How to Become AN AMATEUR RADIO OPERATOR

and secure a U.S. Government License

Including
General Radio Theory,
Questions and Answers Covering
the License Examination.

by

LIEUT MYRON F. EDDY,
U.S.Navy, Retired.

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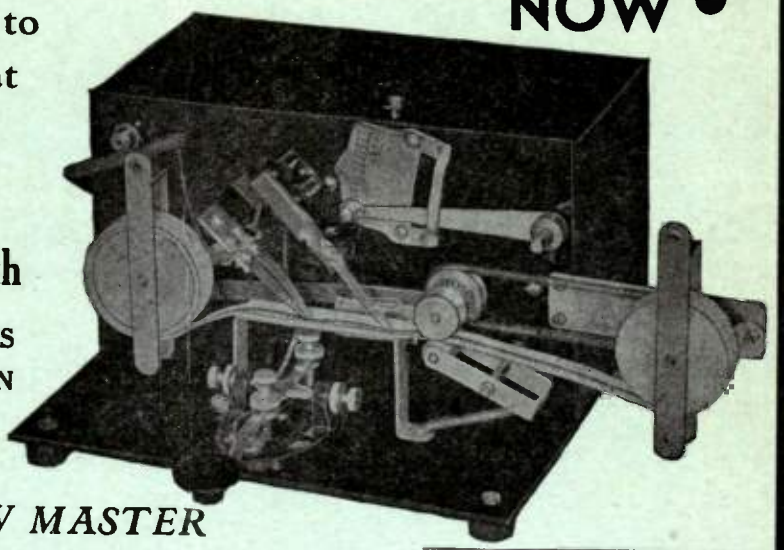

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AND

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How to Learn the Code
General Radio Theory
Questions and Answers Covering
the License Examination

By

Lieut. Myron F. Eddy
U. S. Navy, Retired
Author of "Aircraft Radio," etc.

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Preface

● THIS book has been prepared for those who wish to become licensed amateur radio operators. To do this you must pass a government examination. Therefore a code manual is presented in Chapter 1 and up-to-date questions covering the general scope of this examination, with their answers, are presented for study all through the book.

In addition to these you will find, in Chapter 2, an explanation of radio terms and symbols, followed in the next four chapters by a complete simplified discussion of modern radio theory and apparatus presented from a practical, workable point of view.

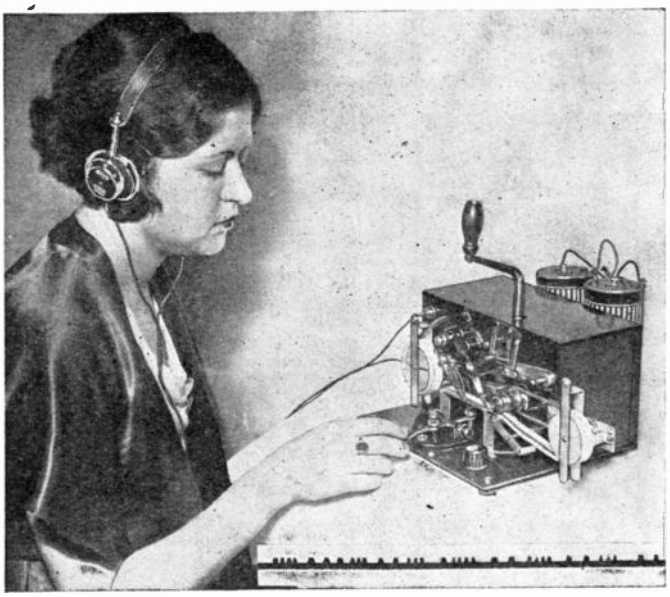
All of this information will help you to secure an amateur license and to become an amateur of standing in your radio district.

MYRON F. EDDY,
Lieut., U. S. Navy, Retired.
November, 1932.

REVISED 1937 EDITION

Contents

MYRON F. EDDY, Lieutenant U. S. NAVY, retired; member Institute of Radio Engineers; Veteran Wireless Operators' Association; The American Academy of Air Law; author of "Aircraft Radio" and numerous magazine articles.



Latest code teaching machine also records your "sending" for comparison. Sample of code record at lower right.

HOW TO LEARN TO SEND *and* RECEIVE

CHAPTER I

Learning the Code

● REQUIREMENTS FOR LICENSE: Applicants for amateur class licenses must pass a code test in transmission and reception at a speed of at least ten words per minute in the Continental Code (five characters to the word). This part of the government license examination is given first and if the applicant fails to pass he will not be given the rest of the examination, which deals with radio apparatus and radio regulations. No applicant who fails to qualify will be reexamined within three months from the date of his failure. For these reasons it is very important that you learn to send and receive accurately and with confidence at about twelve words per minute.

Methods of Learning the Code

Many different methods of learning to send and receive have been tried out in the United States in the past twenty years. The Army has one system, the Navy another. Civilian schools having large classes in attendance naturally use methods that are different from those employed by small private schools, which handle small classes and individual students.

If you expect to learn to send and receive cipher messages as well as plain English messages, an entirely different instruction procedure should be carried out. Most of you know that certain letters occur more frequently in plain English language than others. The letter E occurs more often than any other. Cipher messages are made up of all the letters of the alphabet used indiscriminately. Therefore, students who must qualify for the second class commercial operator's license by copying sixteen code groups per minute will want a great deal of practice in copying code groups in which the more difficult letters such as Q, Z, and X occur just as many times as the simple, easy letters like T and E.

Your problem, however, is not to learn to copy sixteen code groups per minute nor even sixteen plain English words per minute. There is a great deal of difference between learning to copy ten words a minute and learning to copy fifteen or twenty. Likewise, there is a great deal of difference in the method to be applied when a man must learn to send twenty words a minute instead of ten The task before you is to send and receive accurately and without effort about ten words per minute or a little more to be safe The system or method of acquiring this proficiency which will now be laid out for you to follow is designed for this specific purpose

Turn to code chart given on another page. You will notice that E I S and H are all-dot letters; that is they are made up of dots only. Notice also that T M and O are all-dash letters being made up of one, two and three dashes, respectively. You should learn these seven "all-dot" and "all-dash" letters first.

Memorizing the Code

Study the following groups in the order listed. Memorize each group in turn, then send them. Don't attempt to memorize group 2 until you have proven to yourself by actual work on your practice set that you know group 1. You should react instantly and accurately without effort to *each* letter when it is sent to you before deciding that you know the entire group. When sending, each letter should register subconsciously, on sight, as a *com-*

INTERNATIONAL MORSE CODE AND CONVENTIONAL SIGNALS

A •—	R •—•	9 ————•	PERIOD •• •• ••
B —•••	S •••	0 —————	SEMICOLON —•—•—•
C —•—•	T —	"A" •—•— (GERMAN)	COMMA ——••——
D —••	U ••—	Ä or Å •—•— (SPANISH-SCANDINAVIAN)	COLON ———•••
E •	V •••—	CH ———— (GERMAN-SPANISH)	INTERROGATION ••——••
F ••—•	W •——	É ••—•• (FRENCH)	EXCLAMATION POINT —•—••——
G ——•	X —••—	N ——•—— (SPANISH)	APOSTROPHE •————•
H ••••	Y —•——	Ö ———• (GERMAN)	HYPHEN —••••—
I ••	Z ——••	Ü ••—— (GERMAN)	BAR INDICATING FRACTION —••—•
J •————	1 •————		PARENTHESIS —•——•—
K —•—	2 ••———		INVERTED COMMAS •—••—•
L •—••	3 •••——		UNDERLINE ••——•—
M ——	4 ••••—		DOUBLE DASH —••••—
N —•	5 •••••		DISTRESS CALL •••———•••
O ———	6 —••••		ATTENTION CALL TO PRECEDE EVERY TRANSMISSION —•—•—
P •——•	7 ——•••		GENERAL INQUIRY CALL —•—• ——•——
Q ——•—	8 ———••		

FROM (DE)	—•• •
INVITATION TO TRANSMIT (GO AHEAD)	—•—
WARNING - HIGH POWER	———•••———
QUESTION (PLEASE REPEAT AFTER..) INTERRUPTING LONG MESSAGES	••——••
WAIT	•—•••
BREAK (BK.) (DOUBLE DASH)	—•••—
UNDERSTAND	•••—•
ERROR	••••••••
RECEIVED (O.K.)	•—•
POSITION REPORT (TO PRECEDE ALL POSITION MESSAGES)	— •—•
END OF EACH MESSAGE (CROSS)	•—•—•
TRANSMISSION FINISHED (END OF WORK) CONCLUSION OF CORRESPONDENCE	•••—•—

NOTE

[TO BE USED FOR ALL GENERAL PUBLIC-SERVICE RADIO COMMUNICATION. (1) A DASH IS EQUAL TO THREE DOTS; (2) THE SPACE BETWEEN PARTS OF THE SAME LETTER IS EQUAL TO ONE DOT. (3) THE SPACE BETWEEN TWO LETTERS IS EQUAL TO THREE DOTS; (4) THE SPACE BETWEEN TWO WORDS IS EQUAL TO FIVE DOTS]

Above, we have the International Morse Code and Abbrevations, which the student must learn. The most important rule which can be laid down for the code student, is that he should learn to send slowly at first, with accurate spacing of the dots and dashes, and also, the correct length of the characters themselves. The great mistake that many code students make is to speed up their "sending," before they have thoroughly learned how to transmit properly and accurately space the dots and dashes. To become a good code operator requires plenty of practice.

bination of sounds:—E should be reproduced as dit (the t in dit can be silent, if you prefer) M dah dah, etc.

Just as soon as you feel that you *know* all of the letters in each group as to their component sound parts, turn to your key. As you make S, for example, think of it so far as the key is concerned as dit dit dit—the sound which is S. Either pronounce the equivalent sound out loud in memorizing and sending each letter or say it to yourself silently.

When you become tired while studying, rest a few minutes, then continue. It does not pay to concentrate to an extreme degree. Learn what you start out to learn perfectly but you should not make hard work of memorizing the code, because it is a simple natural process, best accomplished when your mental attitude is the same as when playing a game.

Memorizing Groups

1

T dah
M dah dah
O dah dah dah

2

E dit
I dit dit
S dit dit dit
H dit dit dit dit

3

A dit dah
N dah dit
D dah dit dit

4

W dit dah dah
J dit dah dah dah
B dah dit dit dit

5

R dit dah dit
F dit dit dah dit
L dit dah dit dit

6

U dit dit dah
V dit dit dit dah
K dah dit dah

7

C dah dit dah dit
G dah dat dit
Q dah dah dit dah

8

Y dah dit dah dah
Z dah dah dit dit
P dit dah dah dit
X dah dit dit dah

9

1 dit dah dah dah dah
2 dit dit dah dah dah
3 dit dit dit dah dah
4 dit dit dit dit dah
5 dit dit dit dit dit

10

6 dah dit dit dit dit
7 dah dah dit dit dit
8 dah dah dah dit dit
9 dah dah dah dah dit
10 dah dah dah dah dah

11

PERIOD dit dit dit dit dit dit
INTERROGATION dit dit dah dah dit dit
BREAK OR DOUBLE DASH (=) dah dit dit dit dah
ERROR dit dit dit dit dit dit dit dit

12

WAIT dit dah dit dit dit
END OF *MESSAGE* dit dah dit dah dit
END OF *TRANSMISSION* dit dit dit dah dit dah

NOTE: You must remember the error sign from the start. You must learn to make this error sign every time you make a letter wrong.

How to Learn to Send

Learn to send by sending with a good practice set. Fig. 1 is the circuit of an oscillator tube-type set which you should be able to construct with very little trouble or expense. If you prefer a buzzer set make one up as shown in Fig. 2, or buy any of the simple practice sets on the market.

Try to secure an adjustment of the set used which will give you a fairly pleasing tone. In the tube set the amount of current used regulates the tone; in the buzzer set, adjustments on the buzzer itself will change its tone.

Directions for Keying

First adjust the key by means of the set-screws until there is a small gap between contact points and a medium tension on the spring. When manipulating the sending key, or "keying," you should hold down the key three times as long for a dash as for a dot. The time space to be allowed between the characters of each letter (the dots and dashes that make up the letter) should be the equivalent of one dot. Avoid a jerky manner of sending and do not try to send too fast.

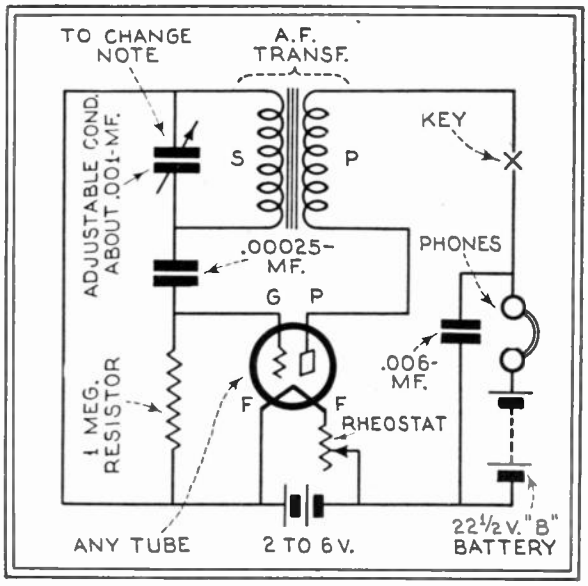


Fig. 1—Simple code practice circuit in which a pair of phones are used, together with an A.F. transformer, a vacuum tube, batteries and condensers, and a key, all arranged in the simple manner shown.

The key should be held about as you hold a pencil—thumb on left side, second finger on right side, first finger mostly on top and on front edge. Keep your wrist limber; do not "grip" the key. See Fig. 3 and 4.

No one can actually teach you to become an operator. Almost any operator, however, can advise you as to good form in keying and you, yourself, must learn by listening, to tell when you are sending "good clean stuff."

It has been said that if any two amateurs would send the Bible to each other they would, by so doing, become operators. It will certainly help, in the beginning, if you can get some operator to send to you and to listen to *your* sending. After you

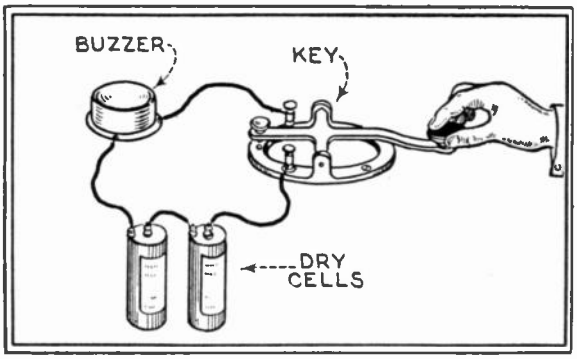


Fig. 2—Simple code practice circuit comprising an ordinary buzzer (or bell with clapper removed,) together with a dry cell or two and a telegraph key.

have learned the code you can "copy" other amateurs, on your receiving set; first just a few of the simpler letters, then whole words and sentences.

Practice making dashes first. Try the letter T, M and O. Then send the following series (Practice exercise 1) over and over until your keying is smooth and effortless. Keep the letter close coupled; that is, with proper spacing between the parts of each letter.

PRACTICE EXERCISE 1. This practice exercise contains the all-dash letters listed in memorizing group 1: T dah; M dah dah; O dah dah dah.

Two-letter Code Groups

TT MM OO MO OM TT MM MT MO TM
TO MO TM OT MT OM TM TO OT OM

Three-letter Code Groups

TOM	MOO	OTO	TOM	OMO	MOO
TTM	OMO	MMT	MMT	OTM	TMO
TOO	MTM	MOM	TOM	TMO	MTM
MOT	TMT	OTM	TOO	OMT	OOM
TMT	TOT	OOM	OOT	MTO	TOM

Four-letter Code Groups

TOMO	TMTM	OTOT	MMOT	MOTO
MTMT	MOMO	TMOM	MOTT	OTOM
TMTO	MTTM	MTMO	TMOT	TOTO
OTMO	MTOM	TOTM	OMTM	TOOM
MOTO	OMTT	TOMT	OTMT	MOTM
OMOT	TOTO	TOMO	MOOT	OTTO

Five-letter Code Groups

TOTOM	MTMOT	TOTTO	OTTOM
MOTMT	MMOOT	MTOMT	MTOMO
OOMTT	TOMTO	MTOTM	TOMOT
MOTTO	MTOTM	OTOMO	OMTTO
TOTMO	OMMOT	TOMOT	TMOTO
MOTOT	OTMTO	MOTTO	MTOMT
TMOTT	TMOTM	TOTOO	TOMMT
TOMOT	OTTOM	MTOMT	MOMOT
OTMOT	TOTOO	MOTOM	TOMOT
MOTTM	TOTOM	OMOTT	OMOTO

Watch your spacing in the above groups, both between letters and between groups. Notice that these groups can be sent from left to right, or backwards from right to left; also both up and down.

PRACTICE EXERCISE 2: Next send dots or dot letters such as I, IS, E, EH, HI, HS, SI and SE. Write up a drill exercise similar to the one which follows. As you write down the letters in the drill exercise say them mentally to yourself, using "dit" and "dah" instead of dot and dash (letter E is dit, I is dit dit, S, dit dit dit, etc.)

This exercise is for sending and receiving the all-dot letters listed in memorizing group 2.

E I S H
. .. .

Two-letter Groups

EI	EH	SH	SI	IH
SS	II	HI	HS	EH
ES	IS	SE	IE	IE
HH	EE	HE	EI	ES

Three-letter Groups

SIS	SIE	ISI	ESH	HIH	ESI
ESE	EIE	ESE	ISH	HIS	SEI
HSI	IEI	ISI	EIE	SIH	
HEH	ISE	IHI	SHE	EIS	
EHE	HSH	ESI	EHS	ISE	

Four-letter Groups

SISE	ISIS	HSEI	SEIS	EHIS
ESHE	SHEE	HIHI	EHIE	SISE
ISHE	HISE	SEHS	SISI	HSIE
HESE	ESHI	SIES	HISH	
HISI	EIEI	SEHI	ISHE	
ISES	HISH	HEHE	SHEI	
SHIS	SHIE	ISHE	ISHI	

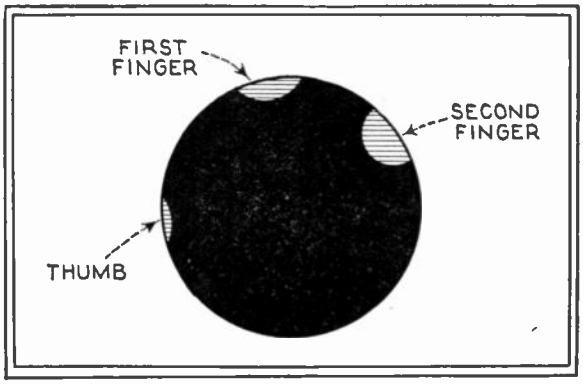


Fig. 3—Top view of telegraph key button showing correct position of thumb, first and second fingers, in gripping the key. The third and little fingers should be kept relaxed beside the key.

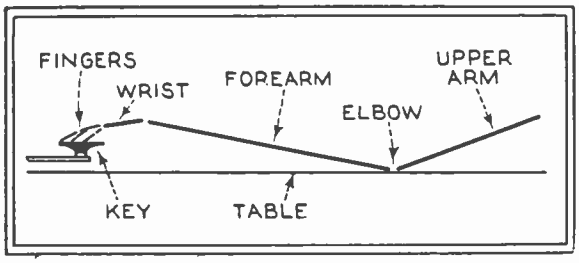


Fig. 4—Remember to relax the arm and finger muscles! Rest elbow on table as shown and allow the wrist to be "loose." If you tense the muscles, your arm and fingers will soon become very tired and you will get "telegrapher's cramp."

Five-letter Groups

ESEES	ESHIE	SISSE	ESSES	HISII
HESHE	SHIHI	ESHIS	IHESI	SHISE
ISHIE	HHIHE	HEESE	SESHE	IHIHE
SHESI	ESSES	SESHI	HISIS	ESHES
IIEEI	SHEIE	ISHIE	SHHSE	HISES
HIHII	ISHIE	ESIHI	HISHI	ESESE
IHESE	HESEI	HIHIE	EHIES	SHEHI

Try to develop cadence and ryhthm in sending the above all-dot letters. The following group is like a drum beat:—ESE. Listen for a similar timing in other groups as you send them.

PRACTICE EXERCISE 3: Containing letters from memorizing group 1 and 2. These letters can be sent back and forth, up and down.

NOTE: Make the error sign every time you make a mistake.

TETES	TEHOS	ESOTI	EMHIT	EOHSI
HISME	EMITO	IHEME	ISTEM	THIOM
OMITH	HOHOE	HOSEM	OEIST	TIHME
EOEST	ISTEM	TETOS	SOMIE	STIEM
ISOIM	STEITH	EHOIM	IESHO	MSETH
MISSI	MESTI	SETOI	SMEIH	IETSO
ITEMT	OIMST	ITESO	OEMTS	OMSIT
OSMIE	OIMSH	HOSME	TSEMO	

The next combination to try is that of words made up of all-dot letters with all-dash letters. Try sending the following words:

It, set, hot, too, him, meet, totem, mites, items, met, home, his, he, me, mist, hot, test, net, sot, toes, some, mete, sim, miss, moss, sit, toss, tom, this, the, hem, otto, them, most, hoist, tee, motto, moist, stem, memo, theme, mess, smite, smote.

The next three letters to be added will be, A. N, D. Try sending and receiving the following words:— and, Dan, name, made, mad, man, hand, sand, an, tan, Nan, maid.

Now you can send and receive certain short sentences. Get some one to send you the following sentences:

It is time to meet him. He is to see Tom at noon. Nan and Tom are Danish. She is a maiden. This time send the men. She met him one time. The man and maid seemed to see them.

PRACTICE EXERCISE 4: The following exercise contains the letters EISHTMOAND from memorizing group 1, 2 and 3.

Five-letter Code Groups

AISHD	DANAS	NINES	DISOM	SMITE
IDSNT	ANOMI	SAMES	DODOS	MISAD
NATID	DITES	MEDIN	OTDIN	DIDAN
ONSET	SNADS	TADAN	SEDNI	INISE
NADAT	MIDAS	MANDA	HDTAN	ADANE
NTMOA	NEADS	AIDIS	OTESA	DIDSN
ENTAH	NEATS	NANED	MADIN	HEOAD
ANADA	ADNAD	ODONA	OSTEA	SANDS

Plain English Five-letter Words

DIDOS	MAIDS	TEEMS	MEANS
HINTS	NAMES	TEAMS	DINES
STINT	DATES	SMASH	DEANS
STAND	ASHES	DANES	MITES
SODAS	AIDES	STEAM	SMITE
DANES	TIDES	MEATS	
DOMES	MAINS	SAINT	
MODES	HEADS	MAIDS	

How many mistakes did you make in sending the above groups? In receiving them? Do not turn to exercise 5 until you can send and receive *all* groups above at least 95% correctly—that means 95 out of every 100 *groups* or 76 out of the 80 listed above.

Two and Three-letter Words

THE	TO	TIE	SIT	DEN
AND	IT	TAT	NET	DIE
TEN	AT	SAT	TOT	NED
END	ODE	MAD	ATE	SIN
TEA	ODD	TEE	TIT	TAN
EAT	SET	AID	SOT	DIN

Simple Four-letter Words

THEM	TEND	SODA	ITEM	MOTE
DATE	NAME	SOME	EAST	NINE
MADE	AMEN	SITE	INTO	MOTH
IDEA	MOAN	TEST	TIME	NAME
TIME	HOME	IDES	EDIT	
HAND	SAND	EASE	TOAD	
TIDE	MATE	EDEN	TITHE	

You should try to send at least four groups without an error or pause, just as you would a four word sentence or message. In copying the two and three letter words there will come a time when you can receive the entire word and write it down as a word instead of copying each individual letter.

PRACTICE EXERCISE 5: From memorizing groups 1, 2, 3 and 4.

Code Groups

IWAWE	JABEW	DIJOW	TWIBE	ESIBN
JASBI	TOWID	SHEJD	SEJOW	OBJSI
EWABD	DBEBI	ISHWJ	OBIDJ	NTOJW
AJIDB	JANDB	ANJEB	MIWAD	BADIJ
OWESJ	BIJEW	EJMWD	JASWB	SWEBT
AJTJS	AJWIN	HAJNB	SMJWA	MIJOB
WAIBJ	BOSWE	WISDJ	JABIW	HEWSJ
EIJWB	WEJTB	JEWAD	WIDEJ	

Plain English Sentences

James said to him, "We both won."
Tom waited to see that the bat was sent home.
Jim boasted that he did not owe Dan.
This job is to be done by the best man.
Nan saw the woman sit down.
We joined both ends and waited.
The doomed men wasted no time.
Both men and women met the men.
It is now mine and no one is to mess with it.
Joe said that he was not a bad man.
The nest was not down at noon.
John and Sam went down town at nine A. M.
Sam is to meet James between ten and noon.
The same man was to be sent this time.
Does she mean that it is not to be seen at this time?

PRACTICE EXERCISE 6: From memorizing groups 1 to 5 inclusive.

Five-letter Code Group

RARIR	DAFIN	LFRWE	FELWI	TLOFR
IRERT	LELIL	SBLJW	JBARL	DWETW
RIRAR	SLOWE	RFWLB	NWJDB	NRWJT
TRIRE	JOLIB	RFLWJ	TRFLE	BSJWD
RASIR	LJWBL	BRFLW	LFRHM	ITEMS
SFIFT	BLEWJ	JBRFL	SWJBH	JAMIB
FEFOS	REFIL	WJBRF	ROFLM	WINES
AFIHF	FRWJB	LWJBR	IJWFS	

PLAIN ENGLISH SENTENCES: I wonder if we three will fill the bottles with old wine? That will be fine if we do. I see that the flow is from both east and west. The foam is not the best of it. The lonesome men went toward the barn. That Indian is not a bad man. He has a red roan horse and shoots fast. Trader Horn went east while the other white men went north. The best three are to be sent with John. He will have one horse and we will want two. To boast is bad form. Between the two of them it will be fine. I saw James ride fast toward the three men. The owner of the horse saw it stolen. There is a jobless man to wait for. The farmer jotted down a memo for both men. Who owns those three bottles of beer? There will be a row when Jim finds that we are late. The best war is a bad war in the end and all soldiers will tell the same tales of all wars. Attend to the joint between the windows.

PRACTICE EXERCISE 7: This exercise contains letters from the first 6 memorizing groups. You should be able to send a complete sentence in Exercise 6, smoothly and without more than one "break" or error at about 6 or 8 words per minute before taking up the following exercise. If you are still making mistakes in sending and receiving EISHTMOAND, go back and review these until you know them perfectly. In sending, make the mistake sign after every error. You have probably already noted that they are being used to fill in between the new letters in each exercise. From this point on you must constantly learn new letters without forgetting the old ones—those in the first three memorizing groups.

FIVE-LETTER CODE GROUPS: Introducing the letters of the 6th memorizing group, U, V and K, while still using letters from groups 1 to 5 inclusive. This is not an easy exercise. Send all groups about ten times from left to right, up and down and from right to left.

RURUF	RFLUV	KIULR	IUSVH	SEARU
IRULU	VIVOR	FLOSD	KERIF	FAVOR
LUFRT	KAKUV	NIFAO	SLHUT	KINKS
ULRUL	EKIKU	MUVIK	VMKOR	DOVES
SUFLU	KESIK	ERIFS	FELTU	KIKOR
VEVIR	UFRKU	LHUTV	IVMKO	VISOR
IVAVL	STOVE	MKARN	SANDR	FORUL
VEVFS	UEVIK	FDLEL	THISF	KESTI

PLAIN ENGLISH SENTENCES: Some of the words in the following sentences contain letters which you have not yet memorized. Omit these while sending and receiving. This will give you practice in "missing"; that is, you must now learn to go right ahead and "copy" the next letter after you have failed to copy one. Whenever you can not instantly write down the letter sent, move your pencil over and listen for the next letter. You will find that this is important.

"Few voters will like that route for sure. Be kind to animals that run. The joke about the vest is rotten. The kids used to like to rush over with their mother to swim. Love lasts with a few. To kill investments is bad business. This animal is a rokomojoremus and is related to a breed of balloriferous wokojokies, the kind that Rolo Johnson wrote about in his book named 'Bojoverlusk the Flabberjashet'."

"To rebuild at this time would be foolish. The bank would not loan enough cash to get the building done and the contractors would not consider it otherwise. We will have to find some other method if it is to be done at all but the veterans loan will not be enough if we are to use brick as a veneer in the four walls. The best argument to advance to the examiners is that six people should seize and pay the money."

PRACTICE EXERCISE 8: The letters from the 7th memorizing group are introduced in this exercise, with letters from exercises 5, 6 and 7 used as fillers rather than the simpler letters of the earlier groups. After finishing this exercise it is suggested that you go back and send the first four exercises over as a review and also see if you can still copy them perfectly.

Five-letter Code Groups

CUCKO	FLRQG	LOGOQ	CRUFL	GURQE
GVGUK	QURFQ	RFVUL	LQFGC	CEGIQ
QUQUE	CGQRU	GVQLR	QURVG	CVKLC
QUOGQ	QUACK	GKVUG	GRUCG	QUART
GUGGO	LFULG	RUCFL	VOTES	GFRKG
QFCKL	RGFQV	KLGCV	KGIQC	FLUGF
KICKS	CLGQF	GKLFR	CFLGR	TCMQG
RVQCF	LUCGQ	FORKE	QGFLC	

In sending the above groups pay particular attention to the spacing within the letter. The letter C can be incorrectly sent so as to sound almost the same as TR, as NN, as KE. Instead, be certain that you learn to send it in such a manner that there is no possibility of confusing it with any of these combinations of letters, or any other letter. This statement applies to the sending of all letters but should be particularly stressed when sending any four-character letter such as C, Q, V, L and J. If you are having any trouble of this sort with any of these letters at this time cure yourself before proceeding to a study of the exercises that follow. Do this by making up a series of drill exercises of your own, containing the letters which you have a tendency to "split," together with short letters like E, I, T, A, etc. The old saying that a chain is no stronger than its weakest link applies in principle to an operator: You must know ALL the letters if you expect to be an operator. Learn them as you go. There are only four more letters to learn. See that you know the ones that you have studied so far before you take up these last four letters and the numerals.

A very good way to test your progress at this time, particularly your accuracy, is to copy the following plain English sentences. They have been made up of words containing just the letters that you have studied. The first sentence contains 30 letters and is therefore the equivalent of 6 words. The second and third sentences consist of 7 words each; the third and fourth contain 8 words each, the last two, 10 words. You should practice until you are able to send the longest sentences in less than a minute.

1. Quick folks jump wider and move fast.
2. Kind people just above us helped West Farm.
3. Few kicks got to those queer velvet persons.
4. This time we and Queen Bojovrkicige flew to town.
5. Tom dashed out with John but was not quick enough.
6. Owing to three vessels having queer cages Que Bufkin jumped.
7. The parade was reviewed by the foolish Queen Gocojokumess.

The following are provided as practice in sending both simple and garbled sentences:

"To be or not to be. That is the question. It is best to send slow at first if the student is to be an operator in time. For that reason send this at the rate of eight words per minute at first, later at ten words per minute. Coat and pants with a vest make a suit of clothes. It seems better for the three garments to hang together over the chair than to be strewn over the bureau. Hypocrites blaspheme and ravenously disintegrate the nebulous effluvium from quicksilver mines on the island of Wakackajemis. Now is the time for all good men to come to the aid of their king. The large brown coyote jumped over the big black dog."

PRACTICE EXERCISE 9: Introducing memorizing group 8: letters Y Z P and X.

YOYOY	YACHT	XADNQ	SGQEH	JAWZX
ZLFRZ	CXZQG	YESTZ	ZONIC	BJXEZ
XUXZC	PAPPA	ZINCS	WAXIW	ISZGL
PAYER	YUSTX	FZQRV	BYZER	ZILOZ
FETQX	FLUXZ	YTZIX	CEXIG	BUZIX
ZEZIZ	GIRLS	GAGIC	PLAXR	SHZXY
XUXVK	BJKRV	ZINCQ	YCZCX	XEXQR
GWJBX	XTXEX	TOXIG	JAXIJ	DALYP

Difficult Words

Some words seem to be more difficult to send than others. Long words containing odd combinations of letters are often the cause of hesitation and inaccuracy. When you "break" in the middle of a long, unusual word and start to send it over again, after making the error sign, there is a "mental hazard"—a tendency to again "break", usually on the same letter that caused you to stumble before. This is probably due to the fact that about 90 per cent of the plain English is "press" or the equivalent—newspaper material or something similar which does not contain any but ordinary words. The following words have been selected to provide training in sending unusually long and unfamiliar words. Send them all, watching your spacing. If you make a mistake, train yourself not to be too much disturbed; send it again, immediately, without any pause except that normally following the error sign and send it right. Avoid the feeling of annoyance at your errors no matter how many times they occur.

"Mississippi, anamorphoscope, benthopelagic, caniculated, demisemiquaver, grossierette, xerophulous, flabeiliform, historiographer, histiogenesis, xylophagous, ischialgia, habergeon, quadripartite, gynecology, ovoviviparous, pederasty, quaddrivium, oxysulphide, prolegomnon, rhizomorphous, ultimogeniture, whimsicality, xiphisternum, zoosporangium, xenogenesis, zoroastrianism, winebibbing, zygapophysis, xanthippe, xan thophyll, quixotic."

PRACTICE EXERCISE 10: These groups contain only numerals 1, 2, 3, 4 and 5. Send them up and down and cross way.

13121	24351	42432	15152
24214	23325	52513	41434
13413	45525	31452	25134
45132	34152	45321	51423
32245	11234	23245	32341
13412	42324	23524	34512
52321	34252	32452	45321
41235	13542	51234	23453
34145	21234	24145	52134
25543	52415	45211	14245

The following are mixed groups containing 1, 2, 3, 4, 5 and the all-dot and all dash letters. When copying a zero put a dot in the middle of it so you won't afterwards read it as an "O". Also put cross bars on the letter I to distinguish it from the numeral "one".

1E2S4	E3215	1S34M	I3452	H4232
1034M	3S142	41522	5H134	5134M
32T14	4I32S	5M32E	43I51	T3453
T3H21	E2451	33415	52423	T3421
452H2	53012	345M1	01242	523H2
T4H5T	4E321	42T35	4213S	45234
E5S3E	T4245	2O153	E1342	SIE45
1432H	H21TO	S1324	525S1	O4153

PRACTICE EXERCISE 11: Containing numerals 6, 7, 8, 9 and 0.

68986	89798	60708	98076
89760	67809	09876	87608
99870	89987	78907	96869
78608	78676	67789	67780
67097	06060	86668	08997
86908	79680	98706	69798
97860	88769	66867	77889
89679	77896	79680	88776
78786	66078	87979	67897
60097	80997	67890	99680

Containing all ten numerals.

12345	59364	67890	43297
02398	37254	98763	02389
98786	23492	76834	23232
32561	54863	54827	93864
26274	93814	14960	15432
98183	93764	67397	31723
74684	93715	83814	52133
76824	11100	12370	41321
73971	12847	72642	21532
14960	37265	89724	14143
93461	72832	46803	58642
10807	36370	36321	23578
30765	77655	32176	75613
55661	27561	44556	89706
96081	46789	50970	79805
23157	28233	35506	35121
37678	50362	70663	51232
32165	02370	66770	41321
94701	90001	95864	31231
09875	58798	85700	45121
38990	42391	84765	84832
87463	46743	46731	32831
43295	46821	63891	12841
32760	72654	92121	42690
78261	84736	67671	87472
84792	84296	97439	78696
97680	01801	12364	68410
72832	31764	44693	79606
72823	42823	39824	85789
67513	33220	32603	48965

REVIEW EXERCISE: Notice that the following six groups contain all 26 letters of the alphabet and also all ten numerals. By sending or receiving the entire exercise you receive practice on all letters and numerals; if you have developed a tendency to miss certain letters or numerals, select the group containing these "pets" (as they are called) and review until your work is perfect.

All of these groups should be sent at from 10 to 12 words per minute. Even if you send slower remember that the time length of each letter (of each dit and dah of each letter) should never be less than it would be if the rate of sending was 10 words per minute. Also, from this time on, try for "perfect copy"—try to send and to "copy" ten groups or words in sequence without "breaking."

J H 7 M O G

HJMOH	MOHJ7	7HO7G	7GOMJ
7HOMJ	HMO7G	JH7MO	MJH7G
M7GHO	7GOMG	HJGJ7	GOMG7
GOMJ7	GO7JM	GJOGH	7GOJM
JHOM7	JMJ7G	JH7GO	HGHMO
JGM7O	HOG7J	MJ7HJ	7OGMT
7MOJG	GJHJO	GJGHM	
GH7OJ	OGM7H	OM7JG	

2 K Y 8 S D

8OGJK	G7S2K	KGOMJ	HOYMG
GSHKD	YSKG2	YDKSJ	KYDS8
SDYOH	HMJOD	HJDYM	K7GO2
MGJOH	YOSKH	DSK82	7GKSD
J7MHD	87MOY	DJH72	82GJH
SD7MY	DY7GO	SHD28	7D8KS
7M28J	8MJ7K	28OHY	
M2GJK	OG8SM	HSKO7	

DEPARTMENT OF COMMERCE

RADIO DIVISION

INTERNATIONAL RADIOTELEGRAPHIC CONVENTION

LIST OF ABBREVIATIONS TO BE USED IN RADIO TRANSMISSIONS

Abbreviations to be used in all services

Abbreviation	QUESTION	ANSWER OR NOTICE
QRA	What is the name of your station?	The name of my station is .....
QRB	At what approximate distance are you from my station?	The approximate distance between our stations is ..... nautical miles (or ..... kilometers).
QRC	By what private company (or government administration) are the accounts for charges of your station liquidated?	The accounts for charges of my station are liquidated by the ..... private company (or by the government administration of .....).
QRD	Where are you going?	I am going to .....
QRE	What is the nationality of your station?	The nationality of my station is .....
QRF	Where do you come from?	I come from .....
QRG	Will you indicate to me my exact wave length in meters (or frequency in kilocycles)?	Your exact wave length is ..... meters (or ..... kilocycles).
QRH	What is your exact wave length in meters (frequency in kilocycles)?	My exact wave length is ..... meters (frequency ..... kilocycles).
QRI	Is my tone bad?	Your tone is bad.
QRJ	Are you receiving me badly? Are my signals weak?	I can not receive you. Your signals are too weak.
QRK	Are you receiving me well? Are my signals good?	I receive you well. Your signals are good.
QRL	Are you busy?	I am busy. Or, (I am busy with .....). Please do not interfere.
QRM	Are you being interfered with?	I am being interfered with.
QRN	Are you troubled by atmospherics?	I am troubled by atmospherics.
QRO	Must I increase power?	Increase power.
QRP	Must I decrease power?	Decrease power.
QRQ	Must I send faster?	Send faster (..... words per minute).
QRS	Must I send more slowly?	Send more slowly (..... words per minute).
QRT	Must I stop sending?	Stop sending.
QRU	Have you anything for me?	I have nothing for you.
QRV	Must I send a series of V's?	Send a series of V's.
QRW	Must I advise ..... that you are calling him?	Please advise ..... that I am calling him.
QRX	Must I wait? When will you call me again?	Wait until I have finished communicating with ..... I will call you immediately (or at ..... o'clock).
QRY	Which is my turn?	Your turn is No. ..... (or according to any other indication).
QRZ	By whom am I being called?	You are being called by .....
QSA	What is the strength of my signals (1 to 5)?	The strength of your signals is ..... (1 to 5).
QSB	Does the strength of my signals vary?	The strength of your signals varies.
QSC	Do my signals disappear entirely at intervals?	Your signals disappear entirely at intervals.
QSD	Is my keying bad?	Your keying is bad.
QSE	Are my signals distinct?	Your signals are unreadable.
QSF	Is my automatic transmission good?	Your signals run together.
QSG	Must I transmit the telegrams by a series of 5, 10 (or according to any other indication)?	Your automatic transmission fades out.
QSH	Must I send one telegram at a time, repeating it twice?	Transmit the telegrams by a series of 5, 10 (or according to any other indication).
QSL	Must I send the telegrams in alternate order without repetition?	Transmit one telegram at a time, repeating it twice.
QSJ	What is the charge to be collected per word for ..... including your internal telegraph charge?	Send the telegrams in alternate order without repetition.
QSK	Must I suspend traffic? At what time will you call me again?	The charge to be collected per word for ..... is ..... francs, including my internal telegraph charge.
QSL	Can you give me acknowledgment of receipt?	Suspend traffic. I will call you again at ..... (o'clock).
QSM	Have you received my acknowledgment of receipt?	I give you acknowledgment of receipt.
QSN	Can you receive me now? Must I continue to listen?	I have not received your acknowledgment of receipt.
QSO	Can you communicate with ..... directly (or through the intermediary of .....)?	I can not receive you now. Continue to listen.
QSP	Will you relay to ..... free of charge?	I can communicate with ..... directly (or through the intermediary of .....).
QSQ	Must I send each word or group once only?	I will relay to ..... free of charge.
QSR	Has the distress call received from ..... been attended to?	Send each word or group once only.
*QSU	Must I send on ..... meters (or ..... kilocycles) waves of type A1, A2, A3, or B?	The distress call received from ..... has been attended to by .....
QSV	Must I shift to the wave of ..... meters (or of ..... kilocycles), for the balance of our communications, and continue after having sent several V's.	Send on ..... meters (or on ..... kilocycles), waves of type A1, A2, A3, or B. I am listening for you.
*QSW	Will you send on ..... meters (or on ..... kilocycles) waves of type A1, A2, A3, or B?	Shift to wave of ..... meters (or of ..... kilocycles) for the balance of our communications and continue after having sent several V's.
QSX	Does my wave length (frequency) vary?	I will send on ..... meters (or ..... kilocycles) waves of types A1, A2, A3, or B. Continue to listen.
QSY	Must I send on the wave of ..... meters (or ..... kilocycles) without changing the type of wave?	Your wave length (frequency) varies.
QSZ	Must I send each word or group twice?	Send on the wave of ..... meters (or ..... kilocycles) without changing the type of wave.
QTA	Must I cancel telegram No. ..... as if it had not been sent?	Send each word or group twice.
QTB	Do you agree with my word count?	Cancel telegram No. ..... as if it had not been sent.
QTC	How many telegrams have you to send?	I do not agree with your word count; I shall repeat the first letter of each word and the first figure of each number.
QTD	Is the word count which I am confirming to you accepted?	I have ..... telegrams for you or for .....
QTE	What is my true bearing? (or)	The word count which you confirm to me is accepted.
	What is my true bearing relative to?	Your true bearing is ..... degrees (or)
QTF	Will you give me the position of my station based on the bearings taken by the radio-compass stations which you control?	Your true bearing relative to ..... is ..... degrees at ..... (o'clock).
QTG	Will you transmit your call signal for one minute on a wave length of ..... meters (or .....kilocycles) in order that I may take your radio-compass bearing?	The position of your station based on the bearings taken by the radio-compass stations which I control is ..... latitude ..... longitude.
QTH	What is your position in latitude and longitude (or according to any other indication)?	I am sending my call signal for one minute on the wave length of ..... meters (or ..... kilocycles) in order that you may take my radio-compass bearing.
QTI	What is your true course?	My position is ..... latitude ..... longitude (or according to any other indication).
QTJ	What is your speed?	My true course is ..... degrees.
QTK	What is the true bearing of ..... relative to you?	My speed is ..... knots, or ..... kilometers, per hour.
QTL	Send radio signals to enable me to determine my bearing with respect to the radiobeacon.	The true bearing of ..... relative to me is ..... degrees at ..... (o'clock).
QTM	Send radio signals and submarine sound signals to enable me to determine my bearing and my distance.	I am sending radio signals to permit you to determine your bearing with respect to the radiobeacon.
QTN	Can you take the bearing of my station (or of .....) relative to you?	I am sending radio signals and submarine sound signals to permit you to determine your bearing and your distance.
QTP	Are you going to enter the dock (or the port)?	I can not take the bearing of your station (or of .....) relative to my station.
QTR	What is the exact time?	I am going to enter the dock (or the port).
QTS	What is the true bearing of your station relative to me?	The exact time is .....
QTU	What are the hours during which your station is open?	The true bearing of my station relative to you is ..... at ..... (o'clock).
		My station is open from ..... to .....

When an abbreviation is followed by a mark of interrogation, it refers to the question indicated for that abbreviation.

* A1=continuous waves, unmodulated (CW).
A2=continuous waves, modulated (ICW or ACCW).
A3=continuous waves, modulated by speech or music (phone).
B=damped waves (spark).

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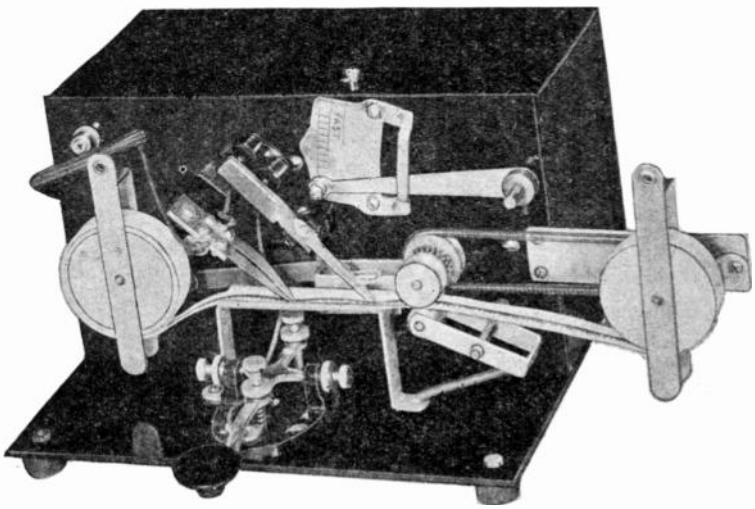
PLAIN ENGLISH: Send and receive a great deal of plain English after finishing the preceding exercise. Use a newspaper, the Bible, this book or a magazine for a text.

Just two more things to caution you about, in conclusion: send clearly, always making the error sign if you make a mistake; copy legibly, remembering that your copy must be *handed* to the radio inspector when you take your examination, not read to him.

New Code Teacher and Recorder

● To record your own *sending* has been the goal of many a short wave amateur, not to mention the code teacher, who has often thought what a fine thing it would be to have a means of recording some of the awful sending beginners hand out and be able to show them by graphic record charts how and where they "sliced" their dots, dashes and spaces. This new Teleplex code teaching machine is about the cleverest device of its kind the editors have yet seen. The student receives a number of standard code, paper tape records, which he can run through the machine and thus learn the proper spacing of the various code characters, the signals being heard in a pair of headphones. A vacuum tube oscillator circuit is used to generate the signals which sound just like those from a regular commercial radio station. The student can place a roll of blank tape in the machine and *record* his own *sending;* the recorded signals are afterwards run through the machine so that he can hear just how *good* or *bad* his transmitting "fist" is. Also the record of the beginner's signals can be visually compared with those on the standard tapes supplied with the machine. A rheostat on the front panel permits changing the tone of the signal.



The latest model of the Teleplex code teaching machine. The signals, as created by the student manipulating the key, are recorded on a paper tape and may be "re-run" through the machine so as to reproduce the signals in the phones, or the graphically recorded signals may be compared with "standard" Teleplex code tapes.

-RADIO SYMBOLS-

ANTENNA	INDUCTOR, VAR. (BY STEPS)	THERMIONIC TUBES:
ANTENNA, LOOP	INDUCTOR (IRON CORE) OR	DIODE (HALF-WAVE RECT'F'R)
AMMETER (A)	JACK	FULL-WAVE RECTIFIER
ARC	KEY	TRIODE (DIRECTLY HEATED CATHODE)
BATTERY + −	LOUD SPEAKER OR	TRIODE (INDIRECTLY HEATED CATHODE)
COND., FIXED OR	MICROPHONE OR	TETRODE (DIRECTLY HEATED CATHODE)
COND., FIXED, SHIELDED	PHOTOTUBE	TETRODE (DIRECTLY HEATED CATHODE)
COND., VAR.	PIEZOELECTRIC PLATE	TETRODE (INDIRECTLY HEATED CATHODE)
COND., VAR. OR MOVING PLATE	RECT'F'R TUBE, HALF-WAVE (COLD CATHODE)	PENTODE (DIRECTLY HEATED CATHODE)
COND., VAR. SHIELDED	RECT'F'R TUBE, FULL-WAVE (COLD CATHODE)	THERMOELEMENT
COUNTERPOISE	RESISTOR OR	TRANSF. (AIR CORE)
CRYSTAL DETECTOR	RES'T'R., VAR. OR	TRANSF. (IRON CORE)
GALVANOMETER (G)	RES'T'R., VAR. (BY STEPS) OR	TRANSF. (VAR. COUP'L'G)
GLOW LAMP (NEON)	SPARK GAP, ROTARY	TRANSF. (MOVING COIL INDICATED)
GROUND OR	SPARK GAP, PLAIN	VOLTMETER (V)
INDUCTOR	SPARK GAP QUENCHED	WIRES, JOINED
INDUCTOR, VAR.	TELEPHONE RECEIVERS	WIRES, NOT JOINED OR

CHAPTER 2.

Radio Terms and Symbols Including Glossary of Radio Terms

● Certain words, terms, phrases are used in connection with radio which have taken on a meaning of their own because of their usage. Every trade, art, hobby, vocation or avocation acquires such a terminolgy. This radio language you will want to learn. Not as you would memorize a formula or a verse but by association with your set and with other radio operators, which association will give each strange word a meaning by the way it is used or defined. To be able to listen intelligently to a broadcast or oral conversation or to engage in discussion on radio, to even read about radio, you will want some ready reference to the more common terms and phrases used. Such a list of common radio words has been selected and presented herewith for your study and for reference. Notice that words are arranged alphabetically and also numbered. These numbers appear in the chapters that follow for ready reference.

This is not a complete list of all radio terms, as such a list would be too long to study. The definitions are not "hide-bound"; there is some latitude allowed in their wording in order that you may readily assimilate the meaning without becoming too technical. A special committee from the Institute of Radio Engineers meets from time to time and lays down certain hard and fast definitions of the various radio terms and you may secure these if you wish. Also, there are several excellent electrical dictionaries and encyclopedias on the market. Perhaps a little later on you will want to get such a book. But right now it will pay you to read over this entire list marking the terms that you will need to review from time to time. If you had an idea about the meaning of any of the words listed that was incorrect, underline the word and try to remember its correct meaning as here listed.

Refer back to this list from following chapters. Numbers in parenthesis hereafter indicate these terms.

1. ADMITTANCE: The reciprocal of the impedance of an alternating current circuit is called the admittance.

2. AUDIO OSCILLATOR: An oscillating tube in an audio-frequency circuit.

3. BIAS: The means of variating the effect of the grid in a vacuum tube is a bias.

4. BIASING BATTERY: This is another term sometimes used to designate a "C" battery, used to bias a tube. (See bias.)

5. BINDING POST: A means of connecting mechanically the wires outside a receiving set to the instruments in the set.

6. BLOCKING CONDENSER: A small-capacity condenser inserted in one of the circuits of a receiving set to separate that circuit from another by "blocking" current.

7. CAPACITY: This is the property of a device to temporarily store electric energy. Capacity and inductance controls the frequency or wavelength of a radio circuit.

8. CLOSE COUPLING: A transformer or a tuning coil is said to be close coupled when the primary and the secondary winding are very close together.

Condenser

9. CONDENSER: A condenser consists of at least two but usually a large number of metal leaves each of which is separated from the one adjoining by a sheet insulator called a "dielectric." Condensers are used for the temporary storage of electric currents, also, in radio work, for "tuning" circuits to bring the circuits into resonance.

10. CONDUCTANCE: The conducting "power" of a wire or other conductor of electricity is generally expressed by the unit mho.

11. ELECTRON: A very small electric charge which passes from the negative to the positive parts of a circuit.

12. ELEMENTS OF VACUUM TUBES: Vacuum tubes have either two, three, four, five or even more elements. In the two-element tube the elements are the filament and the plate. In three-element tube the elements are the filament, plate and grid. In the screen grid tube there are four elements, filament, plate, grid and screen.

13. ETHER: The theoretical "substance" which is supposed to occupy all space as well as the interior of solid bodies. Through it heat, light, and radio waves are transmitted.

14. HARD TUBE: A vacuum tube especially suited for use as an amplifier. It differs from a soft tube in that it is more highly exhausted of gas.

15. HENRY: The unit of inductance.

16. HOOK-UP: A diagrammatic representation of the relative positions of instruments in a circuit and the wiring which connects them.

17. IMPEDANCE: The property of a circuit that tends to hold back or "impede" the flow of alternating current. An inductance, a condenser, or a resistance may impede A.C.

18. IMPEDANCE COUPLING: A method of connecting or linking an inductance, a condenser, or a resistance so as to offer impedance to A.C.

19. INDUCTANCE: This tends to check any change in the flow of current through a coil of wire. Inductance may be either self-inductance or mutual inductance.

Inductance

20. INDUCTION: The action of the lines of force in a magnetic field which produces an electric current in a conductor which is in its field. By induction there is a transfer of electric energy, as from the primary to the secondary circuit of a transformer.

21. JACK: A device used to complete one or more circuits by means of a spring contact into which a plug may be inserted.

22. KILOCYCLE: 1000 cycles.

23. KILOWATT: 1000 watts.

24. LEAD-IN: The wire connecting aerial to the receiving set.

25. LOOSE COUPLER: A device for tuning. Consists of a primary coil into which is fitted a secondary coil which slides in and out, thereby changing the coupling. Out of date now.

26. MAGNETIC FIELD: The region around a magnet in which there are magnetic lines of force.

27. MEGOHM: One million ohms.

28. MHO: The unit of electrical conductance. It is the reciprocal of the ohm.

29. MICROAMPERE: One-millionth of an ampere.

30. MICROFARAD: One-millionth of a farad (unit of capacity).

31. MICROHENRY: One-millionth of a henry.

32. MICROMHO: One-millionth of a mho.

33. MUTUAL INDUCTANCE: The electromotive force inducted by one electric circuit in another.

34. NATURAL FREQUENCY: The frequency of a radio circuit corresponding to its inductance and capacity. Also called fundamental frequency.

35. NEGATIVE BIAS: The negative voltage applied to the grid of a vacuum tube through the connection of the grid return.

36. NEUTRODYNE CIRCUIT: A tuned radio-frequency amplifier in which the capacity couplings between the tubes are neutralized by small condensers.

37. OHM: The unit of electric resistance.

38. OSCILLATING CIRCUIT: A circuit which contains inductance and capacity and has such a low resistance that it oscillates when a suitable voltage is impressed on it.

39. PENTODE: A five-element vacuum tube.

40. PITCH: The intensity of a tone depending upon the rate of the various vibrations producing the tone.

41. POTENTIOMETER: A resistance unit which is used for varying the voltage applied to a circuit. It consists essentially of a variable resistance of high value.

42. PUSH-PULL AMPLIFIER: Two radio vacuum tubes connected into one stage of a receiving set so that a balancing effect is secured between them with the object of obtaining more energy for each tube without distortion.

43. RADIOTRON: A trade name for a particular make of radio vacuum tubes.

44. REACTANCE: The opposition to the flow of a variable current which is produced by a condenser (capacitive reactance) or by a coil of wire (inductive reactance). The practical unit of reactance is the ohm.

45. RECTIFIER: A device which changes alternating electric current into direct current.

46. RESISTANCE COUPLING: The method of linking two circuits together by means of a resistance which is common to both.

47. RESONANCE: A circuit is in resonance when its natural frequency is the same as the frequency of the radio current passing through it.

48. RHEOSTAT: A variable resistance used for controlling the amount of current in a circuit.

49. ROTARY CONVERTER: A machine employing mechanical rotation in changing electrical energy from one form into another.

50. SELECTIVITY: The ability of a radio receiving set to select any particular wavelength and exclude others.

51. SHARP TUNING: This is the condition when a small change in the position of the tuning device produces a marked effect in the strength of signals.

52. SHIELD: A metal plate or casing, usually connected to the ground, which is intended to prevent effects from changes in capacity.

53. SOFT TUBE: A radio vacuum tube which is not thoroughly exhausted of gases.

54. STATIC LEVEL: Reception becomes impractical when the intensity of static disturbanee reaches a certain strength or level. Broadcasting which is received at an intensity below this level is not intelligible.

Tickler

55. TICKLER COIL: A coil which is used to feed back electric current from the plate to the grid circuit of a radio vacuum tube.

56. TUNING: Changing the capacity or inductance as in a radio receiving circuit so that the receiver circuit will be in resonance with the frequency of a transmitted radio signal.

57. TUNER: The part of a receiving set which is used to adjust it to resonance or to adjust the receiving circuit so that it will be in tune.

58. VARIOMETER: A device consisting of two coils connected in series which are arranged so that the mutual inductance between them may be varied.

59. VERNIER CONDENSER: A variable condenser with vernier device for very accurate setting of the dial.

60. VOLT: The unit of electric pressure.

CHAPTER 3

General Radio Theory for Amateur Operators

● The general theory underlying radio has to do with electricity. Electricity itself either moves as an electric current or remains stationary or static as an electrostatic field. Current electricity produces an electro-magnetic field in which we state there are lines of forces. For many years it has been customary to think of electricity flowing in a circuit from the positive to the negative pole. We now think of electricity as being made up of electrons moving from the negative to the positive pole.

The Electron Theory

Every known substance consists of particles called molecules. Molecules are composed of atoms, the smallest particles of matter obtained by chemical action. In the electron theory the heart of the atom is considered to be a minute charge called the proton. Numerous negative charges of electricity called electrons rotate at great speeds.

In an ordinary electric circuit, conductors permit the rapid passage of electrons, causing what is called a flow of electricity, while insulators prevent such electron movement or current flow. Resistances are substances used to regulate the flow of current and are consequently poor conductors and also poor insulators.

ELECTROMOTIVE FORCE, CURRENT AND RESISTANCE: Electromotive force is electrical pressure or voltage. The unit of electrical pressure is the volt. One volt will force one ampere of current through one ohm of resistance. *Current* is the movement of electrons along a current path or circuit. The unit of current is the ampere. Resistance is the stoppage effect which the circuit itself has on the current flow and is always a direct ratio between voltage and amperage. The unit of resistance is the OHM. Conductance is numerically the reciprocal of resistance. Its unit is the mho.

DIRECT CURRENT AND ALTERNATING CURRENT: Direct current flows continuously in one direction from positive to negative. Batteries and certain types of generators furnish direct current. Alternating current periodically reverses its direction of flow. It is furnished by alternating current generators. The number of times alternating current changes its direction per second is called the frequency.

It is important to remember that the ratio between voltage, amperage and resistance does not remain the same when dealing with alternating current as it is with direct current. This is because we have two distinct elements in A.C. work but not important in present D.C. circuits. These elements are known as *inductance* and *capacity*.

Inductance

To thoroughly understand the effect of inductance it is first necessary to understand induction. When current is sent through a conductor, an electro-magnetic field of force is established around that conductor. When the current is stopped, as it must stop in order to reverse in the case of A.C., this magnetic field collapses across the conductor, which causes such a current to flow momentarily in a direction opposite to the current originally forced through the conductor. This phenomenen is called *self-induction*. A wire wound in a coil has considerable concentrated self-induction. Another coil placed in the general proximity will be affected by the inductive effect and when so affected we have mutual induction.

In all radio circuits where energy is transferred from one coil to another, we have inductance which is defined as the coefficient of self-induction. Inductance is that property of a circuit which opposes a change in the flow of current through it. The symbol of inductance is L. Its practical unit is the henry. When a current that is changing in a circuit at the rate of 1 ampere per second induces an e.m.f. of 1 volt, that circuit has an inductance of 1 henry. (1 millihenry=0.001 henry; 1 microhenry=0.000001 henry). Therefore, it is true that inductance is basically a magnetic property that opposes any change in the flux and, therefore, any change in either the magnitude or the direction of the current.

One might say that the property of an A.C. circuit, whereby electrical energy is stored up in the form of electromagnetic lines of force, is inductance. When the current in the circuit is 1 ampere, the number of henrys inductance in a circuit is numerically equal to twice the number of joules stored in the magnetic field. It is sometimes referred to as self-induction, also, quite aptly, as "electrical inertia." In expressing a conception of this highly important property, these phrases are all beneficial.

A.C. circuits always possess inductance and are said to be inductive. The inductance is distributed in a straight wire. If the wire is wound in the form of a coil, the inductance is increased and concentrated. Therefore, rather than refer to a coil introduced in a circuit to furnish inductance as an inductance coil, it is customarily referred to merely as an "inductance". The inductance of a circuit is also usually considered as being made up of these coils, the leads being ignored as of negligible inductive value in radio sets, except at very short wavelengths. The value of the inductance depends

on the size of the wire and the permeability of the core and varies directly as the square of the number of turns. The permeability is 1 and the amperage has no effect on the inductance if the core is air, as in most radio circuits.

RADIO TUBES: Radio tubes can be classified in many ways. The amateur will probably think of them at first as being either transmitting or receiving tubes. For use in transmitters you have heard of "power" tubes, "rectifying" tubes, "amplifying" tubes, etc. In the receiving set you have been shown "detector," "radio amplifier," and "audio amplifier" tubes. Also, you know that there are two-element tubes, three element tubes, four element tubes, screen grid tubes, pentodes, etc. All in all, radio tubes are one of the most interesting and important things in a radio set for an operator to know about. They are the very heart of the modern radio set, whether the set is a receiver or a transmitter and whether it was built by an amateur at a total cost of $1.98 or by the Radio Corporation of America for a quarter of a million.

Two-element Tube

The 2-element tube consists of an evacuated glass tube, containing two elements; a filament heated by electricity and a metal electrode, called a plate, which usually surrounds the filament. The plate and filament are not in contact with each other.

Now, if a high positive potential is applied to the plate, this relatively cold plate will be bombarded by the negative electrons that the hot filament emits and this bombardment charges the plate negatively. Current will then flow in one direction only—from the plate to the filament.

The two-element tube can be used as a rectifier if one wire of an alternating current source is connected to the filament and the other to the plate. The A.C. will be rectified into pulsating direct current by the one-way action of the tube. Remember there is no material connection between the plate and the filament; remember also that because of the fundamental laws governing electron emission the electrons emitted are negative and pass from the filament to the plate. The positive flow of "current electricity" is therefore opposite in direction—from plate to filament. The space between the plate and filament becomes a one-way conductor because of the presence, in steady passage, of negative electrons only. The *filament current does nothing but heat the filament* so that it will emit electrons.

This fundamental conception of how a *rectifying* tube functions is necessary in order that you may understand detector tube action.

Three-element Tube

The 3-element tube contains a plate, a filament, and a third element called a "grid." This grid is a metallic mesh so placed that the electrons emitted by the filament must pass through it to reach the plate. This grid actually controls the flow of electrons. The sensitiveness of a receiving tube depends largely on this controllability; by imposing positive or negative potential on the grid, the amount of "current" flowing between plate and filament is controlled. This "plate current" is increased greatly by a very small increase in the grid potential and the power released by the "plate circuit" is always more than the power expended in the "input circuit." For this reason, amplification can be increased by "feeding back" part of the plate current to the input circuit. By this means, a tube can be made to produce sustained oscillations.

How Tubes Are Manufactured

It is desirable to understand in a general way how ordinary radio tubes are constructed. In manufacturing a tube, a flanged glass cylinder serves as the main support for the elements. The supporting posts and lead-in wires are sealed into the top of the flanged tube by fusing the glass while a smaller exhaust tube is fused into the side also.

The filament, which is usually shaped like an inverted V, is next welded to the supporting posts and then the grid is mounted. The grid is made of fine tungsten wire usually impregnated with thorium. This wire is either welded to, or embedded in, the supporting frame upon which it is wound, and may be wound up cylindrically or flatly looped around a rack of two or more upright frames. If cylindrical in shape, the grid surrounds the filament. If it is a flat "rack" type, it is placed between the filament and plate, which is made in several shapes, varying from a wire-wound type to heavy sheet metal. The plate is usually made of nickel, although sometimes molybdenum or tungsten is employed.

Thorium, barium, and strontium are used in the manufacture of filaments to increase their efficiency in emitting electrons. These are either combined with the metal when it is drawn into wire, or are cemented onto the wire. When thorium is used, the filament is known as a thoriated filament, and when barium or strontium is used the filament is referred to as a coated filament or sometimes as an oxide filament. Oxide filaments operate at a lower temperature than plain, untreated tungsten filaments and less light is thrown off; for this reason they are often called "dull emitters." In some tubes the filament is mounted under tension by a spring.

The final step in building the tube is to enclose the elements in a glass bulb, fuse it to the flange of the flanged tube and pump out the air through the small tube previously fused into the side for that purpose. (Of course if the oxygen of the atmosphere remained, the elements would burn.) The removal of the air is accomplished by a vacuum pump. The small exhaust tube is melted off, permanently sealing the radio tube. Usually, the hotter the tube while exhausting it, the greater the vacuum, and as plain tungsten will stand more heat than oxide-coated filaments, more gas and air can be pumped out of a tungsten-filament than out of

an oxide-filament tube. All tubes release some gas from their inner parts when placed in service and to absorb these gases a small quantity of magnesium, phosphorus, sulphur, or arsenic is left inside. These substances create a silvery film on the inner surface of the bulb which attracts the gas that remains inside, sealing it into the glass walls of the bulb. After pumping out, the bulb is cemented to an insulated base containing four or five small hollow rods which are connected to the contact prongs; two for the filament, one each for the plate and grid. Rigidity of all parts is necessary to prevent vibration, which causes "microphonic noises in the receiver. Each tube is rigidly tested when finished, to determine its fitness for the service for which it is designed.

Tube and Filament Characteristics

A "hard" tube contains practically no gas while a "soft" tube contains a little more gas than a "hard" tube. A soft tube will require an adjustment of voltage to best fit it for the use to which it is put; a hard tube does not require this voltage adjustment. The softer tubes are usually chosen for detectors because they are the most sensitive.

Characteristics of Filaments

The rate of emission of electrons from any hot metal depends on the kind of metal used and its temperature. Tungsten is used for filaments because it is a good emitter and withstands high temperatures. Platinum is not so free an emitter but the number of electrons emitted can be increased considerably by coating it with an oxide such as strontium, barium or calcium.

Oxide-coated filaments are made of a thin strip of nickel-platinum with a surface layer of strontium and barium oxides. This type has a longer life than the filament made of pure tungsten, and emission remains practically constant until bright spots appear, when the filament burns out.

Thoriated-Tungsten Filaments

Made mostly of tungsten but contain a small percentage of thorium oxide which is melted into the tungsten before it is drawn into wire. When heated in service, the thorium oxide changes to metallic thorium which becomes the outside surface of the filament that emits electrons. At about a 10% voltage overload the thorium will evaporate and the emission will be decreased or stopped. For this reason you should not overload your tubes.

Pure tungsten filaments were used in the so-called "type UX-200" and "201" tubes, but these are no longer manufactured because the wattage expended in a pure tungsten filament is about four times more than required by a thoriated tungsten filament for the same emission, and about ten times more than required by an oxide-coated filament. The overall efficiency of the thoriated and oxide filament is just about the same. At the rated operating temperature, the oxide filament is dull red, the tungsten is white, while the thoriated filament is yellowish. The thoriated filament allows a high vacuum to be obtained in manufacture, making a hard tube, very uniform in characteristics. High working temperatures will deteriorate this filament, but on the whole, it is less subject to the injurious effect of *ionization* than the oxide filament.

Ionization

As a perfect vacuum is impossible to obtain, all tubes contain a small number of gas atoms. If these gas atoms are broken up, there will be two parts—a free or negative electron and a positively charged nucleus or ion. These atoms, when so broken up, are said to be *ionized* and become conductors instead of insulators as they were before ionization. The freed electrons break up additional atoms by collision and all the electrons are attracted to the plate, while all the positively charged nuclei, or ions, move toward the filament. This movement produces an increase of current flow through the tube by neutralizing the electric charge in the space between the plate and filament, known as the "space charge." If ionization continues, the surface of the filament breaks down. If a too high plate voltage is applied, a "blue glow" discharge may result and in this condition the plate current is not affected by the grid voltage, consequently the tube becomes insensitive. The more gas in a tube, the more danger of ionization; the "harder" the tube, the less danger.

Operating Characteristics

If the plate or filament voltage is too high, ionization will occur, decreasing the effectiveness of the tube and shortening its useful life. Increased voltage also subjects the elements to an increased temperature which will deteriorate all the elements, especially the filament. Electron bombardment of the plate may make it so hot that sagging will result. For this reason, many high-power tubes are cooled by a water circulating system around their surface, which surface is in many cases the plate. Heat radiates poorly in a vacuum, consequently blackening, sand-blasting, and oxidizing of the plates is often resorted to by manufacturers to increase the heat radiating characteristics. You have probably seen some of these tubes in large transmitters.

Either D.C. or A.C. can be used to heat the filament although alternating current is preferable because it permits a more even distribution of current through the filament.

As a tungsten filament deteriorates from heat, its resistance increases, consequently the current drops and emission decreases. As a higher voltage is applied, the filament temperature rises and of course this shortens the life of the tube.

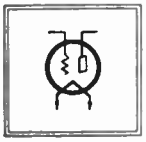
The plate resistance depends on the size of both the plate and the filament, being inversely proportional to their combined area. It also depends on the voltage used and is affected by the *amplification factor*. (See 4Q page 24.) To make the amplifi-

cation factor large and the plate resistance small, the grid is placed close to the filament.

The *plate current* depends on four factors: 1, the distance between the elements; 2, the area of the elements; 3, the shape and size of the grid; and 4, the grid and plate voltages.

Action of Three-element Tube

Fig. 5 is now the standard symbol of a 3-element tube. The filament is heated by an "A" battery or other source of current. The grid is placed between the filament and the plate. It is closer than the



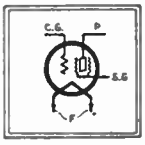


Fig. 5, at left, shows representation of a three element (triode) with directly heated cathode. Fig. 11, at right, represents symbol for screen grid tube; F, filament; CG, control grid; P, plate; SG, screen grid.

plate to the filament and influences it more. The grid is usually charged negatively with respect to the filament. The plate current varies with the filament temperature and plate voltage. It is also varied by the electrostatic charge on the grid which is obtained from an additional source, usually a "C" battery. A negatively charged grid tends to turn back to the filament the electrons emitted therefrom before they hit the plate. This effect is helped by the "space charge" which reduces the plate current. If the negative grid charge is reduced, the number of emitted electrons reaching the plate is increased and vice versa.

A *positive* grid charge will offset the space-charge effect and so the plate current will increase as the positive grid charge increases. Therefore the grid-circuit voltage should be adjustable. The *grid current*, which is small, is measured in micro-amperes, and its value becomes important when a grid leak or grid condenser is used. (See Fig. 6, 7, and 8.)

THE TUBE ACTING AS A CIRCUIT: The *input-circuit* is from grid to filament, while the *output circuit* is from plate to filament through a battery and external load. The elements of a tube

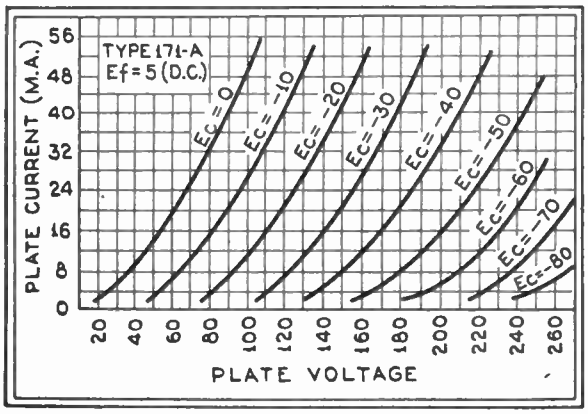


Fig. 6—Graphic chart above shows relation between plate voltage and plate current for different grid voltages.

have a certain amount of capacity in relation to each other, as do also the lead-in wires and the base. Between grid and filament there are about 5 micromicrofarads and between grid and plate about twice that value. There is also an inter-capacity or "coupling" effect between all elements which introduces reactance, with resulting impedance. The whole tube can be conceived as functioning as a variable impedance, or resistance, and the higher the grid resistance, the lower the tube resistance, and vice versa. If A.C. is used in the input circuit, the grid and filament act as condenser plates, permitting current flow in the circuit.

The *mutual conductance* of a tube should be as large as possible. Also, the amplification factor, should be as great as possible. This is desired because every receiving tube *amplifies*, whether used as a detector or as an amplifier.

The Tube as a Detector

The primary function of a detector is to convert the transmitted (radio) A.C. to pulsating D.C. This rectification process is absolutely essential in receiving because D.C. is necessary for the functioning of

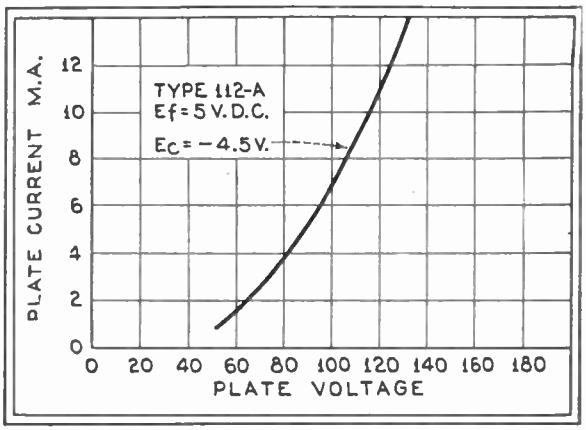


Fig. 7—Curves showing relation of plate voltage to plate current for a 112A tube.

the headphones. The process is accomplished by either the grid or plate according to the type of tube and circuit that is used. Furthermore, the detector amplifies, or increases, the loudness of the incoming signals.

Action of a Detector

Fig. 9. In this receiving circuit the filament rheostat R, in the lead from the "A" battery to the filament, controls the filament voltage. The negative terminal of the "A" battery and also the grid are shown here as negative with respect to the negative terminal of the filament. This negative voltage applied to the grid is called the *grid bias* and the amount of the *biasing voltage* is also controlled by R. The "B" battery insures direct current through the phones and the condenser C by-passes the radio frequency from the plate circuit.

By putting the filament rheostat R in the positive

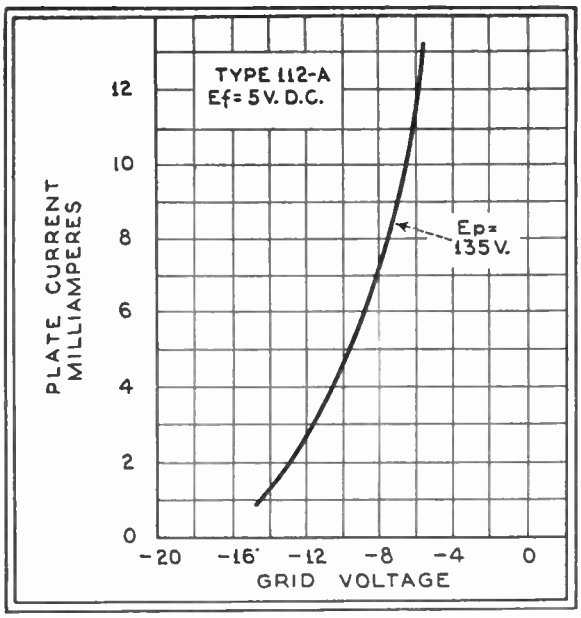


Fig. 8—Typical characteristic curve for a vacuum tube, showing the relation between the plate current in milliamperes with different values of grid voltage for a 112A type tube. Ef-filament voltage, and EP-plate voltage

lead from the "A" battery, the grid bias could be made to equal the voltage of a "C" battery; or, the rheostat R could be so connected as to vary the grid bias from positive to negative. This grid biasing is done in order to operate the tube with a specific relationship between the plate current and grid voltage as shown in Fig. 8, the object being to increase efficiency.

Plate Rectification

Assuming that the receiving circuit (Fig. 9) is in tune with some transmitter, the waves emitted from that transmitter will induce a radio-frequency current in the receiving antenna circuit. As it reverses back and forth from antenna to ground through L_1, it induces a radio-frequency current in L_2, which is reduced to audio frequency, half of each cycle passing through the detector and becoming audible in the headphones. In this circuit, detection is by *plate rectification.*

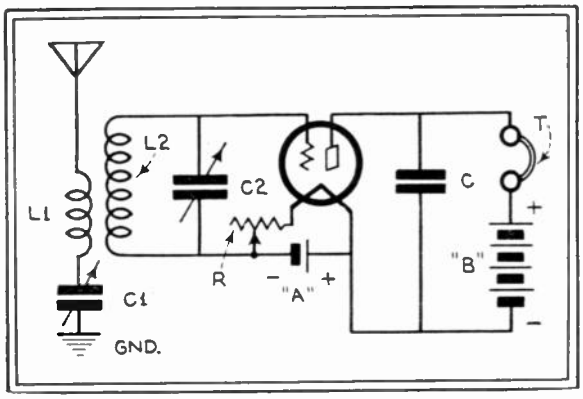


Fig. 9—Simple, straight, non-oscillating 1-tube receiver circuit.

Grid Rectification

See Fig. 10. Here the grid leak is indicated by the symbol R_2, and the grid condenser in parallel as C_3. Both are in series with the grid and the grid return lead is connected to the *positive* side of the "A" battery. The resistance of the grid leak is from 1 to 10 megohms. The small "blocking" condenser C_3 has a capacity of from 100 to 600 micromicrofarads.

Electrons are "trapped" by the grid (C_3, the grid condenser, blocking their release), which becomes more negative as the incoming oscillations become stronger. The negative grid opposes the flow of electrons to the plate, decreasing the plate current while the grid condenser decreases the average value of the plate current. In a soft tube, leakage occurs from the grid to the filament through the gas present so that a grid leak is not needed. In operating this set (Fig. 10) the resistance of the grid leak is such that the rate of leakage is proportional to the *period* of the *audio-frequency* variations of the *radio-frequency oscillations* and not to the *period* of the *radio-frequency oscillations* themselves.

This detection process (with grid leak and condenser) is referred to as *grid rectification.* Radio-frequency voltage is reduced to audio frequency in the grid circuit and the plate circuit amplifies the audio frequency variations. This is a better method than the plate rectification detection when the input voltage is small, because it is more sensitive to weak signals. When the input voltage is large (signals loud), distortion is liable to result from overloading and under these circumstances the plate rectification method is best because, as the output is greater the tube is less liable to overload.

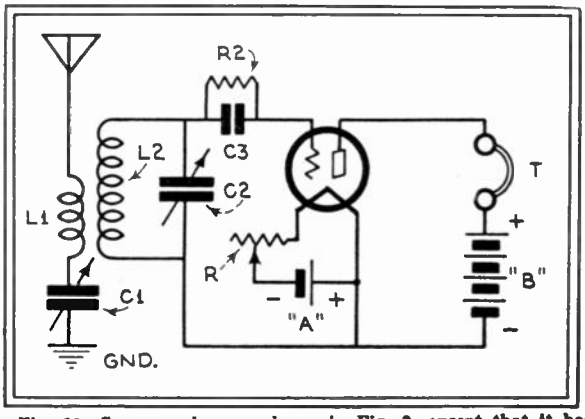


Fig. 10—Same receiver as shown in Fig. 9, except that it has grid-leak and condenser, but no condenser C.

RELATIVE MERITS: Except in a regenerative detector, grid rectification is considered the most sensitive, while the plate rectification detector is considered the most dependable, with less

distortion. These questions of relative merit are mostly matters of opinion, however, usually based upon individual experiences. Remember that in plate rectification the radio-frequency current is first amplified and then rectified, but in the grid-rectification method, the detector rectifies and changes the radio frequency to audio and then amplifies it. In the plate detector, the plate circuit converts radio

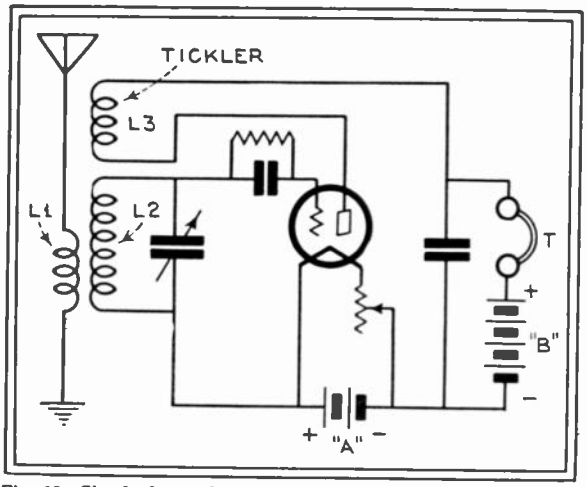


Fig. 12—Simple form of regenerative receiving circuit; the plate and grid circuits are coupled through the tickler coil, L3, which is inductively associated or placed close to coil L2. The antenna coil L1 is also inductively associated with L2.

frequency to audio; in the grid detector, the conversion takes place in the grid circuit and the amplification in the plate circuit.

Four-element (Screen Grid) Tube

See Fig. 11. The four-element tube is generally used as a radio-frequency amplifier with a positive tap from the "B" battery connected to the screen grid. It has been employed with success in transmitters and can be used as a detector. When used as a detector, the first stage of audio-frequency amplification can be dispensed with as this type tube gives an amplification of 40 to 75 per stage.

Regenerative Detector

See Fig. 12. The object of this circuit is to produce amplification without using an additional (amplifying) tube. Either plate or grid rectification can be accomplished with the regenerative detector, a feed-back or *tickler* coil inserted in the plate circuit being inductively coupled to the secondary coil of the receiving circuit. Larger radio-frequency voltage is produced by the feed-back and this creates a louder audio-frequency signal in the headphones. However, at a certain point in the feed-back process, the circuit will commence to oscillate and the received note will become mushy.

Oscillating Tube Detector

The oscillating tube detector is also called the *autodyne*. It is a type of regenerative detector with a large enough feed-back coil to keep it oscillating, being used for the reception of signals from a continuous oscillation arc or tube transmitter. The frequency of oscillation in this tube will be governed mostly by the capacity and inductance of the secondary circuit of the receiver and if this circuit is not quite in tune with the transmitter, there will be two sets of oscillations in the receiver; a new "beat" will be heard and the received note will change with tuning. The current actuating the headphones in this case is resultant of the two currents of different oscillations and the frequency of this resultant current is lower than the two that produce it.

Heterodyne Detector

Two tubes are used in this type detector, one as an oscillating detector and another to superimpose a second set of oscillations. This makes a very sensitive detector, but the circuit supplying the imposed oscillations must be kept carefully tuned. The so-called *super-heterodyne or multiple-heterodyne* system is a name given to a series of heterodyne circuits comprising one receiving circuit.

Detector Tube Efficiency

The detecting efficiency is the ratio of *audio-frequency output power to radio-frequency input power*, as actual power in watts used in the radio-frequency input circuit is not readily measured. It is preferable to express the detecting efficiency as a relation between the radio frequency input voltage and the resistance of the external output circuit. A detection coefficient is used and this factor squared and then multiplied by the ohms resistance in the output circuit will give the detecting efficiency.

In general, with a non-oscillating detector, if the received signal is weak, its strength will be directly proportional to the *square of the radio-frequency voltage applied to the detector.*

If the received signal is strong, or if an oscillating detector is used, its strength will be directly proportional to this radio-frequency voltage, NOT squared.

Types of Detector Tubes

The following "general purpose" tubes all give good results as detectors: '01A, '30, '12, '36 and '27. These tubes have a low plate resistance, are quite sensitive, will take a fairly strong input voltage without overloading, and may be used for either grid-leak or grid-bias detection.

Amplification

In an amplifier tube, the voltage impressed by incoming oscillations on the grid circuit produces oscillations of greater power in the plate circuit than the same voltage would produce if impressed directly on the plate circuit. This is because the small voltage coming into the grid circuit is used to release current from the "B" battery which flows in the plate circuit. The advantage of this amplification process is obvious: the signals sound louder. It can be accomplished

before rectification of the incoming radio-frequency oscillations, when it is called radio-frequency amplification, or, *after* the rectification, when it is called audio-frequency amplification. (See 5Q.)

Amplifier tubes are used for either one or the other of these arrangements and ordinarily are connected into "stages" accordingly. Each stage produces a fluctuating voltage that is fed to the grid circuit of the tube in the next succeeding stage.

The extent to which the amplification, or increase in signal strength, is accomplished is the *amplification factor* and depends almost entirely upon the design of the tube. It is equal to the change in plate voltage divided by the change in grid voltage.

The amplification factor depends on the spacing and size of the grid wires, and increases with greater distance between the grid and plate; it varies directly as the distances between the plate and filament, and between the grid and filament. A fine grid, mounted closer to the filament than the plate, will naturally produce a large amplification factor. This factor becomes a constant (except at very low operating voltages) for each tube manufactured and is a measure of the maximum voltage amplification obtainable from that tube.

Sometime the amount of amplification is expressed as a voltage amplification of a certain number per stage. This number is a ratio of increase between the grid and filament voltage of one stage and the voltage delivered by it to the next stage ahead. An amplification of ten means that the signal is increased to ten times more than it was originally. By "overall gain" is meant the increase in amplification accomplished by the entire receiver.

If connected through a resistance, the stage becomes a resistance-type amplifier; if through a transformer, a transformer type; and if through an inductance coil or coils, it is known by three names: inductance, reactance, or impedance type. If the proper value of capacity and inductance is used, any type can be employed for either radio- or audio-frequency amplification.

If a weak radio-frequency signal is amplified 20 times and then rectified, it will be as loud as if it had been rectified first and then amplified 400 times. For this reason, from one to three radio-frequency amplifiers are usually connected ahead of a detector tube with two or three audio-frequency stages after the detector. Too many audio-frequency stages are apt to cause distortion, howling and other noises.

The Tube as an Oscillation Generator

Any three-element detector or amplifier tube will oscillate under certain conditions. If it is desired to establish and maintain A.C. oscillations of constant frequency, a tube designed for this purpose called an *oscillator tube* is used. With the proper electrical constants, an oscillator tube circuit can be made to supply any frequency of from one to several hundred million cycles per second. This tube, then, becomes the source of oscillations for *continuous-wave* transmitting sets and these sets can be designed for practically any desired frequency or wavelength.

The production of A.C. within this tube depends upon the control which the grid voltage exerts on the plate current; that is, the valve action whereby a small amount of energy applied to the grid releases *a large amount from the plate battery* or an equivalent source. The tube is NOT the original source of energy, but it is the source of A.C. oscillations necessary for the emission of radio waves. A certain amount of each oscillation produced in the plate circuit is admitted to the grid circuit at such a time interval that pulsating current waves are continuously generated into the plate circuit. The time interval is controlled by the electrical constants of the circuit, the condensers and inductances used being variable for this reason.

The Circuit

In the circuit shown in Fig. 13, L_2 and C_2 constitute an oscillating circuit adjusted for a certain frequency. L_1 is coupled to the circuit; L_2C_2 and therefore receive some energy from that circuit, the oscillations in the grid circuit assisting those in the plate circuit.

When the "A" and "B" batteries are switched on and the circuit is tuned, weak oscillations will induce A.C. in L_1, which acts on the grid and produces variations in the plate current which flows

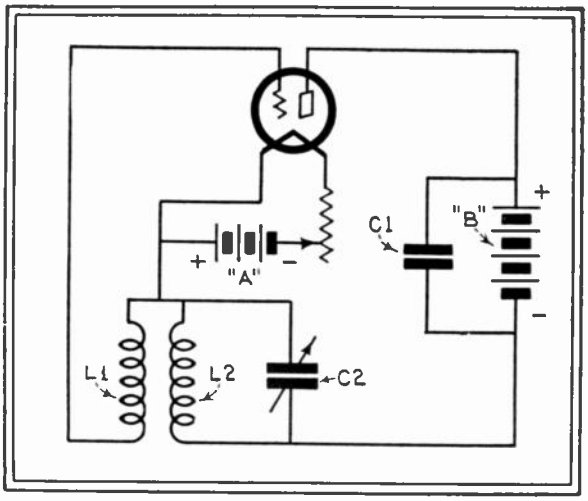


Fig. 13—A simple oscillator tube circuit. The grid and plate are inductively coupled through the coils L1 and L2.

through the oscillating circuit L_2C_2, reinforcing the originally weak oscillation. Each succeeding cycle increases the amplitude of the resulting wave until a continuous A.C. wave is established in L_1. L_1 is often used to further transfer these waves externally, as in the case of a transmitter. If a sensitive radio ammeter is connected into the oscillatory circuit L_2C_2, current flow will be shown by it when oscillations are established.

Once established, continuous oscillations will be

maintained if the voltage induced in the grid circuit produces variations in the amplitude of the plate current sufficient to maintain the voltage in the grid circuit. The necessary feed-back action can be brought about by electrostatic or inductive coupling or by direct coupling from the plate back to the grid circuit.

In Fig. 14, L_2 and L_1 are coupled together in order that the voltage applied from the plate circuit will maintain the oscillations. To allow tuning, C must be variable, instead of fixed, as shown.

In Fig. 15, the coupling is necessary in order to control the grid voltage, because in this case L_2 is not in the oscillatory circuit. Tuning is possible if L_1 is made variable, instead of fixed, as shown.

In all oscillating tube circuits, the varying plate circuit can be considered as partly A.C. and partly D.C.

The frequency of oscillations and the control of frequency are discussed in the chapter on transmitters.

Kinds of Waves

There are four kinds of well known waves; 1—electric or radio waves; 2—sound waves; 3—heat waves and 4—light waves. Radio waves are again classified as radio frequency above 10,000 cycles per second and audio frequency below 10,000 cycles per second. This is because human beings can hear sounds due to vibrations of a body, such as a violin string, when the frequency of vibration is less than 10,000 cycles per second.

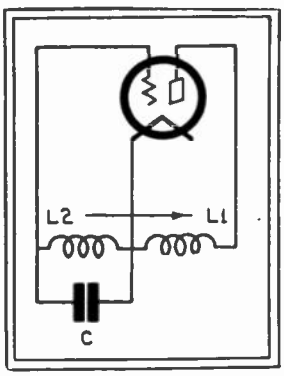


Fig. 14—Tuned-grid oscillator tube circuit.

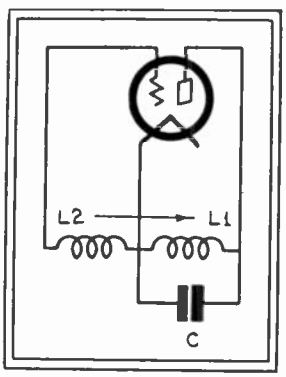


Fig. 15—Tuned-plate oscillator circuit.

(Some people can hear sound waves as low as 18 and as high as 20,000 cycles per second.)

There is a generally accepted theory that all waves, including ultra-violet waves, the shortest waves known, are electric waves of different wavelengths. All waves travel with the speed of light, approximately 186,300 miles or 300,000,000 meters per second.

AMATEUR FREQUENCIES: The amateur bands have been frequently arranged into six bands lettered from A to F inclusive. Band A is 25 meters wide and ranges from 1715 to 2000 kc. Band B is from 75 to 87.7 meters which is the equivalent of 4000 to 3500 kc. Band C is from 41.1 meters (7300 kc.) to 42.9 meters (7000 kc.). Band D is from 20.8 meters (14,400 kc.) to 21.4 meters (14,000 kc.). Band E is from 10 meters (30,000 kc.) to 10.7 meters (28,000 kc.). Band F lies between 5 meters (56,000 kc.) and 5.36 meters (60,000 kc.). This is the narrowest amateur band. Any wave below 5 meters is considered an ultra-short wave (or ultra-high frequency). All waves less than 100 meters are short waves, some people considering even 20 meters as being short. The shorter wavelengths have a tendency to skip certain distances from the transmitter, the theory being that these will bend by refraction in the upper atmosphere, coming back to the earth at points past the zone skipped.

Waves in band A work best at distances up to 500 miles. Therefore, you should build your transmitter for band A if you wish to work comparatively short distances. Band C waves show a decided skip characteristics and consequently are often heard several thousand miles away from the transmitter. Tests have shown that 7000 kilocycle frequency (band C) is better than 3500 kilocycle frequency for long distance work. Amateurs have found that bands A, B, C and D are most suitable for their purposes. The beginner will probably get better results working in band A, as he will find plenty of amateurs within a radius of 300 miles who are on this band and who will work with him. You will find that it is not difficult to build a transmitter to work well if designed to work within this band. Later on, if you wish to communicate with some amateur in Europe, you can modify your original transmitter or build another one to work in bands B, C, and D.

In building your receiver the same general idea should be kept in mind as to frequencies which you wish to cover. It is perfectly possible to build a good receiver which will cover the entire range from about 10 meters to 200 and on this receiver you can copy all amateurs working on bands A, B, C, D, and generally E.

Questions and Answers on Radio Theory

The beginner will probably get better results working in band A, as he will find plenty of amateurs within a radius of 300 miles who are on this band and who will work with him. You will find that it is not difficult to build a transmitter to work well if designed to work within this band. Later on, if you wish to communicate with some amateur in Europe, you can modify your original transmitter or build another one to work in bands B, C, and D.

In building your receiver the same general idea should be kept in mind as to frequencies which you wish to cover. It is perfectly possible to build a good receiver which will cover the entire range from about 10 meters to 200 and on this receiver you can copy all amateurs working on bands A, B, C, D, and generally E.

1 Q. The regulations state that the plate power supply on all tubes in a transmitter for amateur use operating on frequencies below 30,000 kc. must be filtered D.C. Tell why this practice minimizes frequency modulation and prevents the emission of broad signals.

A. The signal which takes up the least space in the radio frequency spectrum and therefore creates the least interference is one having only one frequency. A signal of this type can be obtained only when the plate supply produces continuous and unvarying D.C. to the tube or tubes in the transmitter Rectified but unfiltered current, while D.C. in the sense that it flows in one direction is constantly changing in value and as a result the power output of the transmitter varies in accordance. In transmitters without frequency modulation effects, this change in power modulates the signal at an audio frequency rate and causes side-band frequencies, causing the signal to occupy a band of frequencies instead of a single frequency. In transmitting with frequency modulation effects, the oscillation frequency depends to some extent on the plate voltage so that the frequency will change at a rapid rate with the plate voltage variations causing the signal to be still more broad. The use of a filtered plate supply eliminates these bad features by cutting out the voltage and current variations in the output of the power supplyy.

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

A. Voltage regulation is the change in terminal voltage of a power supply between the limits of no-load and full-load current, most often expressed as a percentage of the full-load voltage. When the change in voltage is small, the power supply is said to have good regulation, and when the change is a large percentage of the full-load voltage, the regulation is poor.

3 Q. What will be the effect of poor voltage regulation in a power supply that supplies a keyed oscillator?

A. The voltage will fall when the key is closed, causing the frequency of the resulting signal to change. This is called a keying "chirp."

4 Q. Tell briefly the use of a filter in a power supply.

A. The filter is used to smooth out the audio frequency voltage fluctuations present in the output of a rectified power supply and to supply the load circuit with continuous and unvarying D.C.

5 Q. What will be the result of using an inadequate power supply filter?

A. The output voltage of a power supply having an inadequate filter will have too much ripple present and cause frequency or amplitude modulation when supplying the plate of an oscillator tube.

6 Q. Why is it good practice to use separate transformers for plate power and filament heating purposes?

A. Separate transformers for these uses are preferable because they tend to isolate the plate and filament supplies and prevent the rapid changes in plate supply load caused by keying from affecting the filament voltage of the tubes. Any change in the filament voltage of the tubes caused by keying is likely to result in a change of oscillator frequenc or "chirp."

7 Q. Why should a direct current generator that is used for plate supply be filtered?

A. A filter is necessary to smooth the ripple caused by the commutator.

8 Q. How can radio frequency currents be kept out of the power supply?

A. Radio frequency currents in the power supply may be eliminated by using RF chokes in series with the leads connecting it to the transmitter, and by using RF by-pass condensers connected across such leads.

9 Q. How does a full wave rectifier differ from a half wave rectifier?

A. A full wave rectifier uses both alternations in a cycle of the input A.C. wave, whereas the half wave rectifier uses only one alternation and is idle during the other.

10 Q. Give three ways of obtaining direct current plate supply.

A. 1. The rectified and filtered output of a transformer operating from A.C.

2. A driven D.C. generator with a filter to eliminate commutator ripple.

3. Batteries connected in series to give the desired voltage.

11 Q. How may plate voltage from one common source be used to supply two or more circuits requiring different operating voltages?

A. By the use of series resistors to drop the voltage to the correct values for the circuits requiring lower voltages than the full voltage of the supply or by the use of a voltage divider with taps on it to get lower voltages.

12 Q. How may one tell when a power supply is actually delivering DC substantially free from ripple?

A. The power supply output can be connected to headphones or a loudspeaker through a high voltage condenser of 2 mfd. or so. The amount of ripple may be judged by the hum from the phones or speaker. Another way is to use the power supply on the plate of a stable oscillator and listen to the signal produced in a monitor. If the plate supply is filtered well enough there will be no modulation on the signal.

13 Q. Why is a filament center tap connection usually used for the plate and grid return circuits with an A.C. filament supply?

A. A center tap connection is used to prevent modulation of the signal by the A.C. filament supply. When the return circuits are connected to the center tap, the voltage between the center tap and the two ends of the filament neutralize each other and prevent the grid and plate voltages

from being influenced by the filament supply.

14 Q. When the filter choke is overloaded by drawing more current through it than designed for, what effect will it have on the inductance of the choke and on its filtering action?

A. The choke's inductance will be decreased and the filtering action will fall off as the lower inductance will allow more ripple to pass through the filter.

15 Q. When can an alternating current generator, of say 500 cycles be legally used for power supply to an amateur transmitter?

A. The generator can be used legally as power supply on any amateur band if its output is rectified and filtered to produce DC without ripple. It can be used however without filtering or rectification on the amateur bands of 56000 kc. and upwards.

16 Q. Tell how a monitoring oscillator is used to check the quality of the emitted signal.

A. The monitoring oscillator should be sufficiently shielded so that the signal picked up is the same volume as the signals heard from other stations on a receiver. In this way using it as an autodyne detector beating with the emitted signal it is possible to hear the emitted signal as it is heard by receivers other than our own.

17 Q. What effect would keying a transmitter between the power source and an adequate filter have on the emitted signal?

A. The keying would be indistinct with the characters running together because of the filter storage capacity power would be supplied even though the key was up, and the keying would be distinct only at very slow speeds. Also if the transmitter is self excited due to the slow rise and fall of the plate voltage in keying chirps would result.

18 Q. Tell how you would ascertain whether the frequency of your transmitter was in an amateur band.

A. To do this a monitoring oscillator or heterodyne frequency meter is necessary in conjunction with the receiver. The transmitter's signal is picked up in the monitor then the transmitter is shut down. The monitor is then picked up on the receiver and the receiver set to zero beat with the monitor. The transmitter frequency is then located on the receiver dial, and from knowledge of the receiver's tuning range it is possible to tell fairly accurately whether or not the transmitter is in an amateur band.

19 Q. Why should one check the "B" battery voltage of a calibrated monitor often?

A. This should be done as a change in the "B" battery voltage will cause a change in the frequency of the oscilator throwing the calibration off.

20 Q. Why is a monitoring oscillator useful in an amateur station?

A. A monitor can be used to set the transmitter in the band, to check the character of the signal, to check the keying and to continuously monitor the signal so that if anything goes wrong with the transmitter it will be evident immediately.

21 Q. Describe a heterodyne frequency meter.

A. A heterodyne frequency meter is a high stability vacuum tube oscillator whose tuning is calibrated in frequency.

22 Q. With the use of a heterodyne frequency meter tell how you would adjust your transmitter to a particular desired frequency in an amateur band.

A. The frequency meter should be set to the desired frequencyy as shown by the calibration chart. The signal from the frequency meter is then picked up on the receiver and the receiver tuned to zero beat with it. The monitoring oscillator is then adjusted to zero beat with the frequency meter and the headphones are then changed over to the monitor and the transmitter is tuned to zero beat with the monitor.

23 Q. Tell how to calibrate a heterodyne meter from received radio signals of known frequency.

A. The receiver, non-oscillating, is adjusted to the signal of known frequency and the heterodyne frequency meter is tuned to zero beat with the known signal. The point on the dial of the frequency meter where this zero beat occurs is the known frequency. If this process is repeated with several signals of known frequency then there will be several points on the dial of known frequency and from these it is possible to make a calibration chart.

24 Q. Why is it necessary to verify frequently the calibration of a frequency meter?

A. Because such things as changes in filament and plate voltage with continued use, temperature effects, ageing of the tube and circuit parts and possible slight damage to the circuit parts are all factors which operate to change the calibration.

25 Q. With a frequency meter of a possible error of 0.5%, what is the lowest frequency in the 14,000 kc. amateur band to which you could set your transmitter and be sure of being in the band, and why?

A. The frequency of 14,070 kc. as shown by the frequency meter calibration chart, because the possible error is such that any setting between 14,000 kc. and 14,070 kc. cannot be depended on to be in the band.

26 Q. In using a frequency meter, what is the effect upon the frequency when the tuning condenser capacity is increased, and why?

A. The frequency is decreased, because in a circuit with a fixed inductance and a variable condenser, the frequency varies inversely as the square root of the capacity.

27 Q. How would you tell whether your transmitter was radiating harmonics or spurious frequencies out of the amateur bands?

A. By listening in with a receiver having all

wave coverage and particularly on frequencies above the frequency of the transmitter. The receiver being outside of the direct field of the transmitter apparatus.

28 Q. If the frequency meter you use is accurate to three (3) kc. when set to 1750 kc. what is its error in kilocycles when set to 3500 kc?

A. 6 kc.

29 Q. Why do nearly all heterodyne frequency meters need "warming up" before they may be used for measuring frequency?

A. Because the tube elements and possibly the circuit elements expand because of the heat radiated from the filament. This causes a small change in the circuit constants but after the frequency meter has reached a certain steady temperature by "warming up" the expansion stops and the calibration ceases to change.

30 Q. Tell how to use a frequency meter calibrated for the 1715-2000 kc. band to set a transmitter in the 3500-4000 kc. band.

A. The answer to this question is the same as question 22 except that the receiver and known signal are adjusted to zero beat with the second harmonic of the frequency meter and the frequency indicated on the calibration chart is half the frequency of the transmitter.

31 Q. What causes the different readings on an absorbtion type frequency meter at different distances from the transmitter?

A. An absorbtion type frequency meter works by taking a small amount of energy from the transmitter and therefore has to be coupled to the transmitter tank circuit. When two circuits such as these are coupled together the frequencies of both are varied with different degrees of coupling or distance between them.

32 Q. Draw a schematic circuit diagram of a self excited oscillator using a single vacuum tube and explain its operation briefly.

A. A shunt fed Hartley circuit is shown in Fig. 16 (2). The filament heated by the battery A, emits electrons. The battery B charges the plate positive with respect to the filament and electrons are drawn to the plate. Any small disturbance in the circuit will cause a change in potential between the plate and grid, causing an instantaneous change in the stream of electrons to the plate. The high reactance of the choke, RFC, prevents the change in plate current from appearing in the B-battery circuit and the change in plate current causes a potential to develop between the plate and filament through the blocking condenser C1 and the section of the coil L between C1 and the filament tap. As this section of L is magnetically coupled to the section between the filament tap and the grid condenser C2 there is a potential induced between the grid and the filament. This potential operates so as to increase the change in plate current. The process continues, reinforced by the amplification of the tube and when there is enough power transferred from the plate circuit to the grid circuit to overcome the grid circuit losses continuous oscillations result. The frequency of oscillation is primarily determined by the constants of C and L. (The grid condenser C2 and the grid leak R are used to keep the average potential of the grid negative with respect to the filament. Electrons are attracted to the grid when the instantaneous grid potential is positive and current flows in the grid-filament circuit. This current is rectified AC and does not flow through the condenser C2 but flows through the grid leak R and this current flows through R to produce the negative grid bias. C2 is used to by-pass the RF currents around the resistor.)

33 Q. Draw a schematic circuit diagram of a self excited oscillator using two vacuum tubes in push pull and explain its operation briefly.

A. The circuit shown in Fig. 16 (2) is a push pull circuit of the tuned plate tuned grid variety. The filaments are heated and emit electrons and these are drawn to the plates causing plate current flow because of the positive potential on the plates from the "B" battery. The circuits LC and L1, C1 are tuned to nearly the same frequency. Any small disturbance in the grid circuit will cause the voltage on the grids to change with respect to the filament, however, as the grids are connected to the opposite ends of the tank circuit LC, a potential which causes the plate current of one tube to increase will cause the plate current of the other tube to decrease. These changes in plate current cause a voltage to develop across the plate tank circuit L1, C1. The voltage developed by each tube is added to the circuit because of the push pull connection. The change in instantaneous plate potential causes a change in grid potential because of feedback through the capacity between the plate and grid of each tube, and the energy feedback reinforces the original change in grid potential. The amplifying process is repeated and when there is sufficient energy transferred from the plate circuit to the grid circuit through the plate-grid capacities of the tubes to overcome grid circuit losses a state of continuous oscillations will be reached. The frequency of oscillation is primarily determined by the constants of LC and L1, C1. The grid leak and grid condenser, R and C2, perform the same action as in the Hartley circuit just described. The condenser C3 is used to keep RF out of the power supply.

34 Q. Show a method of coupling a transmitter to an antenna and explain the method shown.

A. One method is shown in Fig. 16 (3). In this case the transmitter, LC, tank is inductively coupled to the antenna by means of the coupling coil, L1. The RF currents flowing in the tank LC set up lines of ofrce about L and these lines of ofrce cut the coupling coil L1. When the an-

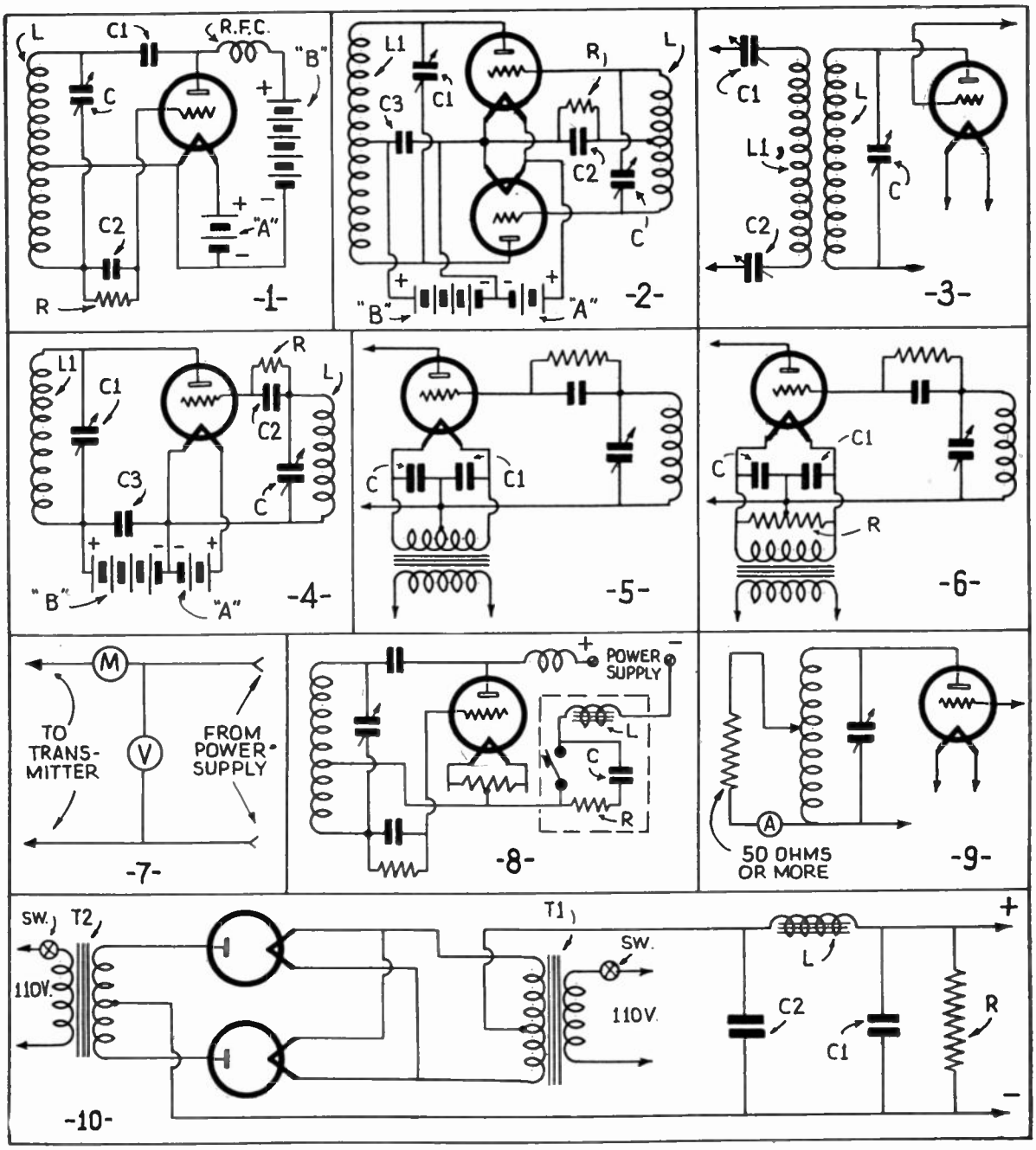


Fig. 16—Simple diagrams explained in the text.

tenna is tuned to resonance with the condensers C1 and C2 these lines of force will induce power into the antenna.

35 Q. Show a vacuum tube oscillator using series plate feed and explain.

A. An oscillator using series plate food is shown in Fig. 16 (4). In series feed the plate power is fed to the transmitter in series with the radio frequency circuit and the direct current plate power therefore flows through the tank coil. The condenser C3 is used to by-pass the RF across the power supply.

38 Q. Show a vacuum tube oscillator using shunt plate feed and explain.

A. An oscillator using shunt plate feed is shown in Fig. 16 (1). In shunt feed the plate

power is fed to the transmitter in parallel with the radio frequency circuit. An RF choke, RFC, must be connected between the power supply and the transmitter to prevent shorting the RF voltage of the tank circuit and a plate blocking condenser, C1, is necessary to prevent shorting the DC plate supply across the plate portion of the tank coil. C1 does not interfere with the flow of RF in the circuit, however.

37 Q. Show a grid return connection to the center tap of a filament transformer and explain this connection.

A. The circuit is shown in Fig. 16 (5). As the filament is heated by alternating current a grid return to one side of the filament would therefore introduce an AC voltage into the power supply which voltage would cause the plate current of the tube to vary at the supply frequency and would cause AC modulation. When the return is connected to the center tap of the filament transformer the voltage of one half of the transformer is neutralized by an opposite voltage in the other half of the transformer and there is no AC introduced into the power supply by the filament transformer and consequently no AC modulation from this source. The condensers C and C1 are used to provide a low impedance path for the RF flowing to the filament, by-passing it across the transformer windings.

38 Q. Show a grid return connection to the electrical center of a filament circuit where the filament heating transformer has no center tap and explain this connection.

A. The circuit is shown in Fig. 16 (6). In this case a resistor R, is used to abtain the electrical mdipoint of the circuit. The grid return is made to the midtap of the resistor which is of sufficient resistance to limit the current flow through itself to a reasonable value. As the voltages across the two halves of the resistor are equal and of opposite potential there is no AC introduced into the power supply by the filament transformer and consequently no AC modulation from this source. The filament by-pass condensers perform the same action as in the previous question.

39 Q. Show grid leak bias in a vacuum tube oscillator and explain.

A. The circuit is Fig. 16 (1). When the grid is positive during the radio frequency cycle, electrons are attracted to it causing a flow of grid current. This current is uni-directional and cannot flow through the condenser C2 as this condenser cannot pass direct current. This grid current therefore flows through the grid leak and as a result of the current flow in the resistor there is a voltage set up across it. The value of this voltage is equal to the product of the resistance R in ohms and the grid current in amperes. The current flows in such a direction so as to place a negative bias on the grid. The grid and filament when the grid is positive act as a rectifier and this half wave rectifier rectifies radio frequency current changing it into DC for bias.

40 Q. Show a method for measuring the plate power input to a vacuum tube oscillator and explain how it is used.

A. See Fig. 16 (7) for the diagram. The voltmeter V reads the voltage at the plate supply terminals of the oscillator and the plate milliammeter M reads the plate current in milliamperes. The plate power input is then found by multiplying the two readings of voltage and milliamperes and dividing by 1000. The milliammeter should be placed as shown so that the reading indicates the current drawn by the transmitter alone and does not indicate in addition the current drawn by the voltmeter which would be the case if the milliammeter was placed between the power supply and the voltmeter.

41 Q. Show a method of eliminating key-clicks when keying a vacuum tube oscillator and explain its operation.

A. See Fig. 16 (8). The choke L is placed in series with the key and because of its inductance this iron core choke prevents surges in current when the key is closed and causes a gradual building up of plate current. Since the choke stores current and this current is released when the key is up the plate current falls off gradually. This prevents key clicks as it is the sudden surges of current and consequent sudden surges of transmitter power that cause them. Arcing at the key is prevented by the condenser C which is used to absorb the energy released by L when the key is opened. C retains a charge when the key is open however and it is necessary to insert the resistor R to prevent sparking when the key is closed. When L, R, and C are correctly proportioned key clicks will be eliminated and sparking at the key will be minimized.

42 Q. Show a dummy antenna connected to a transmitter for test purposes and explain its operation.

A. A dummy, see Fig. 16 (9), antenna is used to dissipate the power output of a transmitter without radiating it. With it power output can be measured. The dummy is useful in tuning adjustments where it is necessary for the transmitter to deliver power but where radiation of power is not necessary.

43 Q. Show a rectifier—filter power supply and explain its operation.

A. See Fig. 16 (10) for diagram. The filaments of the rectifiers are heated by the stepdown transformer T1 and the plates of the rectifiers are connected to the ends of the high voltage transformer, T2. The ends of the secondary winding of T2 alternately become positive with respect to the mid-tap of the secondary and current flows through each rectifier tube when its plate is positive. Since current flows in each tube only when its plate is positive the current in the output of the rectifiers is uni-directional although of rapidly varying voltage. This rectified voltage is applied to the filter which smooths out these voltage variations or ripple. The filter choke and the condensers store

energy when the rectifier output voltage is high and release it when the rectifier output voltage is low and the result is an average voltage without variations or ripple in between the maximum and minimum rectifier output voltage which rapidly varies from zero voltage to the maximum voltage of one side of the transformer winding. (The actual voltage delivered depends on whether condenser or choke filter input is used.) A satisfactory value for the choke L would be 30 henries and 2 mfs. for C1 and C2. The bleeder resistor R is used to prevent the voltage swinging with keying or changing the load on the power supply and to discharge the condensers when the power supply is turned off.

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

A. Because a high ratio of capacity to inductance minimizes variations in circuit capacity due to heating of the tube elements which causes variations of the interelectrode capacities. A high ratio of capacity to inductance in the tank circuit also tends to iron out frequency variations caused by changes in plate suppy voltage with keying.

45 Q. How is harmonic emission prevented when adjusting a transmitter?

A. The antenna coupling should be loose and the transmitter tubes should not be overloaded. Excitation and grid bias should also be kept within reasonable limits to prevent harmonic emission.

46 Q. What might happen to change the frequency of a transmitter in a period of disuse and how would this change be detected before using the transmitter again.

A. The tuning adjustments may have been changed by someone ignorant of them or through accidental jarring received. Before starting up the frequency should always be checked with the monitor or frequency meter to make sure the transmitter frequency has not changed since it was last operated.

47 Q. Name several reasons for the possible erratic shifting of a self excited transmitter.

A. There may be a loose, faulty connection, a tube or other piece of apparatus may be defective, the antenna or feeders may be swinging causing capacity changes affecting the oscillator frequency or the antenna coupling may be too tight causing erratic operation of the oscillator by drawing too much power from it.

48 Q. Describe voltage fed Hertz antenna.

A. One end of the antenna is connected to one side of a tank circuit which is tuned to the transmitter frequency. This tank circuit is then indutively coupled to the transmitter output tank circuit.

49 Q. What advantages has an oscillator-amplifier transmitter over a self-excited transmitter?

A. The frequency stability is better as the oscillator is not coupled to the antenna and works into the amplifier grid which is a fixed load. The oscillator need not be keyed and this eliminates frequency change when keying due to change in plate supply voltage with the varying load on the power supply. The efficiency of a properly operated amplifier is greater than a self excited oscillator as the amplifier does not have to supply its grid losses.

50 Q. If you were operating your transmitter on 3600 kc. and got notice that you were interfering with commercial service on 10800 kc. what trouble would this indicate in your transmitter and how would you get rid of it?

A. This would show that the transmitter was radiating a strong third harmonic. To prevent this several things should be done. The antenna coupling should be loosened, the condenser-inductance ratio of the tank circuits should be increased and the plate voltage of the stages should be reduced. The excitation and the bias should also be reduced. A wave-trap tuned to 10800 kc. should be inserted in the antenna or feeders at the point in the antenna system which represents a current loop figuring the antenna to be working at 10800 kc. not 3600 kc.

51 Q. Describe an antenna for operation in the band in which you are interested.

A. An antenna for the 3500 kc. band would consist of a single wire 130 ft. long with a two wire feeder 65 ft. long. One wire of the feeder attached to one end of the antenna and the other wire of the feeder being left open at the antenna end. The two feeders should be parallel and spaced from 6 to 10 inches by suitable insulator spreaders. The feeders would be tuned by two variable condensers in series with the coupling coil, one condenser in each feeder.

52 Q. What is the advantage of keying the amplifier in an oscillator-amplifier transmitter?

A. There is less chance of requency variation and key chirps when keying the amplifier.

53 Q. How can RF feedback from the transmitter to the power lines be prevented?

A. By inserting radio frequency chokes in the power supply leads to the transmitter. The power supply leads can also be by-passed to ground with condensers.

54 Q. What are the relative advantages of a crystal controlled transmitter and a self excited transmitter?

A. The crystal controlled transmitter has greater frequency stability and stays put in frequency. Higher efficiency and power output can be obtained than with the self excited transmitter, it is more costly and much harder to get operating although it is easier to get a better quality signal with the crystal controlled transmitter. The self excited transmitter though can be operated on any frequency while the crystal transmitter is limited to the frequencies of the crystals available.

55 Q. What should be done if the frequency of

the transmitter varies when the apparatus is vibrated or jarred?

A. The transmitter should be made of more solid construction and should be isolated from vibration and jarring by mounting it on felt or sponge rubber.

56 Q. How would you prevent interference to a broadcast receiver with a wavetrap?

A. The wave trap should have condenser and coil constants so it can be tuned to the frequency of the transmitter and should be inserted in the antenna lead of the proadcast receiver as close as possible to the antenna post of the receiver.

59 Q. What effect has the swinging of the antenna on oscillator amplifier transmitters? On self excited transmitters?

A. The effect on oscillator amplifier transmitters is merely a slight variation in power output at the most but in self excited transmitters in addition to varying the power output the swinging of the antenna will vary the frequency.

58 Q. What is frequency modulation and why does it have to be avoided?

A. Frequency modulation is the variation of the carrier frequency of a phone station by the intelligence transmitted. Frequency modulation causes the signal to occupy a much larger band of frequencies than is necessary with pure amplitude modulation and thereby causes unnecessary interference.

59 Q. Why are modulated self excited oscillators not allowed?

A. Because the frequency of self excited oscillators is affected by changes in plate or grid voltages which changes are necessary in modulation. Modulation therefore results in frequency variations.

60 Q. What is meant by overmodulation and what are the undesirable effects of it?

A. Overmodulation is excessive control of the carrier by the signal voltage of the modulator wherein the carrier is at times completely cut off. It causes radio frequency distortion and creates a very broad interfering wave.

61 Q. Why must a transmitter that is to be modulated for phone work be so arranged that the modulation will not affect the carrier frequency?

A. To prevent frequency modulation.

62 Q. What is a modulator?

A. A modulator is a device used to vary the mapliture of the carrier wave according to the speech or signal to be transmitted.

63 Q. What is a speech amplifier?

A. A speech amplifier is an audio amplifier used to amplify the energy received from the microphone to sufficient level to properly actuate the modulator tube.

64 Q. What is used to convert sound waves into electrical variations for phone work?

A. A microphone consisting of a diaphragm which vibrates according to the sound waves striking it and suitable auxiliary parts to convert these mechanical vibrations into electrical variations.

65 Q. Why is it not possible to operate a phone station as close to the edge of the band as a code station?

A. Because of side bands which in the case of a phone station carry the intelligence. These side bands are frequencies additional to the carrier frequency above and below it and a phone station really occupies a band of frequencies rather than one single frequency and allowance must be made for them when adjusting the transmitter carrier to the edge of the band.

68 Q. What is the determining factor in setting the frequency of a phone station within the band?

A. The highest modulation frequency because the side bands which are the products of modulation and are bands of radio frequencies above and below the carrier frequency are numerically equal to the speech frequencies plus and minus the carrier frequency. If the highest speech frequency is 10,000 cycles and we are transmitting on 3910 kc. our phone will be scattering radio frequencies corresponding to the speech from 3900 kc. to 3920 kc. and even though the carrier is ten kc. in the band our phone is just inside the band.

67 Q. What is modulation?

A. Modulation is the variation of the amplitude of the carrier wave in accordance to the speech or other signal transmitted. (By varying the amplitude is meant the varying of the width of the carrier in frequency. Frequency modulation is the varying of the carrier frequency itself instead of its width.)

68 Q. What bad effects are caused by excessive speech amplification?

A. Distortion of the speech and possibly overmodulation will result.

69 Q. What is the carrier?

A. The carrier is the continuously radiated wave that is acted on by the modulator.

70 Q. What is a gain control?

A. A gain control is a device which is used to regulate the audio input voltage to a speech amplifier and is usually a potentiometer.

71 Q. What are the causes of frequency modulation and how is it prevented?

A. Some possible causes are the variation of the oscillator plate voltage when a common plate supply with poor regulation is used, modulated RF feedback to the oscillator, the improper neutralization of an amplifier with the resulting reaction on the oscillator and mechanical vibration of the oscillator. It can be prevented by isolating the oscillator by buffer amplifiers properly neutralized, by supplying the oscillator with a constant value of plate voltage, and if necessary by shielding the oscillator. The stability of the oscillator can be further insured by using a crystal controlled oscillator.

CHAPTER 4

Radio Receivers for Amateurs

● While you are memorizing the code and learning to send and receive you should also be reading and studying hapters 2, 3, and 4, and building a receiver.

You will undoubtedly learn more about receivers by building and operating one than in any other way. Before starting actual construction work, however, let us present a brief and informal summary of the theory of receivers.

The function of all receivers, whether crystal, tube, long wave or short wave, voice or radio telegraph, is to make audible in headphones or a loudspeaker the signals sent by a transmitter. All radio signals are sent by radio waves which are propagated through space. At the receiving station these waves must be caught and utilized in a circuit which will reproduce the transmitted signals.

Laws of electricity control this circuit. The radio waves sweeping by the receiving antenna generate a weak radio frequency current which oscillates between antenna and ground. This weak alternating current is induced into a second circuit, where it is rectified into a pulsating direct current and amplified.

The receiving circuit must have its electrical characteristics (capacity and inductance) so arranged as to be controllable in order that the receiver may be tuned to receive any one of several transmitters as desired by the operator. It must contain a detector and headphones. You will want a tube for a detector and it is desirable to have one or more additional tubes as amplifiers so that you can receive from distant or low power transmitters.

In many cases, a listener with an old style receiver is reaching out for stations that his better equipped neighbor may not be able to hear. The difference lies in the skill of the operator and his knowledge of when and where to tune.

Many times a lower power station will cover far greater distance than a high power station because the former has certain characteristics of short waves helping the signal along (viz. light or darkness effects, atmospheric conditions, less interference, and the wavelength used being more adapted for distance.) Some listeners wonder why reception of certain stations is not to be had all year round and at any time they happen to be on the air. Such a condition is caused by the effects of night and day, magnetic storms, sunspots and seasonal variations. In winter when the nights are long and the days are shorter many stations above 33 meters may be picked up though they cannot be heard during the summer months. To the contrary stations below 25 meters are aided by daylight.

Of course one can build multitudes of various receivers but generally when starting out it is advisable to begin with something simple even though one plans to build a large outfit in the near future. The experience is invaluable and leads to a better understanding of receiver practice that could hardly be gotten if one plunged into the game all at once. With this in mind several receivers of increasing effectiveness and cost are described in order. Any of them however is sufficient to get a lot of pleasure out of the air waves.

The Twinplex

The Twinplex uses a type 19 tube of the 2 volt battery variety and the set consists of a regenerative detector and one audio stage. Regeneration is controlled by a 50,000 ohm potentiometer resulting in a very smooth working control. The set is mounted on a small aluminum panel and base although a breadboard will serve equally well. Make sure when building that all connections are well made and exactly according to the

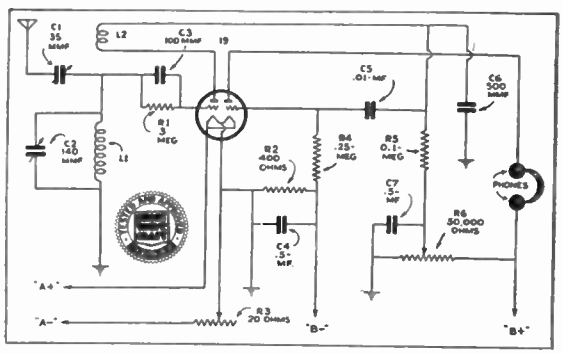


Fig. 17—The Twinplex

diagram. When putting the set into operation the rheostat should be adjusted so the filament voltage is two volts. With everything connected, the potentiometer should be adjusted until the circuit goes into oscillation which will be indicated by a soft hiss. The set should be operated at the point where it just breaks into this hiss and one is then ready to search for stations. When a station is found a whistle will be heard. This whistle should be held and the regeneration control be backed off to the point where the whistle just disappears, and one will then be able to hear the speech or music. The tuning dial should then be readjusted for maximum volume. For code reception the receiver is not taken out of oscillation, but is left just on the edge of oscillation. The antenna condenser C1 will most likely have to be occasionally adjusted to get oscillation in

conjunction with the adjustment of the potentiometer R6. The coils for the receiver can be of the manufactured or homewound type. The batteries for this set can be two dry cells and 90 volts of "B" battery or an eliminator can be used in place of the "B" batteries but this is not advisable. When the set is not in use make sure the "B" batteries are disconnected as the circuit is so arranged that R6 is connected across them and draws very slight current whether the set is working or not.

The aerial used should preferably be as long and as high as it is possible to make it.

Parts List

L1, L2—Alden (Na-Ald) Short Wave Coils, 15-200 meters.
C1—Equalizing condenser 3-35 mmf. EC-35; Hammarlund (National, Cardwell).
C2—Isolantite midget condenser, 140 mmf., MC-140-M; Hammarlund (National; Cardwell).
C3—.001 mf. moulded mica condenser.
C4, C7—.5 mf. tubular by-pass condenser, 200 DCWV.
C5—.01 mf. tubular by-pass condenser, 200 DCWV.
C6—.0005 mf. moulded mica condenser.
R1—3 meg. metallized resistor.
R2—400 ohm metallized resistor.
R3—20 ohm rheostat.
R4—0.25 meg. metallized resistor.
R5—100,000 ohm resistor.
R6—50,000 ohm potentiometer.
1—Aluminum panel, 7"x5"x⅛"; Blan.
1—Aluminum subpanel 14 ga., 7"x3¼"x1"; Blan.
1—3" vernier dial; National.
1—4-prong isolantite socket; Hammarlund (National).
1—6-prong wafer socket; Alden.
1—Ant.-ground binding-post strip.
1—Twin speaker jack assembly.

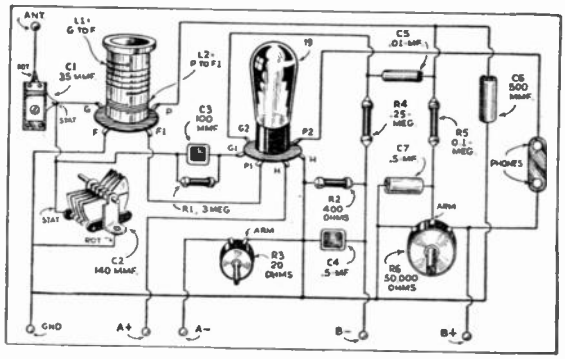


Fig. 18—The Twinplex

1—Type "19" tube RCA.

Plug-in Coil Data

Meters Wave-length	Grid coil turns	Tickler turns	Distance between 2 coils
200-80	52 T. No. 28 En. Wound 32 T. per inch	19 T. No. 30 En. Close Wound (CW)	⅛"
80-40	23 T. No. 28 En. Wound 16 T. per inch	11 T. No. 30 En. C. W.	⅛"
40-20	11 T. No. 28 En. 3-32" between turns	9 T. No. 30 En. C. W.	⅛"
20-10	5 T. No. 28 En. 3-16" between turns	7 T. No. 30 En. C. W.	⅛"

Coil form—2⅛" long by 1¼" dia. 4-pin base.

The Doerle Goes "Band-Spread"

This set is the popular Doerle (Fig. 19) designed especially for amateur use. Of course with the proper coils this set makes an admirable general coverage receiver. For bandspread work however for which the set was primarily designed special bandspread coils are used (see Fig. 20). These are five prong coils having the regular grid coil and tickler but the grid coil has been tapped and to obtain bandspread the main tuning con-

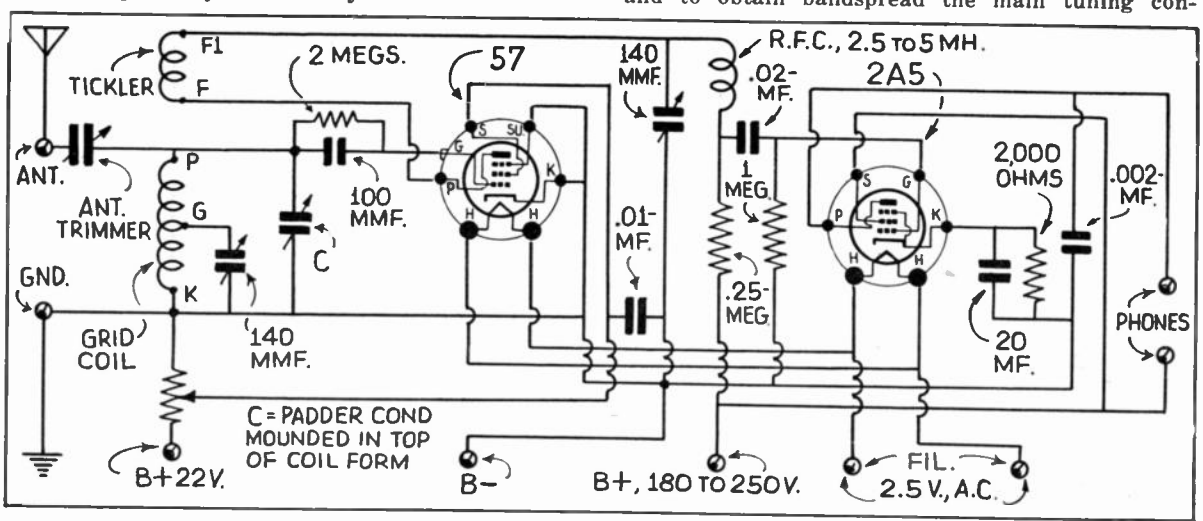


Fig. 19—The Two Tube Doerle

denser is connected across only a portion of the inductance, and a small padding condenser (140 mmf.) has been mounted in the top of the coil form, this capacity being used to tune the coil so the band will appear in the center of the tuning dial. The set uses a 57 regenerative detector with dual regeneration control and a 2A5 pentode audio amplifier. The 57 tube in this case is SHIELDED. The 2A5 pentode is used with a 2000 ohm bias resistor to cut down the plate current for headphone use and there is only a very slight drop in volume, with this value of resistance instead of the customary 500 ohms. The parts are mounted on a ready made chassis obtainable from any radio parts house and the whole layout makes a very neat job. When the set has been carefully wired with all connections well soldered hook up the power supply. It is best to make sure all connections are correct to eliminate the possibility of fireworks. After attaching an antenna of anywhere from 25 to 100 feet long and plugging in the phones one is ready to look for stations and with this peppy two tuber they are very easy to find. The potentiometer of 50,000 ohms should be adjusted so that oscillation will take place when the throttle regeneration control condenser plates are about half unmeshed. The antenna condenser should also be adjusted at the same time for the same purpose. With the set oscillating one can then adjust the condenser in the top of the plug-in coil chosen. (It is best to try one of the high wave coils say the 80 meter band at first as there are a greater number of easily heard stations on the higher bands) to center the band on the middle of the tuning dial.

This receiver is a splendid one for the beginning amateur. It has good volume, is reliable and is relatively inexpensive to build.

Parts List—2-Tube Doerle Band-Spread

1 set of Na-Ald "band-spread" coils.
1 drilled metal chassis.
2 140 mmf. variable tuning condensers. Hammarlund.
1 antenna trimmer (low min. cap.) 35 mmf. max.
1 .0001 mf. mica condenser.
1 .01 mf. bypass condenser.
1 .02 mf. bypass condenser.
1 .002 mf. bypass condenser.
1 20 to 25 mf. 25-volt electrolytic condenser.
1 2 meg. grid-leak.
1 1 meg. grid-leak.
1 250,000 ohm resistor.
1 2,000 ohm resistor.
1 50,000 ohm variable potentiometer.
1 2.5 to 5 mr. R.F. choke. National. (Hammarlund; I.C.A.)
1 5-prong wafer socket.
2 6-prong wafer socket.
1 antenna-ground terminal strip.
1 phone terminal strip.
1 5-wire battery cable.
1 57 tube. R.C.A.
1 2A5 tube. R.C.A.

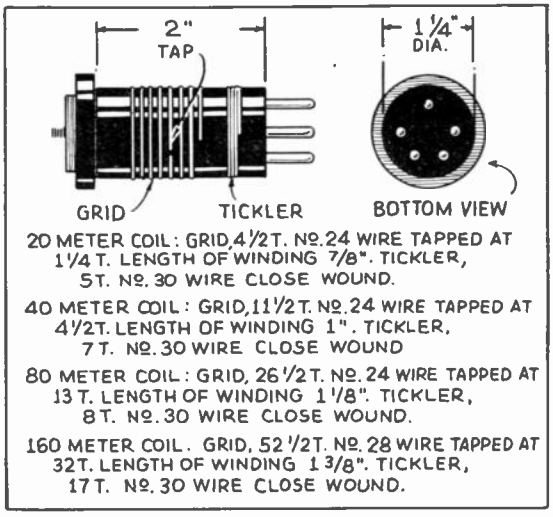


Fig. 20—Coils for the Doerle

Building a 3-Tube Band Spread Loud Speaker Set

Building this 3 tuber (Fig. 21) is a bit more of a task than the two sets previously described but the results are worth it as the tuned RF stage gives one a more stable receiver of greater gain and smoother regeneration than is possible where the antenna is connected directly to the detector. The RF stage allows the detector to work with a constant lead and if the coils are carefully wound with exact similarity it is possible to produce a receiver with very close alignment which makes for loud signals and results in being able to pull in those weak stations.

The set is mounted on an aluminum chassis of 3/32nd inch thick stock and while this would seem rather light material the construction used results in a rigid chassis. The aluminum is preferably cut where it is bought and the bending alone done at home. The bending was done using two pieces of wood, two "C" clamps and a small vise. If care is taken in measuring and bending a very neat and sturdy job can be turned out.

The tubes used as a type 58 tuned RF amplifier, a 57 detector of the electron coupled type which is well known for its stability, and a 47 pentode audio amplifier. If it is desired to use earphones a 56 can be used in the place of the 47 with no changes except placing the bias condenser and resistor R11 and C11 in the cathode lead of the 56 without changing their values and grounding the center tap of R10 directly. The volume control of the RF stage is accomplished by the cathode bias control method which is quiet and causes a minimum of detuning. The grid and screen grid circuits are decoupled by resistors R1 and R5 respectively, R5 also providing the correct screen grid voltage. This together with the proper construction of the shielding eliminates reaction of the RF stage tuning on the detector tuning

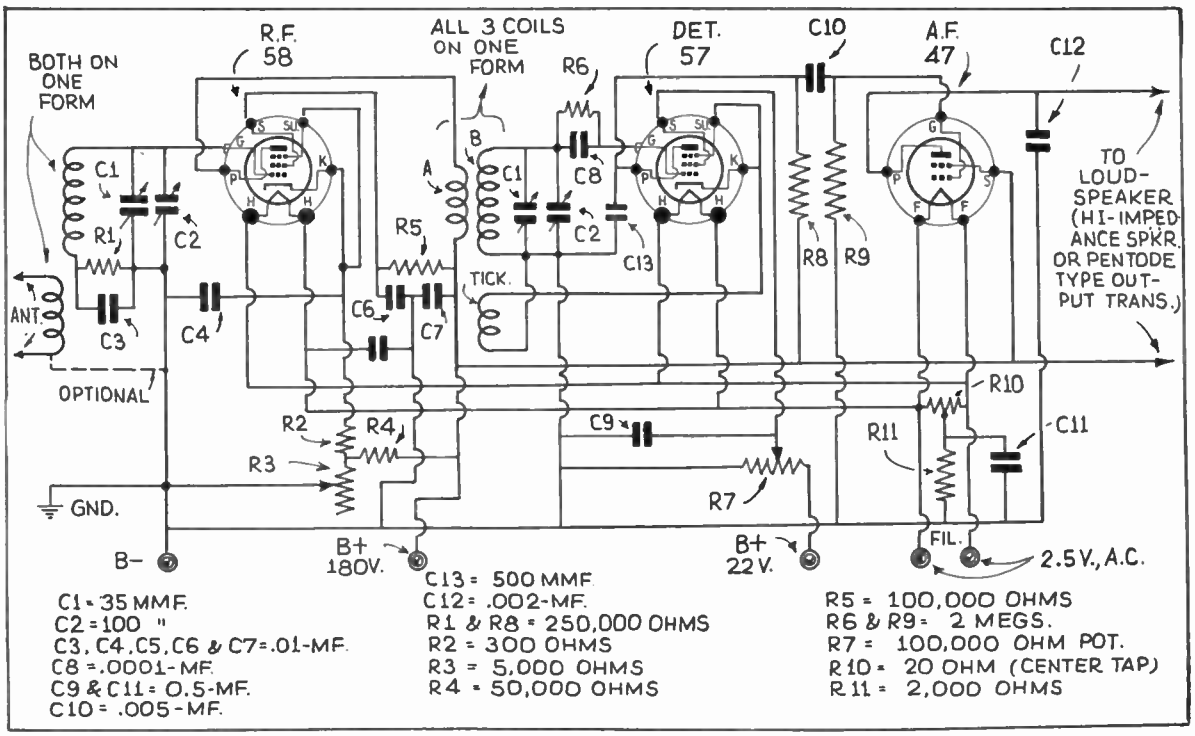


Fig. 21—3 Tube Band-Spreader.

which is sometimes very bothersome on poorly designed sets. Isolantite coil forms are used in conjunction with isolantite sockets because of their low loss.

The separate winding on the detector coil used to couple the RF stage to the detector is far superior to other methods and provides high gain and detector stability. The feed back coil is wound separate from the grid coil and is spaced about ¼ inch from it. This is to be preferred to tapping the grid coil as it results in better coil uniformity and allows better control of regeneration. The turns of the coils are not spaced wound as in this case no regard need be paid to distributed capacity. Bandspread as can be seen from the diagram is accomplished by the use of two low capacity midget condensers ganged together and the use of a separate large, padding condenser on each stage to bring the two tuned circuits to alignment. The two tuning condensers are coupled with an insulated coupling; this being one of the factors responsible for the absence of interlocking. Bandspread by this method allows the use of "high-C" tuned circuits which go a long way in contributing to the overall selectivity and stability of the set. Coil winding data is given (Fig. 23) for the small Hammarlund isolantite coil forms which, in spite of their size, are amply large for the windings for all bands.

Regeneration in this receiver is very smooth and is controlled by a potentiometer varying the screen grid voltage and there is very little trace of detuning.

After the aluminum has been marked (see Fig. 24) for bending it is advisable to drill all the holes as it is very awkward to do so if the aluminum is not flat. It will be found necessary to mount the two ganged tuning condensers with "spacers" so the shafts will be high enough to allow the tuning dial to be placed in a decent position on the front panel.

The RF stage is mounted in the left compartment seen in the illustration (Fig. 22) and the detector stage in the right compartment with the ganged tuning condensers between the audio tube socket is mounted directly behind the tuning condensers. The RF volume control and the RF padding condenser are mounted on the front of the shield similar to the mounting of the detector padding condenser and the regeneration control. As everything is fastened to the shielding there is nothing mounted on the front panel except the dial and all that is necessary to mount the panel is to drill five holes in it, slip it over the protruding shafts of the controls and add another nut to each control bushing. The threaded bushings of the condensers and the variable resistors used are long enough after fastening the controls to the shielding to take the additional thickness of the panel and the extra nut. The RF grid decoupling resistor and condenser are mounted on the bracket that supports the RF coil socket. The grid leak

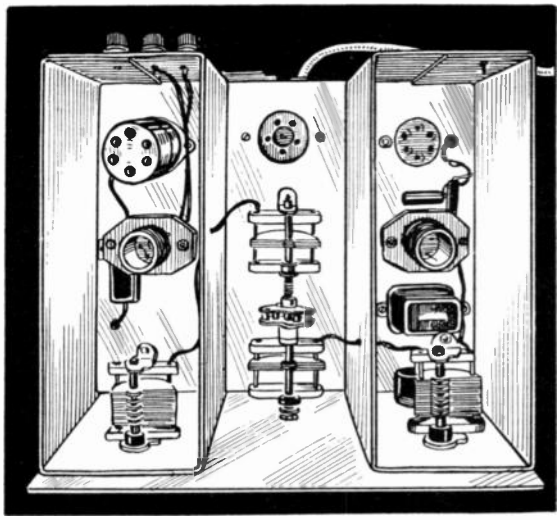


Fig. 22—Layout.

and condenser are mounted in the same fashion in the detector compartment. While on the subject of fixed condensers it should be mentioned that all the fixed condensers in the set .01 mf. and smaller should be of the mica variety as paper condensers in these positions represent the very poorest of practice and operation of the set is liable to be quite erratic if they are used.

In tuning the receiver the two tank condensers are set to approximately the same position at the section of the tuning range it is desired to cover and the tuning is then done with the two smaller condensers which are controlled by the main tuning dial. This method alows bandspreading at any frequency and still allows one to cover all the general frequencies without special coils. For ease in retuning to some station previously received it is suggested that the two tank condensers be calibrated as to their frequency response.

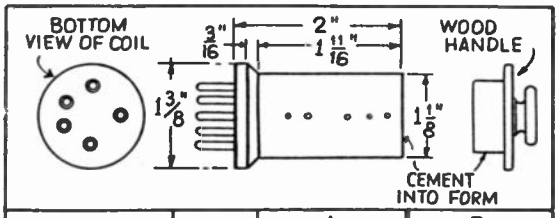
In this receiver it is usually impossible to use the full gain of the RF stage without overloading the detector. It is recommended that the volume control be set at about half way ON in tuning in a station and then bringing up the "volume level" as desired.

List of Parts

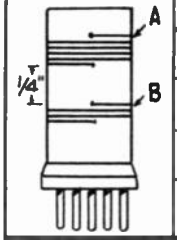
1 7"x10"x$\frac{1}{8}$" aluminum panel.
2 5½"x21½"x$\frac{1}{8}$" sheet aluminum for shields.
1 12"x10" aluminum for base.
1 Type 58 tube. (R.C.A.)
1 Type 57 tube. (R.C.A.)
1 Type 47 tube. (R.C.A.)
6 Hammarlund coil forms (five prong) "small" Isolantite.
2 Hammarlund five-prong sockets Isolantite.
2 Hammarlund six-prong sockets Isolantite.
2 Hammarlund 100 mmf. tuning condensers.
2 Hammarlund 35 mmf. tuning condensers.
1 Hammarlund flexible coupling.
1 National type "B" dial.
1 100,000 ohm Electrad potentiometer.
1 5,000 ohm Electrad potentiometer.
2 Aerovox .5 mf. bypass cond.
5 Aerovox .01 mf. fixed cond.
1 Aerovox .005 mf. fixed cond. (Polymet).
1 Aerovox .0001 mf. fixed cond. (Polymet).
1 Aerovox .00025 fixed cond. (Polymet).
2 Aerovox .250,000 ohm resistor.
1 Aerovox 100,000 ohm resistor.
1 Aerovox 15,000 ohm resistor.
1 Aerovox 2,000 ohm resistor.
1 Aerovox 300 ohm resistor.
2 Aerovox 2 megohm resistor.
1 Aerovox 20 ohm C.T. resistor.
1 Eby five-prong socket.
1 Hammarlund "Triple-grid" tube shield.
1 Five-wire cable.
1 Antenna binding post assembly.
1 Speaker cord tip assembly.

A Superhet

Just as crystal controlled transmitters have practically become the standard in amateur transmitters so have superhets on the reception angle as on the whole they are superior to the TRF receivers. Although the sensitivity is about the same with either type of receiver, conditions in modern day amateur radio demand a receiver that makes the most of its qualities in the crowded bands. The bands are crowded from the distance

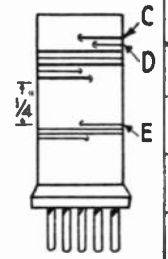


R.F. COILS



METERS	A		B	
	TURNS	WIRE	TURNS	WIRE
20	5	No.28	4	No 32
40	9	"	5	"
80	20	"	9	"
80-200	40	"	12	"

DET. COILS



METERS	C		E		D	
	TURNS	WIRE	TURNS	WIRE	TURNS	WIRE
20	5	No. 28	4	No 32	5	No. 32
40	9	"	6	"	6	"
80	21	"	9	"	14	"
80-200	40	"	12	"	25	"

Fig. 23—Coil Data

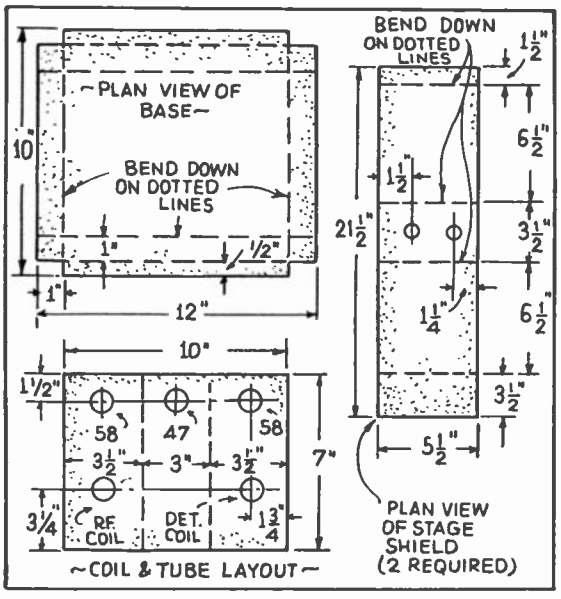


Fig. 24—Chassis Layout.

standpoint and from the local one as well. Nearly every town has several active amateurs and if they all wish to operate at the same time in the same band which is usually the case the one using the TRF receiver generally has to shut down. The reason for this is that the regenerative detector is rather unstable at the best and is very prone to blocking due to the high gain in itself and the fact that to obtain highest sensitivity it must be operated right on the edge of oscillation while the superhet is free from blocking and is stable. For short wave broadcast reception the difference between superhet and TRF receiver results is not so glaring as in the amateur bands.

If one will glance at a diagram of a receiver employing a regenerative or autodyne detector it can be seen that rectification and the production of an audio beat note are accomplished in the one stage. The detector is placed in an oscillating condition and to get a beat note is slightly detuned from the desired signal the amount of detuning determined by the pitch of the beat note desired. If beat note of 1000 cycle pitch is desired it means the receiver must be detuned from the desired signal by 1 kc. As it is possible to detune either above or below the desired signal we have therefore two beat notes for each signal.

In the superhet however after rectification instead of having the detector produce a beat note of say 1000 cycles which will be audible in a suitable headphone circuit connected to the detector it is arranged that a radio frequency beat be produced generally somewhere between 525 to 175 kilocycles depending on the design of the receiver. It is then possible to amplify this beat note with a sensitive radio frequency "IF" amplifier. In contrast with the low gain in an audio frequency amplifier which must be used to amplify the output of an autodyne detector the incoming signal has been detected or rectified but this signal has been used to modulate the local oscillator output to provide the signal for the intermediate frequency amplifier so it is necessary to detect again. After the signal has been detected a beat oscillator is detuned to say 1000 cycles above or below the intermediate or signal frequency to produce the audible beat in the phones. We now have a pair of beat notes for each signal as in the case of the regenerative detector. In superhet operation it is possible also as in the case of the autodyne to detune the receiver itself to get the beat note setting the beat oscillator right on the signal frequency. If the receiver itself is detuned to get the beat note we get a pair of beat notes each of the same signal strength and the signal sounds the same as it does on a regenerative set but if the beat oscillator is detuned to get the beat note, one of the beats is louder than the other and we have single signal "effect." Assume the receiver to be tuned right on the signal and the beat oscillator tuned to 1000 cycles BELOW the IF frequency and we obtain a strong beat. Now to get the other beat it is necessary to *detune* the receiver and naturally if we start tuning away from the incoming signal it will get weaker and the other beat note will be weak. If the IF amplifier tuning is made extremely sharp (selective) by the use of regeneration or a crystal filter, the other beat note will fall off so sharply due to the high selectivity of the IF amplifier that when we come to 1000 cycles off resonance there will be no signal at all and we have a single signal receiver. The effective width of the amateur bands and all other bands is then doubled as we can receive two signals in the same space as it was formerly possible to receive one. Of course due to practical considerations this ideal is not quite realized but it is a big improvement. This sharpening up of the IF amplifier tuning necessary to single signal reception also causes a reduction of interference between stations and also in static noises. Without the sharpness necessary for single signal reception the IF amplifier might pick up static on a band 5000 cycles wide but with the high selectivity for single signal reception the IF then picks up static on a band of only from 50 to 500 cycles wide andthere is of course less noise than before.

The superhet here described is a 3-tube job using multi-purpose tubes so the three tubes perform the functions of five (see Fig. 25 and 26). Either the 2.5 volt heater series or the 6.3 volt series tubes can be used depending on the filament windings on the power transformer. Assuming that the 2.5 volt tubes are to be used, a 6A7 performs the functions of first detector and oscillator, a 50 functions as the IF amplifier and a 53 works as second detector and resistance coupled audio stage. A regenerative IF stage is used—the regenerating boosting the gain. Single signal effect is ignored and the regeneration of the IF

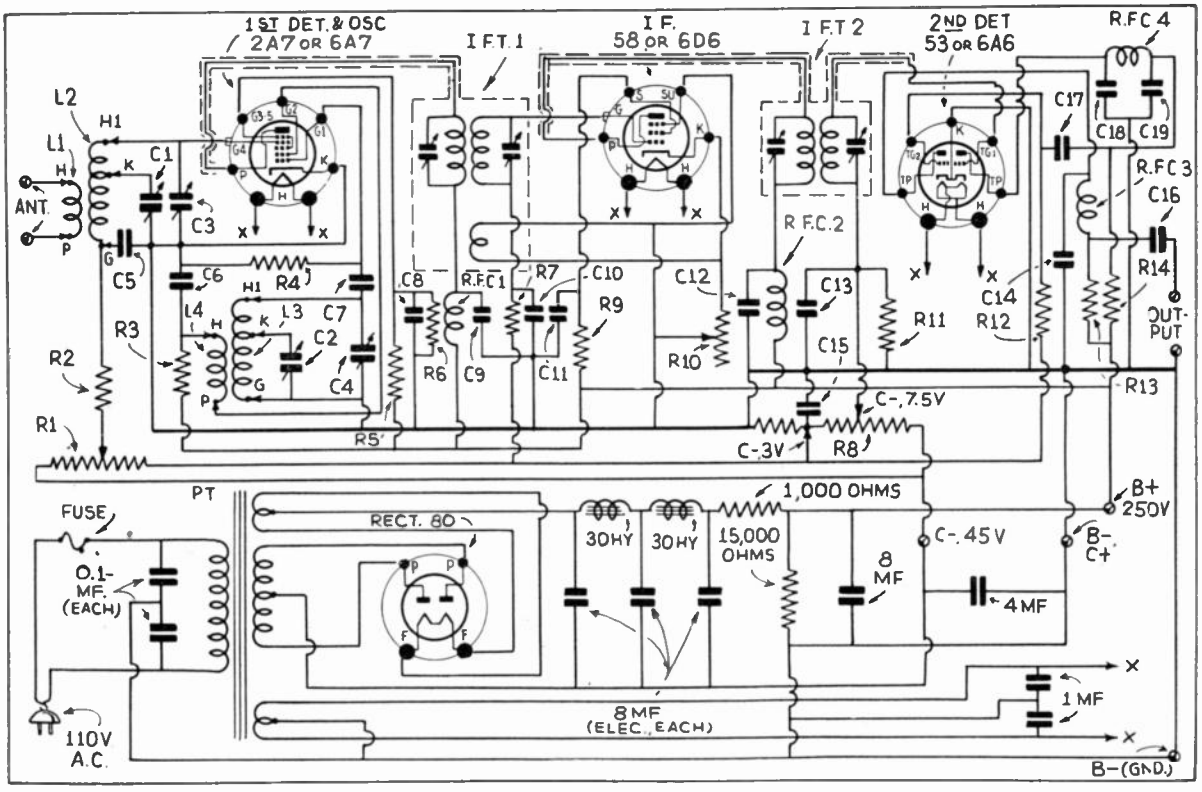


Fig. 25—The Superheterodyne.

stage provides the heterodyne beat note. While this is not the best of practice it keeps the number of tubes and parts in the set at a minimum thus keeping the cost down and yet providing satisfactory results.

The receiver is built into a National Type C-FB7 cabinet. The cabinet provides shielding and protection from dust and dirt. While a cabinet can be made of aluminum in this case the ready made steel cabinet was used. Looking at the foto from the front to the back we see the tuning dial and attached to it the bandspread condensers. Bandspread is obtained by the tapped coil method. Netx to the bandspread condensers are the general coverage tuning condensers. In back of the tuning condensers are the coils with the detector oscillator tube between them. Behind these are the input IF transformer the one with the tickler coil and the 58 IF tube. At the extreme rear of the set is the output IF transformer and the 53 second detector and audio stage in the large tube shield.

The regenerative IF stage requires an IF transformer with a tickler and as none are manufactured with a tickler it is necessary to add one. This is easily done with the National IF transformers used. The grid clip of the IF transformer should be unsoldered and the assembly removed from the can. The following changes are required to couple the tickler to the grid coil of the IF amplifier. The yellow lead is brought down so that it will pass through the bottom of the can and the blue lead is brought through the top. The coil connections should then be as follows: yellow, or inside lead of upper coil, to plate of 2A7, black, outside lead, to B plus; blue, inside lead of lower coil to grid of IF amplifier, red, outside lead, to C10 and R7; if the tickler coil is wound in the same direction as the other coils, the inside lead goes to the cathode lead of the IF tube, and the outside lead to the ground. The exact size of the tickler and its correct spacing from the secondary of the IF transformer will have to be determined experimentally after the receiver is finished. Fig. 27 shows the convenient arrangement for making these adjustments. However, don't forget to drill that ¾ inch diameter hole in the sub-base; its location is indicated by dotted lines. For the 53 the grid lead of the second IF transformer will have to be brought down to pass through the bottom of the can.

The "C" bias is obtained through a bleeder on the power supply instead of the more conventional cathode bias arrangement. Volume control is accomplished by R1 by varying the grid bias on the first detector. In adjusting the taps on the bias resistor if a suitable high resistance voltmeter is not at hand the voltages can be gotten to a very

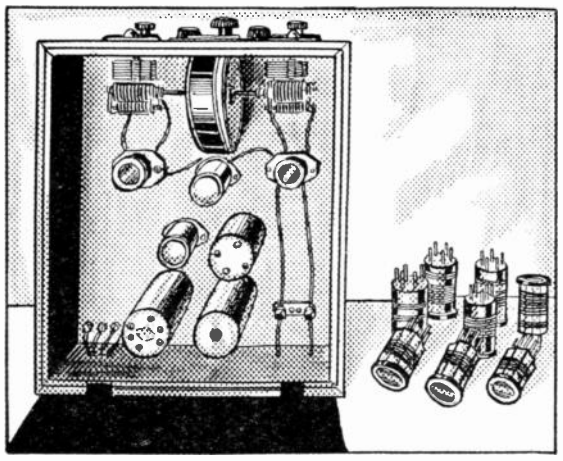


Fig. 26—Layout of Parts

good approximation by gauging the amount of resistance between the taps as the voltage naturally divides itself equally across the resistance.

The coils are wound on Hammarlund XP-53 coil forms and the dimensions are found in the coil table. All coils are wound in the same direction and the windings are connected so that if it were not for the difference in size the detector coils could be used in the oscillator stage.

Before one can look for stations after the set has been finished it is necessary that the IF amplifier be aligned. The usual procedure is followed, however, the selectivity control should be set at minimum selectivity while the adjustments are made. The intermediate frequency should be around 465 kc. and this corresponds to the IF transformer condensers having their plates about half meshed. The setting of the condensers of course will not be exact because of the different interelectrode capacities of the tubes and the fact that the shielded leads from the grids and plates to the IF transformers will be of different lengths. The capacity of these shielded leads adds to the total capacity across the IF transformer coils. After the IF transformers are tuned as accurately as possible, tune in a steady signal preferably on the broadcast band if no test oscillator is on hand and advance the selectivity control until a whistle is heard, indicating that the IF stage is oscillating. If oscillation cannot be obtained the tickler coil connections will have to be reversed. Because an oversize tickler was intentionally specified, very likely it will be necessary to remove from 5 to 10 turns to obtain a smooth regeneration control. A method about as good as any to obtain the correct amount of feedback is to remove turns until the IF circuit just fails to oscillate and then place a washer about the thickness of a soldering lug between the tickler coil dowel and the mounting plate. Since the regeneration control and the volume control "interlock" to some extent it is necessary to make the final adjustment so that oscillation can be obtained at all settings of the volume control. It is good practice to realign the IF circuit after the final tickler coil adjustment has been made.

The tuning is the same as that of any other bandspread receiver. However, to explain the manipulation of the selectivity control a step by step rocedure for tuning in stations on the 49 meter band is given.

With the third set of coils in their respective sockets and the power turned on—advance the regeneration control until oscillation takes place and then back off just a little but not enough to stop oscillation. Set the left hand dial (detector) at 34 and the bandspread dial at 65 exactly. A key station on this band can be W8XK. To receive stations at the same point on the bandspread dial each time this band is explored the right hand dial (oscillator) is rotated slowly from about 26 towards 28 until a strong whistle is heard—the weaker response on 6150 kc. is noted but not used. The OSC dial is set for zero beat and the regeneration control retarded until satisfactory reception is obtained. Tuning is simple and with a little experience one becomes thoroughly familiar with the set.

What is called image will be encountered particularly on the higher frequencies. This is caused by a lack of selectivity in the first detector circuit and can be eliminated or reduced by using one or more tuned RF stages ahead of the detector but this image is not very objectionable and in this receiver from the standpoint of economy the image is tolerated. The reason is that as the oscillator beats with the incoming detected signal to form the intermediate frequency signal it is possible to have the oscillator tuned either above or below the incoming signal in this case with a 465 kc. intermediate either 465 kc. above or below the incoming signal. If therefore there is a signal 465 kc. away from the oscillator and 930 kc. away from the desired signal and the first detector is not very selective as is the case, it will be possible to hear this signal 930 kc. away from the one we are listening to. These image signals are not very bothersome however and it is possible to eliminate any particular image signal by tuning the oscillator above the desired signal if it is below or vice versa. Trouble is sometimes experienced from pseudo-image this being when signals are heard with the oscillator off. This is caused by two signals 465 kc. apart beating together and passing through the first detector to the IF resulting in rather wier sounds. The only remedy for this is additional selectivity ahead of the first detector to sharpen the input response.

List of Parts

1 National Type C-FB7 cabinet (plain)
1 National Type HS drum dial
2 National Type BM-C 3 inch dial
2 National 450-550 kc. I. F. Transformer
1 National Steatite socket S. 7-pin (for 2A7 or 6A7)

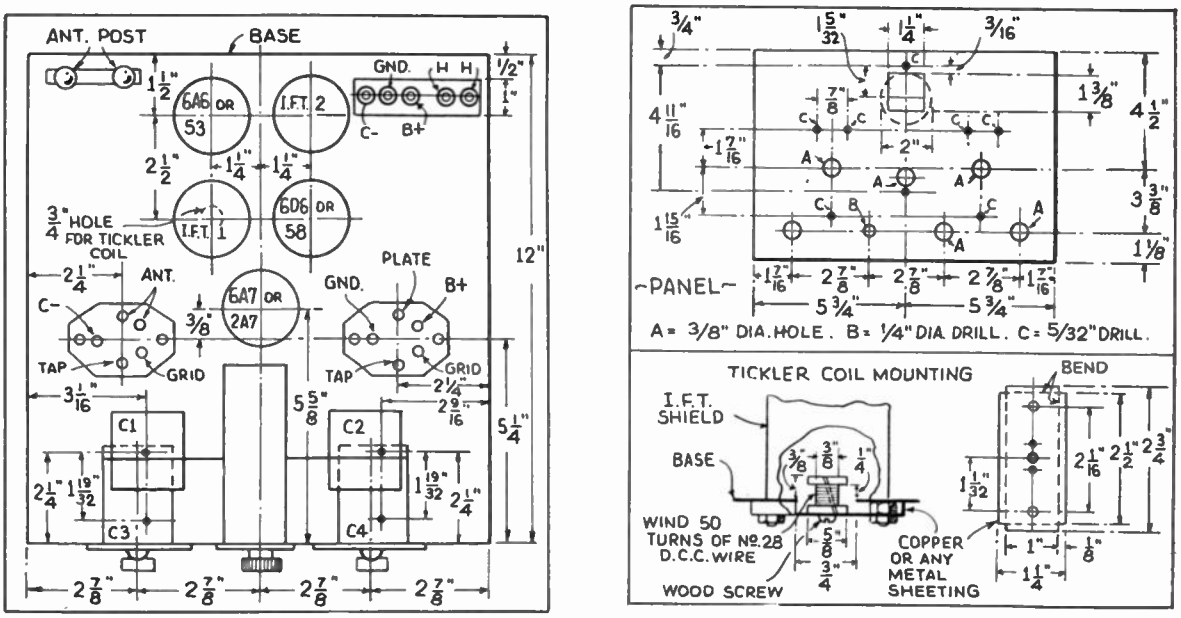


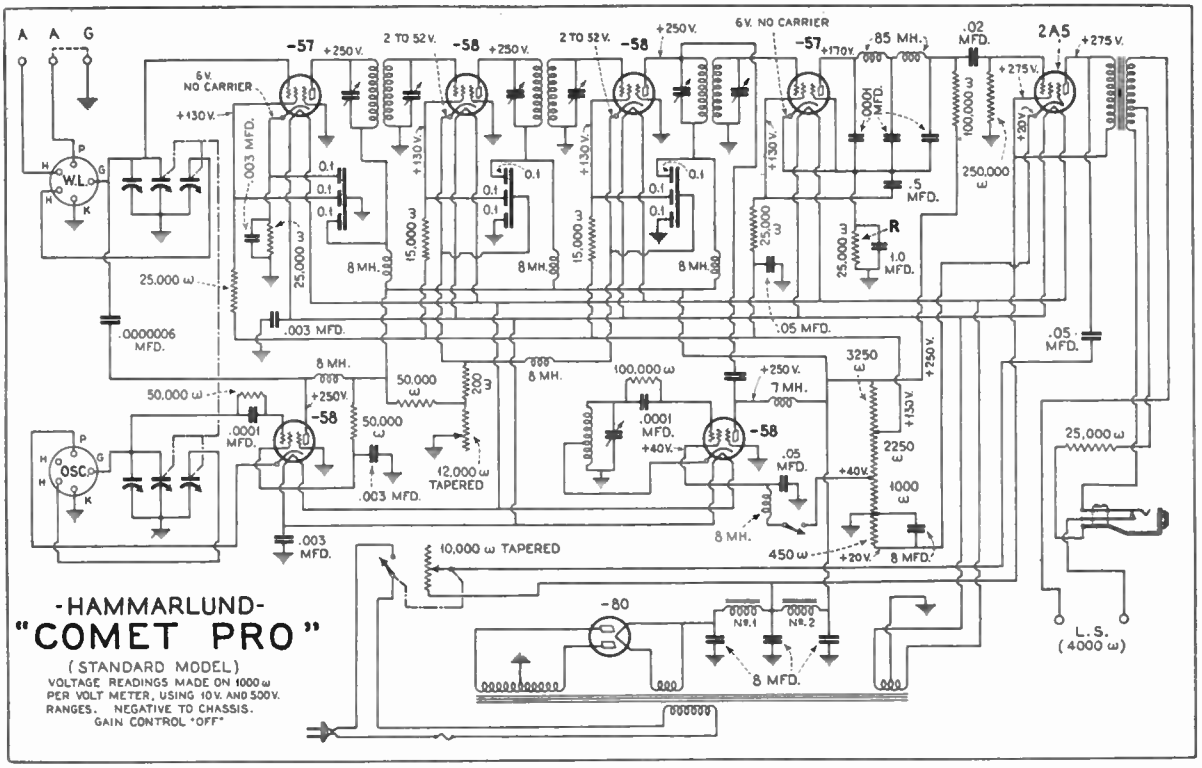
Fig. 27—How the Chassis is drilled.

1 National Steatite socket M. 7-pin (for 53 or 6A6)
1 National Steatite socket 6-pin (for 58 or 6D6) (Hammarlund)
2 National Steatite socket 5-pin (for coils) (Hammarlund)
3 Tube shields (53 requires a National Taype TS)
10 1½" dia. coil forms. 5-prong (Ribbed type preferable for tapping)
1 6"x¼" dia. fibre shaft. 1-phone jack, Hook-up wire, screws, etc.
1 Flexible coupling
C1 National Type SE-100 (Counter-Clockwise)
C2 National Type SE-100 (Standard)
C3 and C4 Hammarlund Type MC-140-M
C5 .01 mf. Mica Aerovox
C6 .01 mf. Mica Aerovox
C7 .0001 mf. Mica Aerovox
C8 .01 mf. Mica Aerovox
C9 .01 mf. Mica Aerovox
C10 .006 mf. Mica Aerovox
C11 .1 mf. 400 volt paper
C12 .01 mf. Mica
C13 .25 mf. 300 volt paper
C14 .0002 mf. Mica
C15 .1 mf. 200 volt paper
C16 .1 mf. 400 volt paper
C17 .1 mf. 400 volt paper
C18 .0004 mf. Mica
C19 .0004 mf. Mica
Condensers C11 to C19—Aerovox
R.F., C.1 to 4 may be any good chokes, around 10 millihenry or larger.
All by-pass condensers may be of the non-inductive paper type.
R1 50,000-ohm Potentiometer, Electrad
R2 250,000-ohm ½-watt Resistor
R3 40,000-ohm 1-watt Resistor
R4 100,000-ohm ½-watt Resistor
R5 40,000-ohm 2-watt Resistor
R6 60,000-ohm 1-watt Resistor
R7 250,000-ohm ½-watt Resistor
R8 2,500-ohm 25-watt (Electrad with 2 or 3 clips)
R9 60,000-ohm 2-watt Resistor
R10 2,000-ohm Potentiometer (shield type)
R11 500-ohm 1-watt Resistor
R12 250,000-ohm ½-watt Resistor
R13 250,000-ohm 1-watt Resistor
R14 100,000-ohm 1-watt Resistor

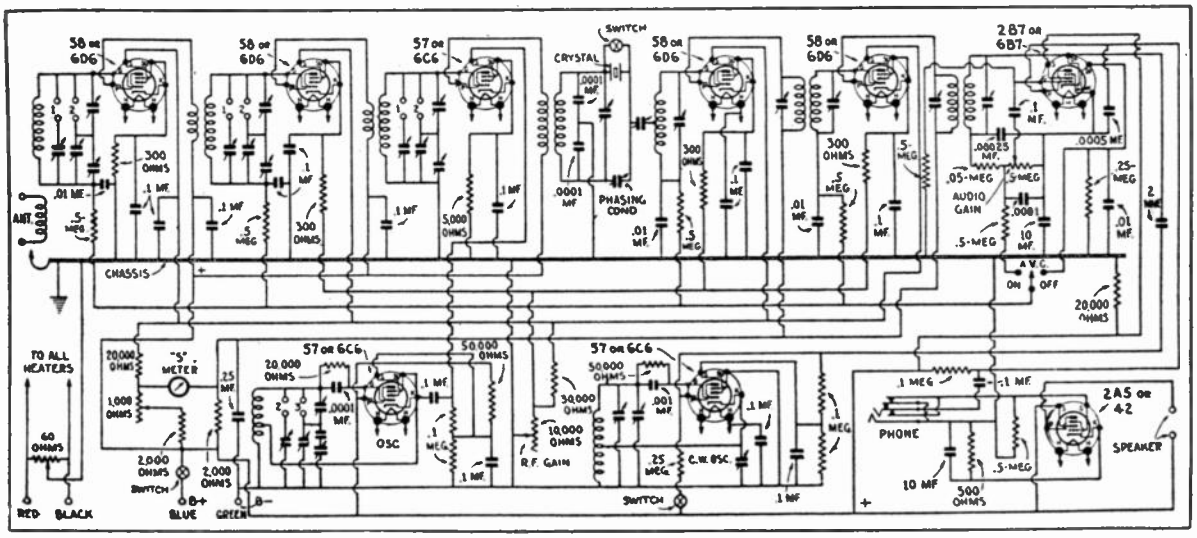
Coil Table

Set No.	Frequency Range	Number of Turns L1	L2	Tap	L3	Tap	Wire Size (L1 L2 L3)	(L4) Tap	Wire Size
1	530 to 1400 kc.	25	115	*	49	*	28 en.	24	34 d.c.c.
2	1400 to 3500 kc.	16	34	*	26	*	24 en.	13	34 d.c.c.
3	3500 to 7000 kc.	9	16	9	19	10	22 d.s.c.	10	34 d.c.c.
4	7 to 14 mc.	6	8	3	8	3	22 d.s.c.	6	34 d.c.c.
5	12 to 24 mc.	3	4	1	4	1	22 d.s.c.	3	34 d.c.c.

The actual range of each set of coils is greater than specified.
*Tap is connected to grid terminal.
The taps are counted off from the lower or ground terminal.
Coil forms are 1½" dia., and all coils are close-wound.
Space between L1 and L2 is about ¼"; between L3 and L4 1/16" or less.



Some, instead of making their own receiver, prefer to buy one of the many excellent superhets on the market today which fact attests that amateur radio certainly is a growing hobby, since so many concerns seem to be profitably manufacturing receivers. Generally speaking one gets about what he pays for when a manufactured superhet is bought except in some cases it is possible to buy one of the older models second hand and get a good bargain. Buying a superhet relieves one of the work of making a set and the consequent adjustments necessary for proper operation and if one isn't very handy with tools it is generally best to purchase a ready built model. When buying a superhet the best policy is to get one built by a reliable firm. In the circuits of the manufactured superhets here printed note the particularly effective provision for gain control and signal strength measurement in the National HRO. The Hammarlund Comet Pro is also built in other models with A.V.C. and crystal filter.



CHAPTER 5

Code and Phone Transmitters

● Amateur transmitters these days are generally crystal controlled as the congested conditions of the bands and, practically speaking, the regulations require. Self excited transmitters are rather hard to adjust for a good note and satisfactory power output at the same time, as is natural for any one thing when it is burdened with two duties. Crystals have become very cheap in comparison to as little as four years ago when the price was quite high. There is not much reason now for not using crystal control. The crystal locks the frequency and the use of an amplifier permits maximum power output to be obtained from a given layout of parts. There need be no compromise with frequency stability or quality of signal, that being already taken care of. One does not have to back off the antenna coupling in a crystal controlled job for stability as is necessary in a self excited rig and this is not booklet balderdash,—from the writer's personal experience you can be assured that it is true. Even when the power output is reduced and sacrificed to stability in the self excited rig there is nearly always the inevitable creeping and the swinging of the antenna on windy days. Back in the dark years when there were only half as many amateurs as there are now and prices were much higher, such transmitters were the general run, and a crystal controlled transmitter excited wonder and comment but today the reverse is true. The days of self excited transmitters are definitely over and the self excited transmitters described here are more for the purpose of showing what has been than for actual use except perhaps in good hands.

For the beginning amateur who wishes to build a simple inexpensive transmitter the series fed Hartley shown in Fig. 28 is a good one preferably for operation on the 1715 to 2000 kc. band. The following parts will be needed and should be mounted on a flat board about the size of a bread board, 8"x16".

C1—Oscillator tuning condenser. This can be a 500 mmf. receiver type condenser with a dial similar to the National Em-500.

C2—Antenna tuning condenser. This is identical with C1 and is mounted to the left of C1.

C3—.005 mf. mica fixed condenser.

C4—250 mmf. mica grid condenser.

C5—.005 mf. mica condenser.

R1—50,000 ohm grid leak, 2 watt.

R2—20 ohm center tapped resistor.

F—Flashlight lamp and socket.

1—4 prong tube socket, 6 inches of bakelite tubing 2½ inches in diameter. 30 feet No. 12 enameled wire, several feet of busbar, 7-Fahnestock clips, 1—45 tube.

The coils are wound on the bakelite tubing with the No. 12 wire. The oscillator coil consists of 18 turns space wound on 3½ inches of the 2½ inch diameter tubing. The tap shown in the diagram is taken off 8 turns from the grid end of the coil. This is done by carefully scraping the

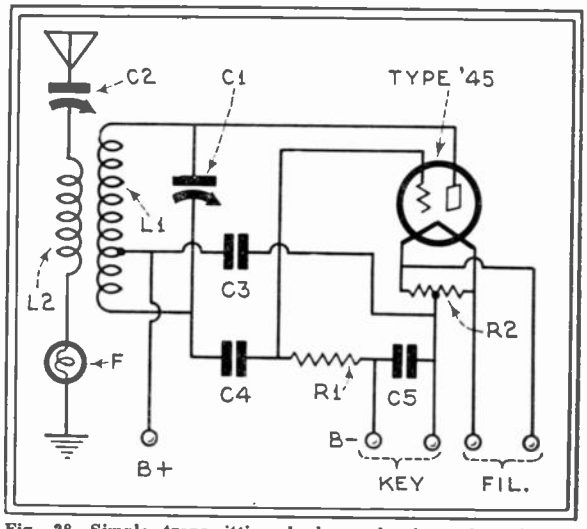


Fig. 28—Simple transmitting hook-up showing where key is connected.

enamel off the wire and soldering the plate supply lead to it. This is quite easily done as the coil is space wound, but be sure that the turns adjacent to the tapped turn are not shorted by the tap. In mounting the coil put it a little above the board using small standoff insulators. Refer to Fig. 32 for layout. The antenna coupling coil is close wound and in the same direction as the oscillator tank coil. It consists of 12 turns on the 2½ inches of tubing left. The antenna coil should be mounted end to end with the oscillator coil and provision should be made for varying slightly the coupling between the coils. The distance between the ends of the windings should not be greater than 1½ inches as less coupling than this reduces the transfered from the transmitter to the anntenna. Likewise greater coupling than this (placing the coils) closer together results in too close coupling and while increasing the output of the transmitter perhaps 10 per cent will cause instability and is liable to affect the quality of the note adversely. If possible, a milliameter should be purchased and placed in the B-plus lead. A 0-100 mill scale is just about right. The oscillator plate current should be anywhere from 10 to 25 mills without the antenna connected, depending on the particular parts and tube used. So long as the current is below about 25 mills there is nothing to worry about as it is not critical. With the antenna tuned properly, the plate current should rise to about 50 or 60 milliamperes.

The antenna for this set can consist of a wire 120 to 160 feet long run in as nearly a straight line as possible away from the transmitter. Any kind of copper wire will do and the antenna should be placed broadside to the district with which communication is most desired. The antenna should also be kept in the clear as much as possible. The ground connection should be the best obtainable as this is the weakest link in the station using a Marconi type antenna as we are in this case. The more effective the ground the

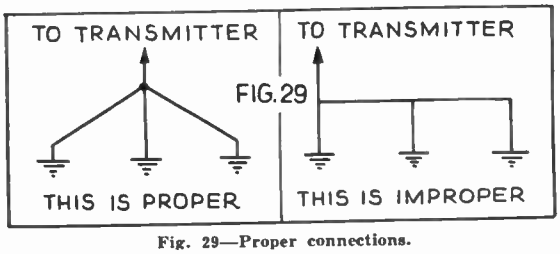


Fig. 29—Proper connections.

greater the antenna current and the greater the radiation. The water piping of the house can be used or a long rod driven into the soil, or both. Make sure all connections are A1 and if several grounds are used to increase the radiation it is particularly important that the connections to them be made in a certain way if their combined effectiveness is to be realized. (See Fig. 29.) This is so the resistance of all the grounds is the same to the transmitter and the current divides equally between them.

When the transmitter is working the antenna should be connected. It is necessary however that the transmitter be in the band before the antenna is attached and tuned up and to do this a monitor and an absorbtion frequency meter must be used. This is the case with any transmitter. The absorbtion frequency meter (Fig. 30) is necessary to make sure the transmitter is near the band or in it and the monitor to make an exact setting in the band. If the monitor (Fig. 31) alone is used due to the beating of harmonics it might seem that the transmitter is in the band when in reality it is way outside.

The absorbtion frequency meter can be calibrated on a regenerative receiver. The receiver should be tuned to the desired band, the frequency

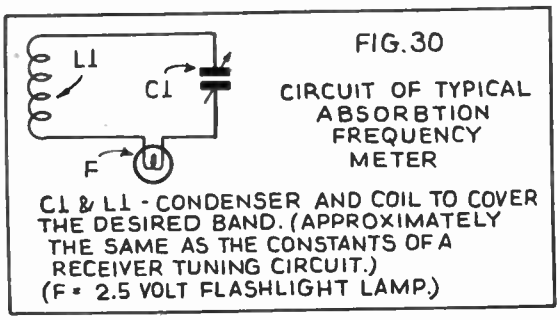


Fig. 30—A Simple Frequency Meter.

mter coil is then held near the coil in the receiver and the tuning of the meter varied. When the meter is in resonance with the receiver, at the same frequency as the receiver, it will pull the receiver out of oscillation, the receiver being set on the edge of oscillation the same as when receiving a CW signal. One should be careful that when holding the frequency meter that the bands do not touch anything but insulation. After resonance between the frequency meter and the receiver has been found one can reduce coupling between the frequency meter and receiver coils so that the frequency meter pulls the receiver out of oscillation only on a band of about 30 kc. The frequency meter is then calibrated roughly, which is all that is necessary. The monitor being used for fine calibration. The coil is held in close proximity to the tank coil of the transmitter. The transmitter is then tuned so the flashlamp of the frequency meter is of greatest brilliancy, the coupling being adjusted so the flashlamp does not burn out at maximum brilliancy. The monitor is then used. With the transmitter turned off tune the receiver to the place in the band where it is desired to set the transmitter then tune the monitor to this place. Then transfer the headphones to the monitor and tune the transmitter till it is heard in the

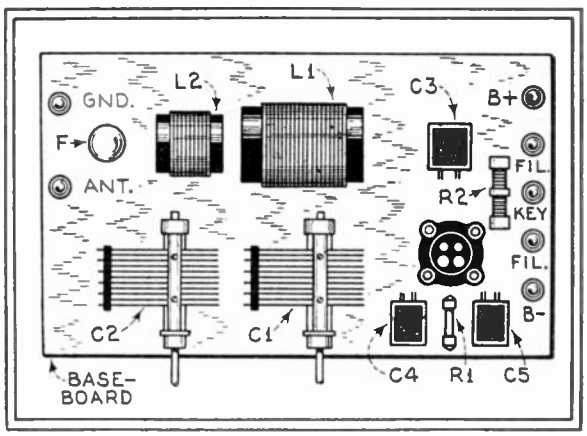


Fig. 32—Layout of Parts

monitor. The antenna of the transmitter can then be tuned, the flashlight lamp in the antenna being brightest with greatest radiation. Tuning up the antenna will probably change the frequency of the transmitter slightly and the transmitter tank condenser should be reset so the transmitter is again heard in the monitor. The antenna coupling should be adjusted to give *greatest radiation with a good note.* The headphones can then be transferred back to the receiver leaving the monitor working and we can double check the frequency of the transmitter in the band and all tuned up we are ready to try for a QSO.

The monitor is an oscillator and should be fully shielded, batteries and all, so that it picks up only a weak signal from the transmitter and in turn is heard only weakly in the receiver. The coils for

the monitor are about the same as for a receiver for the same frequency or a little larger as in the monitor there is no antenna to load up the tuned circuit. The antenna connected to a regenerative detector adds capacity and inductance to the tuned

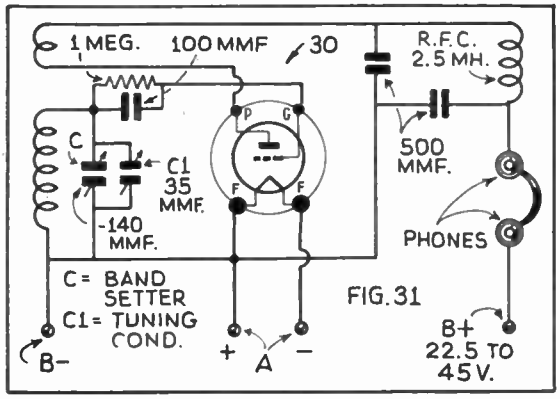


Fig. 31—The Monitor

circuit which increases the wavelength of the circuit. The amount of increase in wavelength depending on how closely the antenna is coupled.

Digression—In a superhet the antenna loads the first detector or RF stage and this is compensated for by varying the padding condenser on the input stage or the next sage etc., but the oscillator is isolated from the antenna so the antenna has no effect on it and the frequency of the receiver is not changed. With the superhet it makes no difference how much the receiving antenna swings in the wind. With a regenerative set with no RF stage the swinging of the antenna can be noticed. Safely getting the transmitter on wave is the same as above for all self excited transmitters.

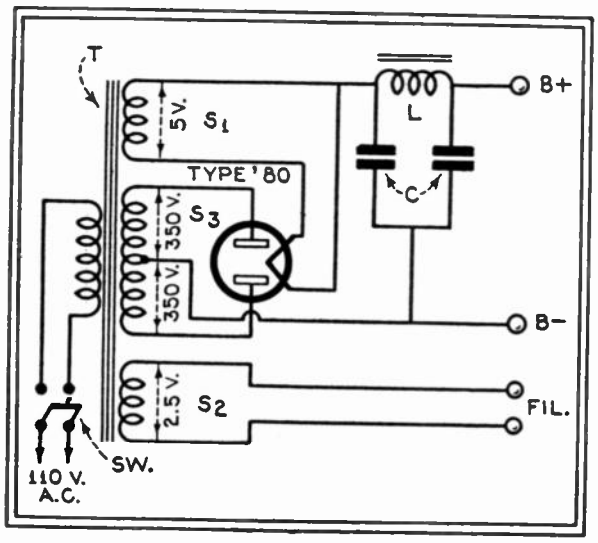


Fig. 33—Power Supply

Power supply for the 45 Hartley transmitter.—The transformer should be capable of supplying 5 volts at 3 amps. for an 80 or an 83, 2½ volts at 1.5 amps. for the 45 and from 350 to 450 volts each side of center tap at 100 mils. for the plate. The choke used should be of 100 mil. capacity and of low D.C. resistance. The filter condensers can be either 4 or 8 mf. units. 4 mf. at 1000 volts in paper condensers or 8 mf. electrolytics. A bleeder will be necessary connected across the high voltage, a suitable value being 25,000 ohms. The resistor need be no greater than 10 watt capacity.

A Popular Radio Telegraph Transmitter for Amateur Use

Most amateurs like a radio telegraph transmitter as their first set, in order to gain proficiency in sending and receiving code and because one can generally send much farther by keying than by voice with any particular transmitting circuit. A *code* transmitter is also simpler and cheaper to build than a phone because it requires no modulator.

The C.W. code transmitter here described is simple to build and operate. It is also inexpensive to build and can be used on all frequencies by changing coils. Any UX tubes can be used if the plate and filament voltages are suitable that is up to plate voltages of 550.

The transmitter circuit is shown in Fig. 34 and 35. This particular version of the push-pull tuned-plate tuned-grid circuit uses '10 tubes and the coils designed for the 40 meter band. The antenna should be approximately 62 to 65 feet long, depending upon the exact frequency of transmission. The length of the feeders will depend directly upon the distance from the transmitter to an end of the antenna. They should be close to an uneven multiple of 35 feet so it is possible to tune the antenna. In other words the feeders should be from 35 to 45 feet long or from 100 to 125 feet long. The feeder wires should be separated about 10 inches with the best feeder spreaders obtainable; paraffined wood, bakelite, hard rubber, Iisolantite, Victron.

The coils: These may be wound with $\frac{1}{8}$ inch copper tubing or heavier or heavy solid wire. The essential thing is rigidity. The coils also should be heavy as this tank circuit is arranged for high C, for stability and naturally the circulating currents will be rather large even though the transmitter is low powered. A total of 5 turns 2½ inches diameter are needed for L1. Constructed exactly like the plate coil, the antenna coils L will depend upon the length of the feeders but 5 turns will generally be correct for each, also 2½ inches in diameter.

Winding the coils is not a difficult job. Place a piece of 2 inch iron pipe in a vise and wind the turns on this. After removing the finished coil from the pipe the turn will spring out to a diameter of about 2½ inches.

Two beehive standoff insulators are required

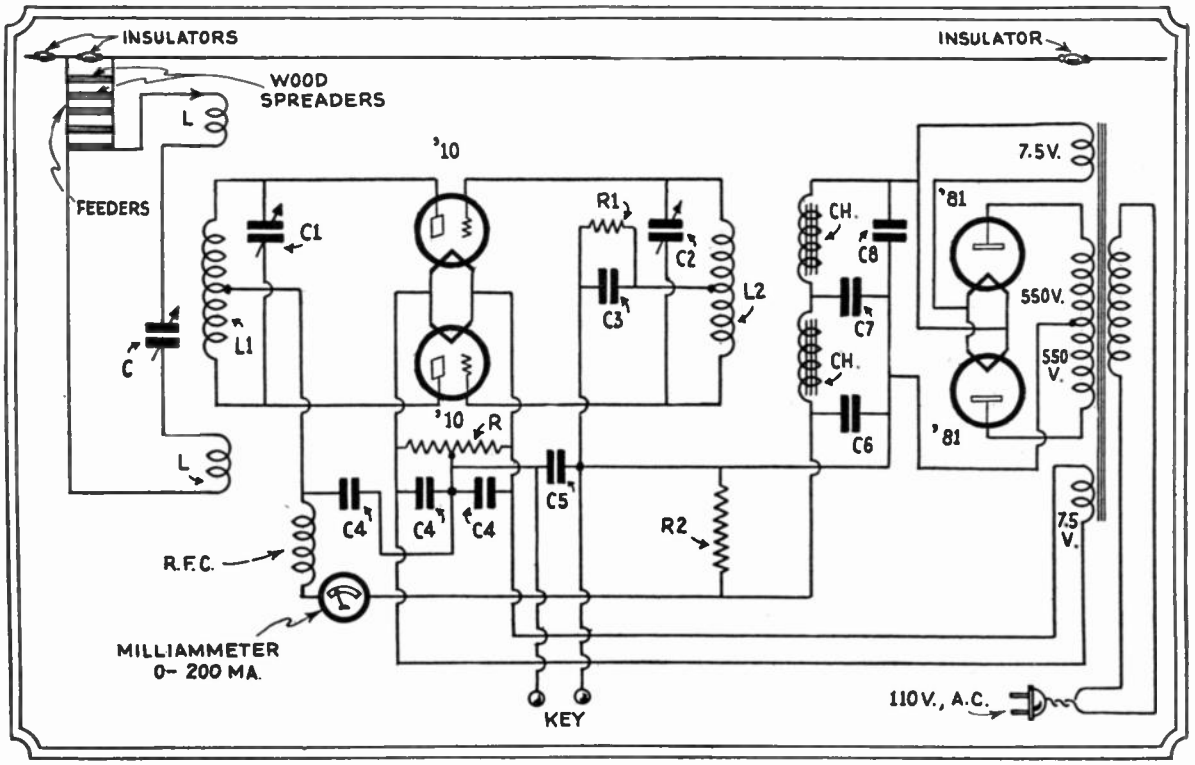


Fig. 34—Diagram of the Push Pull Transmitter

for both grid and plate coils and one for each of the antenna coils. Wing nuts having the same thread as the insulator bolts may well be used permitting the quick removal of coils when operating on other bands.

The tuning condensers C, C1 and C2 are regular .00035 mf. units as employed in broadcast receivers. Condensers having poor insulation should not be used; preference should be given to such types having ample insulation which is out of the direct field of the condenser plates. Low loss tube sockets should also be used. The results obtained naturally depend considerably upon the quality of the parts.

All of the bypass condensers C4 and C5 as well as the grid condenser C3 should be of the higher voltage type, rating at least 1000 volts. The bypass condenser C5, shunted across the key is employed to reduce sparking at the key contacts. The RF choke may be any short wave choke provided it can carry the transmitter plate current without heating as it has very little work to do this being a **series** fed transmitter.

The push pull oscillator tubes are biased by means of a grid leak R1 and condenser C3. The leak should have a value of approximately 10,000 ohms although this may be reduced to 5,000 ohms with a slight increase in power output. If 45 tubes are to be used in this transmitter with a 2.5 volt filament supply and plate voltage of about 450 volts the grid leak should be 50,000 ohms. In no case is a leak of over 25 watts rating needed.

The power supply is conventional in every respect with the power transformer having a center-tapped 1,100 volt winding and in addition two 7.5 volt windings for the rectifier and the oscillator tube filaments. It is preferable however to have a separate filament transformer for the filaments of the oscillator tubes to eliminate any possible RF feedback to the power supply.

The filter chokes CH each have a rating of 30 henries at 150 M.A. Chokes are best bought from reputable firms and generally speaking the heavier the choke the better the filtering action.

The first filter condenser, C8 of 2 mf. capacity, must be rated at 1000 volts D.C. or higher otherwise blowouts may occur often burning out the rectifier tubes and damaging the power transformer. And there is nothing so useless as a burned out filter condenser except perhaps a blown tube. Use amply rated condensers in the first place. The center condenser C7 has a capacity of 4 mf., also rated at 1000 volts; C6 is the same as C7.

The resistor R2 connected directly across the high voltage is used to prevent voltage surges and improves the regulation of the high voltage so that when keying the transmitter is less liable to chirps. The bleeder also discharges the filter con-

densers when the power is turned off which is a good thing if one often makes changes in the power supply.

The layout of the transmitter parts is clearly shown. Some of the smaller parts such as RF choke, bypass condensers, etc., are mounted underneath the baseboard. The layout was not designed to be something elegant to look at but rather for efficiency and short leads. The size of the base is of no importance and can be readily determined by placing all of the parts on a bench, so that the leads in the tank circuits are not unduly long. When you think you have everything as it should be, merely measure the space required and cut the baseboard accordingly.

When wiring, the leads from the coils to condensers should be made with heavy conductor or the same material as used for the coils. It would be entirely useless to construct nice coils out of tubing or large wire and then connect them to the condensers with small hookup wire. The filament connections should be made with No. 14 wire or larger to prevent voltage drop and allow the oscillator tubes to receive the proper filament voltage. The remaining wiring may be made with the usual hookup wire.

The layout of the power supply will not be given since the dimensions and shape of the various makes of chokes, transformers, etc., differ greatly.

Adjustment

The adjustments are simple and getting the set on frequency is the same as with the 45 Hartley transmitter. If the set is properly constructed and used with a good antenna system nothing should go wrong. Adjust the condensers C1 and C2 for the proper frequency with the milliameter showing a low value, around 40 to 60 M.A. When the plate current is adjusted for absolute minimum one should then either increase the capacity of the grid condenser or decrease the capacity of the plate condenser slightly, resulting in a slight increase in plate current, about 10 M.A. over the minimum. At the minimum of plate current the tube supplies itself with very little excitation and in this condition is rather unstable. When the capacity of the grid condenser is slightly increased thus increasing the plate current, the grid excitation is increased making the circuit more stable and better able to supply power. The increase in plate current indicates the additional wattage supplied the grid by feedback through the plate grid capacity of the tube. This grid power is a waste so far as antenna power is concerned but really necessary. The tuning should be adjusted so the transmitter is *on wave* in really the proper operating condition. The antenna then can be tuned to resonance. Resonance can be indicated by the plate metter or by an antenna ammeter.

List of parts for the transmitter

L,L Antenna coupling coils
L1 Oscillator plate coil
L2 Oscillator grid coil
RC RF choke
C .00035 mf. antenna condenser
C1 .00035 mf. plate tuning condenser
C2 .00035 mf. grid tuning condenser
C3 .00025 to .002 mf. grid condenser
C4 .002 to .006 mf. bypass condensers
C5 Optional .52 mf. bypass condenser
C6, C7, C8 Filter condensers (See text)
R 40 to 100 ohm center atpped resistor
R1 10,000 ohm grid leak
R2 50,000 ohm 50 watt resistor
Ch Filter chokes
T Power transformer, 550 volts each side, 150 ma. or more rating.

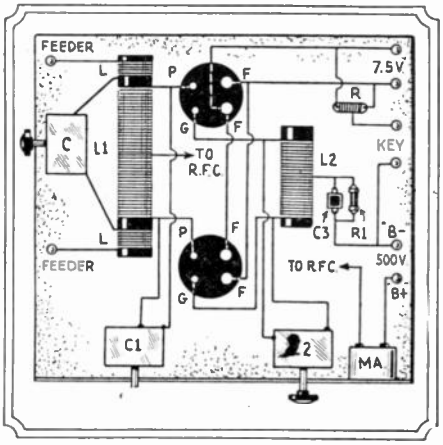


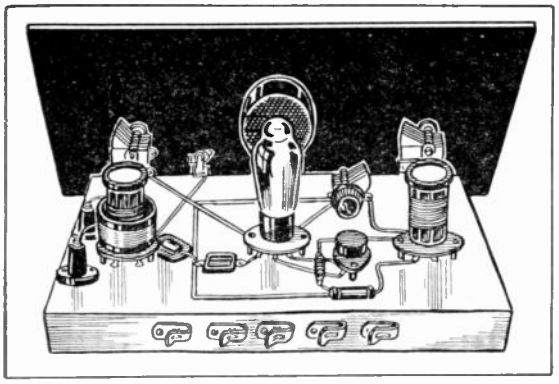
Fig. 35—Plan layout of the code transmitter.

A Low Crystal Controlled Phone and CW Transmitter

This transmitter is of unit construction and is mounted in a wood rack, Fig. 41. It is a complete phone and CW transmitter of approximately 20 watts output on phone and 40 watts on CW. It is built so that one can start out with the exciter unit which is a low power two band transmitter in itself and add to it later, an amplifier and a modulator. The four units comprising the complete transmitter are mounted in a wood rack the dimensions of which are given. The complete transmitter is shown in Figs. 40 and 40A.

The Exciter Unit

The exciter unit is a 1-tube oscillaotr-amplifier affair using one tube the 2B6, in the "Les-Tet" circuit and is shown in Fig. 36 and 37. The 2B6, which consists of two triodes in one envelope and was originally intended for audio amplification, functions as crystal oscillator and a direct coupled amplifier or frequency doubler. This direct coupling between the two triode sections of the tube is undoubtedly responsible for the very efficient operation obtained. This unit as are the others is mounted on a baseboard 8" deep on a 7x19 bakelite panel. Either a 40 or 80 meter crystal can be employed by changing coils to suit the crystal and band chosen.



Sig. 36—The Exciter

The coils are standard Hammarlund* plug-in coils, with the turns adjusted and tapped according to the data given in the coil table. The ticklers of these coils are not needed and are removed. The oscillator coil is tapped approximately one-third the number of turns from one end, in order to obtain neutralizing voltage for the large triode when it is tuned to the crystal frequency. As we cannot get at the grid of the large triode, it is necessary to obtain bias for it via the cathode; this is accomplished with the aid of the 5,000 ohm resistor.

Looking at the front of the panel (section C in the illustration) we find that the oscillator condenser and coil are on the left and the amplifier tuning condenser and coil are on the right hand side. If the reader wishes to reverse the arrangement for some reason, just turn the socket of the tube around so that the heater terminals are facing the rear edge of the wood baseboard instead of the front panel. The antenna coil is

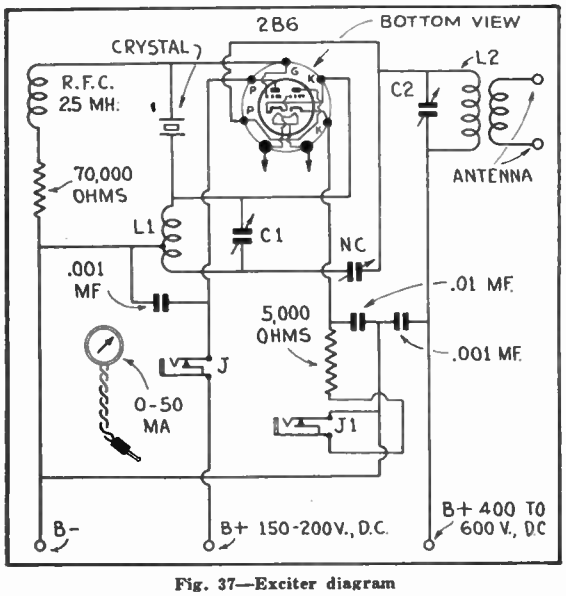


Fig. 37—Exciter diagram

wound on a bakelite tube large enough to fit around the plate coil and is wound with 12 turns of No. 14 enameled antenna wire. The coil is supported by the two antenna insulators which also serve as the antenna connections. The meter in the center of thepanel is used for indicating the plate currents of both triodes. A plug is connected to the meter and the two jacks are used for the different readings. One jack is in the plate lead of the oscillator and the other jack in the cathode of the amplifier. This last mentioned jack is also used for "keying" the transmitter.

The oscillator coil which is placed in the cathode circuit of the small triode, is tapped and this tap is connected to the B minus. The neutralizing condenser "nc" is connected between the *low* side of the coil and the plate of the large triode. This is a 50 mmf. midget variable. When frequency doubling the adjustment of this condenser is not critical.

After the transmitter is wired and checked to make sure that no errors have been made, we are ready for the preliminary adjustments. Apply the heater voltage to the tube and insert the oscillator coil—*leave the amplifier coil out of the socket.* Then apply the low voltage to the plate of the oscilaltor section and plug the meter into jack "J"; the reading on the meter should be around 15 M.A. Now rotate the oscillator tuning condenser until a *dip* is noticed; during this dip the current should fall to about 10 M.A. This dip in current indicates resonance with the crystal frequency. Leave the dial set for minimum current reading on the meter and plug in the amplifier coil—*do not apply the plate voltage to the amplifier at this stage of operation,* we are now ready to neutralize the amplifier, the crystal and coils are chosen so that the amplifier will operate on the same frequency as the oscillator. Swing the amplifier tuning knob from one end of the scale to the other and note that there is a change in plate current of the oscillator at one setting of the amplifier tuning condenser. In order to offset this condition, adjust the neutralizing condenser until there is no change in the oscillator plate current when the amplifier condenser is swung back and forth. This operation should be done very carefully to insure proper results. The transmitter is now ready for operation.

The plate voltage should now be applied to the amplifier; remove the meter plug from the oscillator jack and insert it into jack J1. Rotate the amplifier condenser until the plate current is at a minimum. This indicates resonance between the two circuits. The antenna can now be connected and the amplifier loaded until the meter reads 40 M.A. Always readjusting the amplifier condenser for minimum plate current.

Parts List for Exciter Unit

1 140 mmf. midget condenser, Hammarlund, Bud. (C1)

1 50 mmf. double-spaced, midget condenser, Hammarlund, Bud. (C)

1 50 mmf. midget condenser, Hammarlund, Bud. (NC)
2 .001 mf. mica condensers, 1,000 volts Aerovox
1 .01 mf. mica condenser, Aerovox
1 70,000 ohm wire wound resistor, 5 or 10 watts, Aerovox
2 single closed circuit jacks, I.C.A. (J-J1)
1 phone plug for meter, I.C.A.
2 prong ceramic sockets, Bud.
1 7 prong large ceramic socket, Bud.
1 5 prong ceramic socket, Bud.
2 sets of Hammarlund plug-in coils (see coil table for alteration)
1 2.5 mh. R.F. Choke, Hammarlund
2 stand-off insulators, ICA
1 7"x19"x$\frac{3}{16}$" bakelite panel, ICA
1 O-50 milliammeter
2 metal dials and pointers, ICA
1 crystal and holder, Bliley
5 Fahnestock clips

COIL DATA

Band	Osc.	Tap	LW*	Amp.	Wire	LW
80	30T.	10th	1⅜"	30	No. 20	1⅜"
40	14T.	4th	1¼"	16	No. 18	1⅜"
20				9	No. 14	1¼"

*—Length of Winding.

The Amplifier Unit

The exciter has more than enough power to excite the amplifier which is a pair of 46's in parallel (Fig. 38 and 39). A pair of 46's in parallel will provide an output of 30 to 40 watts when operated with around 500 volts on the plates. The exciter and amplifier units are capable of working on any two of the amateur bands with only one crystal. That is with the 46's operating as a straight amplifier. It is not advisable to work these tubes as doublers when they are used as output amplifiers. They can be used as doublers,

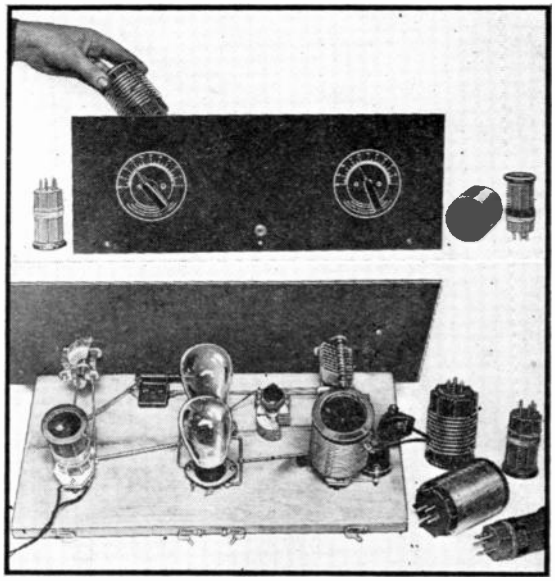


Fig. 38—The amplifier

however, if another stage is added to feed the antenna. This added stage can be anything from a pair of 801's to a 203-A.

The exciter is *link coupled* to the grids of the 46 tubes. This is a very convenient and efficient method of coupling. Both the plate and grid circuits of the last stage are tuned to the frequency at which it operates. A small three turn coil is wound next to the plate coil of the exciter and the grid coil of the amplifier; twisted pair is used to connect these two three turn coils together. Plug in coils are used in the amplifier as well as the oscillator in order to facilitate changing bands. The change from band to band can be made in approximately three minutes, after one has be-

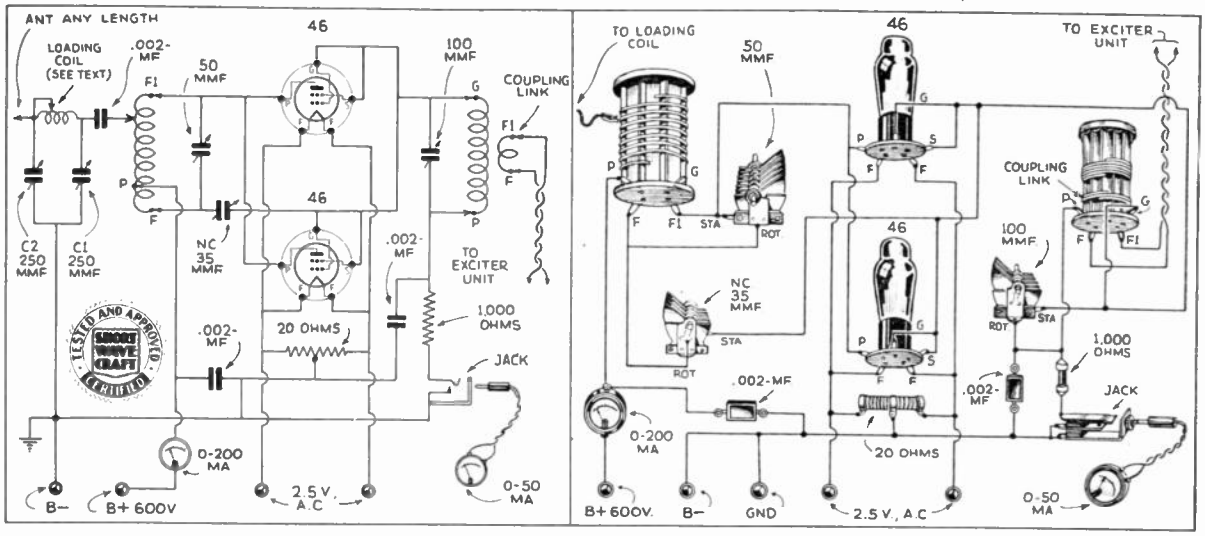


Fig. 39—The Parallel 46 Amplifier Diagrams

come familiar with the transmitter. The amplifier like the exciter is also mounted on a 7x19 inch bakelite panel of ⅜ inch thickness. The same size panels are used because the whole transmitter when finished will be mounted in a wood rack as illustrated. However, the transmitter can just as well be laid out on a table instead of mounting it in the rack with no less electrical efficiency. There are only two dials on the amplifier panel (panel D) and room is left in the center for a meter should the builder desire to incorporate one instead of using the plug system for taking the various readings as is done in this rig. A 0-200 milliammeter is needed for this amplifier but it is mounted in the power supply panel so that readings can be taken in the modulator if one is built.

The 46 type tube is used in the amplifier because of three very important reasons and they are first, its low cost, for this is a lower power, low cost outfit; they need no external bias, and they are very efficient as RF amplifiers. In this role they have their two grids connected and returned to the B minus through a *limiting* resistor. The tubes are placed in the center of the baseboard with the grid tuning circuit on the right and the plate circuit on the left. However, if the builder does not follow the layout of the exciter unit as described he should arrange this unit to suit the arrangement of the exciter. That is, the grid coil should be on the same side of the base that the plate coil is located on the exciter. This is to provide short leads when the amplifier is mounted above the exciter.

The grid oil is wound on a Hammarlund XP-53 4-prong coil form. Two prongs are used for the grid coil and two for the three turn "link" coil. The plate coil is wound on the new 2¼ inch Bud transmitting plug-in coils and provides a very husky and efficient plate inductance. All the plate coils of the amplifier are wound with No. 14 tinned copper wire. Get the soft drawn kind or you will have a difficult time with the winding operation. The two large prongs are used for the plate winding as the heavy wire will not fit through the small prongs. This coil is tapped in order that neutralizing can be effected. The tap is located approximately one third the total number of turns from the end of the winding which is not connected to the tube plates. The plate voltage is fed to the plates of the tubes through this tap. The tuning condenser is connected across the *whole* coil. The tuning condenser is of the double-spaced midget variety and has a capacity of 50 mmf. The reason such a small or low capacity condenser is used is because we are using a very low C circuit in order to obtain high efficiency. When using such low capacity the coils have to be made accurately because we can do very little tuning to compensate for errors in the inductance. So follow carefully the data given in the coil table.

The grid coils are wound with No. 20 double cotton covered wire and there is no spacing between the turns. The three turn link is wound with No. 16 double cotton covered wire. Heavy wire is used because of the high current that is present on this circuit. The link coil should be coupled to the grid end of the grid winding and spaced from it about ⅛ of an inch. A similar three turn coil is added to the plate coil of the exciter unit. Separate grid coils are used for each band in the amplifier although if a larger condenser (140 mmf.) were used a single coil could be made to cover two bands though this would not be quite as efficient. The data for the grid coils are also given in the coil table.

By glancing at the circuit diagram it will be seen that only two bypass condensers have been used one in the grid circuit and one in the plate circuit. The whole amplifier has been built with the idea of keeping the cost down and still not impairing its efficiency; RF chokes provided no benefit, neither did filament bypass condensers, so they were left out.

To the left of the plate coil can be seen the antenna coupling condenser and the stand-off insulator which supports it. This condenser is used to keep the D.C. plate voltage out of the antenna circuit. A small clip is necessary in order to vary the antenna tap on the plate coil. No antenna coupling coil is used because we are going to use an impedance network consisting of two condensers and a loading coil. This system is used because of its simplicity and efficiency.

After the amplifier has been wired and checked to make sure that no mistakes have been made we are ready to tune up. Apply the connections from the exciter to the amplifier and connect the filaments. Apply the plate voltages to the exciter and tune it as described. Adjust the grid condenser of the amplifier until the plate current of the 2B6 rises to a peak value. Next rotate the amplifier plate condenser until RF can be detected in the plate circuit. This will cause a kick in the 2B6 plate current with the milliammeter inserted in J. Now adjust the neutralizing condenser until swinging the amplifier tuning condenser back and forth there is no reaction on the 2B6 plate current. This means the amplifier is neutralized and plate voltage can now be applied. Close the key and immediately adjust the plate condenser until the plate crurent reaches a minimum value. This will be around 15 to 20 M.A.

The antenna can be a plain piece of wire from 75 to 100 feet long; connect it to the input of the network and connect the network to the plate circuit about three turns from the plate end of the coil. Close the key again and adjust C1 till the plate current of the amplifier drops to its lowest value. Then adjust C2 until the plate current reaches 100 M.A. Always adjust C1 last, to bring the plate current of the 46's to a minimum value. The amplifier can be loaded up to about 125 if desired for CW work but for phone the input must be kept at 100 M.A. so the amplifier

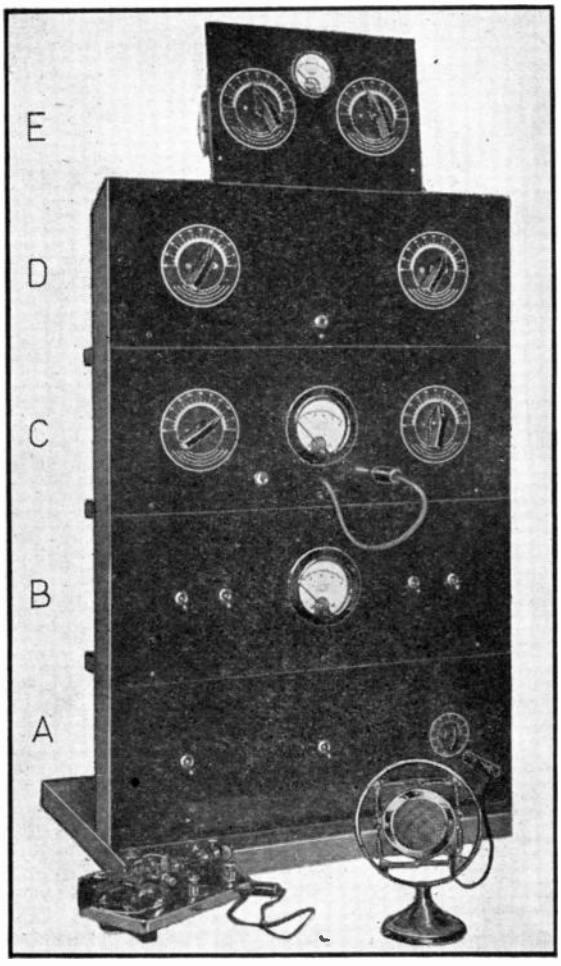


Fig. 40—Front view

furnishes the right resistance to the modulator.

The complete transmitter as can be seen, is mounted on a wood rack or frame. The lower panel "A" is the modulator and its power supply. The next to the bottom is "B" the power supply for the radio frequency portion of the transmitter and the third panel "C" the oscillator. The fourth "D" is the final amplifier with its 46's and above this is the antenna tuning network. All panels are fastened to wood baseboards 16x7¾ inches and these slide into the place made for them in the wood frame. Comlete details for building the wood frame can be obtained from the photograph.

After the rack has been constructed as shown it should be given a coat or two of orange shellac to improve its appearance and preserve the wood. All joints are doweled and glued and the finished rask is very strong and will stand plenty of wear and tear. All saw cuts should be made with a mitrebox so that the finished rack will be straight, otherwise it will look like the leaning tower of Pisa.

The total current drawn by the set is around 150 M.A. and therefore the parts in the power supply should be chosen accordingly. The high voltage transformer should deliver 600 volts at least at 175 M.A. with fairly good regulation. The transformer used has two filament windings, one for the 83 rectifier, which requires 5 volts at 3 amps. and one 2.5 volt winding capabye of supplying the 2B6 and the two 46's. The filter is an ordinary brute force affair using a 30 henry choke and two 1000 volt oil condensers, (one 1 mf. and one 2 mf.). With this power supply the transmitter gives a very clean, pure note. A 50,000 ohm voltage divider and bleeder is used and this is tapped in the center at 25,000 ohms to supply the plate of the small triode in the 2B6, the complete power supply diagram is shown in Fig. 43. Four toggle switches are used in the power supply and break the high voltage, the low

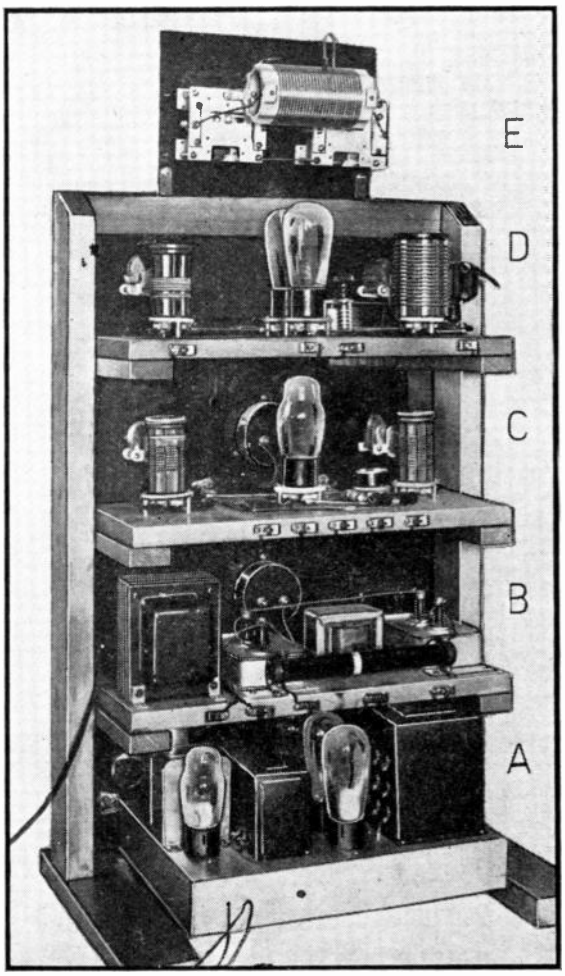


Fig. 40A—Rear view

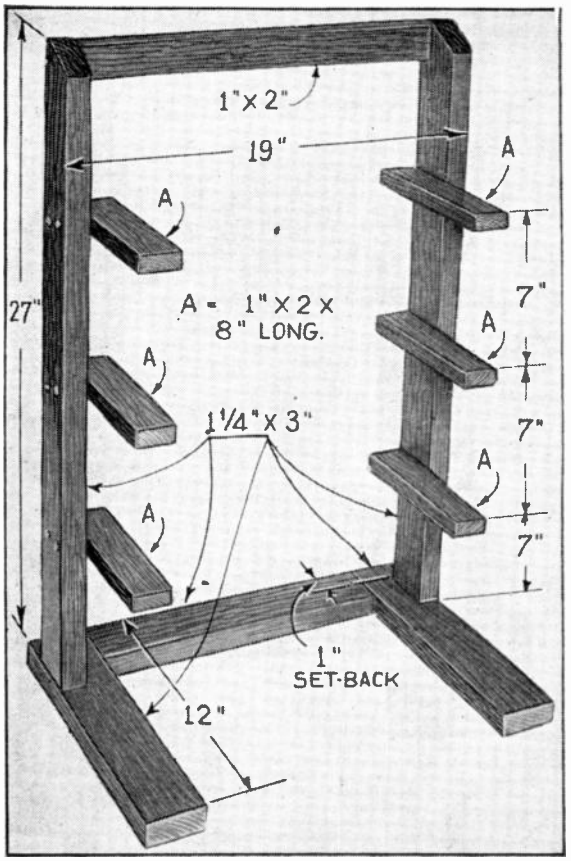


Fig. 41—The Rack

voltage, the B minus which cuts off all DC and one in the primary for cutting off the entire power unit. These are all mounted on the panel together with the 0-200 scale milliammeter. The meter reads the current of the final amplifier or the modulator if one is to be used, depending upon where the plug is inserted.

This transmitter makes a very fine low powered CW transmitters but if phone is desired there is always the space in the rack for the modulator panel "A."

Parts List for RF Power Supply

1 Trasformer with 600-0-600 Volts at 175 ma., 5 volts—3 amp., 2½ volts—6 amp., Kenyon
1 30 henry 175 ma. choke Kenyon
1 2 mf. 1000 volt condenser, Aerovox
1 1 mf. 1000 volt condenser, Aerovox
2 25,000-ohm, 75-watt resistors, Aerovox
1 4-prong socket, Na-Ald
4 toggle switches, ICA
1 0-200 ma. meter, Triplett
1 7x19x⅜ inch bakelite panel, ICA
1 type 83V RCA Radiotron

Parts List for Amplifier

1 50 mmf. double spaced midget condenser, Hammarlund, Bud
1 35 mmf. double spaced midget condenser (NC), Hammarlund, Bud
3 .002, 1000 volt condensers, Aerovox, Sprague
2 250 mmf. antenna tuning condensers, 1000 volt rate (C1, C2), National
3 4 prong plug-in coil forms, 1½ inch outside diameter, Hammarlund
3 large Bud transmitting coil forms, 4 prong
6 4 prong, ceramic sockets, Bud, Hammarlund
2 5 prong ceramic sockets, Bud, Hammarlund
1 20 ohm resistor center tapped, Aerovox
1 1000 ohm resistor, 25-35 watts, Aerovox
1 National ceramic coil form for antenna network
1 7x19x⅜" bakelite panel, ICA
2 dials and pointers, four inches diam., ICA
1 closed circuit jack, ICA
5 Fahnestock clips
1 stand-off insulator, National
1 ceramic 2½ in. form, 26 turns for antenna loading coil

For phone work a modulator is necessary to vary the amplitude of the carrier so that upon detection we get a current that varies, in the reproducer, in accordance with the speech transmitted. There are numerous ways of doing this but before a review of plate and grid bias modulation it is perhaps better to make sure the basic idea of modulation is well understood.

In modulation of course we must vary the amplitude of the carrier, or another way of saying it, vary the amount of radio frequency power in the carrier. The audio signal controls these variations; there is no audio frequency voltage in the final amplifier output or the antenna. There are three things to be considered in modulation, the audio frequency voltage of the modulator, the DC plate voltage of the final amplifier and the radio frequency plate voltage of the final amplifier. The audio frequency voltage of the audio amplifier is an AC voltage and this is placed in series or parallel with the DC voltage of the final amplifier. As it is AC, on negative voltage peaks it will therefore neutralize the DC plate voltage of the final amplifier and on positive peaks will add to it. Similar to an RF circuit, in series feed no choke is necessary, but in parallel feed a choke is used to prevent the audio frequency voltage from getting into the power supply. If allowed to get into the power supply it would lose force the same as RF in a parallel fed Hartley oscillator; if there were no RF choke there would be RF in the power supply. This audio frequency voltage is then confined to the plate of the final amplifier and therefore varies the plate voltage on the final amplifier so the radio frequency voltage in the final amplifier tank which can be seen by placing a pencil on the tank varies accordingly. There is no such thing as the modulator tube taking power from the final amplifier and then the final amplifier taking power from the modulator. What really does happen is that the *average* power supplied to the modulator and the *average* power supplied to the final ampli-

fier stays the same assuming a Class A modulator of course. But at one instant there is less power and voltage than average in both the modulator circuit and the final amplifier circuit and the difference between this scarcity and the average is stored up in the kinetic energy of the audio frequency wave and then at the next instant this is released raises the voltage and power above the average. The appearance of the wave if it could be seen (if you have a cathode ray oscilloscope it can be seen) looks like the waves of the ocean at the beach. The action of the choke in keeping the audio voltage in its place if parallel feed modulation is used is entirely separate to itself and has no direct relation to the action between the modulator and the final amplifier. When a Class A modulator is used for the reason given the *average* current as shown by the milliammeter should be constant and not vary. If it does vary there is something wrong with the bias or the excitation of the amplifier. Likewise the *average* current of the final amplifier should not vary with or without modulation. With a Class B modulator however the plate current of the modulator will vary as the grids in a Class B stage are driven positive. The greater they are driven positive the greater the increase in plate current and power output.

The two most popular methods of modulation are the DC plate voltage variation or Heising method and the grid bias variation method.

In the grid bias variation method a small audio signal is used to vary the grid bias alternately positive and negative at speech frequencies. This results in the efficiency of the amplifier varying at speech frequencies; the efficiency of the amplifier is dependent on the grid voltage. If complete modulation is to be realized however with this system the power output has to be reduced to one fourth normal before modulating so that when the resultant DC plate voltage on audio peaks reaches the usual twice normal and the current also reaches twice normal, instantaneously, as before described, the tube can handle the increase in power. The reason for "one fourth normal" is that power equals voltage times current and as the voltage is doubled and the current doubled there is on instantaneous peaks 4 times the ordinary unmodulated power. The reason for the antenna current of a completely modulated amplifier only rising to 20 to 25% above the unmodulated value even though the power increases 4 times above normal on peaks is that these peaks are only instantaneous and the antenna ammeter reads the *average* increase. Grid bias modulation is used where the transmitter employs large tubes and only a small amount of audio power is available.

The DC plate voltage variation method is the better to use as it is easier to adjust and a better quality phone can be had. The grid bias method is more critical of adjustment for good results. In the Heising method the modulator directly controls the final amplifier plate voltage and the efficiency of the amplifier remains constant. In complete modulation the plate power of the final amplifier swings from 0 to 4 times normal the same as in the grid bias modulated amplifier, the only difference being in the way of doing this. In plate modulation no reduction of output is necessary as in the grid bias type.

The Modulator Unit of the Low Powered Transmitter

This modulator employs a pair of 46 tubes in a Class B amplifier with two stages of speech amplification. Connections are shown in Fig. 42 and 43 for a double button carbon microphone. The crystal microphone can be used however, giving slightly better quality than the carbon mike. The single 57 feeding the 2A5 will give just enough amplification for the crystal mike if one talks

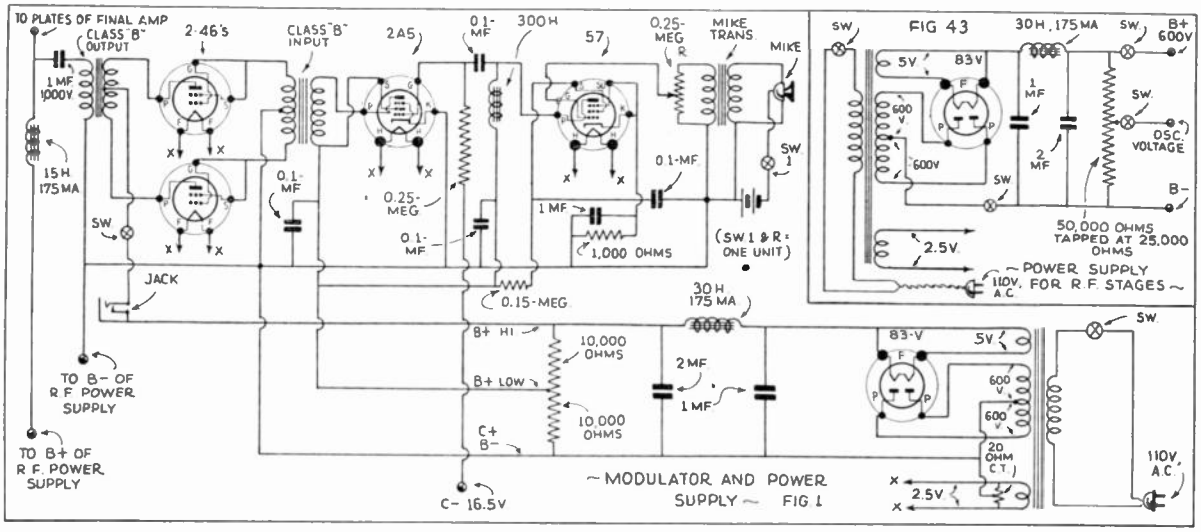


Fig. 42—Modulator Diagram and Power Supply

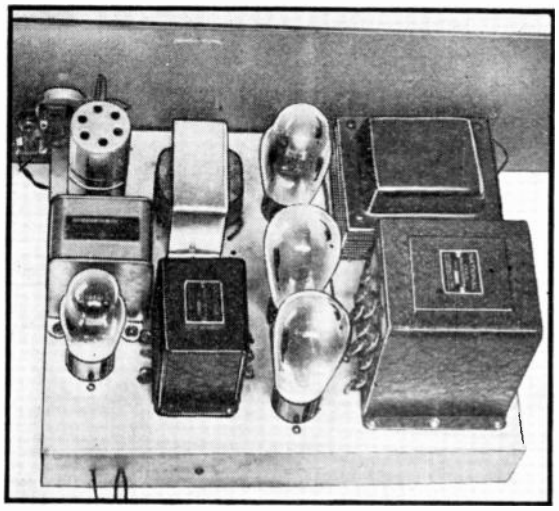


Fig. 43—View of Modulator

within 6 inches of it. For greater pickup it is advisable to use a 56 resistance coupled stage between the 2A5 and the 57. For a carbon mike the 57 alone will suffice. The 300 henry audio choke in the 57 plate circuit provides better gain than the usual resistor. The 2A5 was used because of its high output with relatively low input. The pentode usually renowned for distortion does not prove harmful at voice frequencies; after all Hams don't broadcast music! All reports on phone were "excellent quality" and that is proof enough. Separate battery bias is used for the 2A5 and this helps the quality as well as increasing the output somewhat. While the two 46's in Class B have slightly higher plate voltage on them than the tube manufacturers recommend, a single pair have been run this way for 6 months and exhibited no signs of weakening. This high plate voltage produces considerably more audio power than if they were run with the usual 400 volts. A switch is incorporated in the B plus lead of the 46's to cut them off when standing by for the other station. Choke and condenser coupling is used between the modulator and the Class C amplifier so that the final amplifier plate current does not flow through the secondary of the Class B transformer.

Tuning the Phone Transmitter

Tuning up for code transmission has been described. There is no difference in operation for phone except the plate current of the final amplifier should be adjusted to 100 mils. This is very important as 100 mils. is the correct current at the plate voltage used to give the proper final amplifier resistance to the modulator. The final amplifier as far as the modulator goes is a pure resistance and the modulator would work just as well into a 25 watt wire wound resistance. When we hum a steady note into the mike the gain control of the speech amplifier should be adjusted until the increase in antenna current is about 10 or 15 per cent more than the reading when no sound is made before the mike. It is very important—this increase in antenna current, because if it were to increase over the percentage metioned above there would be the danger of overmodulation and this is not sporting to other amateurs as well as being a violation of the FCC regulations and spoiling the quality of the signal. While talking normally the average percentage of modulation will be around 80%; that is if one talks in an even tone of voice, with no undue rises in the level of the voice when certain words are spoken.

Modulator Power Supply

1 transformer with 600-0-600 Volts at 175 ma., 5 volts—3 amp., 2½ volts—6 amp., Kenyon
1 30 henry 175 ma. choke, Kenyon
1 2 mf. 1000 volt condenser, Aerovox
1 mf. 1000 volt condenser, Aerovox
2 10,000-ohm, 75-watt resistors, Aerovox
1 4-prong socket, Na-Ald
1 toggle switch, ICA
1 0-200 ma. meter, Triplett
1 7x19x⅜ inch bakelite panel, ICA
1 type 83V RCA Radiotron
1 20-ohm ct. resistor, Aerovox

Parts For Modulator

1 aluminum base, see text, Blan (Steel-Korrol)
1 microphone transformer (if carbon mike is used; none needed for crystal mike)
1 300 henry impedance, Kenyon
1 class "B" input transformer, National
1 class "B" output transformer, National
1 15 henry 175 ma. choke, Kenyon
1 250,000-ohm pot. with switch Electrad
1 1000-ohm, 1-watt resistor, Lynch
1 150,000-ohm, 1-watt resistor, Lynch
4 .1 mf. condensers, Sprague
1 1 mf. 1000 volt condenser, Aerovox
2 6-prong wafer sockets, Na-Ald
2 5-prong wafer sockets, Na-Ald
1 toggle switch, ICA
1 single closed-circuit jack, ICA
1 7x19x⅜ inch bakelite panel, ICA
1 22½ volt Burgess "C" battery
1 A static crystal microphone (optional)
1 double-button carbon microphone (optional)
1 type 57 RCA Radiotron
1 type 2A5 RCA Radiotron
2 type 46 RCA Riadotrons
C1, L1 Receiving condenser and coil for grid circuit of suitable values for the frequency employed
C2, L2 Transmitting condenser and tank coil
C3 Plate blocking condenser, .002 mf. 2500 volt rating
C4 Grid blocking condenser, .001 mf. 1250 volt rating
C5 Filament by-pass condensers, .005 mf. 600 volt rating
Cn Neutralizing condenser—50 mmf. small transmitting type

R1 5,000 ohm grid leak 50 watt
R2 100 ohm center tap resistor
RFC Transmitting choke. (Does not have to be a very good one)
MA 0-300 M.A. milliammeter

If desired a higher power amplifier can be added to the low power CW transmitter or any other transmitter capable of supplying sufficient excitation. The diagram is shown in Fig. 46. Coil and condenser sizes for the various bands will be approximately the same only of course of higher power carrying capacity. Neutralizing and tuning will also be exactly similar. A higher powered amplifier such as this will enable one to put out a much more reliable signal. While it is possible under good conditions to work about the same distance with the low power transmitter this amplifier will permit much more consistent DX transmission.

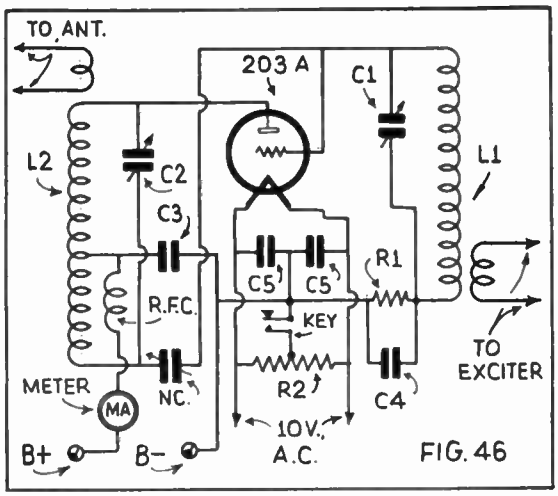


Fig. 46—High Power Amplifier

The input to the above amplifier under optimum conditions will run about 200 to 225 watts at 1000 to 1250 volts. A fifty watt tube is just about the right step after 46's as one of the higher tubes requires a much more expensive power supply with not much more output. For power supply see Fig. 45.

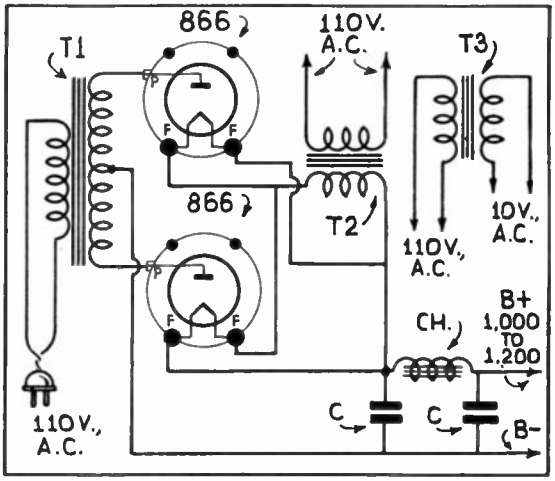


Fig. 45—Power Supply

T1 1000-1250 volt each side transformer at 250 to 300 ma.
T2 2.5 volt filament transformer for 866's. At least 3000 volt insulation.
T3 10 volt filament transformer for 203A. Must be able to carry 3.25 amps.
C 1 or 2 filter condensers, 2000 volt rating.
Ch 10 to 30 henry choke, 300 ma. capacity.

Transceivers have come prominently into use on the 5 meter band for around town communication and for portable-mobile operation. Low power carries quite well for short distances on five meters and loud signals are possible with battery operated outfits. The transceiver swhon in Fig. 44 is typical although recently several have come on the market using Class B with battery type tubes. This results in much greater audio power and consequently better operation. The best distances with transceivers are about 15 miles.

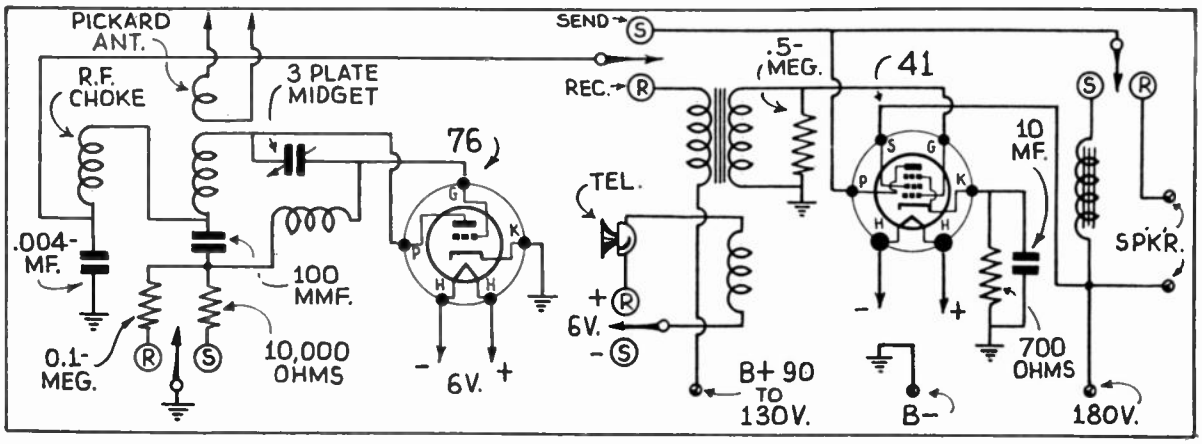


Fig. 44—The Most Popular Type Transceiver

CHAPTER 6

● The amateur and the prospective amateur should be thoroughly familiar with the extracts of the Rules and Regulations of the F.C.C. for amateur stations which follow. Although it is not necessary to know the exact wording it is again stressed that the amateur be thoroughly familiar with them as half of the examination is devoted to the topics of Laws, Regulations and Penalties.

Extracts from the Communications Act of 1934

Section 1. For the purpose of regulating interstate and foreign commerce in communication by wire and radio so as to make available, so far as possible, to all the people of the United States a rapid, efficient, Nation-wide, and world-wide wire an dradio communication service with adequate facilities at reasonable charges, for the purpose of the national defense, 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 interestate and foreign commerce in wire and radio communication, there is hereby created a commission to be known as the "Federal Communications Commission," which shall be constituted as hereinafter provided, and which shall execute and enforce the provisions of this Act.

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

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

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

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

(a) Classify radio stations;

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

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

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

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

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

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

(j) Have authority to make general rules and regulations requiring stations to keep such records

of programs, transmissions of energy, communications, or signals as it may deem desirable;

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

(m) Have authority to suspend the license of any operator for a period not exceeding two years upon proof sufficient to satisfy the Commission that the licensee (1) has violated any provision of any Act or treaty binding on the United States which the Commission is authorized by this Act to administer or any regulation made by the Commission under any such Act or treaty; or (2) has failed to carry out the lawful orders of the master of the vessel on which he is employed; or (3) has wilfully damaged or permitted radio apparatus to be damaged; or (4) has transmitted superfluous radio communications or signals or radio communications containing profane or obscene words or language; or (5) has wilfully or maliciously interfered with any other radio communications or signals;

(n) Have authority to inspect all transmitting apparatus to ascertain whether in construction and operation it conforms to the requirements of this Act, the rules and regulations of the Commission, and the license under which it is constructed 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;

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

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

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

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

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

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

Section 501. Any person who wilfully 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 wilfully and 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 herein, by a fine of not more than $10,000 or by imprisonment for a term of not more than two years, or both.

Sec. 502. Any person who willfully and knowingly violates any rule, regulation, restriction, or condition made or imposed by the Commission under authority of this Act, or any rule, regulation, restriction, or condition made or imposed by any international radio or wire communications treaty or convention, or regulations annexed thereto, to which the United States is or may hereafter become a party, shall, in addition to any other penalties provided by law, be punished, upon convic-

tion thereof, by a fine of not more than $500 for each and every day during which such offense occurs.

Sec. 605. No person receiving or assisting in receiving, or transmitting, or assisting in transmitting, any interstate or foreign communication by wire or radio shall divulge or publish the existence, contents, substance, purport, effect, or meaning thereof, except through authorized channels of transmission or reception, to any person other than the addressee, his agent, or attorney, or to a person employed or authorized to forward such communication to its destination, or to proper accounting or distributing officers of the various communicating centers over which the communication may be passed, or to the master of a ship under whom he is serving, or in response to a 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. (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 peserve the neutrality of the United States, the President may suspend or amend, for such time as he may see fit, the rules and regulations applicable to any or all stations within the jurisdiction of the United States as prescribed by the Commission, and may cause the closing of any station for radio communication and the removal therefrom of its apparatus and equipment, or he may authorize the use or control of any such station and/or its apparatus and equipment by any department of the Government under such regulations as he may prescribe, upon just compensation to the owners.

Extracts from the Rules and Regulations of the F.C.C. for Amateur Stations

1. Prescribed application forms.—Each application for an instrument of authorization shall be made in writing on the appropriate form prescribed by the Commission for the purpose. Separate application shall be filed for each instrument of authorization. The required forms except as provided in paragraph 408 for amateur applicants, may be obtained from the Commission or from the office of any inspector. For a list of such offices and related geographical districts, see paragraph 30.

2. Filing of application.—

h. Each application for amateur facilities shall be filed in accordance with the following instructions:	
(1) Applications for amateur station and/or operators' licenses from applicants residing within 125 miles of Washington, D. C., a radio district office of the Commission, or an examining city (see par. 30).	1 copy to the inspector in charge of the radio district in which the applicant resides
(2) Applications for amateur station and/or operators' licenses from applicants residing more than 125 miles from Washington, D. C., a radio district office of the Commision, or an examining city (see par. 30).	1 copy direct to the Federal Communications Commission, Washington, D. C., in accordance with the instructions specifically set forth on the application form.

14. License where construction permit is not required.—Each application for new license, where a construction permit is not prerequisite thereto, shall be filed at least 60 days prior to the contemplated operation of the station.

16. Renewal of license.—Unless otherwise directed by the Commission, each application for renewal of license shall be filed at least 60 days prior to the expiration date of the license sought to be renewed.

20. Penalty for transfer of license without the consent of Commission.—The transfer of a radio station license, or the rights granted thereunder, without consent of the Commission shall be sufficient ground for the revocation of such license or denial of any application for its renewal. Amateur station licenses and call signals are not transferable.

22. Special authorizations.—The Commission may grant special authority to the licensee of an existing station authorizing the operation of such station for a limited time in a manner, to an extent or for a service other or beyond that authorized in the license.

24. Answering notice of violation.—Any licensee receiving official notice of a violation of Federal laws, the Commission's rules and regulations, or the terms and conditions of a license shall, within 3 days from such receipt, send a written reply direct to the Federal Communications Commission at Washington, D. C. The answer to each notice shall be complete in itself and shall not be abbreviated by reference to other communications or answers to other notices. If the notice relates

to some violation that may be due to the physical or electrical characteristics of the transmitting apparatus, the answer shall state fully what steps, if any, are taken to prevent future violations, and if any new apparatus is to be installed, the date such apparatus was ordered, the name of the manufacturer, and promised date of delivery.

26. If the notice of violation relates to some lack of attention or improper operation of the transmitter, the name and license number of the operator in charge shall be given.

27. **Normal license periods.**—All station licenses will be issued so as to expire at the hour of 3 A. M. Eastern standard time.

e. The licenses for amature stations will be issued for a normal license period of 3 years from the date of expiration of old license or the date of granting a new license or modification of a license.

28. **Designation of call signals.**—Insofar as practicable, call signals of radio stations will be designated in alphabetical order from groups available for assignment, depending upon the class of station to be licensed. Because of the large number of amateur stations, calls will be assigned thereto in regular order and requests for particular calls will not be considered.

29. **Deletion of call signals.**—Call signals of stations will be deleted in each of the following cases:

a. Where an existing instrument of authorization has expired and no application for renewal or extension thereof has been filed.

b. Where a license has been revoked.

c. Where a license is surrendered or canceled.

d. Other cause, such as death, loss of citizenship, or adjudged insanity of the station licensee. Such occurrences coming to notice should be reported to the Commission, preferably accompanied by the station license for cancellation, if available.

30. **Radio districts**—The following list of the radio districts gives the address of each field office of the Federal Communications Commission and the territory embraced in each district:

Radio district	Address of the inspector in charge	Territory within district	
		States	Counties
1	Customhouse, Boston, Mass.	Connecticut	All counties.
		Maine	Do.
		Massachusetts	Do.
		New Hampshire	Do.
		Rhode Island	Do.
		Vermont	Do.
2	United States Subtreasury Building, New York, N. Y.	New York	Albany, Bronx, Columbia, Delaware, Dutchess, Greene, Kings, Nassau, New York, Orange, Putnam, Queens, Rensselaer, Richmond, Rockland, Schenectady, Suffolk, Sullivan, Ulster, and Westchester.
		New Jersey	Bergen, Essex, Hudson, Hunterdon, Mercer, Middlesex, Monmouth, Morris, Passaic, Somerset, Sussex, Union, and Warren.
3	Gimbel Building, 35 South Ninth Street, Philadelphia, Pa.	Pennsylvania	Adams, Berks, Bucks, Carbon, Chester, Cumberland, Dauphin, Delaware, Lancaster, Lebanon, Lehigh, Monroe, Montgomery, Northampton, Perry, Philadelphia, Schuykill, and York.
		New Jersey	Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Ocean, and Salem.
		Delaware	Newcastle.
4	Fort McHenry, Baltimore, Md.	Maryland	All counties.
		District of Columbia	Do.
		Virginia	Arlington, Clark, Fairfax, Fauquier, Frederick, Loudoun, Page, Prince William, Rappahannock, Shenandoah, and Warren.
		Delaware	Kent and Sussex.
5	Customhouse, Norfolk, Va.	Virginia	All except district 4.
		North Carolina	All except district 6.
		Alabama	All counties.
6	411 New P. O. Bldg., Atlanta, Ga.	Georgia	Do.
		South Carolina	Do.
		Tennessee	Do.
		North Carolina	Ashe, Avery, Buncombe, Burke, Caldwell, Cherokee, Clay, Cleveland, Graham, Haywood, Henderson,

			Jackson, McDowell, Macon, Madison, Mitchell, Polk, Rutherford, Swain, Transylvania, Watauga, and Yancey.
7	P. O. Box 150, Miami, Fla.	Florida	All counties.
		Puerto Rico	Do.
		Virgin Islands	Do.
8	Customhouse, New Orleans, La.	Arkansas	Do.
		Louisiana	Do.
		Mississippi	Do.
		Texas	City of Texarkana only.
9	209 Prudential Building, Galveston, Tex.	Texas	Aransas, Brazoria, Brooks, Calhoun, Cameron, Chambers, Fort Bend, Galveston, Goliad, Harris, Hidalgo, Jackson, Jefferson, Jim Wells, Kenedy, Kleberg, Matagorda, Nueces, Refugio, San Patricio, Victoria, Wharton, and Willacy.
10	464 Federal Building, Dallas, Tex.	Texas	All except district 9 and the city of Texarkana.
		Oklahoma	All counties.
		New Mexico	Do.
11	1105 Rives-Strong Building, Los Angeles, Calif.	Arizona	Do.
		Nevada	Clarke.
		California	Imperial, Kern, Kings, Los Angeles, Monterey, Orange, Riverside, San Bernardino, San Diego, San Luis, Obispo, Santa Barbara, Tulare, and Ventura.
12	Customhouse, San Francisco, Cal.	California	All except district 11.
		Nevada	All except Clarke.
		Hawaiian Islands	All counties.
		Guam	Do.
		American Samoa	Do.
13	207 New U. S. Court House Bldg., Portland, Ore.	Oregon	Do.
		Idaho	All except district 14.
14	808 Federal Office Building, Seattle, Wash.	Alaska	All counties.
		Washington	Do.
		Idaho	Benewah, Bonner, Boundary, Clearwater, Idaho, Kootenai, Latah, Lewis, Nez Perce, and Shoshone.
		Montana	Beaverhead, Broadwater, Cascade, Deerlodge, Flathead, Gallatin, Glacier, Granite, Jefferson, Lake, Lewis and Clark, Lincoln, Madison, Meagher, Mineral, Missoula, Pondera, Powell, Ravalli, Sanders, Silver Bow, Teton, and Toole.
15	538 Customhouse, Denver, Colo.	Colorado	All counties.
		Utah	Do.
		Wyoming	Do.
		Montana	Except district 14.
16	Room 927, New P. O. Bldg., St. Paul, Minn.	North Dakota	All counties.
		South Dakota	Do.
		Minnesota	Do.
		Michigan	Alger, Baraga, Chippewa, Delta, Dickinson, Gogebic, Houghton, Iron, Keweenaw, Luce, Mackinac, Marquette, Menominee, Antonagon, and Schoolcraft.
		Wisconsin	All except district 18.
17	410 Federal Bldg., Kansas City, Mo.	Nebraska	All counties.
		Kansas	Do.
		Missouri	Do.
		Iowa	All except district 18.
18	2022 Engineering Building, Chicago, Ill.	Indiana	All counties.
		Illinois	Do.
		Iowa	Allamakee, Buchanan, Cedar, Clayton, Clinton, Delaware, Des Moines, Dubuque, Fayette, Henry, Jackson, Johnson, Jones, Lee, Linn, Louisa, Muscatine, Scott, Washington, and

			Winneshiek.
		Wisconsin	Columbia, Crawford, Dane, Dodge, Grant, Green, Iowa, Jefferson, Kenosha, Lafayette, Milwaukee, Ozaukee, Racine, Richland, Rock, Sauk, Walworth, Washington, and Waukesha.
19	1025 New Federal Bldg., Detroit, Michigina	Michigan	All except district 16.
		Ohio	All counties.
		Kentucky	Do.
		West Virginia	Do.
20	514 Federal Building, Buffalo, N. Y.	New York	All except district 2.
		Pennsylvania	All except district 3.

30a. **Examining Cities**—Examinations for all classes of radio operator licenses will be given frequently at Washington, D. C., and the District Offices of the Commission in accordance with announced schedules.

(1) Such examinations will be held quarterly at:

Schenectady, N. Y.	St. Louis, Mo.
Winston-Salem, N. C.	Pittsburgh, Pa.
Nashville, Tenn.	Cleveland, Ohio
San Antonio, Tex.	Cincinnati, Ohio
Oklahoma City, Okla.	Columbus, Ohio
Des Moines, Iowa	

(2) Examinations will be held not more than twice annually at:

Albuquerque, N. Mex.	Jacksonville, Fla.
Billings, Montana	Little Rock, Ark.
Bismarck, N. Dakota	Phoenix(Ariz.
Boise, Idaho	Salt Lake City, Utah
Butte, Montana	Spokane, Washington

188. **Station.**—The term "station" means all of the radio-transmitting apparatus used at a particular location for one class of service and operated under a single instrument of authorization. In the case of every station other than broadcast, the location of the station shall be considered as that of the radiating antenna.

192. **Portable station.**—The term "portable station" means a station so constructed that it may conveniently be moved about from place to place for communication and that is in fact so moved about from time to time, but not used while in motion.

a. **Portable-mobile station.**—The term "portable mobile station" means a station so constructed that it may conveniently be moved from one mobile unit to another for communication, and that is, in fact, so moved about from time to time and ordinarily used while in motion.

204. **Allocation of bands of frequencies to services.**—Allocations of bands of frequencies to services, such as mobile, fixed, broadcast, amateur, etc., are set forth in article 5 of the General Regulations annexed to the International Radiotelegraph Convention and in the North American Radio Agreement. These allocations will be adhered to in all assignment to stations capable of causing international interference.

207. **Interference, prevention of.**—Licensees shall use radio transmitters, the emissions of which do not cause interference, outside the authorized band, that is detrimental to traffic and programs of other authorized stations.

210. **Distress messages.**—Radio communications or signals relating to ships or aircraft in distress shall be given absolute priority. Upon notice from any station, Government or commercial, all other transmission shall cease on such frequencies and for such time as may, in any way, interfere with the reception of distress signals or related traffic.

213. **Operators.**—One or more licensed operators, of the grade specified by these regulations, shall be on duty at the place where the transmitting apparatus of each station is located and whenever it is being operated; provided, however, that for a station licensed for service other than broadcasting, and remote control is used, the Commission may modify the foregoing requirements, upon proper application and showing being made, so that such operator or operators may be on duty at the control station in lieu of the place where the transmitting apparatus is located. Such modification shall be subject to the following conditions:

a. The transmitter shall be capable of operation and shall be operated in accordance with the terms of the station license.

b. The transmitter shall be monitored from the control station with apparatus that will permit placing the transmitter in an inoperative condition in the event there is a deviation from the terms of the license, in which case the radiation of the transmitter shall be suspended immediately until corrective measures are effectively applied to place the transmitter in proper condition for operation in accordance with the terms of the station license.

c. The transmitter shall be so located or housed that it is not accessible to other than duly authorized persons.

214. **Licensed operator required.**—Only an operator holding a radiotelegraph class of operators' license may manipulate the transmitting key of a manually operated coastal telegraph or mobile telegraph station in the international service; and only a licensed amateur operator may manipulate the transmitting key at a manually operated amateur station. The licensees of other stations operated under the constant supervision of duly licensed operators may permit any person or per-

sons, whether licensed or not, to transmit by voice or otherwise, in accordance with the types of emission specified by the respective licenses.

220. **Maintenance tests.**—Licensees of stations other than broadcast stations are authorized to carry on such routine tests as may be required for the proper maintenance of the stations: Provided, however, That these tests shall be so conducted as not to cause interference with the service of other stations.

221. **Licenses, posting of.**—The original of each station license, except amateur, portable, and portable-mobile stations shall be posted by the licensee in a conspicuous place in the room in which the transmitter is located. In the case of amateur, portable, and portable-mobile stations the original license, or a photostat copy thereof, shall be similarly posted or kept in the personal possession of the operator on duty.

(a) The original license of each station operator, except amateur and aircraft radio station operators, and operators of portable and portable-mobile stations, shall be posted in a conspicuous place in the room occupied by such operator while on duty. In the case of an amateur or aircraft radio operator, and operators of portable or portable-mobile stations, the original operator's license shall be similarly posted or kept in his personal possession and available for inspection at all times while the operator is on duty.

(b) When an operator's license cannot be posted because it has been mailed to an office of the Federal Communications Commission for endorsement or other change, such operator may continue to operate stations in accordance with the class of license held, for a period not to exceed 30 days, but in no case beyond the date of operation of the license.

361. **Definitions, amateur service.**—The term "amateur service" means a radio service carried on by amateur stations.

362. **Definition, amateur station.**—The term "amateur station" means a station used by an "amateur," that is, a duly authorized person interested in radio technique solely with a personal aim and without pecuniary interest.

364. **Definition, amateur operator.**—The term "amateur radio operator" means a person holding a valid license issued by the Federal Radio Commission who is authorized under the regulations to operate amateur radio stations.

365. **Definition, amateur radio communication.**—The term "amateur radio-communication" means radio-communication between amateur radio stations solely with a personal aim and without pecuniary interest.

366. **Station licenses.**—An amateur station license may be issued only to a licensed amateur radio operator who has made a satisfactory showing of ownership or control of proper transmitting apparatus: *Provided, however,* That in the case of a military or naval reserve radio station located in approved public qurarters and established for training purposes, but not operated by the United States Government, a station license may be issued to the person in charge of such station who may not possess an amateur operator's license.

(a.) **Operator's license.**—An amateur operator's license may be granted to a person who does not desire an amateur station license, provided such applicant waives his right to apply for an amateur station license for 90 days subsequent to the date of application for operator's license.

367. **Eligibility for license.**—Amateur radio station licenses shall not be issued to corporation, associations, or other organizations; *Provided, however,* That in the case of a bona fide amateur radio society a station license may be issued to a licensed amateur radio operator as trustee for such society.

368. **Mobile stations.**—Licenses for mobile stations and portable mobile stations will not be granted to amateurs for operation on frequencies below 28,000 kc. However, the licensee of a fixed amateur station may operate portable amateur stations (Rule 192) in accordance with the provisions of Rules 384, 386 and 387; and also portable and portable-mobile amateur stations (Rules 192 and 192a) on authorized amateur frequencies above 28,000 kc. in accordance with Rules 384 and 386, but without regard to Rule 387.

370. **Points of communication.**—Amateur stations shall be used only for amateur service, except that in emergencies or for testing purposes they may be used also for communication with commercial or Government radio stations. In addition, amateur stations may communicate with any mobile radio station which is licensed by the Commission to communicate with amateur stations, and with stations of expeditions which may also be authorized to communicate with amateur stations.

371. **Amateur stations not to be used for broadcasting.**—Amateur stations shall not be used for broadcasting any form of entertainment, nor for the simultaneous retransmission by automatic means of programs or signals emanating from any class of station other than amateur.

372. **Radiotelephone tests.**—Amateur stations may be used for the transmission of music for test purposes of short duration in connection with the development of experimental radiotelephone equipment.

373. **Amateur stations not for hire.**—Amateur radio stations shall not be used to transmit or receive messages for hire, nor for communication for material compensation, direct or indirect, paid or promised.

374. **Frequency bands assigned.**—The following bands of frequencies are allocated exclusively for use by amateur stations:

1,715	to	2,000	kilocycles
3,500	to	4,000	kilocycles
7,000	to	7,300	kilocycles
14,000	to	14,400	kilocycles
28,000	to	30,000	kilocycles

56,000 to 60,000 kilocycles
400,000 to 401,000 kilocycles

374a, The licensee of an amateur station may, subject to change upon further order, operate amateur stations on any frequency above 110,000 kilocycles, without separate license therefor, provided:

(1) That such operation in every respect complies with the Commission's rules governing the operation of amateur stations in the amateur service.

(2) That records are maintained of all transmissions in accordance with the provisions of Rule 386.

375. **Types of emission.**—All bands of frequencies so assigned may be used for radiotelegraphy, type A-1 emission. Type A-2 emission may be used in the following bands of frequencies only:

28,000 to 30,000 kilocycles
56,000 to 60,000 kilocycles
400,000 to 401,000 kilocycles

376. **Frequency bands for telephony.** The following bands of frequencies are allocated for use by amateur stations using radiotelephony, type A-3 emission:

1,800 to 2,000 kilocycles
28,000 to 29,000 kilocycles
56,000 to 60,000 kilocycles
400,000 to 401,000 kilocycles

377. **Additional bands for telephony.**—Provided the station shall be operated by a person who holds an amateur operator's license endorsed for class A privileges, an amateur radio station may use radiotelephony, type A-3 emission, in the following additional bands of frequencies:

3,900 to 4,000 kilocycles
14,150 to 14,250 kilocycles

378. **Amateur television, facsimile, and picture transmission.**—The following bands of frequencies are allocated for use by amateur stations for television, facsimile, and picture transmission:

1,715 to 2,000 kilocycles
56,000 to 60,000 kilocycles

379. **Licenses will not specify individual frequencies.**—Transmissions by an amateur station may be on any frequency within an amateur band above assigned.

380. **Aliens.**—An amateur radio station shall not be located upon premises controlled by an alien.

381. **Prevention of interference.**—Spurious radiotions from an amateur transmitter operating on a frequency below 30,000 kilocycles shall be reduced or eliminated in accordance with good engineering practice and shall not be of sufficient intensity to cause interference on receiving sets of modern design which are tuned outside the frequency band of emission normally required for the type of emission employed. In the case of A-3 emission, the transmitter shall not be modulated in excess of its modulation capability to the extent that interfering spurious radiations occur, and in no case shall the emitted carrier be amplitude-modulated in excess of 100 per cent. Means shall be employed to insure that the transmitter is not modulated in excess of its modulation capability. A spurious radiation is any radiation from a transmitter which is outside the frequency band of emission normal for the type of transmission employed, including any component whose frequency is an integral multiple or submultiple of the carrier frequency (harmonics and subharmonics), spurious modulation products, key clicks and other transient effects, and parasitic oscillations.

381. **Waiver of Rule 381.**—The following order was adopted by the Telegraph Division on August 1, 1934:

> "Until further notice, the provisions of Rule 381 shall not be construed to apply to amateur operation on frequencies above 56,000 kilocycles."

382. **Power supply to transmitter.**—Licensees of amateur stations using frequencies below 30,000 kilocycles, shall use adequately filtered direct-current power supply for the transmitting equipment, to minimize frequency modulation and to prevent the emision of broad signals.

383. **Authorized power.**—Licensees of amateur stations are authorized to use a maximum power input of 1 kilowatt to the plate circuit of the final amplifier stage of an oscillator-amplifier transmitter or to the plate circuit of an oscillator transmitter.

384. **Transmission of call.**—An operator of an amateur station shall transmit its assigned call at least once during each 15 minutes of operation and at the end of each transmission. In addition, an operator of an amateur portable, or portable-mobile radiotelegraph station shall transmit immediately after the call of the station, the break sign ($\overline{BT}$) followed by the number of the amateur call area in which the portable or portable-mobile amateur station is then operating, as for example:

Example 1. Portable or portable-mobile amateur station operating in the third amateur call area calls a fixed amteur station: W1ABC W1ABC W1ABC DE W2DEF $\overline{BT3}$ W2DEF $\overline{BT3}$ W2DEF $\overline{BT3}$ $\overline{AR}$

Example 2. Fixed amateur station answers the portable or portable-mobile amateur station: W2DEF W2DEF W2DEF DE W1ABC W1ABC W1ABC $\overline{K}$

Example 3. Portable or portable-mobile amateur station calls a portable or portable-mobile amateur station: W3GHI W3GHI W3GHI DE W4JKL $\overline{BT4}$ W4JKL $\overline{BT4}$ W4JKL $\overline{BT4}$ $\overline{AR}$

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

384a. In the case of an amateur licensee whose station is licensed to a regularly commissioned or enlisted member of the United States Naval Reserve, the Commandant of the naval district in which such reservist resides may authorize in his discretion the use of the call letter prefix "N," in lieu of the prefix "W" or "K," assigned in the license issued by the Commission, provided that such "N" prefix shall be used only when operating in the frequency bands 1715-2000 kilocycles, 3500-4000 kilocycles, 56,000 to 60,000 kilocycles and 400,000 to 401,000 kilocycles in accordance with instructions to be issued by the Navy Department.

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

386. **Logs.**—Each licensee of an amateur station shall keep an accurate log of station operation to be made available upon request by authorized Government representatives, as follows:

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

c. Call letters of the station called. (This entry need not be repeated for calls made to the same station during any sequence of 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 location of a portable or portable-mobile station at the time of each transmission. (This need be entered only once, provided the location of the station is not changed. However, suitable entry shall be made in the log upon changing location, showing the type of vehicle or mobile unit in which the station is operated, and the approximate geographical location of the station at the time of operation.)

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

387. **Portable stations.**—Advance notice of all locations in which portable amateur stations will be operated shall be given by the licensee to the inspector in charge of the district in which the station is to be operated. Such notices shall be made by letter or other means prior to any operation contemplated and shall state the station call, name of licensee, the date of proposed operation and the approximate locations, as by city, town or county. An amateur station operating under this rule shall not be operated during any period exceeding 30 days without giving further notice to the inspector in charge of the radio inspection district in which the station will be operated. This rule does not apply to the operation of portable or portable-mobile amateur stations on frequencies above 28,000 kc authorized to be used by amateur stations. (See Rule 368)

400. **Only amateur operators may operate amateur stations.**—An amateur station may be operated only by a person holding a valid amateur operator's license, and then only to the extent provided for by the class of privileges for which the operator's license is endorsed.

401. **Validity of operator's license.**—Amateur operator's licenses are valid only for the operation of licensed amateur stations, provided, however, any person holding a valid radio operator's license of any class may operate stations in the experimental service licensed for, and operating on, frequencies above 30,000 kilocycles.

402. **Proof of use.**—Amateur station licenses and/or amateur operator licenses may, upon proper application, be renewed provided: (1) the applicant has used his station to communicate by radio with at least three other amateur stations during the 3-month period prior to the date of submitting the application, or (2) in the case of an applicant possessing only an operator's license, that he has similarly communicated with amateur stations during the same period. Proof of such communication must be included in the application by stating the call letters of the stations with which communication was carried on and the time and date of each communication. Lacking such proof, the applicant will be ineligible for a license for a period of 90 days.

This rule shall not prevent renewal of an amateur station license to an applicant who has recently qualified for license as an amateur operator.

403. **Class of operator and privileges.**—There shall be but one main class of amateur operator's license, to be known as "amateur class," but each such license shall be limited in scope by the signature of the examining officer opposite the particular class or classes of privileges which apply, as follows:

Class A.—Unlimited privileges.

Class B.—Unlimited radiotelegraph privileges. Limited in the operation of radiotelephone amateur stations to the following bands of frequencies: 1,800 to 2,000 kilocycles; 28,000 to 29,000 kilocycles; 56,000 to 60,000 kilocycles; 400,000 to 401,000 kilocycles.

Class C.—Same as class B privileges, except that the Commission may require the licensee to appear at an examining point for a supervisory written examination and practical code test during the license term. Failing to appear for examination when directed to do so, or failing to pass the supervisory examination, the license held will be canceled and the holder thereof will not be issued another license for the class C privileges.

404. **Scope and places of examinations.**—The scope of examinations for amateur operators' licenses shall be based on the class of privileges the applicant desires, as follows:

Class A.—To be eligible for examination for the class A amateur operator's privileges the applicant must have been a licensed amateur operator for at least 1 year and must personally appear at one of the Commission's examining offices, and take the supervisory written examination and code test. (See pars. 2 h (1), 30, and 408.) Examinations will be conducted at Washington, D. C., on Thursday of each week, and at each radio district office of the Commission on the days designated by the inspector in charge of such office. In addition, examinations will be held quarterly in the examining cities listed in paragraph 30 on the dates to be designated by the inspector in charge of the radio district in which the examining city is situated. The examination will include the following:

a. Applicant's ability to send and receive in plain language messages in the Continental Morse Code (5 characters to the word) at a speed of not less than 13 words per minute.

b. Technical knowledge of amateur radio apparatus, both telegraph and telephone.

c. Knowledge of the provisions of the Communications Act of 1934, subsequent acts, treaties, and rules and regulations of the Federal Communications Commission, affecting amateur licensees.

Class B.—The requirements for class B amateur operators' privileges are similar to those for the class A, except that no experience is required and the questions on radiotelephone apparatus are not so comprehensive in scope.

Class C.—The requirements for class C amateur operators' privileges shall be the same as for the class B except the examination will be given by mail. Applicants for class C privileges must reside more than 125 miles air line from the nearest examining point for class B privileges, or in a camp of the Civilian Conservation Corps, or be in the regular military or naval service of the United States at a military post or naval station; or be shown by physician's certificate to be unable to appear for examination due to protracted disability.

405. **Recognition of other classes of licenses.**—An applicant for any class of amateur operator's privileges who has held a radiotelephone second-class operator's license or higher, or an equivalent commercial grade license, or who has been accorded unlimited amateur radiotelephone privileges, within 5 years of the date of application may only be required to submit additional proof as to code ability and/or knowledge of the laws, treaties, and regulations affecting amateur licensees.

406. An applicant for the class B or C amateur operator's privileges who has held a radiotelegraph third-class operator's license or higher, or an equivalent commercial grade license, or who has held an amateur extra first-class license within 5 years of the date of application may be accorded a license by passing an examination in laws, treaties, and regulations affecting amateur licensees.

407. **Code ability to be certified by licensed operator.**—An applicant for the class C amateur operator's privileges must have his application signed in the presence of a person authorized to administer oaths by (1) a licensed radiotelegraph operator other than an amateur operator possessing only the class C privileges or former temporary amateur class license, or (2) by a person who can show evidence of employment as a radiotelegraph operator in the government service of the United States. In either case the radiotelegraph code examiner shall attest to the applicant's ability to send and receive messages in plain language in the continental Morse code (5 characters to the word) at a speed of not less than 13 words per minute. The code certification may be omitted if the applicant can show proof of code ability in accordance with the preceding rule.

408. **Applications.**—Each application for an instrument of authorization shall be made in writing, under oath of the applicant, on a form prescribed and furnished by the Commission. Separate application shall be filed for each instrument of authorization requested.

The required forms may be obtained from the Commission or from any of its field offices.

409. **Grading of examinations.**—The percentage that must be obtained as a passing mark in each examination is 75 out of a possible 100. No credit will be given in the grading of papers for experience or knowledge of the code. If an applicant answers only the questions relating to laws, treaties, and regulations by reason of his right to omit other subjects because of having held

a recognized class of license, a percentage of 75 out of a possible 100 must be obtained on the questions answered.

410. **Operator's and station licenses to run concurrently.**—An amateur station license shall be issued so as to run concurrently with the amateur operator's license and both licenses shall run for 3 years from the date of issuance. If either the station license or the operator's license is modified during the license term, both licenses shall be reissued for the full 3-year term: Provided, however, if an operator's license is modified only with respect to the class of operator's privileges, the old license may be endorsed, in which case the expiration date will not change.

411. **Eligibility for reexamination.**—No applicant who fails to qualify for an operator's license will be reexamined within 90 days from the date of the previous examination.

412. **Penalty.**—Any attempt to obtain an operator's license by fraudulent means, or by attempting to impersonate another, or copying or divulging questions used in examinations, or, if found unqualified or unfit, will constitute a violation of the regulations for which the licensee may suffer suspension of license or be refused a license and/or debartment from further examination for a period not exceeding 2 years at the discretion of the licensing authority.

413. **Duplicate licenses.**—Any licensee applying for a duplicate license to replace an original which has been lost, mutilated, or destroyed, shall submit an affidavit to the Commission attesting to the facts regarding the manner in which the original was lost. Duplicates will be issued in exact conformity with the original, and will be marked "duplicate" on the face of the license.

414. **Oath of secrecy.**—Licenses are not valid until the oath of secrecy has been executed and the signature of the licensee affixed thereto.

415. **Examination to be written in longhand.**—All examinations including the code test, must be written in longhand by the applicant.

Some Probable Questions on Laws and Regulations

1 Q. What is the Federal Communications Commission?

A. The Federal Communications Commission is the authority in the United States which licenses and regulates radio and wire communication. There are seven commissioners appointed by the president who compose the commission. Some of its duties are the licensing and classification of stations, the assignment of frequencies, the regulation of power and operating hours, and the licensing of operators.

2 Q. What is the law on the amount of power to be used for communicating over a given distance?

A. The minimum amount of power necessary to carry on the desired communication should be used at all times excepting communications in regard to vessels in distres.s

3 Q. What is the law on the transmission of indecent or obscene language?

A. No person within the jurisdiction of the United States shall utter any obscene, indecent, or profane language by means of radio communication.

4 Q. What is the law on the transmission of fraudulent communications?

A. No one shall knowingly transmit any false or fraudulent signal of distress or communication relating thereto.

5 Q. What communications hold precedence over all others?

A. Distress calls, messages and traffic hold precedence over all other communications.

6 Q. What is the law on malicious interference?

A. Wilful or malicious interference with any other radio communications or signals is prohibited.

7 Q. What is the international law on superfluous signals?

A. The exchange of superfluous signals not necessary in carrying on the radio communication is forbidden to all stations.

8 Q. What is the international law on the maintenance of constant frequency and the purity of signals?

A. The waves emitted by a station must be kept on the assigned frequency as close as the state of the art permits and their radiation as far as practically possible must be free from all emissions not necessary to the type of communication carried on.

9 Q. What type of communications may be exchanged between amateur stations of different countries?

A. Amateurs in different countries have to confine their exchanges to remarks dealing with their experiments and/or to remarks that would not be sufficiently important to send by public telegraph or cable. Third party messages between two countries cannot be handled unless the governments of the two countries concerned have made special agreements to that effect. A third party message is a message addressed to or from some person other than either of the amateurs concerned with it.

10 Q. What is the reason for amateur station calls beginning with W or K in the United States and possessions?

A. Under international treaty it is agreed upon that each nation shall assign its station calls from the letters given it at the treaty. These letters are from CAA to ZUZ excepting Q which is reserved for the Q signals. Amateur calls in a given country must begin with a prefix of one or two letters in accordnace with this international alphabetical distribution. This prefix must be followed by a numeral and one or more additional letters. The United States is allocated under this international agreement all calls beginning with K, N and W. Our government has

specified that within the United States proper all amateur calls shall begin with W and outside of the United States proper all U. S. amateur calls shall begin with K.

11 Q. Give three Q signals and their meanings?

A. QRA? What is the name of your station?
QRA. The name of mystation is . . .
QRM? Are you being interfered with?
QRM. I am being interfered with.
QRZ? By whom am I being called?
QRZ. You are being called by . . .

12 Q. Give the meaings of SOS, QRT, QRM, CQ, and MAYDAY.

A. SOS is the international distress call for radiotelegraph stations. QRT means stop sending. QRM means I am being interfered with. CQ is the general call to all stations. It may be used as a call of inquiry when desiring to communicate with any station within range when the call is ended with a K. It may also be used as a preface to broadcasts to which no reply is expected in which case the terminating letter K is omitted.

MAYDAY is the international distress call for radiotelephone stations and is from the French pronunciation of the expression ("m'aider" (help me).

13 Q. What is the law on the secrecy of radio communications?

A. The contents or meaning of an addressed message must not be divulged to any other than the addressee or his agent except to an authorized communication channel or upon the demand of a competent court; nor may anyone intercept and divulge a message even to the addressee without the authority of the sender. Also no one may use the information in an addressed message for his own benefit. The secrecy provisions however do not apply to distress traffic or that which has been broadcast for public use.

14 Q. Why must any transmitter have a station license?

A. Because the regulation of interstate communication is a function of the federal government and station licenses are required not only for stations whose signals may extend beyond the borders of the state wherein the transmitter is located but also for stations capable of interfering with the reception of out of state signals on nearby receivers.

15 Q. What does the law provide in regard to the control of radio stations during a national emergency?

A. During a national emergency of any sort the president has the power to suspend or amend any or all the rules and regulations for any stations and may if necessary order all stations closed and dismantled or may authorize the use of all the apparatus of all stations by the government in which case the owners will receive just compenstation for their stations.

16 Q. Give the frequency limits of the amateur bands.

A. 1,715 kc. to 2,000 kc.
3,500 kc. to 4,000 kc.
7,000 kc. to 7,300 kc.
14,000 kc. to 14,400 kc.
28,000 kc. to 30,000 kc.
56,000 kc. to 60,000 kc.
400,000 kc. to 401,000 kc.

17 Q. In what bands must a filtered direct current plate supply be used?

A. 1,715 kc. to 2,000 kc.
3,500 kc. to 4,000 kc.
7,000 kc. to 7,300 kc.
14,000 kc. to 14,400 kc.
28,000 kc. to 30,000 kc.

18 Q. In what bands may tone modulated telegraphy (A-2) emission be used?

A. 56,000 kc. to 60,000 kc.
400,000 kc. to 401,000 kc.
and above 110,000 kc.

19 Q. What types of emission may be used in the 5 meter band?

A. Type A-1 *pure dc telegraphy
Type A-2 *tone modulated telegraphy
Type A-3 *phone
Type A-4 *television or facsimile

20 Q. What type or types of emission may be be used in the 40 meter band?

A. Type A-1 *pure dc telegraphy.

21 Q. What types of emission may be used in the 1800 to 2000 kc. band; 3500 to 3900 kc; 3900 to 4000 kc; and 7000 to 7300 kc?

A. In the 1800 to 2000, A1 and A3; 3500 to 3900;, A1; 3900 to 4000, A3 only by those holding Class A licenses; 7000 to 7300, A1.

22 Q. In what bands may amateurs use phone?

A. Every amateur may use phone in the following bands:

1,800 kc. to 2,000 kc.
28,000 kc. to 29,000 kc.
56,000 kc. to 60,000 kc.
400,000 kc. to 401,000 kc. and above 110,000 kc.

Holders of the Class A license may use phone in the following additional bands.

3,900 kc. to 4,000 kc.
14,150 kc. to 14,250 kc.

23 Q. Which of the five following frequencies have their second harmonic in the 40 meter band, 3490, 3520, 3590, 3645, 3660?

A. Harmonics are multiples of a stated frequency and as the second harmonic is required in the question the frequencies given are multiplied by two. If the third harmonic was asked for it would be necessary to multiply by three and if the fourth was asked for it would be necessary to multiply by four. When the frequencies are multiplied by two it is found that the second harmonic frequencies are respectively 6980, 7040, 7180, 7290, and 7320 and as the limits of the 40 meter band are 7000 kc. to 7300 kc. the frequencies listed that have their second harmonic in the 40 meter band are 3520, 3590, and 3645. The

second harmonics of the others fall outside the 40 meter band.

24 Q. In what bands may an amateur operate a portable-mobile station?

A. In the 28,000 kc. to 30,000 kc., 56,000 kc. to 60,000 kc., and 400,000 kc. to 401,000 kc. bands and from 110,000 kc. upwards.

25 Q. Under what circumstances may "Quiet hours" be imposed?

A. Quiet hours may be imposed from 8:00 p.m. to 10:30 p.m. local time and on Sundays during an additional period from 10:30 a.m. to 1 p.m. local time when the amateur station concerned causes general interference to broadcast program reception on receivers of modern design. Quiet hours need be observed however only on the frequency or frequencies which cause the interference.

26 Q. What is a radio amateur?

A. A radio amateur is a duly authorized person interested in radio technique solely with a personal aim and without pecuniary interest.

27 Q. May amateur stations broadcast entertainment?

A. No, amateur stations may not be used for broadcasting any form of entertainment nor for the simultaneous retransmission by automatic means of programs or signals emanating from any class of station other than amateur.

28 Q. Under what restrictions may amateur stations transmit music?

A. Amateur stations may be used for the transmission of music for test purposes of short duration in connection with the development of experimental radiotelephone equipment.

28 Q. How often must an amateur station sign its call?

A. An operator of an amateur station shall transmit its assigned call at least once during each 15 minutes of operation and at the end of each transmission.

30 Q. What is the maximum power amateur stations can use?

A. Amateur stations are allowed to use a maximum power input of 1 kilowatt to the plate circuit of the final amplifier stage of an oscillator amplifier transmitter or to the plate circuit of an oscillator transmitter.

31 Q. Why do the regulations require that the transmitter be loosely coupled to the radiating system?

A. In order to maintain frequency stability and to minimize harmonics and keying impacts.

32 Q. What is the difference between a portable and a mobile station?

A. A portable station is a station that is built so it can be moved from place to place and is moved but is not operated in motion whereas a mobile station is one that can be moved from place to place and is ordinarily operated while in motion.

33 Q. What restriction exists against accepting pay for services performed by an amateur station?

A. Amateur stations cannot be used for transmitting or receiving messages for hire or for communicating for material compensation, direct, or indirect, paid or promised.

34 Q. Under what conditions may amateur stations communicate with other than amateur stations?

A. In emergencies or for testing purposes amateur stations may also be used to communicate with commercial or government radio stations. Also they may communicate with any mobile radio station which is licensed by the Commission to communicate with amateur stations, and with stations of expeditions which may be authorized to communicate with amateurs.

35 Q. What notice must be given prior to the operation of a portable station?

A. The Inspector-in-charge of the district in which the station is to be operated as a portable must be advised before actual portable operation. The notice to be sent to the Inspector-in-Charge must give the station call, the name of the licensee, the dates of proposed operation, and the approximate locations where operation will take place. This notice will be good for a maximum of 30 days operation and when it is desired to operate beyond a 30 day period further notice must be filed. This pertains to frequencies below 28,000 kc. Above 28,000 kc. no notice is necessary for either portable or portable-mobile operation.

36 Q. Must an amateur keep a log and can an authorized government representative demand it?

A. Yes. Yes.

37 Q. How long before expiration of an amateur license must application for renewal be filed?

A. Application for renewal of license must be filed at least 60 days prior to the expiration of the license to be renewed and this application should be filed with the Federal Communications Commission, Washington, D. C.

38 Q. Who may operate an amateur station?

A. Only a licensed amateur operator may operate an amateur station however an unlicensed person may speak over an amateur station if a licensed amateur operator is present and in charge of the operation of the transmitter.

39 Q. May other than citizens of the United States obtain station or an operator's license? May an alien control the premises on which an amateur station is located?

A. No. No.

40 Q. Can an amateur station be operated by an automatic transmitter without a licensed operator present?

A. No, not without a licensed operator present but an automatic transmitter can be used if a licensed operator is present at all times when the station is in operation.

41 Q. If you were in communication with a foreign amateur and could speak the language of his country would it be permissable for you to use that language for conversation?

A. Yes, because that is still "plain language."

42 Q. Under what conditions may an amateur station be operated on a mobile unit?

A. Amateur stations may be operated on a portable mobile basis in all amateur bands above 28,000 kc.

43 Q. If one wishes to maintain a portable station and a fixed station at the same time will a photostat copy of the station license serve for the portable?

A. Yes, photostat copies of the station will serve for additional stations.

44 Q. What is a portable mobile station?

A. A portable mobile station is a station so constructed that it may be conveniently moved fro mone mobile unit to another for communication and is ordinarily used on a mobile unit while the mobile unit is in motion.

45 Q. What identifying signal, in addition to its call, must a portable or portable mobile station transmit?

A. Directly after signing the regular station call the portable transmitter must send the break sign BT followed by the number of the amateur call area in which it is operating; and also if the portable transmitter is a phone station the call sign must be followed by an announcement of the amateur call area in which the station is operating.

46 Q. What is the meaning of the signal AR, or the signal SK or the letter K after a transmission?

A. The signal AR after a transmission denotes the end of a message, the signal SK the end of communication between two stations, and the letter K is an invitation to the other station to go ahead and indicates to him that you have finished your transmission for the time being and will start listening for him.

47 Q. May a commercial operator who has no license operate an amateur station?

A. No. Only operators who hold amateur operator licenses may operate amateur stations.

48 Q. What facts must be recorded in an amateur station log?

A. 1. The date and time of all transmissions.
2. The name of the person operating.
3. A statement as to the nature of the transmission.
4. The station called.
5. The input power to the stage supplying the antenna.
6. The frequency band used.
7. The location at each transmission in the case of a portable station.
8. The message traffic handled, if any.

49 Q. What would you do as an amateur operator if you heard a ship transmitting a distress signal?

A. All transmission that is capable of interfering with the signals of the distressed ship, or of stations communicating with it should be stopped immediately. The operator should continue with those who can assist it. If no one seems to answer however full particulars should be transmitted by land line to the nearest commercial or government station. Everything possible should be done to bring assistance to the distressed ship without risking radio interference to those who are in a position to aid.

50 Q. What is the penalty to which one is liable for a violation of the provisions of the Communications Act of 1934?

A. A fine of not more than $10,000, or imprisonment for a term of not more than two years, or both, for each offense. In addition a licensed operator convicted of violation of the Communications Act is liable to suspension of his operator's license for a period of not more than two years. The station license if one is held may be revoked.

51 Q. What is the penalty to which one is liable for a violation of any regulation of the Federal Communications Commission established by the Communications Act of 1934?

A. A fine of not more than $500 for each and every day of such offense. In addition a licensed operator convicted of violation is liable to suspension of his operator's license for a period of not more than two years. The station license if one is held may be revoked.

Any person whether he is a licensed operator or not is liable to the penalties for violation of either the Communications Act or the Rules and Regulations of the Federal Communications Commission.

Such things as transmitting profane or obscene language, divulging the contents of messages to unauthorized persons, transmitting a false or fraudulent signal of distress, or operating a licensed amateur station without an amateur operator license are violations of the Communications Act and are subject to the penalties for violations of the Act. The licensee of a licensed amateur station also violates the Communications Act if he permits the operation of his station by an unauthorized person, signs a false station call, operates outside the bands, or maliciously interferes with distress calls or distress communications.

Such things as accepting pay for services rendered by one's amateur station, wilfully failing to observe required quiet hours, failing to keep a log, using an inadequately filtered power supply, operating a phone station in the 80 or 20 meter bands without a class A license, malicious interference with the ordinary transmissions of other stations, or operating a portable on a frequency below 28,000 kc. without having notified the Inspector as required are all violations of the Rules and Regulations and are subject to the penalties provided.

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