punctuation marks, and symbols for special meanings.

INTERNATIONAL MORSE CODE

A	._	di-dah	S	...	di-di-dit
B	_...	dah-di-di-dit	T	_	dah
C	_._.	dah-di-dah-dit	U	.._	di-di-dah
D	_..	dah-di-dit	V	..._	di-di-di-dah
E	.	dit	W	.__	di-dah-dah
F	.._.	di-di-dah-dit	X	_.._	dah-di-di-dah
G	__.	dah-dah-dit	Y	_.__	dah-di-dah-dah
H	....	di-di-di-dit	Z	__..	dah-dah-di-dit
I	..	di-dit	1	.____	di-dah-dah-dah-dah
J	.___	di-dah-dah-dah	2	..___	di-di-dah-dah-dah
K	_._	dah-di-dah	3	...__	di-di-di-dah-dah
L	._..	di-dah-di-dit	4	...._	di-di-di-di-dah
M	__	dah-dah	5	.....	di-di-di-di-dit
N	_.	dah-dit	6	_....	dah-di-di-di-dit
O	___	dah-dah-dah	7	__...	dah-dah-di-di-dit
P	.__.	di-dah-dah-dit	8	___..	dah-dah-dah-di-dit
Q	__._	dah-dah-di-dah	9	____.	dah-dah-dah-dah-dit
R	._.	di-dah-dit	0	_____	dah-dah-dah-dah-dah

Error	....	di-di-di-di-di-di-di-dit
Comma	__..__	dah-dah-di-di-dah-dah
Period	._._._	di-dah-di-dah-di-dah
Question mark	..__..	di-di-dah-dah-di-dit
Hyphen	_...._	dah-di-di-di-di-dah
Semicolon	_._._.	dah-di-dah-di-dah-dit
Colon	___...	dah-dah-dah-di-di-dit
Parenthesis	_.__._	dah-di-dah-dah-di-dah
Quotes	._.._	di-dah-di-di-dah
Wait	._...	di-dah-di-di-dit
End of message	._._.	di-dah-di-dah-dit

Go ahead	—·—	dah-di-dah
End of transmission	···—·—	di-di-di-dah-di-dah

Learning the Code

In the old method of learning code, the alphabet was memorized in terms of dots and dashes. Then, when a combination of dots and dashes was received, it was translated into the equivalent letter. Experience has shown that this method retarded the abilities of most people to learn code quickly.

The modern method of learning code is equivalent to that used to teach children to read. In reading, emphasis is placed on the recognition of complete syllables and words instead of individual letters. Similarly, in code, emphasis should be placed on recognizing the overall sound of each letter, not the order and count of the individual dots and dashes. For this reason don't think of dots and dashes, try to hear groups of dits and dahs. In fact, when thinking or saying a dit, leave off the t, except when it occurs at the end of a group. Use the chart given above as your guide.

When learning the code, learn the letters in random *code groups,* such as:

A N E R T
K S H O M
I U Q C J
L V B D G
Z P X F W
4 1 6 2 7
3 4 5 0 8
9 comma wait
go ahead period
end of message

Learn all the letters in a group before continuing to the next group. While learning new groups, continue to use letters learned in previous groups.

Practicing the Code

The only way to learn the code is by a continuous, sustained effort. To learn rapidly, start practicing the code at once, before attempting to memorize it. The only way to learn the code properly is by practice.

While it is possible to learn to receive code by listening to ham messages or automatic code practice machines, it is virtually impossible to learn to send properly without practicing with another person. If this person knows the code, he can give you some very helpful criticisms; if not, try to help each other to the best of your abilities.

The only way to practice properly is with code practice aids. Code practice sets, which automatically send code messages at any desired speed, are commercially available for approximately $40. Some firms also rent this type of equipment. If you can afford the price, this is a

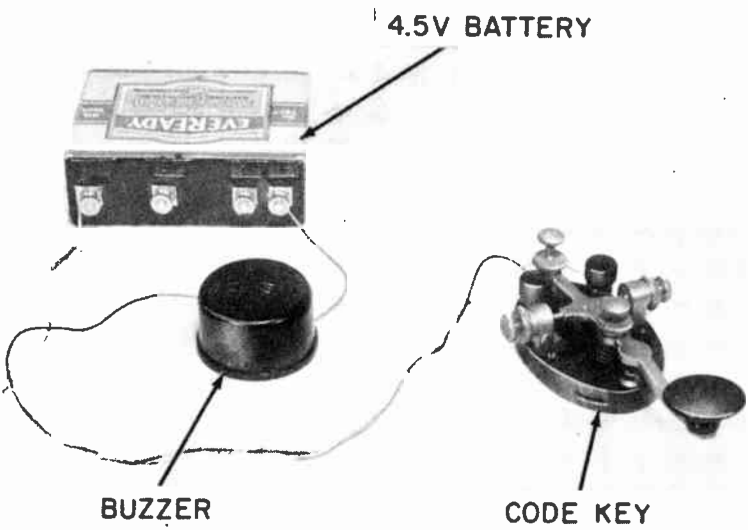


Fig. 2-1. Simple buzzer practice set.

good way to learn code quickly. Code practice phonograph records, which send code at different speeds, are less expensive. One manufacturer sells a set of 10 records (the alphabet through 8 words per minute) for about $8 and a set of 22 records (alphabet through 18 words per minute) for about $13. Most amateurs, however, learn the code by using a simple practice buzzer set. A buzzer code practice kit can be bought for $4, or less, and includes a hand code key, a buzzer, and a battery. Figure 2-1 shows a simple buzzer practice set that you can build yourself.

For copying code, writing is usually faster than printing. Military personnel handling code are required to print all messages to insure legibility. Since the copy you receive is for your own use only, the choice between writing and printing is one of personal preference. At high speeds (above 20 words per minute) many hams use a typewriter (mill).

The following table will help you estimate your progress in learning code. The figures were compiled by the United States Signal Corps. Note that the expression "groups per minute" is used instead of "words per minute"; a standard group contains five letters. In the code test for your amateur license, the code messages will be in clear English text; in this test however, a word is considered to consist of any five letters (equivalent to a group).

TYPICAL HOURS REQUIRED TO LEARN CODE SPEEDS

Desired code speed (groups per minute)	*Average additional hours practice required*	*Average total hours practice required*
5	25 (total)	20 to 30
7	13	30 to 45
10	15	45 to 60
12	15	60 to 75
15	20	75 to 110
over 15	cannot be predicted	———

As shown above, 25 hours of practice will enable the average person to attain a code copying speed of 5 groups per minute, the speed required for the Novice Class license. An additional 13 hours practice will enable the average person to attain a code copying speed of 7 groups per minute. If the necessary time is allowed, the desired code speed may be obtained without difficulty.

If you have a communications receiver, or can borrow one, use it to listen to code transmissions. Tune through the various bands until you find a station sending code at a speed slightly faster than you can receive and transcribe the message. Copy this to the best of your ability. You will be surprised at how quickly you can increase your copying speed.

To help interested persons learn code, the ARRL transmits code messages at various speeds over its own station (W1AW). The schedule of broadcast times for different speeds is printed in the ARRL monthly magazine, *QST*. These transmissions offer the added advantage of enabling you to check your code copying accuracy, since the transmitted material is taken from previously published material in *QST*.

Radio amateurs are a very friendly group. If you want help, don't be ashamed to ask; help will be given gladly. In fact, even if you don't need help, establishing contact with a local ham will give you a background you can't acquire in any other way.

Code Keys

A code key is a switch. Pressing it with your hand closes a circuit, permitting the signal to be transmitted (or a practice buzzer to sound). Releasing the hand pressure from the key opens the circuit, cutting off the signal or stopping the buzzer. There are two types of code keys: the manual hand key and the *bug* (semi-automatic key).

The Hand Key

Figure 2-2 shows a typical hand key. Figure 2-3 shows the various parts of a typical hand key. The key must be properly adjusted and the contacts properly spaced before it can be used.

The spring tension screw (Fig. 2-3) controls the amount of pressure exerted upward by the key against the operator's hand. The amount of tension is an individual preference. However, too much will tend to

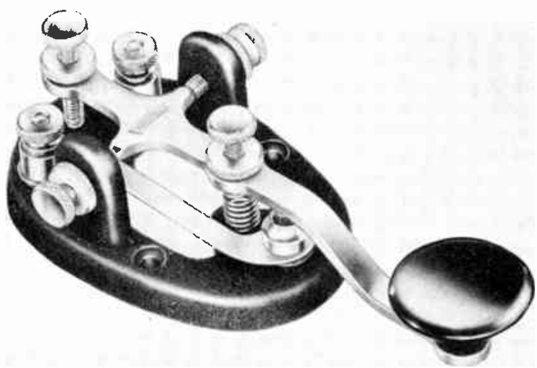


Fig. 2-2. Typical hand code key. ***Courtesy E. F. Johnson Co.***

force the key button up before the dahs are completely formed (making them too short), spacing will be irregular and there will be a tendency to skip dits. If the spring tension is too weak, the characters will tend to run together and the spaces between characters will tend to be too short.

The space adjusting screw should be set to allow a postcard-wide gap between the contacts when the key button is released. The exact gap width varies in accordance with the spring tension selected, so the two adjustments are usually made concurrently. Contacts that are too close together have an effect on transmission similar to that of weak spring tension; contacts that are spaced too far apart have the same effect as too much spring tension.

The two *trunnion screws* (Fig. 2-3) control alignment of the contact points. If they are too tight the key lever will bind; if they are too loose, the contacts will have a sidewise play. Both screws should be set

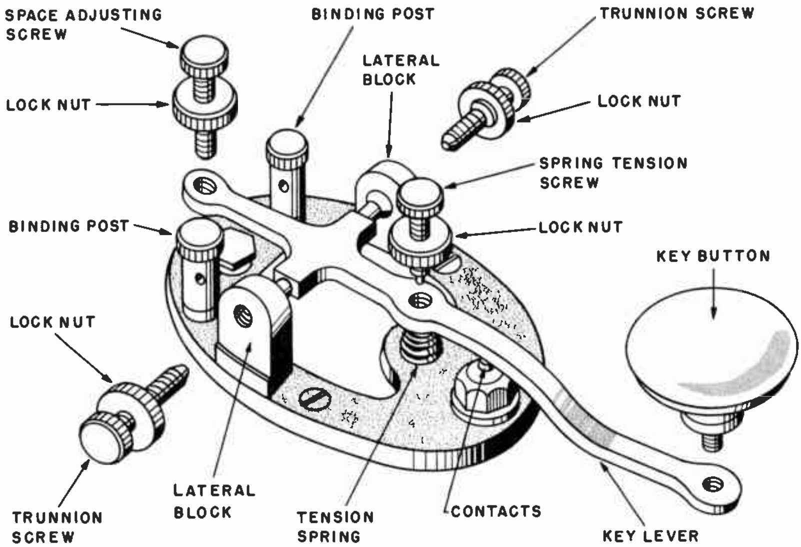


Fig. 2-3. Details of a typical hand code key.

to the same depth. Once they are aligned correctly, no further adjustment is normally required.

At all times make sure the contacts are clean and free from dirt; dirty contact points result in a scratchy signal.

Position of Hand on Hand Key

The hand position on the hand key is extremely important. Incorrect hand positions will result in a rapid tiring of arm and wrist muscles, and a code transmission that lacks rhythm and is rough and inaccurate. The following pointers should be followed for correct hand position on a hand key.

1. Lay your arm along the table in a natural position so that your fingers reach the key button without straining.

2. The tip of your index finger, or the tips of your first two fingers, should touch or just overlap the far edge of the key button. (It is impor-

tant that a code key be wired so that there is no possibility of any electrical shock when accidentally touching the metallic parts of the key.

3. The thumb and third or fourth fingers should touch the right and left sides of the knob lightly, to guide your hand movements and prevent slapping the key.

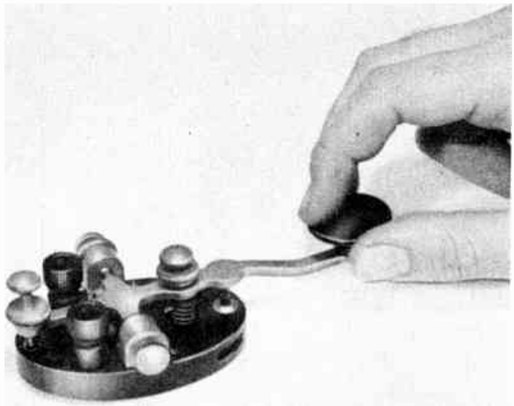


Fig. 2-4. A good code key hand position.

Fig. 2-5. Another view of a good code key hand position.

4. Allow the large muscles of your arm to do most of the work when sending. Putting strain on the smaller muscles of the wrist or hand may result in temporary fatigue.

Figures 2-4 and 2-5 show two views of a good hand position. Use these illustrations as a guide.

The Semi-automatic Key

The semi-automatic key *(bug)* simplifies the mechanics of transmitting code, and helps reduce fatigue.

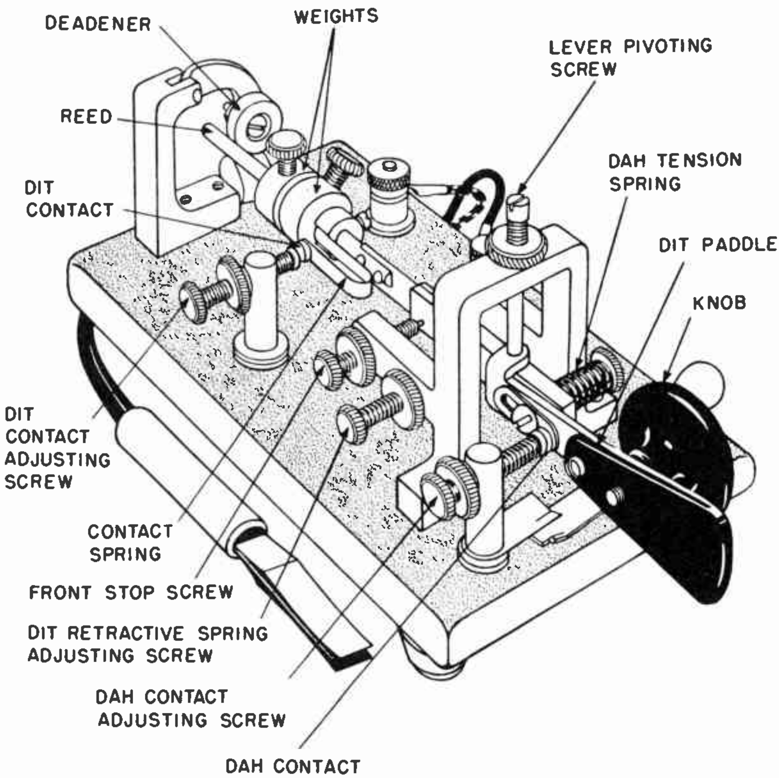


Fig. 2-6. Typical semi-automatic key (bug). *Courtesy Vibroplex Co.*

In sending with the bug (Fig. 2-6), the thumb presses the dit paddle toward the right and the index finger forms the dahs by pressing the knob toward the left. The key will send a succession of dits when the paddle is held to the right. One dit or a series of dits may be sent, depending on how long the thumb pressure is maintained against the paddle. One dah is formed every time the knob is pressed to the left. During sending, the hand pivots at the wrist, and the hand and arm motion is horizontal.

Best operation of the semi-automatic key is obtained when it is adjusted to send dits and spaces of equal length. If you have a bug, adjust it as recommended by the manufacturer.

Since the code test given by the FCC requires use of a standard code key, the beginner is cautioned against using a bug before learning the proper use of the standard key.

Learning to Send Code

The following is a good way of learning to send code.

1. Begin by sending a series of dits to develop timing and to get the feel of the key (or practice buzzer). Try to space the dits equally. As you get the feel, increase your speed. However, if you try to send too fast, your dits will be rough and uneven. After they sound rhythmic and steady, send the series EISH5 (. .. ..).

2. After practicing dits, send a series of dahs. The dah is three times as long as a dit, but the spacing between dahs is the same as that between dits. After the dahs sound rhythmic and regularly spaced, send the series TMO0 (— —— ——— —————).

3. First learn to send simple letters and code groups, such as A R N K D U (.— .—. —. —.— —.. ..—). Continue by learning to send all the other letters and symbols until you have mastered them all.

4. Too much practice alone is harmful; therefore, send to another person. Remember that you must send well enough so that the listener can understand you.

Common Operating Abbreviations

To help increase the speed of transmitting code messages, many common words and phrases are shortened or assigned abbreviations. Some abbreviations are assigned by regulations, while others have evolved through years of radio and telegraphic usage. The most common operating abbreviations are listed on p. 19.

Electronic Code Practice Set

The simple buzzer type of code practice set described previously is very helpful to the beginner in learning code. However, the disadvantage of this buzzer is its rough-sounding tone. In actual station operation, the code signals received have a cleaner, more distinctive tone. The electronic code practice set described below will produce a tone that is typical of the tones received over the air.

The electronic type code practice set is basically a grid-leak oscillator (see Chaps. 3 and 5). Pressing the key applies plate voltage to the oscillator tube, starting oscillations through the audio transformer. Figure 2-7 shows the schematic diagram of this set, and Fig. 2-8 shows the unit after assembly. Note that power is supplied by two batteries; the on-off switch connects the filament battery into the circuit. A 10,000-ohm po-

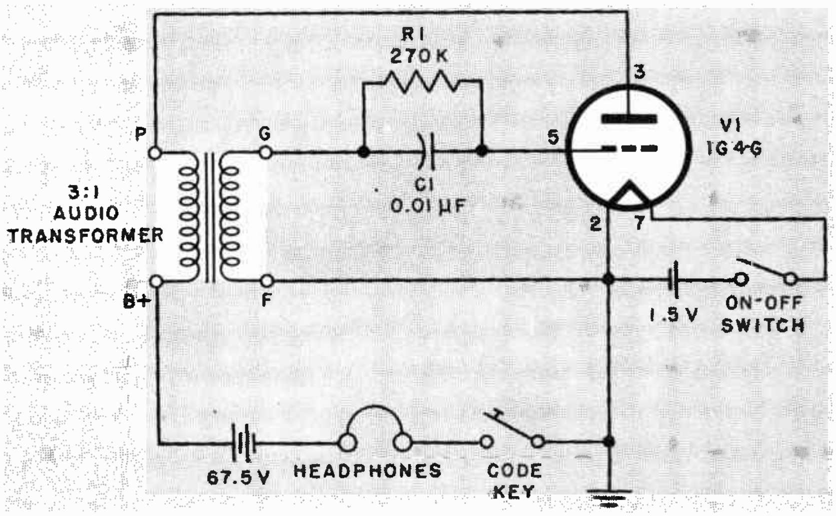


Fig. 2-7. Schematic diagram of an electronic code practice set.

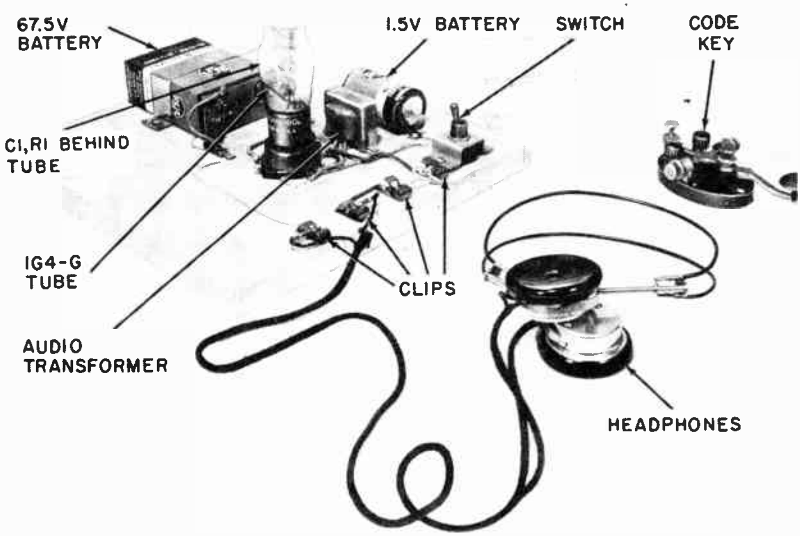


Fig. 2-8. An electronic code practice set.

tentiometer may be inserted in series with the B-plus lead of the 67.5-volt battery. It will vary the loudness of the signal. The list on p. 20 gives all the parts required.

COMMON OPERATING ABBREVIATIONS

AA	All after	NW	Now
AB	All before	OP-OPR	Operator
ABT	About	OT	Old timer
BCL	Broadcast listener	PSE	Please
BK	Break	R	O.K. (all right); received
BN	Between, been	RCD	Received
C	Correct, yes	RI	Radio inspector
CFM	Confirm	SED	Said
CK	Check	SEZ	Says
CL	Closing station	SIG	Signature
CQ	Calling any station	SIGS	Signals
CUD	Could	SINE	Sign
CUL	See you later	SKED	Schedule
DE	From, send by	TMW	Tomorrow
DLD-DLVD	Delivered	TNX	Thanks
DX	Distant	TXT	Text
FB	Fine business, very good	UR(S)	Your(s)
G	Repeat	VY	Very
GA	Go ahead	W-WD	Word
GB	Good bye	WA	Word after
GBA	Give better address	WB	Word before
GE	Good evening	WKD	Worked
GG	Going	WKG	Working
GM	Good morning	WL	Will
GN	Good night, gone	WAT	What
HI	Laughter	WUD	Would
HR	Here, hear	WX	Weather
HV	Have	XMTR	Transmitter
HW	How	XYL	Wife (or married woman)
LID	Poor operator		
MN	Minute	YL	Young lady (or women, in general)
N	No, not received		
ND	Nothing doing	73	Best regards
NIL	Nothing	88	Love and kisses
NR	Number, near		

Quantity	*Part*
1	Breadboard, approximately ½ × 12 × 12 inches
1	Audio transformer, 3:1 (inexpensive)
1	Tube, 1G4-G
1	Tube socket, octal, for wood mounting
1	Resistor, 270K, ½ watt
1	Capacitor, paper, .01 μf, 150 volts
1	Battery, 67.5 volts
1	Battery, 1.5 volts
1	Switch, spst, with wood mounting bracket
1	Code key
1	Headphones, high impedance

Chapter 3: RADIO THEORY FOR OBTAINING A NOVICE CLASS LICENSE

The Novice Class license gives permission to operate an amateur station, subject to certain FCC limitations noted in Chap. 7, Part II. The license permits beginners to acquire the practical operating and technical experience needed to qualify for a more advanced license. A Novice Class license is available to any citizen of the United States (regardless of sex or age), except a former holder of an amateur license (of any class) issued by any agency of the United States government, military or civilian. (Former licensees must apply for the General Class license.) The Novice Class license is good for only one year and is nonrenewable. Therefore, one year is all the time a would-be ham has to obtain the experience and knowledge necessary to meet the requirements for the General Class license.

Obtaining the License

To obtain a Novice Class license, it is necessary to pass a test on:

1. International Morse Code, at a sending speed of 5 words per minute and a receiving speed of 5 words per minute.
2. Rules and regulations essential to beginner's operation, including sufficient elementary radio theory necessary for the understanding of these rules.

At the present time, the code *receiving* test for the Novice Class license consists of 25 five-letter English words, mostly common ones. Punctuation marks and numerals are *not* included.

Since the required transmitting speed is 5 words per minute, it is necessary to be able to send at least 25 consecutive letters correctly. The required code speed is very easy to acquire. In fact, it is possible to send at this speed almost as soon as the code has been memorized. It is a good idea to learn to send at least 7 words per minute before attempting to take the test, in case nervousness cuts your speed. (Note that in the code *sending* test, punctuation marks and numerals may be required.) With a knowledge of the code and sufficient practice, it should be easy to pass the code test requirements of the licensing examination.

The written part of the test consists of 20 multiple-choice questions on basic amateur regulations and radio theory. Knowledge of the material in this chapter will make it easy to pass the radio theory part of the examination. Chapter 4 gives a group of study questions for review and an actual sample examination on which to test yourself. Since this is not a textbook, the following technical material has been condensed. If possible, it should be supplemented by a good textbook on radio fundamentals.

Theory

The basic units of an amateur radio station are the *receiver,* the *transmitter,* and the *antenna* (Fig. 3-1). The antenna picks up the radio waves in the air and conveys these waves to the receiver. The receiver separates the useful (intelligence) part from the unwanted (carrier) part of the radio wave, then amplifies the intelligence and converts it into sound. To do this, the receiver utilizes vacuum tubes, resistors, capacitors, switches, coils, etc., as explained later in this chapter. The source of operating power is generally a home electrical outlet.

The receiver has an on-off switch; a volume control knob; a tuning knob that selects different stations by means of tuning capacitors; a fine-frequency control (vernier) knob for more exact station tuning; and a bfo switch permitting reception of code, all of which make it possible for the ham to control his operation.

The amateur radio transmitter is similar to a broadcast station. The intelligence, either voice or code, is transmitted through the air on a *carrier.* As explained in more detail later, the transmitter generates this carrier by means of an *oscillator,* and combines the intelligence with it by a process called *modulation.* The combined radio signal is called a modulated signal. It is amplified and sent out through the antenna.

The transmitter's oscillator determines the frequency of the carrier, and is often controlled by a quartz crystal to insure that the frequency is maintained. The ham controls the functions of the transmitter by the knobs and switches that are connected from the components to the outside of the chassis. The transmitter also utilizes vacuum tubes, resistors, capacitors, coils, etc., and generally uses the electrical wall outlet for its source of power.

The antenna performs two functions: it receives radio signals for the receiver and it transmits radio signals from the transmitter into the air. It can only perform these functions one at a time. Although it is possible to utilize one antenna for both reception and transmission by

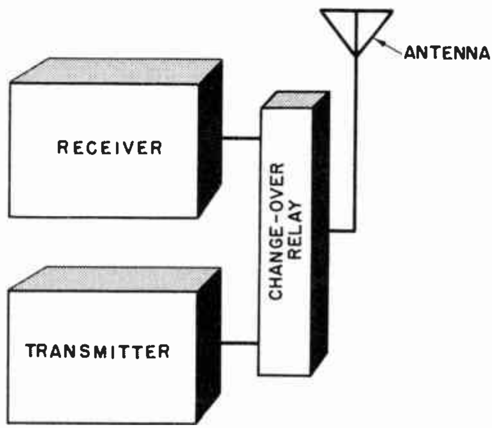


Fig. 3-1. The basic units of an amateur station.

use of a changeover relay, this relay normally connects the antenna to the receiver, and to the transmitter only during actual transmissions. Thus, if it is desired to transmit and receive simultaneously, two separate antennas are necessary.

The antenna is usually a piece of wire, of a specified length, stretched horizontally between two points. It is usually attached to the receiver and transmitter by other wires called *lead-ins*.

Electricity

The discovery of electricity dates back to 600 BC or earlier, when it was found that when amber is rubbed with certain substances it will attract light-weight bodies. The word "electricity" is derived from the Greek word for amber.

All matter is composed of atoms, which in turn are composed of protons (positive charges) and electrons (negative charges). In each atom, the electrons revolve about the protons, in somewhat the same manner as the planets revolving around the sun. The atoms of different elements are characterized by the different numbers and arrangements of their protons and electrons.

Since electricity is the form of energy produced by the atom-to-atom movement of electrons, materials such as silver and copper, which have atoms whose electrons are loosely bound, are good *conductors* of electricity. Atoms of such materials as porcelain and glass cannot easily yield their electrons, and are *insulators*.

An electric current is a sustained movement of electrons. This electron movement is analogous to that of water inside a pipe. If pressure is applied at one end, water comes out the other end. A single electron does not maintain a sustained movement through the circuit; it is only part of a chain of movements. The electrons are made to move through the wire by a voltage (difference of potential) between the ends of the wire, as described under *Voltage* below.

Note: Too great a flow of electric current can damage electrical equipment. To prevent this, a protective device, such as a fuse or circuit breaker, is usually incorporated in the wiring of electrical equipment. When the current exceeds the capacity of the fuse, the fuse burns out, breaking the circuit and causing all current flow to stop. Fuses are available in all current carrying capacities (sizes), as well as with special characteristics, such as the amount or duration of overload allowed.

The unit of current is the ampere. In amateur radio work, however, it is more usual to encounter currents of much smaller quantities, measured in thousandths of an ampere, or milliamperes (ma; 1 ma = .001 ampere).

Resistors and Resistance

Resistance (R) is that characteristic of a material which impedes the flow of electric current. Any device specifically inserted into a circuit to impede the flow of current (I) is called a resistor. Resistors consume (dissipate in heat) an amount of power (W) equal to:

$$W = I^2R$$

To dissipate the heat efficiently, resistors that must consume large amounts of power are physically larger than resistors which dissipate small amounts of power. Low-wattage resistors are usually made of carbon, and high-wattage resistors are usually formed by winding a coil of resistance wire around a hollow ceramic form. The hollow form permits heat radiation from the center of the resistor as well as from the outside of the resistance wire.

The unit of resistance is the ohm (Ω). The abbreviations K and MEG signify 1000 and 1,000,000 respectively. Thus, for example, 8 K and 7 MEG commonly signify 8000 ohms and 7,000,000 ohms, respectively.

Resistors may be *fixed* or *variable.* A fixed resistor is one whose value of resistance cannot be varied. A variable resistor (often called a potentiometer) is one whose resistance can be changed to any desired value up to its maximum value. For example, a 50,000-ohm variable resistor can provide resistance between zero and 50,000 ohms, depending upon the position of the arm contact, which is moved by a shaft.

The total resistance of two resistors *in series* (one following the other, so that the same current flows through both) is the sum of their separate resistances. The total resistance of resistors *in parallel* (connected alongside each other, so that the current splits between them) is less than that of the smallest resistor.

For resistors in series,

$$R_T = R_1 + R_2 + R_3 + \ldots$$

Where R_T is the total resistance and R_1, R_2, and R_3 are the individual resistances.

For several resistors in parallel,

$$R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots}$$

When two resistors are connected in parallel,

$$R_T = \frac{R_1 \times R_2}{R_1 + R_2}$$

Voltage

Voltage (or *emf*) is a difference of potential that causes an electric current to flow through a closed circuit. Commonly known sources of voltage include dry cells and storage batteries. Since one side of any battery is positively charged and the other negatively charged,[1] a difference of potential exists between the two. Since electrons (negative charges) are attracted to protons (positive charges), electric current is said to flow from minus (−) to plus (+). Connecting the battery to a

[1] The positive (+) side of the battery has atoms or molecules which are deficient in electrons, while the negative (−) side of the battery has atoms or molecules with an excess of electrons.

circuit will cause a current to flow in an amount depending on the voltage of the battery and the resistance of the circuit. The voltage between the outside terminals of a battery may be considered to be unvarying, and is known as a d-c (direct-current) voltage. A regularly varying voltage of alternating polarity is called an a-c (alternating-current) voltage. A-C voltage regularly varies from zero to a maximum positive value, then back through zero to a maximum negative value, and finally back to zero. This action is usually *sinusoidal,* and is shown in Fig. 3-2. AC is the form of electricity used in most homes. The unit of voltage is the volt; house current is usually 117 volts.

WARNING

Voltage causes electric current to flow through a closed circuit. If safety precautions are not taken, you may be part of such a circuit. While small voltages will give only a small shock, a potential of 100 volts or more can kill you. (How high the voltage must be to become dangerous depends upon many factors, including the weather and the type of floor you are standing on.) *Don't take chances.* Try to avoid working on electrical equipment when it is turned on. When it is necessary to work with power turned on, work with one hand in your pocket. This practice often precludes the chance of getting a shock. Remember that to get a shock, you must touch two points of different potential (usually a high-potential point and ground). If you are standing on a good conductor, such as a metal floor or a damp concrete floor, you are asking for trouble. Always stand (or sit) on an insulator, such as dry wood. Never touch anyone in contact with a dangerous voltage; turn off the voltage first. Then, if required, apply artificial respiration.

Capacitors and Capacitance

A capacitor (sometimes called a *condenser*) is a device that tends to keep voltage constant, due to its ability to store energy (electrons).

Capacitance is a measure of the ability of a capacitor to store electrons. As the applied voltage decreases, the capacitor releases its reserve, which temporarily tends to keep the circuit voltage constant. The greater the number of electrons a capacitor stores at a given voltage, the greater its capacitance. All capacitors are composed of metal plates separated by an insulator known as the *dielectric.* The plates can be made of many metals, such as silver or aluminum, and the material between them may be air, paraffin, mica, or virtually any other insulator.

Capacitors may be fixed or variable. A fixed capacitor is one with a constant capacitance. A variable capacitor is one whose value of capacitance can be changed. Although a variable resistor can be adjusted to zero resistance, a variable capacitor cannot be adjusted to zero capacitance. Therefore, variable capacitors are usually rated in terms of their minimum and maximum capacitance. If only one value is specified, it is the maximum value, and the minimum value is as low as manufacturing processes permit.

Besides storing electrons, another important property of a capacitor is its ability to pass only alternating current (and block direct current). This is useful in separating power supply voltages from the signal

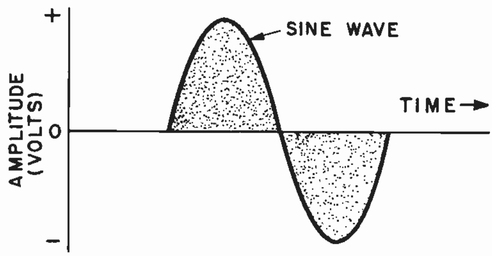


Fig. 3-2. Sine wave.

voltage. In addition, the capacitor is a frequency discriminating device, passing high frequencies more easily than lower frequencies. This permits the *bypassing* or *filtering* of the high frequencies from points where they are not wanted. The plate circuit of a tube might utilize a capacitor to bypass some high frequencies to ground; a power supply capacitor filters the pulsations (high frequencies) from the pulsating dc by bypassing the higher frequencies to ground. Thus, capacitors are used for d-c blocking, bypassing, and filtering purposes.

The unit of capacitance is the farad. However, a 1-farad capacitor could be the size of a small room. In radio work, most capacitors are rated in microfarads (one millionth of a farad) or in micromicrofarads (one millionth of a microfarad).

It is very important that the capacitor size be chosen for the voltage that will exist across its terminals. This size factor is expressed by the *voltage rating* of the capacitor. The voltage across the capacitor must always be less than the capacitor voltage rating, otherwise the capacitor will become defective.

The total capacitance of capacitors in parallel is the sum of the individual capacitances; the total capacitance of capacitors in series is less than that of the smallest capacitor. This effect is the opposite of that for resistors.

For capacitors in parallel,

$$C_T = C_1 + C_2 + C_3 + \ldots$$

Where C_T is the total capacitance and C_1, C_2, and C_3 are the capacitances of the separate capacitors.

For several capacitors in series,

$$C_T = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots}$$

For only two capacitors in series,

$$C_T = \frac{C_1 \times C_2}{C_1 + C_2}$$

Inductance and Transformers

A flow of current produces a magnetic field; and a moving or changing magnetic field causes a current to flow in a nearby closed circuit. Whenever current flowing through a conductor establishes a magnetic field, the magnetic field produces an opposite (bucking or counter) voltage and current, which in turn, produces a magnetic field opposing the first current and, in addition, any change in it. The characteristic of opposing any change in applied current is called *inductance;* any device having this characteristic is called an *inductor.* Most inductors are coils of wire.

The inductance of a coil depends on its construction. Its diameter, the number of turns, and whether or not it uses an iron core are all important. An iron core increases the inductance, as does an increased number of turns of wire. Coils offer greater opposition to the flow of higher-frequency ac than they do to lower frequencies. For this reason they are sometimes called *chokes.*

Due to the action of the magnetic field, inductors can be placed near each other to form *transformers.* A transformer transfers energy from one coil to another. With suitable physical configurations, transformers can be used to transfer electrical energy of the ac type at step-up, step-down, or 1:1 voltage ratios. (The ratio of the number of turns in the two coils determines the voltage ratio.)

The transformer coil to which the power is applied is called the *primary,* while the coil from which the power is taken is called the *secondary.* The action of transfering the power is referred to as transformer action. Some transformers have several secondaries, each being physically constructed to supply different voltages and currents. The total power removed from the combined transformer secondaries can never exceed the power applied to the primary. For identification purposes, each coil terminates in a different colored wire, or at a numbered terminal post. In all cases, these are called the terminals of the transformer.

The normal r-f (radio-frequency) coil is a winding of wire on an insulator form. Audio-frequency chokes are similar to r-f coils, but with the addition of an iron core. Audio and power transformers are composed of several windings on a common iron core. R-f transformers frequently utilize air cores.

The value of inductance is expressed in henries.

Remember that (a) a radio-frequency choke opposes the flow of radio-frequency current, while allowing direct and audio-frequency currents to flow without appreciable attenuation; (b) an audio-frequency choke opposes the flow of audio- and higher-frequency currents, while permitting direct current to flow; and (c) a filter choke smoothes the pulsating d-c output from a rectifier.

Frequency and Wavelength

Frequency expresses the number of alternations of current or voltage with respect to time. The a-c voltage present at a home electrical outlet usually has a frequency of 60 cps (cycles per second). A cycle is a complete alternation, composed of two equal but opposite halves, like the *sine wave* shown in Fig. 3-2. If this cycle is completed once each second, the frequency is 1 cps; if it is completed 1000 times in one second, the frequency is then 1000 cps, or 1 kc. One mc (megacycle per second) is 1,000,000 cps.

The concept of frequency is implicit in the term *wavelength.* Radio waves travel at the same speed as light (186,000 miles per second or 300,000,000 meters per second; a meter is a unit of length equal to about 39.37 inches). Thus for an r-f (radio-frequency) current wave with a frequency of 30,000,000 cps, one cycle of the wave would cover 300,000,000/30,000,000 meters, or 10 meters. This distance is equal to the physical length of a wave, or its *wavelength.* Mathematically, this relationship is:

$$\lambda = \frac{300,000,000}{f}$$

where λ is the wavelength (in meters) and f is the frequency (in cps). If f is expressed in megacycles, this relationship becomes

$$\lambda = \frac{300}{f}$$

The expression *frequency band* means a range of frequencies. The frequencies on which a holder of a Novice Class license may operate are given below:

3700 - 3750 kc	(A-1 emission, with geographical restrictions as set forth in Section 12.111, Part II, Chap. 7.)
7150 - 7200 kc	(A-1 emission.)
21.10 - 21.25 mc	(A-1 emission.)
145 - 147 mc	(See Section 12.23, Part II, Chap. 7, any type of emission except pulse and Type B.)

When a musical instrument produces a certain note, the note contains harmonics. Harmonics are multiples of the original (fundamental) frequency of the note. For example, in radio communication, if the fundamental were 3000 cps, the second harmonic would be 6000 cps, the third harmonic 9000 cps, the fourth harmonic 12,000 cps, etc. (This terminology is different from that used in music, where the first multiple of a fundamental frequency is called the first harmonic.)

Ohm's Law

Ohm's Law is an important basic electrical relationship and should be memorized. This law states that current in a d-c circuit is directly proportional to the voltage producing it and inversely proportional to the resistance of the circuit. Mathematically, this is expressed as

$$I = \frac{E}{R}$$

where I is the current in amperes, E the voltage in volts, and R the resistance in ohms. Ohm's law may be rewritten as

$$R = \frac{E}{I} \text{ and } E = IR$$

This law is also true for an a-c circuit, with the substitution of impedance (Z) for resistance (R). (The concept of impedance is discussed in Chap. 5.)

Ohm's law is useful in solving many problems, such as that illustrated in Fig. 3-3. In this problem a 20-volt battery (E) has been placed across

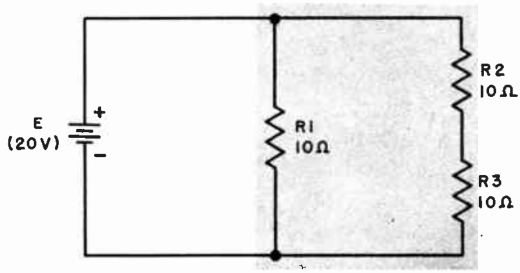


Fig. 3-3. Ohm's law problem.

three resistors of known values, and the current flowing through each resistor is to be found. Let I_{R1} stand for the current flowing through R1,

$$I_{R1} = \frac{E}{R1}$$
$$= \frac{20}{10}$$
$$= 2 \text{ amperes}$$

Since the same voltage is impressed across R2 and R3 in series,

$$I_{R2} = I_{R3} = \frac{E}{R2 + R3} = \frac{20}{20} = 1 \text{ ampere.}$$

Power

Power (W) is a term combining both voltage and current and is expressed in watts. Power (W) = E (voltage) × I (current) where W is in watts, E is in volts and I in amps. Expressed mathematically, for d-c circuits:

$$W = EI = I^2R = \frac{E^2}{R}$$

The maximum power input permitted to the final stage (last tube) of a transmitter in a Novice Class station is 75 watts. Since the Novice Class stations utilize very small amounts of power, household appliances can be operated while the station power is on, without fear of overloading a house circuit. (General Class stations are permitted power inputs of up to 1000 watts to the final stage of the transmitter.)

Radio Waves

A radio wave is electromagnetic energy, similar to light, that has been liberated into space. The radio wave contains electrostatic energy (corresponding to the voltage of the wave), as well as electromagnetic energy (corresponding to the current of the wave). Radio waves, like light waves, travel at a speed of 300,000,000 meters (approximately 186,000 miles) per second, and move by condensations and rarefactions of energy. When a sinusoidal force, such as a radio signal, produces the wave, its wavelength is the distance traveled by the wave in a period of time corresponding to one cycle. Thus:

$$\text{wavelength} = \frac{300{,}000{,}000 \text{ meters}}{\text{frequency (in cycles)}}$$

Wave Propagation

A radio wave is transmitted into space by an antenna or an antenna system. Although the antenna can radiate the wave energy in all directions, the radiation is usually made stronger in some directions than

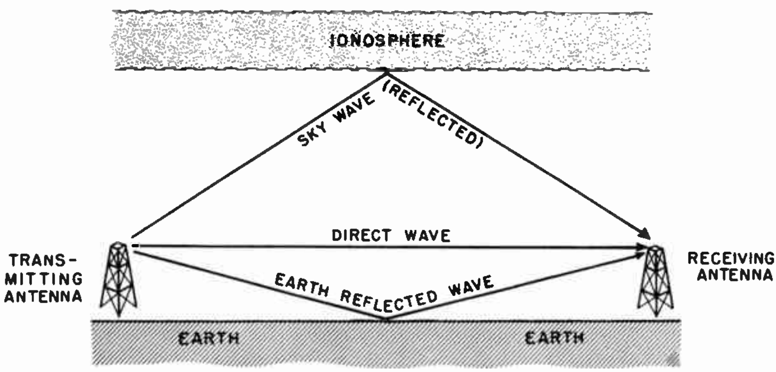


Fig. 3-4. Paths of a transmitted wave.

others. The direction in which the wave is transmitted is determined by the frequency of the radio wave and the type of transmitting antenna used.

As shown in Fig. 3-4, the transmitted waves follow three paths to arrive at the point of reception. These paths are (a) a direct line, following the *line-of-sight* path through the atmosphere, from the transmitting antenna to the receiving antenna; (b) a ground path, in which the *ground wave* is reflected along the earth's surface to the point of reception; and (c) a "bouncing" path in which a *sky wave* is transmitted up to the ionosphere, from which it is bent (reflected) down to the point of reception.

Waves following the direct path can be received very easily and strongly, but such transmissions are limited to the line of sight from the transmitting antenna to the receiving antenna.

The strength of ground-wave radiations decreases rapidly with distance, but is constant at all points under any atmospheric conditions and can be relied on from day to day and year to year.

The strength of the sky-wave radiation decreases more slowly with distance than that of the ground wave, but is more readily affected by sun spots, ionosphere height and density, atmospheric conditions, etc.

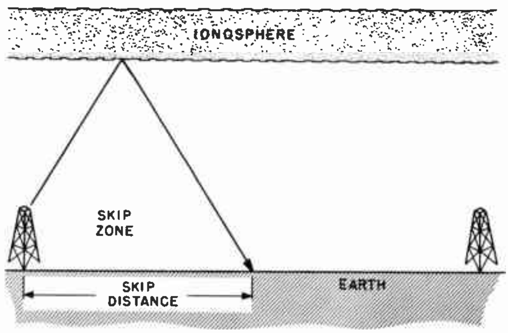


Fig. 3-5. Skip zone.

In spite of this, sky-wave signals can be used for consistent communication over long distances by using proper frequencies during different periods of day and night to adjust for the variations in the height and density of the ionosphere layers. Thus the bouncing effect of the sky wave makes it the most useful for long distance communication.

Not all of the sky-wave signal is bent back to the earth. The higher the frequency of the transmitted wave, the less will the ionosphere reflect back to the earth; the lower the frequency of the transmitted wave, the greater portion of the wave will be reflected back to earth. For this reason, at high frequencies the transmitted signal is confined to low angles.

The exact angle at which radio waves should be transmitted for best reception thus depends upon the frequency of the wave, the height and density of the ionosphere, the distance to be covered, and the means of reception. Long distance communication requires that the signal be radiated at an angle between 5° and 15° above the horizon.

The distance between the transmitting antenna and the nearest point at which the sky-wave signal returns to earth is called the *skip distance.* No signal can be received in the intermediate skip zone. (See Fig. 3-5.) The lower the angle of the transmitted radiation with respect to the horizon, the greater the skip zone area. Of course, the earth sometimes bends the reflected sky-wave signal back up to the ionosphere again, from which it will be reflected to the earth once more. This can be repeated many times to produce multiple reflections, as shown in Fig. 3-6.

Antennas

The purpose of a *transmitting antenna* is to take the signal output from the transmitter (via the transmission line) and, with as little signal and power loss as possible, radiate this signal out into the atmosphere

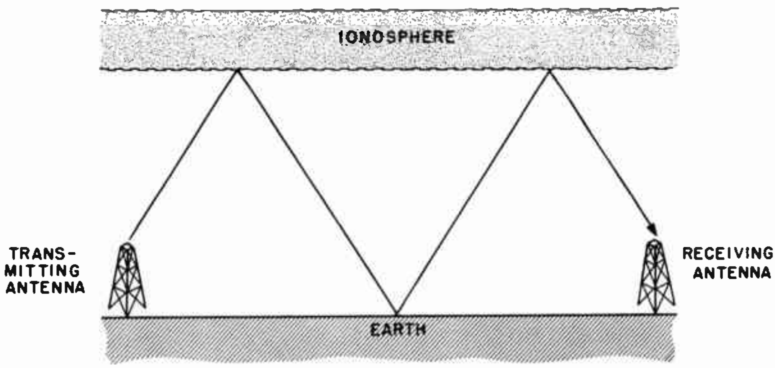


Fig. 3-6. Multiple reflections.

as a radio wave. Figure 3-7 illustrates the radiation pattern of a grounded quarter-wave vertical transmitting antenna. The purpose of a *receiving antenna* is to pick up the desired signal and feed it to the receiver at maximum energy transfer.

The transmitting and receiving antennas are as much a part of the ham radio circuits as any other components. Although they may be only a straight piece of wire, when in use they have voltage and current distributed along them, as well as resistance and impedance characteristics. Thus an antenna is considered as a continuation of the transmitter or receiver circuits, shaped and cut to the specific length that will permit the best radiation and direction of a transmitted signal or the best pick-up of a received signal.

A transmitting antenna has a characteristic impedance and a resistance; power and current are fed by the transmitter through the transmission line. Although the radio signals are confined to the circuit elements in the transmitter, all radio signals could radiate through the atmosphere; the transmitting antenna merely serves to radiate and direct these waves in a controlled way for optimum distance and power of transmission.

A receiving antenna also has a characteristic impedance and a resistance. Radio waves from the atmosphere sweep over this antenna and induce a voltage that is distributed along its length. This distributed voltage causes current to flow so that, when a load is inserted in series with the antenna, the energy from the radio signal picked up by the antenna will be delivered to the load (the receiver).

The theory behind ham transmitting and receiving antennas is the same, thus the following discussion applies to both. However, in ham radio, transmitting antennas are more critical than receiving antennas.

Antenna Voltage and Current Distribution

Since the antenna is a circuit continuation, voltage and current are distributed along it. The antenna wire is connected to the set at one end (by the transmission line); the other end is "open." When an

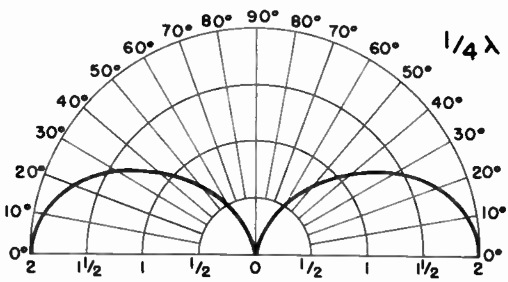
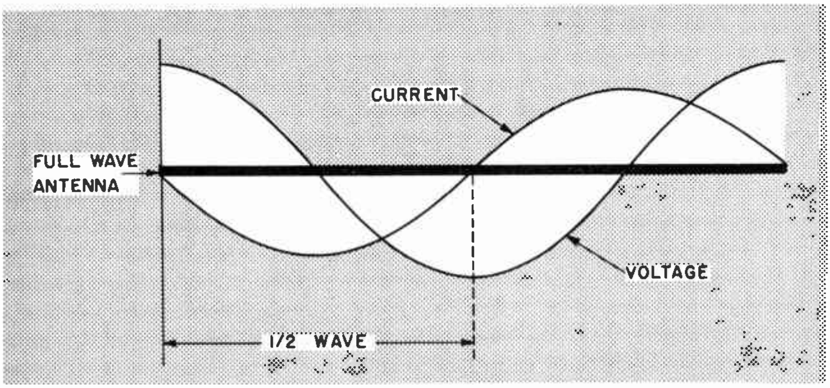


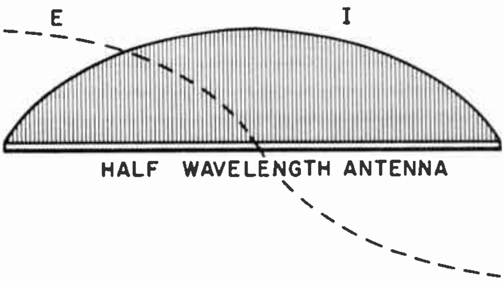
Fig. 3-7. Cross-section radiation pattern of a grounded quarter-wave vertical antenna.

antenna wire of any specific length has an open end, current and voltage are so distributed on it that there will be a current minimum and a voltage maximum at each point on the wire corresponding to a full-wavelength of signal. (See Fig. 3-8A.) On such an open-ended wire, there will also be a current minimum and voltage maximum point at each half-wavelength point. For example, if the open-ended wire were one wavelength long, minimum current and maximum voltage would exist at both ends and at the midpoint of the wire, as shown in Fig. 3-8A.

A radio-frequency wave traveling to the end of such a wire would be reflected back to its starting point, and would meet the original wave in such a manner that the voltages and currents of the two curves (the



(A)



(B)

Fig. 3-8. (A) Full wavelength straight-wire antenna with standing current and voltage waves. (B) Standing waves on a half-wave antenna.

original and the reflected) would *add* algebraically so that voltage and current waves would always exist on the antenna. Such waves (Fig. 3-8A) are called *standing waves,* and should exist on antennas for them to be good transmitting or receiving elements.

The voltage and current standing waves on a transmitting antenna are the result of the transmitting signal being fed to it from the transmitter; they are induced on the receiving antenna by the radio signals that are picked up.

Under these current and voltage conditions, the antenna is said to *resonate.* The lowest frequency at which an antenna will resonate is called its *fundamental frequency* — and the shortest, most simple antenna that will resonate is approximately as long as a half-wavelength of the frequency being transmitted or received. Thus, instead of using a full-wavelength open-ended piece of wire as an antenna for ham radio, a half-wavelength antenna is commonly used, as shown in Fig. 3-8B. Such half-wave antennas are also called dipoles (because the voltage at one end or pole is positive and the other negative), or *Hertz* antennas (after the innovator). A half-wave antenna has, ideally, zero current and maximum voltage at its ends and maximum current and zero voltage at its center. Thus, for proper transmission and reception, the antenna should be approximately one-half the wavelength of the signal.

Antenna Length

Actually, however, the *physical* length of the antenna should be slightly less than half the electrical length of the wave. Since the radio-frequency wave moves through the antenna more slowly than it would travel in the atmosphere, and since the antenna wire has a capacitance effect to ground, the wire must be about 5% shorter than the actual half-wavelength. To find the actual physical length for a half-wavelength antenna, first find the wavelength of the signal in meters by using the formula wavelength = 300,000,000 (meters)/frequency (in cycles), convert this to feet (one meter = 3.28 feet), take half the length (to find the half-wavelength), and then use about 95% of this number. This can all be done merely by multiplying the wavelength by 1.558, since

$$1 \text{ meter} = 3.28 \text{ feet and}$$

$$3.28 \times \tfrac{1}{2} \times 95\% = 1.558$$

Thus, to find the physical length in feet of a half-wavelength antenna, multiply the electrical wavelength, in meters, by the constant 1.558. For example, to find the physical length of a half-wavelength antenna for a 3700-kc signal:

$$\text{wavelength} = \frac{300{,}000{,}000 \text{ meters}}{3{,}700{,}000 \text{ cps}} = 81.081 \text{ meters}$$

$$\text{Half-wave antenna length} = 81.081 \times 1.558 = 126.324 \text{ feet}$$

Thus it is simple to calculate the actual length needed for a half-wave antenna.

The half-wavelength antenna is the basis of most ham radio antennas. Various manufacturers use different trade names, such as Doublet, Delta-Matched, Zepp, etc., but these are all half-wavelength antennas, varying only in the method of feeding the signal to or from the transmission line. (Quarter-wavelength antennas also exist, and are commonly called Marconi antennas, after their innovator. Since these quarter-wavelength antennas use the ground to act as the other quarter-wavelength, their ground connection must be exceptionally good. These quarter-wavelength antennas are used at low frequencies where the length of a half-wavelength would be excessive.)

The half-wavelength antenna is commonly referred to as a dipole since it consists of two quarter-wave sections.

Antenna Transmission Lines

Transmission lines connect the transmitter to the transmitting antenna and the receiving antenna to the receiver.

Figure 3-8B illustrates the voltage and current distribution on a half-wave antenna. Since the voltage is at a maximum when the current is at a minimum, the power throughout the antenna is constant. The impedance at any point in a circuit, including the antenna, is the ratio between the voltage and current at that point. The impedance of an antenna should be known so that proper termination can be made with the required transmission line. The transmission line, then, must match the impedance of the antenna to feed the maximum amount of signal power to the antenna. All power sent into a transmission line will be absorbed by the antennas without reflections back into the line if the load (transmitting antenna) impedance is equal to the *characteristic impedance* of the line. There are two basic types of transmission lines, nonresonant (untuned) lines, and resonant (tuned) lines.

Nonresonant lines are usually coaxial cables, twisted wires (pair), shielded wires (pair), or twin leads. Resonant lines are usually a form of open wire line composed of two parallel conductors which are kept at a fixed separation by means of insulating spacers or spreaders.

Each type of transmission line has its own characteristic impedance. This is listed by the manufacturer in his catalog, or can be calculated simply from the inductance and capacitance for a unit length of the line.

If voltage is applied across the input terminals of a transmission line, the square root of the ratio of the inductance to the capacitance would be the characteristic input impedance of the line (assuming the line to be uniform). This impedance would be the characteristic impedance of the line, regardless of its length.

$$\text{Characteristic impedance (in ohms)} = \sqrt{\frac{L}{C}}$$

where L and C are the inductance and capacitance, respectively, per unit length. This equation is used for all types of transmission lines — resonant or nonresonant.

Since the impedance of an antenna varies with frequency, a perfectly matched condition between transmission line and antenna can be obtained only at one frequency. At all other frequencies an impedance mismatch will occur. This mismatch causes standing waves along the transmission line. Although standing waves are needed on antennas, standing waves on transmission lines indicate losses due to undesirable radiation from the line itself.

To check for standing waves on a transmission line, simply move a neon lamp along it, holding the base of the lamp while keeping the glass of the lamp near the transmission line. If, as it is moved along

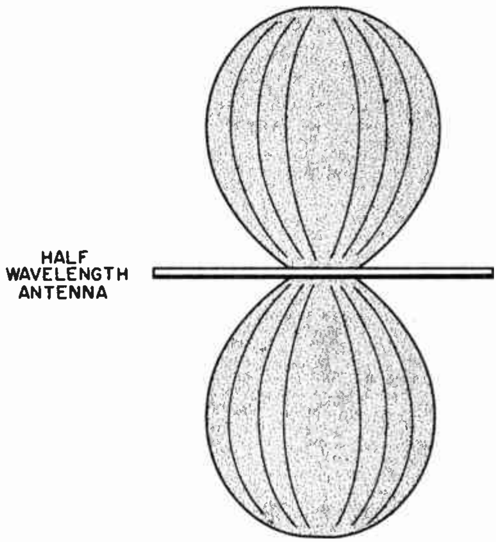


Fig. 3-9. Radiation pattern of a half-wave horizontal antenna.

the line, the lamp lights brilliantly at various points and dims down to extinction between these points, there are standing waves on the line. If the neon lamp does not light at any point there are no standing waves on the line.

Antenna Arrays

As illustrated in Fig. 3-9, the maximum radiation density of a radio wave is usually broadside to the antenna. Since a half-wavelength antenna has limited directional properties, it is necessary to use special *antenna arrays* whose length or spacing gives unilateral directivity. The most common of these arrays is the *parasitic;* it is simple to understand and operate.

To understand how the directive effect is obtained, first imagine that two conductors of *equal length* are placed parallel to each other without touching. If one of these conductors is excited, or driven, with r-f energy at its resonant frequency, a current will be induced into the

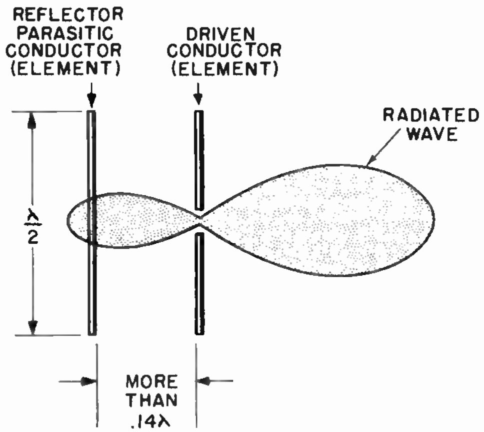


Fig. 3-10. A reflector: reinforcement of r-f energy in the direction of the driven element.

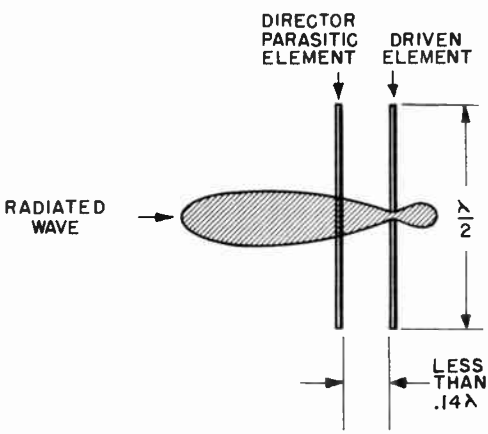


Fig. 3-11. A director: reinforcement of r-f energy in the direction of the parasitic element.

other conductor. Since the second conductor is also resonant, it will produce a radiated wave and, therefore, both conductors will radiate energy. If these equal-length conductors are spaced more than 0.14 wavelength apart, the secondary radiated wave from the parasitic conductor will combine with the energy of the driven conductor to reinforce it in the direction of the driven conductor. In this case the parasitic conductor is called a *reflector.* (See Fig. 3-10.)

If the spacing of the equal-length conductors is less than 0.14 wavelength, the radiated wave will be reinforced in the direction of the parasitic conductor. In this case the parasitic conductor is called a *director.* (See Fig. 3-11.)

When the parasitic conductor is the same length as the driven conductor (radiator) it is said to be *self resonant* and the spacing determines whether it will be a director or reflector. If the parasitic self-

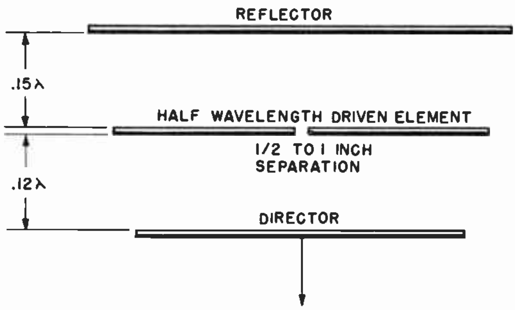


Fig. 3-12. A three-element parasitic array.

resonant conductor is shorter than the driven conductor, it acts as a director; if longer, it acts as a reflector.

In practice, the spacing between these elements determines the gain of an antenna-director or antenna-reflector combination. The length of the elements determines the sharpness of resonance of the array.

As illustrated in Fig. 3-12, an array usually consists of a driven element, a reflector, and a director. This increases the sharpness of the transmitted wave, by eliminating transmission from the back of the antenna, thereby increasing its forward power. Adding additional directors or stacking the arrays also sharpens the transmitted wave and increases its forward power. Adding or changing elements in an antenna array also changes its characteristic impedance. Table 3-I lists the gain and impedances of different antenna arrays with reference to a half wavelength dipole.

Figures 3-13, 3-14, 3-15, and 3-16 illustrate various types of antennas and the different methods by which they are fed.

Vacuum Tubes

The vacuum tube is the component most responsible for modern-day radio communications. The vacuum tube contains a heater or filament inside a glass or metal enclosed vacuum. To some extent it resembles a light bulb; however, the vacuum tube filament is designed to emit electrons rather than light. In many modern tubes, a cathode heated by the filament is used to increase the emission of electrons.

Other elements, such as a plate and grids, are located inside the tube envelope so that the filament (which gives off electrons) is at the center, with the grids (open mesh networks) and then the plate or

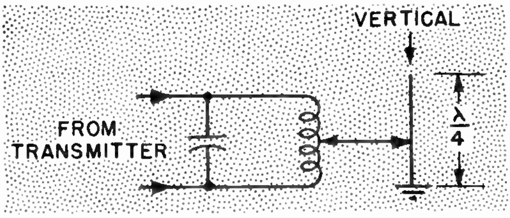


Fig. 3-13. Series tuned Marconi antenna.

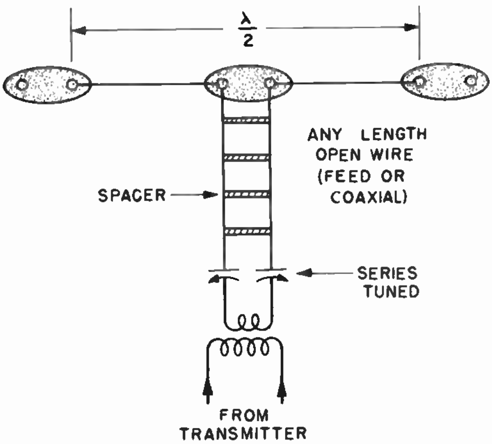


Fig. 3-14. Series tuned doublet (Hertz) antenna.

TABLE 3-I
ANTENNA GAIN AND IMPEDANCE
(HALF-WAVE DIPOLE ARRAYS)

Type of Antenna	*Input Impedance (ohms)*	*Gain Over Dipole (db)*
Dipole	72	—
Dipole and reflector	60	3 to 4
Dipole, reflector and director	20 to 30	4 to 6
Stacked dipoles	35 to 40	3 to 4
Stacked dipoles and reflectors	25 to 30	6 to 7

anode (solid metal) surrounding it. The plate is positively charged so that electrons will move toward it. (If the plate were negatively charged, it would repel the electrons, and there would be no current flow.) The

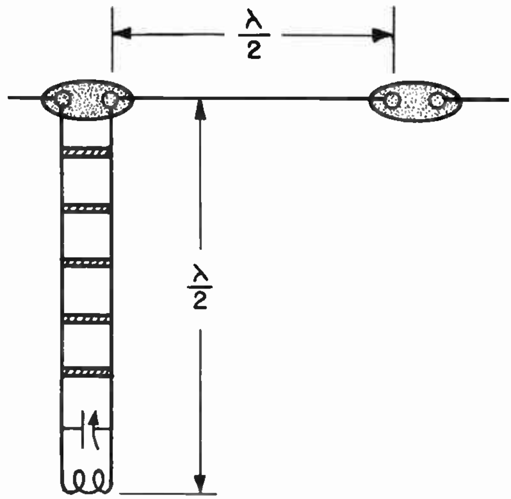


Fig. 3-15. A Zepp (end-fed Hertz) antenna.

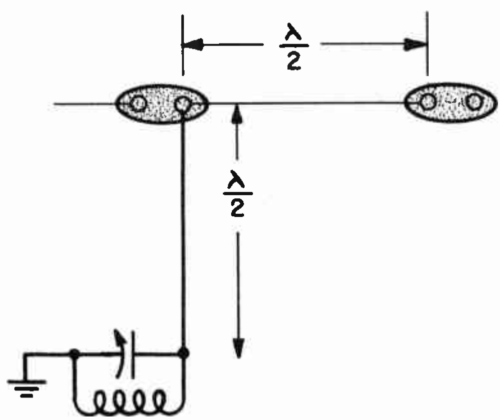


Fig. 3-16. A single-wire end-fed Hertz antenna.

insertion of the open mesh grid between the plate and filament or cathode permits control of the amount of electron flow.

When a positive voltage is connected to the plate and an a-c signal is fed to the grid of the tube, the output will vary in accordance with the instantaneous changes in the voltage of the a-c signal. With proper resistors in the plate circuit of the tube, the a-c signal can be amplified to 10 or even 100 times its original strength. Such a tube is called an *amplifier tube.* Its basic tube elements are identified in Fig. 3-17.

A tube with only a filament (or a cathode) and a plate is a *rectifier* or *detector.* When ac is placed on the plate of this type of tube, the electrons will move toward it only when the voltage is positive; no current will flow when the voltage (and therefore the plate) is negative. Such a tube changes an a-c voltage to a fluctuating d-c voltage. This

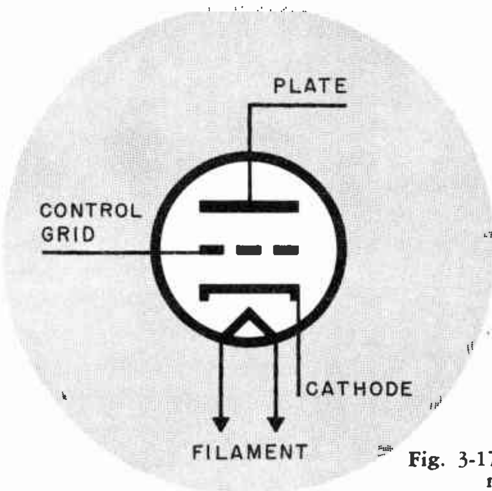


Fig. 3-17. Tube elements.

operation is called *rectification* or *detection.* A rectifier tube is used to convert a-c power to d-c power; a detector tube (with its associated circuit) is used in a receiver to separate the audio intelligence from the r-f carrier.

If part of the output from the plate of a triode (three-element) tube is fed back to its input (the control grid), a condition is set up wherein the tube supplies its own input. This condition is called *oscillation,* and the tube used in this way is called an *oscillator.* A circuit of this kind is used in the electronic code practice oscillator set described in Chap. 2. There are many tube types, each designed for a particular application. All tubes of any one type have the same general characteristics, regardless of the manufacturer. Every tube type is identified by a number specifying its complete characteristics, such as 6V6-GT, 6AQ7, etc. Never substitute one tube type for another without the advice of an experienced person.

A diode has two elements (cathode and plate), a triode three elements (cathode, plate, and control grid), a tetrode four elements (cathode, plate, control grid, and screen grid), and a pentode five elements (cathode, plate, control grid, screen grid, and suppressor grid). Every tube, whatever its purpose, has a cathode or filament and a plate, although the number of grids may vary. A tube manual, which can be bought at any local radio parts store, will supply you with more information on the many applications, as well as specific data on all modern receiving tubes.

Meters

Meters are devices used to measure electrical quantities; resistance is measured with an ohmmeter, current with an ammeter, voltage with a voltmeter, power with a wattmeter, and energy with a watt-hour meter. Most meters operate on the principle that current through a coil creates a magnetic field, which can be used to move a pointer. The larger the current the greater the movement of the pointer. This is the basic ammeter. With the addition of multiplier resistors, this meter can be used as a voltmeter. With the addition of resistors and a battery, it can also be used as an ohmmeter. A wattmeter is a combination of a voltmeter and an ammeter; it permits simultaneous measurement of voltage and current to read power. Watt-hour meters usually do not use a moving coil; they are used in homes to indicate the electric power consumed.

The FCC requires that periodic measurements of a station's transmitting frequency be made by a means independent of that used to control the transmitting frequency. Since the Novice Class transmitter must be controlled by a quartz crystal in the oscillator circuit, a frequency meter can be used for this purpose.

Basic Power Supply

Figure 3-18 shows a basic power supply and filter. The a-c power is fed to the primary (terminals 1 and 2) of the transformer T1. If the a-c voltage across the primary has the polarity (− and +) shown in this figure, the secondaries (terminals 3 and 5, 6 and 7) will have the opposite polarities, as shown, due to normal transformer action. Secondary No. 1 (terminals 3 and 5) supplies a stepped-up voltage to the plates (pins 4 and 6) of tube V1, while secondary No. 2 (terminals

6 and 7) supplies a stepped-down voltage to the filament of V1. Since one plate (pin 6) of V1 is positive, an electron current will flow to it and then through terminal 4 to the filter.

In Fig. 3-18, the ground symbol indicates a common junction point, usually the metal chassis on which the parts are mounted. Therefore, many connections are made through the chassis (ground) rather than

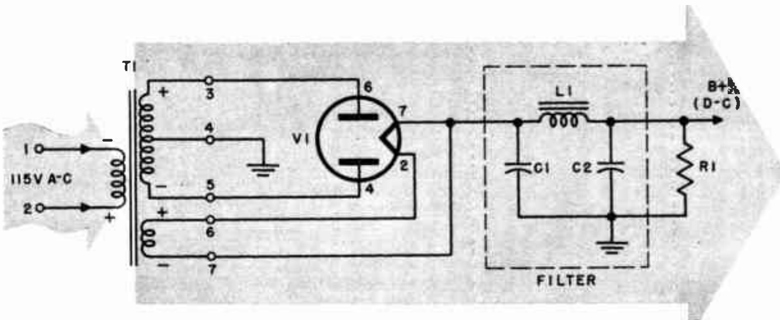


Fig. 3-18. Basic power supply.

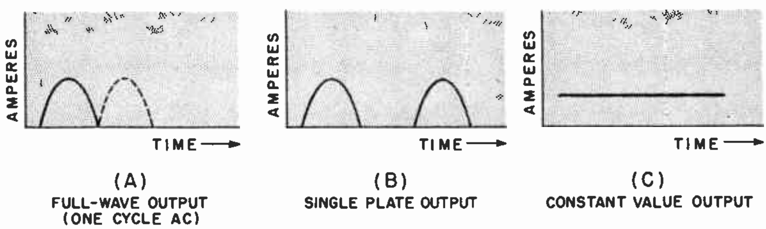


Fig. 3-19. Filter output waveforms.

by separate wires. Using the chassis as a ground (which, in turn, is grounded to an external ground, such as the earth) is a generally accepted safety precaution against shocks.

The current flowing to the filter is shown by the solid curve on Fig. 3-19, and is a pulsating dc. When the polarity of the a-c voltage across the primary of the transformer is opposite to that shown in Fig. 3-18, the polarities in the secondaries are also reversed, and the other plate (pin 4) of V1 conducts.

This pulsating d-c output (shown as the dashed curve on Fig. 3-19A) also goes to the filter, via terminal 4. The combined solid and dashed curves on Fig. 3-19A thus represent a full-wave output from the rectifier due to one cycle of ac in the primary of the transformer. For a 60-cps

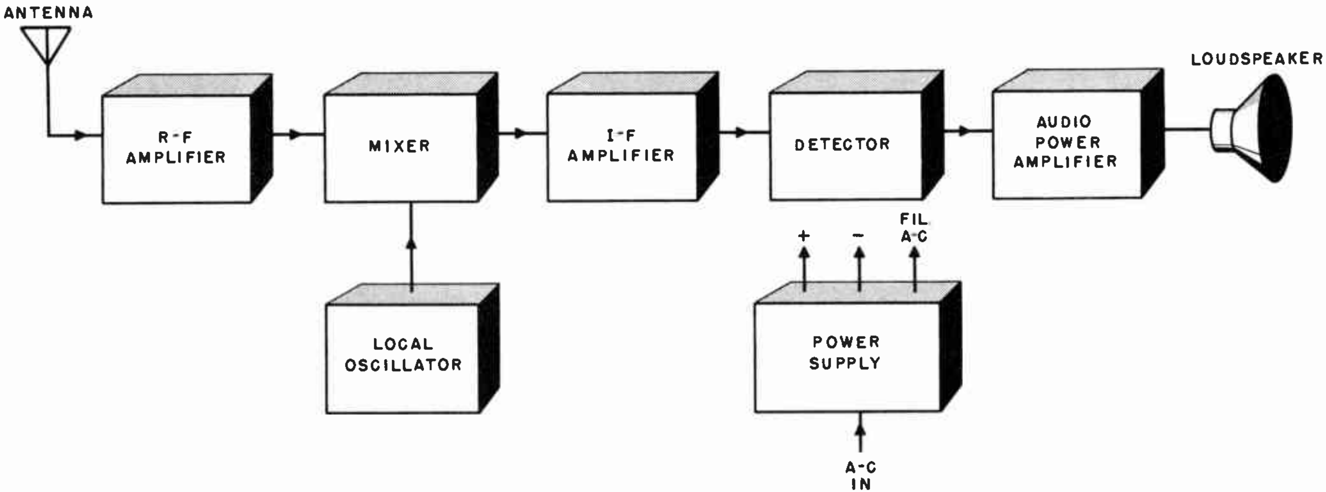


Fig. 3-20. Block diagram of a superheterodyne receiver.

a-c voltage, the output would contain 60 of these combined curves for each second of time. If V1 had only a single plate, the tube would conduct for only one-half the time, and the output of the filter would appear similar to that shown in Fig. 3-19B. This is called half-wave rectification. The filter illustrated is called a "pi" type because of its schematic resemblance to the Greek letter π.

The purpose of the filter is to smooth the output current to a constant value, as ideally illustrated in Fig. 3-19C. Components C1, L1, and C2 offer different impedances (a-c resistances) at different frequencies, and are arranged to offer ac an easier path to ground than the dc, thus removing the pulsations (ripple) from the pulsating dc to provide a "pure" dc.

Resistor R1 is called a bleeder resistor, and provides for a minimum (regulatory) load on the rectifier and, as a safety feature, discharges capacitors C1 and C2 when the power supply is turned off. The d-c output is used to supply positive voltages (plate and screen supply or B+) to all other vacuum tubes.

Amplifiers and Oscillators

Fundamentally, an amplifier is a circuit in which a small signal is fed to the input circuit of a tube, and a larger or amplified signal is taken from the output circuit. The input circuit is generally between control grid and cathode; the output circuit is between plate and cathode. The cathode circuit is thus common to both input and output circuits, and is usually grounded or brought to ground through a cathode bias resistor. The amount of signal amplification depends upon many things, such as the type of tube, the voltages applied to the tube elements, and the frequency of the signal. Amplifiers designed simply to build up the strength of a signal are called voltage amplifiers. Those used to deliver a large amount of power (such as that needed to drive a loudspeaker) are called power amplifiers.

Oscillators are basically amplifiers in which a portion of the amplifier output signal is fed back to the input circuit. If sufficient signal is fed back to overcome the various losses in the circuit, the circuit delivers a continuous train of oscillations. The frequency of oscillation is determined by the inductance and capacitance in the frequency-determining portion of the oscillator circuit. The strength or amplitude of the oscillations depends upon the amount of signal fed back, the tube type, the amount of coupling between coils, and various other factors. The most common types of oscillators used in amateur radio are the Hartley, Colpitts, electron-coupled, tuned-plate tuned-grid and various similar circuits. Crystal oscillators are both important and popular because they enable the construction of oscillator circuits that are extremely stable (i.e., the oscillator frequency does not vary appreciably).

Basic Receiver

Figure 3-20 is a block diagram of a basic superheterodyne receiver. In block diagrams, each stage (tube and associated parts) is represented by a box (block). While there are other types of receivers, the super-

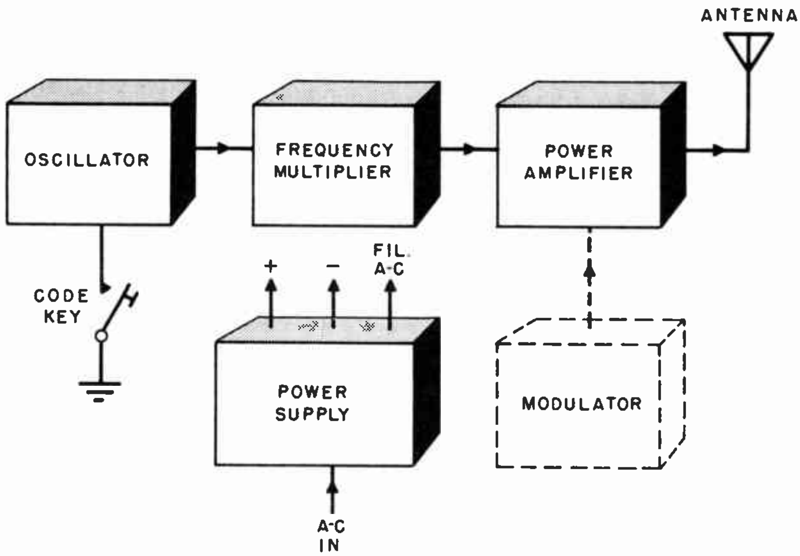


Fig. 3-21. Block diagram of a transmitter.

heterodyne is the most widely used; most home radio-broadcast sets are superheterodynes.

The signal from the antenna is amplified by an amplifier tube and then fed to the mixer tube in conjunction with the output from the local (internal) oscillator. The mixer output has a resultant frequency equal to the difference between the incoming signal and oscillator frequencies. This is called the intermediate frequency (i.f.). The i.f. is amplified (built up) and then detected by a detector. The detector separates the audio (a-f) intelligence from the i-f carrier. The a-f intelligence is then amplified to a sufficient power level to drive a loudspeaker. The power

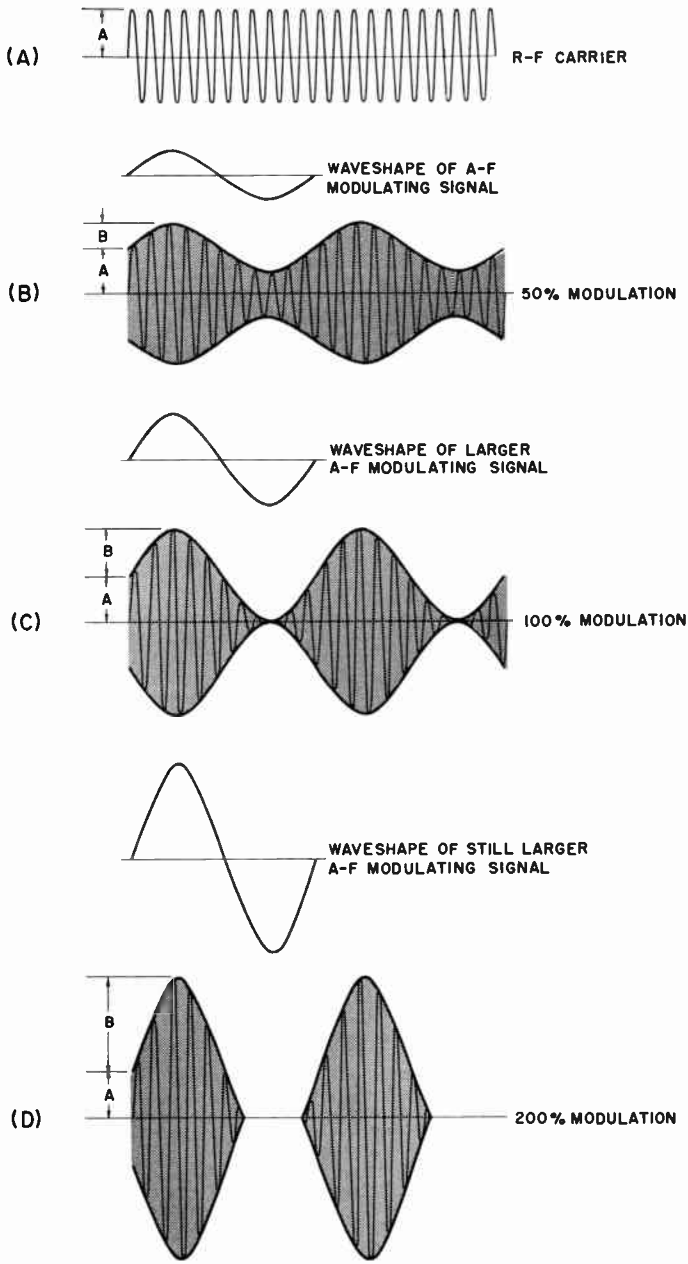


Fig. 3-22. Modulation envelope waveforms.

supply provides all necessary tube, filament, B+, and bias voltages for the other stages.

Basic Transmitter

Figure 3-21 is a block diagram of a basic transmitter. The oscillator develops the carrier signal, usually in conjunction with a frequency-setting crystal. A *frequency multiplier* (usually a vacuum tube stage) is then commonly employed to allow operation on some multiple of the oscillator frequency. (See Chap. 4.) The amplifier provides final power amplification before transmission over the antenna.

In a code transmitter, a telegraph key is used to interrupt transmission of the oscillator frequency. In a voice transmitter, a *modulator* (shown dashed in Fig. 3-21) superimposes an audio signal on the carrier before transmission. The power supply serves the same functions as in the receiver.

Modulation

Modulation is the process in which intelligence is added to the r-f carrier. The carrier is a sinusoidal signal and can be varied three ways: in amplitude, frequency, or phase.

Regardless of the type of modulation used, groups of sideband frequencies are set up above and below the carrier frequency. The intelligence is carried in these sidebands.

Figure 3-22 illustrates an r-f carrier being amplitude modulated by an audio frequency (af). Parts B, C, and D of Fig. 3-22 show different modulation patterns. Modulation is measured in terms of a percentage of the carrier amplitude, and is computed mathematically by:

$$\%\ \text{modulation} = \frac{B}{A} \times 100\%. \text{ (See Fig. 3-22.)}$$

On this basis it is evident that the percentages of modulation shown in parts B, C, and D of Fig. 3-22 are 50%, 100%, and 200% respectively. Note that the maximum modulation permitted by the FCC is 100%. Overmodulation (modulation over 100%) creates extraneous radiations, which cause interference on other frequencies, some of which may be outside the ham bands. Overmodulation also has a bad effect on the purity and stability of the ham emission.

Chapter 4: STUDY QUESTIONS AND SAMPLE NOVICE CLASS LICENSE EXAMINATION

This chapter provides study questions (with answers) for the written part of the Novice Class license examination and an actual sample test (with answers).

The Novice Class Examination

The Novice Class license examination is given by mail only, not at the FCC offices. It is given by volunteer examiners; when you are ready to take the test, notify the nearest FCC Field Office. (See the list in Chap. 7, Part III.) The FCC will notify you of the arrangements made for the test.

Common Radio Abbreviations

The following common radio abbreviations must be memorized:

a-m or am	—	amplitude modulation
cps	—	cycles per second
CST	—	Central Standard Time
c-w or cw	—	continuous wave (code)
EST	—	Eastern Standard Time
f-m or fm	—	frequency modulation
GMT	—	Greenwich Mean Time
kc	—	kilocycles
mc	—	megacycles
MST	—	Mountain Standard Time
PST	—	Pacific Standard Time

Rules and Regulations

Before proceeding with the Study Questions for the Novice Class examination, be sure to read the Rules and Regulations of the FCC given in Chap. 7.

Study Questions

The following 33 questions are study questions for the Novice Class examination, as furnished by the FCC to all interested persons. The correct answers are provided immediately after each question. If you understand the questions and the answers fully, you will have no trouble passing the written part of the test.

The answers to questions relating to the rules and regulations of the FCC are followed by parenthetical notes, as follows: (Act *X*) refers to Section *X* of the Communications Act of 1934 (contained in Part I of Chap. 7); (§12.*M*) refers to rule 12.*M* of Part 12 of the FCC Rules and Regulations (contained in Part II of Chap. 7).

1. What is the maximum input power permitted to the final stage of the transmitter in a station licensed to the holder of a Novice Class license or operated by such an operator?

The maximum input power permitted in the final stage of a Novice transmitter is 75 watts. (§12.23)

2. What is the maximum penalty for a violation of the rules and regulations of the Federal Communications Commission?

A fine of up to $500 for each day during which the offense occurred, suspension of the operator's license, and revocation of the station license. (Act 502)

3. On what frequency bands may the holder of a Novice Class license operate an amateur station?

3700 - 3750 kc	(A-1 emission, with geographical restrictions set forth in §12.111.)
7150 - 7200 kc	(A-1 emission.)
21.10 - 21.25 mc	(A-1 emission.)
145 - 147 mc	(Any type emission except pulse and
(§12.23)	Type B.)

4. On what frequency bands may the holder of a Novice Class license operate an amateur radiotelephone station?

145 - 147 mc. (§12.23)

5. What is the log of an amateur station, and what infomation is required to be entered therein? How long must it be preserved?

The log of an amateur station is the written record of the operations of the station. The log must include the following:

1. The date and time of each transmission.

2. The signature of each licensed operator operating the equipment and the name of any person not holding a license who speaks over a radiotelephone transmitter. (Unlicensed operators may not send code.)

3. The call sign of the station called.

4. The input power to the final amplifier stage of the transmitter.

5. The frequency band used.

6. The type of emission used (A1, A3, etc.; see Chap. 7).

7. The location of the station (approximate if mobile) at the time of the transmission.

8. The message traffic handled.

Data such as the input power, frequency band, type of emission and location of station need be entered only once, provided the conditions are unchanged. Similarly, the first entry of the date need not be repeated for other transmissions made on the same date.

The log must be preserved for at least one year following the last entry. (§12.136)

6. What is the term of an amateur Novice Class license? Under what conditions may this license be renewed?

The amateur Novice Class license is good for one year. (§12.29) It cannot be renewed under any conditions. (§12.27b)

7. What are the rules and regulations regarding the transmission of improper language, false signals, or malicious interference?

The transmission of obscene, indecent, or profane language or meaning, or of false or deceptive signals or call letters, or of malicious interference is prohibited. There are penalties for violation. (§12.157, §12.158, §12.160)

8. What are the rules and regulations regarding the purity and stability of emissions?

Below 144 mc, spurious radiations must be reduced or eliminated in accordance with good engineering practice, and must not cause interference to nearby receivers of good engineering design which are not tuned to the frequency of the transmitter. Voice modulation of a transmitter must not cause spurious radiations; the maximum permissible modulation is 100 percent. Simultaneous frequency modulation and amplitude modulation is not allowed. The frequency of the emitted carrier must be as constant as the state of the art permits. (§12.133)

9. What method of frequency control is required to be used in the transmitter of a station licensed to the holder of a Novice Class license?

The frequency must be crystal controlled. (§12.23)

10. What are the rules and regulations regarding the measurements of the frequencies of the emissions of an amateur radio station?

Periodic measurement of the transmitter frequency is required. This measurement must be by means independent of that used to control the transmitting frequency, and must be of sufficient accuracy to ensure operation within the frequency band used. (§12.135)

11. Who may be permitted to operate the transmitter of an amateur radio station licensed to the holder of a Novice Class license?

Any amateur radio operator except an operator of the Technician Class. (§12.28)

12. Under what circumstances may an amateur radio station be used by a person who does not hold a valid license?

A person not properly licensed may speak over the microphone of an amateur radiotelephone station if the duly-licensed operator is present to control the emission. The unlicensed person may not operate the station controls. (§12.28)

13. What is the maximum permissible percentage of modulation of an amateur radiotelephone station?

100 percent (100%). (§12.133)

14. At what intervals must an amateur station be identified by the transmission of its call sign? May any transmission be made without identification of the station?

An amateur station must transmit its call sign at the beginning and end of each transmission and at least once every 10 minutes during transmission. No transmission may be made without identification of the station; however, a series of transmissions between stations having established communications may be regarded as a single transmission; if the entire series is less than three minutes long, the identification at the end may be omitted. (§12.82)

15. Under what conditions is notice of portable or mobile operation required to be given, and to whom in each case?

Notice of intended portable or mobile operation must be given to the FCC Engineer-in-Charge of the radio inspection district in which such portable or mobile operation is intended, but only when the operation is likely to be for a period in excess of 48 hours. (§12.91)

16. What are the recognized abbreviations for: kilocycles, megacycles, Eastern Standard Time, Greenwich Mean Time, continuous wave, frequency modulation, amplitude modulation?

kilocycles	kc
megacycles	mc
Eastern Standard Time	EST
Greenwich Mean Time	GMT
continuous wave	cw or c-w
frequency modulation	fm or f-m
amplitude modulation	am or a-m

17. What is the relationship between a fundamental frequency and its second harmonic; its third harmonic, etc?

The second harmonic is twice the frequency of the fundamental; the third harmonic is three times the fundamental frequency, etc. A harmonic is always an integral multiple of the fundamental; e.g., 2, 3, 4, 5, etc.

18. What is the relationship between a cycle, a kilocycle, and a megacycle?

1 kilocycle = 1000 cycles
1 megacycle = 1000 kilocycles = 1,000,000 cycles

19. What instrument is used to measure: electrical potential, electrical current, electrical power, electrical energy?

Electrical potential is measured by a voltmeter.
Electrical current is measured by an ammeter
Electrical power is measured by a wattmeter.
Electrical energy is measured by a watt-hour meter.

20. What is the purpose of: a modulator, an amplifier, a rectifier, a filter?

A modulator is used to vary the amplitude, frequency, or phase of the radio-frequency carrier output of a transmitter for the purpose of transmitting intelligence.

A rectifier is used to change alternating current to pulsating direct current.

A filter is used to cut down the strength of signals of undesired frequencies while simultaneously passing signals in a desired band of frequencies and/or direct current.

An amplifier is used to increase the amplitude (or strength) of a signal.

21. What is meant by: amplification, modulation, detection, attenuation?

Amplification is the process of increasing the amplitude, frequency, or phase of the radio-frequency carrier output of a transmitter.

Detection or demodulation is the process of separating the intelligence contained in the modulation of a radio-frequency carrier from the carrier itself.

Attenuation of a signal is a reduction in amplitude (or strength) of the signal (or voltage).

22. What is the purpose of a radio-frequency choke, an audio-frequency choke, a filter choke?

A radio-frequency choke opposes the flow of radio-frequency current while allowing direct current and audio-frequency currents to flow without appreciable attenuation.

An audio-frequency choke opposes the flow of audio-frequency (and higher frequency) currents while permitting direct current to flow.

A filter choke smoothes the pulsating direct-current output from a rectifier to a steady value.

23. How is the actual power input to the tube or tubes supplying energy to the antenna of an amateur transmitter determined?

Power is expressed mathematically by: $W = EI$, where W is the power in watts, E is the voltage in volts, and I is the current in amperes. In this case, the power input in watts is equal to the plate voltage in volts multiplied by the plate current in amperes. For example, if two tubes in the final stage of the transmitter draw 25 milliamperes each, at a plate voltage of 250 volts, the total plate current is $2 \times 25 = 50$ milliamperes, or 0.05 ampere. The power input is, therefore, $250 \times 0.05 = 12.5$ watts.

24. Why are a rectifier and a filter required in the plate power-supply system of an amateur transmitter being operated from alternating current?

Direct current is needed for the plate supply. Amateur regulations require that an adequately-filtered plate supply be used on transmitters operating below 144 mc. The rectifier converts alternating current into pulsating direct current. The filter is used to smooth out the pulsations so that the output is essentially smooth, that is, free from pulsations or "ripple."

25. What is a frequency multiplier?

A frequency multiplier is a device (usually a vacuum tube stage) whose output is an integral multiple of the input frequency. The output of a frequency multiplier contains harmonics of the fundamental (input) frequency (such as 2, 3, or 4 times the fundamental frequency).

26. What are the undesirable effects of overmodulation in radiotelephony?

Overmodulation produces spurious radiations, falling outside the band of frequencies actually required for transmitting the information contained in the modulation. This spurious radiation interferes with communications on near-by channels and may even fall outside an amateur band. In addition, this radiation may cause interference with radio or TV broadcast reception in the immediate locality.

27. What is meant by a "parasitic" oscillation?

A parasitic oscillation is an oscillation not used in the operation of the equipment, and may occur on a frequency relatively distant from the operating frequency.

28. What is the purpose of a "key-click" filter and when should it be used?

A key-click filter reduces or suppresses spurious radiation resulting from the make-and-break keying of a radio-telegraph transmitter.

29. What is Ohm's Law?

Ohm's Law is the basic relationship between potential (voltage), current, and resistance in a d-c circuit. Mathematically it is expressed as:

$$I = \frac{E}{R}.$$

$E = IR$, or $R = \frac{E}{I}$ where I is current in amperes, E is potential in volts, and R is resistance in ohms.

30. What precautions should be taken to avoid the danger of shock from high-voltage electrical circuits?

All high voltage circuits should be physically covered to prevent the operator from accidentally touching them when the power is turned on. Work on such circuits only after the power has been turned off. All power-supply filter capacitors should have bleeder resistors connected across them to discharge the capacitors after the power is turned off. If bleeders are not provided, discharge the capacitors by shorting their "hot" terminals with a grounded metal strap or screwdriver blade before working near them.

31. What is the relationship between the frequency and the wavelength of a radio wave if its velocity in space is 300,000,000 meters per second?

The formula for calculating frequency (f) when the wavelength (λ) is known is expressed by:

$$\lambda = \frac{300{,}000{,}000}{f},$$ where λ is in meters, when f is in cycles per second

For example, the wavelength of a signal whose frequency is 3800 kc is:

$$\lambda = \frac{300{,}000{,}000}{3{,}800{,}000} = \frac{3000}{38} = 78.95 \text{ meters}$$

32. What symbol is used in the amateur rules to designate amplitude-modulated telegraphy without the use of modulating audio frequencies (on-off keying)?

A1. ("A" signifies amplitude modulation; "1" signifies telegraphy by on-off keying).

33. What is the ruling regarding eligibility for re-examination?

An applicant who fails an operator examination may not take another examination for the same or higher class license for at least 30 days. This limitation, however, does not apply to an examination for a General Class license following an examination conducted by a volunteer examiner for a Novice, Technician, or Conditional Class license. (§12.49)

Sample License Examination

The written examination for the Novice Class license is extremely simple, consisting of only 20 multiple-choice questions on basic amateur regulations and theory . The following is a *typical examination;* the correct answers appear at the end of this chapter.

1. The maximum input power permitted to the final stage of a transmitter operated by a Novice Class operator is:

   a. 25 watts b. 50 watts c. 75 watts d. 100 watts

2. The holder of a Novice Class license may operate an amateur radiotelephone station on:

   a. 3700-3750 kc b. 7150-7200 kc c. 21.10-21.25 mc d. 145-147 mc

3. The following information is *not* required to be recorded in the log of an amateur station:

   a. Call sign of the station called.
   b. The signature of each licensed operator operating the station.
   c. Date and time of each transmission.
   d. Total number of hours that station is used.

4. The term of an amateur Novice Class license is:

   a. 1 yr. b. 2 yrs. c. 3 yrs. d. 5 yrs.

5. The method of frequency control required to be used in a station licensed to the holder of a Novice Class license is:

   a. Crystal controlled
   b. Automatic frequency controlled.
   c. Automatic gain controlled.
   d. Hartley oscillator controlled.

6. The maximum permissible percentage of modulation of an amateur radiotelephone station is:

   a. 50% b. 75% c. 100% d. 200%

7. During a lengthy transmission, an amateur station must be identified by the transmission of its call sign at least once every:

   a. 10 minutes b. 20 minutes c. 30 minutes d. 60 minutes

8. The abbreviation for megacycles is:
   a. meg b. mcps c. m-cycles d. mc

9. The fourth harmonic of 3 megacycles is:
   a. ¾ mc b. ¾ kc c. 12 mc d. 30,000 mc

10. One megacycle is equal to:
   a. 1000 cps b. 100 kc c. 1,000,000 cps d. 1,000,000 kc

11. The instrument used to measure electrical potential is:
   a. a voltmeter b. an ammeter c. an ohmmeter d. a wattmeter

12. Intelligence is added to the carrier of a transmitter by:
   a. a filter b. a rectifier c. an amplifier d. a modulator

13. The process used to remove the intelligence from an incoming carrier of a radiotelephone station is called:
   a. amplification b. attenuation c. detection d. modulation

14. A device used in a power supply to smooth out the pulsating d-c output of the rectifier is:
   a. an r-f choke b. an r-f coil c. a filter choke d. a transformer

15. The d-c power input to a tube with a plate voltage of 150 volts and a plate current of 20 milliamperes is:
   a. 0.3 watt b. 3 watts c. 300 watts d. 3000 watts

16. Alternating current is changed to pulsating direct current by:
   a. a rectifier b. an amplifier c. a mixer d. an oscillator

17. A frequency multiplier in a transmitter will:
   a. Decrease the voltage but increase the current.
   b. Increase the power of the fundamental frequency.
   c. Increase the frequency in multiples of 2, 3, 4, etc.
   d. Multiply the resonant frequency of the antenna.

18. An undesirable effect of overmodulating a transmitter is:
   a. Generation of spurious radiations.
   b. Generation of power in excess of the allowed maximum.
   c. A power loss due to fading.
   d. Insufficient rectifier output.

19. If a 10-ohm resistor is placed across a 30-volt battery, the current that flows will be:
   a. 1/3 ampere b. 3 amperes c. 300 amperes d. 20 amperes

20. If a 3500-kc signal travels with a speed of 300 million meters per second, its wavelength is:
   a. 85.7 meters b. 105 meters c. 296.5 meters d. 303.5 meters

Answers to Questions for the Sample Novice Class license Examination

1. c	5. a	9. c	13. c	17. c
2. d	6. c	10. c	14. c	18. a
3. d	7. a	11. a	15. b	19. b
4. a	8. d	12. d	16. a	20. a

Chapter 5: RADIO THEORY FOR OBTAINING A GENERAL CLASS LICENSE

The General Class license grants all amateur privileges, is good for five years, is renewable, and is available to any citizen of the United States, regardless of sex or age. This class of license is held by the majority of hams; its possession indicates a high level of technical competence.

To obtain a General Class license it is necessary to pass a test on:

1. International Morse Code, at a speed of 13 words per minute.
2. Amateur radio theory, operation, and apparatus, for both radiotelephone and radiotelegraph.
3. General regulations, provisions of treaties, statutes, and rules and regulations affecting all amateur stations and operators.

The receiving code test for the General license usually consists of a clear-text transmission including numerals and common punctuation marks. Since the required code speed is 13 words per minute, you will be expected to transcribe at least 13 consecutive words correctly. In the sending test, you may also be asked to send punctuation marks and numerals.

The written test consists of 50 questions. Most of these will be of the multiple-choice type; however, some may require the drawing of schematic diagrams of specified circuits. Knowledge of the material in Chap. 3 and in this chapter (and an understanding of the Study Questions and Answers in Chap. 6) should enable you to pass the written portion of the General Class license examination.

The General Class license examination must be taken in person at an FCC field office. (See list in Chap. 7, Part III.) Under special circumstances (Chap. 7, Part II, Section 12.44), the test may be taken at home; however, the license issued will be the Conditional Class license, which carries the same privileges as the General Class license.

When you are ready to take the test, notify the nearest field office of the FCC. You will be sent the proper forms and notification of the dates on which the examination is given.

A Novice Class license is not a prerequisite for the General or Conditional Class license.

Privileges of the License

The General Class license permits operation of an amateur station in accordance with all authorized amateur privileges. The license is good for a five-year term, and is renewable every five years.

To be entitled to renew your license, you must have operated your station a minimum number of hours and must still be able to send and receive the International Morse Code at a speed not less than that which you needed to pass the original license test. These conditions are explained fully in Chap. 7, Part II, Rule 12.27.

Chapter 3 and the remainder of this chapter provide the basic radio theory necessary to obtain the General Class license. Chapter 6 contains a group of study questions on rules and regulations, a group of study questions on theory, and a typical General Class license examination.

Do not neglect work on code practice. Although a code speed of only 13 words per minute is required, be certain that you can transcribe at least 15 words per minute before attempting to take the test.

The following paragraphs summarize the basic information needed to pass the theory part of the General Class license examination. Since this is not a textbook, the material is necessarily condensed. If possible, it should be supplemented by reading any good textbook covering radio fundamentals.

Vacuum Tubes

As previously described in Chap. 3, the vacuum tube is essentially composed of a filament or cathode, grid, and plate. Depending upon how many grids a tube has, it is called a diode, triode, tetrode, pentode, etc. Figure 5-1 shows these tube types.

In all tubes, voltage to the heater heats the cathode. The cathode encircles the heater or (in filamentary cathode tubes) is part of the filament itself; when heated it emits electrons. If the plate is connected to a positive voltage, the electrons emitted by the cathode flow to the plate and return to the positive side of the plate power supply through the plate load.

In a diode, an a-c voltage is applied between the plate and cathode. Current flows to the plate only during the half cycles when the plate is positive with respect to the cathode. This results in a pulsating d-c output. The diode is called a rectifier or detector depending on its use.

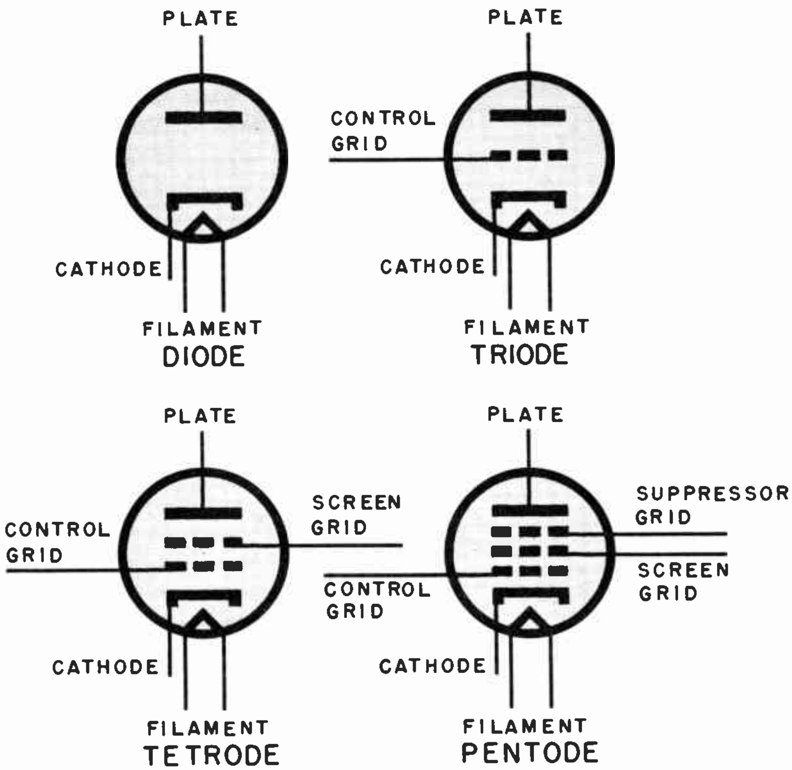


Fig. 5-1. Basic tube types.

The process of converting ac to pulsating dc for power supply purposes is called rectification. The similar process which takes place in a diode detector circuit is called detection or demodulation.

Insertion of a control grid between the cathode and plate permits variation of the plate current in accordance with variations in voltage on the control grid. If the control grid is made positive with respect to the cathode, the control grid tends to act like a plate. To prevent this, the grid is made of a wire mesh. Electrons attracted to the grid are usually accelerated toward it, but most of them miss the wires and continue through to the plate. If the grid is made negative with respect to the cathode, the plate-current flow is impeded; a sufficiently negative grid potential will stop all plate current.

Due to the electrical characteristics of a triode amplifier tube circuit, all input signals are built up (amplified) in the tube, and a variation in voltage on the control grid varies the plate current accordingly.

The triode type of tube, however, has disadvantages due to internal *interelectrode* capacitance between the cathode, grid, and plate. In high-gain r-f amplifier circuits, these interelectrode capacitances can couple the input circuit (grid-to-cathode) to the output circuit (plate-to-cathode), causing the amplifier to oscillate unless externally neutralized.

To eliminate this disadvantage of the triode, a screen grid is often added to the triode, making it a tetrode tube. The screen grid is usually made slightly less positive than the plate, effectively reducing the interelectrode capacitance, and tremendously increasing the amplification available without external neutralization.

However, the addition of the screen grid created another problem, secondary emission. Electrons attracted to the plate hit it with tremendous speeds, knocking electrons out from the plate. Since the plate voltage varies, it is possible for it to be less than the screen voltage. When this is the case, the electrons bouncing off the plate would be attracted to the screen grid, decreasing the plate current.

To eliminate this problem, a third (suppressor) grid was added to the tetrode between the screen grid and plate, creating a pentode tube. The suppressor grid is usually connected directly to the cathode or a more negative point and any electrons bouncing off the plate will be repelled by the suppressor grid back to the plate.

Classes of Operation

There are four classes of amplifiers: A, AB, B, and C. The classifications are based on the fraction of input cycle (a-c signal on control grid) during which plate current is expected to flow. The term "cutoff bias" denotes that value of d-c grid voltage (or grid-bias voltage) at which plate current is reduced to zero in the absence of an input signal on the grid. The four amplifier classes are defined as follows:

Class-A amplifiers: An amplifier in which the d-c grid bias and a-c input grid voltage are such that plate current flows in an absence of input signal as well as during all portions of the input signal cycle.

Class-AB amplifier: An amplifier in which the d-c grid bias and a-c input grid voltage are such that plate current flows in the absence of input signal and for more than half, but less than the entire input signal cycle.

Class-B amplifier: An amplifier in which the d-c grid bias is approximately equal to the cutoff value, so that plate current is approximately zero when no a-c input signal is applied, and flows for approximately one-half of each cycle when an a-c signal is applied.

Class-C amplifier: An amplifier in which the d-c grid bias is greater than the cutoff value, so that the plate current is zero when no a-c grid voltage is applied, and plate current flows for less than one-half of each cycle when an a-c input signal is applied.

NOTE: the suffix 1, if added to the above classification letters, denotes that grid current does not flow during any part of the input cycle; the suffix 2 denotes that grid current flows during some part of the cycle.

Substitutes for Tubes

Diode type tubes may be successfully replaced by selenium or germanium diodes. Selenium rectifiers are used in power supply circuits, while germanium rectifiers are used in r-f and audio circuits. In both cases, the material allows current to flow in one direction much more readily than in the other, giving a pulsating d-c output from an applied a-c input.

Recent discoveries with germanium crystals have resulted in *transistors.* In ham equipment, transistors can be used instead of vacuum tubes, to serve as rectifiers, amplifiers, oscillators, etc. Transistors may be of particular use to hams because they are extremely small in size, mechanically rugged, and have a much longer life than conventional tubes. Transistors are still being improved to give satisfactory operation at high temperatures and in various frequency ranges; to increase their power handling capacity; and to reduce their initial cost.

Reactance

Reactance is the term used to define the opposition that coils and capacitors have to the flow of alternating current. Reactance is expressed in ohms (like the unit of resistance measurement) and is generally symbolized by the letter X. The amount of reactance that a coil or capacitor presents depends on the frequency of the alternating current and the value of inductance of the coil or capacitance of the capacitor. *Capacitive reactance* is provided by a capacitor and *inductive reactance* is provided by a coil. These two reactance values are expressed by the following formulas:

$$X_C = \frac{1}{2\pi fC}$$

where X_C = capacitive reactance (in ohms), π = 3.14 (approx.), f = frequency of the applied ac (in cps), and C = capacitance (in farads).

$$X_L = 2\pi fL$$

where X_L = inductive reactance (in ohms), π = 3.14 (approx.), f = frequency (in cps), and L = inductance (in henrys).

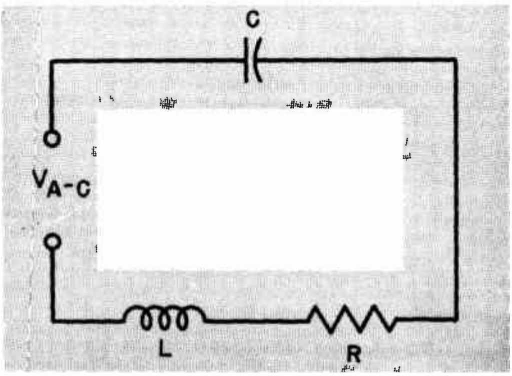


Fig. 5-2. Series resonant circuit.

As seen from the above formulas, the higher the frequency of the ac across a capacitor, the *lower* its reactance; and the higher the frequency of the ac across an inductor, the *higher* its reactance.

Resonance and Impedance

A circuit containing a capacitor and inductor is said to be in *resonance* when the capacitive reactance equals the inductive reactance. Figure 5-2 shows a series circuit consisting of a capacitor, a coil, a resistor, and an applied alternating voltage. Since all inductors have both reactance and (d-c) resistance, these two values are usually given separately on schematics. The value of R is considered to be that for the fixed d-c resistance while any inductive reactance (depending upon the frequency of the a-c voltage) would occur across L. By definition, at resonance:

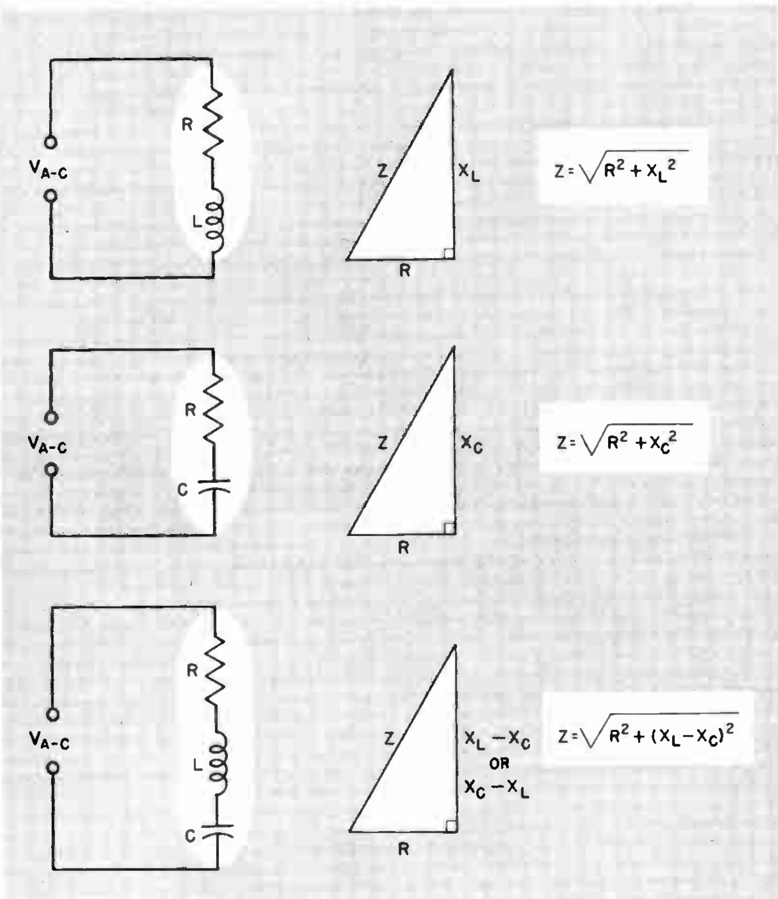


Fig. 5-3. Impedance networks.

$$X_L = X_C$$

$$\text{then, } 2\pi fL = \frac{1}{2\pi fC}$$

$$\text{and, } f = \frac{1}{2\pi\sqrt{LC}}$$

where f is the frequency (in cps), L is the inductance (in henrys), C is the capacitance (in farads), and π is 3.14 (approx.). The value of f at which resonance occurs (usually symbolized as f_o or f_r) is called the *resonant frequency.* This frequency is independent of any dc resistance in the circuit.

It is very important to understand that at resonance the voltage drop across the capacitor is the same as that across the coil but, being instantaneously opposite in polarity, they cancel out. At resonance, the amount of current flowing in the circuit depends solely upon the value of d-c resistance, R.

Impedance, Z, is the vectorial sum of the d-c resistance and the reactance of a circuit. These quantities are *not* to be added algebraically, since $Z^2 = R^2 + X^2$, or, as more commonly expressed, $Z = \sqrt{R^2 + X^2}$.

Figure 5-3 illustrates three different circuits, with correct impedance formulas. When both inductance and capacitance are present in a circuit,

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

The quantity $(X_L - X_C)^2$ indicates that the difference between the reactances must be squared. It does not matter whether the numerical

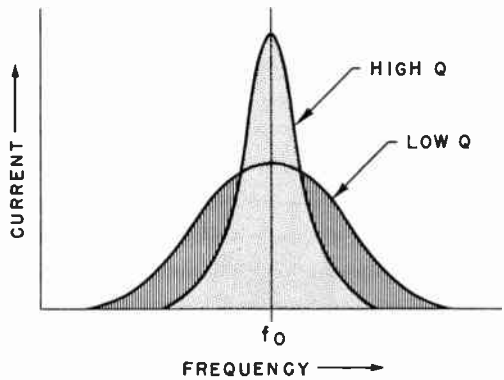


Fig. 5-4. Frequency response curves.

result of the subtraction is a plus or minus figure, since the square, by the rules of algebra, is always positive. The squared figure is added to R^2 and the square root of the total gives the value of Z.

It is interesting to note that at resonance, when $X_L = X_C$, $Z = R$; the total impedance *is* the d-c resistance. The formulas for voltages and currents are similar to those given previously for Ohm's Law (Chap. 3), simply substituting Z for R:

$$I = \frac{E}{Z} \text{ and } E = IZ.$$

When Z = R, current flow is at a maximum. At frequencies below and above the resonant frequency current flow is below its maximum value. Figure 5-4 is a curve of a typical fall-off of current with frequency below and above the resonant frequency, f_0. The sharpness of the curve depends on the Q of the circuit, where:

$$Q = \frac{X_L}{R} = \frac{2\pi fL}{R}.$$

A high-Q circuit (i.e., one in which the ratio of X_L to R is high) is usually preferred, since it provides good selectivity around the resonant frequency. (The currents flowing at frequencies slightly off resonance are much less than that at resonance.) In low-Q circuits, the curve is flattened around the resonant frequency and both the desired and undesired adjacent frequencies provide more nearly equal currents. Such circuits have poor selectivity.

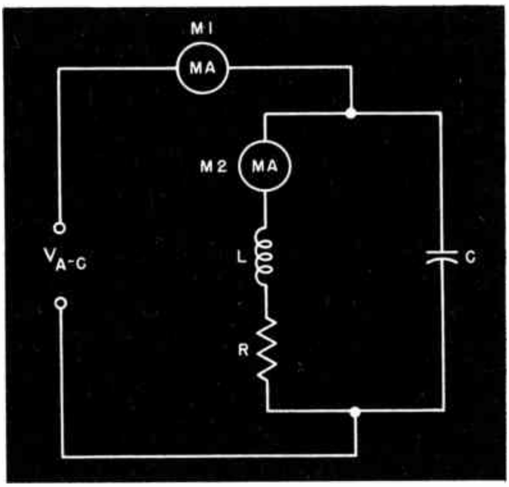


Fig. 5-5. Parallel resonant circuit.

Parallel Resonant Circuits

Figure 5-5 illustrates a parallel resonant circuit. This type of circuit is more commonly found in radio circuits than the series type. As shown, the parallel resonant circuit (commonly called the *tank* circuit) is composed of a parallel combination of inductance and capacitance, which together are in series with the remainder of the circuit. At resonance ($X_L = X_C$) the circulating current in the tank circuit, as read by meter *M2*, is usually very large; however, the total line current, as read by meter *M1*, is usually very small. The parallel resonant circuit acts in a manner opposite to that of the series resonant circuit. (See Fig. 5-2.) The impedance (or voltage) curve for parallel resonant circuits is almost identical to the current curve for series resonant circuits (Fig. 5-4). The impedance of a circuit at resonance is directly proportional to its Q. As in a series circuit, the high Q is desirable to provide good selectivity. A high impedance is desired to develop as high a voltage as possible across the tank circuit for coupling to the next stage. Since the voltage across the tank at resonance is dependent upon the Q of the tank, it is possible to produce very high peak voltages across a high-Q tank with very small values of line current. It should be noted, however, that coupling succeeding stages to the tank circuit will load it down, effectively increasing its resistance and decreasing its Q.

Chapter 6: STUDY QUESTIONS AND SAMPLE GENERAL CLASS LICENSE EXAMINATION

This chapter provides study questions (and answers) on FCC rules and regulations and on radio theory for the written part of the General Class license examination. The last part of the chapter is an actual sample test (with answers).

Study Questions (FCC Rules and Regulations)

The following questions were taken from the Communications Act of 1934 and the Rules and Regulations of the FCC, Part 12. Before testing yourself on the following questions, be sure to read the complete Act and Rule 12 (Parts I and II of Chap. 7).

The answers to the study questions are followed by parenthetical notes as follows: (Act *X*) refers to Section *X* of the Communications Act of 1934 (contained in Part I of Chap. 7); (§12. *X*) refers to Rule 12. *X* of Part 12 of the FCC Rules and Regulations (contained in Part II of Chap. 7).

1. What persons may operate an amateur radio station without a license?

   None. (Acts 301, 318)

2. What agency has complete control over all communications?

   The Federal Communications Commission (FCC).

3. What radio messages have absolute priority over all other communications?

   Radio communications or signals relating to distress. (Act 321b)

4. When the legal power input to an amateur transmitter is 1 kw, what power input should be used for a particular desired communication?

The minimum amount of power necessary to carry out the communication desired. (Act 324)

5. Under what conditions may an amateur radio operator transmit a false distress call.

Never. (Act 325a)

6. What is the penalty for any person who willfully and knowingly does or allows to be done anything prohibited by the FCC?

A fine of $500 for each and every day during which such offense occurs and suspension of the operator's license. If there is willful interference with distress communications, an additional fine of $10,000 or imprisonment up to two years or both, in addition to revocation of the station license also may be imposed. (Acts 301, 501, 502)

7. What types of communications may be divulged or used for personal benefits?

Only those of broadcasting stations or by others for the use of the general public or relating to distress. (Act 605)

8. Who may suspend or amend the present rules and regulations of the FCC?

The President of the United States, as necessary for the national defense and security. (Act. 606)

9. What are the privileges of the General Class license?

All authorized amateur privileges (§12.23) as enumerated in §12.111.

10. Where should the original operator's license be kept?

In the personal possession of the operator while operating the amateur station. (§12.25)

11. For how long is the General Class license issued?

For 5 years. (§12.29)

12. Where should the original station license be kept?

Posted in a conspicuous place in the room occupied by the licensed operator while the station is being operated, or in his personal possession. (§12.68)

13. When is it necessary to notify the FCC radio inspector of your intentions of portable operation?

It is not necessary when the period of portable operation will be less than 48 hours. It is necessary when the period will be more than 48 hours. (§12.91a)

14. When may an amateur accept remuneration for use of his station?

Never. (§12.102)

15. When may an amateur transmit music?

The transmission of music by an amateur station is forbidden. (§12.104)

16. When may an amateur station emit an unmodulated carrier?

Type A0 emission (unmodulated carrier) may be used for brief tests or adjustments, but is otherwise prohibited on all frequencies except in the 26.960-27.230 mc band and on all bands above 51 mc. (§12.111, §12.114, §12.134)

17. What is the maximum authorized plate-power input to the final stage of an amateur transmitter?

The maximum power input is 1 kilowatt on all bands except 1800-2000 kc and 420-450 mc. One kilowatt is allowed only if means are provided for accurately measuring this power; if accurate measuring instruments are not provided, the maximum power allowed is 900 watts. In the 1800-2000 kc bands, final-stage input power is restricted in some localities to prevent interference with Loran navigation equipment. In the 420-450 mc band, final-stage input power is limited to 50 watts.

18. The requirements for adequately filtered dc plate power supply to minimize modulation from this source applies to operation of a transmitter on what amateur frequency bands?

On all frequency bands below 144 mc. (§12.132)

19. What is the maximum permissible modulation?

One hundred per cent (100%) modulation is the maximum permitted. In addition, means should be employed to insure that the transmitter is not modulated in excess of its modulation capability for proper technical operation. (§12.133)

20. For how long should the station log entries be kept?

For at least 1 year. (§12.137)

21. What are the general conditions of a state of communications emergency?

a. A communications emergency is determined by the FCC, which will proclaim this state.

b. The FCC may designate amateur bands or sections of bands for exclusive emergency use with all other types of communication prohibited.

c. The initial announcements designating these conditions may be made at any time; the state will remain in effect as long as the FCC deems necessary. (§12.156)

22. What is a CONELRAD Radio Alert and how does it affect the operation of an amateur station?

a. The CONELRAD (Control of Electromagnetic Radiation) radio alert is a term applied to the Military Warning that an air attack is probable or imminent; it automatically orders the immediate implementation of CONELRAD procedures for all radio stations.

b. During a CONELRAD radio alert, the operation of all amateur radio stations, except stations in the Radio Amateur Civil Emergency Services (RACES) and stations specifically authorized otherwise, must be immediately discontinued until the Radio All Clear is issued. (§12.190 through §12.196)

23. Under what condition may third party traffic be exchanged between amateur stations of different countries?

None. This is absolutely forbidden. (Chap. 7, Part II, Appendix 2, Article 42, Sec. 2-1).

24. What are the symbols for the following types of transmissions and modulations: (a) amplitude modulated telephony; (b) frequency modulated telephony; (c) pulsed emissions.

a. A3. b. F3. c. P. (Chap. 7, Part III, Appendix 3).

Study Questions (Theory)

The following questions were chosen from a list of study questions specifically prepared by the Federal Communications Commission. They indicate the scope of the theoretical knowledge required to pass the General Class license examination. If you do not fully understand a question or answer, refer to any good book on radio fundamentals. Do not guess; be sure everything is completely understood.

1. What are the basic units of voltage (or electromotive force or potential difference), current, resistance, reactance, impedance, capacitance, inductance, power, energy, conductance, frequency, electrical quantity and magnetomotive force?

Voltage (or electromotive force or potential difference)	volt
Current	ampere
Resistance, reactance, or impedance	ohm
Capacitance	farad
Inductance	henry
Power	watt
Energy	joule
Conductance	mho
Frequency	cycles per second
Electrical quantity	coulomb
Magnetomotive force	gilbert

2. What instruments are used to measure voltage (or electromotive force or potential difference), current, resistance, power, and frequency?

Voltage	Voltmeter
Current	Ammeter
Resistance	Ohmmeter
Power	Wattmeter
Frequency	Frequency meter

3. What is a door interlock switch and why is it used?

A door interlock switch is a power on-off switch that is disconnected by the opening, and connected by the closing of a door. It is usually used in a transmitter cabinet to turn off the power automatically whenever the cabinet door is opened. It serves as a safety device to prevent anyone from accidentally being shocked by contact with high-voltage circuits.

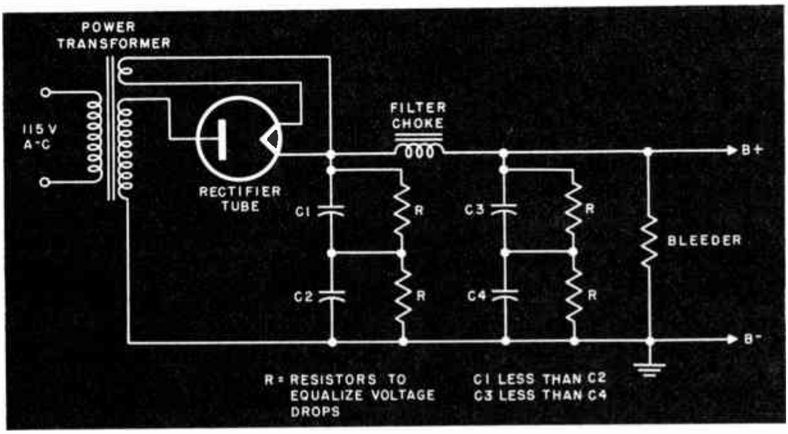


Fig. 6-1. Schematic of half-wave rectifier.

4. Why should a fuse be incorporated in the primary circuit of a power transformer?

To prevent possible damage to the transformer from an overload.

5. What is the primary function of a capacitor?

To store electrostatic energy.

6. What precautions should be taken to avoid the danger of shock from high-voltage electrical circuits?

Before working on any equipment turn off its power switch and, to be doubly sure, disconnect the interconnecting power cable from the source of power. Then, using a long screwdriver with an insulated handle, use the screwdriver blade to short every high-potential point (such as filter capacitors, tank circuit capacitors, tube plate connections, etc.) to the chassis. This will insure that no high voltage exists within the unit. It should be noted that the ordinary 117-volt house circuits also present a high-voltage, high-current source of a lethal nature. However, disconnecting the power cable from the unit will allow you to work on the unit without fear of shock.

7. Name the two prime essentials of a good power supply filter choke.

   a. High inductance

   b. Low d-c resistance

8. What is the primary function of a power supply filter choke?

   To smooth out the pulsating dc from the rectifier tube to produce an output which is essentially a pure dc.

9. What type filter choke would you use to help keep the output voltage constant under a varying load?

   A swinging choke. This type choke increases its inductance under decreasing load currents.

10. What is the purpose of a power supply bleeder resistor?

   A bleeder resistor connected across the output of a high-voltage plate-power supply will result in better voltage regulation. After the power is turned off it will discharge the high-voltage filter capacitors, thus reducing the possibility of a shock.

11. Draw a simplified schematic diagram of a half-wave rectifier with a capacitor input pi-type filter. Use filter capacitors of unequal capacitance connected in series, with a means of equalizing the d-c drop across the different capacitors.

   See Fig. 6-1.

12. What is the advantage of a full-wave rectifier over a half-wave rectifier?

   The full-wave rectifier has a much smoother output waveform (higher ripple frequency) than a half-wave rectifier.

13. Draw a simplified schematic diagram of a mercury-vapor full-wave single-phase power supply using a center-tapped high voltage secondary. Include a filter circuit for the best possible regulation, a bleeder supplying two different output voltages and a circuit for suppressing "hash" interference from the mercury vapor tubes.

   See Fig. 6-2

14. Draw a simplified schematic diagram of a d-c plate supply utilizing a power transformer, full-wave rectifier system and capacitor input filter system.

   See Fig. 6-3

15. If the high voltage secondary of a transformer were changed from full-wave, center-tapped connections to bridge-rectifier connections, what would happen?

The output voltage would be doubled while the current capacity would be halved. Filter capacitors of twice the voltage rating required

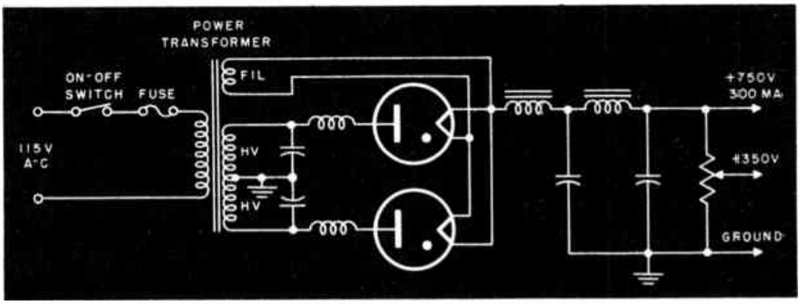


Fig. 6-2. Schematic of mercury-vapor full-wave rectifier.

for a full-wave circuit might be required, while a filter choke of half the original current-carrying capacity might be used.

16. What is the output voltage ripple frequency of a full-wave single-phase rectifier in terms of the a-c supply frequency?

Twice the a-c supply frequency. The output voltage ripple frequency of a half-wave single-phase rectifier is the same as the a-c supply frequency.

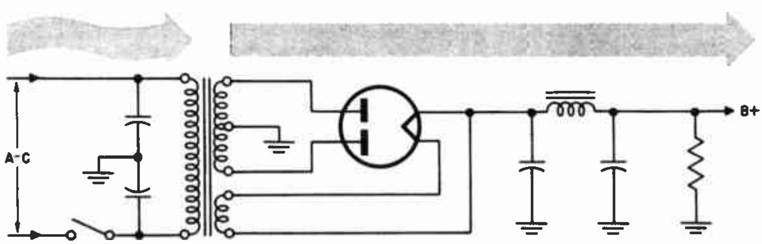


Fig. 6-3. Schematic of a high-vacuum full-wave rectifier.

In a full-wave rectifier the pulses are doubled, thereby doubling the ripple frequency (120-cps ripple with a 60-cps supply).

17. Given several values of rectifier output ripple frequencies, which value would be easiest to filter, assuming other factors being equal?

The highest rectifier output ripple frequency is easiest to filter (requires the least amount of filtering). The higher the ripple frequency the closer the graph of the output approaches a straight line (pure dc).

18. What would happen if the power supply shown in Fig. 6-1 were plugged into 117-volt dc instead of ac?

In a normal a-c circuit, the transformer primary winding has a d-c resistance and a-c reactance. However, in a d-c circuit, the transformer primary has no reactance, only d-c resistance. As the average transformer primary winding has a d-c resistance of approximately 1 ohm, the current that would flow would be:

$$I = \frac{E}{R} = \frac{117}{1} = 117 \text{ amperes.}$$

This is an excessive amount of current and would burn out the transformer primary unless the fuse "blew" first.

19. How would you prevent modulation of a transmitting tube by its a-c filament supply?

Use a center-tap return connection from the plate and grid circuits to the secondary winding of the filament supply. (The plate-circuit return is the lead from the cathode.)

20. What are the relative advantages and disadvantages of mercury-vapor and thermionic high-vacuum rectifier tubes having comparable filament ratings?

The mercury-vapor tube has a lower internal voltage drop with a high current-carrying capacity, but its critical inverse peak-current rating limits its use to choke input filters.

The high-vacuum tube has a greater internal voltage drop and lower current-carrying capacity, but its inverse peak-current rating is not critical, permitting use with a capacitor input filter.

21. If a power supply filter capacitor becomes short-circuited, what would be the physically visible indications?

If mercury-vapor rectifier tubes are used, the normal bluish color would become much brighter. If high-vacuum rectifier tubes are used, the plate would become red hot.

22. Why it is recommended that the oscillator stage of a transmitter have its own (separate) power supply?

To prevent coupling of plate voltage variations from other stages to the oscillator, which would cause frequency modulation of the transmitted carrier.

23. How many grids has each of the following kinds of tubes: tetrode, triode, pentode, diode?

Tetrode	Two
Triode	One

Pentode	Three
Diode	None

24. What is the purpose of the suppressor grid in a pentode?
To eliminate secondary emission from the plate.

25. Why is a tetrode (or pentode) preferred over a triode for use as an amplifier in a transmitter?

The screen grid reduces the interelectrode capacitance between the control grid and plate, eliminating the need for an external neutralization circuit.

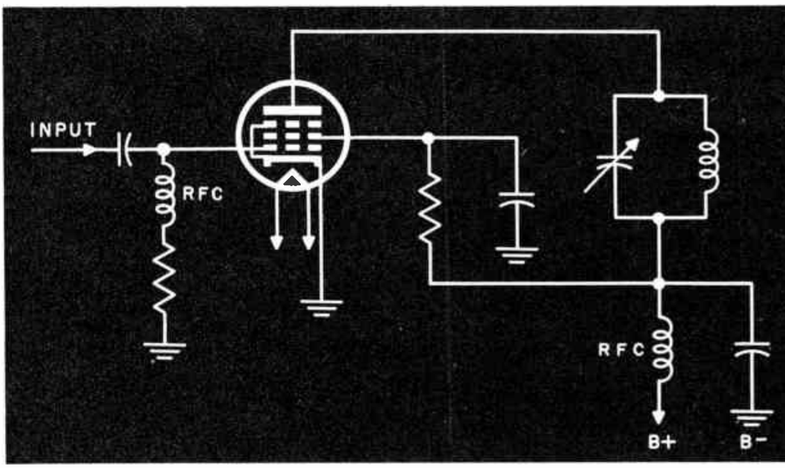


Fig. 6-4. Schematic of r-f amplifier with series-fed plate.

26. Given the plate output power and the power loss in the plate element of a vacuum tube, how would you determine the plate efficiency of the tube?

$$\text{Efficiency} = \frac{\text{r-f power output}}{\text{d-c power input}} \times 100\%$$

$$= \frac{\text{power output}}{\text{power output} + \text{power loss}} \times 100\%$$

27. What are the major operating characteristics of a Class A audio amplifier?

The grid bias and grid signal voltage are such that plate current flows at all times. The output waveform is exactly similar to the signal voltage on the grid.

28. What are the important operating characteristics of a Class C type amplifier?

The d-c grid bias is greater than the cutoff value, so that the plate current is zero when no a-c grid voltage is applied, hence plate current flows for less than one-half of each cycle when an a-c grid voltage is applied. The plate efficiency is high.

29. Why is a push-pull r-f amplifier stage preferred to a single-ended stage?

All even harmonics (2nd, 4th, 6th, etc.) of the carrier frequency are completely cancelled out.

30. If an amplifier is operating at a plate voltage of 500 volts with a plate current of 100 ma, what is the plate power input?

$$W = EI = 500\ (0.1) = 50 \text{ watts}$$

31. With respect to a tube, what is meant by the term "maximum plate dissipation"?

The maximum amount of heat which the plate of a tube can safely dissipate (radiate). This quantity is expressed in watts.

32. Draw a simple schematic diagram of an r-f amplifier with a series-fed plate circuit.

See Fig. 6-4.

33. Draw a simple schematic diagram of an r-f amplifier stage with a parallel-fed plate circuit.

See Fig. 6-5.

34. Draw a diagram of a coupling system between two audio-frequency amplifier stages employing resistance elements.

See Fig. 6-6.

35. Draw a simple schematic diagram of a class-C push-pull amplifier stage using triode tubes, including a circuit for proper neutralization.

See Fig. 6-7.

36. What is the effect of operating an unneutralized triode class-C r-f amplifier in a transmitter?

The triode may self-oscillate and radiate at frequencies possibly outside the amateur band. Loss of output at the desired frequency also occurs.

37. What is the procedure for obtaining proper neutralization of a triode r-f power amplifier utilizing an r-f indicator coupled to the plate tank circuit?

a. First, be sure to disconnect the plate voltage.

b. Tune the input and output circuits to resonance with the carrier frequency, as shown by a maximum glow or reading of the r-f indicator.

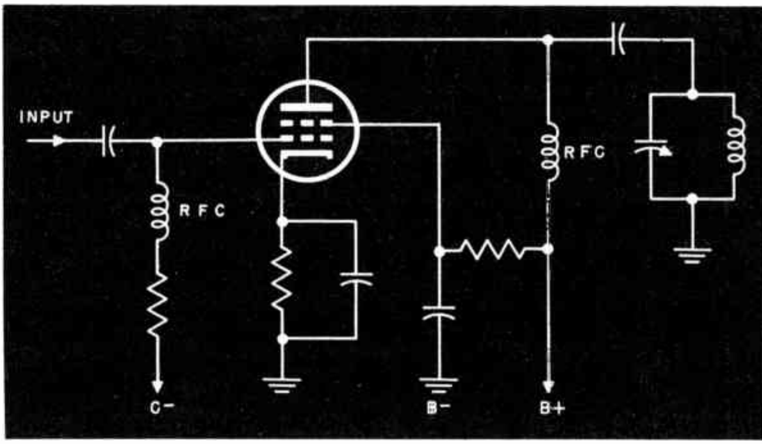


Fig. 6-5. Schematic of r-f amplifier with a parallel-fed plate.

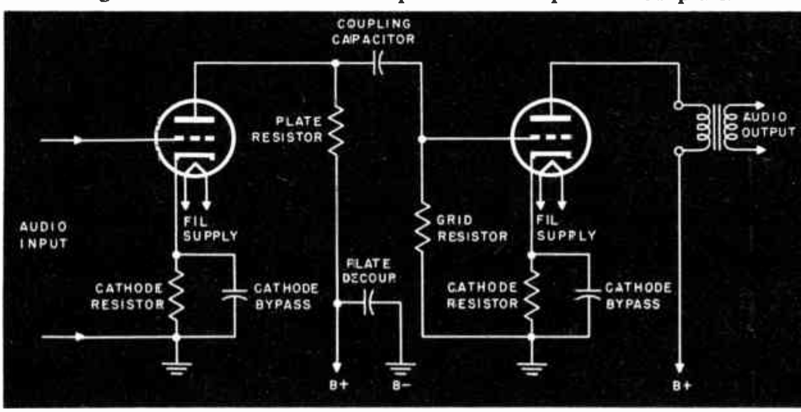


Fig. 6-6. Schematic of resistance-capacitance coupling between two a-f amplifier stages.

c. Adjust the neutralizing capacitors until the r-f indicator shows that there is no r-f energy in the plate tank circuit. Ideally, the glow should disappear entirely or the reading drop to zero.

38. What is the Q of a series resonant circuit?

Q is a measure of the quality of a resonant circuit. The higher the Q the larger the percentage of energy stored to that lost. Mathematically,

$$Q = \frac{X}{R}$$

where X = Reactance of either the coil or the capacitor (ohms); $X_L = X_C$ at resonance; R = d-c resistance (ohms).

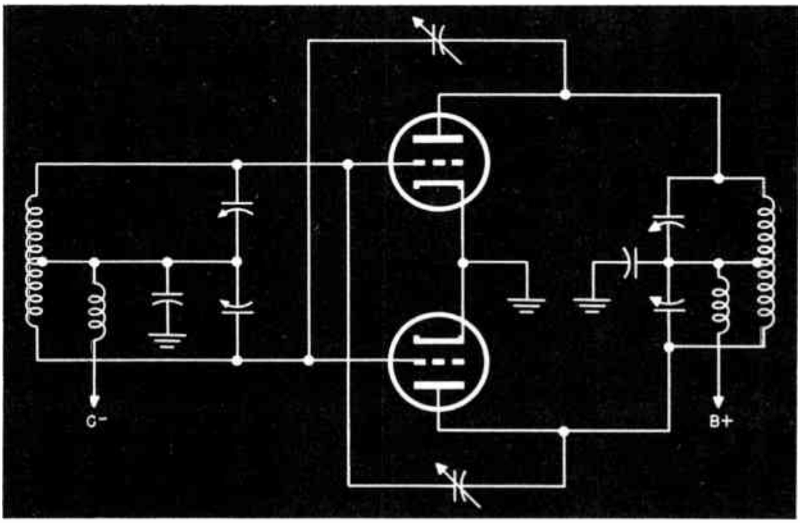


Fig. 6-7. Schematic of class-C push-pull triode amplifiers, neutralized.

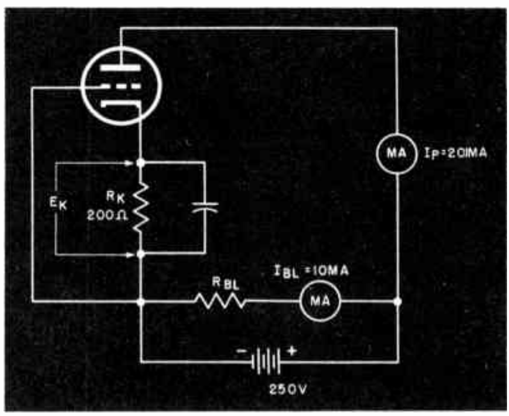


Fig. 6-8. Circuit for calculation of cathode bias.

39. Why is a high-Q circuit desirable?

A high-Q circuit is desirable because it is highly selective, discriminating against unwanted side frequencies.

40. What is the plate-current indication of resonance in the plate tank circuit of an r-f power amplifier?

At resonance, the plate current is a minimum; off resonance, it rises abruptly to an excessive value.

41. In the diagram shown in Fig. 6-8, what is the value of cathode bias (E_K) and the bleeder load resistor (R_{BL})?

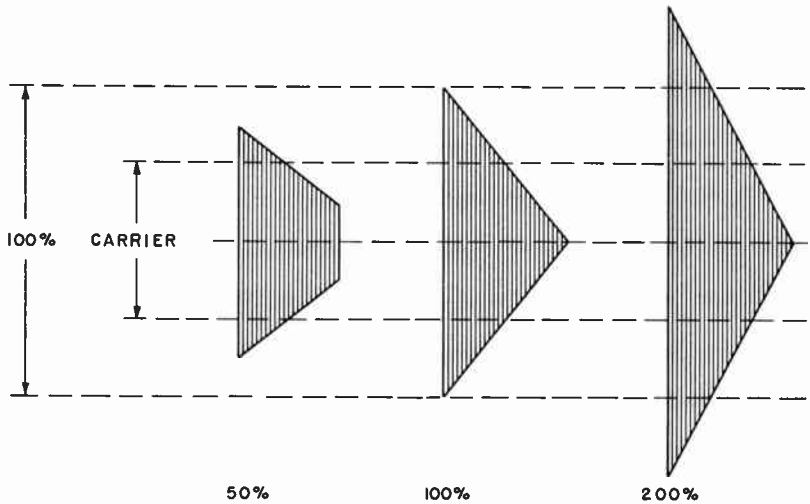


Fig. 6-9. Trapezoidal-type modulation patterns.

Note: The cathode current (I_K) is the same as the plate current (I_P). Therefore, $I_K = I_P = 20$ ma $= .02$ amp.

By Ohm's law, $E_K = I_K R_K = (.02)\ (200) = 4$ volts

$$\text{Also, by Ohm's law, } R_{BL} = \frac{E}{I_{BL}} = \frac{250}{0.01} = 25{,}000 \text{ ohms}$$

42. Draw trapezoidal type patterns or modulation envelope patterns illustrating 50% modulation, 100% modulation, and overmodulation.

Refer to Fig. 6-9 for the trapezoidal type patterns and to Fig. 3-22 for modulation envelope patterns.

43. What are some of the adverse effects of overmodulation?

The modulated wave is distorted (unintelligible) and the modulation contains harmonics of the audio modulating frequencies, generating spurious sidebands or *splatter*.

44. What is the meaning of the term "sidebands" with respect to amplitude modulation?

A result of the process of amplitude modulation is the production of new frequencies in the output of the transmitter which are equal to the sum of the carrier and modulating frequency and the difference between these same two frequencies. Sidebands are the frequency bands (both above and below the carrier) containing groups of these new frequencies when the modulating signal is composed of many frequencies, as in voice communication. Note that the intelligence of the message is, therefore, carried in the sidebands, not in the carrier.

45. What are the two most popular methods of modulation?

Plate modulation and grid modulation.

46. What may cause the antenna current to decrease when the carrier of an amplitude-modulated radiotelephone transmitter is modulated by the plate modulation method?

The output tank circuit not being properly tuned to the antenna.

47. What is the amount of modulator sinusoidal power output required for 100% amplitude of a specified unmodulated power input of a class-C amplifier?

50% of the power input of the class-C amplifier.

48. What are the relative bandwidths of types A1 and A3 emissions, and of SSB and double sideband am?

Although theoretically, type A1 emission (cw) can have a bandwidth of as little as 1 cps, in practice it usually requires approximately 2 kc. Type A3 (voice) may require a total bandwidth of as much as 10 kc. Single sideband (SSB) may require up to 5 kc, the width of one sideband of double-sideband am.

49. What is the relationship between a fundamental frequency and its second harmonic, its third harmonic, etc?

The second harmonic is twice the frequency of the fundamental; the third harmonic is three times the frequency of the fundamental, etc.

50. In which stages would a high harmonic output be desirable and undesirable?

Desirable in an oscillator of the frequency multiplier stage. Undesirable in any other stage.

51. What conditions would minimize harmonic component outputs from an r-f amplifier stage?

a. Minimum excitation voltage.

b. Grid bias slightly below cutoff.

c. Large ratio of capacitance to inductance in the plate-tank circuit.

52. What conditions would increase the harmonic component outputs for a frequency doubler amplifier or other multiplier stage?

a. More than sufficient excitation voltage.

b. Very high grid bias, well below cutoff.

c. High-impedance plate circuit.

53. To obtain optimum output power from an r-f amplifier, what should be the relationship between the output circuit impedance and the rated tube load impedance?

They should both have the same impedance values.

54. If a resistor-capacitor circuit is composed of 50 ohms and 100 microfarads, what is the time constant?

The time constant, T = RC = 50 × 0.0001 = .005 second. The time constant is defined as the time required for a charging capacitor to be charged to 63% of its full capacity or for a discharging capacitor to be discharged to 37% of its full capacity.

55. What is "skin effect"?

Direct and low-frequency a-c currents flow uniformly through the entire cross-section of a wire. However, at radio frequencies the current tends to flow near the outside of the wire. At extremely high radio fre-

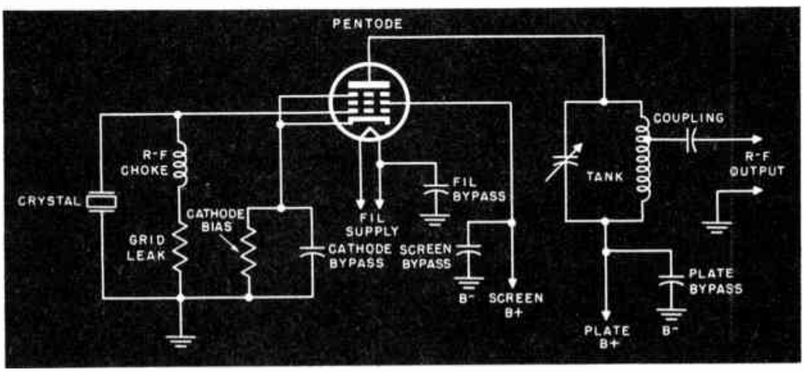


Fig. 6-10. Schematic of pentode-type crystal-controlled oscillator.

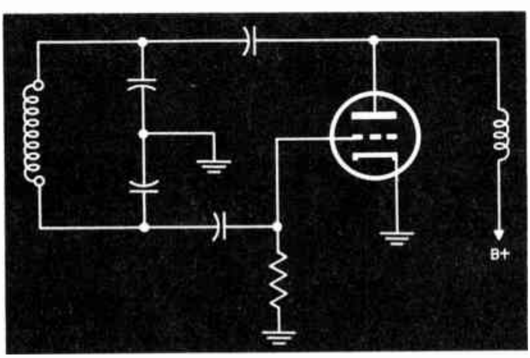


Fig. 6-11. Schematic of Colpitts-type oscillator.

quencies this effect is so pronounced that it is possible to cut out the center section of the wire without any effect on the current flow. This phenomenon is called "skin effect."

56. What is meant by QRK?, QRM?, QRS?, QRT?, QSA?, QSL?, QSY?, QSZ?, and QTH?

QRK?—What is my readability (legibility of my signal)?

QRM?—Are you being interfered with?

QRS?—Shall I send slower?

QRT?—Shall I stop sending?
QSA?—What is the strength of my signals?
QSL?—Will you acknowledge receipt?
QSY?—Shall I transmit on another frequency?
QSZ?—Shall I send each word or group more than once?
QTH?—Where are you located?

57. What is the purpose of an antenna grounding switch?

To protect the station equipment from damage due to charges of atmospheric electricity on the antenna.

58. What type of coupling is most commonly used between a transmitter power amplifier and the antenna network, or between two physically separated r-f amplifiers?

Link coupling.

59. Name four different types of oscillator circuits.

a. Hartley
b. Colpitts
c. Electron-coupled
d. Tuned-plate, tuned-grid

60. Draw a simple schematic diagram of a crystal-controlled oscillator using a pentode type tube. Indicate the polarity of all supply voltages.

See Fig. 6-10.

61. Draw a simplified schematic diagram of a Colpitts oscillator circuit.

See Fig. 6-11.

62. What is a Faraday shield?

A Faraday shield is an electrostatic shield built internally into inductive-type components (such as transformers) to reduce undesirable effects due to capacitive coupling.

63. What is the formula for determining the total resistance of two or more resistors connected in parallel? In series?

$$R_T = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots}$$

where R_T = total resistance of resistors in parallel

$$R_T = R_1 + R_2 + R_3 + \ldots$$

where R_T = total resistance of resistors in series

Note that when there are only two resistors in parallel:

$$R_T = \frac{R_1 \times R_2}{R_1 + R_2}$$

64. What is the formula for determining the total capacitance of two or more capacitors, connected in series? In parallel?

$$C_T = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \ldots}$$

where C_T = total capacitance of capacitors in series

$$C_T = C_1 + C_2 + C_3 + \ldots$$

where C_T = total capacitance of capacitors in parallel

Note that when there are only two capacitors in series:

$$C_T = \frac{C_1 \times C_2}{C_1 + C_2}$$

65. What is the Ohm's law formula for circuits containing resistance only?

$$I = \frac{E}{R}; \; E = IR; \; R = \frac{E}{I}$$

66. What is the formula for determining power in resistive circuits when the voltage and current values are known; when voltage and resistance are known; when current and resistance are known?

$$W = EI; \quad W = \frac{E^2}{R}; \quad W = I^2R$$

67. What is the formula for calculating the total inductance (in the absence of mutual effects) when two or more inductors are connected in series? In parallel?

$$L_T = L_1 + L_2 + L_3 + \ldots$$

where L_T = total inductance of inductors in series

$$L_T = \frac{1}{\frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + \ldots}$$

where L_T = total inductance of inductors in parallel

Note that when there are only two inductors in parallel:

$$L_T = \frac{L_1 \times L_2}{L_1 + L_2}$$

68. What is the formula for calculating the reactance of a capacitor?

$$X_C = \frac{1}{2\pi fC}$$

where X_C = reactance of the capacitor (ohms), f = frequency (cps), C = capacitance (farads), and π = 3.14.

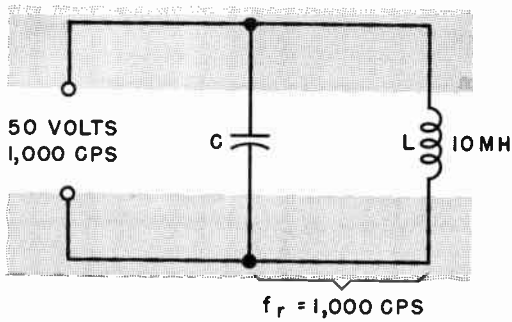


Fig. 6-12. Calculation for parallel-resonant circuit.

69. In the resonant af circuit shown in Fig. 6-12, what is the value of C?

$$\text{Since } f_o = \frac{1}{2\pi\sqrt{LC}}$$

$$\text{Then } f_o^2 = \frac{1}{4\pi^2 LC}$$

$$\text{and } C = \frac{1}{4\pi^2 Lf^2} = \frac{1}{(4)\ (3.14)^2\ (.01)\ (1{,}000)^2}$$

$$= \frac{1}{4\ (9.86)\ (.01)\ (1{,}000{,}000)} = \frac{1}{(.3944)\ (1{,}000{,}000)}$$

$$= 2.54\ (.000001)$$

$$= 2.54 \text{ microfarads}$$

70. What is the formula for determining the characteristic impedance of an air-insulated parallel conductor transmission line?

$$Z_o = \sqrt{\frac{L}{C}}$$

where Z_o = characteristic impedance (ohms), L = inductance per unit length (henrys), and C = capacitance per unit length (farads).

71. What are the impedances of series-tuned and parallel-tuned circuits at resonance?

At resonance, the impedance of the series tuned circuit is usually considered to be zero (actually it is equal to the d-c resistance of the circuit) and the impedance of the parallel tuned circuit is considered to be infinite (acting as an open circuit).

72. What would be the effect on the resonant frequency of a tuned circuit if the coil develops a short-circuited turn?

A short-circuited turn would reduce the inductance of the coil. From the formula $f = 1/2\pi\sqrt{LC}$, it may be seen that a smaller inductance would result in a higher resonant frequency, f.

73. In a tuned circuit: (a) what must be done to the value of C to double the resonant frequency, and (b) what must be done to the LC product to halve the resonant frequency:

$$\text{Since } f_0 = \frac{1}{2\pi\sqrt{LC}}$$

a. To double the resonant frequency, f_0, the denominator $(2\pi\sqrt{LC})$ must be halved. Since C is under a square root sign, making C one-fourth of its original value will halve the denominator and double the resonant fequency.

b. To halve the resonant frequency, f_0, the denominator must be doubled. Since the term LC is under a square root sign, making LC four times as large as it was will double the denominator and halve the resonant frequency.

74. What is the formula used to determine the wavelength of radio waves?

$$\lambda = \frac{300{,}000}{f}$$

where λ = wavelength (meters) and f = frequency (kc).

75. How would you determine the approximate length of a half-wave dipole antenna for a given frequency?

$$L = \frac{468}{f}$$

where L = length (in feet) and f = frequency (in mc).

76. What is the formula for determining the standing wave ratio in a transmission line?

The standing wave ratio (SWR) is always expressed as a number greater than 1. Therefore,

$$SWR = \frac{Z_R}{Z_0} \text{ or } \frac{Z_0}{Z_R}$$

where SWR = standing wave ratio, Z_R = load impedance (pure resistance) and Z_0 = characteristic impedance of the line.

77. Using a frequency meter with a possible error of 0.5%, at what whole-number kilocycle frequency nearest the low end of the 1,800 to 2,000-kc band may a transmitter be operated?

$$f_x = \frac{f_l}{1-N}$$

where f_x = Lowest operating frequency safely within band limits, f_l = Low end of band (as defined by FCC) and N = Error of meter (in decimals, not percentage).

$$f_x = \frac{1,800}{1-0.005} = \frac{1,800}{0.995}$$

$$= 1,809.04 \text{ kc}$$

Operate at 1,810 kc, not 1,809 kc.

78. Using a frequency meter with a possible error of 0.8% at what whole-number kilocycle frequency nearest the high end of the 7,000-7,300 kc band may a transmitter be operated?

$$f_x = \frac{f_u}{1+N}$$

where f_x = Highest operating frequency safely within band limits, f_u = High end of band (as defined by FCC) and N = Error of meter (in decimals, not percentage).

$$f_x = \frac{7,300}{1+0.008} = \frac{7,300}{1.008} = 7,242.06 \text{ kc}$$

Operate at 7,242 kc, not 7,243 kc.

79. Given a transmitter frequency tolerance of + x kc and a maximum audio frequency in the modulation system of y cycles, how close to the edge of an amateur band may one operate an amplitude modulated phone transmitter?

Due to the sidebands generated, always operate at least x + y from either edge of an amateur band.

80. Why is a crystal used as a frequency controlling element in transmitters?

It is a high-Q device and is extremely accurate (frequency-wise), being relatively free from variations due to changes in values of other components. It does not drift much, and requires no warmup.

81. A 4,000-kc crystal has a negative temperative coefficient of 10 cycles per megacycle per degree centigrade. If the crystal is started in operation

when the temperature is 30° C, what will the crystal oscillation frequency be at 50° C?. It is assumed that temperature-frequency variation is linear.

The total temperature change is 20°. Since 4,000 kc = 4 mc, the frequency change per degree of temperature change is 4 × 10 = 40 cycles. A negative temperature coefficient means that the frequency drops

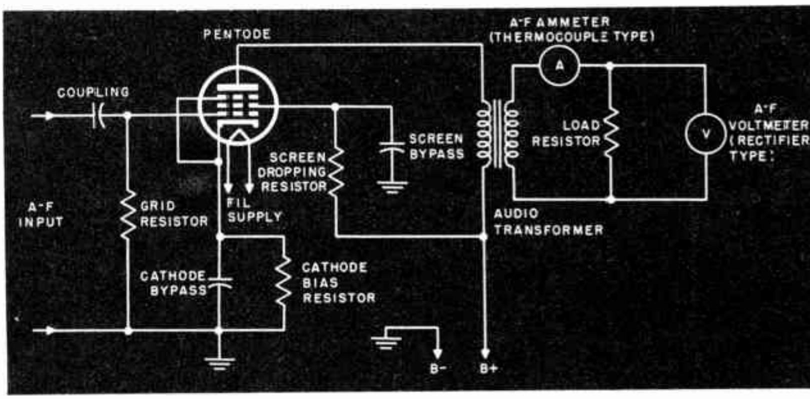


Fig. 6-13. Schematic of a-f power amplifier stage.

with increasing temperature. Therefore, the total decrease in frequency is 40 × 20 = 800 cycles, or 0.8 kc. The final frequency = 4,000 kc − 0.8 kc, or 3,999.2 kc.

82. A 3750-kc crystal has a positive temperature coefficient of 75 cycles per degree centigrade. If the crystal is started in operation when the temperature is 35° C, what will the crystal oscillation be at 50° C? It is assumed that the temperature-frequency variation is linear.

The total temperature change is 15°. The total frequency change due to the temperature change, therefore, is 15 × 75 = 1,125 cps or 1.125 kc.

A positive temperature coefficient means that the frequency rises with increasing temperature. Therefore, the final frequency is 3,750 kc + 1.125 kc or 3,751.125 kc.

83. Draw a schematic diagram of a pentode audio power-amplifier stage with an output coupling transformer and load resistor, showing suitable instruments connected in the secondary for measurements of the audio-frequency voltage and current. Name each component part.

See Fig. 6-13.

84. Draw a simplified schematic diagram of a wavemeter with an indicating device.

See Fig. 6-14.

85. Draw a simplified schematic diagram of a low-pass filter to be used on an amateur transmitter to reduce harmonic radiation falling in the TV bands.

See Fig. 6-15.

86. Draw a simplified schematic diagram of a high-pass filter to be used at a TV receiver to reduce blanket interference caused by a properly operating amateur transmitter.

See Fig. 6-16.

87. Draw a simplified schematic diagram of a high-pass filter with a constant-K pi section, balanced type.

See Fig. 6-17.

88. Draw a simplified schematic diagram of a low-pass filter with a constant-K pi section, unbalanced type.

See Fig. 6-18.

89. Draw a schematic diagram of a filter for reducing amateur interference to broadcast reception consisting of a series-tuned circuit con-

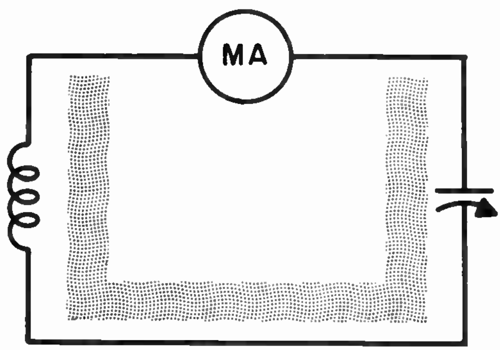


Fig. 6-14. Schematic of wavemeter.

nected to shunt with the broadcast receiver input to bypass the interfering signal and a parallel-tuned (trap) circuit in series with the receiver input to reject the interfering signal.

See Fig. 6-19.

90. Draw a simple schematic diagram of two r-f amplifier stages using triode tubes, showing neutralizing circuits, link coupling between stages and between output and antenna system, a keying connection and a key-click filter.

See Fig. 6-20.

91. Draw a schematic diagram of a plate-neutralized triode r-f amplifier stage.

See Fig. 6-21.

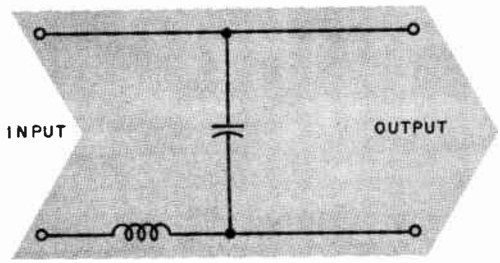


Fig. 6-15. Schematic of low-pass filter.

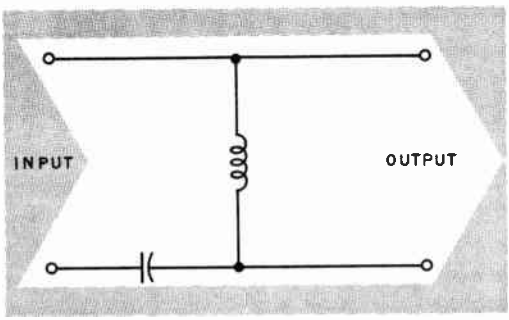


Fig. 6-16. Schematic of high-pass filter.

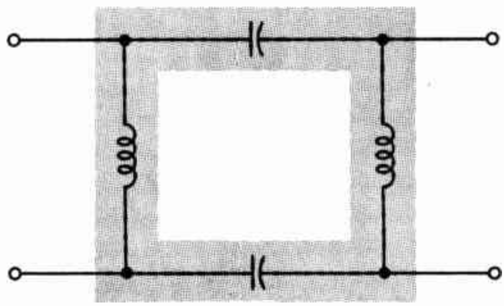


Fig. 6-17. Schematic of constant-K balanced-type high-pass filter.

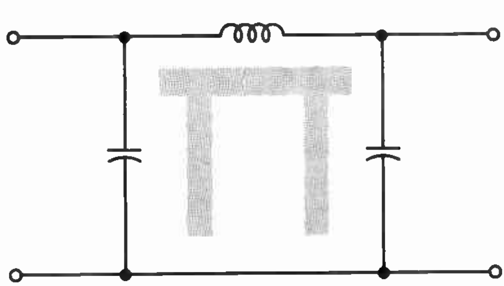


Fig. 6-18. Schematic of constant-K unbalanced-type low-pass filter.

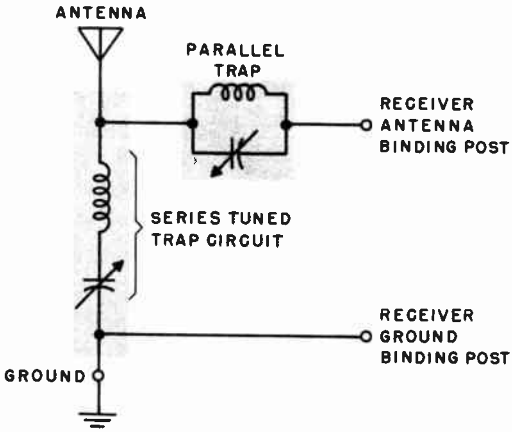


Fig. 6-19. Schematic of broadcast interference trap.

Typical General Class License Examination

The written examination for the General Class license consists of 50 multiple-choice questions on general amateur regulations and basic amateur practices.

Here is a typical examination; the correct answers are given at the end of this chapter.

1. The following agency has complete control over all communications.
   a. The Department of the Interior.
   b. The Radio Broadcasters of America.
   c. The Federal Communications Commission.
   d. The Senate Internal Security Bureau.
2. The following type of radio communication has absolute priority over all other communications.
   a. Distress signals.
   b. News dispatches.
   c. A Presidential radio broadcast.
   d. Telegraph messages.
3. The following is the legal maximum power authorized for transmissions:
   a. 300 watts b. 500 watts c. 750 watts d. 1,000 watts
4. It is necessary to notify the FCC of intended portable operation if this operation is expected to extend for more than:
   a. 12 hours b. 24 hours c. 36 hours d. 48 hours
5. An amateur may accept remuneration for the use of his station under the following condition.

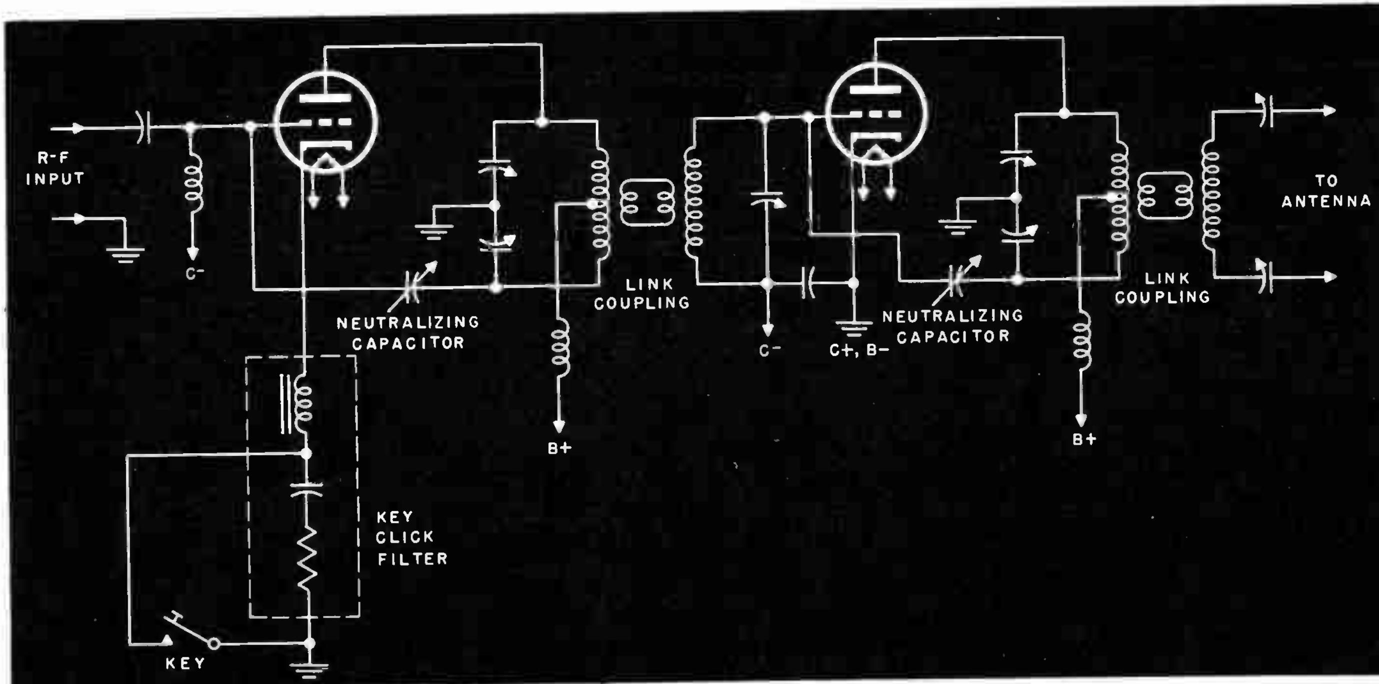


Fig. 6-20. Schematic of two neutralized r-f amplifier stages.

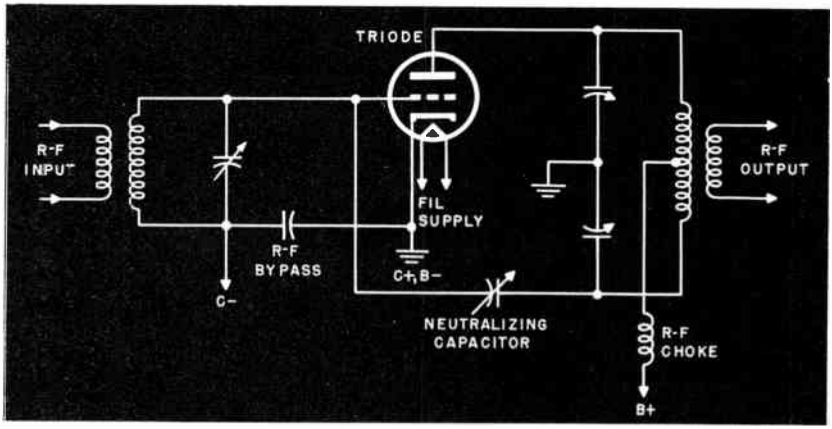


Fig. 6-21. Schematic of plate-neutralized triode r-f amplifier.

a. For transmission of commercial messages.
b. For contacting people overseas.
c. For rebroadcasting music.
d. Under no condition.

6. An adequately filtered d-c plate power supply is required for transmissions at the following frequencies:
a. On all frequencies below 144 mc.
b. On the frequency band 1,800 - 2,000 kc.
c. On the frequency band 7,000 - 7,300 kc.
d. On all frequencies above 7,300 kc.

7. The following percentage of modulation is the maximum allowed:
a. 50% b. 75% c. 100% d. 200%.

8. The basic unit of power is:
a. the watt. b. the volt. c. the ohm. d. the ampere.

9. The instrument used to measure current is:
a. the ohmmeter. b. the ammeter. c. the voltmeter. d. the ampere.

10. A fuse in the primary winding circuit of a power transformer:
a. Decreases the current that would normally flow.
b. Increases the power capability of the transformer.
c. Measures the current flowing
d. Acts as a safety device to prevent damage to the transformer from an overload.

11. Draw a simplified schematic diagram of a half-wave rectifier with a capacitor input, pi-type filter. Use filter capacitors of unequal capacitance connected in series, with a means of equalizing the d-c drop across the different capacitors.

12. Draw a simplified schematic diagram of a mercury-vapor full-wave single-phase power supply using a center-tapped high voltage secondary. Include a filter circuit for the best possible regulation, a bleeder supplying two different output voltages and a circuit for suppressing "hash" interference from the mercury vapor tubes.

13. If a power transformer with a primary winding of ½-ohm d-c resistance were connected to 115 volts, d-c, how much current would flow?

a. 230 amps. b. 57.5 amps. c. 115.5 amps. d. 115 amps.

14. The following method could be used to prevent modulation of a transmitting tube by its a-c filament supply.

a. Ground one side of the filament.

b. Use a center-tap return connection to the secondary winding of the filament supply.

c. Ground one side of the a-c filament supply.

d. Insert a filament bypass capacitor.

15. A full-wave bridge rectifier circuit using the same power transformer as a full-wave center-tapped rectifier circuit would have:

a. The same output voltage.

b. Twice the current flowing.

c. Twice the output voltage.

d. One-half the output voltage.

16. The advantage of the full-wave rectifier over the half-wave rectifier is:

a. A transformer can be used.

b. Larger filter capacitors can be used.

c. A larger bleeder resistor can be used.

d. It provides a smoother output with a higher ripple frequency which is easier to filter.

17. The following component is used in a rectifier circuit to help keep the output voltage constant under a varying load.

a. A transformer.

b. A swinging choke.

c. A pi-type filter.

d. A mercury-vapor rectifier tube.

18. The output ripple frequency of a full-wave rectifier connected to a 60-cps input voltage is:

a. 120 cps.

b. 30 cps.

c. 60 cps.

d. 90 cps.

19. A vacuum tube containing 3 grids is called a:
    a. Diode.
    b. Triode.
    c. Tetrode.
    d. Pentode.

20. A suppressor grid:
    a. Controls the current flow to the plate.
    b. Eliminates secondary emission.
    c. Speeds up the plate current flow.
    d. Prolongs the life of the filament.

21. A tetrode (or pentode) is preferred to a triode as an amplifier in a transmitter because:
    a. It has fewer internal elements.
    b. It is a cheaper tube.
    c. It does not require neutralization.
    d. It has a smaller amplification factor.

22. The following is *not* characteristic of a class A amplifier stage:
    a. High efficiency.
    b. Tube operates on linear portion of grid-voltage plate-current ($E_g - I_p$) curve.
    c. Average plate current is constant.
    d. Grid is not driven positive with respect to cathode.

23. A push-pull amplifier:
    a. Multiplies all even harmonics.
    b. Cancels all even harmonics.
    c. Amplifies only r-f signals.
    d. Has unity voltage gain.

24. If the plate voltage of an amplifier is 300 volts and its plate current is 50 ma, its plate power input is:
    a. 5 watts.
    b. 15 watts.
    c. 300 watts.
    d. 1500 watts.

25. If a tube operates with an efficiency of 50%, what is its output power if its d-c input power is 5 watts?
    a. 2.5 watts.
    b. 5 watts.
    c. 10 watts.
    d. 25 watts.

26. Operating an unneutralized r-f triode amplifier may produce:
    a. A demodulated output.
    b. Less gain.
    c. More gain.
    d. Spurious radiation.
27. At resonance, the plate current of an r-f power amplifier:
    a. Is the same as for other input frequencies.
    b. Is at minimum value.
    c. Is at maximum value.
    d. Doubles in value.
28. In the diagram shown in Fig. 4-13 what is the value of cathode bias (E_K)?
    a. 4 volts. b. 1 volt. c. 10 volts. d. 40 volts.
29. Draw an illustration showing 50%, 100% and 200% modulation.
30. If a 7-mc carrier is amplitude-modulated with a 10-kc audio signal, its sideband frequencies are:
    a. 6,990 kc and 7,010 kc.
    b. 6,993 kc and 7 mc.
    c. 6,993 kc and 10 kc.
    d. 7 mc and 10 kc.
31. A high harmonic output is desirable in the following kind of stages:
    a. Frequency multiplier.
    b. Rectifier.
    c. Demodulator.
    d. Final r-f power amplifier.
32. Which of the following arrangements would increase the output of harmonic components from a frequency-multiplier stage?
    a. Low-impedance plate circuit.
    b. Very low grid bias.
    c. Very high grid bias.
    d. Insufficient excitation voltage.
33. To obtain maximum power output from an r-f power amplifier:
    a. Resistance-capacitance coupling is necessary.
    b. A wave trap must be used.
    c. A push-pull stage must be used.
    d. The impedance of the antenna system should be matched to the load impedance of the r-f amplifier.
34. If a resistance-capacitance (RC) circuit is composed of 100 ohms and 50 microfarads, the time constant is:
    a. .005 second.
    b. .006 second.

c. .150 second.
d. .050 second.

35. The abbreviation "QRM" means:
a. Send slower.
b. I am being interfered with.
c. I am located at ....
d. The readability of your signal is ....

36. An antenna grounding switch:
a. Permits switching between two antennas.
b. Protects the station from atmospheric electricity.
c. Switches the antenna from the transmitter to the receiver.
d. Grounds the main power on-off switch of the entire station.

37. A "link coupling" is composed of:
a. A resistance-capacitance connection.
b. A choke.
c. A capacitor.
d. A pair of transformer windings connected by a transmission line.

38. The following is *not* a type of oscillator:
a. Colpitts.
b. Hartley.
c. Faraday.
d. Electron-coupled.

39. A Faraday shield between the output of an r-f power amplifier and the antenna will:
a. Automatically neutralize the r-f power amplifier.
b. Reduce undesirable harmonic radiation.
c. Cut off all output to the antenna.
d. Eliminate the need for the antenna.

40. If the coil in a tuned circuit developed a short-circuited turn, the effect would be:
a. A higher resonant frequency.
b. Increased coil inductance.
c. Increased d-c resistance in the coil.
d. Increased a-c resistance (reactance) in the coil.

41. In the resonant circuit shown in Fig. 6-12, what is the value of C?
a. 1.74 microfarads.
b. 2.52 microfarads.
c. 10.02 microfarads.
d. 46.73 microfarads.

42. Using a frequency meter with a possible error of 0.75%, on what whole-number kilocycle frequency nearest the low frequency end of the

7,000-7,300 kc band could a transmitter be set safely? Allow 1 kc for additional variations due to temperature and circuit constants.

a. 6946 kc.
b. 7246 kc.
c. 7053 kc.
d. 7054 kc.

43. In a parallel circuit consisting of two 10-ohm resistors, the total resistance is:

a. 5 ohms. b. 10 ohms. c. 20 ohms. d. 100 ohms.

44. A 7-mc crystal has a positive temperature coefficient of 100 cycles per degree centigrade and is started in operation at 45 degrees centigrade. What will its frequency be at 70 degrees centigrade?

a. 7,002.5 kc.
b. 6,997.5 kc.
c. 7 mc.
d. 7,250 kc.

45. Draw a diagram of a plate-neutralized triode r-f amplifier stage.

46. Draw a diagram of a wavemeter with an indicating device.

47. Draw a schematic diagram of a filter for reducing amateur interference to broadcast reception, consisting of a series-tuned circuit connected in shunt with the broadcast receiver input, to bypass the interference.

48. Draw a simple schematic diagram of a crystal-controlled oscillator using a pentode type tube. Indicate the polarity of all supply voltages.

49. Draw a simple schematic diagram of an r-f amplifier with a series-fed plate circuit.

50. Draw a diagram of a coupling system employing resistance elements between two audio-frequency amplifier stages.

Answers to Questions for the Typical General Class License Examination

1. c
2. a
3. d
4. d
5. d
6. a.
7. c
8. a
9. b
10. d
11. See Fig. 6-1
12. See Fig. 6-2
13. a
14. b
15. c
16. d
17. b
18. a
19. d
20. b
21. c
22. a
23. b
24. b
25. a
26. d
27. b
28. a
29. See Figs. 3-8 and 6-9
30. a
31. a
32. c
33. d
34. a
35. b
36. b
37. d
38. c
39. b
40. a
41. b
42. d
43. a
44. a
45. See Fig. 6-21
46. See Fig. 6-14
47. See Fig. 6-19, series-tuned trap circuit.
48. See Fig. 6-10
49. See Fig. 6-14
50. See Fig. 6-5

Chapter 7: REGULATIONS

All rules and regulations affecting communications are determined by the FCC (Federal Communications Commission), which was created by Congress in the *Communications Act of 1934.* Part I of this chapter contains excerpts from this Act.

Since 1934, the FCC has issued rules and regulations for all the various communication services. Part 12 of the Federal Communications Commission Rules and Regulations covers *Rules Governing Amateur Radio Service.* Excerpts from this and the latest amendments appear as Part II of this chapter.

Since these rules and regulations are constantly being revised, be sure to obtain the latest information by requesting it from the Government Printing Office, Washington 25, D. C. Their booklet, number PL82, lists all pertinent publications in the radio and communications field.

The information included in this chapter should be read carefully. It is not necessary to memorize any of it; however, try to become generally familiar with its provisions.

If you have any questions that are not answered in these rules and regulations, contact the FCC (Federal Communications Commission, Washington 25, D. C.) directly. For example, an existing agreement between the U.S. and Canada permits reciprocal operation by visiting radio amateurs under certain conditions. This type of information (or any other questions) should be requested directly from the FCC, to avoid possible violations of the law.

Part III of this chapter contains a list of all FCC field offices throughout the United States and its possessions. Information relative to amateur radio is available from them.

Part I. Excerpts From The Communications Act of 1934

BEING AN ACT TO PROVIDE FOR THE REGULATION OF INTERSTATE AND FOREIGN COMMUNICATION BY WIRE OR RADIO, AND FOR OTHER PURPOSES

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

Sec. 1. For the purpose of regulating interstate and foreign commerce in communication by wire and radio so as to make available, so far as possible, to all the people of the United States a rapid, efficient, Nation-wide, and world-wide wire and radio communication service with adequate facilities at reasonable charges, for the purpose of the national defense, for the purpose of promoting safety of life and property through the use of wire and radio communication, and for the purpose of securing a more effective execution of this policy by centralizing authority heretofore granted by law to several agencies and by granting additional authority with respect to interstate and foreign commerce in wire and radio communication, there is hereby created a commission to be known as the "Federal Communications Commission," which shall be constituted as hereinafter provided, and which shall execute and enforce the provisions of this Act.

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

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

(1) The Commission may perform any and all acts, make such rules and regulations, and issue such orders, not inconsistent with this Act, as may be necessary in the execution of its functions.

Sec. 301. It is the purpose of this Act, among other things, to maintain the control of the United States over all the channels of interstate and foreign radio transmission; and to provide for the use of such channels, but not the ownership thereof, by persons for limited periods of time, under licenses granted by Federal authority, and no such license shall be construed to create any right, beyond the terms, conditions, and periods of the license. No person shall use or operate any apparatus for the transmission of energy or communications or signals by radio . . . except under and in accordance with this Act and with a license in that behalf granted under the provisions of this Act.

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

(a) Classify radio stations;

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

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

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

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

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

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

(h) Have authority to establish areas or zones to be served by any station;

(i) Have authority to make special regulations applicable to radio stations engaged to chain broadcasting;

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

(k) Have authority to exclude from the requirements of any regulations in whole or in part any radio station upon railroad rolling stock, or to modify such regulations in its discretion;

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

(m) (1) Have authority to suspend the license of any operator upon proof sufficient to satisfy the Commission that the licensee —

(A) Has violated any provision of any Act, treaty, or convention binding on the United States, which the Commission is authorized to administer, or any regulation made by the Commission under any such Act, treaty, or convention; or

(B) Has failed to carry out a lawful order of the master or person lawfully in charge of the ship or aircraft on which he is employed; or

(C) Has willfully damaged or permitted radio apparatus or installations to be damaged; or

(D) Has transmitted superfluous radio communications or signals or communications containing profane or obscene words, language, or meaning, or has knowingly transmitted —

(1) False or deceptive signals or communications; or

(2) A call signal or letter which has not been assigned by proper authority to the station he is operating; or

(E) Has willfully or maliciously interfered with any other radio communications or signals; or

(F) Has obtained or attempted to obtain, or has assisted another to obtain or attempt to obtain, an operator's license by fraudulent means.

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

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

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

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

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

Sec. 318. The actual operation of all transmitting apparatus in any radio station for which a station license is required by this Act shall be carried on only by a person holding an operator's license issued hereunder, and no person shall operate any such apparatus in such station except under and in accordance with an operator's license issued to him by the Commission: *Provided, however,* That the Commission if it shall find that the public interest, convenience, or necessity will be served thereby may waive or modify the foregoing provisions of this section for the operation of any station except (1) stations for which licensed operators are required by international agreement, (2) stations for which licensed operators are required for safety purposes, (3) stations engaged in broadcasting, and (4) stations operated as common carriers on frequencies below thirty thousand kilocycles: *Provided further,* That the Commission shall have power to make special regulations governing the granting of licenses for the use of automatic radio devices and for the operation of such devices.

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

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

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

Sec. 501. Any person who willfully and knowingly does or causes or suffers to be done any act, matter, or thing, in this Act prohibited or declared to be unlawful, or who willfully or knowingly omits or fails to do any act, matter, or thing in this Act required to be done, or willfully and knowingly causes or suffers such omission or failure, shall, upon conviction thereof, be punished for such offense, for which no penalty (other than a forfeiture) is provided in the Act, by a fine of not more than $10,000 or by imprisonment for a term not exceeding one year, or both; except that any person, having been once convicted of an offense punishable under this section, who is subsequently convicted of violating any provision of this Act punishable under this section, shall be punished by a fine of not more than $10,000 or by imprisonment for a term not exceeding two years, or both.

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

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

Sec. 606. (a) During the continuance of a war in which the United States is engaged, the President is authorized, if he finds it necessary for the national defense and security, to direct that such communications as in his judgment may be essential to the national defense and security shall have preference or priority with any carrier subject to this Act. He may give these directions at and for such times as he may determine, and may modify, change, suspend, or annul them and for any such purpose he is hereby authorized to issue orders directly, or through the Commission. Any carrier complying with any such order or direction for preference or priority herein authorized shall be exempt from any and all provisions in existing law imposing civil or criminal penalties, obligations, or liabilities upon carriers by reason of giving preference or priority in compliance with such order or direction.

(b) It shall be unlawful for any person during any way in which the United States is engaged to knowingly or willfully, by physical force or intimidation by threats of physical force, obstruct or retard or aid in obstructing or retarding interstate or foreign communication by radio or wire. The President is hereby authorized, whenever in his judgment the public interest requires, to employ the armed forces of the United States to prevent any such obstruction or retardation of communication: *Provided,* That nothing in this section shall be construed to repeal, modify, or affect either section 6 or section 20 of the Act entitled, "An Act to supplement existing laws against unlawful restraints and monopolies, and for other purposes", approved October 15, 1914.

(c) Upon proclamation by the President that there exists war or a threat of war, or a state of public peril or disaster or other national emergency, or in order to preserve the neutrality of the United States, the President, if he deems it necessary in the interest of national security, or defense, may suspend or amend, for such time as he may see fit, the rules and regulations applicable to any or all stations or devices capable of emitting electromagnetic radiations within the jurisdiction of the United States as prescribed by the Commission, and may cause the closing of any station for radio communication, or any device capable of emitting electromagnetic radiations between 10 kilocycles and 100,000 megacycles, which is suitable for use as a navigational aid beyond five miles, and the removal therefrom of its apparatus and equipment, or he may authorize the use or control of any such station or device and/or its apparatus and equipment, by any department of the Government under such regulations as he may prescribe upon just compensation to the owners. The authority granted to the President, under this subsection, to cause the closing of any station or device and the removal therefrom of its apparatus and equipment, or to authorize the use or control of any station or device and/or its apparatus and equipment, may be exercised in the Canal Zone.

Part II. Excerpt from Part 12 of FCC Rules and Regulations

SUBPART A — AMATEUR RADIO STATIONS AND OPERATORS

§12.0 *Basis and purpose.* The rules and regulations in this part are designed to provide an amateur radio service having a fundamental purpose as expressed in the following principles:

(a) Recognition and enhancement of the value of the amateur service to the public as a voluntary noncommercial communication service, particularly with respect to providing emergency communications.

(b) Continuation and extension of the amateur's proven ability to contribute to the advancement of the radio art.

(c) Encouragement and improvement of the amateur radio service through rules which provide for advancing skills in both the communication and technical phases of the art.

(d) Expansion of the existing reservoir within the amateur radio service of trained operators, technicians, and electronics experts.

(e) Continuation and extension of the amateur's unique ability to enhance international good will.

DEFINITIONS

§12.1 *Amateur service.* The term "amateur service" means a radio service carried on by amateur stations.

§12.2 *Amateur operator.* The term "amateur operator" means a person interested in radio technique solely with a personal aim and without pecuniary interest, holding a valid license issued by the Federal Communications Commission authorizing him to operate licensed amateur stations.

§12.3 *Amateur station.* The term "amateur station" means a station used by an amateur operator, and it embraces all radio transmitting apparatus at a particular location used for amateur service and operated under a single instrument of authorization.

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

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

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

§12.7 *Remote control.* The term "remote control" as applied to the amateur radio service, means control of transmitting equipment of an amateur station from an operating position other than one at which the transmitter is in view and immediately accessible; except that, direct mechanical control or direct electrical control by wired connections of an amateur transmitter from a point located on board any aircraft, vessel or vehicle on which such transmitter is located shall be considered remote control within the meaning of this definition.

§12.9 *Antenna structure defined.* The term "antenna structure" includes the radiating system and its supporting structures.

AMATEUR OPERATOR LICENSES, PRIVILEGES

§12.20 *Classes of amateur operator licenses.*
Amateur Extra Class.
Advanced Class (previously Class A).

General Class (previously Class B).
Conditional Class (previously Class C).
Technician Class.
Novice Class.

§12.21 *Eligibility for license.* Persons are eligible to apply for the various classes of amateur operator licenses as follows:

(a) *Amateur Extra Class.* Any citizen of the United States who either (1) at any time prior to receipt of his application by the Commission has held for a period of two years or more a valid amateur operator license issued by the Federal Communications Commission, excluding licenses of the Novice and Technician Classes, or (2) submits evidence of having held a valid amateur radio station or operator license issued by any agency of the United States Government during or prior to April, 1917.

(b) *Advanced Class.* New Advanced Class amateur operator licenses will not be issued; however, Advanced Class (or Class A) licenses may continue to be renewed as set forth in §12.27.

(c) *General Class.* Any citizen of the United States.

(d) *Conditional Class.* Any citizen of the United States whose actual residence and amateur station location are more than 75 miles airline distance from the nearest location at which examinations are held at intervals of not more than 3 months for General Class amateur operator license; or who is shown by physician's certificate to be unable to appear for examination because of protracted disability; or who is shown by certificate of the commanding officer to be in the armed forces of the United States at an Army, Navy, Air Force or Coast Guard station and, for that reason, to be unable to appear for examination at the time and place designated by the Commission.

(e) *Technician Class.* Any citizen of the United States.

(f) *Novice Class.* Any citizen of the United States except a former holder of an amateur license of any class issued by any agency of the United States government, military or civilian.

§12.22 *Application for amateur operator license.* The application for any new amateur operator license, including application for any change in operating privileges, shall be submitted in person or by mail to the district field office of the Commission at which the applicant desires his application to be considered and acted upon, which office will make the final arrangements for conducting any required examination. If the application is for a license which is obtained upon successful completion of an examination by volunteer examiners under special provisions of §12.44 (c), the application shall be submitted to the district field office which supplied the examination material. Applications for renewal or modification of license, or for duplicate license, when no change in operating privileges is involved, shall be filed directly with the Commission at its Washington 25, D. C., office.

§12.23. *Classes and privileges of amateur operator licenses —*

(a) *Amateur Extra Class.* All authorized amateur privileges including such additional privileges in both communication and technical phases of the art which the Commission may consider as appropriately limited to holders of this class of license.

(b) *Advanced Class.* All amateur privileges except those which may be reserved to holders of the Amateur Extra Class license.

(c) *General and Conditional Classes.* All authorized amateur privileges.

(d) *Technician Class.* All authorized amateur privileges in the amateur frequency band 50 to 54 Mc and in the amateur frequency bands above 220 Mc.

(e) *Novice Class.* Those amateur privileges as designated and limited as follows:

(1) The d.c. plate power input to the vacuum tube or tubes supplying power to the antenna shall not exceed 75 watts.

(2) Only the following frequency bands and types of emission may be used, and the emissions of the transmitter must be crystal-controlled:

(i) 3700 to 3750 kc, radiotelegraphy using only type A-1 emission in accordance with the geographical restrictions set forth in §12.111.

(ii) 7150 to 7200 kc radiotelegraphy using only type A-1 emission.

(iii) 21.10 to 21.25 Mc, radiotelegraphy using only type A-1 emission.

(iv) 145 to 147 Mc, radiotelegraphy or radiotelephony using any type of emission except pulsed emission and type B emission.

§12.25 *Availability of operator license.* The original operator license of each operator shall be kept in the personal possession of the operator while operating an amateur station at a fixed location, however, the license may be posted in a conspicuous place in the room occupied by the operator. The license shall be available for inspection by any authorized Government official whenever the operator is operating an amateur station and at other times upon request made by an authorized representative of the Commission, except when such license has been filed with application for modification or renewal thereof, or has been mutilated, lost or destroyed, and application has been made for a duplicate license in accordance with §12.26. No recognition shall be accorded to any photocopy of an operator license; however, nothing in this section shall be construed to prohibit the photocopying for other purposes of any amateur radio operator license.

§12.27 *Renewal of amateur operator license.* (a) An amateur operator license except the Novice Class, may be renewed upon proper application in which it is stated that the applicant has lawfully accumulated, at an amateur station licensed by the Commission, a minimum total of either 2 hours operating time during the last 3 month or 5 hours operating time during the last 12 months of the license term. Such operating time, for the purpose of renewal, shall be counted as the total of all that time between the entries in the station log showing the beginning and end of transmissions as required in §12.136 (a), both during single transmissions and during a sequence of transmissions. The application shall, in addition to the foregoing, include a statement that the applicant can send by hand key, i.e., straight key or any other type of hand operated key such as a semi-automatic or electronic key, and receive by ear, in plain language, messages in the International Morse Code at a speed of not less than that which is required in qualifying for an original license of the class being renewed.

(b) The Novice Class license will not be renewed.

(c) The applicant shall qualify for a new license by examination if the requirements of this section are not fulfilled.

(d) A renewal application which includes a modification (change of address or operator class) shall be submitted on FCC Form 610 and shall be accompanied by the applicant's amateur operator license if he holds one.

(e) Application for renewal of an amateur operator license without modification shall be submitted on FCC Form 405-A. Applications on Form 405-A should not be accompanied by the applicant's license. Unless otherwise directed by the Commission, each application for renewal of license shall be filed during the last 120 days of the license term or within a period of grace of one year after the expiration date of such license. During this one year period of grace an expired license is not valid. A renewed license issued upon the basis of an application filed during the grace period will be dated currently and will not be back-dated to the date of expiration of the license being renewed. In any case in which the licensee has, in accordance with the Commission's rules made timely and sufficient application for renewal of license, no license with reference to any activity of a continuing nature shall expire until such application shall have been finally determined.

(f) Renewal applications shall be governed by applicable rules in force on the date when application is filed.

§12.28 *Who may operate an amateur station.* An amateur radio station may be operated only by a person holding a valid amateur operator license. Such station may be operated by the licensee only in the manner and to the extent provided in his amateur operator license. Persons other than the station licensee, when operating such station, may operate it only to the extent and in the manner authorized to the license of the station and not exceeding the operating authority of such person's own amateur operator license. When an amateur station is used for telephony, the station licensee may permit any person to transmit by voice, provided during such transmission call signs are announced as prescribed by §12.82

and a duly licensed amateur operator maintains actual control over the emissions, including turning the carrier on and off for each transmission and signing the station off after communication with each station has been completed.

§12.29 *License term.* Amateur operator licenses are normally valid for a period of 5 years from the date of issuance of a new or renewed license, except the Novice Class which is normally valid for a period of 1 year from the date of issuance. Modified and duplicate licenses shall bear the same date of expiration as the licenses for which they are modifications or duplicates.

EXAMINATIONS

§12.41 *When examination is required.* Examination is required for the issuance of a new amateur operator license, and for a change in class of operating privileges. Credit may be given, however, for certain elements of examination as provided in §12.46.

§12.42 *Examination elements.* Examinations for amateur operator privileges will comprise one or more of the following examination elements:

Element 1 (A): *Beginner's code test.* Code test at five (5) words per minute.

Element 1 (B): *General code test.* Code test at thirteen (13) words per minute.

Element 1 (C): *Expert's code test.* Code test at twenty (20) words per minute.

Element 2: *Basic amateur practice.* Amateur radio operation and apparatus, including radiotelephone and radiotelegraph.

Element 3 (A): *Basic law.* Rules and regulations essential to beginners' operation, including sufficient elementary radio theory for the understanding of those rules.

Element 3 (B): *General regulations.* Provisions of treaties, statutes, and rules and regulations affecting all amateur stations and operators.

Element 4 (B): *Advanced amateur practice.* Advanced radio theory and operation as applicable to modern amateur techniques, including, but not limited to, radiotelephone, radiotelegraphy, and transmissions of energy for measurements and observations applied to propagation, for the radio control of remote objects and for similar experimental purposes.

§12.43 *Examination requirements.* Applicants for original licenses will be required to pass examination as follows:

(a) *Amateur Extra Class.* Elements 1 (C), 2, 3 (B) and 4 (B).

(b) *General Class.* Elements 1 (B), 2 and 3 (B).

(c) *Conditional Class.* Elements 1 (B), 2 and 3 (B).

(d) *Technician Class.* Elements 1 (A), 2 and 3 (B).

(e) *Novice Class.* Elements 1 (A) and 3 (A).

§12.44 *Manner of conducting examinations.*

(a) The examinations for Extra and General Classes of amateur operator licenses will be conducted by an authorized Commission employee or representative at locations and at times specified by the Commission. The examinations for Conditional Class, as well as Technician and Novice Class licenses, will be conducted in accordance with the provisions of paragraph (c) of this section. The examinations for Conditional Class will be available only under one or more of the following conditions:

(1) If the applicant's actual residence and proposed amateur station location are more than 75 miles airline distance from the nearest location at which examinations are conducted by an authorized Commission employee or representative at intervals of not more than 3 months for amateur operator licenses; or

(2) If the applicant is shown by physician's certificate to be unable to appear for examination because of protracted disability; or

(3) If the applicant is shown by certificate of the commanding officer to be in the armed forces of the United States at an Army, Navy, Air Force, or Coast

Guard station and, for that reason, to be unable to appear for examination at the time and place designated by the Commission.

(b) A holder of a Conditional, Technician, or Novice Class license obtained on the basis of an examination under the provisions of paragraph (c) of this section is not required to be re-examined when changing residence and station location to within a regular examination area, nor when a new examination location is established within 75 miles of such licensee's residence and station location.

(c) Each examination for Conditional Class license, or for Technician, or Novice Class license shall be conducted and supervised by not more than two volunteer examiners, whom the Commission may designate or permit the applicant to select (not more than one examiner for the code test and not more than one examiner for the complete written examination). In the event the examiner for the code test is selected by the applicant, such examiner shall be the holder of an Extra Class, Advanced Class, or General Class amateur operator license; or shall have held, within the 5 years prior to the date of the examination, a commercial radiotelegraph operator license issued by the Commission or within that time shall have been employed in the service of the United States as the operator of a manually operated radiotelegraph station. The examiner for the written test shall be at least 21 years of age. Examinations for Conditional Class will be available only under special conditions set forth in paragraph (a) (1), (2), or (3) of this section.

§12.45 *Additional examination for holders of Conditional Class operator licenses.* (a) The Commission may require a licensee holding a Conditional Class of operator license to appear for a General Class license examination at a location designated by the Commission. If the licensee fails to appear for the General Class examination when directed to do so, or fails to pass such examination, the Conditional Class operator license previously issued shall be subject to cancellation and, upon cancellation, a new license will not be issued for the Conditional Class privileges.

(b) Whenever the holder of a conditional class amateur operator license is required by the Commission to restrict the operation of his amateur station, in accordance with the provisions of §§12.152, 12.153 and 12.154, the necessity for those restrictions shall be considered sufficient grounds to require the holder of the Conditional Class license to appear for the General Class examination.

§12.46 *Examination credit.* (a) An applicant for a higher class of amateur operator license who holds a valid amateur operator license issued upon the basis of an examination by the Commission will be required to pass only those elements of the higher class examination that were not included in the examination for the amateur license held when such application was filed. However, credit will not be allowed for licenses issued on the basis of an examination given under the provisions of §12.44 (c).

(b) An applicant for any class of amateur operator license, except the Extra Class, will be given credit for the telegraph code element if within five years prior to the receipt of his application by the Commission he held a commercial radiotelegraph operator license or permit issued by the Federal Communications Commission.

(c) An applicant for Amateur Extra Class operator license will be given credit for examination elements 1 (C) and 4 (B) if he so requests and submits evidence of having held a valid amateur radio station or operator license issued by any agency of the United States Government during or prior to April 1917, and qualifies for or currently holds a valid amateur operator license of the General or Advanced Class.

(d) No examination credit, except as herein provided, shall be allowed on the basis of holding or having held any amateur or commercial operator license.

§12.47 *Examination procedure.* All written portions of the examinations for amateur operator privileges shall be completed by the applicant in legible handwriting or hand printing, and diagrams shall be drawn by hand, by means of either pen and ink or pencil. Whenever the applicant's signature is required, his normal signature shall be used. Applicants unable to comply with these requirements, because of physical disability, may dictate their answers to the examination questions and the receiving code test and if unable to draw required diagrams, may dictate a detailed description essentially equivalent. If the examination or any part thereof is dictated, the examiner shall certify the nature of the applicant's disability and the name and address of the person(s) taking and transcribing the applicant's dictation.

§12.48 *Grading.* (a) Code tests for sending and receiving are graded separately. Failure to pass the required code test for either sending or receiving will terminate the examination.

(b) Seventy-four percent is the passing grade for written examinations. For the purpose of grading, all elements, other than element 4 (B), required in qualifying for a particular license will be considered a single examination, and element 4 (B), will be considered as a separate examination.

§12.49 *Eligibility for reexamination.* An applicant who fails examination for an amateur operator license may not take another examination for the same or a higher class amateur operator license within 30 days, except that this limitation shall not apply to an examination for a General Class license following an examination conducted by a volunteer examiner for a Novice, Technician, or Conditional Class license.

§12.50 *Code test procedure.* The code test required of an applicant for amateur radio operator license, in accordance with the provisions of §§12.42 and 12.43 shall determine the applicant's ability to transmit by hand key (straight key or if supplied by the applicant, any other type of hand operated key such as a semi-automatic or electronic key) and to receive by ear, in plain language, messages in the International Morse Code at not less than the prescribed speed, free from omission or other error for a continuous period of at least 1 minute during a test period of 5 minutes counting five characters to the word, each numeral or punctuation mark counting as two characters.

AMATEUR RADIO STATIONS LICENSES

§12.60 *Limitation on antenna structures.* (a) No new antenna structure shall be erected for use by any station in the Amateur Radio Service, and no change shall be made in any existing antenna structure used or intended to be used by any station in the Amateur Radio Service so as to increase its over-all height above ground level, without prior approval by the Commission, in any case when either (1) the antenna structure proposed to be erected will exceed an over-all height of 170 feet above ground level, except in the case where the antenna is mounted on top of an existing man-made structure and does not increase the over-all height of such man-made structure by more than 20 feet, or (2) the antenna structure proposed to be erected will exceed an over-all height of one foot above the established elevation of any landing area for each 200 feet of distance, or fraction thereof, from the nearest boundary of such landing area, except in the case where the antenna structure does not exceed 20 feet above the ground or is mounted on top of an existing man-made structure or natural formation and does not increase the over-all height of such man-made structure or natural formation by more than 20 feet as a result of such mounting. Application for Commission approval, when such approval is required, shall be submitted on FCC Form No. 401-A, in triplicate.

(b) In cases where FCC Form No. 401-A is required to be filed, further details as to whether an aeronautical study and/or obstruction marking may be required, and specifications for obstruction marking when required, may be obtained from Part 17 of this chapter. "Rules Concerning the Construction, Marking, and Lighting of Antenna Towers and Supporting Structures." Information regarding requirements as to inspection of obstruction marking, recording of information regarding such inspection, and maintenance of antenna structures is also contained in Part 17.

§12.61 *Eligibility for amateur station license.* A license for an amateur station will be issued in response to proper application therefor to a licensed amateur operator who has made a satisfactory showing of control of the transmitting station for which license is desired and of control of the specific premises upon which all of the station apparatus is to be located, at a designated fixed location. An amateur station license may be issued to an individual, not a licensed amateur operator (other than an alien or a representative of an alien or of a foreign government), who is in charge of a proposed amateur station located in approved public quarters and established for training purposes in connection with the armed forces of the United States, but not operated by the United States Government.

§12.62 *Eligibility of corporations or organizations to hold license.* An amateur station license will not be issued to a school, company, corporation, association, or other organization, nor for its use, except that in the case of a bona fide amateur radio organization or society, a station license may be issued to a licensed amateur operator, other than the holder of a Novice Class license, as trustee for such society.

§12.63 *Application for amateur station license.* (a) Each application for an amateur station license shall comply with the Commission's rules and regulations and shall be made in writing, subscribed and verified on FCC Form No. 610 (application for amateur operator and/or station license). FCC Form No. 602 should be used where the applicant is in charge of a proposed amateur station located in approved public quarters and established for training purposes in connection with the armed forces of the United States, but not operated by the United States Government.

(b) One application and all papers incorporated therein and made a part thereof shall be submitted for each amateur station license. If the application is for station license only, it shall be filed directly with the Commission at its Washington 25, D. C., office. If the application also contains application for any class of amateur operator license, it shall be filed in accordance with the provisions of §12.22.

§12.64 *Location of station.* (a) Every amateur station shall have a fixed transmitter location. Only one fixed transmitter location will be authorized and will be designated on the license for each amateur station, except that when remote control is authorized, the location of the remote control position as well as the location of the remotely controlled transmitter shall be considered as fixed transmitter locations and will be so designated on the station license. Unless remote control of the transmitting apparatus is authorized, such apparatus shall be operated only by a duly licensed amateur radio operator present at the location of such apparatus.

(b) Authority for operation of an amateur station with the licensed operator on duty at a specific remote control point in lieu of the remote transmitter location may be granted upon filing an application for a modified station license on FCC Form No. 610 or FCC Form No. 602, as appropriate, and provided that the following conditions are met:

(1) The remote control point as well as the remotely controlled transmitter, shall be located on premises controlled by the licensee.

(2) The remotely controlled transmitter shall be so installed and protected that it is inaccessible to other than duly authorized persons.

(3) In addition to the requirements of §12.68 a photocopy of the amateur station license shall be posted in a conspicuous place at the location of the remotely controlled transmitter.

(4) Means shall be provided at the control point to permit the continuous monitoring of the emissions of the remotely controlled transmitter, and it shall be continuously monitored when in operation.

(5) Means shall be provided at the remote control point immediately to suspend the radiation of the transmitter when there is any deviation from the terms of the station license or from the Rules Governing Amateur Radio Service.

(6) In the event that operation of an amateur transmitter from a remote control point by radio is desired, an application for a modified station license on FCC Form No. 610 or FCC Form No. 602, as appropriate, should be submitted with a letter requesting authority to operate in such a manner stating that the controlling transmitter at the remote location will operate within amateur frequency bands 420 megacycles or higher and that there will be full compliance with §12.64 (b), subparagraphs (1) through (5). Supplemental statements and diagrams should accompany the application and show how radio remote control will be accomplished and what means will be employed to prevent unauthorized operation of the transmitter by signals other than those from the controlling unit. There should be included complete data on control channels, relays and functions of each, directional

antenna design for the transmitter and receiver in the control circuit, and means employed for turning on and off the main transmitter from the remote control location.

§12.65. *License period.* The license for an amateur station is normally valid for a period of 5 years from the date of issuance of a new or renewed license except that an amateur station license issued to the holder of a Novice Class amateur operator license is normally valid for a period of 1 year from the date of issuance. Any modified or duplicate license shall bear the same expiration date as the license for which it is a modification or duplicate.

§12.66 *Authorized apparatus.* An amateur station license authorizes the use under control of the license of all transmitting apparatus at the fixed location specified in the station license which is operated on any frequency, or frequencies allocated to the amateur service, and in addition authorizes the use, under control of the licensee, of portable and mobile transmitting apparatus operated at other locations.

§12.68 *Availability of station license.* The original license of each amateur station or a photocopy thereof shall be posted in a conspicuous place in the room occupied by the licensed operator while the station is being operated at a fixed location or shall be kept in his personal possession. When the station is operated at other than a fixed location, the original station license or a photocopy thereof shall be kept in the personal possession of the station licensee (or a licensed representative) who shall be present at the station while it is being operated as a portable or mobile station. The original station license shall be available for inspection by any authorized Government official at all times while the station is being operated and at other times upon request made by an authorized representative of the Commission, except when such license has been filed with application for modification or renewal thereof, or has been mutilated, lost, or destroyed, and application has been made for a duplicate license in accordance with §12.26.

CALL SIGNS

§12.81 *Assignment of call sign.* (a) The call signs of amateur stations will be assigned systematically by the Commission with the following exceptions:

(1) A specific unassigned call sign may be reassigned to the most recent holder thereof;

(2) A specific unassigned call sign may be assigned to a previous holder if not under license during the past 5 years;

(3) A specific unassigned call sign may be assigned to an amateur organization in memoriam to a deceased member and former holder thereof;

(4) A specific call sign may be temporarily assigned to a station connected with an event, or events, of general public interest;

(5) An unassigned "two-letter call sign" (a call sign having two letters following the numeral) may be assigned to a previous holder of a two-letter call sign the prefix of which consisted of not more than a single letter.

(b) An amateur call sign will consist of a sequence of one or two letters, a numeral designating the call sign area, and two or three letters. The call sign areas are as follows:

No.

1. Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut.
2. New York, New Jersey.
3. Pennsylvania, Delaware, Maryland, District of Columbia.
4. Virginia, North and South Carolina, Georgia, Florida, Alabama, Tennessee, Kentucky, Puerto Rico and Virgin Islands.
5. Mississippi, Louisiana, Arkansas, Oklahoma, Texas, New Mexico.
6 California, Hawaii and Pacific possessions except those included in area 7.
7. Oregon, Washington, Idaho, Montana, Wyoming, Arizona, Nevada, Utah, Alaska and adjacent islands.
8. Michigan, Ohio, West Virginia.

9. Wisconsin, Illinois, Indiana.
10. Colorado, Nebraska, North and South Dakota, Kansas, Minnesota, Iowa, Missouri.

§12.82 *Transmission of call signs.* (a) (1) The operator of an amateur station shall transmit the call sign of the station or stations (or may transmit the generally accepted identification of the network) being called or communicated with, or shall identify appropriately any other purpose of a transmission, followed by the authorized call sign of the station transmitting:

(i) At the beginning and end of each single transmission or;

(ii) At the beginning and end of a series of transmissions between stations having established communication, each transmission of which is of less than three minutes duration (the identification at the end of such a series may be omitted when the duration of the entire series is less than three minutes), and;

(iii) At least once every ten minutes or as soon thereafter as possible during a series of transmissions between stations having established communication, and;

(iv) At least once every ten minutes during any single transmission of more than ten minutes duration.

(2) The required identification shall be transmitted on the frequency or frequencies being employed at the time and, in accordance with the type of emission authorized thereon, shall be by either telegraphy using the International Morse Code, or telephony. In addition to the foregoing, when a method of communication other than telephony or telegraphy using the International Morse Code is being used or attempted, the prescribed identification shall also be transmitted by that method.

(b) In addition to complying with the requirements of paragraph (a) of this section, an operator of an amateur station operated as a portable or mobile station using radiotelegraphy shall transmit immediately after the call sign of such station, the fraction-bar character (DN) followed by the number of the amateur call sign area in which the portable or mobile amateur station is then being operated, as for example:

Example 1. Portable or mobile amateur station operating in the third amateur call sign area calls a fixed amateur station: W1ABC W1ABC W1ABC DE W2DEF DN 3 W2DEF DN 3 W2DEF DN 3 AR.

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

Example 3. Portable or mobile amateur station calls a portable or mobile amateur station: W3GHI W3GHI W3GHI DE W4JKL DN 4 W4JKL DN 4 W4JKL DN 4 AR.

When telephony is used, the call sign of the station shall be preceded by the words "this is" or the word "from" instead of the letters "de", followed by an announcement of the geographical location in which the portable or mobile station is being operated.

Example 4. Portable or mobile amateur radiotelephone station operating in the third call area calls a fixed amateur station: W1ABC W1ABC W1ABC "this is" or the word "from" W2DEF W2DEF W2DEF operating portable (or mobile) 3 miles north of Bethesda, Md., over.

(c) When telephony is used, the transmission of call signs prescribed by paragraphs (a) and (b) of this section may be made by the person transmitting by voice in lieu of a duly licensed operator provided the licensed operator maintains the control required by §12.28.

(d) When using telephony, phonetic aids to identify the call sign of the station may be employed.

(e) In addition to complying with the requirements of paragraph (a) of this section, an operator of an amateur station operated as a mobile station aboard a vessel on the high sea, or aboard an aircraft en route on an international flight, shall, when the vessel or aircraft is outside the 10 call sign areas prescribed by the commission in §12.81 (b), comply with the following calling procedure:

(1) Mobile operations aboard a vessel.

(i) When using telegraphy the amateur operator shall transmit immediately after the call sign of the station the fraction bar DN followed by the designator

MM to indicate that the station is being operated as a mobile station aboard a vessel. In addition, the name of the vessel and its approximate geographical location shall be transmitted at the end of each transmission immediately prior to signing off. If the vessel does not have a name, the number of the vessel shall be transmitted in lieu of the name of the vessel.

(ii) When using telephony the call sign of the station shall be preceded by the words "this is," or the word "from" followed by the words "maritime mobile" to indicate that the station is being operated as a mobile station aboard a vessel. In addition the name of the vessel, and its approximate geographical location shall be transmitted at the end of each transmission immediately prior to signing off. If the vessel does not have a name, the number of the vessel shall be transmitted in lieu of the name of the vessel.

(2) Mobile operations aboard aircraft.

(i) When using telegraphy the amateur operator shall transmit immediately after the call sign of the station the fraction bar DN followed by the designator AM to indicate that the station is being operated as a mobile station aboard an aircraft. In addition, the number of the aircraft and its approximate geographical location shall be transmitted at the end of each transmission immediately prior to signing off.

(ii) When using telephony the call sign of the station shall be preceded by the words "this is," or the word "from" followed by the words "aeronautical mobile," to indicate that the station is being operated as a mobile station aboard an aircraft. In addition, the number of the aircraft and its approximate geographical location shall be transmitted at the end of each transmission immediately prior to signing off.

§12.91 *Requirements for portable and mobile operation.* (a) Within the continental limits of the United States, its territories, or possessions, an amateur station may be operated as either a portable or a mobile station on any frequency authorized and available for the amateur radio service. Whenever portable operation is, or is likely to be, for an over-all period in excess of 48 hours away from the fixed transmitter location designated in the station license, the licensee shall give prior written notice to the Engineer in Charge of the radio inspection district in which such portable operation is intended. This notice is required even though the station is, or is likely to be operated during any part of this over-all period at the fixed transmitter location. Whenever mobile operation is, or is likely to be, for a period in excess of 48 hours without return to the fixed transmitter location designated in the station license, the licensee shall give prior written notice to the Engineer in Charge of the radio inspection district in which such mobile operation is intended. The notice required for either portable or mobile operation shall state the station call sign, the name of the licensee, the date or dates of proposed operation and the contemplated portable station locations, or mobile station itinerary, as specifically as possible. Additional advanced written notice shall also be given, in accordance with the foregoing, whenever such operation away from the fixed station location designated in the station license exceeds one month, and for each additional month of such operation.

(b) When outside the continental limits of the United States, its territories, or possessions, an amateur radio station may be operated as portable or mobile only under the following conditions:

(1) Operation may not be conducted within the jurisdiction of a foreign government except pursuant to, and in accordance with, expressed authority granted to the licensee by such foreign government.

(2) Operation may be conducted only in the amateur frequency bands 21.0 to 21.45 Mc and 28.0 to 29.7 Mc: *Provided,* That this limitation shall not be construed to prevent the use of other amateur frequency bands where operation is within the jurisdiction of a foreign government which permits United States amateurs to operate within such foreign territory. (See Appendix 4 of this part for the text of treaties or agreements between the United States and foreign governments relative to reciprocal amateur radio operation.)

(3) Whenever portable or mobile operation is, or is likely to be, away from the territorial limits of the United States for a period in excess of 48 hours, the licensee shall give prior written notice thereof to the Engineer in Charge of the radio inspection district having jurisdiction of the authorized fixed transmitter site of the station; *Provided*, That only one such notice shall be required during any one continued absence.

§12.93 *Special provisions for non-portable stations.* The specific provisions of these rules relative to portable stations are not applicable to a nonportable station except that —

(a) An amateur station that has been moved from one permanent location to another permanent location may be operated at the latter location, in accordance with the provisions governing portable stations (including notice to the Engineer in Charge of the District in which the station is located) for a period not exceeding four consecutive months, but in no event beyond the expiration date of the license, provided a formal application for modification of license to change the permanent location has been filed with the Commission.

(b) The licensee of an amateur station who changes residence temporarily, but retains a permanent residence associated with the fixed station location designated in the station license, and moves his amateur station to a temporary location associated with his temporary residence, or the licensee-trustee for an amateur radio society which changes the normal location of its amateur station to a different and temporary location, may use the station at such temporary location under the following conditions:

(1) Advance notice in writing shall be given by the amateur station licensee or licensee-trustee to the Commission in Washington, D. C., and, for each month of such operation, to the Engineer in Charge of the radio inspection district in which the station is to be temporarily operated.

(2) Similar notice shall be given for each change in such temporary location, for the return of the station to the former permanent location, or for the establishment of a new permanent location; *Provided*, That additional monthly notices to the Engineer in Charge shall not be required when such operation takes place at the fixed station location designated in the station license held by the licensee.

(3) The notice of operation at a temporary location, as required under the preceding provisions of this paragraph, shall clearly identify the station call-sign and licensee or licensee-trustee, shall indicate both the permanent, and the temporary station locations, shall indicate the address at which the licensee or licensee-trustee can be readily reached during such temporary operation, and shall show the reason why operation at that location is considered temporary rather than a change of permanent location.

(c) When the station is operated under the provisions of this section the calling procedure specified in §12.82 shall be used, including transmissions of the fractional bar character when telegraphy is used followed by the number of the amateur call sign area in which the station is being operated. When telephony is used, an announcement shall be made of the geographical location in which the station is being operated.

USE OF AMATEUR STATIONS

§12.101 *Points of communication.* An amateur station may be used to communicate only with other amateur stations, except that in emergencies or for test purposes it may also be used temporarily for communication with other classes of stations licensed by the Commission, and with United States Government stations. Amateur stations may also be used to communicate with any radio station other than amateur which is authorized by the Commission to communicate with amateur stations. Amateur stations may be used also for transmitting signals, or communications, or measurement of emissions, temporary observation of transmission phenomena, radio control of remote objects, and for similar experimental purposes and for the purposes set forth in §12.106.

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

§12.103 *Broadcasting prohibited.* Subject to the provisions of §12.106, an amateur station shall not be used to engage in any form of broadcasting, that is, the dissemination of radio communications intended to be received by the public directly or by the intermediary of relay stations, nor for the retransmission by automatic means of programs or signals emanating from any class of station other than amateur. The fore-going provision shall not be construed to prohibit amateur operators from giving their consent to the rebroadcast by broadcast stations of the transmissions of their amateur stations, provided, that the transmissions of the amateur stations shall not contain any direct or indirect reference to the rebroadcast.

§12.104 *Radio telephone tests.* The transmission of music by an amateur station is forbidden. However, single audio-frequency tones may be transmitted for test purposes of short duration for the development and perfection of amateur radio telephone equipment.

§12.105 *Codes and ciphers prohibited.* The transmission by radio of messages in codes or ciphers in domestic and international communications to or between amateur stations is prohibited. All communications regardless of type of emission employed shall be in plain language except that generally recognized abbreviations established by regulation or custom and usage are permissible as are any other abbreviations or signals where the intent is not to obscure the meaning but only to facilitate communications.

§12.106 *One-way communications.* In addition to the experimental one-way transmissions permitted by §12.101, the following kinds of one-way communications, addressed to amateur stations, are authorized and will not be construed as broadcasting: (a) Emergency communications, including bonafide emergency drill practice transmissions; (b) Information bulletins consisting solely of subject matter having direct interest to the amateur radio service as such; (c) Round-table discussions or net-type operations where more than two amateur stations are in communication, each station taking a turn at transmitting to other station(s) of the group; and (d) Code practice transmission intended for persons learning or improving proficiency in the International Morse Code.

ALLOCATION OF FREQUENCIES

§12.111 *Frequencies and types of emission for use of amateur stations.* Subject to the limitations and restrictions set forth in this section and in §12.114, the following frequency bands and types of emissions are allocated and available for amateur station operation:

(a) 1800 to 2000 kc. Use of this band is on a shared basis with the Loran system of radionavigation. The amateur service may use, in any area, whichever bands, 1800-1825, 1875-1900, 1900-1925 or 1975-2000 kc, are not required for Loran in that area, in accordance with the following conditions:

(1) The use of these frequencies by the amateur service shall not be a bar to the expansion of the radionavigation (Loran) service.

(2) The use of these frequencies by stations in the amateur service shall not cause harmful interference to the Loran system of radionavigation. If an amateur station causes such interference, the station licensee shall, as directed by the Commission, immediately cease operation on the frequencies involved.

(3) Only type A1 or A3 emission shall be employed.

(4) Amateur operation shall be limited to the following areas, to the indicated frequency bands within each such area, and to the indicated maximum plate power input to the tube or tubes supplying energy to the antenna during day and night hours, respectively, on such frequencies:

Area	*Authorized bands, kc*	*DC plate input power in watts*	
		Day	*Night*
Minnesota, Iowa, Missouri, Arkansas, Louisiana and States to the east of these States, including District of Columbia	1800-1825, 1875-1900	500	200
North Dakota, South Dakota, Nebraska, Colorado, New Mexico and States to the west of these States except the State of Washington	1900-1925, 1975-2000	500	200
State of Washington	1900-1925, 1975-2000	200	50
Texas, Oklahoma, and Kansas	1800-1825, 1875-1900	200	75
Hawaiian Islands	1900-1925, 1975-2000	500	200
Puerto Rico and Virgin Islands	1800-1825, 1875-1900	500	200
Alaska, Guam, and other Territories and possessions of the United States not listed above	None	No operation	No operation

(5) The provisions of this subparagraph shall be considered as temporary in the sense that they shall remain subject to cancellation or to revision, in whole or in part, by order of the Commission without hearing whenever the Commission shall deem such cancellation or revision to be necessary or desirable in the light of the priority within this band of the Loran system of radionavigation.

(b) 3500 to 4000 kc, using type A1 emission, and on frequencies 3500 to 3800 kc, using type F1 emission, and on frequencies 3800 to 4000 kc, using type A3 emission and narrow band frequency or phase modulation for radiotelephony: except that frequencies 3900 to 4000 kc are not available to stations located within the following United States possessions in Region 3, as defined in the Atlantic City, 1947, Radio Regulations: Baker, Canton, Enderbury, Guam, Howland, Jarvis, Palmyra, American Samoa, and Wake Islands.

(c) 7000 to 7300 kc, using type A1 emission and, on frequencies 7000 to 7200 kc, using type F1 emission and, on frequencies 7200 to 7300 kc, using type A3 emission or narrow band frequency or phase modulation for radiotelephony.

(d) 14,000 to 14,350 kc, using type A1 emission, 14,000 to 14,200 kc and 14,300 to 14,350 kc using type F1 emission and on frequencies 14,200 to 14,300 kc, type A3 emission or narrow band frequency or phase modulation for radiotelephony.

(e) 21.00 to 21.45 Mc, using type A1 emission; 21.00 to 21.25 Mc, using type F1 emission, 21.25 to 21.45 Mc, using type A3 emission and narrow band frequency or phase modulation for telephony.

(f) 26.960 to 27.230 Mc using A0, A1, A2, A3, and A4 emission and also special emission for frequency modulation (radiotelephone transmissions and radiotelegraph transmissions employing carrier shift or other frequency modulation techniques), subject to such interference as may result from the emissions of industrial, scientific and medical devices within 160 kc of the frequency 27.120 Mc.

(g) 28.0 to 29.7 Mc, using type A1 emission and, on frequencies 28.5 to 29.7 Mc using type A3 emission and narrow band frequency or phase modulation for radiotelephony and, on frequencies 29.0 to 29.7, using special emission for frequency modulation (radiotelephone transmissions and radiotelegraph transmissions employing carrier shift or other frequency modulation techniques).

(h) 50.0 to 54.0 Mc using types A1, A2, A3, and A4 emissions and narrow band frequency or phase modulation for radiotelephony, 51.0 to 54.0 Mc using type A0 emission, and on frequencies 52.5 to 54.0 Mc special emission for frequency modulation (radiotelephone transmissions and radiotelegraph transmissions employing carrier shift or other frequency modulation techniques).

(i) 144 to 148 Mc, using types A0, A1, A2, A3, and A4 emission and special emission for frequency modulation (radiotelephone transmissions and radiotelegraph transmissions employing carrier shift or other frequency modulation techniques).

(j) 220 to 225 Mc[1] using types A0, A1, A2, A3, and A4 emission and special emission for frequency modulation (radiotelephone transmissions and radiotelegraph transmissions employing carrier shift or other frequency modulation techniques).

(k) 420 to 450 Mc, using types A0, A1, A2, A3, A4, and A5 emissions and special emission for frequency modulation (radiotelephone transmissions and radiotelegraph transmissions employing carrier shift or other frequency modulation techniques).

The maximum DC plate power input to the final stage of the transmitter shall not exceed 50 watts.

(l) 1215 to 1300 Mc, using types A0, A1, A2, A3, A4, and A5 emissions and special emission for frequency modulation (radiotelephone transmissions and radiotelegraph transmissions employing carrier shift or other frequency modulation techniques).

(m) 2300 to 2450 Mc, 3300 to 3500 Mc, 5650 to 5925 Mc, 10,000 to 10,500 Mc, 21,000 to 22,000 Mc, and any frequency or frequencies above 30,000 Mc, using on these frequencies types A0, A1, A2, A3, A4, A5 emission and special emission for frequency modulation (radiotelephone transmissions and radiotelegraph transmissions employing carrier shift or other frequency modulation techniques), and pulse emission. Operations in the frequency bands 2300 to 2450 Mc and 5650 to 5925 Mc are subject to such interference between 2400 and 2450 Mc and between 5775 and 5925 Mc, respectively, as may result from emissions of industrial, scientific and medical devices on the frequencies 2450 and 5850 Mc, respectively.

§12.113 *Individual frequency not specified.* Transmissions by an amateur station may be on any frequency within any authorized amateur band. Sideband frequencies resulting from keying or modulating a carrier wave shall be confined within the authorized amateur band.

§12.114 *Types of emission.* (a) Type A0 emission, where not specifically designated in the bands listed in §12.111, may be used for short periods of time when required for authorized remote control purposes or for experimental purposes. However, these limitations do not apply where type A0 emission is specifically designated.

(b) Whenever code practice, in accordance with section 12.106 (d), is conducted in bands authorized for A3 emission, tone modulation of the radiotelephone transmitter may be utilized when interspersed with appropriate voice instructions.

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[1]In those portions of the states of Texas and New Mexico in the area bounded on the south by parallel 31° 53' N., on the east by longitude 105° 40' W., on the north by parallel 33° 24' N., and on the west by longitude 106° 40' W., the frequency band 220-225 Mc is not available for use by amateur stations engaged in normal amateur operation between the hours of 0500 and 1800 local time Monday through Friday inclusive of each week. However, the entire frequency band 220-225 Mc shall be applicable in all areas to those amateur stations authorized to operate in organized civil defense drills between the hours and within the area set forth above may be made upon mutual agreement between the Federal Communications Commission Engineer in Charge at Dallas, Texas, and the Area Frequency Coordinator at White Sands, New Mexico, if it appears necessary to conduct such drills. Such arrangements shall specify dates and times, and will depend upon the degree of use of the frequency band at White Sands at any particular time.

(c) The use of narrow band frequency or phase modulation is subject to the conditions that the band-width of the modulated carrier shall not exceed the band-width occupied by an amplitude-modulated carrier of the same audio characteristics, and that the purity and stability of such emissions shall be maintained in accordance with the requirements of §12.133.

EQUIPMENT AND OPERATION

§12.131. *Maximum authorized power.* Except on frequencies within the band 420 to 450 megacycles (where the maximum DC plate power input to the final stage of the transmitter shall not exceed 50 watts) each amateur transmitter may be operated with a power input not exceeding 1 kilowatt to the plate circuit of the final amplifier stage of an amplifier-oscillator transmitter or to the plate circuit of an oscillator transmitter. An amateur transmitter operating with a power input exceeding 900 watts to the plate circuit shall provide means for accurately measuring the plate power input to the vacuum tube or tubes supplying power to the antenna

§12.132 *Power supply to transmitter.* The licensee of an amateur station using frequencies below 144 megacycles shall use adequately filtered direct-current plate power supply for the transmitting equipment to minimize modulation from this source.

§12.133 *Purity and stability of emissions.* Spurious radiation from an amateur station being operated with a carrier frequency below 144 megacycles shall be reduced or eliminated in accordance with good engineering practice. This spurious radiation shall not be of sufficient intensity to cause interference in receiving equipment of good engineering design including adequate selectivity characteristics, which is tuned to a frequency or frequencies outside the frequency band of emission normally required for the type of emission being employed by the amateur station. In the case of A3 emission, the amateur transmitter shall not be modulated to the extent that interfering spurious radiation occurs, and in no case shall the emitted carrier wave be amplitude-modulated in excess of 100 percent. Means shall be employed to insure that the transmitter is not modulated in excess of its modulation capability for proper technical operation. For the purposes of this section a spurious radiation is any radiation from a transmitter which is outside the frequency band of emission normal for the type of transmission employed, including any component whose frequency is an integral multiple or submultiple of the carrier frequency (harmonics and sub-harmonics), spurious modulation products, key clicks, and other transient effects, and parasitic oscillations. When using amplitude modulation on frequencies below 144 megacycles, simultaneous frequency modulation is not permitted and when using frequency modulation on frequencies below 144 megacycles simultaneous amplitude modulation is not permitted. The frequency of the emitted carrier wave shall be as constant as the state of the art permits.

§12.134 *Modulation of carrier wave.* Except for brief tests or adjustments and except for operation in the band 26.96 to 27.23 Mc, an amateur radiotelephone station shall not emit a carrier wave on frequencies below 51 Mc unless modulated for the purpose of communication.

§12.135. *Frequency measurement and regular check.* The licensee of an amateur station shall provide for measurement of the emitted carrier frequency or frequencies and shall establish procedure for making such measurement regularly. The measurement of the emitted carrier frequency or frequencies shall be made by means independent of the means used to control the radio frequency or frequencies generated by the transmitting apparatus and shall be of sufficient accuracy to assure operation within the amateur frequency band used.

§12.136 *Logs.* Each licensee of an amateur station shall keep an accurate log of station operation, which shall include the following:

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

(b) The signature of each licensed operator who manipulates the key of a radiotelegraph transmitter or the signature of each licensed operator who operates a transmitter of any other type and the name of any person not holding an amateur operator license who transmits by voice over a radiotelephone transmitter. The signature of the operator need only be entered once in the log, in those cases when all transmissions are made by or under the supervision of the signatory operator, provided a statement to that effect also is entered. The signature of any other operator who operated the station shall be entered in the proper space for that operator's transmission.

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

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

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

(f) The type of emission used. (This need be entered only once until there is a change in the type of emission.)

(g) The location of the station (or the approximate geographical location of a mobile station) at the time of each transmission. (This need be entered only once provided the location of the station is not changed. However, suitable entry shall be made in the log upon changing the location. Where operating at other than a fixed location, the type and identity of the vehicle or other mobile unit in which the station is operated shall be shown.)

(h) The message traffic handled. (If record communications are handled in regular message form, a copy of each message sent and received shall be entered in the log or retained on file at the station for at least 1 year.)

§12.137 *Retention of logs.* The log shall be preserved for a period of at least 1 year following the last date of entry. The copies of record communications and station log required by §12.136 shall be available for inspection by authorized representatives of the Commission.

SPECIAL CONDITIONS

§12.151 *Additional conditions to be observed by licensee.* In all respects not specifically covered by these regulations each amateur station shall be operated in accordance with good engineering and good amateur practice.

§12.152 *Restricted operation.* (a) If the operation of an amateur station causes general interference to the reception of transmissions from stations operating in the domestic broadcast service when receivers of good engineering design including adequate selectivity characteristics are used to receive such transmissions and this fact is made known to the amateur station licensee, the amateur station shall not be operated during the hours from 8 p.m. to 10:30 p.m., local time, and on Sunday for the additional period from 10:30 a.m. until 1 p.m., local time, upon the frequency or frequencies used when the interference is created.

(b) In general, such steps as may be necessary to minimize interference to stations operating in other services may be required after investigation by the Commission.

§12.156 *Operation in emergencies.* In the event of an emergency disrupting normally available communication facilities in any widespread area or areas, the Commission, in its discretion, may declare that a general state of Communications emergency exists, designate the area or areas concerned, and specify the amateur frequency bands, or segments of such bands, for use only by amateurs participating in emergency communication within or with such affected area or areas. Amateurs desiring to request the declaration of such a state of emergency should communicate with the Commission's Regional Manager of the area concerned. Whenever such declaration has been made, operation of and with amateur stations in the area concerned shall be only in accordance with the requirements hereinafter set forth, but such requirements shall in nowise affect other normal amateur communication in the affected area when conducted on frequencies not designated for emergency operation.

(a) All transmissions within all designated amateur emergency communication bands other than communications relating directly to relief work, emergency service, or the establishment and maintenance of efficient amateur radio networks for the handling of such communications, shall be suspended. Incidental calling, answering, testing or working (including casual conversation, remarks or messages) not pertinent to constructive handling of the emergency situation shall be prohibited within these bands.

(b) The Commission may designate certain amateur stations to assist in the promulgation of information relating to the declaration of a general state of communications emergency, to monitor the designated amateur emergency communications bands, and to warn non-complying stations observed, to be operating in those bands. Such station, when so designated, may transmit for that purpose on any frequency or frequencies authorized to be used by that station, provided such transmissions shall preferably be made on authorized frequencies immediately adjacent to those segments of the amateur bands being cleared for the emergency. Individual transmissions for the purpose of advising other stations of the existence of the communications emergency shall refer to this section by number (§12.156) and shall specify, briefly and concisely, the date of the Commission's declaration, the area and nature of the emergency, and the amateur frequency bands or segments of such bands which constitute the amateur emergency communications bands at the time. The designated stations shall not enter into discussions with other stations beyond furnishing essential facts relative to the emergency, or acting as advisors to stations desiring to assist in the emergency, and the operators of such designated stations shall report fully to the Commission the identity of any stations failing to comply, after notice, with any of the pertinent provisions of this section.

(c) The special conditions imposed under the provisions of this section shall cease to apply only after the Commission, or its authorized representative, shall have declared such general state of communications emergency to be terminated; however, nothing in this paragraph shall be deemed to prevent the Commission from modifying the terms of its declaration from time to time as may be necessary during the period of a communications emergency, or from removing those conditions with respect to any amateur frequency band or segment of such band which no longer appears essential to the conduct of the emergency communications.

§12.157. *Obscenity, indecency, profanity.* No licensed radio operator or other person shall transmit communications containing obscene, indecent, or profane words, language, or meaning.

§12.158 *False signals.* No licensed radio operator shall transmit false or deceptive signals or communications by radio, or any call letter or signal which has not been assigned by proper authority to the radio station he is operating.

§12.159. *Unidentified communications.* No licensed radio operator shall transmit unidentified radio communications or signals.

§12.160. *Interference.* No licensed radio operator shall willfully or maliciously interfere with or cause interference to any radio communication or signal.

§12.161 *Damage to apparatus.* No licensed radio operator shall willfully damage, or cause or permit to be damaged, any radio apparatus or installation in any licensed radio station.

§12.162 *Fraudulent licenses.* No licensed radio operator or other person shall obtain or attempt to obtain, or assist another to obtain or attempt to obtain, an operator license by fraudulent means.

CONELRAD

Note: These rules apply to Continental U.S. only.

§12.190 *Scope and objective of CONELRAD.* Control of Electromagnetic Radiation applies to all radio stations in the Amateur Radio Service and is for the purpose of providing for the alerting and operation of radio stations in this service during periods of air attack or imminent threat thereof. The objective is to minimize the navigational aid that may be obtained by an enemy from the electromagnetic radiations emanating from radio stations in the Amateur Radio Service while simultaneously providing for a continued service under controlled conditions when such operation is essential to the public welfare.

§12.191 *CONELRAD Radio Alert.* The CONELRAD Radio Alert is the term applied to the Military Warning that an air attack is probable or imminent and which automatically orders the immediate implementation of CONELRAD procedures for all radio stations. The CONELRAD Radio Alert is distinct from the military or Civil Air Defense warnings Yellow or Red, but may be coincidental with such warnings.

§12.192 *Reception of Radio Alert.* (a) The licensee of a station in the Amateur Radio Service is required to provide a means for reception of the CONELRAD Radio Alert or a means for the determination that such alert is in force.

(b) All operators of stations in the Amateur Radio Service will be responsible for the reception of the CONELRAD Radio Alert or indication that such alert is in force by:

(1) Reception of a CONELRAD Radio Alert message which will be broadcast by each standard, FM and TV broadcast station on its regular assigned frequency before they leave the air; or

(2) Reception of standard broadcast stations operating under CONELRAD requirements during the period of the alert on 640 or 1240 kc; or

(3) Determining that an alert is in force by lack of normal broadcast station operation (observations made before amateur station operation is begun and at least once every ten minutes during operation thereafter will be considered as sufficient for compliance with this section); or

(4) Other means if so authorized by the Federal Communications Commission.

§12.193 *Operation during an alert.* During a CONELRAD Radio Alert the operation of all amateur radio stations, except stations in the Radio Amateur Civil Emergency Services (RACES) and stations specifically authorized otherwise, will be immediately discontinued until the Radio All Clear is issued. Stations in the RACES and such others as are specifically authorized to operate during the alert will conduct operations under the following restrictions.

(a) No transmission shall be made unless it is of extreme emergency affecting the national safety or the safety of life and property.

(b) Transmissions shall be as short as possible.

(c) No station identification shall be given, either by transmission of call letters or by announcement of location (if station identification is necessary to carry on the service, tactical calls or other means of identification will be utilized in accordance with §12.246).

(d) The radio station carrier shall be discontinued during periods of no message transmission.

§12.194 *Special operation.* In certain cases, the Federal Communications Commission may authorize specific stations to operate during a CONELRAD Radio Alert in a manner not governed by §§12.190 to 12.196, provided, such operation is determined to be necessary in the interest of National Defense or the public welfare.

§12.195 *Resumption of normal operation.* At the conclusion of a CONELRAD Radio Alert, each standard, FM and TV broadcast station will broadcast a

CONELRAD Radio All Clear Message. Unless otherwise restricted by order of the Federal Communications Commission, normal operation of stations in the Amateur Radio Service may be resumed upon reception of the CONELRAD Radio All Clear. Only the CONELRAD Radio All Clear will authorize termination of the CONELRAD Radio Alert.

§12.196 *CONELRAD TESTS.* So far as practicable, tests and practice operation will be conducted at appropriate intervals.

APPENDIX 2

EXTRACTS FROM RADIO REGULATIONS ANNEXED TO THE INTERNATIONAL TELECOMMUNICATION CONVENTION

(Atlantic City, 1947)

Article 42 — Amateur Stations

Section 1. Radiocommunications between amateur stations of different countries shall be forbidden if the administration of one of the countries concerned has notified that it objects to such radiocommunications.

Section 2. (1) When transmission between amateur stations of different countries are permitted they must be made in plain language and must be limited to messages of a technical nature relating to tests and to remarks of a personal character for which, by reason of their unimportance, resource to the public telecommunications service is not justified. It is absolutely forbidden for amateur stations to be used for transmitting international communications on behalf of third parties.

(2) The preceding provisions may be modified by special arrangements between the countries concerned.

Section 3. (1) Any person operating the apparatus in an amateur station must have proved that he is able to transmit, and to receive by ear, tests in Morse code signals. Administrations concerned may, however, waive this requirement in the case of stations making use exclusively of frequencies above 1000 (one thousand) Mc/s.

(2) Administrations shall take such measures as they judge necessary to verify the qualifications, from a technical point of view, of any person operating the apparatus of an amateur station.

Section 4. The maximum power of amateur stations shall be fixed by the administration concerned, having regard to the technical qualifications of the operators and to the conditions under which these stations must work.

Section 5. (1) All the general rules of the Convention and of the present Regulations shall apply to amateur stations. In particular, the transmitting frequency must be as constant and as free from harmonics as the state of technical development for stations of this nature permits.

(2) During the course of their transmissions amateur stations must transmit their call sign at short intervals.

APPENDIX 3

CLASSIFICATION OF EMISSIONS

For convenient reference the tabulation below is extracted from the "Classification of Emissions" tables in Part 2 of the Commission's Rules and Regulations and in the Atlantic City (1947) Radio Regulations, and it includes only those general classifications which appear most applicable to the Amateur Radio Service.

Type of Modulation or Emission	*Type of Transmission*	*Symbol*
1. Amplitude	Absence of any modulation	A0
	Telegraphy without the use of modulating audio frequency (on-off keying)	A1
	Telegraphy by the keying of a modulating audio frequency or audio frequencies or by the keying of the modulated emission (special case: an unkeyed modulated emission)	A2
	Telephony	A3
	Facsimile	A4
	Television	A5
2. Frequency (or phase) modulated.	Absence of any modulation	F0
	Telegraphy without the use of modulating audio frequency or audio frequencies or by keying of the modulated emission (special case: an unkeyed emission modulated frequency)	F1
	Telephony	F3
	Facsimile	F4
	Television	F5
3. Pulsed emissions.		P

APPENDIX 4

Convention Between the United States of America and Canada, Relating to the Operation by Citizens of Either Country of Certain Radio Equipment or Stations in the other Country (Effective May 15, 1952)

Article III

It is agreed that persons holding appropriate amateur licenses issued by either country may operate their amateur stations in the territory of the other country under the following conditions:

(a) Each visiting amateur may be required to register and receive a permit before operating any amateur station licensed by his government.

(b) The visiting amateur will identify his station by:

(1) Radiotelegraph operation. The amateur call sign issued to him by the licensing country followed by a slant (/) sign and the amateur call sign prefix and call area number of the country he is visiting.

(2) Radiotelephone operation. The amateur call sign in English issued to him by the licensing country followed by the words, "fixed," "portable" or "mobile", as appropriate, and the amateur call sign prefix and call number of the country he is visiting.

(c) Each amateur station shall indicate at least once during each contact with another station its geographical location as nearly as possible by city and state or city and province.

(d) In other respects the amateur station shall be operated in accordance with the laws and regulations of the country in which the station is temporarily located.

LATEST AMENDMENTS TO FCC RULES AND REGULATIONS
FEDERAL COMMUNICATIONS COMMISSION
Washington, D. C.

AMENDMENT NO. 12-19

PART 12 — RULES GOVERNING AMATEUR RADIO SERVICE

(The nineteenth amendment to edition revised to November 20, 1953)

Directions for altering text:
The table associated with Section 12,000 (a) (4) is amended to read as follows:

Area	*Authorized Bands (kc)*	*DC plate input power in watts*	
		Day	*Night*
Minnesota, Iowa, Wisconsin, Michigan, Pennsylvania, Maryland, Delaware, and States to the north of these, including the District of Columbia.	1800-1825 1875-1900	500	200
North Dakota, South Dakota, Nebraska, Colorado, New Mexico, and States to the west of these States (except State of Washington).	1900-1925 1975-2000	500	200
State of Washington	1900-1925 1975-2000	200	50
Oklahoma, Kansas, Missouri, Arkansas, Illinois, Indiana, Kentucky, Tennessee, Ohio, West Virginia, Virginia, North Carolina, South Carolina, Texas (West of 99° W. or North of 32° N.).	1800-1825 1875-1900	200	50
Hawaiian Islands	1900-1925 1975-2000	500	200
Texas (East of 99° W. and South of 32° N.), Louisiana, Mississippi, Alabama, Georgia, Florida, Puerto Rico, Virgin Islands, Alaska, Guam, and other Territories and possessions of the U.S. not listed above.	None	No operation	No operation

(Amdt. 12-19; Eff. 7-9-56)

Note: This amendment was adopted by the Commission May 16, 1956, effective July 9, 1956 (FCC 56-467); published in the Federal Register May 22, 1956 (21 FR 3371).

FEDERAL COMMUNICATIONS COMMISSION
Washington 25, D. C.

AMENDMENT NO. 12-20

PART 12 — AMATEUR RADIO SERVICE.

(The twentieth amendment to edition revised to November 20, 1953)

Directions for altering text:
1. *Amend §12.9 to read as follows:*
§12.9 Antenna structure defined. The term "antenna structure" includes the radiating system, its supporting structures, and any surmounting appurtenances. (Amdt. 12-20; Eff. 7-11-56)
2. *Amend §12.60 (a) (1), (2), and (b) to read as follows:*
(a) * * * (1) the antenna structure proposed to be erected will exceed an overall height of 170 feet above ground level, except where the antenna is mounted on an existing man-made structure other than an antenna structure and does not increase the overall height of such man-made structure by more than 20 feet, or (2) the antenna structure proposed to be erected will exceed an overall height of one foot above the established airport (landing area) elevation for each 200 feet of distance, or fraction thereof, from the nearest boundary of such landing area, except where the antenna does not exceed 20 feet above the ground or if the antenna is mounted on an existing man-made structure other than an antenna or natural formation and does not increase the overall height of such man-made structures or natural formation by more than 20 feet as a result of such mounting. Application for Commission approval, when such approval is required, shall be submitted on FCC Form 401-A (revised), in triplicate.
(b) In cases where FCC Form 401-A (revised) is required to be filed further details as to whether an aeronautical study and/or obstruction marking may be required, and specifications for obstruction marking when required, may be obtained from Part 17 of this chapter, "Construction, Marking and Lighting of Antenna Structures." Information regarding requirements as to inspection of obstruction marking, recording of information regarding such inspection, and maintenance of antenna structures is also contained in Part 17 of this chapter.
(Amdt. 12-20; Eff. 7-11-56)

NOTE: This amendment was adopted by the Commission July 11, 1956, effective July 11, 1956; published in the Federal Register July 18, 1956 (21 FR 5365.

FEDERAL COMMUNICATIONS COMMISSION
Washington 25, D. C.

AMENDMENT NO. 12-21

PART 12 — AMATEUR RADIO SERVICE.

(The twenty-first amendment to edition revised to November 20, 1953).

Directions for altering text:
1. Amend Appendix I, Part 12, by removing Jackson, Mississippi, from the "quarterly" listing, adding that city in alphabetical sequence to the "semiannual" listing within this subsection.
2. Amend Appendix I, Part 12, by removing from the "semiannual" listing the city of Butte, Montana, adding this city in alphabetical sequence to the "annual" listing within this subsection.
3. Amend Appendix I, Part 12, by removing from the "annual" listing the city of Tallahassee, Florida.

NOTE: This amendment was adopted by the Commission July 31, 1956, effective September 10, 1956; published in the Federal Register August 4, 1956 (21 FR 5823).

FEDERAL COMMUNICATIONS COMMISSION
Washington 25, D. C.

AMENDMENT 12-22

PART 12 — AMATEUR RADIO SERVICE.

(The twenty-second amendment to edition revised to November 20, 1953)

Directions for altering text:

1a. *Section 12.23 (e) (2) (i) is amended to read as follows:*

(i) 3700 to 3750 kc, radiotelegraphy using only type A1 emission.
(Amdt. 12-22; Eff. 8-27-56)

b. *Section 12.23 (e) (2) (iv) is amended to read as follows:*

(iv) 145 to 147 Mc, radiotelegraphy or radiotelephony using types of emission as set forth in Section 12.111.
(Amdt. 12-22; Eff. 8-27-56)

2. *Section 12.27 (d) is amended to read as follows:*

(d) A renewal application which includes a modification (change of address) shall be submitted on FCC form 610 and shall be accompanied by the applicant's amateur operator license, and also by his amateur station license if he holds one.
(Amdt. 12-22; Eff. 8-27-56)

3. *That portion of §12.156 which precedes paragraph (a) is amended as follows: Change* "Regional Manager" *to* "Engineer in Charge."

4. *Appendix I of Part 12 is amended to delete the list of the offices of the Regional Managers of the Field Engineering and Monitoring Bureau.*

NOTE: This amendment was adopted by the Commission August 16, 1956, effective August 27, 1956; published in the Federal Register August 21, 1956 (21 FR 6276).

PART III — FEDERAL COMMUNICATIONS COMMISSION FIELD ENGINEERING OFFICES

Alabama, Mobile 10
419 U.S. Courthouse and Customhouse

Alaska, Anchorage P.O. Box 644
Room 53, U.S. Post Office and Courthouse Building

Alaska, Juneau P.O. Box 1421
Room 6, Shattuck Building

California, Los Angeles 12
539 U.S. Post Office and Courthouse
Temple and Spring Streets

California, San Diego 1
15 - C, U.S. Customhouse

California, San Francisco 26
323 - A, Customhouse
555 Battery Street

Colorado, Denver 2
521 New Customhouse
19th between California and Stout Streets

District of Columbia, Washington 25
Briggs Building
415 - 22nd Street, N.W.

Florida, Miami 1 P.O. Box 150
312 Federal Building

Florida, Tampa 2
409-410 Post Office Building

Georgia, Atlanta 3
718 Atlanta National Building
50 Whitehall Street, S.W.

Georgia, Savannah P.O. Box 77
214 Post Office Building

Hawaii, Honolulu 1
502 Federal Building

Illinois, Chicago 4
826 U.S. Courthouse
219 South Clark Street

Louisiana, New Orleans 12
600 South Street

Maryland, Baltimore 2
500 McCawley Building
400 E. Lombard Street

Massachusetts, Boston 9
1600 Customhouse

Michigan, Detroit 26
1029 New Federal Building

Minnesota, St. Paul 2
208 Uptown Post Office and
Federal Courts Building
5th and Washington Streets

Missouri, Kansas City 6E
3100 Federal Office Building
911 Walnut Street

New York, Buffalo 3
328 Post Office Building
Ellicott and Swan Streets

New York, New York 14
748 Federal Building
641 Washington Street

Oregon, Portland 5
433 New U.S. Courthouse
620 S.W. Main Street

Pennsylvania, Philadelphia 6
1005 New U.S. Customhouse

Puerto Rico, San Juan 13
P.O Box 2987
322-323 Federal Building

Texas, Beaumont P.O. Box 1527
329 Post Office Building
300 Willow Street

Texas, Dallas 2 P.O. Box 5238
500 U.S. Terminal Annex Building
Houston and Jackson Streets

Texas, Houston 11
324 U.S. Appraisers Building
7300 Wingate Street

Virginia, Norfolk 10
402 Federal Building

Washington, Seattle 4
802 Federal Office Building
1st Avenue and Marion Street

ADDRESS: Engineer in Charge,
Federal Communications Commission

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