1937 Radio Data Book

PUBLISHED BY
RADIO NEWS AND SHORT WAVE RADIO

1937 RADIO DATA BOOK

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461 Eighth Avenue

New York, N. Y.

Printed in U. S. A.

Opportunity In Television

by Laurence M. Cockaday

MORE than 30 years ago some scientific writer suggested that the time would come when the telephone subscriber would be able to see the person with whom he converses. That statement fired the public imagination. With the popularization of radio broadcasting there were more rumors and forecasts, based on radio being a more adaptable medium for the purpose. Then, in 1931 or 1932 it was even possible to buy television receivers and kits, such as they were. The furor of excitement was short-lived, however, when it developed that the electrical and mechanical problems had not been satisfactorily solved by these scanning-disc systems.

Along about 1934 it was learned that several large radio laboratories were at work developing cathode-ray television. Occasional news of their progress leaked out but those engaged in the experimental development work were extremely coy, keeping news of their progress secret and discouraging public interest.

Finally the clamor of the public and press caused a modification of this policy of coyness, with the result that actual demonstrations of their experimental results have now been given by several of the leading laboratories—demonstrations for the press primarily, but reports were passed along to the public by the writers who were privileged to participate. As a result the old question "Do you think we will ever have television?" has given way to "How soon will we have television for the home?"

Just how soon television receivers will be available to the public, is anybody's guess. In the laboratory television *is* a success. The clarity and definition of the images on the televisor screen are equal to good home movies, although smaller in size — the television picture size being about 5 by 7 inches. Movie films can be readily reproduced by television, and direct pick-up of persons and scenes, indoor and outdoor, is successfully accomplished. For this purpose slightly higher light values are required than for movie photography but this is not either an insurmountable obstacle nor is it, in the meantime, a serious drawback because where conditions are unfavorable for direct televising of a scene, it can be recorded on movie film and then reproduced by television.

If these are the facts, what is holding up the parade? There are several reasons, some valid and other questionable. First of all, there must be television transmitting stations and these must be duly licensed and assigned operating frequencies by the government. Secondly, it is jointly agreed by the prospective broadcasters, the prospective television manufacturers and the government, that certain technical standards must be decided upon and adopted before regular television transmissions can begin; standards which will protect the purchasers of televisors and prevent monopolies in both the broadcasting and manufacturing ends.

Beyond these there appear to be some other obstacles of a commercial nature. One is concerned with the question of who is to pay the costs of equipping and maintaining the television stations. This is apparently not a serious obstacle, however, because it seems to be the feeling that television broadcasting will find itself financed in much the same way as radio broadcasting. A more serious consideration and likely cause for delay is the attitude, on the part of some of the key manufacturers of equipment, that television should be born in full bloom—that it should be withheld from the public until perfected. Also until receiving equipment can be placed on the market at a reasonably low price.

ACTUAL TELEVISION PICTURE

This picture was taken with an ordinary camera, focussed on the screen of a television receiver, during a recent demonstration by the Philco Radio and Television Corp., after the image had been sent through the air a distance of 7½ miles by ultra-short-wave radio.

Let us consider these factors causing the delay. Most of them are legitimate and understandable but some of them smack of business racketeering. The necessity for due consideration in adopting standards and in assigning transmitting frequencies is self evident. Standardization will aid, for instance, in the simplification of receivers, and the lower cost which attends this simplification. But, as for withholding television until it is fully perfected and refined, there is room for suspicion concerning the motives. Unprejudiced opinion is that a combination sight and sound receiver can be produced today to sell at $200, which seems fair enough. The automobile was not withheld for perfecting—nor was the radio—yet the public had many years of enjoyment from both while in their infancy. Moreover, production experience and healthy competition are necessary in perfecting any device as complicated as a television receiver—and neither is possible under this proposed plan of "laboratory incubation and maturing".

Frequency assignment is a special problem, where television is concerned, because a single television transmitter requires a band 300 to 400 times as wide as the 10-kilocycle channels assigned to regular broadcast stations. The only portion of the explored radio spectrum where such wide bands are available is in the ultra-high-frequency ranges above 40,000 kc. (7.5 meters), and relatively little is known as to the characteristics of these frequencies. At present it appears that the ranges of 42-56 and 60-90 megacycles will be made available for television; in fact experimental licenses are now being issued in these ranges.

No attempt is made here to predict the date when television will arrive. From the standpoint of those who plan to make television their life work, the important thing is that television development is well under way and whether it comes in six months or two years it will be a field of opportunities, and this time can well be spent in preparing for it.

There are opportunities today in the laboratories that are carrying on this development. Such opportunities are largely limited to engineers who are well qualified in the electronic and optical sciences. When the manufacturers are ready to go into production, there will be all sorts of openings available for men who are versed in the various phases of radio production work. Following this there will be openings in the sales and service ends of the new industry. In fact it is believed that we will again go through a period of opportunity comparable with that provided by the early days of radio. The major difference will be that television will be more highly technical than was radio in its early days and the opportunities which do open up will be

(*Turn to page* 61)

ALL-WAVE RECEPTION AIDS

DX Tips

So many new listeners are being introduced to short-wave reception via a new all-wave radio receiver, persons who have little idea of the problems of reception on these bands, that this section of timely hints should be of first importance in many a household.

The following tips are aimed at the newcomer to the DX pastime, with the hope that all of them may be helpful to some—and some of them helpful to all. An effort has been made to pack the meat of varied researches of the editors into one section, making a ready reference for the tyro in the DX sport who does not wish to wade through one or several years' copies of Radio News in order to find this or that item of needed information.

First, let us consider several pointers which apply to short-wave listening (and incidentally, to long-wave DX too). The importance of an appropriate aerial is always plainly stressed and often rightly so. It is largely a matter of location—dependent on how much (or how little, if you are in a fortune spot) unwanted aerial matter there may be near your receiver, such as power lines, trolley wires or steel buildings. Such metal masses will rob the incoming signal of a portion of its strength. Hence your aerial must be efficient to counteract those losses.

World Time Conversion

In attempting very distant or transoceanic reception, consideration must be given to differences in time. Thus, when it is noon (Standard Time) in New York City, it is 9 a.m. in Los Angeles, 5 p.m. in Daventry and London, 6 p.m. in Berlin and Rome, 5:30 a.m. in Honolulu, and (the *following* morning) 1 a.m. in Shanghai, 2 a.m. in Tokyo, and 4:30 a.m. in New Zealand. The general rule is that places 15 degrees of longitude apart vary one hour in time. The World Time Conversion Chart (Figure 3) provides a simple means for computing the time in any place in the world.

To use this chart, first locate your country, or your section of your country, in the alphabetical list, to find its longitude. Then locate this longitude on line A. Next, consult the alphabetical list to determine the longitude of the country whose time you want to find, and locate this longitude on line C. Now lay a ruler or other straight-edge across the chart so that it connects these two points on lines A and C. The point at which it crosses line B shows the time difference between these points. If the hour is preceded by a plus sign, add this figure to the time in your locality. If a minus sign is shown, deduct the hours.

From the foregoing it is evident that the use of this chart represents an utterly simple method of accurately determining the time in any part of the world, corresponding with that in any other part. If desired, a strip of cardboard may be employed in place of a ruler, pivoting one end on line A in a position corresponding to one's own location so that the straight-edge may be swung through an arc sufficiently long to reach all points on line C. This will still further simplify the use of the chart.

Tuning For Stations

Hardly a day goes by but what some new drama of the ether is unfolded and it is this unexpected and dramatic interest that makes short-wave reception so exhilarating. Although we are not all privileged to "sail the seven seas," we can all be transported, at least for a time ,far from the hum-drum realities of our everyday existence by sailing the ether lanes on our present-day short-wave radio receiver.

To get the most pleasure from your short-wave receiver, there are certain facts that should be kept in mind.

It is commonly known that short-wave stations do not operate at all hours, or every day. It is also well known that these stations change their wavelengths with the changing seasons, and some of the large stations use different frequencies at certain hours of the day. Short-wave broadcasting also covers only narrow bands within a wide wave spectrum which runs from 1500 to some 40, or even 50 thousand kilocycles, including thousands of separate channels. If it were not for the up-to-date and accurate World Short-Wave Timetable, published monthly in Radio News, all the best equipment in the world would be of very little use, as it would be like searching for a "needle in a haystack" to find out *when* the stations were operating, *where* they were located, and *upon what frequencies* they were operating.

Short-wave tuning is different from broadcast tuning. On the long waves we know almost when and where (on the dials) to find stations, for we grow accustomed to tuning them in day after day. But on a short-wave set we must search for the stations at first and then keep a record of the dial-reading in order to go back and get it later. It is not necessary to keep a written record always, as dial settings on a short-wave set soon get fixed in mind just the same as on long waves. But you must search for the station at first, and to get it you must tune *when it is on the air!*

In running up and down the dials you might pass over a distant station dozens

TWO WELL-KNOWN SHORT-WAVE STATIONS

At almost any time, day or night, you can hear these stations on short-waves. Figure 1, right, is the B. B. C. building in London, England. Figure 2, below, is the German broadcast center.

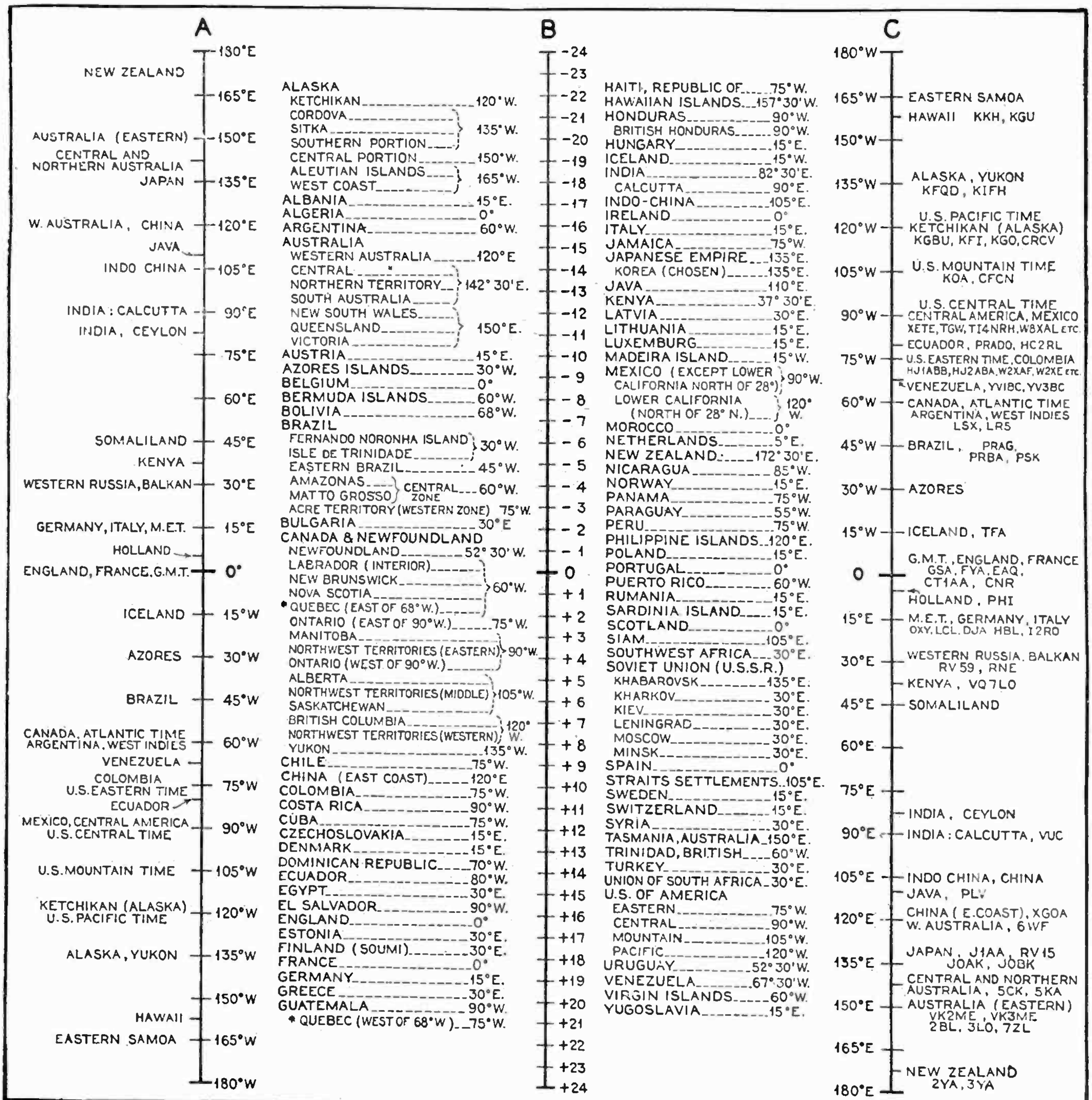


Figure 3—World Time Conversion Chart

of times and never know it is a station unless you happen to stop right on the exact spot where the signal is located. Therefore, you must tune slowly. Short-wave stations are mostly experimental and change quite often. Be sure your station list is up to date and kept up to date or you will spend much time tuning for stations that are not on the air. Then, paying particular attention to the time each station is on the air, tune for it near where the local station was heard on the dial. For example, you can easily tune in W2XAF, New York, on 31.48 meters and station VK3ME is just a shade on the dials above it.

Helpful Hints

The non-technical broadcast listener is often apt to forget that headphones sometimes will bring in a weak DX signal where in some cases loudspeaker reception might be unsatisfactory. If your receiver has no phone jack, a suitable adapter can be made or purchased.

For the utmost success in DX dialing, it is not enough to "tune slowly," always. Rather, you must move the condenser control over one (or one-half) point on the dial scale, leaving it motionless there for a half minute or longer, depending on air conditions. Fading, atmospherics and the like may completely blank out a faint signal, which may come in with fair strength after a short wait.

The various DX Clubs are a real help to the enthusiastic nighthawk listener. They provide, generally at nominal cost, a valuable exchange of hard-to-get information—tips, station changes, schedules, special DX programmes, and perhaps best of all, the sporting spirit of competition which makes one try to acquire a better log than the other fellow.

By all means, consult the Short-Wave Timetable in Radio News, for your "regular" short-wave listening-in. It will save you time and insure you getting real results out of your receiver! Also consult the listeners' reports in The DX Corner to see if you can better the records other listeners are making.

Anyone with an all-wave set is missing an opportunity for a lot of pleasure and satisfaction if they do not try a twist at the fascinating high frequencies—a plunge into the earth-girdling short waves. It seems that everyone and his auntie are doing it. Here one can recapture the thrills of early days in radio—*multiplied tenfold!*

To such as may be hesitating on the brink of this plunge, the advice of a confirmed addict will invariably be, "Go ahead—you'll never regret it!" To get the full mixture of joy, exasperation and surprises from the game, start off by building a small short-wave receiver for yourself. Every schoolboy nowadays has the necessary diagram for just the best circuit very clearly in his mind, right where the algebra should be!

A REGULAR STANDBY

Figure 4, above, shows the studio of the powerful station EAQ at Madrid, Spain.

You may by some miracle get by without once mastering a jigsaw puzzle and face posterity with a certain assumed air of calmness. But never will you be able to look your grandchildren in the optics if you failed to throw together a two or three-tube blooper, and (with the aid of the plumber, the postman and Miss Nextdoor) drag in "Rah-de-oh Rom-ah" by brute force and some ear-stretching.

A general working rule for short-wave radio reception, as regards the best time of day for the various bands, would be: below 30 meters during daylight, and above that wavelength at night.

There is little point in trying to *tell* anyone just how sharp the tuning is on short-wave reception, as it is one of those facts capable of being grasped properly only by personal experience. However, if the newcomer to the high-frequency channels, after building or buying the first receiver, can control or at least faintly moderate his eagerness to bring Australia "pounding in" till after the first evenings tuning, there is a gradual means of approach to the full realization of this extremely sharp tuning.

Influence of Weather

Weather is often the bane of the serious DX hunter, yet at times even its vagaries can be put to worthwhile use. On the short-waves, the season of warm weather will bring the best results, especially on the 16-meter, 19, 25 and 31-meter bands. Sometimes damp cloudy days are wonderful for S.W. DX. Or, if you wish to listen to the overseas stations on the long waves, the best results will follow attempts made during the cold seasons. On such transmissions, the most likely hours are naturally those when the signal path is dark.

A general rule as to DX efforts during what seems to be poor radio weather, might be one advising the listener to stick to the short waves at such times—more particularly, frequencies above 7000 kc. Yet here, as in most things, the exception sometimes proves the rule.

HEARD AUSTRALIA YET?

Figure 5, above, shows the 20 kw. short-wave transmitter, VK2ME situated at Radio Center, Pennant Hills, Sydney, Australia. It can be recognized during announcements by the call of the "laughing jackass," (shown in Figure 6, at right), which, by the way, is a bird and not the four-footed, stubborn variety of mammal.

Good air conditions for big DX often appear to lie in directional strips across the world. Thus a listener near the Great Lakes may experience a night when he can log most of the European stations yet be unable to hear anything of value from Asia or Australia. Another night the reverse may hold true.

Antennas and Grounds

SOME receivers perform better, in the case of signals coming (for the major portion of their travel) across a large body of water, using no ground connection. In other cases, reception has been improved (static noticeably lessened) by disconnecting the usual aerial, and changing the ground wire to the antenna post. Go ahead and experiment! Almost anything is worth a trial—save perhaps such carefree gestures as applying "B" (plate) voltages to the tube filaments. Even the long-bearded experts in this wireless game will at times admit there are a few things yet to be learned.

One of the best DX grounds can be easily made, as follows: a coil of wire, anything from 18 to 22 gauge or the like, is wound on a 2- or 3-foot length of copper pipe, of which the diameter may be anywhere between or near 1 and 2 inches. Bury the assembly well down in moist earth. One fault with the usual cold-water pipe ground is that there may be an insulating gasket in a pipe connection between your ground wire and earth. Almost any metallic mass buried in moist ground will make a good "ground". An old clothes boiler, automobile radiator, hot water tank—all are good.

All joints in aerial and ground leads must be carefully made and soldered to insure both a strong mechanical and electrical contact. The metal surfaces to be joined should be scraped or filed to a clean, uniform brightness. Fasten firmly together. For best results and permanency add all three finishing touches—solder, tape and paint.

An outdoor aerial should be at right angles to a nearby power line, railway or the like. Aerial wire is better if stranded and enamelled. If a shielded lead-in is employed, ground the shielding.

Suppose you fear or suspect that your aerial is too long for the station tuned in, or the receiver in use, but do not wish to do a job of roof-climbing after midnight. Here is a quick way to decrease the aerial's effective length: put a 100 mmfd. fixed condenser in series with your lead-in wire.

Inspection should be made from time to time of the outdoor portions of your aerial system. Insulation is all-important. Remember that even the wet wood of a roof or house wall forms a partial conductor, eager to steal those vital micro-volts from the incoming signal.

Give all tube-prongs a light sandpaper cleaning several times per year. Keep variable condenser plates free of dust—applying the same care to exposed resistor surfaces and similar gear.

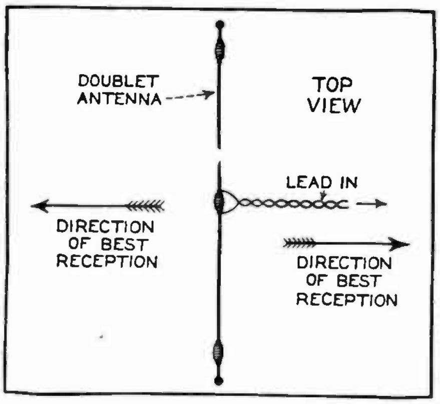


Figure 7

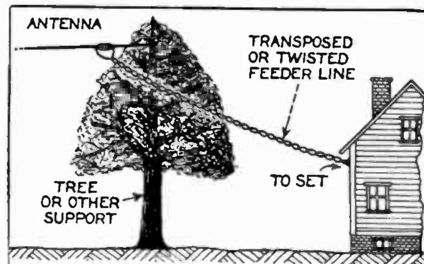
Such minor attentions may appear insignificant, taken separately. Adopted collectively, they may reward you with the long-awaited logging of Shanghai or Africa.

Noise-Reducing Antennas

In spite of the huge amount of literature that has been published on this subject, people still entertain the queerest notions about it. Let's get the fundamentals straightened out first. To start, it is not the antenna that reduces local noise, but the lead-in. If the antenna itself cannot be placed outside of the noise zone, it will continue to feed noise as well as radio signals to the receiver, regardless of the fanciness of the lead-in or whether it consists of twisted wire or a transposed or parallel line. This goes for end-fed half-wave wires, for center-connected dipoles and for double-doublets, regardless of who makes them or what magical properties are attached to them by advertising copy writers who themselves have never climbed a water tank or hung precariously over the edge of a roof with arms and legs entangled with wire.

Every location presents an individual problem as far as the placement of the antenna is concerned. The patient listener who is willing to spend a little time experimenting with the aerial's position is likely to be rewarded with real results. The lead-in, if properly constructed, picks up practically nothing of its own accord, and serves only to transmit to the receiver what the antenna plucks out of the atmosphere.

An important point to remember is that the distance between the aerial and the local noise area is what counts, and that this distance may be horizontal just as well as vertical. Many a listener has been pleasantly surprised to find that a rather low antenna strung fifty, seventy-five or even two hundred feet in back of the house, such as shown in Figure 7, is extremely quiet, whereas a similar antenna strung on the highest practicable poles above the house is noisy.



AN ANTENNA ERECTED A DISTANCE BEHIND THE HOUSE MAY BE MUCH QUIETER THAN ONE ON IT.

Figure 8

Incidentally, much better signals are often obtained with both feeder wires connected to the aerial binding post than with the recommended coupling device. This is due to the fact that the lead-in may be quite long in comparison with the horizontal "doublet" on the roof. When the two feeder wires are shorted together, they act as an ordinary lead-in and become a part of the aerial proper, picking up considerably more energy than the small doublet. This means louder signals, but also more noise if the lead-in happens to pass through a noise zone.

A doublet antenna receives best in the directions at right angles to its length. (See Figure 8.) This effect is most marked when the antenna is out in the open, but is subject to considerable variation if large buildings or other structures are nearby.

International Call Letters

CALL letters of code stations as well as broadcasters heard are of special interest to the short-wave fan because from these it is possible to tell the nationality of the transmitter. Thus any call beginning with K, N or W indicates a station in the United States, its territories or its ships. The larger countries of the world have similar assignments: G for Great Britain; F for France, D for Germany, etc. Smaller countries with fewer transmitters have more limited assignments. Morocco, for instance, is assigned all calls which employ CN as the first two letters. The list of these "International Call Letter Assignments" is given below.

In code transmission the call letters are always preceded by — . . . (de). The letters of the station called are usually repeated 3 times, followed by the letters of the caller, also repeated 3 times, thus: XAB, XAB, XAB de KNL, KNL, KNL, would indicate a U. S. Station calling a Mexican Station.

Study of the Morse Code on Page 10 of this book will enable short-wave listeners to gain sufficient knowledge of the various letters to readily identify c.w. stations.

Inasmuch as c.w. (code) transmissions carry further than 'phone or broadcast signals, and as many c.w. stations employ high power, it is possible to log many countries in this way, who either do not have broadcast transmitters or whose broadcast transmitters do not reach out.

Call Signal	*Country*
CAA-CEZ	Chile
CFA-CKZ	Canada
CLA-CMZ	Cuba
CNA-CNZ	Morocco
COA-COZ	Cuba
CPA-CPZ	Bolivia
CQA-CRZ	Portuguese Colonies
CSA-CUZ	Portugal
CVA-CXZ	Uruguay
CYA-CZZ	Canada
D	Germany
EAA-EHZ	Spain
EIA-EIZ	Irish Free State
ELA-ELZ	Liberia
EPA-EQZ	Persia
ESA-ESZ	Estonia
ETA-ETZ	Ethiopia
EZA-EZZ	Territory of the Saar
F	France and colonies and protectorates
G	Great Britain
HAA-HAZ	Hungary
HBA-HBZ	Switzerland
HCA-HCZ	Ecuador
HHA-HHZ	Haiti
HIA-HIZ	Dominican Republic
HIA-HKZ	Colombia
HPA-HPZ	Republic of Panama
HRA-HRZ	Honduras
HSA-HSZ	Siam
HVA-HVZ	Vatican City
HZA-HZZ	Saudi Arabia
I	Italy and Colonies
J	Japan
K	United States of America
LAA-LNZ	Norway
LOA-LWZ	Argentina
LXA-LXZ	Luxemburg
LYA-LYZ	Lithuania
LZA-LZZ	Bulgaria
M	Great Britain
N	United States of America
OAA-OCZ	Peru
OEA-OEZ	Austria
OFA-OHZ OIA-OJZ	Finland
OKA-OKZ	Czechoslovakia

Call Signal	*Country*
ONA-OTZ	Belgium and colonies
QUA-OZZ	Denmark
PAA-PIZ	Netherlands
PJA-PJZ	Curacao
PKA-POZ	Dutch East Indies
PPA-PYZ	Brazil
PZA-PZZ	Surinam
Q	(abbreviations)
R	U. S. S. R.
SAA-SMZ	Sweden
SOA-SRZ	Poland
SSA-SSZ STA-SUZ	Egypt
SVA-SZZ	Greece
TAA-TCZ	Turkey
TFA-TFZ	Iceland
TGA-TGZ	Guatemala
TIA-TIZ	Costa Rica
TKA-TZZ	France and colonies and protectorates
U	U. S. S. R.
VAA-VGZ	Canada
VHA-VMZ	Australia
VOA-VOZ	Newfoundland
VPA-VSZ	British colonies and protectorates
VTA-VWZ	British India
VXA-VYZ	Canada
W	United States of America
XAA-XFZ	Mexico
XGA-XUZ	China
XYA-XZZ	British India
YAA-YAZ	Afghanistan
YBA-YHZ	Dutch East Indies
YIA-YIZ	Iraq
YIA-YJZ	New Hebrides
YLA-YLZ	Latvia
YMA-YMZ	Free City of Danzig
YNA-YNZ	Nicaragua
YOA-YRZ	Roumania
YSA-YSZ	Republic of El Salvador
YTA-YUZ	Yugoslavia
YVA-YWZ	Venezuela
ZAA-ZAZ	Albania
ZBA-ZJZ	British colonies and protectorates
ZKA-ZMZ	New Zealand
ZPA-ZPZ	Paraguay
ZSA-ZUZ	Union of South Africa
ZVA-ZZZ	Brazil

Verifying Short-Wave Calls

ONE of the incidental pleasures of long-distance reception, on either short-wave or broadcast bands, is obtaining written verifications from the foreign stations. Many of these "veris" are elaborate, multi-colored documents and are well-worth framing; even the simpler and less pretentious ones make good exhibits when you have company and want to show off your standing as a DX fan of international accomplishments.

Merely hearing a foreign station is only the first step in the process of getting a veri. You must appreciate the fact that writing to a foreign country is not like requesting a catalog from a nearby mail-order house. The first and most important rule is: WRITE PLAINLY! If at all possible, typewrite your letter or have someone else do it for you. At most of the radio stations in Europe, Asia and South

Figure 9—Short-Wave Station Identification Chart

Call	Name or Slogan	Address
CB960	"El Praso"	P.O. Box 1342, Santiago, Chile
CEC		Compania Internacional de Radio S.A. Casilla 16-D, Santiago, Chile
CFN, CFU		Consolidated Mining & Smelting Co. of Canada, Ltd., Slate Creek, B. C., Canada
CGA, CJA, etc.		Canadian Marconi Co., P.O. Box 1690, Montreal, Que., Canada
CGP, CZQ, VXX		North-West Telephone Co., 768 Seymour St., Vancouver, B.C., Can.
CHNX	"The Key Station of the Maritimes"	Maritime Broadcasting Co. Ltd., P.O. Box 998, Halifax, N.S., Canada
CJRO, CJRX		Jas. Richardson and Sons Ltd., Royal Alexandra Hotel 155, Winnipeg, Manitoba, Canada
CMB2		Cuba Transatlantic Radio Corp., Havana, Cuba
CNR	"Radio Maroc"	L'Inspecteur General, Directeur de l'Office des Postes, Rabat, Morocco
COCD	"La Voz del Aire"	P.O. Box 2294, Havana, Cuba
COCH		Calle B. No. 2, Vedado, Havana, Cuba
COCO		P.O. Box 98, Havana, Cuba
COKG (CO9GC)		Apartado 137, Santiago, Cuba
CO9JQ		Calle del General Gomez No. 4, Camaguey, Cuba
CO9WR		P.O. Box 85, Sancti Spiritus, Cuba
CP5, CP6, CP7	"Radio Illimani"	Compania Radio Boliviana, Calle Socabaya 231, La Paz, Bolivia
CQN		General Post Office, Macao, Asia
CR6AA	"Radio Eddystone"	P.O. Box 103, Lobito, Angola, Portuguese W. Africa
CR7AA		Gremia dos Radiofilos da Colonia de Mozambique, Caixa Postal 594, Lourenzo Marques, Mozambique
CSL	"Emissora Nacional"	Lisbon, Portugal
CT1AA	"Radio Colonial"	Av. Duque de Avila 86, Lisbon, Portugal
CT1CT	"Estacao Radio Eddystone"	Rua Carvalho Araujo 97 -3 D, Lisbon, Portugal
CT1GL, CT1GO		Radio Club Portugues, Parede, Portugal
CT2AJ		Ponta Delgada, San Miguel, Azores
DAF, DAN		Hauptfunkstelle Norddeich, Norden-Land, Germany
DDBR, DDCP, DDFF, DDFT		North German Lloyd, Pier 42 North River, New York City
DHAO, DHDL, DHEY, DHJZ, DHRL		Hamburg American Lines, Pier 86 North River, New York City
DOAH, DOAI		North German Lloyd, Pier 4, Foot of 58th Street, Brooklyn, N. Y.
DFA, DFB, all Nauen stations		Reichspostzentralamt, Schoeneberger Strasse 11-15, Berlin-Tempelhof, Germany
DJA, DJB, all Zeesen sta.		Reichsrundfunkgesellschaft, Haus des Rundfunks, Berlin-Charlottenburg 9, Germany
EAQ		Transradio Espanola, Apartado 951, Madrid, Spain
FIU	"Radio Tananarive"	Administration des Postes, des Telegraphes et des Telephones, Tananarive, Madagascar
FNSK		French Lines, Pier 88 North River, New York City
FNSM, FTNQ		French Lines, Pier 57 North River, New York City
FQO, FRO, FTA, Ste. Assise stations		Societe Francaise Radio-electrique 79 Bvd. Haussman, Paris (8), France
FYA	"Radio Coloniale"	Bvd. Haussman 98 bis, Paris (8), France
FZR, FZS		Cie. Generale de T. S. F., P.O. Box 238, Saigon, French Indo-China
GAA, GBA, all Rugby sta		Engineer-in-Chief, GPO (Radio Section), Armour House, St. Marins Le Grand, London EC1, England,
GBZW, all British ships		International Marine Radio Co. Ltd. Connaught House, 63 Aldwych, London WC2, England
HAS, HAT	"Justice for Hungary"	Research Labs. for Electrical Communication of the Hungarian Post, Gyali-ut 22, Budapest, Hungary
HBL, HBO, HBP, etc.	"Radio Nations"	Information Section, League of Nations, Geneva, Switzerland
HB9B		Radio Club Basle; P.O. Box Basle 1 Switzerland
HCETC	"Teatro Bolivar"	Casilla 134, Quito, Ecuador
HCJB	"La Voz de los Andes"	Casilla 691, Quito, Ecuador
HC2CW	"Ondas del Pacifico"	P.O. Box 1166, Guayaquil, Ecuador
HC2JSB	"Ecuador Radio"	Guayaquil, Ecuador
HC2RL		Box 759, Guayaquil, Ecuador
HH2S		Societe Haitienne de Radiodiffusion Port-au-Prince, Haiti
HH3W		P.O. Box A-117, Port-au-Prince, Haiti
HIG	"Portavoz de la Farmacia Legalidad"	Trujillo, D. R.
HIH	"La Voz del Higuamo"	San Pedro de Macoris, D. R.
HIL		Box 623, Trujillo, D. R.
HIT	"La Voz de la R.C.A.-Victor"	Box 1105 Trujillo, D. R.
HIX		Mr. J. R. Saladin, Director station HIX, Trujillo, D. R.
HIZ		Calle Duarte 68, Trujillo, D. R.
HI1A	"La Voz del Yaque"	P.O. Box 423, Santiago de los Caballeros, D. R.
HI1J		P.O. Box 204, San Pedro de Macoris, D. R.
HI1S	"La Voz de la Hispaniola"	Puerto Plata, D. R.
HI3C	"La Voz de Rio Dulce"	La Romana, D. R.
HI3U	"La Voz del Comercio"	Santiago de los Caballeros, D. R.
HI4D	"La Voz de Quisqueya"	Trujillo, D. R.
HI4V	"La Voz de la Marina"	Calle Duarte 48, Trujillo, D. R.
HI9B	"Broadcasting Hotel Mercedes, Broadcasting Columbus"	P.O. Box 95, Santiago de los Caballeros, D. R.
HI5M	"La Voz del Almacen Dominicano"	Santiago de los Caballeros, D. R.
HJA3		Compania Telefonica de Barranquilla, Apartado Nacional 263, Barranquilla, Colombia
HJB		Marconi's Wireless Telegraph Co. Ltd., Apartado 1591, Bogota, Colombia
HJN	"Radio—emisora Nacional"	Bogota, Colombia
HJU	"La Voz del Pacifico"	Ferrocariles Nacionales, Buenaventura, Colombia
HJ1ABB	"La Voz de Barranquilla"	P.O. Box 715, Barranquilla, Colombia
HJ1ABC	"La Voz de Choco"	Intendencia de Choco, Director of Public Education, Quibdo, Choco, Colombia
HJ1ABE	"La Voz de los Laboratorios Fuentes"	P.O. Box 31, Cartagena, Colombia
HJ1ABG	"La Voz del Atlantico"	Apartado 445, Barranquilla, Colombia
HJ1ABH	"La Voz de Cienaga"	Cienaga, Colombia
HJ1ABJ	"La Voz de Santa Marta"	Santa Marta, Colombia
HJ2ABA	"La Voz del Pais"	Tunja, Colombia
HJ2ABC	"La Voz de Cucuta"	Cucuta, Colombia
HJ3ABD	"Colombia Broadcasting"	Alford Radio, Calle 16 No. 5—40, Bogota, Colombia
HJ3ABF	"La Voz de Bogota"	Apartado Postal 317, Bogota, Colombia
HJ3ABH	"La Voz de la Victor"	Apartado 565, Bogota, Colombia
HJ3ABI		Apartado 513, Bogota, Colombia
HJ4ABA	"Ecos de la Montana"	Medellin, Colombia
HJ4ABB	"Radio Monte Carlo"	Manizales, Colombia
HJ4ABC	"La Voz de Pereira"	Pereira, Colombia
HJ4ABC	"Ecos del Combeima"	Box 39, Ibague, Colombia
HJ4ABD	"La Voz de Castilla"	Medellin, Colombia
HJ4ABE	"La Voz de Antioquia"	Medellin, Colombia
HJ5ABC	"La Voz de Colombia"	Calle 12 no. 235, Cali, Colombia
HJ5ABD	"La Voz del Valle"	Cali, Colombia
HJ5ABE		Cia. Radiodifusora Colombiana, Apartado 50, Cali, Colombia
	"Radiodifusora Cartagena"	Apartado 37, Cartagena Colombia
HKE		Observatorio Nacional de San Bartolomew, Bogota, Colombia
HKV		Ministry of War, Bogota, Colombia
HP5B	"Estacion Miramar"	Apartado 910, Panama City, Panama
HP5F	"La Voz de Colon"	Apartado 405, Colon, Panama
HP5J	"La Voz de Panama"	Cia. de Servicio Publico de Radio S. A., Apartado 867, Panama City, Panama
HRN	"La Voz de Honduras"	Tegucigalpa, Honduras
HRP1	"El Eco de Honduras en San Pedro Sula"	San Pedro Sula, Honduras
HRV	"La Voz de Atlantica"	La Ceiba, Honduras
HRW		Tropical Fruit Importers, La Faba, Honduras
HRY		Tropical Fruit Importers, Tela, Honduras
HVJ	"Radio-Vaticano"	Pontificia Academia della Scienze, Roma-Castino Pio IV, Vatican City
IAC		Radio Maritime Coltano, Pisa, Italy
IRM, IRW, etc		Societe Italo Radio, Servici Radioelettrici, Via Calabua 46-48, Rome, Italy
I2RO, 2RO	"Prato Smeraldo"	Ente Italiano Audizione Radiofoniche, 5 Via Montello, Rome, Italy
JIA, JIB, JIC		Kokusai-Denwa Kaisha, Tyurek Station, Tyureki, Formosa
JVC, JVD, all Nazaki sta		Kokusai-Denwa Kaisha Ltd., Osaka Bldg., Kojimachiku, Tokio, Japan
JYK, JYR, Kemikawa Stations		Kemikawa Sending Station, Kemikawa Cho, Chiba-Ken, Japan
JZA, TDE, TDD		Manchukuo Telephone and Telegraph Co., Shinkyo, Manchukuo

Call	Name or Slogan	Address
KAX, FBI, etc. Manila stations		Radio Corp, of the Philippines Plaza Moraga, Manila, P. I.
KEB, KEC, etc. Bolinas Station		RCA Communications, Inc., Pacific Division, 28 Geary St., San Francisco, Calif.
KWN, KWO, etc. Dixon stations		Transpacific Communication Co., Ltd., 140 Monthomery St., San Francisco, Calif.
KZGH, KZGF, etc		Philippine Long Distance Telephone Co., Manila, P. I.
LKJ1		Dept. of Commerce, Division of Radio Telegraphy, Oslo, Norway
LRU, LRX	"Radio El Mundo"	Maipu 555, Buenos Aires, Argentina
LSL, LSM, all Hurlingham stations		Compania Internacional de Radio, Defensa 143, Buenos Aires, Argentina
LSF, LSX, LSY, Monte Grande Stations		Transradio Internacional, San Martin 329, Buenos Aires, Argentina
OAX4D	"Radio DUSA", "The Voice of Peru"	All American Cables, Casilla 2336, Lima, Peru
OAX4G		Robert Grellaud & Cia., Apartado 1242, Lima, Peru
OER2, OER3		Oesterr. Radioverkehrs A. G., Johannesgasse 46, Vienna, Austria
ORG, ORK, ORP	"Belradio"	Direction des Radiocommunications, Brussels, Belgium
OXY		Statsradiofonien, Heibergsgade 7, Copenhagen, Denmark
PCJ		Philips Radio, Emmasingel, Eindhoven, Holland
PHI		PHOHI Studios, Hilversum, Holland
PIIJ		Middelbare Technische School, Oranjelaan 12, Dordrecht, Holland
PLV and other Bandoeng stations		Mr. H. Van der Veen, Engineer-in-Charge, Java Radio Stations, Bandoeng, Java, N. E. I.
PPQ, PSH, all Sepetiba and Maripicu stations		Compania Telegraphica Brasileira. Caixa Postal 500, Rio de Janeiro, Brazil
PRADO	"El Prado"	Apartado de correos 98, Riobamba, Ecuador
PRA8	"A Voz do Norte"	Avenida Cruz Cabuga 394, Pernambuco, Brazil
RV15	"Far East Radio Station"	Radio Committee, Khabarovsk, Siberia
RV59, RNE		Radio Centre, Solianka 12, Moscow, U.S.S.R.
SM5SD		Lumas Kortvagssandare, Stockholm 20, Sweden
SPW		Polskie Radjo S.A., Kredytowa 1, Warsaw, Poland
SUV, SUX		Marconi Radio Telegraph Co., of Egypt, Box 795, Cairo, Egypt
TFK, TFJ, TEL		Icelandic State Broadcasting, Box 457, Reykjavik, Iceland
TGS		Radiotransmisora de la Casa Presidencial, Guatemala City, Guatemala
TGW, TGWA, TG1X	"Radiodifusora Nacional"	Guatemala City, Guatemala
TG1A	"Ministerio de Fomente"	Guatemala City, Guatemala
TG2X	"La Vox de Policia Nacional"	Guatemala, City, Guatemala
TIEP	"La Voz del Tropico"	Apartado 257, San Jose, Costa Rica
TIGPH	"Alma Tica"	P. O. Box 775, San Jose, Costa Rica
TIPG	"La Voz de la Victor"	Apartado 225, San Jose, Costa Rica
TIRCC	"Radioemisora Catolica Costarricense"	Apartado 40, San Jose, Costa Rica
TI5HH	"La Voz de San Ramon"	San Ramon, Costa Rica
VE9AS		University of New Brunswick, Fredericton, N. B., Canada
VE9BJ		C. A. Munro, Ltd., 16 Simonds St., St. Johns, N. B.
VE9BK		Radio Sales and Service, Ltd., 780 Beatty St., Vancouver, B. C., Canada
VE9CA	"The Voice of the Prairies"	Western Broadcasting Co., Toronto General Trusts Bldg., Calgary, Alberta, Canada
VE9CS		Radio Service Engineers, 734 Davie St., Vancouver, B. C., Canada
VE9DN, VE9DR		Canadian Marconi Co., P. O. Box 1690, Montreal, Que., Canada
VE9EH		The Island Radio Broadcasting Co., Ltd., Charlottetown, P. E. I., Canada
VK2ME		Amalgamated Wireless (Australasia) Ltd., 47 York St., Sydney, Australia
VK3LR		Postmaster General's Dept., Treasury Gardens, Melbourne C2, Australia
VK3ME		Amalgamated Wireless (Australasia) Ltd., Box 1272 L, Elizabeth St. P.O., Melbourne, Australia
VK3XX		501 Royal Parade, Rockville N-2, Melbourne, Australia
VK3ZX		33 Saturn St., Caulfield, Australia
VP1A, VPD	"Radio Suva"	Amalgamated Wireless (Australasia) Ltd., Suva, Fiji Islands
VP3BG		1 Wellington St., Georgetown, Brit. Guiana
VP3MR	"The Voice of Guiana"	Georgetown, Brit. Guiana
VQ7LO		Cable and Wireless, Ltd., P. O. Box 777, Nairobi, Kenya, Africa
VUB, VUY		Indian State Broadcasting Service, Irwin House, Sprott Road, Ballard Estate, Bombay, India
VXX		North West Telephone Co., 768 Seymour St., Vancouver, B. C., Canada
WMI, WOO, etc. Stations at Deal, Lawrenceville and Ocean Gate, N. J.		American Telephone and Telegraph Co., Long Lines Dept., 32 Sixth Ave., New York, N. Y.
WAJ, WEF, stations at Rocky Point		R.C.A. Central Frequency Bureau, 66 Broad St., New York, N. Y.
WVD		Alaskan Telephone Co., 517 Federal Office Bldg., Seattle, Wash.
W1XAL		World Wide Broadcasting Co., 70 Brookline Ave., Boston, Mass.
W1XK		Westinghouse Radio Stations in New England, Hotel Bradford, Boston, Mass.
W2XAD, W2XAF	"The Voice of Electricity"	General Electric Co., 1 River Road, Schenectady, N. Y.
W2XE		Columbia Broadcasting System, 485 Madison Ave., New York, N. Y.
W3XAL, W3XL		National Broadcasting Co., 30 Rockefeller Plaza, New York, N. Y.
W3XAU		WCAU Bldg., 1622 Chestnut St., Philadelphia, Pa.
W4XB		c/o WIOD, News Tower, Miami, Fla.
W8XAL	"The Nation's Station"	Crosley Radio Corp., Cincinnati, Ohio
W9XAA	"Voice of Farmer and Labor"	Chicago Federation of Labor, 666 Lake Shore Drive, Chicago, Ill.
W9XBS, W9XF		National Broadcasting Co., Merchandise Mart, Chicago, Ill.
XBJQ		P.O. Box 2825, Mexico, D.F., Mexico
XEBT	"El Buen Tono"	Apartado 79-44, Mexico D.F., Mexico
XECW	"Del Caballero Xantocam"	Calle del Bajio 120, Xantocam, Mex.
XEDQ		Cia. Radiofonografia, Apartado 197, Guadalajara, Jalisco, Mexico
XEFT	"La Voz de Veracruz"	Ave. Independencia 28, Veracruz, Vera., Mexico
XEUW	"El Eco de Sotavente desde Veracruz"	Ave. Independencia 98, Veracruz, Vera., Mexico
XEVI	"The Voice of the World"	Apartado 2874, Mexico, D.F., Mexico
XEXA		Secretary of Public Education, Mexico, D.F., Mexico
XQAJ		80 Love Lane, Shanghai, China
X1CB		Liga Mexicana de Radio experimentadores, Mexico, D.F., Mexico
YBJ		Chief Engineer, 6th District, Post Telegraph and Telephone Service, Medan, Sumatra, N. E. I.
YNE		Box 830, New Orleans, La.
YNLF	"La Vos de Nicaragua"	Calle 15 de Septembre 206, Managua, Nicaragua
YN1GG	"La Voz de los Lagos"	Managua, Nicaragua
YVQ	"Estacion Nacional de Radio"	Maracay, Venezuela
YV2RC	"Radio Caracas"	Apartado 2009, Caracas, Venezuela
YV3RC	"Radiodifusora Venezuela"	Pasaje Ramella, Caracas, Venezuela
YV4RB		P. O. Box 983, Caracas, Venezuela
YV5RMO	"Ecos del Caribe"	Apartado de Correos 214, Maracaibo, Venezuela
YV6RV	"La Vox de Carabobo"	Valencia, Venezuela
YV7RMO	"Radiodifusora Maracaibo"	P. O. Box 100, Maracaibo, Venezuela
YV8RB	"La Voz de Lara"	Barquisimeto, Venezuela
YV12RM	"Emisora 12 de Julio"	Maracay, Venezuela
ZCK		P. O. Box 200, Hong Kong, China
ZGE		Malayan Amateur Radio Society, Kuala Lumpur, F. M. S.
ZHI		Radio Service of Malaya, 2 Orchard Road, Singapore, F. M. S.
ZHJ		Penang Wireless Society, 40 Park Road, Penang, Straits Settlements
ZP10	"Rueda del Oeste"	Asuncion, Paraguay

Figure 10—Short-Wave Station Identification Chart

America there is someone with at least a book knowledge of English.

Use plain white paper, and write on only one side of the sheet. Spell out the name of your town and state. To a person unfamiliar with domestic geography, N.Y., N.J., N.H. and N.M: all look somewhat alike.

If you can find the full street and city address of the foreign station in any of the published call lists, put it on your outgoing envelope. If you can't, the mere call letters or name of the station, the city and country are enough. Outside of the United States, practically all radio stations are government controlled, and the postal authorities know where to deliver anything mailed "radio." The Identification Charts herewith, Figures 9 and 10, will give you the addresses of most of the leading short-wave stations. Of course, put your own name and full address, including "U.S.A." after the state, on the outside of the envelope.

Here is one way of reporting a QSL (verification card or letter) which has usually brought courteous and generally prompt answer. First, be sure of what you have heard. Don't rush off a glowing letter to German or French stations after catching an odd word or two in their respective languages, and making a hopeful stab at guessing the wavelength! Remember there are certain broadcasts from transmitters on this side of the pond offered in various foreign tongues which you might mistake for foreign transmissions.

List these facts in your report asking verification:

- Call letters, place name, or identifying sound used.
- Approximate frequency or wavelength.
- The date.
- The time (reduced to that of the transmitter's locality).
- Names of at least two musical selections heard (or the equivalent of an address, newscast, etc.).
- Your airline DX in miles from the station. (This can be ascertained by reference to the World Distance Chart, Figure 11.)
- Local weather conditions.
- Quality of reception: (1) Clarity, (2) Volume, (3) Fading.
- Type of receiver and aerial (if any).
- DX Club membership, or connection with radio work.

MOSCOW, U.S.S.R.	43	83	76	90	11	78	71	46	50	41	57	59	55	72	16	15	10	70	10	34	21	46	59	39	66	22	13	103	10	51	25	22	15	63	62	52	46	60	38
KHABAROVSK, U.S.S.R.	29	113	58	57	49	99	108	57	42	14	83	69	10	85	51	52	47	40	48	31	53	9	41	67	66	63	50	66	44	25	60	57	52	91	82	58	60	51	
LOS ANGELES, U.S.A.	23	61	93	74	62	48	63	22	11	65	35	23	56	35	55	57	58	25	62	81	63	54	89	97	16	59	56	66	54	73	56	58	59	99	36	16	25		
NEW YORK, U.S.A.	33	53	118	99	42	40	48	4	25	73	25	13	38	29	34	36	40	50	43	79	42	67	101	74	22	36	36	89	37	85	33	36	39	77	22	9			
ST. LOUIS, U.S.A.	29	55	108	90	49	41	52	7	17	72	26	13	45	28	42	44	47	44	51	82	51	63	99	83	14	45	44	80	43	82	42	44	47	86	25				
CARACAS, VENEZUELA	54	31	108	95	54	19	28	25	42	95	6	14	52	11	46	47	52	60	55	96	52	88	121	71	23	41	49	81	52	106	40	43	49	63					
CAPETOWN, SOUTH AFRICA	104	42	54	68	56	53	38	81	101	79	65	77	61	66	59	57	59	115	56	59	52	91	59	25	85	49	60	70	65	74	53	53	51						
GENEVA, SWITZERLAND	49	68	87	105	5	63	56	39	51	57	55	50	7	60	4	3	5	77	6	47	4	61	72	38	60	11	4	118	9	66	9	6							
MADRID, SPAIN	51	62	91	110	11	57	50	37	52	62	49	46	13	54	8	6	11	78	12	53	8	67	77	39	56	5	9	124	15	73	3								
LISBON, PORTUGAL	51	59	94	113	14	54	47	35	51	66	46	43	15	51	9	9	14	78	15	56	12	70	81	40	54	4	12	120	17	75									
MANILA, P.I.	53	110	32	39	61	117	111	81	65	12	107	94	60	107	67	67	62	53	61	22	61	18	17	58	88	76	64	52	60										
OSLO, NORWAY	40	76	87	99	8	68	64	36	45	50	57	49	3	62	7	8	5	78	9	45	12	53	69	44	57	20	5	110											
WELLINGTON, NEW ZEALAND	73	61	32	14	113	67	72	87	72	62	75	78	112	69	118	118	113	47	112	71	115	58	46	84	68	118	116												
HUIZEN, NETHERLANDS	44	71	88	103	5	65	59	37	48	54	55	49	3	60	3	3	4	72	7	47	8	58	72	41	58	14													
RABAT, MOROCCO	55	58	92	112	15	52	46	38	54	67	47	45	17	52	12	11	16	81	16	56	12	72	79	38	56														
MEXICO CITY	38	46	100	80	63	33	58	21	25	70	20	11	59	19	56	57	61	38	64	96	62	70	103	92															
NAIROBI, KENYA	82	64	55	75	37	71	55	75	89	58	76	81	42	79	42	40	39	50	36	38	38	70	49																
BANDOENG, JAVA	36	93	18	32	67	107	95	93	82	36	121	110	69	118	74	73	68	66	66	25	69	36																	
TOKIO, JAPAN	35	114	50	48	57	103	117	64	47	12	88	74	55	89	60	60	56	38	56	32	61																		
ROME, ITALY	52	69	83	101	5	65	57	44	55	56	58	54	9	63	9	7	7	80	5	45																			
CALCUTTA, INDIA	58	102	42	57	43	108	92	77	70	20	102	92	43	106	49	49	44	70	41																				
BUDAPEST, HUNGARY	49	73	81	99	2	69	61	44	52	51	61	55	6	66	9	7	4	76																					
HONOLULU, HAWAII	28	75	68	51	76	66	82	46	27	50	57	48	71	55	72	74	72																						
BERLIN, GERMANY	45	73	85	101	3	68	61	40	49	51	58	52	2	63	6	5																							
PARIS, FRANCE	47	68	89	105	6	62	56	37	49	56	54	48	6	58	2																								
LONDON, ENGLAND	45	69	91	106	9	61	58	35	47	55	53	46	6	57																									
QUITO, ECUADOR	56	22	99	83	63	14	29	31	43	99	5	16	63																										
COPENHAGEN, DENMARK	43	74	85	99	5	68	62	39	47	50	58	51																											
HAVANA, CUBA	40	43	110	90	54	29	42	15	28	83	14																												
BOGOTA, COLOMBIA	55	29	98	88	59	15	28	28	42	98																													
NANKING, CHINA	43	122	44	50	51	112	112	70	56																														
VANCOUVER, CANADA	13	70	92	78	52	70	69	21																															
TORONTO, CANADA	29	56	113	96	43	52	52																																
RIO DE JANEIRO, BRAZIL	81	12	83	72	61	16																																	
LA PAZ, BOLIVIA	69	13	90	80	68																																		
VIENNA, AUSTRIA	48	73	83	99																																			
SYDNEY, AUSTRALIA	73	72	20																																				
PERTH, AUSTRALIA	83	76																																					
BUENOS AIRES, ARGENTINA	83																																						
ANCHORAGE, ALASKA																																							

WINNIPEG, MAN.																													
WASHINGTON, D.C.																													126
VANCOUVER, B.C.																												238	118
TULSA, OKLA.																											165	106	96
ST. LOUIS, MO.																										36	179	174	86
SAN FRANCISCO, CAL.																									174	146	81	244	152
SALT LAKE CITY, UTAH																								60	116	92	81	185	96
RALEIGH, N.C.																							183	240	64	97	243	23	136
PORTLAND, ORE.																						239	64	54	173	154	26	236	123
PITTSBURGH, PA.																					218	33	167	227	56	92	220	19	107
PIEDRAS NEGRAS, MEX.																				144	170	138	107	142	91	59	188	154	150
PHOENIX, ARIZ.																			86	183	102	190	51	66	126	93	124	198	138
NEW YORK, N.Y.																		215	173	32	246	44	197	258	188	223	246	21	126
NEW ORLEANS, LA.																	119	132	65	93	207	77	144	193	60	55	220	98	144
MONTREAL, QUE.																141	38	220	189	48	236	73	195	255	98	134	232	39	115
MINNEAPOLIS, MINN.															96	106	102	130	121	74	144	100	99	159	46	63	145	93	39
MIAMI, FLA.														152	143	68	112	200	128	103	272	70	210	261	108	119	283	94	192
MEMPHIS, TENN.													88	70	113	36	197	126	76	67	186	64	125	180	25	34	195	77	110
LOS ANGELES, CAL.												161	237	153	247	169	247	37	113	214	83	224	57	34	159	127	108	230	154
HELENA, MONT.											93	140	227	91	184	166	194	92	140	166	52	188	41	81	124	110	55	185	73
FORT WORTH, TEX.										124	122	45	115	88	155	47	141	86	35	111	162	109	99	146	57	26	177	122	121
DETROIT, MICH.									103	145	198	46	118	54	53	96	49	169	137	21	197	52	149	209	46	81	198	40	86
DES MOINES, IA.								54	66	98	144	49	135	24	104	84	103	115	99	72	148	91	95	155	79	48	153	90	61
DENVER, COL.							61	116	66	124	83	88	174	70	163	109	163	59	82	132	99	147	37	95	79	55	112	149	81
CLEVELAND, O.						123	51	54	106	159	206	64	111	64	49	94	40	176	140	11	208	43	157	218	50	86	208	30	86
CINCINNATI, O.					23	109	51	24	84	151	190	42	87	60	71	72	58	158	118	26	199	40	145	204	32	66	203	40	98
CHICAGO, ILL.				25	32	92	31	24	83	128	175	49	120	35	75	184	72	140	117	41	177	64	126	185	21	60	179	60	73
BOSTON, MASS.			84	74	54	177	115	61	158	205	260	164	128	153	144	137	18	229	191	49	255	61	210	270	104	140	226	55	130
ATLANTA, GA.		94	59	38	56	121	75	60	75	173	195	33	61	92	100	43	76	160	103	53	218	35	159	214	47	67	226	55	131
ALBUQUERQUE, N.M.	127	196	112	124	142	33	83	136	56	86	67	161	170	98	187	103	181	33	57	149	112	157	50	90	93	59	130	165	114

Figure 11

U. S. & World-Wide Mileage Chart

TO determine mileage between any two of the listed cities of the world, first find these two cities on the top triangle of the world chart (Figure 11). Follow the horizontal column across the chart from the upper city, and the vertical column up from the lower city. The box at which these two columns intersect shows the required mileage in hundreds. The same method applies to the U. S. chart (lower triangle) except that mileages are shown in tens.

All mileages show the shortest (great circle) paths between points.

Just for an example, suppose you live in New York City and hear a station in Tokyo. By glancing at the mileage chart, following the horizontal column next to New York across until it bisects the vertical column up from Tokyo, you find the distance to be 6,700 miles.

Or, if you live in San Francisco and want to find out how far away a station in Atlanta, Ga. is, refer to the U. S. Mileage Chart (lower right hand corner of Figure 11). Follow the horizontal column next to Atlanta, Ga. until it bisects the vertical column down from San Francisco. You will find the distance to be 2140 miles.

Amateur Radio

LISTEN in on 20, 80 and 160 meters for the Amateur Stations and see what a "kick" you can get out of their conversations. You may think at first that these "Ham" voices are talking English; then a few moments later begin to question your rash assumption—because of much that you will hear, it may seem as if the boys are making sport of the alphabet, with a pronounced liking for the letter Q.

The translation of a few of their short abbreviation forms follows:

yl—*young lady*
R9—*very loud*
sk—*end of transmission*
om—*old man*
xmitter—*transmitter*
qsl—*verification*
sked—*schedule*
qrm—*interference*
qrt—*stop sending*
Aussie—*Australian ham*
cans—*headphones*
lid—*poor operator*
ow—*old woman*
Zedder—*N. Zealand ham*
cq—*general call*
hi—*laughter*
cw—*code (continuous wave)*
xyl—*wife*
qra—*address*
shack—*radio room*
qrl—*busy*
qrn—*static*
qrx—*stand by*
bcl—*broadcast listener*
cul—*see you later*
op—*operator*
qso—*2-way communication*
73—*best regards*
88—*love and kisses*

Instead of saying "sk" (end of transmission), friend ham may throw it into a vocal imitation of the code characters for those two letters (...—.—) thus: dit dit dit dah dit dah. Or if he is in a more exuberant frame of mind and oral output, his rendering of sk may be something like "diddely bump de bump." In like manner "hi" (laughter) becomes dit-dit-dit-dit, dit-dit.

How To Learn The Morse Code

MANY short-wave broadcast listeners are intrigued by the code transmissions of commercial stations and amateur stations encountered in tuning the short waves. To read code at the speeds normally transmitted is, of course, out of the question unless one has had long practice at it. However, slow-speed sending is often heard when stations are testing or when one is

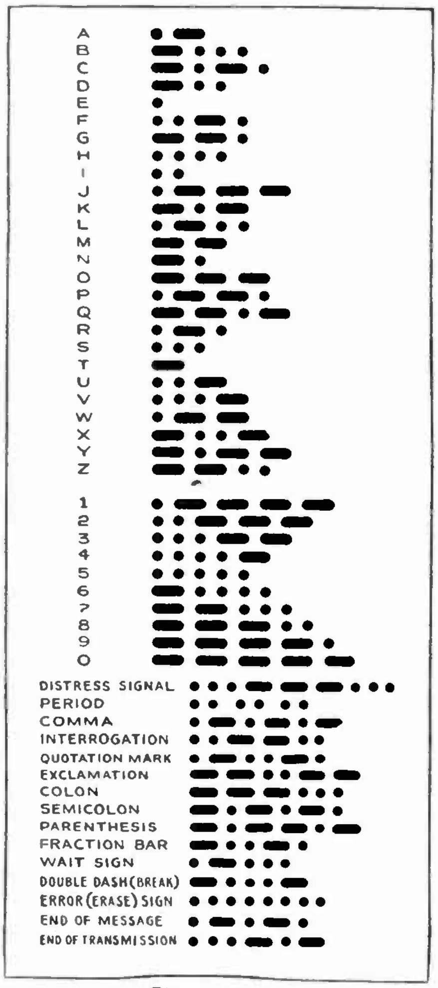


Figure 12

calling another. In either case, the test signal or the call letters of the station called, together with the call letters of the transmitting station, are repeated over and over again, in many cases so slowly that the rankest novice can catch these calls and interpret them with the aid of the code printed herewith. (Figure 12).

It is fun to know the code, and those of us who possess short-wave or dual-wave receivers are missing many an evening of good solid entertainment if we do not know the International Morse code. There are new and recurrent thrills; radio signals from merchant and naval vessels in all parts of the world, weather bulletins, news flashes, time signals and oceanic services competing with the world's cable system; there are the thousands and thousands of amateur radio operators to whom most of the credit must be given for developing and opening up the shorter waves. All of these stations communicate by Morse code. Messages, some bearing on world affairs, tragedy and comedy, love and simple fellowship are buzzing out from radio stations all over the world; they are there for those of us who know the code. Though we are bound to secrecy in what we intercept (it is a serious offense and there are severe penalties for *divulging* the contents of radio messages) we are at liberty to "eavesdrop" all we want.

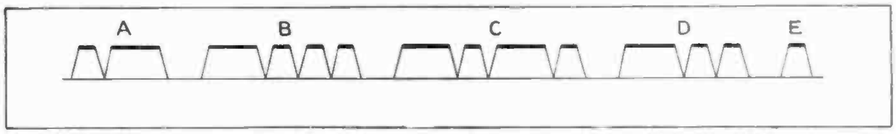


Figure 13

"But," you say, "it takes a lot of study and it's hard to learn the code. I could never do it." And that is where you are wrong. During the war, Great Britain turned out high-speed operators in less than a month's training. There is a right and wrong way, a pleasant and an unpleasant way, to learn the code.

Most of us make the mistake of thinking of the code in terms of "dots and dashes"; unknowingly we separate the dots from the dashes, we break into its component parts a character that should be thought of as a whole. Forget the dots and dashes, and in their place think of dits and dahs; think of the sound of each character as one complete unit—*a*, for instance, becomes *dit dah.*

Each letter of the alphabet has a separate and distinct sound of its own. Very good code can be produced by whistling, or on any wind instrument of the orchestra. As a novelty, it is often the practice at radio operators' conventions to pass out wooden whistles with which it is possible to blow good code, readable blocks away. So, with this simple music lesson we start out to learn the code.

The International Morse code shown herewith is the accepted radio code. Now, we'll make a copy of the code, but instead of putting down dot-dash for *a* we'll draw two little tents, one short and one long (Figure 13); and every time we see this group in our future study of the code, we'll think of it as *dit dah*, repeating it in our minds and verbally droning the signal out on our lips. A sharp staccato dit is followed by a longer dah (about 3 times as long as the dit). These sounds can be made distinctly with the tongue and lips, and hummed over a few times it doesn't take long for us to know without a doubt that the familiar little tune of dit dah can be nothing but the letter *a*.

Next comes *b*, which we put on paper as one long tent and three short ones, *dahhh-dit-dit-dit*. The writing of the characters as short and long tents help to prevent us from learning the groups as dots and dashes; instead, it gives us the impression of sound.

Each character follows with equal ease and simplicity. Practice each letter from A to Z just as you like; let the numerals go until you have mastered the alphabet. Hand the printed dit dahs over to some fellow sufferer and have him skip around and call out characters for you to respond to in song. It's pleasant, like doing a cross-word puzzle, and you'll find yourself repeating the signals over and over, whether you be president of Amalgamated Mushrooms or Johnny Clerk; and you both can expect and get just as much ultimate pleasure out of knowing the code as the rest of us.

You don't have to have telegraph keys, buzzers, oscillators and batteries to learn the code. Start today and make your voice the buzzer and your lips and tongue the key. In this manner the characters, dits and dahs, are more quickly and lastingly impressed on the brain and the sound is conveyed with directness and realism to the ears. Later on if you like, you can equip yourself with a telegraph key and buzzer or oscillator. If you use the dot-and-dash method you'll find yourself counting the number of dots and dashes to make the characters, and if you have to hesitate, see it in your mind's eye, take your mental pencil and point out each dot and dash, you'll find yourself greatly hampered and soon you'll give up in disgust at your slow progress.

Perhaps by now you are settling down to copy all the code you hear. All right, good, but tune until you can find some slow signal. They're there, especially between 8000 and 9000 kilocycles on your receiver dial. Just listen without trying to put anything on paper. After a moment you'll single out individual characters. Try listening for some predetermined letter and confine your efforts to recognition of that particular sound. You'll find that in a remarkably short time you can recognize that selected character without any trouble at all. Just watch the individual characters; never mind the words and sentences, they'll come later.

It's not work, it's fun; get a group together—father, son, and all the youngsters and oldsters in the neighborhood, a boy scout troop—it doesn't matter, but do get in line for the fun you can get out of such little and pleasant effort.

Wavelength - Frequency Conversion

Formerly all short-wave enthusiasts thought in terms of wavelengths and receivers, if calibrated at all, were calibrated in wavelengths. Now, however, the trend is definitely toward the use of frequencies rather than wavelengths.

Because of this changing situation it is often found necessary to convert frequency listings to terms of wavelengths and vice versa. A common practice is to divide the known unit into 300,000 to determine the unknown unit. Thus if one knows that a certain broadcast station transmits on 25 meters, and wants to find the frequency, he divides 25 into 300,000 and the answer—12,000—is correct to an accuracy of a fraction of 1 percent. Or if he knows the frequency of this station and wants to find the wavelength, he simply reverses the process, dividing 12,000 into 300,000.

It is to be noted that 300,000 represents the speed of radio waves in km. per second. This figure is not quite correct, the latest experiments giving 299,760, but 300,000 is used for conversion by international agreement.

CHARACTERISTICS OF RECEIVING TUBES

THE time has long since passed when a serviceman, an amateur or an engineer could quote from memory the "basing" and all the "characteristics" of the available vacuum tubes. From a modest beginning, the number of types has increased to a total so great that not even the type designations can be memorized with assurance. The purpose of the consolidated tube charts (Figures 15, 16, 17, 18 and 19) is to group together the essential data on each type so that information can be had in a minimum of time.

Glass Octal Base Tubes

In studying the vacuum tubes available today, two groups can be formed. The first includes tubes of the conventional glass type manufactured prior to the introduction of the metal tube in April, 1935. The second group includes all-metal tubes and several classes of glass tubes designed to be interchangeable with metal tubes.

Glass tubes designed to be interchangeable with the all-metal types can be subdivided into two general classifications. First of these is the "G" classification (or group in which the tubes are glass but are equipped with the octal base first introduced on metal tubes. These "G" tubes, except for the base, appear to be exactly like certain of the conventional glass tubes and indeed they are. For example, type 6K7G is a 78 with an octal base and type 6A8G is type 6A7 with an octal base. When fitted with a "glove" shield, these tubes are practically interchangeable with the all-metal 6K7 and 6A8 types.

Metal-Glass Tubes

The second group includes the "metal-glass" tubes. These M.G. tubes are the conventional glass types which correspond in characteristics to the all-metal tubes but they are equipped with the octal-type base and are covered with a close-fitting sleeve cover of shield metal. In general they are designated with the same number used for the all-metal tubes followed by the suffix MG. In receivers of modern design, the MG tubes like those in the G classification can be substituted for all-metal tubes with small realignment adjustments. The smallest of the metal-glass tubes are the "Coronet" type. These, except for height, correspond to the regular MG tubes, although they are designated with the same type numbers which apply to the all-metal tubes.

Present Numbering System

The application of type designations to vacuum tubes was a haphazard process until the Radio Manufacturers Association set up a committee of engineers from the radio tube industry to handle the numbering of tubes and associated problems connected with the new types. From this committee came the present numbering system of: a numeral to indicate approximate filament or heater operating voltage; a letter to show the function of the tube, and a numeral to indicate the number of elements. Thus the 25Z5 tells by its first numeral group that the filament or heater operates at approximately 25 volts, by the letter Z that the tube is a rectifier and by the final numeral that the tube has five connected elements: two plates, two cathodes and one common heater. Reference to the charts will show that more than seventy-five tubes appear under the old numbering system of an arbitrary numeral. No doubt there are many more tubes in this class which for some reason (usually poor adaptability to circuits) were dropped by the manufacturer who introduced them.

Special Tubes

Among the special tubes listed in the charts are several of the "spray shield" type introduced by Majestic. The replacement tubes now furnished for them are no longer sprayed with metal in most cases, but are fitted with a "glove shield" soldered at the joints.

Socket Connections

The basing views shown with the tube charts are for the bottom of the tube base or the bottom of the socket. This arrangement provides the clearest picture of connections, since construction (or service) involves the bottom of the base in all cases. The pin numbering, looking at the bottom of the base or socket, runs clockwise. In the conventional base glass tubes, with the filament or heater pins toward the observer, the left-hand pin is number one. In the octal base tubes, looking at the bottom of the base, the first pin in a clockwise direction from the key is the No. 1 pin. While this explanation is unnecessary in reference to the base diagrams shown, it is useful in checking the basing of new types where the pin numbers and their corresponding internal connections may be published without a diagram.

Plate Supply Voltage

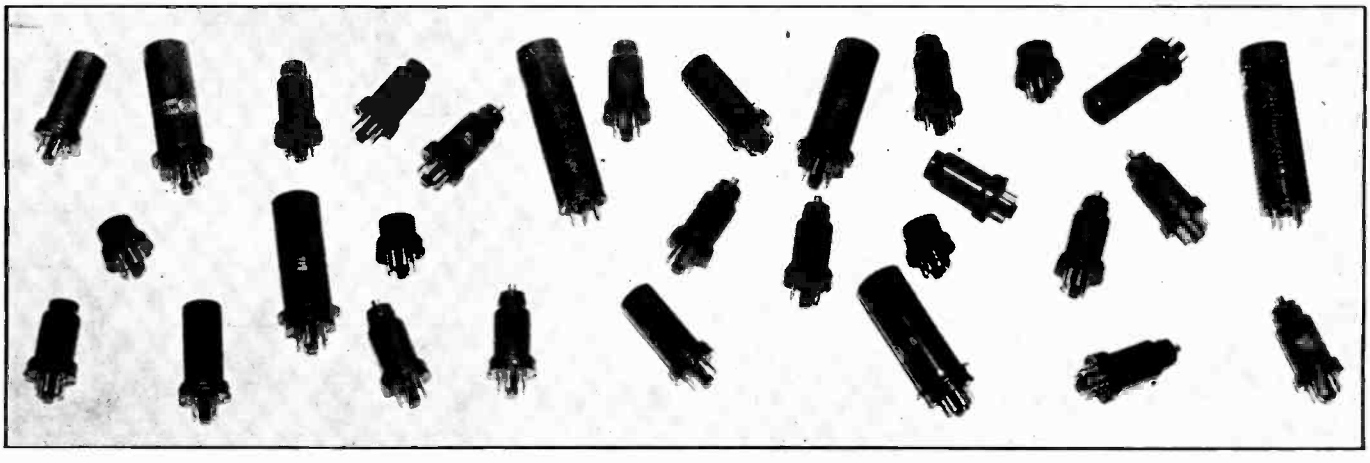
The data given in the tube charts covers essential points of interest for each type. It should be noted that the plate *supply* voltage is indicated. In resistance-coupled amplifiers, the *actual* plate voltage will be considerably lower due to the drop in the plate resistor. In adjusting bias to the proper value, this lower plate voltage should be taken into account.

Internal Capacitance

The values of internal capacitance are useful in the design of radio-frequency circuits and in figuring shunt effect on high audio frequencies in high-gain, resistance-coupled amplifiers.

Filament voltages should be held within a few percent for the older thoriated, tungsten-filament tubes such as the 01A, V99 and X99. Oxide-coated filaments and the heaters for oxide-coated cathode tubes should be maintained within 10 percent of the rated values.

Figure 14—Some of the New Metal Tubes



COMPLETE TUBE CHART

1.1 VOLT D.C. DETECTOR AND AMPLIFIER TUBES

Type No.	Description: Type	Description: Cathode	Basing (See Socket Connection Chart)	Fil. Current Amps.	Capacitances Micro-Micro-Farads: Grid-Plate	Capacitances: Input	Capacitances: Output	Operating Conditions and Characteristics: When Used As	Plate Supply Volts	Scr. Grid Volts	Grid Bias Volts (Neg.)	Plate Current M.A.	Ampl. Factor	Plate Resis. Ohms	Mut. Cond. µmhos	Max. Undist. Output Watts	Recomm. Load Resis. Ohms	Cut-Off Bias Volts
WD-11 WX-12	TRIODE	FIL.	4F Spec. 4 Pin / 4D Med. 4 Pin	0.25	3.3	2.5	2.5	Grid Leak Det.	45		+A							
								Amplifier	90		4.5	2.5	6.6	15500	425	0.007	15000	
									135		10.5	3.0	6.6	15000	440	0.040	15000	
864	TRIODE	FIL.	4E SM. 4 PIN	.25				Non Microphonic Amplifier	90		4.5	2.9	8.2	13500	610		15000	
									135		9.0	3.5	8.2	12700	645		15000	

2.0 VOLT D.C. DETECTOR AND AMPLIFIER TUBES

Type No.	Description: Type	Description: Cathode	Basing (See Socket Connection Chart)	Fil. Current Amps.	Capacitances Micro-Micro-Farads: Grid-Plate	Capacitances: Input	Capacitances: Output	Operating Conditions and Characteristics: When Used As	Plate Supply Volts	Scr. Grid Volts	Grid Bias Volts (Neg.)	Plate Current M.A.	Ampl. Factor	Plate Resis. Ohms	Mut. Cond. µmhos	Max. Undist. Output Watts	Recomm. Load Resis. Ohms	Cut-Off Bias Volts
15	PENTODE	HEATER	5F SM 5 PIN	.22				Det-Osc	135	67.5	1.5	1.85	500	800000	750			
								Bias Detect.	180		18							
30	TRIODE	FIL	4D SM 4 PIN	0.060	6.0	3.7	2.1	Amplifier	135		9	3	9.3	10300	900	0.07	20000	
									180		13.5	3.1	9.3	10300	900	0.13	20000	
31	TRIODE	FIL.	4D SM 4 PIN	0.130				Amplifier	135		22.5	8	3.8	4100	925	0.185	7000	
									180		30	12.3	3.8	3600	1050	0.375	5700	
32	TETRODE	FIL.	4K MED 4 PIN	0.060	0.015 MAX.	6.0	11.7	Detector	180	67.5	6						150000	
								Amplifier	135	67.5	3	1.7	610	.95MΩ	640			9
									180	67.5	3	1.7	780	1.2MΩ	650			9
33	PENTODE	FIL	5K MED. 5 PIN	0.260				Amplifier	100	100	8	10.5	60	50000	1200	0.30	7000	
									135	135	13.5	14.5	70	50000	1450	0.70	7000	
34	REMOTE CUT-OFF PENTODE	FIL	4M MED 4 PIN	0.060	0.015 MAX.	6.0	12.6	1st Detector	67.5 to 180	67.5	5							
								Amplifier	135	67.5	3	2.8	360	0.6MΩ	600			27
									180	67.5	3	2.8	620	1.0MΩ	620			27
49	DOUBLE GRID TRIODE	FIL	5C MED 5 PIN	0.120				Class A	135		20	5.7	4.5	4000	1125	0.17	11000	
								CL.B (Avg. 2 Tubes)	180		0	4 to 30				3.0	9000 Min.	
19	TWIN TRIODE	FIL.	6C SM. 6 PIN	0.260				Complete CL.A (Both Sections)	135		0	10 to 35				2.1	10000	
									135		3	4 to 35				1.9	10000	
1A4	TETRODE	FIL.	4K SM 4 PIN	0.060	0.007 MAX.	4.6	11	Amplifier	180	67.5	3	2.3	720	0.90MΩ	750			20
1A6	HEPTODE	FIL.	6L SM. 6 PIN	0.060	0.8	5	6	Oscillator Sect.	135		a 50000Ω b 20000Ω	2.3						
					0.25	10.5	9	Mixer Section	(a) 180	67.5	3	1.3		0.5MΩ	300	Conversion Conductance	R_{c2} 0.02MΩ	22.5
									(b) 180	45	−F	1.2		0.6MΩ	250			11
1B4 / 951	TETRODE	FIL	4K SM 4 PIN	0.060	0.007 MAX	4.6	11	1st Detector	180	67.5	6							
								Amplifier	180	67.5	3	1.7	780	1.0MΩ	650			9
1B5 / 25S	DUPLEX DIODE TRIODE	FIL	6M SM 6 PIN	0.060	3.6	2	3	Diode Detect. Triode Ampli.	135		3	0.8	20.0	35000	575			
1C6	HEPTODE	FIL	6L SM. 6 PIN	0.120	1.5	6	6	Oscillator Sect.	180		0.05MΩ	3.3				Conversion Conductance	R_{c2} 0.02MΩ	
					0.3	10	10	Mixer Section	180	67.5	3	1.5		0.75MΩ	325			14
1F4	PENTODE	FIL.	5K MED 5 PIN	0.120				Amplifier	135	135	4.5	8.0	340	0.2MΩ	1700	0.34	16000	
1F6	DUODIODE PENTODE	FIL.	6T SM 6 PIN	.060	.007	4	9	R.F. Det.-Ampli.	180	67.5	1.5	2.0	650	1 MEG	650			12.0
								A.F. Det.-Ampli.	135	135 Supply	2.0	Plate Resistor .25 Meg. Screen Resistor .8 Meg.						

2.5 VOLT A.C. DETECTOR AND AMPLIFIER TUBES

Type No.	Description: Type	Description: Cathode	Basing (See Socket Connection Chart)	Fil. Current Amps.	Capacitances Micro-Micro-Farads: Grid-Plate	Capacitances: Input	Capacitances: Output	Operating Conditions and Characteristics: When Used As	Plate Supply Volts	Scr. Grid Volts	Grid Bias Volts (Neg.)	Plate Current M.A.	Ampl. Factor	Plate Resis. Ohms	Mut. Cond. µmhos	Max. Undist. Output Watts	Recomm. Load Resis. Ohms	Cut-Off Bias Volts
24A	TETRODE	HEATER	5E MED 5 PIN	1.75	0.007 MAX.	5.0	10.5	Detector	250	45	5						0.25MΩ	
								A.F. Amplifier	250	25	1	0.5	1000	2.0MΩ	500		0.1MΩ	
								R.F. Amplifier	180	90	3	4.0	600	0.4MΩ	1000			15
									250	90	3	4.0	630	0.6MΩ	1050			15
26	TRIODE	1.5 V.A.C. FIL.	4D MED 4 PIN	1.5 V 1.05 a	8.1	3.5	2.2	Amplifier	135		10	5.5	8.3	7600	1100	0.08	8800	
									180		14.5	6.2	8.3	7300	1150	0.18	10500	
27	TRIODE	HEATER	5A SM. 5 PIN	1.75	3.3	3.5	3.0	Bias Detector	250		30							
								Amplifier	135		9	4.5	9	9000	1000	0.08	13000	
									180		13.5	5.0	9	9000	1000	0.165	19000	
									250		21	5.2	9	9250	975	0.30	34000	
35 / 51	REMOTE CUT-OFF TETRODE	HEATER	5E MED. 5 PIN	1.75	0.007 MAX.	5.0	10.5	1st Detector	250	90	7 App.							
								Amplifier	180	90	3	6.3	305	0.3MΩ	1020			50
									250	90	3	6.5	420	0.4MΩ	1050			50
45	TRIODE	FIL.	4D MED 4 PIN	1.50				Single Ampli.	180		31.5	31	3.5	1650	2125	0.82	2700	
									275		56	36	3.5	1700	2050	2.0	4600	
								Push-Pull (Avg. 2 tubes)	300		70	44 to 70				10	9000	
46	DOUBLE GRID TRIODE	FIL.	5C MED. 5 PIN	1.75				Class A	250		33	22	5.6	2400	2350	1.25	6400	
								CL.B (Avg. 2 Tubes)	300		0	8 to 70				16	5000 Min.	
									400		0	12 to 75				20	5500 Min.	
47	PENTODE	FIL.	5B MED. 5 PIN	1.75				Amplifier	250	250	16.5	31	150	60000	2500	2.7	7000	
53	TWIN TRIODE	HEATER	7B MED. 7 PIN LG. PIN CIRCLE	2.0				CL.A (Parallel Conn.)	294		6	7	35	11000	3200	0.37	35000	
								Complete CL.B (Both Sections)	250		0	28 to 50				8	8000	
									300		0	35 to 50				10	10000	
55	DUPLEX DIODE TRIODE	HEATER	6G SM 6 PIN	1.0	2.0	2.0	4.0	Diode Detect. Triode Ampli.	180		13.5	6	8.3	8500	975	0.16	20000	
									250		20	8	8.3	7500	1100	0.35	20000	
56	TRIODE	HEATER	5A SM 5 PIN	1.0	3.2	3.2	2.2	Bias Detect.	250		20							
								Amplifier	250		13.5	5.0	13.8	9500	1450	0.26	47000	
57	PENTODE	HEATER	6F SM. 6 PIN	1.0	0.007 MAX.	5.0	6.5	Detector	250	100	38						0.25MΩ	
								Amplifier	250	100	3	2.0	2000	2.0MΩ	1225			7
58	REMOTE CUT-OFF PENTODE	HEATER	6F SM. 6 PIN	1.0	0.007 MAX.	5.0	6.5	1st Detect.	250	100	10							
								Amplifier	250	100	3	8.2	1280	0.8MΩ	1600			50
59	TRIPLE GRID	HEATER	7A MED. 7 PIN LG. PIN CIRCLE	2.0				Class A Triode	250		28	26	6	2400	2600	1.25	5000	
								Class A Pentode	250	250	18	35	100	40000	2500	3	6000	
								CL.B Triode (Avg. 2 Tubes)	400		0	25 to 75				20	6000 MIN	
2A3 / 2A3H	TRIODE	FIL. / HEATER	4D MED 4 PIN / 4Q	2.5 / 2.8				Single Ampli.	250		45	60	4.2	800	5250	3.5	2500	
								Class AB (2 Tubes)	300	Self Bias	62	80 to 100				10	5000	
									300	Self Bias	62	80 to 150				15	3000	
2A5	PENTODE	HEATER	6B MED 6 PIN	1.75				Pentode	250	250	16.5	34	220	0.1MΩ	2300	3	7000	
					# 2 GR. to PL. CLASS AB TRIODE 2 TUBES				350		38	42 to 90				18	8000	
2A6	DUPLEX DIODE TRIODE	HEATER	6G SM 6 PIN	0.8	2.0	2.0	4.0	Diode Detect	250		2	0.8	100	91000	1100			
								Triode Ampli	250		2	0.1					0.25MΩ	
2A7	HEPTODE	HEATER	7C SM 7 PIN	0.8	1.0	7	5.5	Osc Section	250		50000Ω	4					R_{c2} 0.02MΩ	
					0.3	8.5	9	Mixer Section	250	100	3	4		0.36MΩ	520	Conversion Conductance		45
2B7	DUPLEX DIODE PENTODE	HEATER	7D SM 7 PIN	0.8	0.010 MAX	3.3	10	Diode Detect.	100	100	3	5.8	285	0.3MΩ	950			17
								R.F. Amplifier	250	100	3	6.0	800	0.8MΩ	1000			17
								Dio. Det. & A.F. Amp.	250	50	4.5	0.65					0.20MΩ	

Figure 15

Type No.	Description: Type	Description: Cathode	Basing (see socket connection chart)	Fil. Current Amps	Capacitances (Micro-Micro Farads): Grid Plate	Input	Output	When Used As	Plate Supply Volts	Scr. Grid Volts	Grid Bias Volts (Neg.)	Plate Current M.A.	Amp. Factor	Plate Resis. Ohms	Mut. Cond. µmhos	Max. Undist. Output Watts	Recomm. Load Resis. Ohms	Cut-off Bias Volts
3.3 VOLT D.C. DETECTOR AND AMPLIFIER TUBES																		
20	Triode	Fil.	4D Sm. 4 Pin	0.132				Amplifier	135		22.5	6.5	3.3	6300	525	0.110	6500	
V-99 / X-99	Triode	Fil.	4E Spec. 4 Pin / 4D Sm. 4 Pin	0.063	3.3	2.5	2.5	Gr. Leak Det.	45		+A	1.5	6.6	17000	370			
								Amplifier	90		4.5	2.5	6.6	15500	425	0.007	15500	
22	Screen Grid	Fil.	4K Med. 4 Pin	0.132	0.020 Max.	3.3	12	R.F. Ampli.	135	67.5	1.5	3.7	160	0.32MΩ	500			7.5
								Audio Ampli.	180	22.5	0.75	0.3	350	2.0MΩ	175		0.25MΩ	
5.0 VOLT D.C. DETECTOR AND AMPLIFIER TUBES																		
12A	Triode	Fil.	4D Med. 4 Pin	0.25	8.0	4.0	2.0	Amplifier	135		DC 9.0 / AC	6.2	8.5	5100	1650	0.13	9000	
									180		13.5	7.7	8.5	4700	1800	0.85	10700	
71A	Triode	Fil.	4D Med. 4 Pin	0.25				Amplifier	135		27.0 / 29.5	17.3	3.0	1820	1650	0.40	3000	
									180		40.5 / 43.0	20	3.0	1750	1700	0.79	4800	
200A	Cs Vapor Triode	Fil.	4D Med. 4 Pin	0.25	8.5	3.2	2.0	Gr. Leak Det.	45		−A	1.5	20	30000	670			
01A	Triode	Fil.	4D Med. 4 Pin	0.25	8.1	3.1	2.2	Gr. Leak Det.	45		+A	1.8	8.0	12000	670			
								Amplifier	90		4.5	2.5	8.0	11000	725	0.015	25000	
									135		9	3.0	8.0	10000	800	0.055	20000	
40	Triode	Fil.	4D Med. 4 Pin	0.25	8.8	3.4	1.5	Bias Detect.	180		4.5	0.1					0.25MΩ	
								Audio Ampli.	180		3	0.2	30	0.15MΩ	200		0.25MΩ	
6.3 VOLT A.C. OR D.C. DETECTOR AND AMPLIFIER TUBES																		
36	Tetrode	Heater	5E Sm. 5 Pin	0.30	0.007 Max.	3.7	9.2	Detector	180	67.5	6						0.25MΩ	
								Amplifier	100	55	1.5	1.8	470	0.55MΩ	850			7
									250	90	3	3.2	595	0.55MΩ	1080			7
37	Triode	Heater	5A Sm. 5 Pin	0.30	2.0	3.5	2.2	Bias Detector	180		20							
								Amplifier	90		6	2.5	9.2	11500	800	0.03	17500	
									250		18	7.5	9.2	8400	1100	0.34	20000	
38	Pentode	Heater	5F Sm. 5 Pin	0.30				Amplifier	100	100	9	7	80	85000	950	0.27	13500	
									135	135	13.5	9	100	0.1MΩ	1000	0.525	13500	
									250	250	25	22	120	0.1MΩ	1200	2.5	10000	
39 / 44	Remote Cut-off Pentode	Heater	5F Sm. 5 Pin	0.30	0.007 Max.	3.5	10	1st Detector	90 to 250	90	7 App.							
								Amplifier	90	90	3	5.6	360	0.375MΩ	960			42
									250	90	3	5.8	1050	1.0MΩ	1050			42
41	Pentode	Heater	6B Sm. 6 Pin	0.40				Amplifier	180	180	13.5	18.5	150	81000	1850	1.5	9000	
									250	250	18	32	150	68000	2200	3.4	7600	
42	Pentode	Heater	6B Med. 6 Pin	0.70				Pentode Amplifier	250	250	16.5	34	185	79000	2350	3	7000	
									315	315	22	42	230	0.1MΩ	2300	5	7000	
								#2 Gr. to Pl. Cl. A.B. Triode (2 Tubes)	350		38	42 to 90				18	8000	
52	Double Grid Triode	Fil.	5C Med. 5 Pin	0.30				Class A	110		0	43	5.2	1750	3000	1.5	2000	
								Cl. B (Avg. 2 Tubes)	180		0	6 to 40				6	9000 Min.	
75	Duplex Diode Triode	Heater	6G Sm. 5 Pin	0.30	2.0	2.0	4.0	Diode Detect	250		2	0.8	100	91000	1100			
								Triode Ampli.	250		2	0.1					0.25MΩ	
76	Triode	Heater	5G Sm. 6 Pin	0.30	2.8	3.5	2.5	Oscillator	90		0							
								Amplifier	250		13.5	5.0	13.8	9500	1450	0.25	50000	
77	Pentode	Heater	6F Sm. 6 Pin	0.30	0.007 Max.	4.0	11	Detector	250	100	4.3							
								Amplifier	250	100	3	2.3	1500	1.5MΩ	1250			7.5
78	Remote Cut-off Pentode	Heater	6F Sm. 6 Pin	0.30	0.007 Max.	4.0	11	1st Detector	250	100	10							
								Amplifier	250	100	3	7.0	1160	0.8MΩ	1450			42
79	Twin Triode	Heater	6H Sm. 6 Pin	0.60				Complete Cl. B Both Sections	250		0	20 to 60				8	14000	
85	Duplex Diode Triode	Heater	6G Sm. 6 Pin	0.30	2.0	2.0	4.0	Diode Detect.	180		13.5	6	8.3	8500	975	0.16	20000	
								Triode Ampli.	250		20	8	8.3	7500	1100	0.35	20000	
89	Triple Grid	Heater	6F Sm. 6 Pin	0.40				Cl. A Triode	250		31	32	4.7	2600	1800	0.9	5500	
								Cl. A Pentode	250	250	25	32	125	70000	1800	3.4	6750	
								Cl. B Triode (Avg. 2 Tubes)	250		0	6 to 50				5	10000 Min.	
6A3	Triode	Fil.	4D Med. 4 Pin	1.0				Single Ampli.	250		45	60	4.2	800	5250	3.3	2500	
								Class AB (2 Tubes)	325	Self Bias	63	130 to 150				10	5000	
									325	Fixed Bias	63	140 to 200				15	3000	
6A4 LA	Pentode	Fil.	5B Med. 5 Pin	0.30				Amplifier	180	180	12	22	100	4500	2200	1.4	8000	
								Cl. AB (2 Tubes)	230	230	22	32	Self-Bias R_{c1} = 700Ω			4.2	16000	
12A5	Pentode	Heater	7F Sm. 7 Pin	6.3V. 0.6A / 12.6V. 0.3A	8.5	4	2	Amplifier	100	100	15	17			1700	0.65	4500	
									180	180	27	38			2300	2.6	3800	
6A6	Twin Triode	Heater	7B Med. 7 Pin Lg. Pin Circle	0.8				Cl. A Parallel Conn.	294		6	7	35	11000	3200	0.37	35000	
								Complete Cl. B Both Sections	250		0	28 to 50				8	8000	
									300		0	35 to 50				10	10000	
6A7	Heptode	Heater	7C Sm. 7 Pin	0.30	1.0	7	5.5	Osc. Section	250		50000Ω	4					R_{c2} 0.02MΩ	
					0.3	8.5	9	Mixer Section	250	100	3	4		0.36MΩ	520	Conversion Conductance		45
6B5	Dual Triode	Heater	6D Med. 6 Pin	0.80				Single Tube	Each 300		0	Out put 45, In put 8	58	24000	2400	4	7000	Volts RMS 15
									" 325		0	51 9				5.2	7000	17
								Two Tubes	" 250		0	33 65				8.5	10000	38
									" 325		0	51 9				13.5	10000	42
6B7	Duplex Diode Pentode	Heater	7D Sm. 7 Pin	0.30	0.010 Max.	3.3	10	Diode Detect.	100	100	3	5.8	285	0.3MΩ	950			17
								R.F. Amplifier	250	100	3	6.0	800	0.8MΩ	1000			17
								Dio. Det. & A.F. Ampli.	250	50	4.5	0.65					0.2MΩ	
6C6	Pentode	Heater	6F Sm. 6 Pin	0.30	0.007 Max.	5.2	6.8	Detector	250	100	3.8						0.25MΩ	
								Amplifier	250	100	3	2.0	2500	2.0MΩ	1225			7
6D6	Remote Cut-off Pentode	Heater	6F Sm. 6 Pin	0.30	0.007 Max.	5.2	6.8	1st Detect	250	100	10							
								Amplifier	250	100	3	8.2	1280	0.8MΩ	1600			50
6E5	Cathode Ray	Heater	6R Sm. 6 Pin	0.30				Tuning Indicator	With plate 250V (thru 1MΩ) target 250V I_b = 0.25 m.a. and shadow angle is 90° at E_c = 0V, angle is zero at E_c = −8V approx.									
6E6	Twin Triode	Heater	7B Med. 7 Pin	0.60				Complete Cl. A Both Sections	180		20	23	6.0	2150	2800	0.75	15000	
									250		27.5	36	6.0	1750	3400	0.6	14000	
6F7	Triode Pentode	Heater	7E Sm. 7 Pin	0.30	2.0	2.5	3.0	Triode Ampli.	100		3	3.5	8	18000	500			
					0.008 Max.	3.2	12	Pentode 1st Det.	250	100	10							
								Pentode Amp.	250	100	3	6.5	900	0.85MΩ	1100			50
6G5	Cathode Ray	Heater	6R Sm. 6 Pin	0.30				Tuning Indicator	With plate 250V (thru 1MΩ) target 250V I_b = 0.25 m.a. and shadow angle is 90° at E_c = 0V, angle is zero at E_c = −22V approx.									
6N7G	Twin Triode	Heater	8B Octal Med. Shell 8 Pin	0.80								Same	As	6A6				

Figure 16

TYPE NO.	DESCRIPTION: TYPE	DESCRIPTION: CATHODE	BASING SEE SOCKET CONNECTION CHART	FIL. CURRENT AMPS.	CAPACITANCES MICRO-MICRO FARADS: GRID PLATE	INPUT	OUTPUT	OPERATING CONDITIONS AND CHARACTERISTICS: WHEN USED AS	PLATE SUPPLY VOLTS	SCR. GRID VOLTS	GRID BIAS VOLTS (NEG.)	PLATE CURRENT M.A.	AMPL. FACTOR	PLATE RESIST. OHMS	MUT. COND. µMHOS.	MAX. UNDIST. OUTPUT WATTS	RECOMM. LOAD RESIST. OHMS	CUT-OFF BIAS VOLTS
7.5 VOLT AC POWER AMPLIFIER TUBES																		
10	TRIODE	FIL.	4D MED. 4 PIN	1.25				AMPLIFIER	350		31	16	8.0	5150	1550	0.9	11000	
									425		39	18	8.0	5000	1600	1.6	10000	
50	TRIODE	FIL.	4D MED. 4 PIN	1.25				AMPLIFIER	350		63	45	3.8	1900	2000	2.4	4100	
									450		84	55	3.8	1800	2100	4.6	4350	
SERIES FILAMENT POWER AMPLIFIER TUBES																		
43	PENTODE	HEATER	6B MED. 6 PIN	0.3a 25V.				AMPLIFIER	95	95	15	20	90	45000	2000	0.9	4500	
									180	135	20	38	100	40000	2500	2.75	5000	
48	PENTODE	HEATER	6B MED. 6 PIN	0.4a 30 V.				AMPLIFIER	96	96	1.9	52			3800	2.0	1500	
									125	100	22.5	56			3900	2.5	1500	
12A7	PENTODE & DIODE	HEATER	7K SM. 7 PIN	0.3a 12.6V.				AMPLIFIER	135	135	13.5	9	100	0.1MΩ	975	0.55	13500	
								RECTIFIER	125 RMS			30 MAX						
METAL DETECTOR AND AMPLIFIER TUBES																		
6A8	HEPTODE	HEATER	8A OCTAL 8P.	0.3	1	7	4.5	OSC. SECTION	250		50000Ω	4						
					0.05	13	13.0	MIXER SECTION	250	100	3	4		0.36MΩ	520 CONVERSION CONDUCTANCE			
6C5	TRIODE	HEATER	6Q OCTAL 6P.	0.30	2.0	4.5	14	OSCILLATOR	90		0							
								AMPLIFIER	250		8	8	20	10000	2000			
6F5	TRIODE	HEATER	5M OCTAL 5P.	0.30				AMPLIFIER	250		2	0.9	100	66000	1500			
									250		2	0.1					0.25MΩ	
6F6	PENTODE	HEATER	7S OCTAL 7 PIN	0.70				PENTODE AMP.	250	250	16.5	34	185	79000	2350	3	7000	
								TRIODE (G2 TO P)	250		20	31	6.2	2700	2300	0.85	4000	
								CL. AB PENTODE	375	250	340Ω SELF	54				19	10000	
								AMPLI. (2 TUBES)	375	250	26 FIXED	34				19	10000	
6H6	TWIN DIODE	HEATER	7Q O.7 P.	0.30				DIODE DET.	100 MAX AC			2 MAX EA. DIODE						
6J7	PENTODE	HEATER	7R OCTAL 7 PIN	0.30	0.002	8	12	DETECTOR	250	100	3.8						0.25MΩ	
								AMPLIFIER	250	125	3	4			1550			9
									250	100	3	2	2500	2.0MΩ	1225			7
6K7	PENTODE	HEATER	7R OCTAL 7 PIN	0.30	0.002	8	12	1st DETECTOR	250	100	10							
								AMPLIFIER	250	125	3	10.5	990	0.6MΩ	1650			52
									250	100	3	7	1160	0.8MΩ	1450			42
6L6	TETRODE	HEATER	7Y SMALL OCTAL 7 PIN	0.9				PWR. AMPLI.	250	250	14V	72	135	22500	6000	SCR G. CURRENT 5MA		
								PWR AMP. FIXED BIAS	375	125	9	24				4.2	14000	
								PWR AMP. SELF BIAS	375	125	9	24				4.0	14000	
								FIXED BIAS	375	250	17.5	57				11.5	4000	
								2 TUBES CLASS AB FIX. BIAS	400	250	20.0	88 TO 168				40	6000	
								2 TUBES CLASS AB FIX. BIAS	400	300	25.0	102 TO 230				60	3800	
6L7	HEPTODE	HEATER	7T OCT. 7 PIN	0.30	G1 0.001	G1 8.5 G3 11.5	13	MIXER	250	150	G1 6 G3 16	3.3	Ig2-4 8.3	2.0MΩ	350 CONVERSION CONDUCTANCE			G1 45
								AMPLIFIER	250	100	G1 G3 3	5.3	880	0.8MΩ	1100			G1 25 G3 12
6Q7	DUPLEX DIODE TRIODE	HEATER	7V OCT. 7 PIN	0.30	1.2	6	4.5	DIODE DETECT.	100		1.5	0.35	70	0.87MΩ	800			
								TRIODE AMP.	250		3	1.1	70	0.58MΩ	1200		0.25MΩ	
6R7	DUPLEX DIODE TRIODE	HEATER	7V O.7 P.	0.30	2.0	6	4.5	DIODE DETECTOR TRIODE AMPLIFIER	250		90	9.5	16	8500	1900	0.28	15000	
25A6	PENTODE	HEATER	7S O.7 P.	0.3a 25.0V.				AMPLIFIER	95	95	15	20	90	45000	2000	0.9	4500	
									180	135	20	38	100	40000	2500	2.75	5000	

RECTIFIER TUBES

					FIL. AMPS	FIL. VOLTS	MAX. AC VOLTS PER ANODE	MAX. DC OUT. CURR. (AMPS)	MAX. PEAK INVERSE VOLTS	MAX. PEAK PLATE CURR.	MIN. CHOKE BEFORE FILTER CONDENSER	MAX. HEATER CATHODE BIAS	MAX. DC VOLTS DEL. TO FILTER (NOM.): CONDENSER INPUT	CHOKE INPUT
BA	FULL WAVE	GAS	COLD	4J M. 4 P.	—	—	350	0.350	1000	1.00				300
BH	FULL WAVE	GAS	COLD	4J M. 4 P.	—	—	350	0.125	1000	0.40				300
BR	HALF WAVE	GAS	COLD	4H M. 4 P.	—	—	300	0.050	850	0.20			300	
1-V	HALF WAVE	HIGH VAC.	HEATER	4G SM. 4 PIN	0.3	6.3	350	0.050	1000	0.20		500	400	
80	FULL WAVE	HIGH VAC.	FIL.	4C MED. 4 PIN	2.0	5.0	350	0.125	1000	0.40			300	225
							400	0.110	1100	0.35			370	275
							550	0.135	1500	0.30	20 HENRIES			425
81	HALF WAVE	HIGH VACUUM	FIL.	4B MED. 4 PIN	1.25	7.5	700	0.085	2000	0.60 FULL WAVE			750	550
82	FULL WAVE	MERCURY VAPOR	FIL.	4C MED. 4 PIN	3.0	2.5	500	0.125	1400	0.40			590	425
83	FULL WAVE	MERCURY VAPOR	FIL.	4C MED. 4 PIN	3.0	5.0	500	0.250	1400	0.80			530	400
83V	FULL WAVE	HIGH VACUUM	HEATER	4L MED. 4 PIN	2.0	5.0	500	0.250	1400	0.80			510	385
0Z3	FULL WAVE	GAS	COLD	5N SM. 5 PIN	—	—	350	0.075 MAX. 0.030 MIN.	1250	0.20			425	300
0Z4	FULL WAVE	GAS	COLD	4R OCT. 4 PIN	—	—	350	0.075 MAX. 0.030 MIN.	1250	0.20			425	300
5Y3	FULL WAVE	HIGH VAC.	FIL.	5L OCTAL MED. SHELL 5 PIN	2.0	5.0		SAME	AS	TYPE	80			
5Z3	FULL WAVE	HIGH VAC.	FIL.	4C MED. 4 PIN	3.0	5.0	500	0.250	1400	0.70			480	360
6Z4 / 84	FULL WAVE	HIGH VAC.	HEATER	5D SM. 5 PIN	0.5	6.3	350	0.060	1000	0.20		500	425	300
12Z3	HALF WAVE	HIGH VAC.	HEATER	4G SM. 4 PIN	0.3	12.6	250	0.060	700	0.30		350	310	
25Z5	RECTIFIER DOUBLER	HIGH VAC.	HEATER	6E SM. 6 PIN	0.3	25.0	125	0.200	700	0.40	RECTIFIER	350	200	
								0.100	700	0.20	DOUBLER	350	120	

METAL RECTIFIER TUBES

					FIL. AMPS	FIL. VOLTS	MAX. AC VOLTS PER ANODE	MAX. DC OUT. CURR. (AMPS)	MAX. PEAK INVERSE VOLTS	MAX. PEAK PLATE CURR.	MIN. CHOKE BEFORE FILTER CONDENSER	MAX. HEATER CATHODE BIAS	CONDENSER INPUT	CHOKE INPUT
5W4	FULL WAVE	HIGH VACUUM	FIL.	5H SM. OCT. 5 PIN	1.5	5.0	350	0.110					370	
5Z4	FULL WAVE	HIGH VACUUM	HEATER	5L OCT. 5 PIN	2.0	5.0	400	0.125	1100	0.50			425	275
6X5	FULL WAVE	HIGH VACUUM	HEATER	6S OCT. 6 PIN	0.6	6.3	350	0.075	1250	0.25		500	400	
25Z6	RECTIFIER DOUBLER	HIGH VACUUM	HEATER	7Q OCT. 7 PIN	0.3	25.0	125	0.170	700	0.35	RECTIFIER	350	225	
								0.085	700	0.17	DOUBLER		115	

Figure 17

SPECIAL TUBES

TYPE NO.	FILAMENT VOLTS	FILAMENT AMPS	BASING VIEW	BASING SHIELD CONN. TO	CHARACTERISTICS USE & DIMENSIONS
2S/4S	2.5	1.35	5D	CATHODE PIN	APPROXIMATELY 40 MA ON EA. DIODE PLATE AT 50 VOLTS DC. DUPLEX DIODE DETECTOR
24S	2.5	1.75	5E	CATHODE PIN	SAME AS 24A
27S	2.5	1.75	5E	CATHODE PIN	SAME AS 27
35/51S	2.5	1.75	5E	CATHODE PIN	SAME AS 35
55S	2.5	1.0	6G	CATHODE PIN	SAME AS 55
56S	2.5	1.0	5A	CATHODE PIN	SAME AS 56
57S	2.5	1.0	6F	CATHODE PIN	SAME AS 57
57AS	6.3	0.4	6F	CATHODE PIN	SAME AS 6C6 EXCEPT HEATER AMPS.
58S	2.5	1.0	6F	CATHODE PIN	SAME AS 58
58AS	6.3	0.4	6F	CATHODE PIN	SAME AS 6D6 EXCEPT HEATER AMPS.
75S	6.3	0.3	6G	CATHODE PIN	SAME AS 75
85AS	6.3	0.3	6G	HEATER PIN ADJACENT TO CATHODE PIN	SIMILAR TO 85 EXCEPT AMP. FACTOR = 20 MUTUAL COND. = 1250. PLATE CURR. = 5.5MA PLATE VOLTS = 250V; GRID BIAS = −9V.
182B	5.0	1.25	4D	NO SHIELD	SIM. TO 45 EXCEPT FIL. VOLTS. AMP. FACT. = 5.0 MUTUAL COND. = 1500, PLATE CURR. = 18 MA. PL. VOLTS = 250V. GR. BIAS = −35V.
183	5.0	1.25	4D	NO SHIELD	SIM. TO 45 EXCEPT FIL. VOLTS: AMP. FACT. = 3.0, MUT COND. = 1500, PL. CURR. = 20 MA., PL. VOLTS = 250V, GR. BIAS = −[illegible]V.
485	3.0	1.25	5A	NO SHIELD	SIM. TO 27 EXCEPT HEATER VOLTS; AMP. FACT. = 12.8 MUT COND. = 1300, PL. CURR. = 5.2 M.A., PL. VOLTS = 180V., GR. BIAS = −10V.
950	2.0	0.12	5K	NO SHIELD	SIM. TO 33 EXCEPT FIL. AMPS; PL. CURR. = 7MA POWER OUTPUT = 0.45 WATTS, PL. & SCR. VOLTS = 135V. MAX. CONT. GR. BIAS = −16.5
2A7S	2.5	1.0	7C	CATHODE PIN	SAME AS 2A7
2Z2/G84	2.5	1.5	4B	NO SHIELD	SIMILAR TO 1-V
6A7S	6.3	0.3	7C	CATHODE PIN	SAME AS 6A7
6B7S	6.3	0.3	7D	CATHODE PIN	SAME AS 6B7
6C7	6.3	0.3	7G	SEPARATE PIN	SAME AS 85A-S
6D7	6.3	0.3	7H	SEPARATE PIN	SAME AS 6C6
6E7	6.3	0.3	7H	SEPARATE PIN	SAME AS 6D6
6F7S	6.3	0.3	7E	CATHODE PIN	SAME AS 6F7
6Y5	6.3	0.8	6J	SEPARATE PIN	SIMILAR TO 6Z4/84
6Z5	12.6/6.3	0.4/0.8	6K	NO SHIELD	SIMILAR TO 6Z4/84

COMPARISON CHART
SIMILAR CHARACTERISTICS

OCTAL BASE GLASS	METAL GLASS	METAL	GLASS
5Y3	5Z4MG		80
6A8G	6A8MG		6A7
6C5G	6C5MG	6C5	
6F5G	6F5MG	6F5	75 TRIODE
6F6G	6F6MG	6F6	42
6H6G	6H6MG	6H6	
6J7G	6J7MG	6J7	77
6K7G	6K7MG	6K7	78
6L7G	6L7MG	6L7	
6N7G	6N7MG		6A6
	6N6MG		6B5
6Q7G	6Q7MG	6Q7	
6R7G	6R7MG	6R7	
6X5G	6X5MG	6X5	
6B6	6B6		75
6P7	6P7		6F7
25A6G	25A6MG	25A6	43
25Z6G	25Z6MG	25Z6	25Z5

BASE CONNECTIONS
OCTAL BASE TWO VOLT GLASS TUBES

OCTAL BASE "G" TYPES	EQUIV. TYPES	1	2	3	4	5	6	7	8	TOP CAP
1C7G	1C6	NC	+F	P	G_3G_5	G_1	G_2	−F	NC	G_4
1D5G	1A4	NC	+F	P	G_2	NC	—	−F	NC	G_1
1D7G	1A6	NC	+F	P	G_3G_5	G_1	G_2	−F	NC	G_4
1E5G	1B4	NC	+F	P	G_2	NC	—	−F	NC	G_1
1F5G	1F4	NC	+F	P	G_2	G_1	—	−F	NC	—
1H4G	30	NC	+F	P	NC	G_1	—	−F	NC	—
1H6G	1B5/25S	NC	+F	P	D(+)	D(−)	G	−F	NC	—
1J6G	19	NC	+F	P_1	G_1	G_2	P_2	−F	NC	—

TABLE OF COMPARATIVE TYPES

OCTAL BASE GLASS	METAL GLASS	METAL	GLASS
5V4			83V
6L6G		6L6	
1C7G			1C6
1D5G			1A4
1D7G			1A6
1E5G			1B4
1F5G			1F4
1H4G			30
1H6G			1B5/25S
1J6G			19

Figure 18

SOCKET CONNECTIONS—BOTTOM VIEW

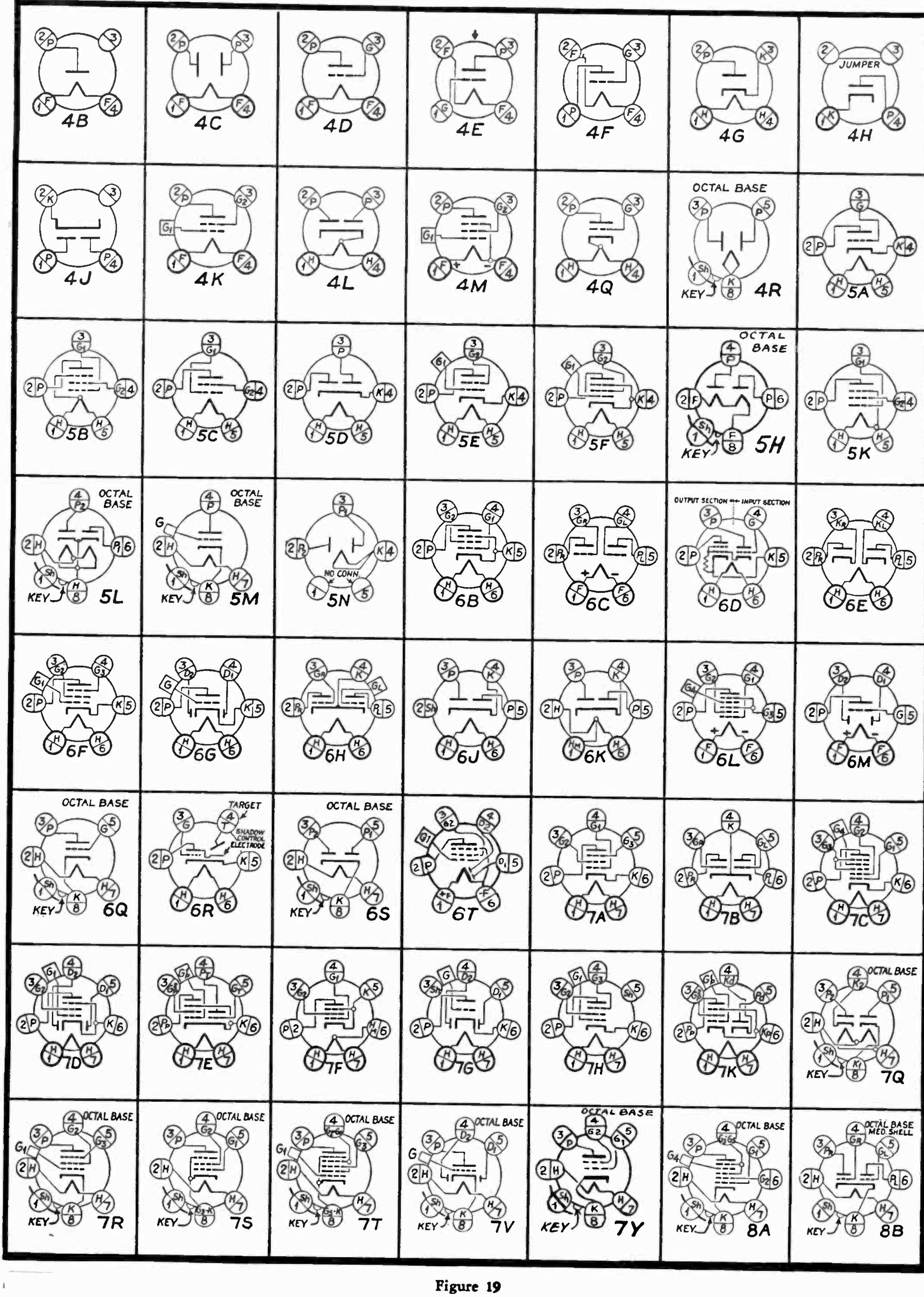


Figure 19

RADIO RECEIVER CONSTRUCTION

Portable 10-Tube A.C.-D.C. Receiver

HERE is a compact receiver which may be used wherever a.c. or d.c. lines are available. No antenna is needed, yet it will provide excellent reception even under the most adverse conditions.

Some of the outstanding features of the set include:

(1) A readily-procurable portable radio cabinet, with a built-in screen aerial, which when closed looks like a high-grade suitcase, as shown in Figure 21.

(2) Two tuned r.f. stages and one i.f. stage.

(3) Three stages of audio amplification.

(4) The use of transformerless rectifier circuits employing two 25Z5 tubes.

(5) The employment of two low-gain, well-stabilized audio stages driving a pair of 48 tubes in push-pull, and an unusually good rectifier and filter system.

(6) The inclusion of an illuminated airplane dial, tuning meter, automatic volume control and a balanced circuit, tested over many months.

Assuming that you purchase the cabinet as listed, the chassis is made as follows: It is of 1/16 inch aluminum, 15 inches wide, 5 inches high and 5½ inches from front to back, all outside dimensions. The top, front and ends are formed from a single piece with flanges on the ends as illustrated in Figure 23. The back is a separate piece and is attached to the rear flanges of the end pieces. The bottom end flanges are drilled for fastening the apparatus in the case. A cut-out will have to be made in the front and top of the chassis to accommodate the speaker. Although the constructor may cut the socket and other small holes in the base himself it is wise to let the base maker cut the speaker hole, as that is none too easy a job. Drill as many of the required holes as possible before mounting any of the apparatus. The antenna coupler, the i.f. output and the oscillation transformer are mounted with ¼ inch tapped brass rods and 6-32 machine screws about ½ inch below deck to allow room for wiring.

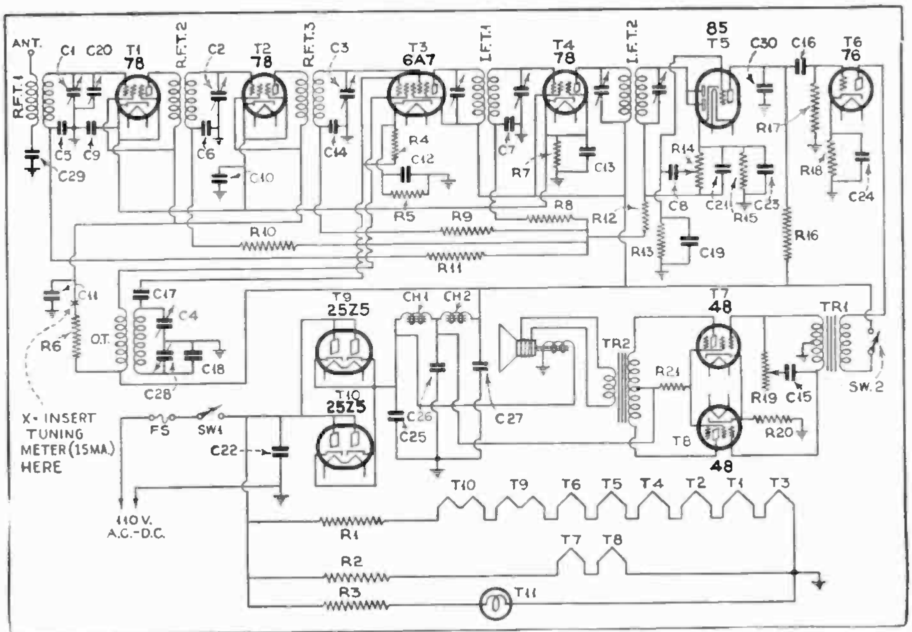


Figure 20

Practical Construction

To obtain maximum volume without howling, the speaker is supported on rubber and held down by simple clamps as noted in the parts list. The five speaker wires are run through a rubber-grommeted hole in the base. The two resistors R1 and R3 that radiate considerable heat are mounted above deck with fibre washers top and bottom, thus leaving the interior of the base free from practically all heat-radiating parts. A panel-controlled midget condenser, C20, is shunted across the secondary of the antenna coupler, to permit precise tuning with either an outside antenna or the self-contained one. To bring about more ex-

Figure 21

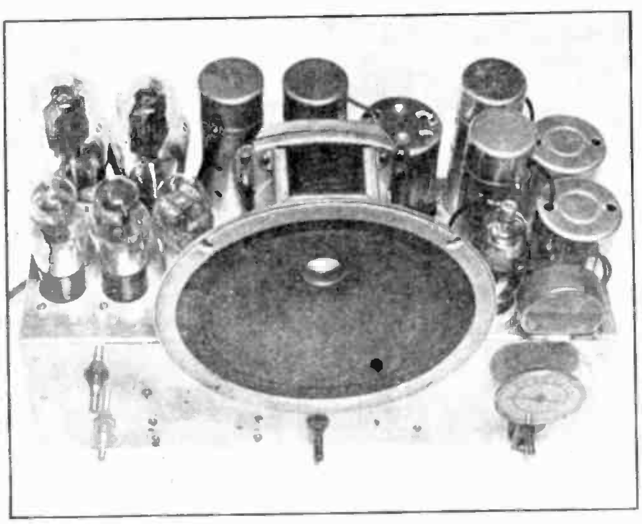
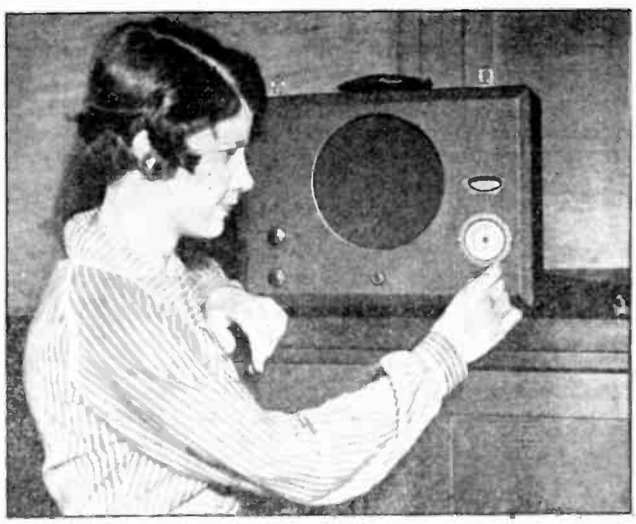


Figure 22



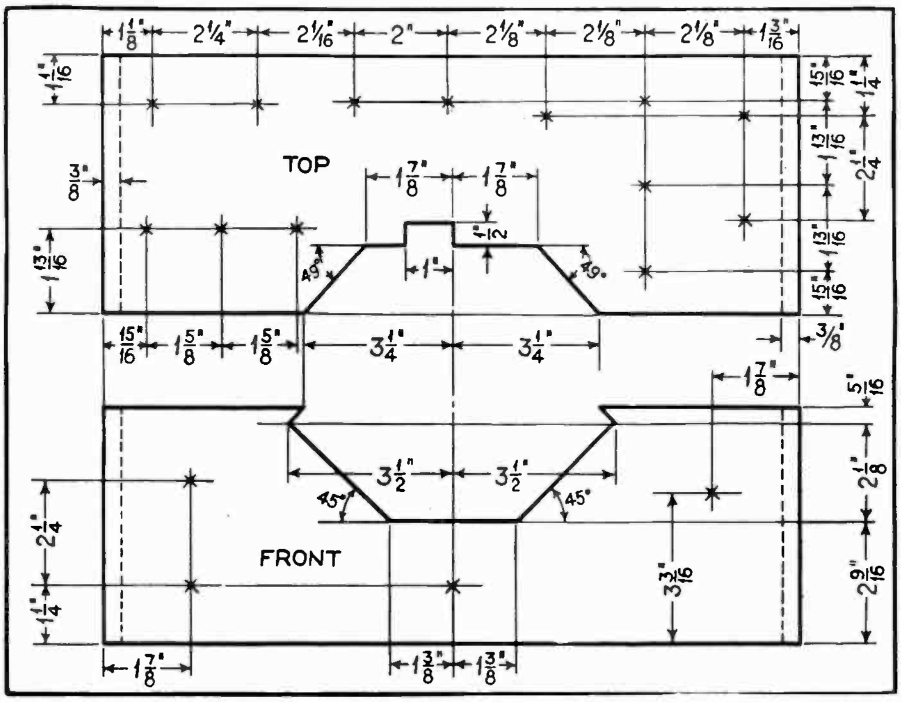


Figure 23

act tracking, C14 was reduced to .01 mfd. and a suitable decrease in the oscillator padding was made giving a noticeable gain on the tuning meter. Another set-up might present a little different problem in tracking.

It is good practice to wire the sockets first, then the r.f. and i.f. transformers, the gang condenser, tuning meter and dial bulb socket, leaving the small resistors and by-pass condensers until later. |Next wire the resistors R1 and R3 and then the tone and volume controls and the speaker. There are so many wires to be grounded that a piece of bare bus bar about two inches long and perpendicular to the base will be found useful as a ground terminal. The power cord and switch should now be wired in, then the audio transformer and filter chokes, and the electrolytic condensers last. To guard against a.c. hum pickup the input push-pull transformer should be placed at right angles to the filter chokes, and the control grid of T5 and the lead to the high side of the volume control shielded.

The type 48 tubes were selected as output tubes because, at low voltages, these tubes produce greater undistorted output than any other type.

No External Ground Connection

As the chassis of this receiver is grounded to one side of the line *an external ground connection must not be used.* The antenna circuit is insulated from the line by the stopping condenser C29, and is therefore entirely safe to handle.

Although broadcast stations can be used in aligning the tuned circuits a service oscillator is to be preferred. If an a.c.-d.c. type is used, do not use the ground connection.

Align the r.f. transformers first. To do this, remove the clip from the antenna and clip it onto any part of the chassis. Connect the output of the test oscillator between the first detector control grid and chassis. Tune the service oscillator to 175 kc. and adjust the signal input until the tuning meter swings only slightly to the right of its normal no-signal position. Now adjust four condensers in the two i.f. transformer shields for greatest swing of the meter. Begin with the fourth, counting from left to right on the circuit diagram (Figure 20), and work back to the first. Check over the adjustments twice more and then proceed to the r.f. and oscillator adjustments.

Tune the service oscillator to 1400 kc. and connect to the antenna terminal and chassis. Adjust the trimmer condensers, one of which will be found on each section of the gang condenser, until maximum swing of the tuning meter occurs about twenty divisions from the end of the dial. The trimmer across the first section of the gang condenser should be set at minimum capacity as the panel-controlled midget condenser C20 acts as trimmer for this section.

Next set the service oscillator to 600 kc. Adjust only the oscillator padding condenser C28, at the same time turning the dial of the receiver back and forth through the signal until the greatest swing of the tuning meter is obtained. Repeat the 1400 kc. adjustment of the oscillator trimmer to compensate for any change caused by adjustment of C28.

Parts List

C1, C2, C3, C4—General Instrument variable condensers—4-gang—.000364 mfd. with ⅛ inch shaft, all sections alike.
C5, C6, C7, C9, C10, C11, C12, C13—Acratest tubular paper condensers, .1 mfd., 200 volts.
C8, C16, C22—Tubular paper condensers, .05 mfd., 600 volt.
C14—Acratest tubular paper condenser, .01 mfd., 200 volt.
C15—Acratest tubular paper condenser, .006 mfd., 200 volt.
C17, C21—Acratest moulded mica condenser, .0002 mfd.
C18—Acratest moulded mica condenser, .00065 mfd.
C19—Acratest moulded mica condenser, .001 mfd.
C20—Hammerlund Star midget variable condenser, 20 mmfd.
C23, C24—Aerovox electrolytic condenser, 10 mfd., 25 volts, d.c.
C25, C26—Edison cardboard electrolytic condenser, 175 volts (working voltage) C25 being 24 mfd. and C26 16 mfd.
C27—2 Edison cardboard electrolytic condensers in parallel 8 mfd., 175 volts.
C28—Acratest compression type padding condenser, 94-419 mfd.
C29, C30—Mica condensers, .002 mfd.
CH1—Acratest heavy duty filter choke, 100 ohms, 150 ma.
CH2—Acratest midget filter choke, 200 ohms, 50 ma.
IFT1, IFT2—Gen-Win i.f. transformers, 175 kc.
OT—Sickles oscillation transformer 175 kc (for .000365 mfd. condenser).
R1—Electrad type A 10 watt, 100 ohms, cut down to 91 ohms.
R2—Power cord resistor, 140 ohms.
R3—Acratest, 1200 ohms, 10 watt.
R4—Acratest, 18,000 ohms, ¼ watt.
R5—Acratest, 300 ohms, ½ watt.
R6, R15—Acratest, 2000 ohms, ½ watt.
R7—Acratest, 200 ohms, ½ watt.
R8, R9, R10, R11, R12—Acratest, .5 meg., ¼ watt.
R13—Acratest, 60,000 ohm, ¼ watt.
R14, R19—Centralab volume controls, with switch; .5 meg., taper No. 6.
R16—Acratest, .25 meg., ½ watt.
R17—Acratest, 38,000 ohm, ¼ watt.
R18—Acratest, 2500 ohms, ½ watt.
R20—Acratest, 200 ohms, 2 watt.
R21—Acratest, 1500 ohms, 1 watt.
RFT1—Sickles antenna transformer.
RFT2, RFT3—Sickles r.f. transformers Sw1—On-off switch (on volume control).
Sw2—Silent tuning switch (on tone control).
T11—Dial bulb, 6 volts, .1 ampere, with bracket.
TR1—Acratest input push-pull transformer—large core.
TR2—(Supplied with speaker).
1 Readrite tuning meter.
1 Aluminum chassis.
1 Ansley suit-case type cabinet 15½ in. long, 11 inches high, 6 inches deep, inside dim.
1 8-inch Magnovox dynamic speaker with 2000-ohm field, equipped with output transformer for push-pull 48 tubes and hold-down hardware.
1 Airplane dial 2⅜ inches outside diameter.
2 Pointer knobs.
1 tuning knob.
4 Aluminum tube shields.
10 Eby wafer sockets.
Fs—2 amp. auto fuse and holder.
1 Mueller No. 45 clip for aerial.
1 roll of push-back hook-up wire.

A 2½-555 Meter Receiver

THE name of A. J. Haynes will recall to the oldtimers the early days of radio and his achievements with regenerative circuits, especially his well-known DX Circuit and its slogan, "One Thousand Miles for $15.00." In those days his circuit designs had a tremendous following among home set-builders. Now he has brought his old skill into play, in the design of this new 2½- to 555-meter regenerative receiver which has proved surprisingly effective in "on the air" Listening Post tests.

The "R-S-R" (regenerative-super-regenerative) 5-tube receiver comes complete with an electro-dynamic speaker and housed in a crackle-finished metal cabinet, and features complete and continuous wavelength coverage from 555 to 2½ meters (540 kilocycles to 120 megacycles).

Some readers may wonder what the bands under 15 meters have to offer. At the

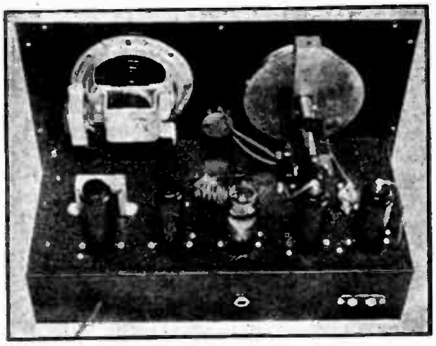


Figure 24

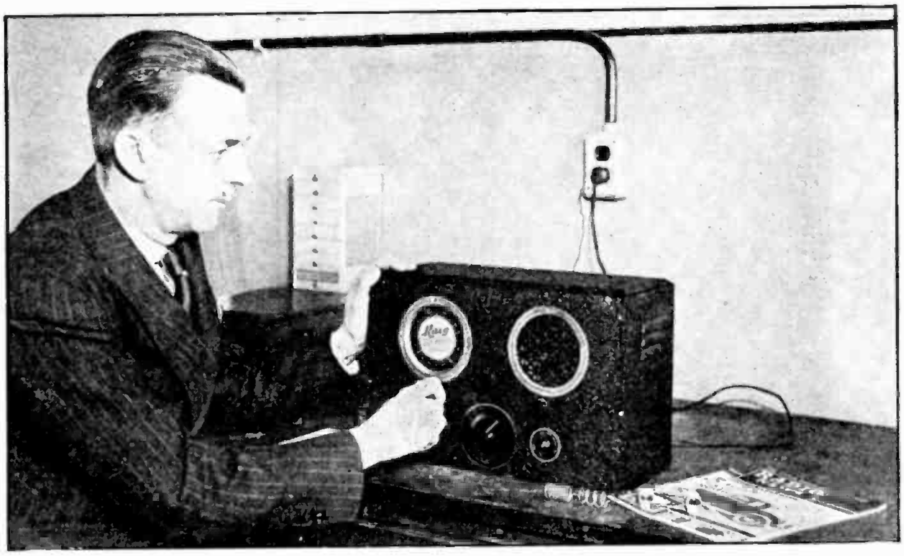


Figure 25

present time there are the amateur phone stations on the 10-meter band which can be heard at phenomenal distances, commercial experimental stations between 6 and 10 meters broadcasting music and speech, amateur phones on 5 meters, and two-way police calls around 7 and 8 meters. This ultra-high-frequency range will come into prominence when television arrives, for both the image signal and the sound accompaniment. In fact, further expansion of radio entertainment will probably all take place in the range below 15 meters.

A Real Go-Getter

Under test in two New York City Listening Posts, the receiver considerably exceeded expectations. Short-wave stations were tuned in, all on the loudspeaker, from Spain, Italy, England, France, Germany, Colombia, Cuba, Canada (and of course the U. S.), on the 25-, 31- and 49-meter bands.

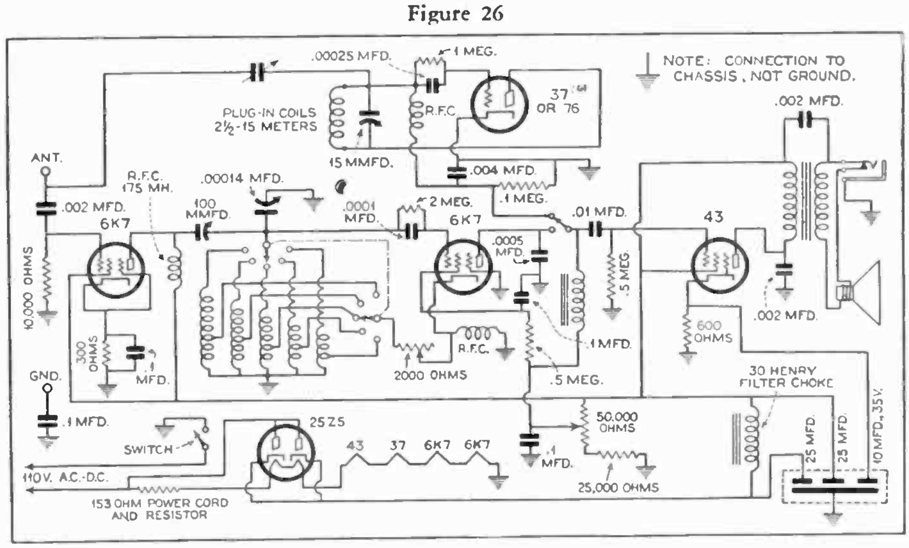
Reception of the 5-meter amateur band proved beyond a doubt that the ultra-high-frequency ranges of this little receiver really work. Any number of 5-meter ham stations were tuned in with every indication that this receiver is as effective as many of the receivers especially designed for this range.

Two Tuners in One

Reference to the schematic circuit, Figure 26, discloses that this little set is actually two receivers in one. One tuner, which consists of a 37 tube employed as a super-regenerative detector, covers the range from 2½ to 15 meters. The other tuner consists of an untuned r.f. stage and a regenerative detector and covers all wavelengths from 15 to 555 meters. The audio amplifier stage and loudspeaker may be connected to either of these tuners at will by means of a small switch on the front panel. The lower frequencies are tuned by means of the main airplane dial while the ultra high frequencies are tuned by means of the large pointer knob at the lower center of the front panel.

Small self-supported plug in coils are employed to cover the ultra high frequency range while from 15 meters up there are 5 overlapping tuning ranges any one of which is selected at will by means of a switch on the front panel. The receiver operates from any 110 volt a.c. or d.c. line and any ordinary type of antenna may be employed. The loudspeaker is included in the receiver and a headphone jack is provided at the rear of the chassis. Thus the receiver is an entirely self-contained, line-operated job and has all the neatness in appearance of a regular commercial receiver.

Figure 26



Low-Current Farm Receiver

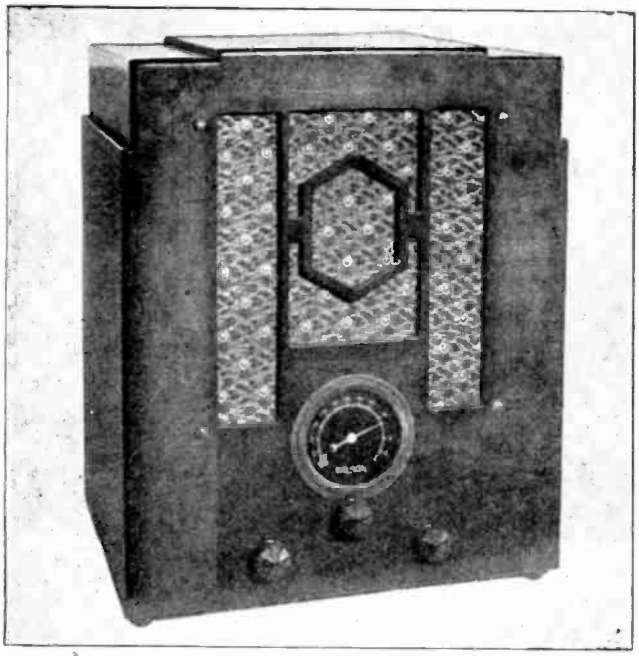
A BATTERY-operated inexpensive radio that will compare in performance and operating cost with the average five tube a.c. set. The design includes the following features:

1. Low current drain. (3.2 watts with 135 volts B battery.)
2. No C battery is used.
3. Ability to play with run-down B batteries until the total voltage drops below 60 volts.
4. Full automatic volume control without any sacrifice of signal strength on weak stations, or the use of any extra tubes.
5. Quiet operation — no power unit noise.
6. A high degree of selectivity. Most stations operating with a frequency difference of 10 kilocycles can be separated without objectionable cross-talk or interference.
7. The sensitivity is sufficient to bring signals in with loudspeaker volume from most 50 kilowatt broadcast stations within a radius of 500 miles, in daylight, without the use of any antenna, but with a good ground connection made to the antenna post, and chassis left ungrounded.
8. The battery connections are simple and easy to make.

This set is quite easy to construct. Directions for drilling are shown in Figure 29, and the circuit is given in Figure 30.

Wiring the Set

The r.f. and intermediate transformers are color-coded and are to be connected as follows: Red to "B" plus; Blue to plate; Green to grid; and Black to ground or a.v.c. return. In mounting and wiring these transformers, care should be taken to keep the grid and plate leads as short as possible to avoid unwanted coupling and



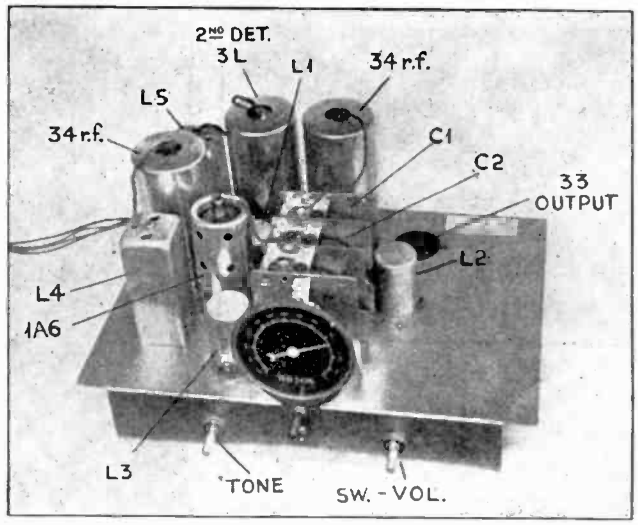


Figure 27—Left

Figure 28—Above

oscillation. Connect all bypass condensers directly to the coil or tube socket where bypass is to occur and make ground returns to a common point whenever possible. Trouble due to oscillation may be frequently traced to a neglect of the above precaution.

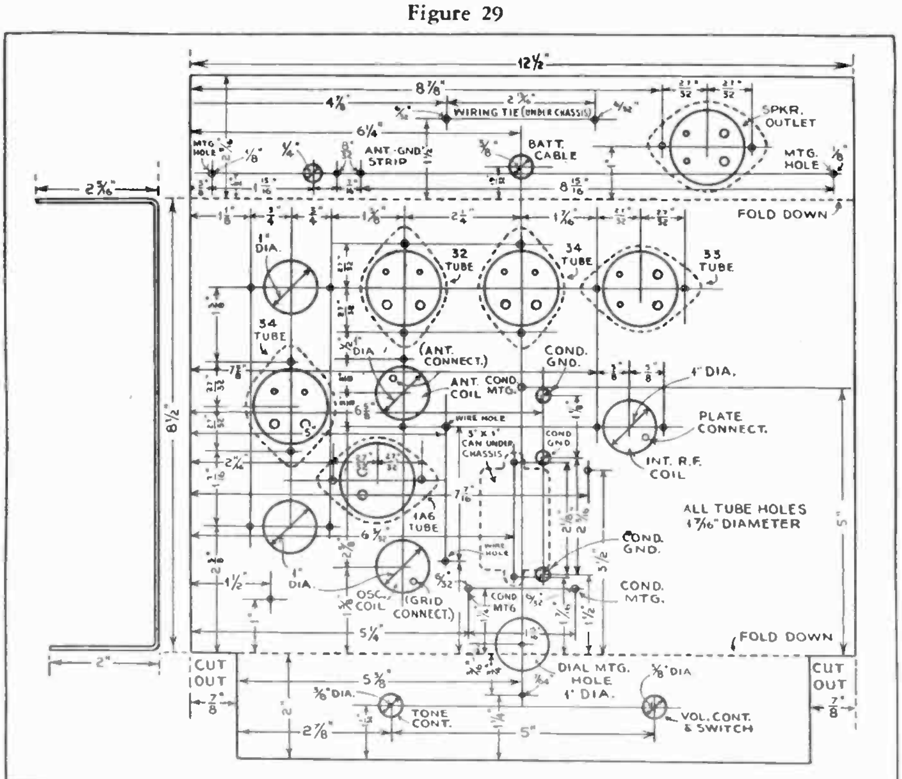
One side of the dial lamp assembly should be grounded and the other side connected to "A" plus at one of the tube sockets. A special 2-volt dial bulb is available for use in sets of this type—the drain is the same as for a 30 tube. However, a dial bulb should not be used unless the set is operated from a 2 volt storage battery or "Air Cell." Note also that B— is *not grounded*. A little careful checking may save ruining a set of tubes.

Notice the method of obtaining bias voltages. The grid of the 33 tube is returned to B—, however, B— is grounded through 1000 ohms resistance and the voltage drop across this resistance affords bias for the tube. The 10 mfd. electrolytic condenser is to bypass the lower audio frequencies and also prevent motorboating. A larger capacity may be used if necessary. The grids of all the other tubes are returned to a common point of a.v.c. voltage source and from there through 500,000 ohms to a point 200 ohms from ground. The voltage drop across this resistance is sufficient to maintain minimum bias on the rest of the tubes, for maximum sensitivity of the r.f. and detector circuits. The ½ megohm resister in the circuit allows a higher voltage to be built up in the rest of the a.v.c. network.

The type 32 second detector circuit is standard with the exception that the grid return is connected to the a.v.c. network just as it would be for diode detection. When connected in this way, the tube acts as a diode rectifier as far as the a.v.c. circuit is concerned, and when a strong signal comes through the i.f., we get a proportional d.c. voltage in the a.v.c. circuit which is due to this rectifying action

The tubes are not operated with the bias recommended by the manufacturers. They are all slightly overbiased to reduce the drain on the B batteries.

Figure 29



Alignment

With batteries and speaker connected, and an outside antenna and ground, the set should receive some signals as soon as it is turned on if all connections have been properly made. It is desirable to have a good calibrated service oscillator in order to properly adjust the various tuned circuits. However, temporary adjustments can be made without it. Find a broadcast station you can easily identify at about 1400 kilocycles, and reset the dial so that it reads the frequency of this station you are going to use as a basis for calibration. Retune the set to this station by varying the trimmer on the oscillator section of the variable condenser (C3) until it comes in at the correct place on the dial. Now adjust the r.f. and detector trimmers for maximum response without making any change in the dial setting. The i.f. transformers may next be adjusted for maximum response by making slight movements of the trimmer screws. Find a station around 600 kilocycles, and if it does not come in at the proper place on the dial, bend the rotor plates of the oscillator section of the variable condenser very slightly until the station comes in at the correct dial setting.

Adjustment of the r.f. and detector sections may be made in a similar manner.

For the greatest economy in operation, the receiver should be used with a 2 volt storage A battery of at least 300 ampere hours capacity, and two heavy duty B batteries. For places where an ordinary wet battery would be undesirable, a special storage cell with semi-solid acid may be obtained. In case a 3 volt dry A battery or an "Air-Cell" is used for the filament supply, it will be necessary to use a resistance or voltage regulator tube to step the voltage down to 2 volts at the tubes.

List of Parts

1 Crowe airplane type tuning dial calibrated in kilocycles
1 DeJur-Amsco three gang tuning condenser with 175 kc. oscillator tracking section
2 Meissner 175 kc. intermediate transformers
3 Gen-Ral r.f. coils:
  1 Antenna coil
  1 Oscillator coil
  1 Intermediate, det. coil

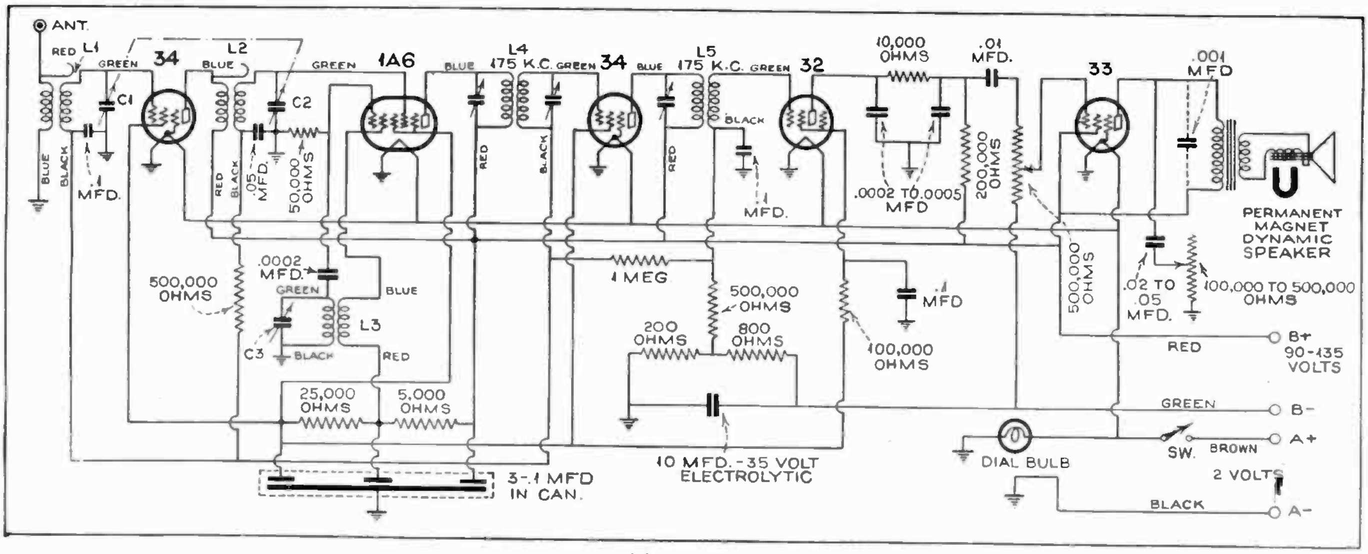


Figure 30

- Resistors and condensers as shown in Figure 30
- 1 Piece alloy chassis metal—12¾ x 12½
- 3 Large tube shields
- 1 Small tube shield
- 4 Four-prong wafer sockets
- 1 Five-prong wafer socket
- 1 Six-prong wafer socket
- 1 Terminal strip—5 wire
- 3 Knobs
- 1 Antenna-ground strip
- 4 Grid clips
- 1 Dial light assembly
- 1 Double wiring tie
- 2 Single wiring ties
- 1 Four-wire battery cable
- Miscellaneous screws, solder and hook-up wire

Accessories

- 1 Cabinet
- 1 Rola 6" PM. dynamic speaker
- 1 Speaker plug—4-prong
- 3 45-volt "B" batteries (or less)
- 1 2-volt "A" battery (1 dial lamp)

New Converter With Metal Tubes

IN the design of this preselector-converter-amplifier, the shortcomings of the ordinary converter of a year or so ago were clearly kept in mind. Consequently, the design consists of a sharply-tuned antenna circuit and one stage of radio-frequency amplification before the converter tube. Thus inherently, amplification as well as selectivity and image suppression is obtained in this apparatus itself.

The unit, besides providing preamplification, combines the functions of a preselector and all-wave converter. Then it goes one step further and also allows remote control if desired. It will be noted from the schematic diagram (Figure 34) that it is a complete unit in itself containing its own power supply and hence may be placed at some distance from the receiver with which it is used. Unlike the common converter, it covers the *long-wave broadcast band as well as the short-waves!* Thus, the receiver proper is tuned to 550 K.C. and then left entirely alone.

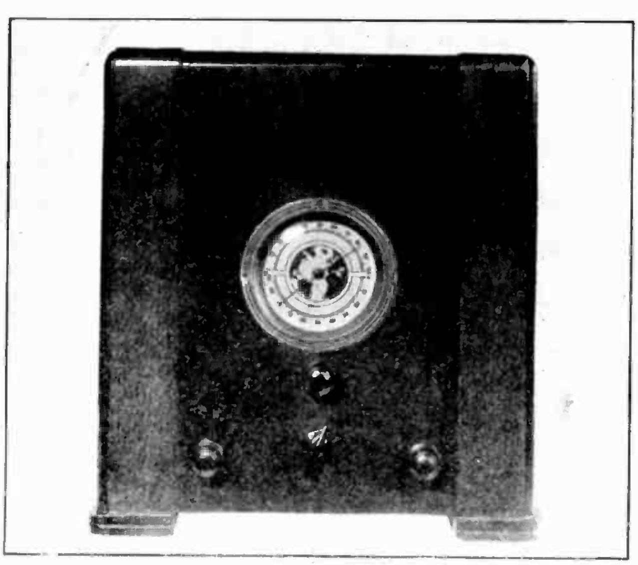
While the unit is so designed that it may be used with any receiver, from the lowly one-tube regenerator up to the most elaborate "super" with preamplification, it is of particular interest when used in combination with a superheterodyne—and it doesn't necessarily have to be a very good one either—to provide *double superheterodyne reception*. This results in double frequency-conversion and extremely fine selectivity.

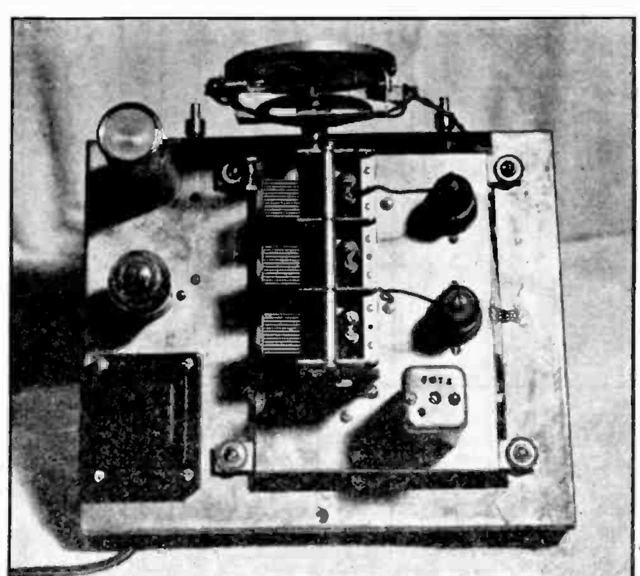
The unit itself gives such great preamplification that it is not necessary to use much gain in the intermediate amplifier of the original superheterodyne, and it can thus be adjusted and left at a point well below its own noise level.

A socket connection for plugging in the broadcast receiver is provided in the rear of the chassis so that the "off-and-on" switch will control both units. The only other connection between the two units is a lead which carries the intermediate-frequency currents from the transformer output to the antenna post of the broadcast receiver. This does not have to be shielded except in the case where a local station has a broadcast frequency near 550 kilocycles.

Figure 31—Below

Figure 32—Right





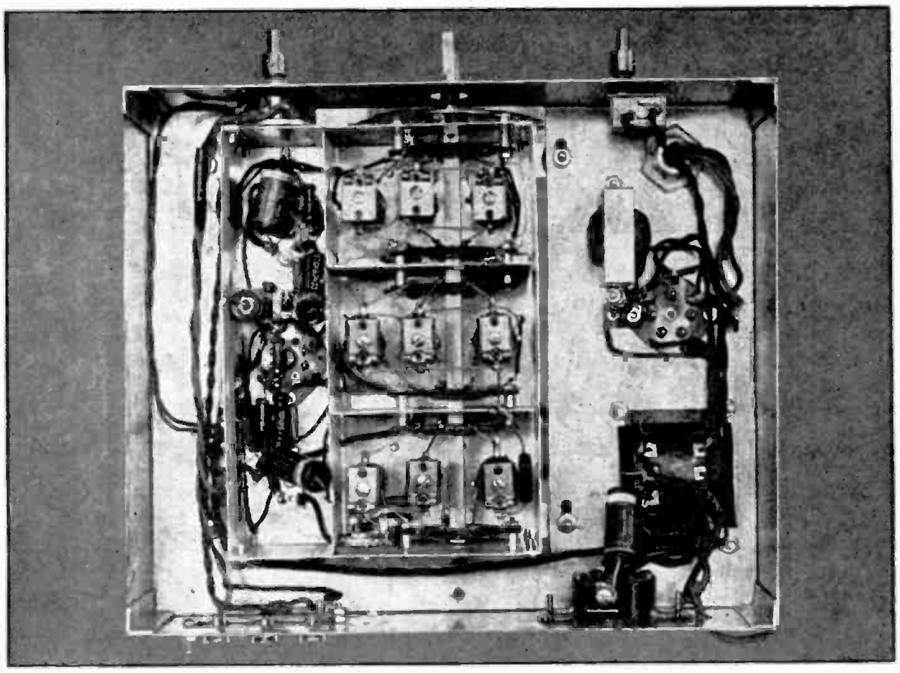


Figure 33

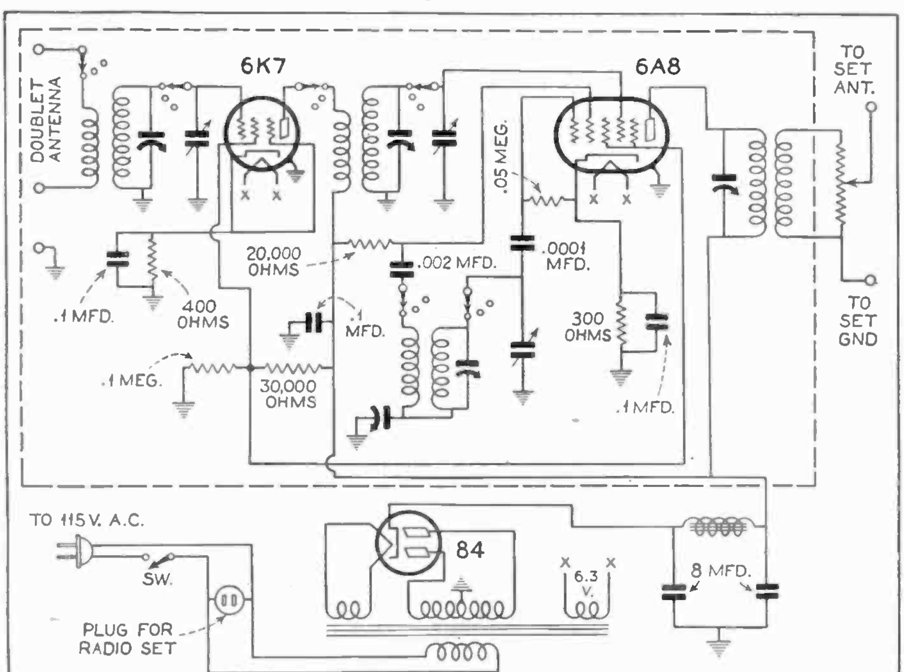
In such a case shielding is necessary so that broadcast stations will not be picked up on the lead between the receiver and the converter. Generally it is not necessary to ground the two units together, as the lighting circuit performs this operation satisfactorily. In all cases, however, it is advisable to determine whether or not a direct ground connection between the two is necessary. If there is any hum in reception, reversing the A. C. plug will remedy it.

Covers Three Bands

The unit covers a frequency range from .56 to 18 megacycles in three bands. Band No. 1 has a range from 5.6 to 18 mc.; band 2 from 1.7 to 5.7 mc.; and band 3 from .56 to 1.84 mc. The three sets of three coils each are placed in a tuning catacomb with shields separating the antenna, r.f., and oscillator coils. Coil-switching is employed and the switch blades are mounted in the same catacomb as the coils. The switching is so arranged that all coils in the tuning catacomb, not being employed in the circuit, are automatically short-circuited. This applies to primary and tickler as well as secondary windings. Thus, dead spots are entirely eliminated which might be caused by coil absorption.

A 3-gang tuning condenser is mounted on top of the coil catacomb as shown in Figure 32. Each of the individual coils has its own trimming condenser so that correct alignment may be obtained on all bands. The 6K7 tube is used as an r.f. amplifier while the 6A8 is used as an oscillator mixer. The 6A8 metal tube is somewhat better as an oscillator mixer than the corresponding glass tube 6A7, for not only is its conversion conductance greater but it is apparently considerably quieter in operation.

Figure 34



All resistors, condensers, etc., associated with these tubes are mounted in the tuning catacomb of the Tobe P.C.A. Tuner which may be obtained as an integral unit.

The tuned antenna circuit and the r.f. amplifier have other functions besides increasing overall selectivity. One of these functions is what is known as image suppression. It is generally known that image frequencies appear on any superheterodyne if the incoming signal is allowed to produce a voltage on the grid of the mixer tube, for a signal will be received whenever the difference between the incoming signal and the signal produced by the oscillator gives the intermediate frequency. Consequently, if the oscillator is tuned over a frequency range of twice the intermediate a repeat spot will be obtained. By employing a tuned antenna circuit and a stage of radio frequency amplification an appreciable voltage will only be produced on the grid of the mixer tube when the antenna circuit and r.f. amplifier are tuned to the incoming frequency.

Another function of the tuned antenna circuit and stage of r.f. amplification is its ability to increase the signal-to-noise ratio. It has been found in superheterodyne design that if the intermediate amplifier is run at a low level and high gain is obtained in the r.f. amplifier preceding the mixer tube, that a material reduction in noise for a given amount of signal is obtained.

The parts for this unit may be obtained in kit form and assembled in less than two hours as all the wiring has been done on the tuning catacomb, r.f. amplifier, and oscillator mixer tubes. Consequently, the set-builder has only to mount the apparatus, wire the power supply, volume control, switches, etc.

Construction Details

The first step in the construction of the complete unit is to mount the socket for the 84-type rectifier tube, the power transformer, choke, filter condenser, 110 volt outlet plug switch and volume control on the main chassis. When this is done the power supply should be completely wired before the tuner is placed in position. This tuner is mounted on soft rubber grommets which not only insulate it from the chassis but also give it a cushioning effect. The tuner then should be grounded to the main chassis at one point only. There are only six connections other than a ground that need to be made to this tuner. Two of these are for the filament supply; two for the doublet, or plain antenna and ground; one for the plus B; and one for the output volume control.

The photographs, Figures 32 and 33, show where the various parts are placed. The unit is then completed and ready to attach to any radio set. This is done simply by connecting the output to the antenna post of the receiver. The 110-volt plug from the original receiver is then plugged into the receptacle provided for this connection on the converter, whereupon the "off" and "on" switch of the latter will control both units. A doublet antenna may be used or, if an ordinary antenna is used, the doublet connection should be grounded to the chassis. The main receiver should be set for a frequency of 550 K.C. with some degree of accuracy, for if the intermediate frequency is a considerable amount off, the tuning unit will not track accurately over the band.

A tuned impedance-matching output transformer is used between the plate of the 6A8 mixer oscillator tube and the output of the converter, which is connected to the radio receiver. This transformer has been tuned for a frequency of 550 K.C. but the frequency to which it is tuned may change slightly when its secondary is connected to the broadcast receiver. Consequently, it will be necessary to slightly adjust the tuned circuit. This may be done conveniently by setting the volume control at the point of maximum response (turn clockwise). Set the band selector switch on band 2. Disconnect the antenna from the converter. Turn the volume control on the broadcast receiver so that a slight hiss is heard in the loudspeaker. Adjust the condenser in the output transformer for maximum hiss (this condenser is adjusted by means of a screw-driver through a hole in the top of the output-transformer can). It then is in operating condition. It will be found that for average reception the broadcast receiver should be set for a sensitivity of about 50 to 100 microvolts. The lower the volume control is set on the main receiver the better the signal-to-noise ratio on the whole combination. Of course sufficient sensitivity must be retained for the desired volume.

As stated before, the tuner itself is carefully aligned and tracked at the factory, consequently none of the trimming or padding condensers should be adjusted except in rare cases. Tracking and aligning are identical with the process followed in tracking and aligning the Tobe Super-Tuner in the Browning 35 All-Wave Receiver, and is completely covered in literature on that set.

Blueprints, including a full-size picture wiring diagram showing exact placement of each wire in assembling this converter, have been prepared by our Technical Staff especially for the benefit of our readers who have never built or assembled a set before. These may be obtained by sending 25 cents in cash or U. S. postage to RADIO NEWS, Blueprint Department, 461 Eighth Avenue, New York City.

List of Parts

- 1 Tobe three band P.C.A. tuner (the dial, escutcheon, and knobs are included with this tuner).
- 1 power transformer 250 volts at 20 M A with 6 3/10 volts filament winding to carry 1 Amp. United Transformer Co.
- 1 10 to 12 henry 400 ohm choke. United Transformer Co.
- 1 5 prong socket
- 1 100 volt receptacle
- 1 line cord
- 1 single pole rotary 110 volt switch
- 1 10,000 ohm volume control—Centralab
- 1 chassis and antenna strip (Tobe)
- 1 .05 mfd. 300 volt condenser. Tobe M S O
- 1 double 8 mfd. 500 volt Electrolic condenser knobs for volume control and switch. Tobe 628A

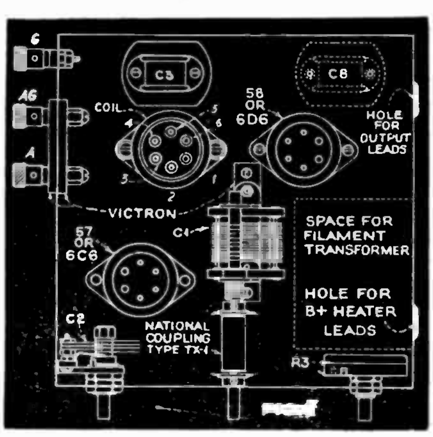
All-Wave Pre-Selector

THIS compact unit which may be connected ahead of any type of receiver, provides an additional stage of tuned r.f. amplification, with a separate regenerative tube to provide still further amplification when needed. Plug-in coils permit its use in any wavelength range.

The trend in designing highly sensitive receivers has been more and more during the past two years in the direction of more preselection and pre-amplification. A favorable signal-to-noise ratio requires that a relatively high signal voltage be applied to the converter tube. Unless this is done, maximum usable sensitivity cannot be obtained, regardless of the amount of amplification provided at the intermediate frequencies.

A number of receivers during the past year or so have incorporated two stages of two tuned r.f. ahead of the converter and these circuits have definitely proven the distinct advantages offered by a high degree of pre-amplification. In many cases DX'ers and short-wave listeners are using superheterodyne receivers which do not have sufficient pre-amplification. Naturally, they do not feel that they can afford to discard the receivers, but on the other hand, they are interested in obtaining maximum usable sensitivity. A good preselector such as the unit described here offers the solution of this problem. It can be constructed at home and has proven highly successful with both t.r.f. and superheterodyne receivers.

Figure 35



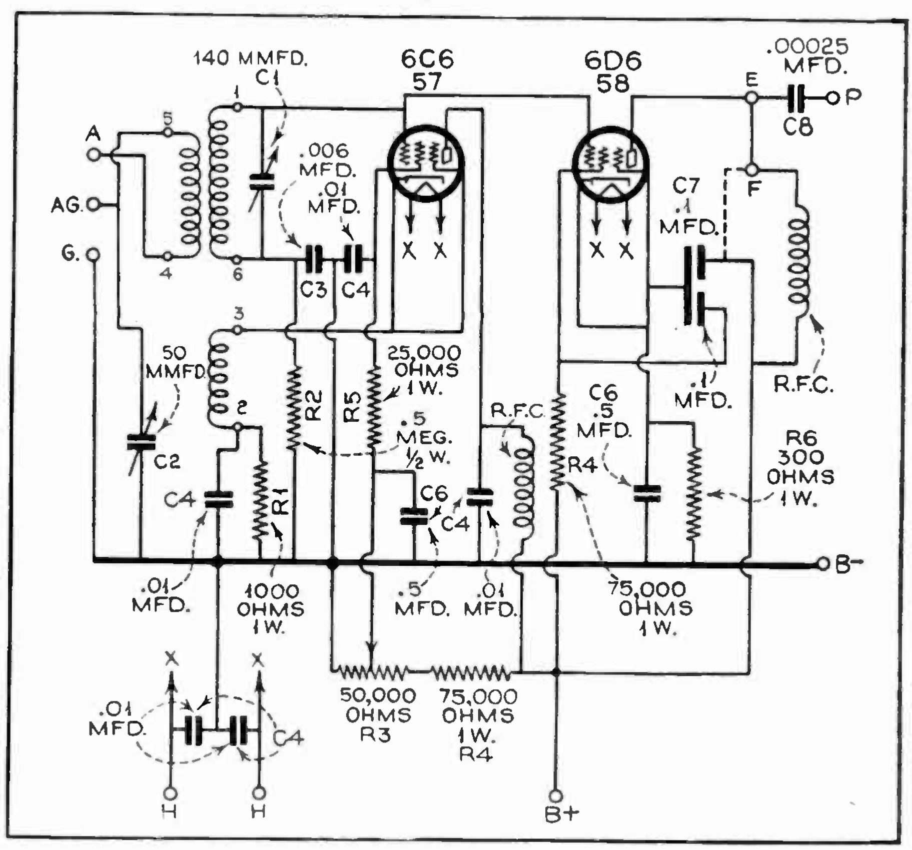
Heretofore, most preselectors have employed a single regenerative r.f. tube and as a result have for the most part been cranky in operation and extremely critical so far as antenna coupling is concerned. If antenna absorption or improper design resulted in the inability to bring the tube up to a point of active regeneration, such preselectors have resulted in actual loss of signal strength at the particular frequencies where this condition obtained.

For this and other reasons it is important that the functions of amplification and regeneration be handled by two separate tubes. In this way the amplifier tube always functions as an amplifier so that increased signal voltage is obtained at all frequencies. Then, when still further sensitivity is required for weak signals, the regeneration provided by the separate tube is brought into play to provide an extremely high degree of additional amplification as well as decidedly improved selectivity.

The input circuit shown in Figure 36 can be used only with ordinary "L" type antennas with a single lead-in wire. It is flexible, however, and can readily be adjusted for special antenna systems, as will be described later. Since the rotor of C2 is grounded, it can be mounted on the front panel.

Unless certain precautions are taken a regenerative r.f. stage is apt to develop undersirable characteristics, especially when

Figure 36



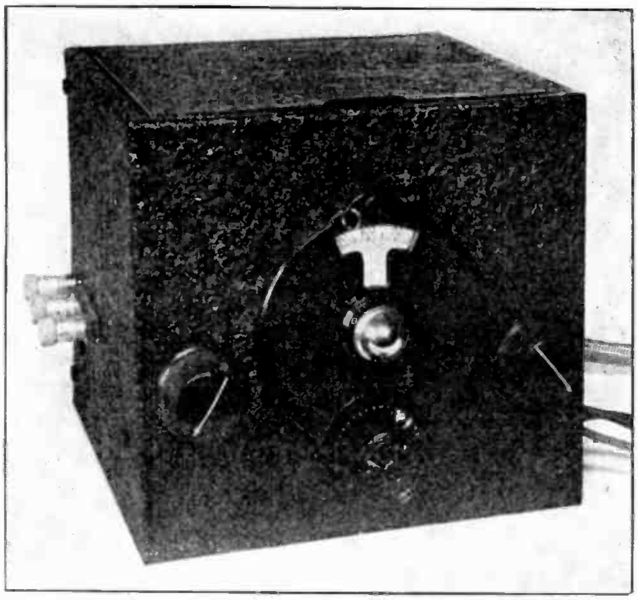


Figure 37—

Front view of the completed preselector which in tests showed a veritable "kick like a Missouri mule."

coupled to a regenerative receiver. One of these precautions is to insulate the rotor of the tuning condenser C1 from the chassis and dial. R2 and C3 were also found essential for maximum isolation. A metal cabinet, as shown in Figure 37, solves the shielding problem most adequately. A tube of the 58 or 6D6 type is used as the amplifier to prevent cross-modulation. The regenerative tube may best be a 6C6 or a 57.

The tuning condenser, C2, is fastened to a piece of victron, (bakelite will do) and this assembly is mounted on two pillars so that the rotor will be insulated from the sub-base. The half-inch bushings supplied with Hammarlund sockets were just the right height for lining up the condenser shaft with the bushing of the tuning dial.

Short Leads Stressed

If the layout in Figure 35 is approximated the r.f. leads will be quite short and the efficiency of the coil will not be impaired by the shielding. The components beneath the sub-base should be arranged so that the important leads will be short, and all the r.f. grounds should be made at one point on the sub-base. Heavy copper wire should be used to connect this ground point to the ground post. If the heater current for two tubes would overload the power transformer in the main receiver, mount a small filament transformer in the space indicated by dotted lines in Figure 35.

The Hammarlund plug-in coils were selected because of their efficiency and reasonable price; nevertheless there is no apparent reason why the constructor should find it difficult to wind his own coils, or to adapt other makes or types.

A choke-capacity coupled output is indicated in Figure 36, but if the receiver input is designed for antenna systems with two lead-in wires, that is, if it has a separate and insulated antenna coil, leave out the connection between points marked E and F, connect C7 as shown by the dotten line and connect the out-put leads to E and F. A twisted pair may then be used for the output leads, but they will have to be as short as it is possible to make them. With the choke-capacity coupled output it will usually be found desirable to use a shielded lead. In that case, a single-conductor cable of the low-capacity type with a ½-inch outside diameter should be used. By connecting one end of the shield to the ground post of the receiver and the other end to the ground point of the pre-selector, the shield will serve as the ground and B-lead. The B plus lead may be connected to any point on the filtered side of the receiver's plate supply, where a voltage between 150 to 250 volts is obtained.

The operation of this pre-selector is very simple. While "fishing" for signals little or no regeneration should be employed, C2 is set for maximum capacity, and the circuit tuned approximately to the center of the band to be explored. Since C2 affects the tuning its best setting for each coil-range should be determined, noted, and duplicated after the signal of a desired station has been tuned in on the receiver. Then, the dial of the pre-selector is adjusted for maximum volume.

Receiving conditions and the preferences of the operator will determine whether or not regeneration should be used. Adjusting the regeneration control to the best setting will increase the sensitivity and selectivity to a surprising degree. The tuning becomes quite critical and it is good practice to tune for maximum volume after each adjustment of the regeneration control. Every regenerative set has a few peculiarities of its own, and a little patience and practice may be necessary to fully realize the advantages of r.f. regeneration. In general the considerations applicable to a regenerative detector also apply to a regenerative r.f. stage except that oscillation is undesirable even for CW reception.

To adjust the input for special antenna systems with two lead-in wires disconnect C2 from AG, connect the antenna leads to A and AG, and then remove turns from the primary until oscillation is obtained over the entire tuning range of the coil at maximum screen-grid voltage. The turns should be removed from the top of the winding, that is, from the end connected to terminal No. 5.

Parts List

C1—Hammarlund midget condenser type MC-140M, 140 mmfd.
C2—National midget condenser type SSS-50, 50 mmfd.
C3—.006 mfd. mica condenser
C4—.01 mfd. mica condenser (5)
C6—.5 mfd. paper condenser (2)
C7—.1 mfd. paper condenser (2)
C8—250 mmfd. mica condenser
R1—1,000 ohms, 1 watt metallized
R2—500,000 ohms, ½ watt metallized
R3—50,000 ohms potentiometer
R4—75,000 ohms, 1 watt metallized (2)
R5—25,000 ohms, 1 watt metallized
R6—300 ohms, 1 watt metallized
RFC-Hammarlund r.f. choke type CH-8 (2)
1 set of 4 Hammarlund 3-circuit, 6-prong plug-in coils
2 Hammarlund tube shields, type TS-50
3 National Steatite 6-prong sockets
1 National dial, type B
1 National cabinet, type C-SRR (plain)
1 National coupling, type TX-1
2½" x 2" pieces of victron (any low-loss insulation from 1/16" to 3/16" thick will do)
3 binding posts
1 3/16" x ½" x 3" piece of bakelite, for mounting the tuning condenser

Amateur Communication Receiver

THIS particular receiver is the result of many different models of high-frequency supers built and tested ever since the first single-signal receiver made its appearance. Although it has only eight tubes and is simple in design and construction, this receiver is proving its worth daily in leading amateur stations. It would be well to note first the standards set for this receiver. These are: stability, consistency of operation and a high signal-to-noise ratio as foremost—and it is in these respects that some receivers fall down on the job. The first named requirement is obtained by using *only* air-spaced tuning and trimming condensers throughout, single purpose tubes, low-gain high-bias audio stages, elimination of all unnecessary frills, good shielding, and a system of wiring which makes possible the greatest isolation of individual stages. What is probably one of the greatest contributions to easy tuning and precise logging is the new National PW type of gang-condenser and dial. The 500-degree precision dial and isolated rotor condensers of this unit form the basis of a high-gain, stable high-frequency section with band-spread tuning for all frequencies. A very high signal-to-noise ratio is obtained by realization of some of the fundamental super-heterodyne design principles—and their proper utilization. One of these principles is that of dividing the total receiver gain properly between the three frequencies used in a superhet—namely signal (high) frequency, intermediate-frequency (465 kc.) and the audio-frequency band. Excessive gain on anyone of the latter two frequencies gives an unnecessarily large amount of noise. These three frequencies are represented respectively by the pre-r.f., detector and high-frequency oscillator—the 1st and 2nd i.f. stages, diode section of the 55 second detector and beat oscillator—and the triode section of the 55 tube and the 59 output tube.

Regeneration is used in the pre-r.f. stage, with the cathode-coupled circuit for greatest

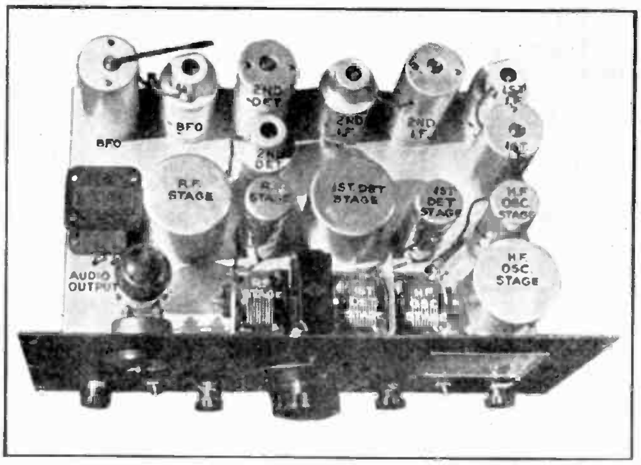


Figure 38

Figure 39

stability and smoothness of control. This regenerative pre-r.f. stage is the equivalent of two ordinary stages and solves quite adequately the problem of getting high pre-r.f. gain, which in turn is the all-important link in obtaining our much desired high signal-to-noise ratio. This regenerative pre-r.f. stage also solves another problem encountered in superhet receivers—that of image-frequency interference.

In order to keep the pre-r.f. gain high at all times no a.v.c. is used on either the pre-r.f. or 1st detector, being confined alone to the two i.f. stages. The high-frequency oscillator is of the standard electron-coupled type. The coupling to the screen-grid of the 1st detector from the oscillator has been found the best of the many methods tried.

The design of the i.f. amplifier is more or less usual except for the method used for obtaining selectivity sufficient for single-signal c.w. reception. Instead of the more complicated crystal filter usually used for this purpose we use merely a regenerative 1st i.f. stage. This regeneration is also obtained by the cathode-coupled method. A simple 3-turn cathode coil, wound next to the grid coil in the 1st i.f. transformer and a variable cathode voltage control do the trick. The degree of selectivity obtained through this regeneration approaches closely that obtained by use of a crystal.

The strictly class A audio system used is the final step in securing really enjoyable musical results on the foreign broadcasters. The most important feature in the construction of this i.f. amplifier section is the use of the Hammarlund air-tuned i.f. transformers. Using regeneration to obtain high selectivity in the i.f. section means that the tuned circuits must be kept exactly on the peak of resonance at all times, and only good air-tuned intermediates will do this.

Layout of the Set

The knob just to the right of the tuning-dial is a screen voltage control on the pre-r.f. tube and controls both the pre-r.f. gain and regeneration. The knob furthest to the right on the panel is a grid bias (or cathode) voltage control on the 1st i.f. stage. This quite satisfactorily takes care of both the i.f. gain and 1st tube regeneration (selectivity). The separate audio gain control on the extreme left of the panel, as shown in Figure 39, permits of adjustment of speaker output without disturbing either the signal-to-noise ratio, image rejection or degree of selectivity previously obtained by proper adjustment of the other two gain controls A switch mounted on the audio gain control cuts "off" the B voltage.

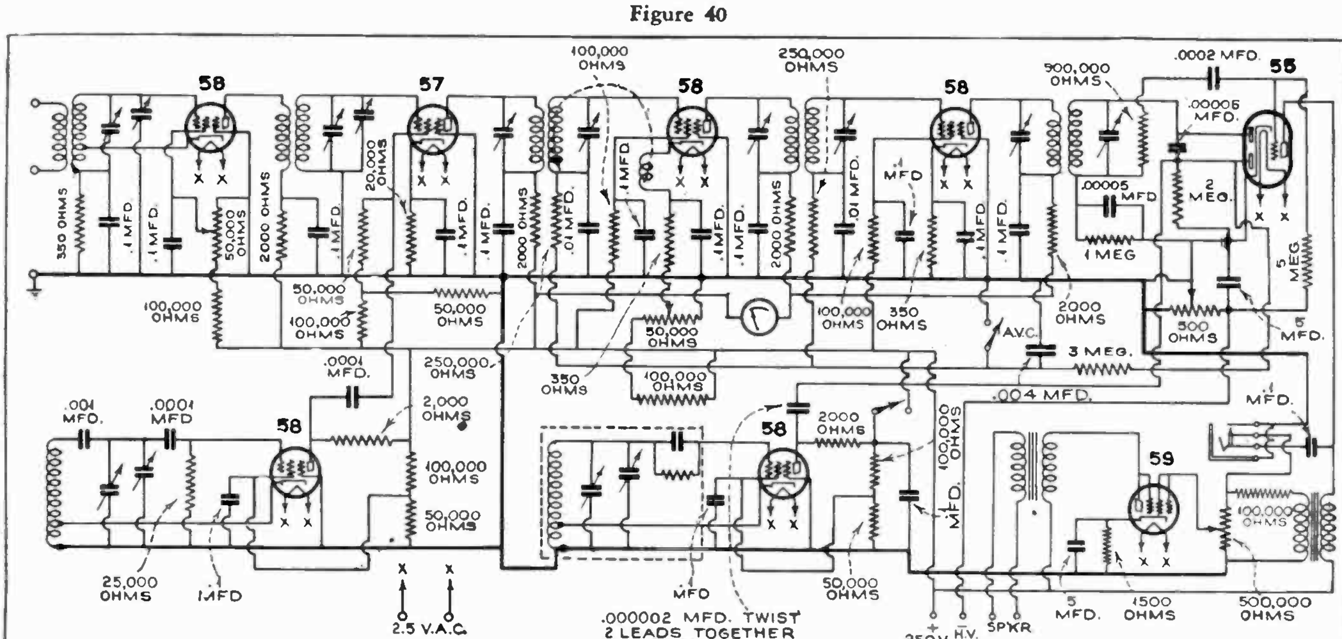
The beat-frequency oscillator stage is quite ordinary in design and is coupled capacitatively to the diodes of the 2nd detector.

The circuit diagram is given in Figure 40. The layout of the 2nd detector circuit, both diode and audio triode sections, and the a.v.c. system should be very carefully followed. It has had careful and painstaking design and testing.

The mechanical design and construction are next of interest. The band-spread system used is properly a point of mechanical interest. As said before, the 500-degree, 12-foot equivalent-scale-length dial permits of good band-spread over the entire range of all sets of coils. There are four coil sets used. They cover the ranges shown in the coil-data table (Figure 41). As will be noticed there is an amateur band at both ends of every range. Although the number of dial degrees for each amateur band appear to be small, the spread on the dial is actually much greater. This is because each dial division is a full quarter-inch wide, so that, for instance, the 25-degree spread of the 20-meter amateur band is a full half-dial wide, and equal to a 100 degree spread on any ordinary dial.

The air-trimmer condensers mounted in the coils eliminate the neccessity for auxiliary trimmers on the panel and provide the means for precise relogging of any station when shifting sets of coils. The only auxiliary tuning control on the panel is the small pre-r.f. trimmer on the left of the main tuning dial. The combination of varying antenna load and extreme sharpness of

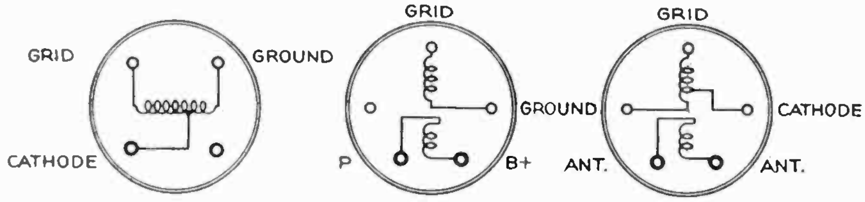
Figure 40



COIL DATA TABLE

BAND		10-20 METERS TURNS	RIBS	20-40 METERS TURNS	RIBS	40-80 METERS TURNS	RIBS	80-160 METERS TURNS	RIBS
R.F.	PRIMARY	3	1	6	1	6	1	12	1
R.F.	SEC. TAP	1	5	2	5	3	5	6	5
	SEC. GRID	2	8	7	3	16	3	40	3
DET.	PRIMARY	3	1	4	1	13	1	15	1
	SEC.	2	7	7	8	17	8	42	8
OSC.	TAP	USE 20M OSC.		2	5	3	5	6	5
	GRID			7	7	16	7	40	7
		GRID WINDINGS SPACED ± TO DIAMETER OF WIRE.							

COIL TURNS ABOVE ARE FROM ONE TAP TO THE NEXT. FOR INSTANCE, THE SECONDARY OF THE 20-40 METER R.F. COIL HAS A TOTAL OF 9 TURNS AND 8 RIBS, *NOT* 7 TURNS AND 3 RIBS.



OSCILLATOR DETECTOR PRE-R.F.

ABOVE ARE BOTTOM VIEWS FOR BOTH COILS AND COIL SOCKETS.

Figure 41

tuning, due to regeneration, makes it impossible to track the pre-r.f. stage exactly over an entire coil range. The degree of change necessary with this trimmer is actually quite small, so that it can be set and left for any particular amateur or broadcast-band being received. With it, changes in the antenna can be taken care of right on the front panel.

Constructional Details

Several points should be emphasized before construction of this amateur communications receiver is begun. They are: the necessity of using only those parts specified; keeping the exact layout of parts as shown; and making no changes in either wiring diagram or the single-ground-point, short-lead wiring system to be described.

Before the first i.f. transformer is mounted it should be disassembled and the cathode coil wound. Three turns of No. 30 wire should be wound on the dowel about a quarter inch above the grid coil. Two small holes through the dowel will hold the winding in place. Space these holes a little so that the coil can be moved up and down later for correct adjustment. The two leads from this coil should be cut several inches longer than necessary to come out one of the holes in the bottom of the can and a piece of "spaghetti" shoved up over them almost up to the coil.

Adjusting the Receiver

In lining up and adjusting the receiver the i.f. amplifier should be lined up first using a 465 kc. test oscillator. The cathode coil leads should be tried connected both ways to find which way the 1st i.f. stage oscillates best. After this is done it will probably be found that the oscillation point on the cathode regeneration control comes either too far down or possibly can not be reached with the control full on. The 3-turn cathode coil should be slid up or down until the oscillation point is reached with the control turned from two-thirds to three-quarters on. Remember that all i.f. transformer trimmers must be exactly in resonance for proper regeneration. The a.v.c. switch should be turned off during this adjustment.

We can now take the final step and adjust and track the high-frequency coils. With the antenna connected we will find that although not lined up properly some signals will still come in. Tune in a signal near the high-frequency (500 degree) end of the range and line up exactly the r.f. stage panel trimmer knob and the detector coil trimmer. Then swing the dial to the low-frequency (0 degree) end of the range and tune in a steady signal there. Do *not* touch either the r.f. or detector trimmer while tuning in this second station. After this station is tuned in, reset the detector trimmer to proper resonance. If this trimmer must be *decreased* in capacity for resonance it means that the detector circuit is tuning too wide a range and must have the coil inductance reduced. This is done by spacing the turns of the grid winding further. If the trimmer capacity must be increased in capacity the range is too small and the inductance must be increased by moving the turns of the grid coil closer together. After each adjustment of the coil turns check the tracking again until the detector trimmer does no have to be changed from one end of the band to the other. All the trimmers should now be re-adjusted so that the coil range will cover the amateur bands at either end. Always remember that the oscillator trimmer must be set on the high-frequency beat for proper tracking.

The same process should be gone through with the r.f. coil of each set. Due to the antenna load and regeneration, we will not be able to keep this r.f. panel trimmer at exactly the same setting through the entire dial swing, but we should adjust the coil so that the control will tune the r.f. stage to resonance at any place on the dial. Another factor entering the adjustment of the r.f. coil is the degree of regeneration to be obtained. Spacing the grid coil turns further apart at the ground end while moving them closer at the grid end to keep the same inductance will reduce the degree of regeneration, and vice-versa. The oscillation point on the r.f. regeneration control should occur in the range from one-half maximum to full. A small trimmer condenser connected externally in the antenna lead will permit of the easiest adjustment of antenna load, which will in turn determine the oscillation point on the r.f. regeneration control. These adjustments are really easier than they sound. The coils can now be doped to hold the turns in place permanently. Use a good lacquer, such as the Victron Q-Max No. 3.

The A. V. C. Circuit

To check the a.v.c. circuit before placing the receiver in service just watch the tuning meter while tuning in a steady carrier with the a.v.c. switch turned on. It should read nearly maximum when no signal is turned in. With the carrier tuned to resonance it should dip, the amount of the dip depending upon the strength of the carrier. A strong signal should knock it down to about two to four mils. The adjustment of the coupling from the beat oscillator to the diodes should be adjusted for best single-signal effect. This "coupling condenser" consists of a pair of insulated wires twisted together for about two inches. Cutting off a little of either wire or loosening the twist will reduce the coupling and vice-versa. This beat oscillator coupling should be adjusted with the a.v.c. switch turned off, as no single-signal effect will be obtained with a.v.c. on—in fact the oscillation point will not be reached when using the a.v.c. This condition is quite desirable for 'phone or broadcast reception.

These instructions should cover all the problems that may be encountered during construction and adjustment of this receiver. As has been said before, a strict adherence to these instructions will produce a receiver which will give the builder the fine performance he should rightly expect of it. The stability of operation and exceptionally low noise level should prove a boon to the operator whether he be an amateur or short-wave listener—or a commercial operator.

Parts List

1—Three-gang tuning unit National PW type
1—25 mmfd. Cardwell Trimmair
7—25 mmfd. Hammarlund APC type trimmers
2—5-prong Hammarlund isolantite coil sockets
1—4-prong Hammarlund isolantite coil socket
1—4-prong wafer socket
7—6-prong wafer sockets
1—7-prong wafer socket
3—Hammarlund coil shields
7—58 type tube shields
1—double circuit phone jack
1—Leeds interstage audio transformer, type AU-107
2—465 kc. i.f. transformers, Hammarlund, air-tuned
1—465 kc. i.f. transformer, Hammarlund, center-tapped, air-tuned
1—465 kc. b.o. transformer, Hammerlund, air-tuned
5—binding posts with insulating bushings
4—knobs
2—s.p.s.t. toggle switches
1—0-10 mil. meter, 2-inch diameter
3—Hammarlund SW-4 coil forms
8—Hammarlund SW-5 coil forms
3—350 ohm, 1 watt resistors
6—2,000 ohm, 1 watt resistors
1—20,000 ohm, 1 watt resistor
1—25,000 ohm, 1 watt resistor
4—50,000 ohm, 1 watt resistors
9—100,000 ohm, 1 watt resistors
2—250,000 ohm, 1 watt resisors
1—500,000 ohm, 1 watt resistor
1—1 meg., 1 watt resistor
1—2 meg., 1 watt resistor
1—3 meg., 1 watt resistor
1—5 meg., 1 watt resistor
1—500 ohm, 10 watt resistor
1—1500 ohm, 10 watt resistor
1—500,000 ohm potentiometer
2—50,000 ohm potentiometers
14—.1 mfd., 400 v., paper condensers
2—.01 mfd., 400 v., paper condensers
1—.004 mfd., midget, mica condenser
2—.0001 mfd., midget, mica condensers
1—.0002 mfd., midget, mica condenser
2—.00005 mfd., midget, mica condensers
2—5 mfd., 50 v., electrolytic condensers
1—19"x8¾" crackle-finish specially drilled panel Bergen Radio Lab.
1—11" x 17" x 2½" cadmium plated specially drilled chassis—Bergen Radio Lab.
1—black crackle-finish cabinet—Bergen Radio Lab.
1—set of construction plans—Bergen Radio Lab.

EXPERIMENTAL RADIO DATA

Making Your Own Relays

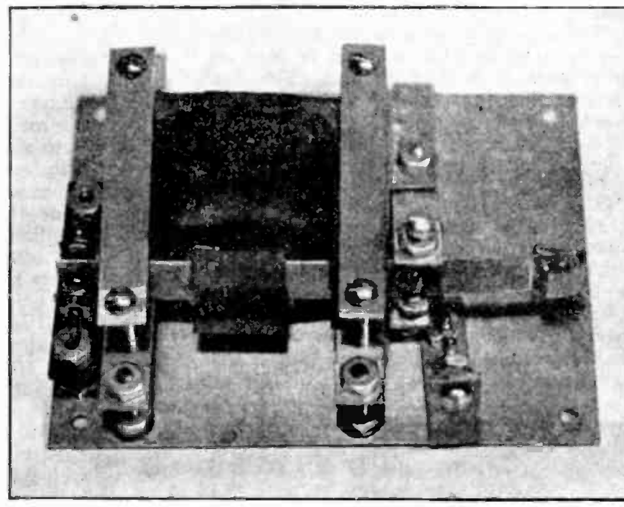
EXCELLENT relays, including those which will be actuated by a current of 1 milliampere, can be easily made from the windings and core of an audio transformer or choke. Only a few common tools are required and the materials are easily obtainable. The work does not require skill and if carefully done the relay will give excellent results. This is largerly due to the very efficient electro-magnet formed by the transformer core and coils.

A transformer with an "E" type core is the most common type and therefore is used in the relay described here. The electromagnet assembly consists of the core, coil and mounting. The transformer is taken apart and the core and coil assembled with all of the "E" laminations in one position. The "I" laminations are not used in this assembly. The core is well designed and adds greatly to the efficiency of the electro-magnet by providing a good path for the magnetic flux. With a given core and armature arrangement and spring tension the sensitivity of the relay depends on the number of ampere turns of the coil. If the resistance of the circuit is very high, and the current small, as in the plate circuit of some vacuum tubes, highest sensitivity is obtained with the greatest number of turns of fine wire. In most circuits the amount of current to be carried and the amount of resistance that may be introduced into the circuit limit the size of wire. An audio transformer secondary will carry at least 5 ma. and the primary 10 to 15 ma. continuously. If the current is intermittent, as in a keying relay, more current may be carried safely. The maximum current depends entirely on the heating of the windings. Ordinarily currents will be well within the maximum limits, but in certain cases, as when the windings are parallelled this matter must be watched.

If the relay is to close on the smallest current through the windings, they should be connected in series. If it is to close on the least voltage across the windings they should be connected in parallel. This choice adds greatly to the value of such relays in experimental applications.

Figure 42—

Here is an example of what can be accomplished through the use of an old transformer. Under test, it operated dependably on 0.8 ma.



Construction Details

The electromagnet assembly is best mounted by means of clamps made from non-magnetic material. The armature should be made from material that is a good carrier of magnetic flux. For most purposes ordinary sheet iron is entirely satisfactory. Soft iron is much better than hard iron. in small relays a single strip of heavy sheet iron such as No. 20 is satisfactory. For heavy relays extra strips the length of the pole pieces may be riveted on or the left-over "I" laminations may be used. Figure 43 shows the arrangement of core, armature and contacts; the manner of mounting is illustrated in the photograph.

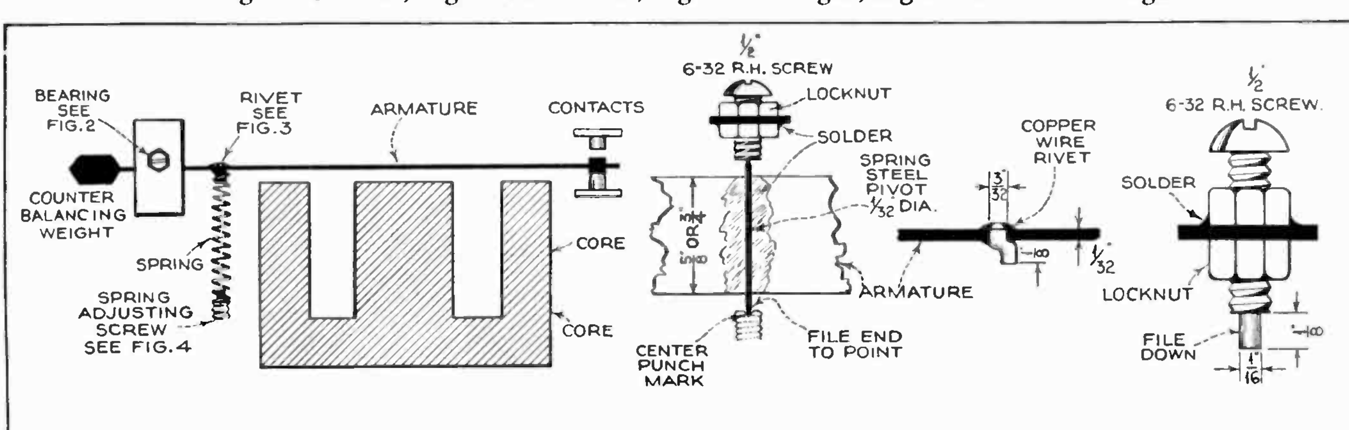
In delicate relays where only a little tension is used on the armature it is desirable to counter-balance the armature to minimize the effect of vibration. A weight made of solder is satisfactory for this use. The armature should be balanced in all positions.

Mounting the Armature

A simple yet good bearing may be made by soldering a piece of hard steel wire, a little longer than the width of the armature and sharpened to a point on each end, to the armature. These points rest in deep center-punch marks in the ends of two screws which are adjustable and can be locked in place by means of locknuts; this is illustrated in Figure 44.

Springs may be taken from old automobile tire valve insides. The spring may be held in place by a rivet made from No.

Figure 43—Left; Figure 44—Center; Figure 45—Right; Figure 46—Extreme Right



12 wire and riveted to the armature (as shown in Figure 45). It should project about one-eighth inch from the bearing.

The adjusting screw can be made by filing down about one-eighth inch of the end of a machine screw. (See Figure 46.) If a nut is put on the screw before filing any damage to the threads will be removed when the nut is taken off.

If the relay is to open and close rapidly the armature should not be too heavy and the spring tension should not be too light. In cases where the spring tension is great enough it may be desirable to eliminate the counterweight.

When the contacts are connected directly to the armature the spring carries the current. The bearings should not carry current. Stranded wire carries the current in case of insulated contacts.

The stationary contacts also act as stops for the armature. Contacts may be obtained from automobile supply stores. The contacts used on gas engines with make and break ignition are good.

Compact 5-Watt P.A. Amplifier

Here is an extremely compact portable sound system using only two amplifier tubes which operates from a 6-volt storage battery and is capable of delivering over 5 watts Class A undistorted power output. The type 6B5 tube used in the power stage makes possible the high power output and simplicity and economy of circuit design

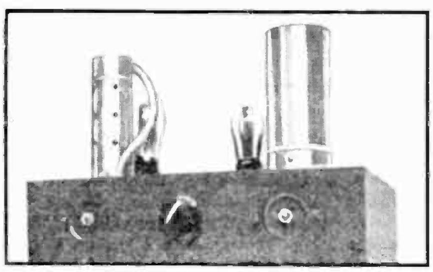
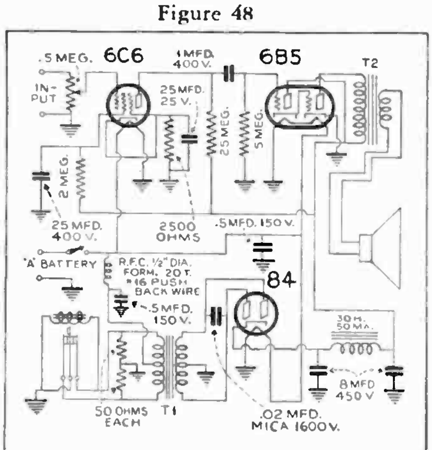


Figure 47

not obtainable with any other type of power tube in a comparable P. A. system. The tube has two triodes contained in a single glass envelope, the output of the first section of the tube is direct-coupled, internally to the second triode.

The circuit diagram in Figure 48 shows a 6C6 used as a high-gain pentode in the first stage, the output of which is resistance-coupled to the type 6B5 power tube. The power supply is of the vibrator type using an 84 tube as a rectifier. The power transformer is the kind employed in most

Figure 48



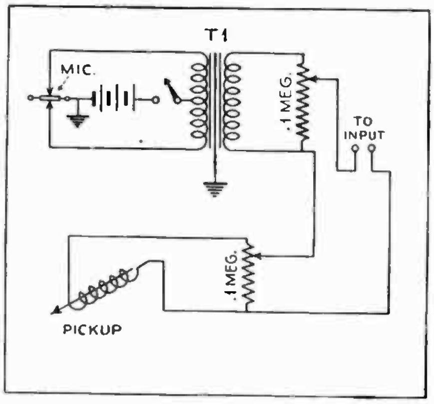


Figure 49

auto radio receiving sets having 7 tubes or more. This transformer can be bought from any distriubtor of auto radios or from the large radio mail-order houses. The best procedure is to use a vibrator matched to the power transformer, however, this is not absolutely necessary, and a good universal vibrator for the purpose is the Mallory type 53 or Radiart types No. 3260 or No. 3417. All other parts are standard. The power supply should be capable of delivering an output voltage of from 225 to 350 volts on full load. If desired, two 5-mfd., 150-volt condensers may be used in place of the two 50 ohm resistors shown connected across the primary winding of the power transformer T1.

Two individual input channels are provided in the mixing unit (Figure 49) one for a double-button carbon microphone and the other for a high-impedance phonograph pickup or a crystal microphone. It will be noted that each channel has its own individual volume control and there is a master control to the input of the first tube.

The mixing unit can either be connected directly to the amplifier input or it can be used as a remote unit and in this case a shielded cable between the mixer and the amplifier is recommended. This cable must be grounded to both units. It is extremely important to use heavy connecting wires from the battery to the amplifier and power unit.

Non-Slip Dial Cables

If the cord friction cable which drives a tuning dial has been stretched, or if the cable or pulley has been worn smooth, there will sometimes be slippage, resulting in a great deal of annoyance in tuning the receiver. This trouble is easily overcome by rubbing some powdered rosin on the section of the cable that travels over the drive pulley and also on the traction surface of the pulley. The friction will be much greater and the traction as originally intended. The idea can be applied with equal success to small pulley-driven, mechanized parts in remote control systems and photograph equipment or similar apparatus. This wrinkle is not very effective on metal wire cables.

Plug-In Coil Shields

One of the big drawbacks to the use of coil shields in home constructed short-wave receivers using plug-in type coils is the difficulty of obtaining easy access to the coils. This trouble can be easily overcome by adapting the shields to either of the plug-in arrangements shown in the drawing.

In the first method, Figure 50A, the fastening lugs, generally machine screws eyeleted to the side of the shield can, are filed down to make a snug fit into a pair of standard tip-jacks mounted on the chassis as illustrated. If the shields do not have fastening lugs, the second arrangement as shown in Figure 50B can be used to advantage. Two phone tips and two tip-jacks are used for this arrangement. The first thing to do is to cut 2 half circles at the

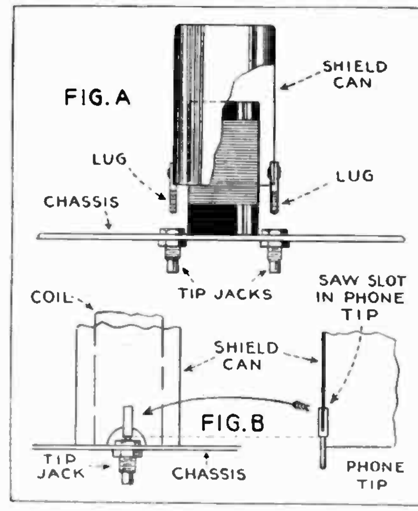


Figure 50

bottom of opposite sides of the shield can, just high enough to clear the tip-jacks. Then high enough to clear the tip-jacks. Then prepare the phone tips by slitting them at the top for possibly ¼ inch so they will slip over the shield in the cut-away portion as shown. To secure the tip, solder it to the can. The rest is self-explanatory.

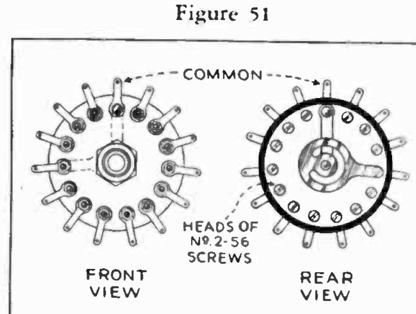
Home-Made Multi-Point Switch

Experimenters will be interested in this little kink for making a multi-point switch from a discarded Centralab type volume control. The accompanying sketch, Figure 51, clearly outlines the procedure for assembling the switch and no trouble should be encountered in its construction.

The first thing to do is to remove the back plate, then loosen the lock-nut in the front, which will loosen the contact arm assembly. The metal ring that rides on the carbon resistance strip should now be cut away with wire cutters. The carbon resistance strip is broken away from its two terminal studs and lifted out. An examination of the contact arm will show that a small wheel-like fiber plug is attached to the end of this arm. This is easily poked out with a screwdriver. The arm is then replaced in the case.

The switch shown has 14 taps not including the arm terminal. The number of taps or points will, of course, depend upon one's requirements. Alignment of the holes is accomplished by marking them through

Figure 51

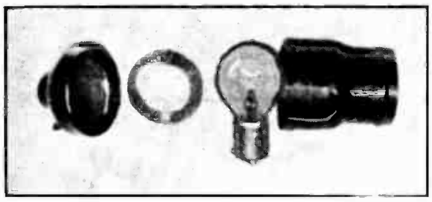


the hole on the contact arm from which the fiber plug was removed. The machine screws employed for the taps are size No. 2-56; one-half inch long and are inserted with the heads inside the case. On the outside of the case very small soldering lugs are inserted over the screw and they are tightened with the nuts.

Lamp for Photo-Cell Use

A small light source for use with photocells may be made from an old light socket case and a 6-volt headlight bulb.

By enlarging the chain or key slot in the case to accommodate the base of the headlight bulb, it will be found that the lamp can be enclosed in the case very neatly. A small concave metal disk may be inserted in the top of the case as a reflector and the whole unit held in a small clamp such as is sold for use on automobile dash-



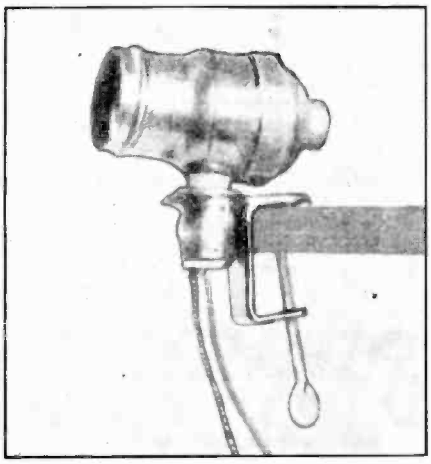


Figure 52—Top; Figure 53—Above

boards. If a concentrated spot of light is desired, a flashlight lens may be fitted on the front by means of an improvised wire support.

You can run the light source from a small transformer and will find this means of illumination much more convenient than an electric lamp.

Improving the All-Star Receiver

Owners of the All-Star All-Wave Senior receiver, which was described in the September 1934 issue of RADIO NEWS may be interested in the revisions that can be made in this circuit so as to obtain the additional features of automatic volume control, a tuning meter, and manual audio volume control. With the assistance of these circuit revisions and the use of a doublet antenna you will be able to improve reception results on all bands and especially so on the 20 meter phone band.

A reference to the schematic circuit diagram (Figure 54) will show that only 4 tubes are employed in the revised circuit, one i.f. stage having been eliminated. A single i.f. stage provides ample gain, consistent with a good signal-to-noise ratio.

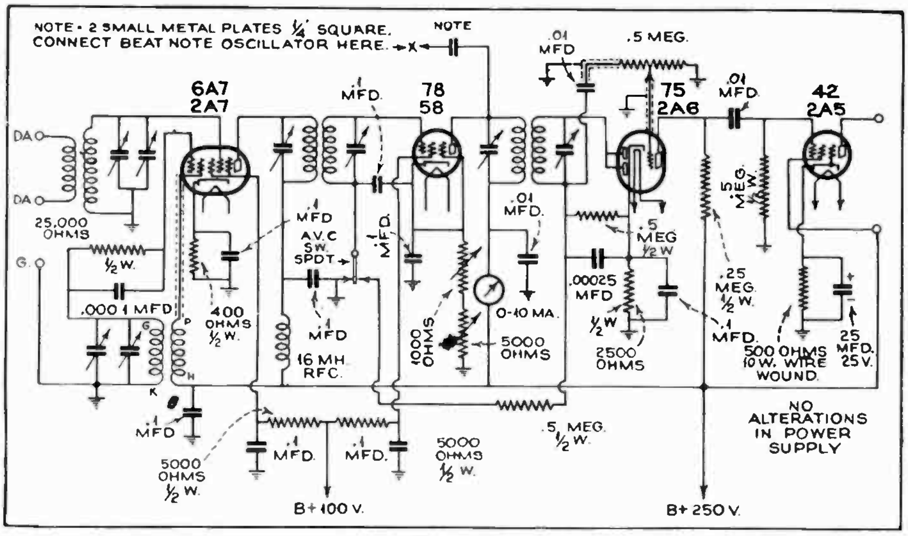


Figure 54

The tone control has also been eliminated, but for those who want to retain this feature it can be incorporated in the plate circuit of the power tube.

The sensitivity or r.f. volume control R2, is a 5,000 ohm linear unit instead of the 25,000 ohm unit previously used. The 1000 ohm rheostat is employed to adjust the C bias to the i.f. tube for best results, also to adjust the tuning meter to full scale reading with no signal tuned in. The sensitivity control R2 should be advanced to the extreme point, that is, with all the resistance out, when the automatic volume control switch is turned to the "on" position. This is necessary in order to make the a.v.c. action complete, it also permits maximum retardation of the tuning meter when signals are tuned in. This meter is not only an advantage in tuning but it also serves as a direct indicator of signal strength.

The audio volume control, R3, is a ½ megohm left-hand tapered potentiometer which can be mounted on the front panel in the place previously occupied by the tone control. This control is of material assistance in holding down very powerful signals. All leads to this control and to the 2A6 grid cap must be shielded and the shields grounded.

The beat note oscillator is connected at the point marked "X" instead of to the detector plate in the original set. A small coupling condenser can be made from two small ¼-inch metal plates, or from two small pieces of push-back wire twisted together. The a.v.c. switch should be thrown to the "off" side when receiving code on the beat oscillator. The tuning meter will give quite a wide swing on strong signals and will be helpful in centering DX broadcast stations for best quality, although the very weak signals will hardly move the meter.

The doublet type antenna is 16 feet each side of the center with a Lynch "Giant Killer" lead-in cable approximately 18 feet long, the small matching coil for the antenna input circuit is made of two turns of No. 20 d.c.c. wire approximately 2 inches in diameter, placed right around the antenna inductance. The two ends of this coil are connected directly to the two leads of the lead-in cable. Tests indicated that this type of antenna matching gave best results in noise elimination.

Pilot Light for Soldering Iron

An efficient little pilot light device for the electric soldering iron can be made up by building a small cardboard form and arranging an electric light plug in one side and an electric light socket in the top and holding them together by filling the form with sealing wax after the wire connections have been made as per Figure 56. The

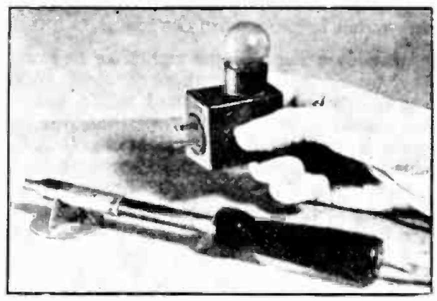


Figure 55

three-wire lamp cord is connected in such a manner to the switch that the third wire leading from the red (7-watt) lamp is connected to the iron side of the circuit.

The form with the lamp fastened in it can be plugged into any standard socket of

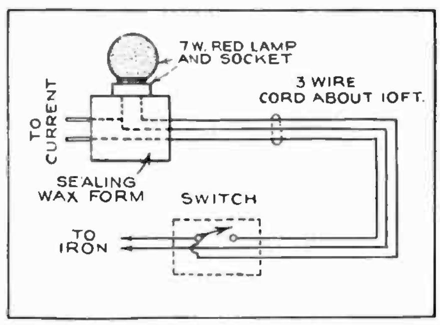


Figure 56

suitable size and with the operator it will become second nature to keep the iron at the proper operating temperature while doing the work by being able to observe out of the corner of his eye if the current is on or off.

A Simple Stroboscope

Many forms of motion, too fast for the unaided eye to follow, can be "slowed down" and analyzed with a high-speed movie camera. In similar fashion you can use this little gadget to get a slow-motion picture of the rectification process in mercury-vapor tubes, and to find just what fraction of the cycle is being used. An investigation of this kind would ordinarily require the use of an oscillograph.

The device, as shown in Figure 57, consists of a heavy cardboard disc mounted on the shaft of a fan motor from which the guard has been removed. The disc may be eight or more inches in diameter, with

Figure 57

two slots about an inch square located near opposite edges. A tight-fitting spool makes a convenient hub for mounting the disc. For speed control, a lamp socket and a heavy-duty rheostat of at least 30 ohms are wired in series with the motor.

Employ a lamp of the right size to bring the motor speed to approximately 1800 r.p.m. An easy way to find this speed is to examine, through the rotating disc, a neon lamp lighted from the 110-volt A.C. line. As the speed approaches synchronism (1800 r.p.m.) the glow will flicker slowly, shifting from one plate to the other. When the disc is in step the glow will remain on one plate or the other.

Now, with the disc slightly off synchronism, examine an operating mercury-vapor tube of the 82 or 83 type by the method shown in Figure 58. The blue glow will be seen to shift from one plate to the other, showing that the plates carry current in alternation. With the disc in step, the glow will appear on one plate only, while if the tube be viewed from a point 180 degrees around the circumference of the disc, the glow will appear on the other plate. Still other portions of the cycle can be selected by shifting your viewpoint.

Amateurs using 866 type rectifiers will find the device useful, because when the disc is in step the angle over which the glow is visible indicates how much of the cycle is being used by the tube. For example, if the filter is of the condenser-input

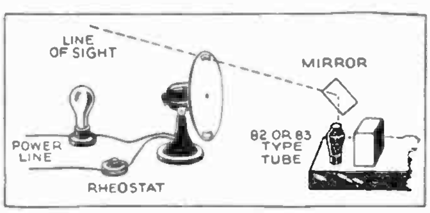


Figure 58

type and the first condenser is too large, the glow will be seen through a narrow angle only. This indicates that the tube is carrying a current in brief spurts of possibly dangerous peak value. Higher audio frequencies can be observed in like manner by using discs with more holes. Of course, the stroboscope can be used to study many other forms of high speed motion, such as motors, alternators, engines, etc.

A Handy Tool

The cutting of tube-socket holes or any large size cut-out in a metal chassis is probably the most troublesome job in home radio-set construction. It is difficult only because so few radio constructors are familiar with the proper tool for that purpose and the proper means of supporting the chassis itself, during the drilling operation.

The tool for the job is a very simple and inexpensive device called a circle cutter which fits in any standard hand brace. While three sizes are available it is only necessary to possess the medium size model, (costing a little more than a dollar) for radio construction work. This size is capable of cutting holes from 1 to 4 inches in diameter in aluminum, steel, bakelite, hard rubber and wood.

To anyone who has laboriously made socket holes with a small drill, a cold chisel and a file, the circle cutter will be an absolute revelation. Holes that previously took 15 or 20 minutes can now be made in 15 or 20 seconds, and furthermore, they are really round!

As the cutting tool of the cutter takes a healthy bite out of the metal chassis, the latter must be braced securely so that

Figure 59

there is no possibility of twisting and the best aid for this is a large husky vise, but a small one is satisfactory if it is supplemented by some short pieces of 2 by 4 wood blocks and a couple of ten-cent C clamps. The accompanying illustration, Figure 59, shows how a 12 inch steel chassis was handled in a vise having only 2¼-inch jaws. A 6-inch stub of a 2 by 4 was first tightened in the vise in a vertical position, and the chassis held in place over it by a single clamp, as shown. The drilling pressure was then applied against the heavy wood, which in turn was solidly supported by the vise. The chassis remained perfectly fixed and the holes were made in quick order.

The same set-up was used in cutting holes in the short sides of the chassis. In this case the clamp was merely turned around so that the handle was out of the way of the long arm of the circle cutter.

In cutting 2- and 3-inch holes in panels for meters, it is advisable to use a scrap piece of board as a backing in the vise. This will prevent the panel from buckling under the pressure of the brace. To avoid clamp marks, place bits of hard wood under the feet of the clamp and tighten the latter carefully.

Overcoming Refrigerator Interference

Quite often radio interference can be traced to static discharges from the motor belt of electric refrigerators. To eliminate this type of interference simply connect a wire from the motor frame to the compressor and continue this lead to a good ground.

Two Soldering Kinks

Strange to say, few irons have been produced with a rest attached. The one shown in the diagram, Figure 60, is similar to the folding rest on a carving fork and can be constructed in a short time from odds and ends of hardware.

Make a band to fit around the iron, from flat brass and clamp together below with a

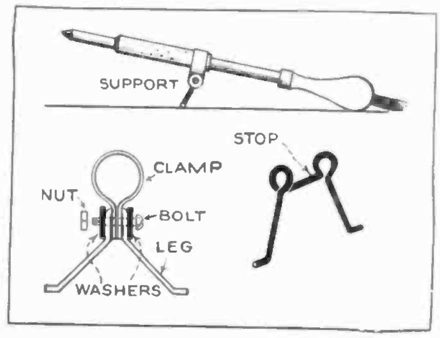


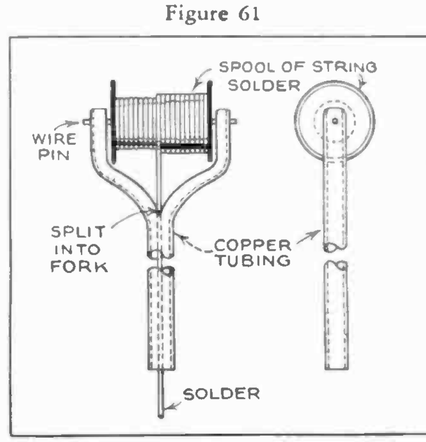
Figure 60

small bolt. Then from stiff wire bend the rest as shown in detail. The legs spread out at the bottom and the two eyes fit around the bolt; the cross bar between them serving as a stop bar when the legs are in a vertical position. This bar straddles the clamp and the eyes go between the clamp and washers as shown. By using lock washers the tension can be regulated and and held by the tension of the nut on the bolt. Thus your iron can be rested above the bench or the rest folded back against the shank when not in use.

String solder wound on spools is awkward to hold and it is much easier to rack it, as shown in the little holder in the sketch, Figure 61. Take a piece of suitable copper tubing about 8 inches long and split down one end, for a third of the distance with a hack-saw. Open this split and drill the ends. Then insert the spool of solder and hold it with a metal pin inserted in the holes in the ends of the prongs.

Run the solder through the tubing until it projects from the end. By wrapping the

Figure 61



tubing with a layer of electricians' tape or felt it can be used as the solder holder in lengthy jobs without the heat of the solder being imparted to the hand.

Identifying Replacement Connections

In replacing transformers, condenser blocks, and similar parts with numerous leads, the problem of reconnecting the wires to the proper points may be greatly simplified and a great deal of time saved if the old leads are clipped off close to the defective component.

After the defective part has been removed, the color-coded loose wires remaining will indicate where the leads from the replacement unit are to be connected.

If an exact duplicate replacement part is used, one need only replace the old leads with each new lead having the same color coding, one by one. If a different replacement part is used, the slip accompanying same will enable one to identify the corresponding lead.

A Simple Vacuum-Tube Voltmeter

Figure 62 shows the circuit diagram of a diode-type vacuum-tube voltmeter that can be used for a wide variety of tests, where a slight circuit load is not objectionable. Being substantially independent of frequency it is adaptable to either a.f. or r.f circuit

The value of R1 will depend upon the sensitivity desired. For full-scale deflection

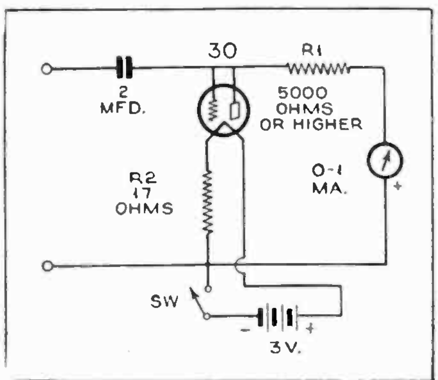


Figure 62

with 100 volts input the value of this resistor should be about 75,000 ohms. For greater sensitivity R1 can be decreased so as to cover any desired range. The device has a fairly linear scale and it may be calibrated on an A.C. 60 cycle supply line by connecting it in parallel with an A.C. meter. This calibration will hold for radio frequency as well as audio frequency

Every Experimenter Can Use This Rack

Every radio experimenter at one time or another experiences the difficulty of finding sufficient space to store his ever-increasing radio equipment. We all know how tables can become cluttered with equipment until they cannot accommodate another article and how parts and sets are pushed under the table or in corners until needed. The wooden rack shown in the photographs. Figures 63 and 64, completely answered one experimenter's requirements and now his workshop is not only neater, but he can

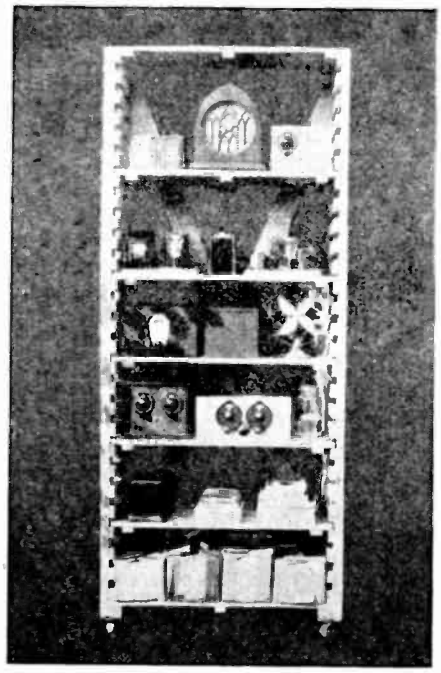


Figure 63

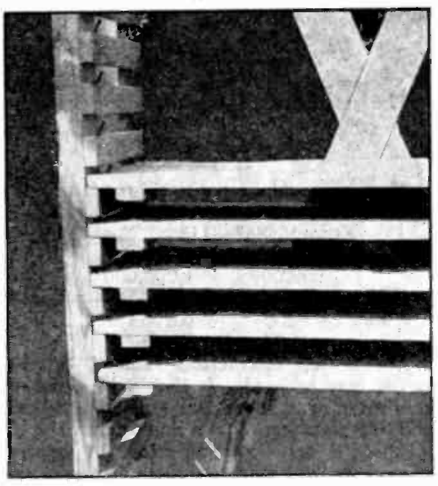
easily find any radio item without calling on Providence and everyone to help him.

The rack provides a relatively large amount of shelf-space and it is so designed that the shelves can be adjusted to various heights which makes the rack especially suitable for holding a variety of radio equipment such as parts, receivers, transmitting equipment, etc. The rack is mounted on heavy rollers for added convenience.

The depth of this rack is 14 inches, the width 36 inches and height 86 inches. The net inside area of each shelf is roughly 13 by 31 inches and the height above each shelf can be adjusted in steps of 3 inches.

Seasoned pine wood is used throughout in the construction of the rack. Four different sizes, as enumerated below are employed and are easily procurable from any lumber yard. The 2 cross braces on the rack are 1 by 4 inches. Half the thickness of each one of these cross pieces is cut out at the point where they cross and they are locked and screwed together supplying a back brace for the rack. For the 4 uprights and for the 2 bottom cross pieces. 2 by 4 inch material is used. Regular floor material 1 by 4 inches is used for the top, bottom and the removable shelves. This material is tongued and grooved and for neatness the tongue or groove should be planed off the front and rear board of each

Figure 64



shelf. For the cross-ties at the top and bottom, for the shelves and the supports nailed to the uprights, use 1 by 2 inch material. The casters have wheels 2½ inches in diameter, with rims 1 inch in width.

The close-up illustration of the rack shows the shelves, side supports and back cross pieces. The front corner of each shelf has a countersunk hole leading diagonally down through the shelf and into the corresponding side support. Wood screws of the proper length are used to screw the shelves into fixed positions. In the picture, one screw is shown with its head protruding above the top shelf and three screws are shown sticking up from pilot holes in side supports which carry no shelves.

Relay Made From Old Audio Transformer

A highly sensitive relay that will operate on 1 milliampere or less can be made from an old audio transformer. A Kellogg 3-to-1 transformer was used in this particular

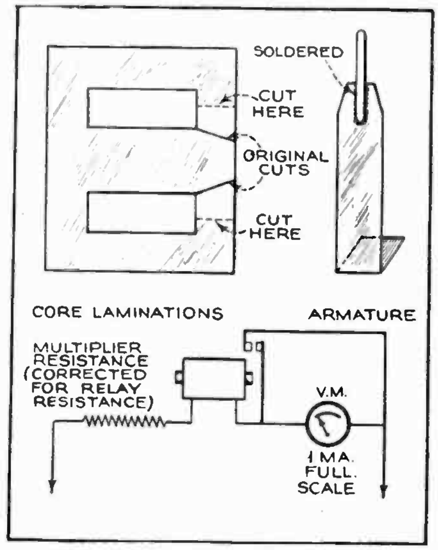


Figure 65-Top left; Figure 66-Top right; Figure 67-Above

relay, but any kind may be used if the windings are intact and the core laminations have the form shown in Figure 65. The laminations have two diagonal cuts across

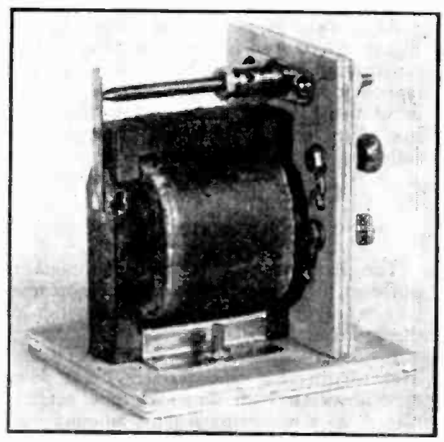


Figure 68

the center leg to permit assembly. Remove all the laminations, cut off two small pieces from each as indicated, and re-assemble to form an E-shaped core. A brass clamp around the bottom leg serves to mount the relay on a suitable wooden base. Make the armature from an extra lamination as in Figure 66, bend the small tab of the armature at right angles and solder to the brass clamp. Be sure that the lower end of the armature is in contact with the bottom pole piece.

The contacts are self-explanatory, one being a thin strip of brass soldered to the armature, the other a long machine screw working through a binding post and lock nut. The primary and secondary leads are brought out to binding posts on the small panel and allow a choice of connections. Using the primary coil alone, the contacts should close on about 5 milliamperes. Using both coils connected in series-aiding, less than one milliampere will be needed, making the relay ideal for photo-electric and similar work. If heavy currents are to be controlled, an auxiliary power relay or contactor must be used.

Figure 67 suggests a possible use for the relay in protecting a sensitive votlmeter from a dangerous overloads.

A correction has to be made for the resistance of the relay winding and the multiplier resistors reduced accordingly.

Resonance Indicator for Aligning A.V.C. Receivers

This device using the type 6E5 tube as a resonance indicator eliminates the usual difficulty of aligning receivers by means of an output meter and replaces the more ex-

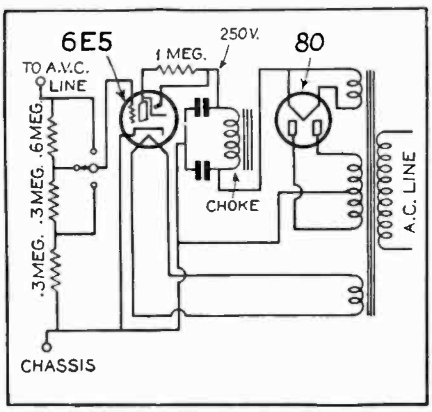


Figure 69

pensive vacuum tube voltmeter or cathode ray oscillograph.

As shown in the accompanying circuit, Figure 69, it consists of the 6E5 electron ray tuning indicator tube hooked up with tapped input circuit and power supply, the input being simply connected to the a.v.c. line of the receiver and the usual procedure followed.

Concrete Foundation for Antenna Mast

The irresistible urge to try something different, especially in the way of antennas, is one of the principal characteristics of the radio amateur.

In order to facilitate a quick changeover to different type aerial systems when experimenting with antennas, one amateur rigged up a mounting for his antenna mast as illustrated in the accompanying diagram 70, A and B. A cube of concrete, measuring 2 feet in each dimension, is embedded in the earth with the top surface level with the ground. This block contains three 1-inch iron eye-bolts about one foot long. The mast is mounted on a wood block 18 inches square by 4½ inches thick and is securely held in place by four 2- by 4-inch

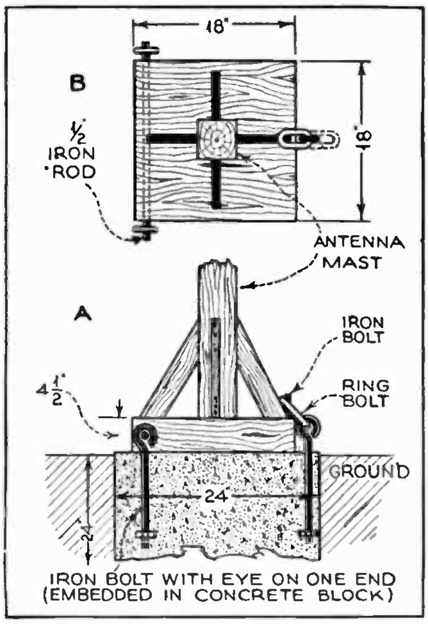


Figure 70

braces. A hole is bored through one end of the block and a ½-inch steel rod 2 feet long is placed in this hole, the ends protruding to form "hinges" when used in conjunction with the eye-bolts as shown. A short bolt or rod is placed in the center at the opposite side and with the ring-bolt locks the mast in the vertical position.

The chief advantage gained by the use of this mounting is the ease with which the mast can be raised or lowered. One man, with the help of a long ladder, can easily raise a 20- or 30-foot sunnort, and once it is in the vertical position it will not fall over in the opposite direction as is usually the case when a wood mast is buried in the earth.

New Uses for Condensers

It is not generally known that a condenser can be used as a voltage-dropping device for lighting from one to several tubes directly from 110 volts A.C. line supply. This method has some advantages over the line-cord dropping resistor. It does not develop any heat and it saves power. The required capacity for a given tube can be calculated as follows. Suppose one 6.3-volt tube requiring .3 ampere is to be heated directly from a 115-volt, 60-cycle line. What is the size of the required condenser?

The total impedance of the circuit should be:

$$Z=\frac{115}{.3}=383 \text{ ohms}$$

The resistance of the filament itself is:

$$R=\frac{6.3}{.3}=21 \text{ ohms}$$

The required capacitive reactance is then:

$$Xc=\sqrt{383^2-21^2}=372.4 \text{ ohms}$$

and the capacity is:

$$C=\frac{1,000,000}{2\pi f\,Xc}=\frac{1,000,000}{376.8\times372.4}=$$

6.96 microfarads

The nearest commercial value, 7 microfarads may be used. It should be a paper condenser of at least 200 volts d.c. rating and the right capacity is important.

There is very little difference in the required capacity when another tube is to be added. Up to three tubes can probably be connected in series with 7 mfd.

With an 8 mfd. condenser in series you can light nine 6.3-volt type tubes operating on .3 ampere such as the type 39, 43, 44, 75, 77, 78, etc., or one 25Z5 and five ordinary tubes or one 25Z5, one 43 and one other 6.3-volt tube.

A single 2-volt .06-amp. tube requires 1.33 mmfd. *Don't use electrolytics.*

Improving the Browning 35

The type 6B5 tube proves an excellent output tube for receivers which employ a single 42 in the power stage. In order to change over from the 42 to the 6B5, all that is necessary is to short circuit the bias resistor, as shown in Figure 71. The drain on the power supply is practically the same and the replacement tube requires the same output impedance as the type 42. The result is better quality and higher output (4 watts). This change has been tried on

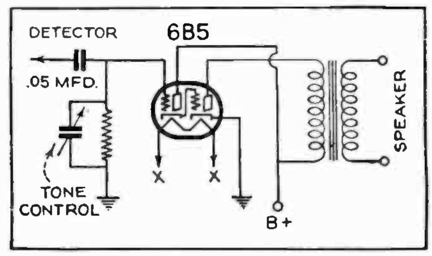


Figure 71

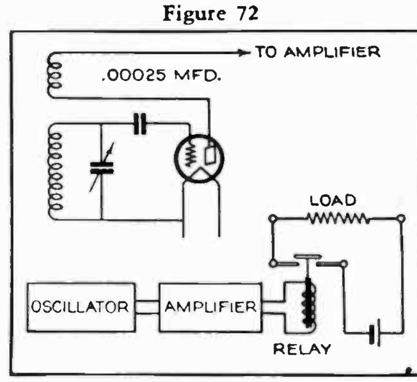
a Browning 35 receiver and found to work very satisfactorily and can of course, be used with equal success in other receivers that use the type 42.

An Electronic Interrupter

An interesting application of a vacuum tube is shown in Figure 72, in which a regenerative circuit with grid-leak omitted, is utilized to operate a relay which in turn operates its secondary circuit periodically. The rate at which the circuit is interrupted is regulated by the tuning condenser of the oscillator and of course is limited by the sensitivity of the relay. The amount of amplification depends on the relay as well as on the type of tube used. Using the 30 tube, with two stages of transformer-coupled amplification, sufficient power is available to operate a relay, rated at 3 ma. at 3 volts, over a variety of speeds. The tuning unit may be from an old broadcast receiver or made up of some similar combination of apparatus that will cause the tube to "motorboat" when in a circuit of this sort.

This apparatus may be used for flashing signals or in any circuit where an intermittent current is desired.

Figure 72



AMATEUR RADIO

The Popular 5-Meter Range

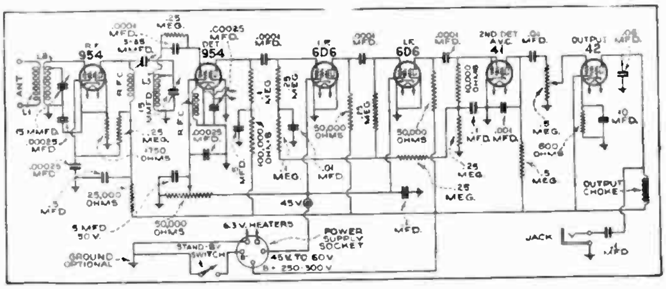
FOR the uninitiated it will be interesting to know that 5-meter amateur radio (and commercial experimental radio) is enjoying a tremendous growth in popularity. It is estimated that in the New York metropolitan district alone there are over 1000 active 5-meter "ham" stations on the air and every large city boasts numerous experimenters in this field. Not only that, but the suburban and even rural sections boast numerous 5-meter signals.

The popularity of 5-meters is explained in 3 ways. First the equipment necessary for transmission and reception is extremely inexpensive as compared with the equipment required for operation on the other amateur bands. Second, for local contacts the 5-meter transmitter will provide dependable communication with very low power as is demonstrated by the fact that a number of New York "hams" have worked 400 or more 5-meter stations in this area. The great majority of the 5-meter transmitters around New York City put considerably less than 10 watts into the antenna and many of them put out only a fraction of a watt. The majority of such transmitters employ receiving tubes exclusively. In fact the 5-meter transmitter that uses one or more regular transmitting tubes is the exception rather than the rule. The third reason for the popularity is found in the fact that this ultra-high-frequency band provides a tremendous field for the experimentally inclined. While 5-meter radio dates back several years it is still in a constant process of development. Every month produces appreciable advances in the art. During these past years a great deal has been learned but the field has not as yet advanced sufficiently far to be "over the head" of the novice who has perhaps tired of the more conventional frequency ranges and is looking for new worlds to conquer.

The requirements of receiver equipment for 5-meter operation in some respects differ radically from those encountered in the lower-frequency amateur bands and the short and long-wave broadcast ranges. This is essentially a "local" band. Under ordinary conditions reception of signals over range greater than 25 or 30 miles constitutes real DX. On the other hand, good stable communication, with good signal intensity can be expected even from low-powered stations within a radius of 20 to 25 miles. The ranges will be expanded in time through the use of directional transmitting and receiving antennas and through other developments which overcome the tendency of 5-meter signals to travel in straight lines rather than following the curvature of the earth.

Figure 73—

A typical 5-meter receiver circuit using 6 tubes.



5-meter receivers need not have anything like the degree of selectivity or sensitivity required in receivers operating on the regular short-wave or broadcast ranges. In fact extreme sensitivity or high selectivity seem to be undesirable at the present state of development. The average 5-meter transmitter does not maintain constant frequency and for that reason a receiver having extreme selectivity would not be able to hold a signal from such a transmitter. Transmitter frequency shifts of 50 to 100 kilocycles or even more are not at all uncommon on 5-meters. Until such time as transmitters are developed to the point of employing crystal control, M.O. P.A. or other means for stabilizing frequency, high selectivity will continue to constitute a distinct disadvantage.

Super-Regenerative Receivers

Too much sensitivity is likewise a disadvantage in the average noisy location or at least is unnecessary because of the interference from automobile ignition systems and certain other types of "man-made static." Most of the noise interference familiar on other wavelengths, including atmospheric static, is not present on 5 meters but unfortunately ignition noise *is* present in exaggerated form as are some other forms of interference such as from high-frequency diathermy equipment, some oil burners, etc. Definite values of required sensitivity and selectivity have probably not been worked out but it is estimated that receiver sensitivity better than 5 microvolts is superfluous.

At the present time there two types of receivers in general use. These are the super-regenerative and the superheterodyne types. Each type has its staunch supporters and each type has its definite advantages as well as disadvantages. The super-regenerative receiver has the advantage that it is particularly effective on 5-meters. When properly designed and operated it shows good sensitivity. Perhaps its outstanding characteristic is its peculiar tendency to reject external noise. Even when used in sections where the automobile traffic is continuous, the super-regenerative receiver is not particularly susceptible to ignition disturbance. Such a receiver is likewise simple to operate.

As against these conditions, adherents of the superheterodyne type will point out 3 basic drawbacks to this type of receiver. The super-regenerative detector is inherently unselective. Furthermore, when connected direct to the receiving antenna it radiates badly. Third, the operation of the super-regenerative detector is characterized by a "rushing" sound. On strong signals this rush disappears completely but, on the other hand, it is very much in evidence on weak signals. The amplitude of this rushing sound varies considerably in different

Figure 74

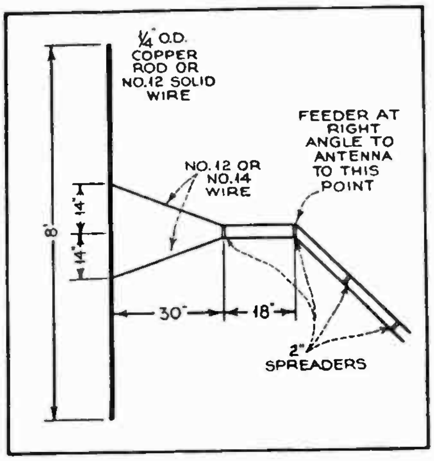
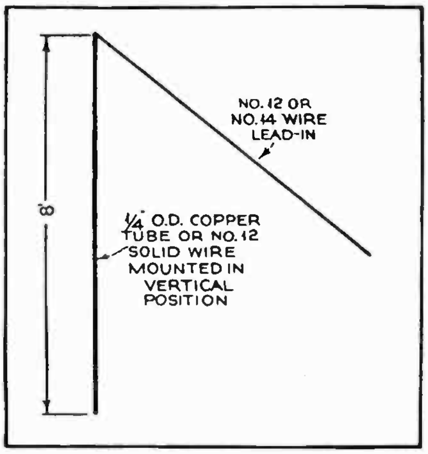


Figure 74A



TRANSMITTING TUBE CHART

TYPE NO.	DESCRIPTION CATH.	DESCRIPTION BASE	FILAMENT VOLTS	FILAMENT AMPS	CAPACITANCES MICRO-MICRO FARADS Cgp	Cgf	Cpf	PURPOSE	RATED VOLTAGES PLATE	GRID (NEG.)	SCR. GRID	SUPP. GRID	RATED MA. PLATE	GRID	SCR GRID	POWER PLATE DISS.	OUT-PUT	REQ'D. DRIVER PWR.	REC'D. GRID LEAK
TRIODES																			
10	THOR. FIL.	4 PIN-MED.	7.5	1.25	7.0	4.0	3.0	CLASS C AMP.	500	135			60	10		12	20	4	15000
								CLASS B MOD.	425	50			4			12	13		
RK-18	THOR FIL	4 PIN-MED.	7.5	1.25	5.0	3.8	2.0	CLASS C AMP.	1000	150			85	15		40	50	3	15000
RK-24	OXIDE FIL.	4 PIN-SMALL	2.0	.120	5.5	3.5	3.0	5M. PORT. OSC.	180	45			20			1.5	1.2		
RK-30	THOR FIL.	4 PIN-MED.	7.5	3.25	2.5	2.7	1.0	CLASS C AMP.	1250	175			70	15		35	65	4	10000
								CL. C MOD. AMP.	1000	200			70	15		35	50	4	10000
								CL. B LINEAR AMP.	1000	55			42			35	14		
RK-31	THOR. FIL.	4 PIN-MED.	7.5	3.0				CLASS C AMP.	1000	50			85	15		35	50	5	3000
								CLASS B MOD.	1250	0			20			35	70		
RK-32	THOR FIL.	4 PIN-MED.	7.5	3.25	2.5	2.0	.7	CLASS C AMP.	1250	200			100			50	85	7	15000
								CL. C MOD. AMP.	1000	180			100			50	65	7	15000
RK-34 P-P DUAL TRIODE	OXIDE CATH.	7 PIN-MED.	6.3	.8	2.7	4.2	2.1	CL. C OSC-AMP.	300	36			80	18		10	14	2.5	2000
								CLASS B MOD.	300	15			30				12		
45	OX. FIL.	4 PIN-MED.	2.5	1.75				CL C OSC-AMP.	400	200			40			10	10	3	50000
46	OXIDE FIL.	5 PIN-MED.	2.5	1.75	(AS HI-MU TRIODE)			CLASS C AMP.	400	50			40	3		10	10	3	20000
								CLASS B MOD.	400	0			6			10	10		
F-100	TUNGS	SPECIAL	11.0	25.0	10.	4.0	2.0	CLASS C AMP.	2000	300			500			500	600		10000
F-108A	TUNGS	4 PIN-JUMBO	10.0	11.0	7.0	3.0	2.0	CLASS C AMP.	3000	350			200			175	400		15000
150T	THOR TUNGS.	4 PIN JUMBO	5.0	10.0	3.5	3.0	5	CLASS C AMP.	1000	200			200	35		150	150	7	5700
								CLASS C AMP.	2000	400			200	35		150	300	17	12000
								CLASS C AMP.	3000	600			200	35		150	450	35	17000
HF-200	THOR TUNGS.	4 PIN-JUMBO	10.5	3.4	5.8	5.2	1.2	CLASS C AMP.	1500	190			175	30		150	175	25	6000
								CLASS C AMP.	2500	280			175	30		150	300	40	8500
203A	THOR TUNGS.	4 PIN-JUMBO	10.0	3.25	14.5	6.5	5.5	CLASS C AMP.	1250	125			150	25		100	130	7	5000
								CL. C MOD. AMP.	1000	135			150	50		100	100	14	3000
								CL. B LINEAR AMP.	1250	45			106			100	42.5		
204A	THOR TUNGS	SPECIAL	11.0	3.85	15.0	12.5	2.3	CLASS C AMP.	2000	175			250	50		250	350		5000
50T	THOR TUNGS.	4 PIN-MED	5.0	6.0	2.0	2.0	.4	CLASS C AMP.	1000	200			100	25		50	75		8000
								CLASS C AMP.	2000	400			100	25		50	150		16000
								CLASS C AMP.	3000	600			100	25		50	250		24000
211	THOR TUNGS.	4 PIN JUMBO	10.0	3.25	14.5	6.0	5.5	CLASS C AMP.	1250	225			150	18		100	130	7	10000
								CL. C MOD. AMP.	1000	260			150	35		100	100	14	5000
								CL. B LINEAR AMP.	1250	100			106			100	42.5		
242A	THOR TUNGS.	4 PIN JUMBO	10.0	3.25	13.0	6.5	4.0	CLASS C AMP.	1000	150			150			100	125		5000
								CL. B LINEAR AMP.	1250	100			100			100	31		
HF-300	THOR TUNGS.	4 PIN JUMBO	11.5	4.0	6.5	6.0	1.4	CLASS C AMP.	1500	150			250	50		200	275	40	3000
								CLASS C AMP.	2500	250			225	50		200	450	60	5000
354	THOR TUNGS	4 PIN JUMBO	5.0	7.75	3.7	9.0	.4	CLASS C AMP.	3000	275			150			150	300		10000
300T	THOR TUNGS.	4 PIN-JUMBO	7.5	11.0	4.0	3.5	1.5	CLASS C AMP.	2000	300			300	30		300	450	60	10000
								CLASS C AMP.	3000	450			300	35		300	700	75	15000
								CLASS C AMP.	4000	600			300	35		300	950	90	20000
500T	THOR TUNGS.	SPECIAL	7.5	20.0	4.5	4.0	1.5	CLASS C AMP.	1000	185			500	50		500	350		3500
								CLASS C AMP.	2000	370			500	50		500	750		7000
								CLASS C AMP.	3000	550			500	50		500	1150		10000
800	SEE	RK-30																	
801	THOR TUNGS.	4 PIN-MED.	7.5	1.25	6.0	4.5	1.5	CLASS C AMP.	600	150			65	15		20	25	4.0	10000
								CL. C MOD. AMP.	500	190			55	15		20	18	4.5	10000
								CL. B LINEAR AMP.	600	75			45			20	7.5		
								GRID BIAS MOD. AMP.	600				50	2		20	10.	2.0	
830	THOR TUNGS	4 PIN-MED.	10.0	2.15	9.9	4.9	2.2	CLASS C AMP.	750	180			110	18		40	55	7	10000
								GRID BIAS MOD. AMP.	1000	200			50	2		40	15	3	
831	THOR TUNGS	SPECIAL	11.0	10.0	4.0	3.8	1.4	CLASS C AMP.	3500	400			275	40		400	590	30	10000
834	SEE	RK-32																	
838	THOR. TUNGS.	4 PIN-JUMBO	10.0	3.25	8.0	6.5	5.0	CLASS C AMP.	1250	80			150	30		100	130	6	3000
								CL. C MOD. AMP.	1000	135			150	60		100	100	16	3000
								CLASS B MOD.	1250	0			74			100	130		
849	THOR TUNGS.	SPECIAL	11.0	5.0	33.5	17	3	CLASS C AMP.	2000	200			300			400	450		5000
								CLASS B MOD.	2500	130			20			400	500	7	
852	THOR TUNGS	4 PIN-MED.	10.0	3.25	2.6	1.9	1.0	CLASS C AMP.	3000	600			85	15		100	165	12	10000
								CL. C MOD. AMP.	2000	500			67	30		100	75	23	10000
								CL. B LIN. AMP.	3000	250			43	—		100	40		
TETRODES AND PENTODES																			
802	OXIDE CATH	7 PIN-MED.	6.3	.95	0.15	12.0	8.5	CLASS C AMP.	500	100	250	+40	45	2	12	10	16	.25	15000
								SUPP. MOD. AMP.	500	90	200	-45	22	4.5	28	10	3.5	.5	15000
								CL. B LINEAR AMP.	500	28	200	0	25	0	7	10	3.5	.18	
RK-23	OX. CATH.	7 PIN-MED.	2.5	2.0	.02	10.0	10.0	CL. C OSC-AMP.	500	90	200	0	50	6-8	40	10	18.	.8	15000
RK-25	OX. CATH.	7 PIN-MED.	6.3	.9	.02	10.0	10.0	CL. C OSC-AMP.	500	90	200	+45	55	6-8	35	10	24	.8	15000
								SUPP. MOD. AMP.	500	90	200	-45	32	6-8	40	10	5.5	.8	15000
865	THOR TUNGS.	4 PIN-MED.	7.5	2.0	.01	8.5	8.5	CLASS C AMP.	750	80	125		40	5.5		15	16	1.0	15000
								CL. C MOD. AMP.	500	120	125		40	9		15	10	2.5	15000
								CL. B LINEAR AMP.	750	30	125		22			15	4.5		
RK-20	THOR. TUNGS.	5 PIN-MED.	7.5	3.0	012	11.0	10.0	CLASS C AMP.	1250	100	300	0	80	7-10	37	40	64	1.0	15000
								CLASS C AMP.	1250	100	300	+45	92	7-10	32	40	80	1.0	15000
								SUPP. MOD. AMP.	1250	100	300	-45	43	7-10	36	40	18	1.0	15000
803	THOR TUNGS.	5 PIN-JUMBO	10.0	3.25	0.15	15.5	28.5	CLASS C AMP.	2000		500	-30	160	16	42	125	210	1.6	5000
								SUPP. MOD. AMP.	2000		500	-50	80	15	55	125	53	1.6	5000
								CL. B LINEAR AMP.	2000		500	-40	80	3	15	125	53	1.5	
804	THOR TUNGS.	5 PIN-MED.	7.5	3.0	.01	16.	14.5	CLASS C AMP.	1250	100	300	0	80	7	33	40	64	.9	15000
								CLASS C AMP.	1250	100	300	45	92	7	27	40	80	.9	15000
								SUPP. MOD. AMP.	1250	100	300	-50	48	7	35.5	40	21	.85	15000
RK-28	THOR TUNGS	5 PIN-JUMBO	10.0	5.0	.02	15.5	5.5	CLASS C AMP.	2000	100	400	0	120	10-12	75	125	160	1.8	10000
								CLASS C AMP.	2000	100	400	+45	140	10-12	60	125	200	1.8	10000
								SUPP. MOD. AMP.	2000	100	400	-45	80	10-12	85	125	60	2.7	10000
850	THOR TUNGS	4 PIN-JUMBO	10.0	3.25	.2	17	26	CLASS C AMP.	1250	150	175		160	35		100	130	10	5000
860	THOR. TUNGS.	4 PIN-MED.	10.0	3.25	.08	7.75	7.5	CLASS C AMP.	3000	150	300		85	15		100	165	7	10000
								CL. C MOD. AMP.	2000	225	300		67	30		100	75	15	10000
								CL. B LINEAR AMP.	3000	150	300		43			100	40		
861	THOR TUNGS	SPECIAL	11.0	10.0	0.1	17.0	13.0	CLASS C AMP.	3500	250	600		275	30		400	590	25	8000

Figure 75

super-regenerative receivers, depending upon the care put into the design and adjustment. Claims are made that if a receiver is properly designed, the rush (with no signal tuned in) can be reduced to a point close to inaudibility. However, there are few 5-meter experimenters that have ever been able to reach this ideal condition without greatly decreasing the inherent sensitivity of this type of circuit.

The Superheterodyne

Recently super-regenerative detectors have been improved greatly through the use of a preselector stage. Such an amplifier stage provides increased selectivity and, being connected between the detector and the antenna, effectively eliminates radiation. It also, in many instances, reduces the "rush" when receiving weak signals. This is not true in the case of all receivers having a preselector stage, however, because it is a rather difficult matter to obtain any appreciable gain in a t.r.f. stage at this ultra-high frequency unless one resorts to the use of the "Acorn" pentode tube (954) and even then extremely high gain is not to be expected.

The superheterodyne receiver, (for typical circuit, see Figure 73), has the advantage of providing almost unlimited sensitivity and selectivity. Strange as it may seem, it has been necessary, in designing 5-meter superheterodynes, to intentionally reduce the selectivity and to purposely avoid building in too much sensitivity. This has usually been accomplished by avoiding the use of the usual double-tuned i.f. transformers and substituting resistance-coupled i.f. stages with the resistance and coupling condenser values so selected as to broadly tune each stage to the desired frequency. These intermediate amplifiers will usually pass a band 40 to 100 kc. wide. Such selectivity as is desired is then obtained in the r.f. circuits ahead of the intermediate amplifiers.

It is a common practice to use the autodyne system of frequency conversion. To accomplish this the first detector is used in an oscillating condition and instead of being tuned to peak on signals it is tuned enough off the signal frequency to beat the signal to the intermediate frequency. To make this practical, the intermediate frequency selected is of a very low order, usually in the neighborhood of 20 or 30 kc. so that the detuning of the first detector will not materially reduce signal strength. Many experimental superheterodynes are provided with a preselector stage with the object of improving the signal-to-noise ratio and also of preventing radiation from the oscillating detector. There are, in some instances, a resulting improvement in signal selectivity and in sensitivity. The one weakness of the superheterodyne is that it lacks the noise-reducing characteristic of the super-regenerative receiver.

Unquestionably the ideal receiver installation for a 5-meter amateur station would consist of two receivers, one of each type. With a low prevailing-noise condition the superheterodyne receiver could be employed for weak signals; or at times, when the 5-meter band is crowded with signals, advantage could be taken of the superior selectivity of the superheterodyne. When the noise conditions grow bad or where high selectivity is not needed the super-regenerative receiver can be switched in. It is more than likely that some manufacturer will produce a receiver in which are combined these two circuits with a switch to permit either one to be selected as required.

In 5-meter reception, the antenna plays an extremely important part and for best results the antenna should be one which resonates at 5 meters and should be a vertical rather than a horizontal wire.

The most common practice is to employ an 8-foot length of ¼-inch copper tubing mounted in a vertical position and supported by means of stand-off insulators on a wood mast. This type of mounting not only holds the copper tubing rigid but also provides a firm anchorage for the lead-in.

The lead-in is a parallel pair with the wires spaced two inches apart as shown in Figure 74. In such a combination, the two wires are fanned out beginning at a point 30 inches from the antenna, and spreading to a distance of 28 inches where they connect to the antenna rod. This type of lead-in should be continued at a right angle to the antenna rod for a ¼-wave (4 feet) and from that point on may be run to the receiver at any desired angle.

Another excellent receiving antenna system employs an 8-foot copper rod with the single wire lead-in taken off the top end as shown in Figure 74A.

There are numerous other effective types of 5-meter receiving antennas but the two mentioned have the advantage of high efficiency and simplicity. Incidently, the 8-foot length is selected not as a matter of convenience, but because this length resonates (½-wave) at 5 meters and therefore, provides extremely effective pick-up for 5 meter signals. Any type of antenna, including a broadcast receiver antenna, will provide a certain amount of pick-up at 5 meters but such antennas are very definitely less effective than the types shown.

5-Meter M.O.P.A. Transmitter

STABILITY equal to that obtainable on lower amateur frequencies may be obtained at 5 meters by following standard M.O.P.A. design practice, provided certain precautions are taken with respect to mechanical layout and choice of tubes.

Signals from the transmitter described have been received on a standard all-wave superheterodyne using two sharply-tuned, transformer-coupled i.f. stages. Absence of frequency modulation has been further demonstrated by satisfactory reception of 'phone signals on this same receiver operated with its beat oscillator in the "ON" position. Attempts to receive typical modulated oscillators of the long-line type have, by way of comparison, proven completely fruitless on this type of receiver.

C.W. reception of the emitted signal is completely practical, comparing favorably with present-day 40- or 80-meter transmission.

The circuit shown in Figure 77 is fundamentally sound in every respect; all "tricks" have been avoided. There are no twin tubes, push-pull stages which are hard to excite, or pentodes in the final

Figure 77

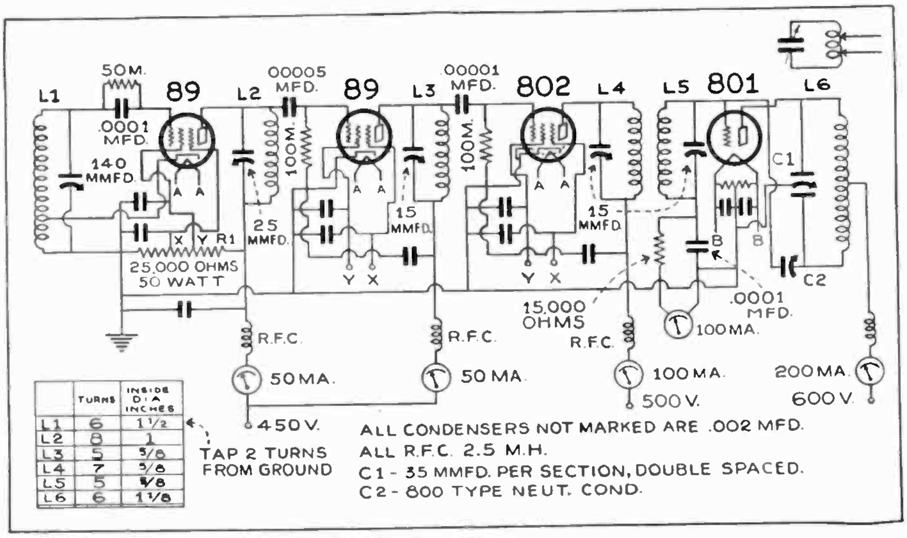
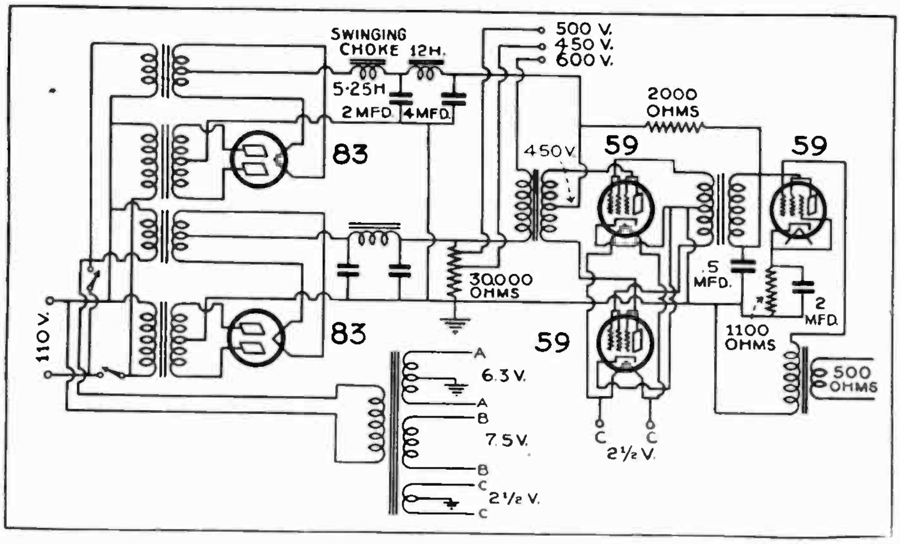


Figure 76



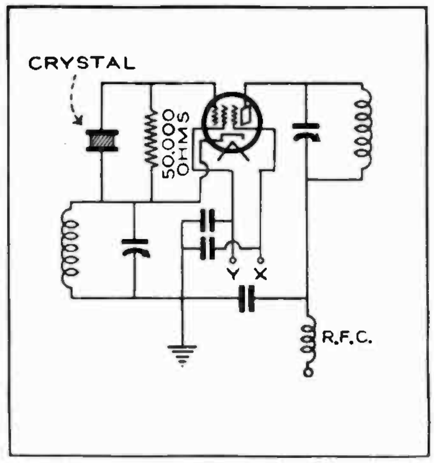


Figure 78—Left; Figure 79—Above

stages which are difficult to keep from going "up in smoke" when under modulation. By avoiding all so-called short cuts and concentrating on high-frequency facts, a stable, high-efficiency transmitter can be constructed.

The 89 oscillator of this M.O.P.A. transmitter is operated on 20 meters, electron coupled. The plate circuit is tuned to 10 meters and feeds into the second tube, an 89 doubling from 10 to 5. An 802 buffer provides ample excitation to an 801 in the final stage running 60 watts input. The omission of an r.f.c. in the grid circuits of the 89 doubler and 802 stages is rather unusual. However, by so doing, stray capacities are avoided and a high leak resistance provides a minimum of grid losses.

Inductive coupling is desirable from the 802 buffer to the final stage to furnish maximum energy transfer and to further isolate the modulated stage from the rest of the transmitter. The use of a triode in this stage was thought desirable when one studies the inter-electrode capacities of pentode and screen-grid tubes. The tank circuit of the 801 is of the split-stator variety, supplying high efficiency by virtue of the high l.c. ratio. This is accomplished by reducing the circulating tank current and consequently the heating of this circuit and of the tube itself.

The power supplies are mounted on the lower shelf along with the modulator, and supply 600 volts for the 801 final, 500 volts for the 802 buffer and 450 volts for the oscillator and doubler. This transformer is a special U. T. C. job delivering 600 volts at 350 ma. which feeds all the r.f. stages. The modulator consists of a pair of 59's in Class B, driven by a single 59 Class A; all of which is run from the second supply of 450 volts at 200 ma. The speech amplifier (not shown) consists of a 6F5 high-mu triode, resistance-coupled to a 6C5 transformer-coupled to the 59 driver. This unit provides sufficient gain for a crystal mike, but it is not shown, as it is assumed that most every "ham" has his own "pet" speech amplifier and mike.

All coils are wound with No. 14 enameled copper wire with the exception of the oscillator grid and final plate, which are of No. 12. The remainder of the transmitter is more or less straight-forward practice, as can be seen in Figures 77 and 78.

In adjustment, nothing could be more simple. With the 801, 802 and 89 doubler out of their sockets, apply plate voltage to the oscillator. Check the screen and suppressor voltage with a voltmeter. They should read approximately 200 volts and 45 volts respectively. This tube should oscillate immediately and can be checked with a neon bulb. Operation is identical with any other electron-coupled oscillator.

The plate circuit is tuned to 10 meters by watching for a dip in plate milliameter of this tube. It is possible to use the crystal oscillator circuit, shown in Figure 79, with this rig with similar results when substituted for the electro-coupled input circuit. The 89 doubler is plugged in its socket and its plate circuit also tuned to resonance. Likewise with the 802 buffer. The next step is quite important and deals with the loading of the 802 buffer with the grid of the 801.

This can be done most effectively by disconnecting the plate voltage from the final stage and placing the 801 in its socket. By watching the grid meter on this tube and rotating the grid condenser, a sharp rise in grid current will result. When properly tuned, the grid current should read between 18 and 20 milliamperes. If a lower reading is obtained, bend the grid coil near or further away from the buffer plate coil. Once this coupling is found, the stage should be neutralized in the usual manner by checking the dip in grid current as the tank condenser is rotated through resonance.

The antenna coupling will depend on the type of antenna or feeder used. In the original tests a Zepp feeder was used, inductively coupled to the plate end of the tank. The remaining step is to connect the modulator and speech and the rig is ready for QSO.

Two-Way Auto Radio

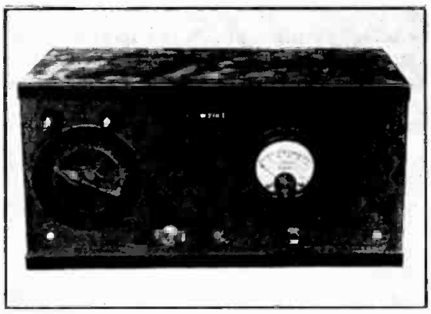
MANY American amateurs have been having a lot of fun and gaining experience in the operation of portable mobile radio installations by building and operating a 5-meter radio telephone transmitter and receiver for their cars. The activities on the 5-meter band have increased to such an extent, recently, that no matter where you drive there are always a number of stations you can contact along the path of travel. This article gives the details of construction of such a transmitter and receiver.

The complete car-radio installation is made in two small metal cabinets installed in a shelf under the back window, as illustrated in Figure 80. One of these contains a complete transmitter and the other a superheterodyne receiver.

The Transmitter

The transmitter itself consists of one 6A6 oscillator tube using a T.N.T. circuit, with another 6A6 tube as a Class B modulator, and a third 6A6 tube as a Class A driver. The transmitting equipment is enclosed in a metal cabinet 5½ inches by 6 inches by 12 inches, as shown in Figure 81. On the front panel are: the tuning dial (at the left) with the two antenna terminals directly above; a s.p.s.t. switch to cut on and off the B-plus supply for transmission-reception, a microphone jack and a 0-100 milliammeter for checking operation At the right-hand side of this cabinet is a 5-pronged socket for connecting a plug running to the power supply. B batteries are employed for furnishing the plate energy and the transmitter operates very well with B voltages as low as 100 volts and develops full power with 275 volts on the plate. At the present time B batteries are used and the oscillator is biased so that it draws about 60 milliamperes at 275 volts. The transmitter has worked very successfully with ranges from 10 to 20 miles, with reports of R8 to R9 reception. Both the transmitter and the receiver are suitable for duplex operation so that the car can be moving along while the transmitter is in operation and signals can be received and transmitted at the same time, as in a regular telephone conversation.

Details of the coils for the transmitter are as follows: The oscillator plate-tank coil consists of nine turns of No. 12 or



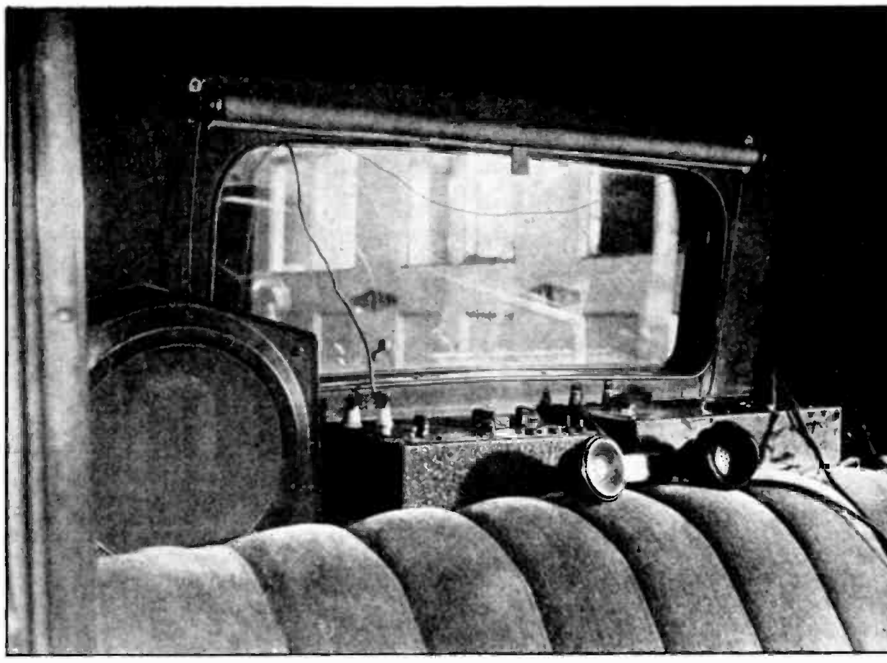


Figure 80—Right; Figure 81—Above

No. 14 wire, wound in a spiral ⅝ths of an inch in diameter and spaced a distance of the diameter of one wire. This tank circuit is tuned by a three-plate 35 mmfd. condenser. The grid-tank may have 14 to 15 turns of No. 14 wire, wound in a spiral ½ inch in diameter and spaced a distance of the diameter of one wire.

The circuit for this transmitter is shown in Figure 82 and the various parts are noted on the diagram, together with their circuit constants.

A single-button carbon microphone is used with the transmitter and good quality reproduction is assured with a regular telephone hand set.

The Rod Antenna

The antenna itself is mounted directly on the license plate rack, bolted and grounded in this way onto the frame. A single-wire feeder is tapped off this rod direct to the antenna post on the transmitter. The rod is 52 inches long and the tap is made 35½ inches from the top end. This point is very critical in adjustment and should be carefully checked, for a difference of only ¾ of an inch up (or down) in this adjustment will cause the signal to drop from an R9 to an R5. Final adjustment of this tap is made while contacting a distant station duplex so that the receiving station can report at which point the transmitter is operating most efficiently.

The Receiver

The receiver, shown in Figure 84, utilizes 5 tubes in an autodyne "superhet" circuit, using resistance-coupled r.f's. The coils are home-made and full winding instructions for making them are given in the wiring diagram (Figure 83). The first tube, which serves as a combination oscillator and detector, is a 6C6. The two r.f. stages use 6D6 tubes while the output detector is a 76 triode tube. Many "hams" prefer to use the set in a car with head-phones (to exclude noises while driving along the road) but shown in the circuit is an additional output tube, connected by a switch, for amplifying the signals so that a loudspeaker may also be used.

Construction Details

The set is constructed in a metal cabinet of the same dimensions as that used in the transmitter.

Going back to the wiring diagram (Figure 83), it will be noticed that the tuning condenser is a small midget of 15 mmfd. The conventional grid leak and condenser are used for coupling to the grid of the first tube. Notice that the r.f. choke is incorporated in the cathode-to-ground lead. Two of the grids are connected together and brought over to the resistance control which is .5 megohms with a .1 mfd. by-pass condenser to ground. The chassis is used as a general ground for the various points so designated in the diagram. The first plate-coupling resistor is 20,000 ohms, the second and third ones are 50,000 ohms each. All of the other grid resistors are ¼ megohm. The cathode variable resistor, for the first and second 6D6 tubes, is returned to ground for controlling volume. A 10 microfarad con-

Figure 82—Below

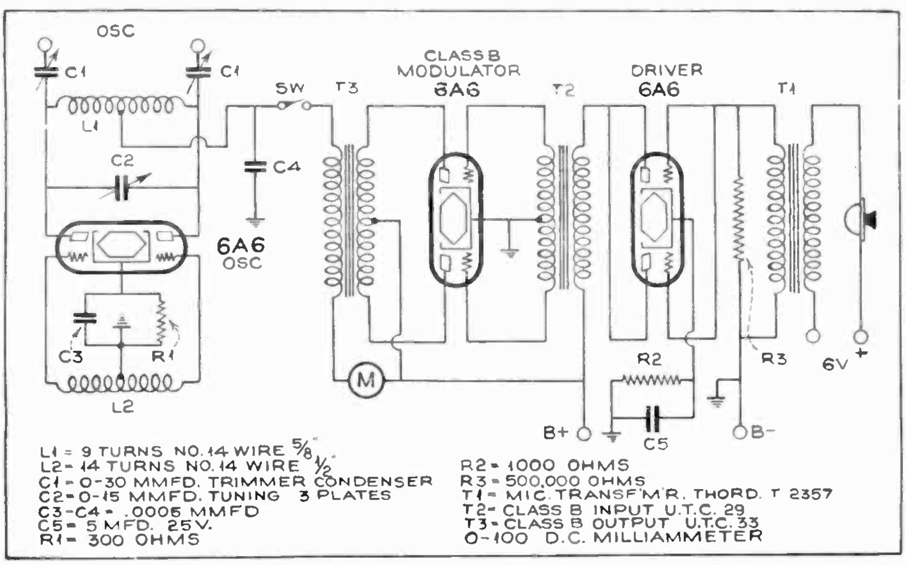
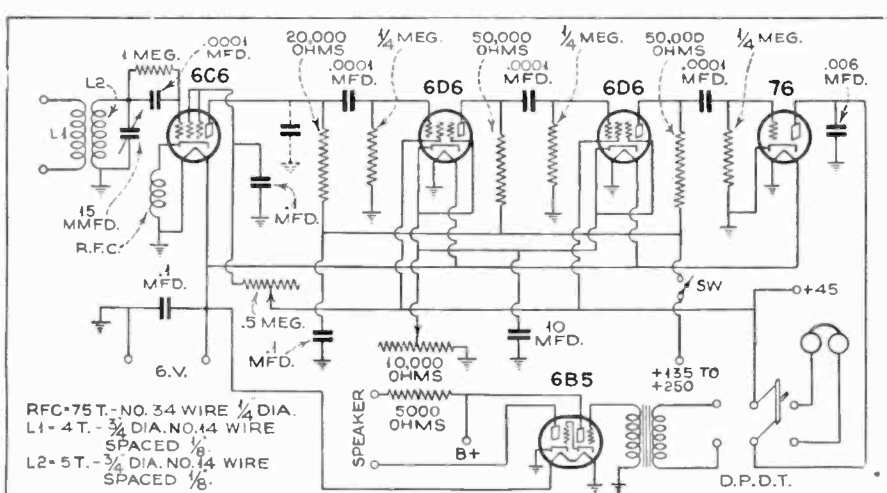


Figure 83—Bottom



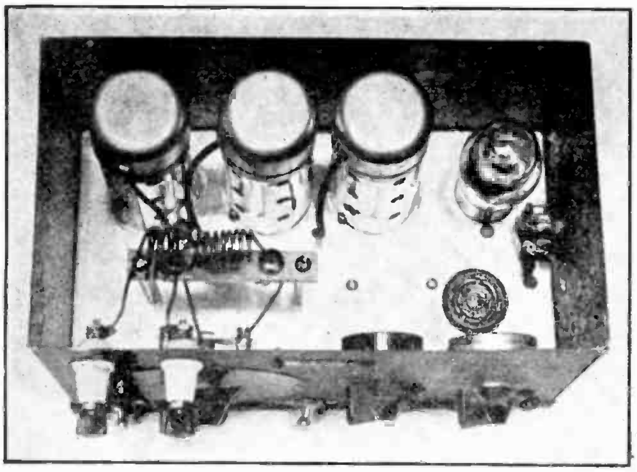


Figure 84—

Birdseye view of the receiver. Looking down on the autodyne receiver discloses the arrangement of the parts in the top compartment and on the front panel.

denser by-passes this part of the circuit for both of these tubes.

The receiver operates very well on 135 volts B and up to 250 volts B. It is used with a 6-volt storage battery. The detector operates with 45 volts on the plate as shown. The r.f. choke can be built by winding 75 turns of No. 34 insulated wire on a wooden or glass peg (or a bakelite tube) ¼ inch in diameter. If wood is used it should be boiled in paraffin first to exclude moisture.

The receiver can be used with a short length of wire installed in the car roof as an antenna or it can be used with the transmitting antenna, with a switching arrangement for changing over "transmit" to "send."

The receiver is operated by tuning the main dial over the band slowly with the volume control turned part way on for suitable volume while the oscillator adjustment dial is kept in position just beyond the oscillating point. It will be remembered that the autodyne circuit uses the single tube as a detector and oscillator in one. This would not be a very efficient circuit on the higher wavelengths but on ultra-short waves, using a wide-band resistance-coupled i.f. amplifier it seems to work out quite efficiently giving great sensitivity.

Ten Meter Transmission

THE 10-meter amateur band has become tremendously active. It has opened up, and there is DX galore to be had with the proper transmitting and receiving equipment. As a matter of fact, for the last year there have been an ever-increasing number of stations on the band, and when conditions have been "right" contacts over several thousands of miles with small amounts of power have not been uncommon. With the increasing number of stations operating on it, more and more is being learned about the necessary types of transmitters, receivers and antennas.

Antennas

In general, it has been found that a half-wave doublet is about as effective as any antenna that can be erected for 10 meters. A majority of the stations are using variations of this system. It would appear, judging from the results obtained by most stations on the band, that a horizontal antenna is the most effective. This may be due to the fact most receiving antennas are horizontal, and naturally are more effective in receiving horizontally polarized waves. The radiation pattern from a half-wave antenna, of course, provides the greatest amounts of radiation in the two directions at right angles to the axis of the antenna, as shown in Figure 88. Therefore, its erection direction is important.

As for feeding the horizontal doublet, any of the accepted methods may be used. These are three: matched impedance voltage fed; twisted-pair matched impedance and the transformer or Johnson "Q" method. All three are effective. It might be pointed out that a station on the West Coast has done considerable experimentation with different types of antenna, including beams, diamonds, etc., and was heard to say recently that he has always returned to his Johnson "Q" for the best results.

Another type of antenna which should give excellent results but on which complete data is not usually available, is two half-wavelength antennas operating in phase. This type of aerial is less directional than the half-wave type. It merely consists of two half-wave Zeppelin antennas strung end-to-end and fed in the middle with a common pair of feeder wires. It might be called a current-fed 20-meter antenna. This type antenna provides good radiation in four directions at about forty degrees to the axis of the aerial wire.

The height above ground also is important. It is something that should be experimented with until the best results are obtained. One station in the East has found that it is desirable to tilt the antenna in the direction it is desired to "spray" the signals. Between 30 and 45 degrees will give the most marked directional characteristic. The station in question tilts the antenna toward Europe in the morning and toward the West Coast in the afternoon.

It is impossible to predict when the 10-meter band will "open" up during any one day, but observation over an extended period seems to indicate that stations from Europe begin coming through at about 8 A.M. on Sunday morning and other days when these stations are free to operate. Sometimes it is as late as 9 o'clock before they begin to filter through. Stations to the West begin coming through shorly after noon (on the East Coast) and seem to arrive at a peak at about 4 P.M. The times given here are Eastern Standard Time, and of course, conditions will vary in the different time zones, but should follow about the same trend in other sections.

Furthermore, there is no means of forecasting when the 10-meter band will be good. Some Sundays it will be excellent, and on others no distant signals may be heard at all. Some study of sun-spot phenomena might give some clue as to what may be expected for a given time, but this would not always follow. In general, it seems that with a sudden increase in

Figure 85

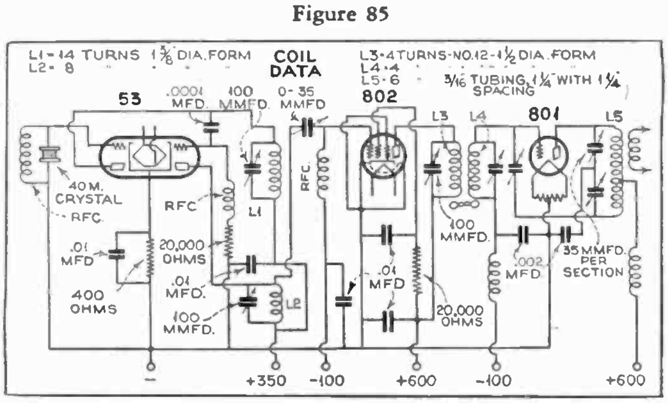
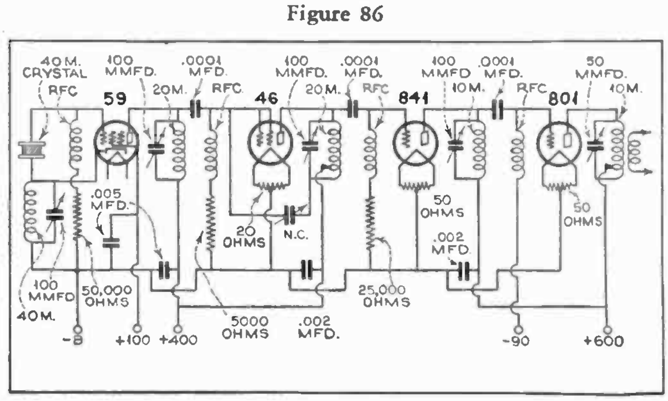


Figure 86



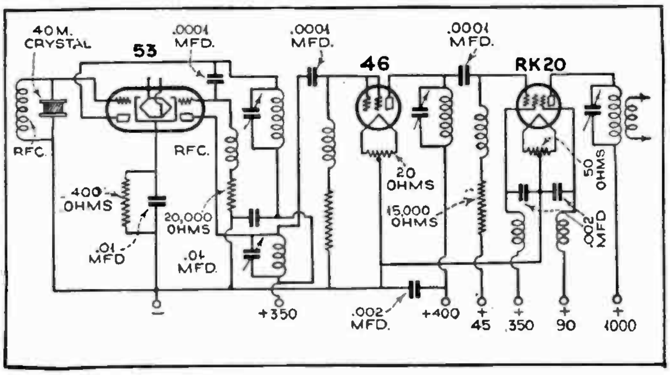


Figure 87

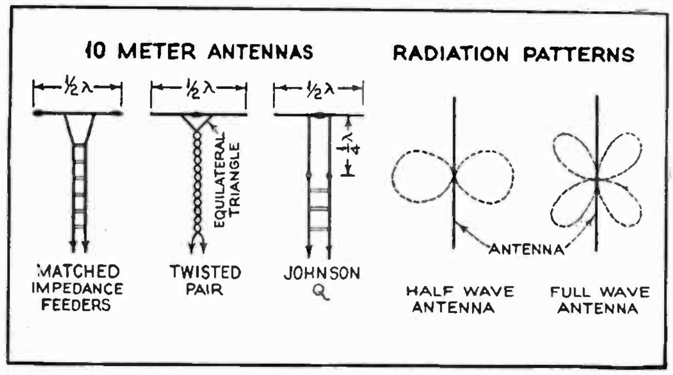


Figure 88

the sun-spot curve, short-wave radio improves. Sun-spots, in addition to following the general eleven-year cycle from time to time, show increase for a few days at a time. At such intervals it has been found that instead of improving high-frequency transmission, they have the contrary effect and have been known to cause complete dead spots. Also, another factor enters into the problem of forecasting conditions, that is magnetic storms. These, too, are generally accepted as being related to sun-spot activity. But. unlike the effect the spots have on the ionosphere, which appears to follow in step with the sun-spot cycles, the magnetic storms seem to be further removed from the cause. That is, they do not seem to follow immediately after the sun-spot activity which causes them. Therefore, with this additional influencing factor, the problem of predicting conditions is made more difficult.

Transmitters

Several suggested transmitting layouts are illustrated here. Each of them have been in use at different Eastern amateur stations and have provided excellent results. The one which seems to provide the greatest all-around stability and effectiveness is that shown at Figure 85. It is a conventional layout. The tube line-up is a 53 used as 40-meter oscillator——20-meter doubler; an 802 for doubling into 10 meters and an 801 type tube in the final. It was possible to run up to 100 watts input in the final amplifier with a high degree of efficiency.

Another suggested layout is shown at Figure 86. It consists of a 59 tri-tet oscillator using a 40-meter crystal with the output tuned to 20 meters, a 46 amplifier, an 841 doubler and an 801 in the final. This arrangement proved quite effective with 50-watts input to the 801.

A third suggested layout is shown at Figure 87. This consists of a 53 oscillator, quadrupler, a 46 buffer and an RK-20 amplifier. By using regeneration in the 53 amplifier—it is possible to obtain sufficient excitation to drive the 46 at low input in 10 meters. Of course, the output from the 46 will be sufficient to drive the pentode final amplifier on ten meters, as 5 milliamperes grid current is more than sufficient to operate this tube at a normal input. A high c.w. output and a 15 to 20-watt carrier, with suppressor grid modulation, may be obtained.

Receivers

Receivers for 10 meters are another problem. Few of the all-wave receivers that perform exceptionally well on frequencies of 14,000 kilocycles or lower are proportionally as efficient on 10 meters. Some will give satisfactory results, but the chief problem on 10 meters is that most all-wave receivers tune so many kilocycles per dial division that only very careful tuning will reveal signals. Ten-meter signals seem to be much sharper than those of lower frequencies. This, of course, is only apparent, as it requires only a small amount of capacity change in an L.C. circuit to cover several kilocycles, with a result a far greater degree of band spreading is necessary than available for lower frequencies. In receivers with changeable coils, the band-spreading problem is simplified by the fact it is possible to change the tuning ratio more in keeping with the frequency. The 10-meter band, however, covers 2,000 kilocycles, and even with a receiver designed to spread the whole band over a 180 degrees of a dial, tuning will be found to be exceedingly sharp.

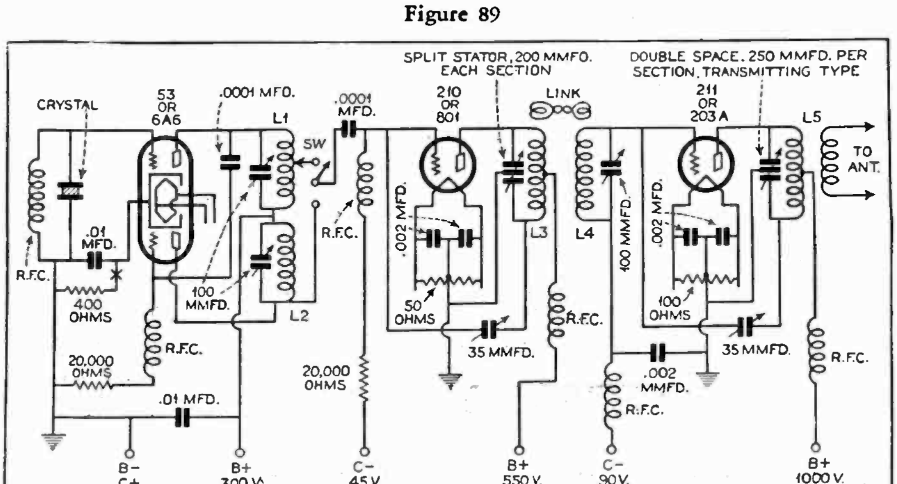
This in a general way covers the problems of 10-meter operation. It is hoped with the increased activity, more will be learned about the band, and just what may be expected of it. As we said before, in addition to providing good DX possibilities, it also is an excellent band for local communication.

All-Band Transmitter

THE last few years have brought so many new developments both in equipment and circuit design, that it is difficult to keep pace. New tubes have been developed that lessen the number required for a given amount of power in a transmitter; new exciter units have been designed that facilitate greater flexibility and band switching equipment has been made available. In view of these developments it is possible now to build a transmitter that may be operated on all but the ultra-high frequencies (above 56 megacycles) and even these may be covered with some of the latest types of equipment. It no longer is necessary to have a separate transmitter for different bands as it once was; either changeable coils or switches may be installed that facilitate all-band operation with a single unit.

For instance, a typical all band transmitter might be something like this: A 53 or 6A6 type tube as oscillator and frequency multiplier, a 210 or 801 buffer stage and a 203A or 211 final amplifier. Such a transmiter may be operated on all frequencies ranging from 1,800 to 28,000 kilocycles. In the experimental model shown in Figure 90 plug-in coils and semi-bread board construction were used, but the layout lends itself well for standard rack and panel mounting. With it, it is possible to jump from 1,800 to any other band in

Figure 89



COIL DATA					
BAND	L1	L2	L3	L4	L5
1.8MC	65 TURNS ON 1½" FORM. No. 22 TAPPED	—	55 TURNS 2" No. 18	55 TURNS 2" No. 18	45 TURNS 3" No. 14
3.5MC	SAME AS FOR 1.8 MC	25 TURNS 1½" No. 18	28 TURNS 2" No. 18	28 TURNS 2" No. 18	34 TURNS 2½" No. 12
7 MC.	14 TURNS 1½" No. 18 TAPPED	—	22 TURNS 2" No. 14 SPACED	22 TURNS 2" No. 14 SPACED	16 TURNS 2½" 3/16 DIA. COPPER TUBING
14 MC.	SAME AS FOR 7 MC.	7 TURNS 1½" No. 18 SPACED	10 TURNS 2" No. 12 SPACED	10 TURNS 2" No. 12 SPACED	9 TURNS 2" ¼" DIA. COPPER TUBING
28 MC.	"	"	"	"	3 TURNS ¼" COPPER TUBING, WIDELY SPACED
THE TAP FOR L1 COILS IS ¼ THE NUMBER OF TURNS FROM THE PLATE END.					

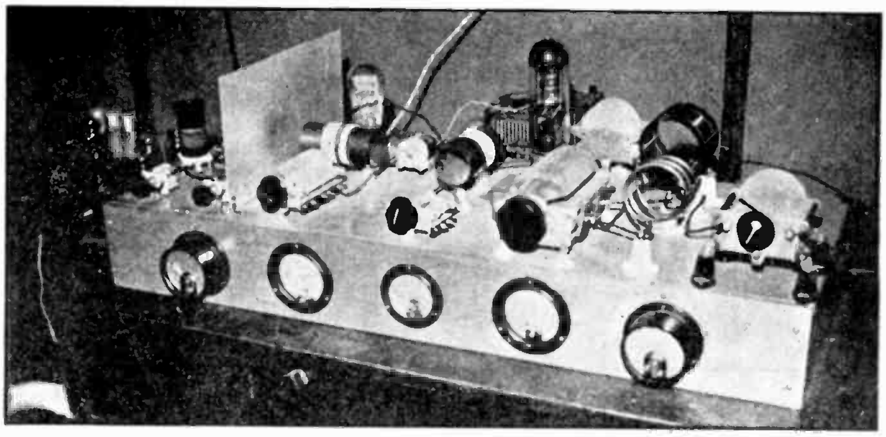


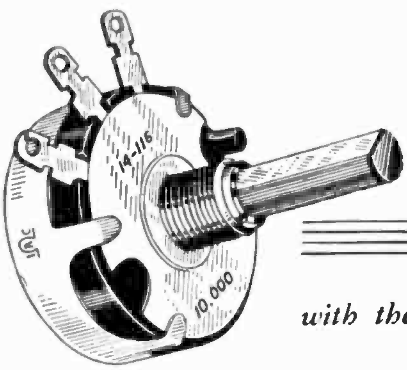
Figure 90—Above; Figure 91—Left

about thirty seconds; to use 'phone with either grid or high level plate modulation or C.W. merely by switching or plugging in the necessary coils, crystal or amplifier.

With a variety of crystals, each in a separate holder, it is possible to operate on any band. In the experimental transmitter two crystals were used, one at 1,995 kilocycles and the other at 7,100 and with these operation is possible on 1995 or 3,990 kilocycles with one and on 7,100, 14,200 and 28,400 with the other, thus facilitating five band operation. This necessitates two crystal coils each tapped one-quarter the total number of turns from the plate for fundamental operation; two doubler coils, one for 75 meter operation and the other for 20 meters; four sets of buffer plate and amplifier grid coils each with separate links and five tank coils for the final amplifier. All are of the plug in type, although coil switching arrangements could be used in all cases if desired.

The circuit diagram is shown in Figure 89 and complete coil data is given in Figure 91.

To operate the transmitter on the 1,800 kilocycle band the necessary oscillator coil is plugged in, and the plate coil of the doubler section of the 53 oscillator is removed from the circuit. This disconnects the plate voltage from the second triode section. If tapped coils are used in this circuit, it will be necessary to provide a switch to cut this unit out of the circuit. The exciter control switch is connected to the oscillator coil tap by means of the single-pole-double-throw-switch; the 1800 buffer tank, amplifier grid and plate coils are plugged in the circuit. To shift the transmitter to the 75 meter 'phone band, the oscillator coil of course is the same; the doubler coil is inserted in the second 53 triode plate circuit; the exciter switch is connected to the plate of the frequency multiplier; the 75-meter coils are plugged in the remaining three circuits. A similar procedure to that for 1800-kc. operation is followed for putting the transmitter on 7100; and the doubling procedure for 14-200-kilocycle operation. To operate the transmitter on 10 meters, everything is the same as for 20 meters, excepting the final tank coil, which uses the final amplifier as a doubler. This arrangement is not as efficient as exciting the final amplifier at 28 megacycles, but will give adequate output for reliable work at this frequency.



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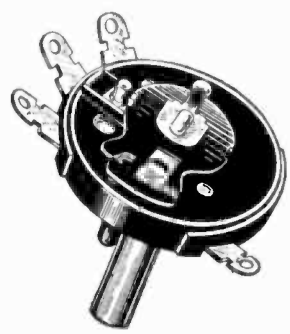

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SERVICING AND ENGINEERING NOTES

All-Wave Frequency Meter

IN response to an insistent demand for an all-wave oscillator of high frequency stability, low cost and small size, this simple instrument has been developed. The range extends from 540 kc. to 22,800 kc., which is sufficient to cover all short-wave bands from 14 meters up as well as the regular broadcast band. Through its use, the calibration of all-wave receivers may be readily checked, or one may determine immediately the frequency of an incoming signal with a high degree of precision.

The circuit employed is an improved negative resistance type which extends the outstanding features of this type of oscillator to ultra-high-frequency operation. The simplicity, high stability and excellent waveform characteristics of the negative resistance circuit described in the RCA Radiotron Company's Application Note No. 45 stimulated our endeavors to find some way of overcoming its inherent limitations, namely, failure to operate consistently at radio frequencies above 15 megacycles and weak oscillation at somewhat lower radio frequencies.

In analyzing the circuit, it was discovered that by shifting the phase of a large portion of the shunt impedances and considering other transconductance relationships, the frequency range might be greatly extended and its normal high-frequency performance definitely improved. This was confirmed experimentally and the present circuit (Figure 96) illustrates an application of the new method. Briefly it is done by inserting low-inductance, ultra-high-frequency chokes in the control-grid and plate circuits.

Uses Standard Parts

The instrument shown in Figure 94 is entirely self-contained. A small transformer designed to operate from the a.c. line furnishes filament current. Since the total cathode current is but 2 ma., the other voltages required are economically supplied by a small Burgess 22½-volt type 5156 battery and a 4½-volt C battery, type 2370. Five Hammarlund plug-in coils are used to cover all the usual short-

Figure 95

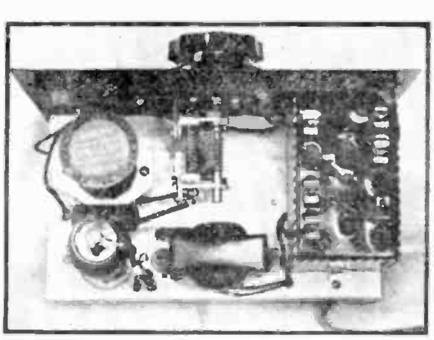
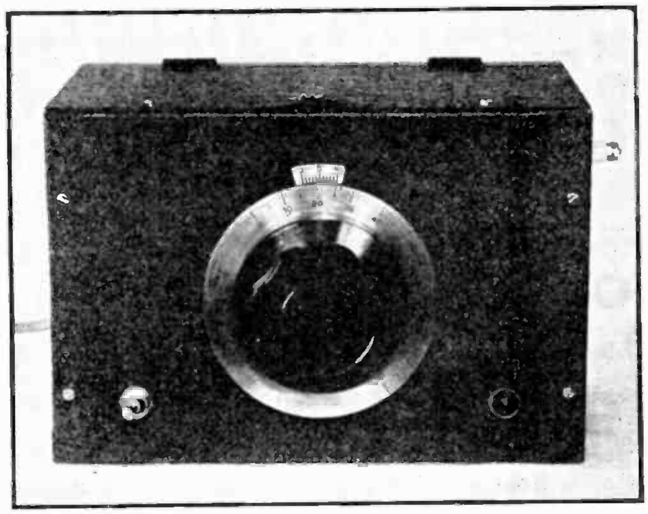


Figure 94—

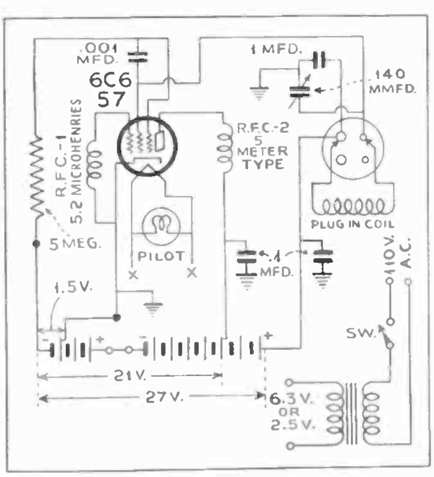
The vernier dial permits accurate readings to 1/10 of 1 degree. Once calibrated from broadcast stations by the harmonic method, the calibration will be accurately maintained indefinitely.



wave bands and the broadcast band. The special high-frequency coil may be wound quite simply by hand. It consists of but 5 turns of No. 20 wire spaced of 1⅜ inches on a Hammarlund coil form. The manufactured coils all have an extra winding of fine wire, which is not used in this design. A Hammarlund 140 mmfd. midget Midline variable condenser is used for tuning. It is supported by a heavy brass angle bracket as shown in the photograph. A Crowe precision vernier dial makes for ease in tuning and exact calibration. The Yaxley pilot light and bull's-eye is used as a reminder to those of us who occasionally forget to turn off the power when the instrument is not in use.

The layout as shown in the photograph should be carefully followed. The Hammarlund Isolantite tube socket is mounted slightly below the chassis, spacing washers serving to prevent any accidental shorts to

Figure 96

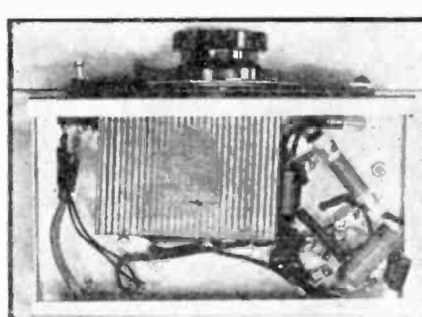


the chassis. The coil socket of the same make is elevated about ¾ inch above the chassis to facilitate coil changing and decrease coil losses. The Ohmite 5.2 microhenry r.f. choke is in the control-grid circuit and the Insuline 5-meter r.f. choke is used in the plate circuit.

Simple and Compact

While a type 6C6 tube was used in this instrument, the corresponding 2.5-volt type 57 may likewise be used if a suitable filament transformer is on hand. The type 57 is capable of an even greater frequency range and output. The Insuline cabinet is 9 inches long, 6 inches high and 5 inches deep, and the chassis of the same make is 8½ by 4¾ by 1½ inches. The small stand-off insulator post serves as the oscillator output connection. For sensitive receivers, the nut and screw terminal projecting into the case will provide sufficient pickup when receiving weak signals, particularly in the short-wave ranges. If greater output is desired, a 4-inch length

Figure 97



of wire may be bent around the output terminal and curved over near the coil winding.

Lower frequencies may be covered by using simple, single-winding coils. No other changes will be required. The circuit is readily adaptable to band-spreading and to operation at much higher frequencies, if suitable chokes are used.

In spite of the fact that this oscillator uses a small tuning condenser (a "low C" circuit) its stability is nevertheless excellent, as indicated by the following descripton of tests made at W2JCR. The model shown in the photographs was turned on *cold* and turned to zero beat with the crystal-controlled carrier of WEAF, 660 kc. During the following ten minutes the oscillator drifted very slowly through a range of only 200 cycles. At the end of this ten-minute period the oscillator was again tuned to zero beat and for the two hours following did not vary more than 60 cycles. At the end of this test the oscillator was turned off and everything was left without change until the following morning. When the oscillator was again turn on *cold* it was found to be 240 cycles off resonance but at the end of a ten-minute period had again arrived at a point within a few cycles of zero beat.

The foregoing test—and this test was borne out by numerous others — indicates that the *maximum frequency variation encountered from a cold start was less than 300 cycles* when tuned to a frequency of 660,000 cycles (660 kc.), or one part in 2200.

The stability of this oscillator can be still further improved by employing a "high C" tuning circuit. In the present model a wide tuning range was required for universal operation. However, if the constructor desires to use the oscillator in some particular ranges, as in covering the relatively narrow amateur bands, a fixed shunt capacity of at least 100 mmfd. could be employed. The fixed capacity value could be selected to provide the coverage or amount of band-spreading desired. The Hammarlund plug-in coils have provision for mounting adjustable tank capacities within the coil. Either their type APC air condensers or type IBT mica compression condensers fit these mounting holes. The former are available in capacities up to 100 mmfd. and the latter in capacities up to 220 mmfd., both with screwdriver adjustment. This plan cannot be used in the very high-frequency range because with such high capacity the inductance required would be too small to permit stable oscillation.

Simple B. F. Audio Oscillator

OSCILLATORS covering a wide range of audio frequencies form an indispensable part of the equipment of all radio laboratories and factories. They are used in making performance curves and in production testing of practically every type of sound reproducing apparatus. With the present trend toward increasingly high fidelity of reproduction, widespread interest has developed among service organizations for satisfactory instruments of this type.

The beat-frequency type offers distinct advantages in speedy operation over a wide and continuously variable range of audio frequencies. Through its use, speaker rattles or other deficiencies are quickly revealed. It is essential for the proper adjustment of audio filters in high fidelity receivers.

A satisfactory instrument of this type should have substantially pure sine wave output, since a high percentage of harmonics will make it useless for measurement purposes. It should be free from "birdies", a common defect caused by spurious beats occurring between undesired frequencies generated in the individual oscillators and mixer. To avoid frequency drift, each oscillator must be of identical design, free from harmonics and with carefully adjusted voltages. Furthermore, the circuits must have high inherent electrical stability.

The instrument shown in Figure 98 meets these requirements yet is no more difficult to build than a simple receiver. There are no special coils to wind, no ticklers or taps to adjust, no special shielding, no ponderous array of batteries. Yet, as the oscillograms in Figure 101 indicate, its output is substantially a pure sine wave, slight distortion being apparent only at 30 cycles.

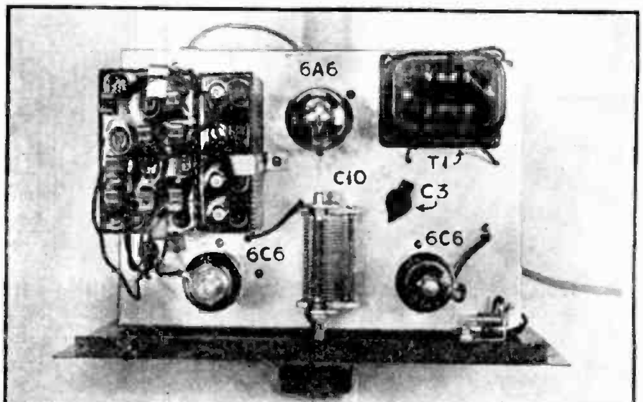
A relatively unfamiliar means of obtaining oscillation has been adapted to both the variable and fixed frequency oscillators. In spite of its simplicity, it should be distinctly understood that it is not a secondary emission dynatron. It utilizes the negative resistance characteristics of pentodes which results when voltages of the values indicated are applied to individual elements. This method of obtaining negative resistance is thoroughly described in Application Note No. 45, issued by the RCA Radiotron Company.

The Circuit Details

As shown in Figure 100, the instrument employs three tubes, 6C6's being used as the oscillators and a dual triode 6A6 as the mixer. A 22½ volt B battery and a 4½ volt C battery mounted within the case, and an external filament supply transformer constitute the entire power supply. If desired, the filament supply may be taken from the associated amplifier or a storage battery. The filament transformer is mounted externally to avoid any possibility of hum-pick-up. The inductances L1 and L2 are simple 2.1 milli-henry Hammerlund r.f. chokes. The fixed-frequency oscillator is tuned to approximately 108 kc. by means of C3 and C4. The variable frequency oscillator range extends from 108 kc (with C10 and C11 at minimum capacity setting) to approximately 94 kc. C11 is a 15 mmfd. midget variable condenser from which one rotor plate was removed and the remaining one bent to give a small capacity change at low-capacity settings. The total rated range is from 30 to 13,000 cycles, but it will be found possible to operate below 30 cycles if desired since there is no noticeable tendency toward interlocking with this circuit even as low as 2 or 3 cycles per second. The upper limit may be increased or decreased by using smaller or larger capacitances to replace C4 and C12. The variable-frequency oscillator output is fed through R5, and the blocking condenser C7 to one grid of the 6A6. R5 limits the input to the grid and also minimizes back-coupling reaction from the plate of the 6A6 to the suppressor of the 6C6. The fixed-frequency oscillator output appears across R1 and R2 in series. The very small voltage drop across R2 is fed into the remaining grid of the 6A6. This form of coupling has been selected because it keeps the grid at low potential with respect to stray voltages so no shielding is required. The plates of the 6A6 are connected in parallel, so that modulation of the stronger variable frequency by the weaker fixed frequencv is effected in the

Figure 98

Figure 99



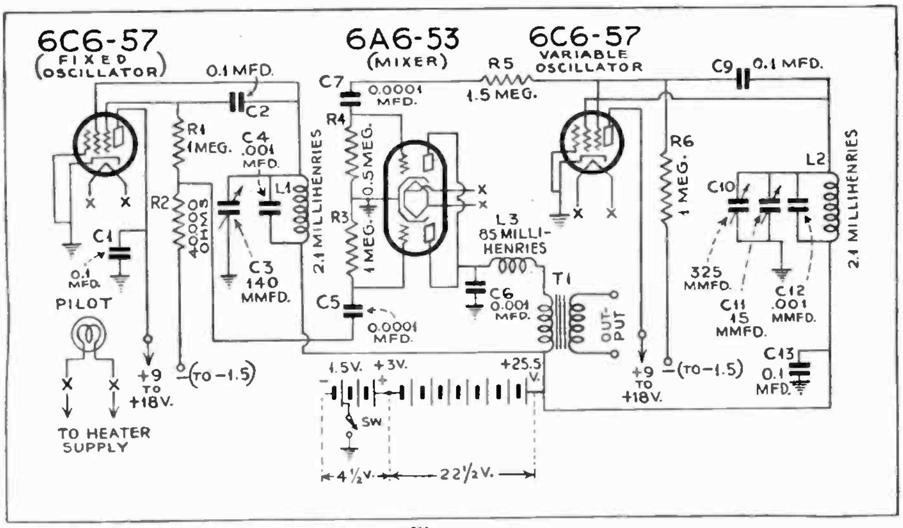


Figure 100

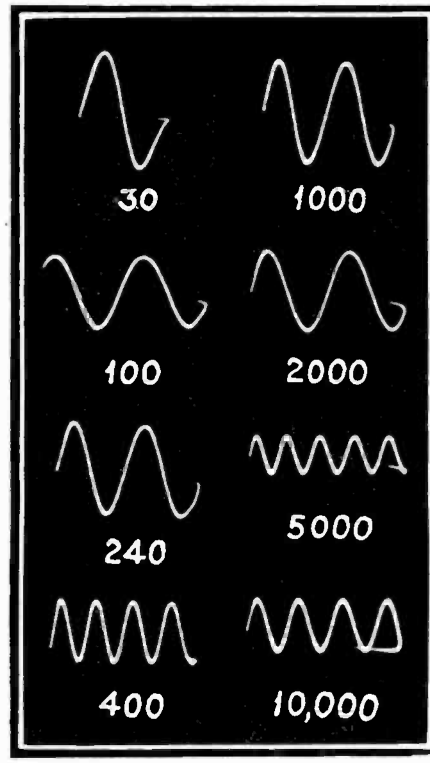


Figure 101

plate circuit. The oscillograms prove that grid rectification as used in this instrument is satisfactory. The 85 millihenry r.f. choke L3, with C6, are used to by-pass r.f. components. T2 is an interstage transformer, its excellent frequency characteristic making it desirable for this instrument.

Construction Data

The instrument is assembled on an Insuline chassis measuring 7½ by 11 by 2½ inches. After drilling, the parts may be assembled and wired in accordance with the general layout indicated in the photographs, Figures 99 and 102. Keep the wiring of the oscillator circuits as nearly alike as possible. The inductances, L1 and L2, should be placed at right angles, though the stray field is small. The leads to the 6A6 grids should be well separated. Particular care should be taken with the heater leads. These should be twisted together and kept as far as possible from leads carrying r.f. The 22½ and 4½ volt batteries are joined in series. Voltages indicated are with respect to ground, which is taken at the -3 tap on the 4½ volt battery. The plate voltages are not critical. The higher voltage gives greater output and the lower, maximum stability.

When completed, the output terminals should be joined to the input of a good two-stage audio amplifier. The oscillator has a high-impedance output designed to work directly into a grid, therefore the leads should be short. Connect a speaker to the amplifier and vary C10 until an audio note is heard. With C10 and C11 at minimum capacity setting, adjust C3 (which is mounted on the chassis) until no sound is heard (zero beat). Leaving C3 set, varying either C10 or C11 should cause a low-frequency note to be heard. If C3 cannot be adjusted to zero beat as indicated, interchange C12 and C4 and repeat. C4 should have the lower capacitance. C3 is used to compensate for inequalities of capacitance.

It is desirable to match the tubes in any beat-frequency oscillator. This may be done by interchanging the tubes with the instrument adjusted to a very low frequency. The frequency change should be as small as possible. They should likewise be matched for thermal characteristics. Disconnect the filament supply while listening to a low note. Only a slight change in pitch should result as the tubes cool.

Calibration without laboratory apparatus may be effected by comparison with notes of a musical instrument. Middle C on the piano is 256 cycles (international pitch) and the frequency will double for each octave above this point. Likewise, we may divide by two for each lower octave. After obtaining several points, a curve may be plotted and the higher frequency points determined by extrapolation. A musician's pitch pipe, forms a convenient means of rechecking frequency calibration each time the instrument is used, for precise work.

In operating, the small dial is calibrated for the lower frequency range while the large dial is used for the balance. This combination will be found to give a smooth and non-critical coverage of the entire range without the use of specially shaped variable condensers.

The output of this instrument is about .3 volts at 400 cycles. Therefore, an amplifier will be necessary for nearly all applications. Both the RADIO NEWS amplifier described on page 47 and the small unit described on page 60 and 61 of this book have given excellent results.

Parts List

C1, C2, C8, C9—Aerovox tubular by-pass condenser 0.1 mfd., 200 volt
C3—Hammarlund Type MC-140M midget Midline variable condenser, 140 mmfd.
C4, C6, C12—Aerovox fixed mica condensers, .001 mfd.
C5, C7—Aerovox fixed mica condensers .0001 mfd.
C10—Hammarlund Type MC-325M midget Midline variable condenser, 325 mmfd.
C11—Hammarlund "Star" midget variable condenser, 15 mmfd. (see text)
L1, L2—Hammarlund Type CH-X midget r.f. chokes, 2.1 m.h.

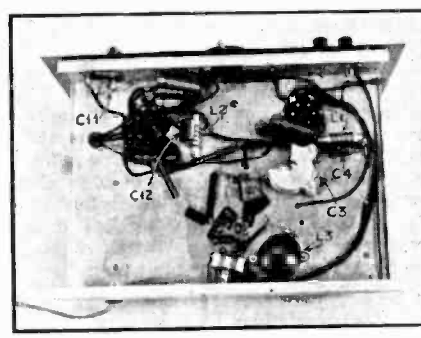


Figure 102

L3—Hammarlund Type RF-85 r.f. choke, 85 m.h.
R1, R3, R6—I.R.C. resistors, 1 meg., 1 watt
R2—I.R.C. resistor, 40,000 ohms, 1 watt
R4—I.R.C. resistor, .5 meg., 1 watt
R5—I.R.C. resistor, 1.5 meg., 1 watt
R6—Center-tapped filament resistor, 60 ohms, (used only if filament transformer is not center tapped)
SW—Insuline s.p.s.t. toggle switch
T1—Amertran De Luxe interstage a.f. transformer, Type D-11
1 National Precision dial, type N., O-100, clockwise rotation
1 Yaxley pilot light, bracket and bulls eye
1 Insuline No. 2218 dial plate and pointer knob, 0-100
1 Insuline pointer knob
1 Insuline steel cabinet, No. 3828, 12x8x7 inches
1 Insuline steel chassis No. 1531 (not drilled), 11x7½x2½ inches
1 Binding post terminal strip, 2-gang
2 wafer sockets 6-prong
1 Wafer socket 7-prong (large)
2—6C6 or 5 tubes
1—6A6 or 53 tubes
1 Filament transformer (see text)
1 22½-volt type 5156 Burgess battery
1 4½-volt type 2370 Burgess battery
1 Line cord and plug

Crystal Calibrating-Oscillator

RECENTLY a need was felt in the RADIO NEWS laboratory for an accurate frequency standard for use in checking receiver calibration, r.f. oscillator calibration, etc. The accompanying photographs and circuit diagram show the instrument which was built up to fill this need. The unit is a crystal oscillator with built-in power supply to operate from the a.c. line, using a 6L6 "beam-power" amplifier tube for the oscillator because of the abundance of strong harmonics which this tube provides. So

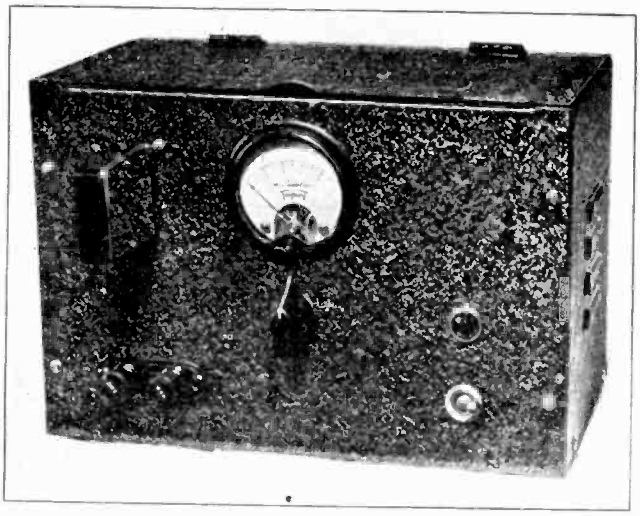


Figure 103—

A speedy and highly accurate instrument for checking receiver or signal generator calibrations throughout all ranges. A built-in power supply furnishes all operating voltages from the a.c. line.

useful has this device proved that the circuit (Figure 104), photos (Figures 103, 105 and 106) and parts lists are presented herewith for the benefit of others who may have need for a similar unit.

The crystal employed will depend on the purpose for which it is to be primarily used. The cheapest crystals are those employed by amateurs and resonate in the 160, 80 and 40 meter bands. One resonating around 2000 kc. will prove very useful for checking the calibration of tunable r.f. oscillators or signal generators. Such a crystal will provide check points every 2000 kc. throughout the high-frequency range of the oscillator. Then by tuning the oscillator in the low frequency ranges so that its harmonics beat with the crystal fundamental, additional calibration points are obtained at ½, ⅓, ¼. etc., of the crystal frequency. When the calibration of an r.f. oscillator has been checked, it in turn can be employed to check the calibration of receivers or other equipment.

Determining Frequency

It is not necessary to purchase an expensive crystal of accurately known frequency for this work. If it is rated at *approximately* 2000 kc., for instance, its frequency can be readily determined to 1 part in 10,000 by a simple procedure, requiring only the use of a receiver and any sort of a tuned r.f. oscillator. This is accomplished by first tuning the receiver to resonance with the crystal fundamental frequency, then tuning the other oscillator around the 1000 kc. range until its second harmonic heterodynes the crystal to zero beat as heard in the receiver. Next tune the receiver to resonance with the tuned oscillator to determine its approximate frequency then tune in a broadcast station on the nearest adjacent broadcast channel. The result will be an audible heterodyne between the tuned oscillator and the broadcast station on that channel. The pitch of this heterodyne is then estimated, or can be more accurately determined by finding the nearest note on a piano and converting this pitch to terms of frequency.

As an example, suppose after following this procedure, the broadcast station proved to be KDKA and it was just lower in frequency than the tuned oscillator, heterodyning at some audible frequency. Inasmuch as broadcast stations are required to maintain their carrier frequencies constant within 50 cycles and most of them stay well within this range, the frequency of the tuned oscillator would be 980 kc. less the frequency of the audible heterodyne. Now, running up a piano keyboard the note nearest might be found to be middle E. The frequency of this note is 320 cycles, therefore the tuned oscillator frequency is 980,000 cycles less 320 cycles or 979.68 kc. The crystal frequency would therefore be twice this, or 1959.36 kc. The only factors of error here are those resulting from inability to determine by ear exact zero beat between the oscillators, and to precisely judge the frequency of the audible heterodyne between the oscillator and the broadcast station carrier. With due care these errors combined should not amount to more than approximately 100 cycles. For applications around the laboratory or shop this degree of accuracy is so far superior to the accuracy with which receiver or signal generator dials can be read that is entirely negligible.

The harmonics of this crystal oscillator will provide good strong signals all the way down to 1 or 2 meters. Using a crystal that resonated at 737.81 k.c., for instance, a 5-meter receiver was calibrated using harmonics around the eightieth which were sufficiently strong to be the equivalent of a good R9+ signal in the 5-meter receiver.

Use with Tuned R.F. Oscillator

One practice followed in the laboratory is to use this oscillator in conjunction with a simple tuned r.f. oscillator. Naturally, when an attempt is made to use the harmonics of a relatively low-frequency oscillator, there is usually some difficulty in identifying the harmonics. To overcome this the tuned r.f. oscillator is adjusted to one of the low harmonics of the crystal, such as the fifth for instance. Then as the receiver under test is tuned down through its range the audible beat of the two oscillators will be heard at the fifth harmonic of the crystal frequency, the tenth harmonic, etc. Then between these multiples of five it is easy to keep track of the other harmonics

No modulation was provided in the crystal oscillator as all the crystal harmonics will show up in a receiver either by watching the tuning meter if it has one, by listening to the suppression of noise in a.v.c. receivers or by the use of a beat-frequency oscillator if the receiver in question is equipped with one.

Where a very low frequency crystal is employed, such as 100 kc., numerous calibration points can be obtained to check calibrations in the broadcast band. If the main interest is in short wave or ultra-short wave calibrations, a crystal of higher frequency can be employed.

The method suggested above can be reversed with a fair degree of success by adjusting the tunable oscillator so that the crystal will beat with one of its harmonics. In that case, any of the conventional tubes could be used in the crystal oscillator as its higher harmonics would not be used.

The method of using the oscillator to check the calibration of a receiver should be quite obvious. The first step is to make, by simple multiplication, a complete list of the frequencies at which harmonics of the crystal fall. Then it is only necessary to tune the receiver through its range, starting at the low frequency end (assuming that a low-frequency crystal is used). As the receiver is tuned to resonance with each harmonic, a notation is made of the frequency as read on the receiver dial and beside it is noted the frequency of the harmonic. The difference between these two will be the calibration error of the receiver. Due to the relatively high power of the harmonics of the crystal oscillator, it will normally not be difficult to keep track of them if tuned in regular sequence but in any event the use of a separate tuned oscillator will provide an audio beat at every fifth harmonic (or other multiple)

Figure 104

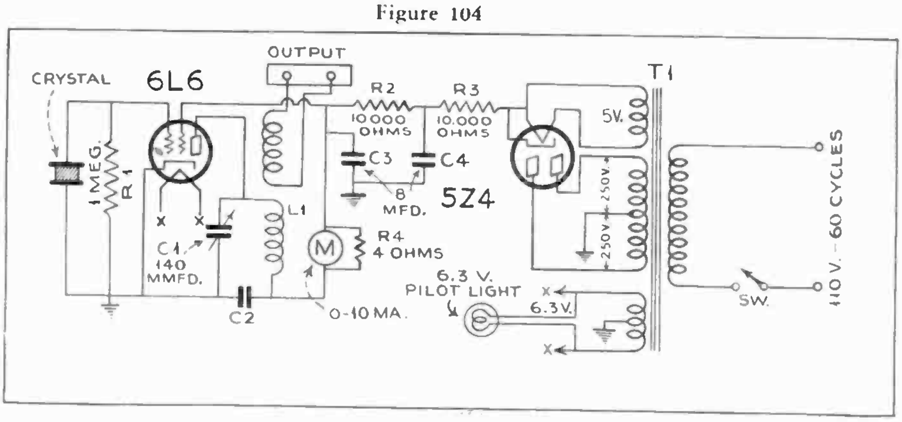
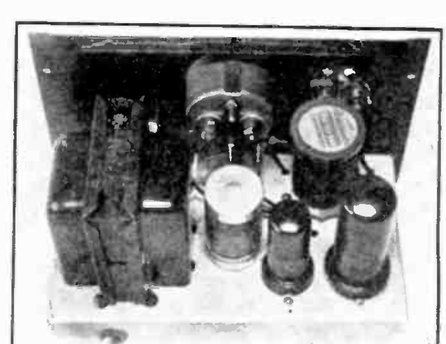


Figure 105



thus providing a sufficient check to keep the harmonic count straight.

Provides For Different Crystals

The unit provides for using different crystals if desired. The crystal plugs into an ordinary 6-prong tube socket and coils of the plug-in type make the tuned circuit adaptable to crystals of any frequency. When crystal and coil are plugged in it is only necessary to rotate the condenser until the meter dips, thus indicating an oscillating condition. Best operation is obtained just off the point of maximum dip. The non-oscillating plate current is around 12 ma. The meter may be an 0-10 ma. meter shunted to provide full-scale deflection when the circuit is not oscillating. Or a higher range meter may be employed without a shunt if desired.

Parts List

C1—Hammarlund "Star" midget variable condenser, 140 mmfd.
C2—Aerovox fixed tubular condenser, type 484, .05 mfd., 400 volt
C3, C4—Aerovox 2-section electrolytic condenser, type GG. 8-8 mfd., 200 volt
R1—I.R.C. carbon resistor, 1 meg., ½ watt.
R2, R3—Electrad wire-wound resistors, 10,000 ohms, 10 watts
R4—Wire resistor meter shunt
T1—Wholesale Radio Service Company power transformer, type MYB 1353, primary 110 v., 60 cycles; secondary, 250/250 v. at 65 ma.; 6.3 volt., 5 v.
1 Triplett type 223 milliammeter, 0-10 ma.
1 Bud crystal holder
1 crystal
1 Hammarlund plug-in coil, 4 prong (range to suit crystal)
1 6-prong wafer socket for crystal
1 4-prong wafer socket for coil
2 Octal wafer sockets
1 Insuline steel cabinet, 9x5x6 inches, type 3825
1 Insuline cadmium plated steel chassis, blank, 8½x4¾x1½ inches, type 1560
1 Yaxley pilot light bracket and bulls eye

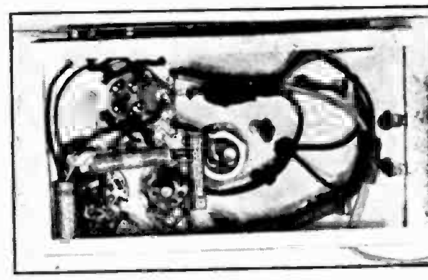


Figure 106
Under-chassis view of oscillator

1 double binding post strip
1 Insuline toggle switch, S.P.S.T.
1 Insuline pointer knob (small)
Rubber grommets, assorted sizes
1 6.3 volt pilot light
6 feet power cord, plug

Resonance Tester

IN radio-frequency work the serviceman and experimenter often find it necessary to match coils, check the tracking properties of tuning condensers or to adjust a series of tuned circuits to resonance. The instrument described here is designed for just such uses.

Fundamentally this simple unit consists of a high-frequency oscillator beating with some harmonic of a low-frequency oscillator so that a condition of zero beat is indicated in headphones connected in the plate circuit of the former. Now when a tuned circuit is connected across the grid circuit of the low-frequency oscillator and C1 (Figure 108) is adjusted to zero beat with some harmonic a very slight change in the electrical characteristics of this tuned circuit will upset the condition of zero beat. Thus we have a simple and very accurate method of comparing tuned circuits, tuning coils and condensers, and adjusting them to exact resonance.

Three type —27 tubes are used, two as oscillators and one as rectifier in the plate supply. Of course, any other suitable triode may be used, such as the 56, 76, 6C5, etc. The entire unit is contained in a metal case 8¾ inches long, 7 inches high and 5 inches deep with a panel 9½ inches long, 8 inches high, of 1/16 inch steel. The accompanying photographs show the layout of the parts and general method of construction.

The two oscillator coils are home made. L1 consists of 45 turns secondary, 20 turns tickler, L2 consists of 11 turns secondary, 7 turns tickler. All windings are wound with No. 26 enameled wire on a 1½ inch form.

A detailed account of the construction of this device is not necessary as the illustrations and drawings are self explanatory. Suffice it to say that the small filament

Figure 109

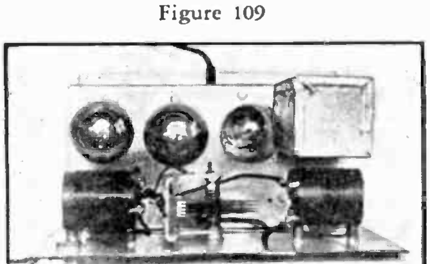
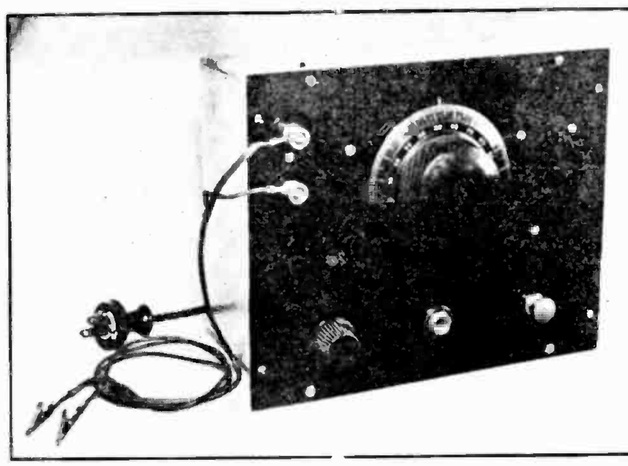


Figure 107—
Not only will this instrument provide an accurate indicator for matching coils and condensers but it is equally effective in checking alignment of tuned circuits.

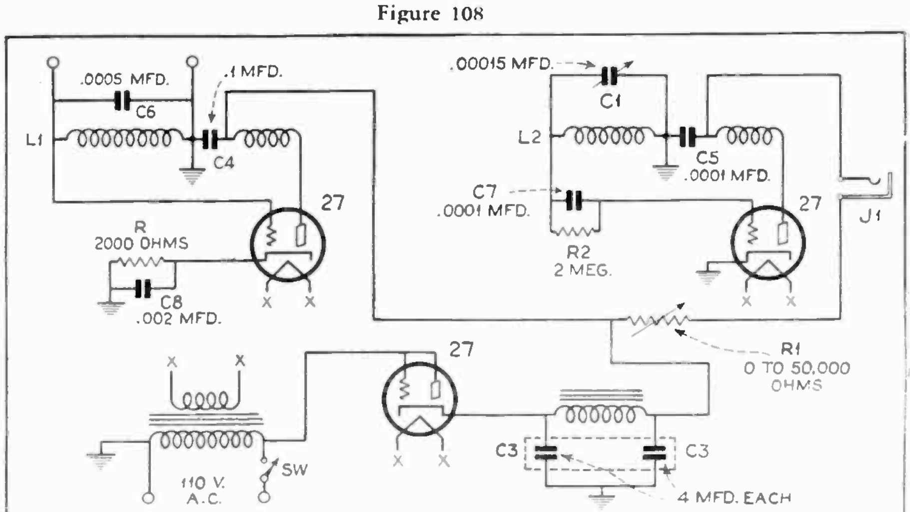


transformer is mounted under the bottom panel as is also the filter choke. The filter condensers are mounted directly above the transformer on the top side of the panel. The two oscillator coils, variable condenser, power switch, phone jack, and variable resistor are mounted on the front panel. Precautions for insulation should be taken where necessary.

Operating Data

After the unit has been assembled and wired, insert tubes and plug in headphones. If the high-frequency oscillator is functioning properly a distinct click should be heard upon touching the stator plates of the variable condenser with a

Figure 108



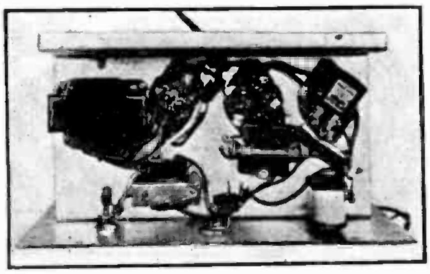


Figure 110

metal screw driver. If there are indications that this circuit is not oscillating try reversing the tickler connections. The variable resistor should control any howls or squeals that may take place. Now upon rotation of the tuning condenser a series of beat notes should be heard, one every 10 or 15 points on the dial. This shows that the low-frequency oscillator is functioning and after placing the instrument in its shielding case it is ready for use. A shielded lead about 20 inches long provided with spring clips on one end and spade tips on the other is used for connecting to the circuit under test.

If a tuned radio-frequency amplifier is to be aligned the procedure is as follows: Make sure tubes and shields of receiver are in place. *The external grounds should be disconnected.* The test lead is clipped to the ground (chassis) and grid end of the detector tuning coil. Now turn the indicator dial until a beat note is heard in the phones and carefully tune to zero beat. Next move the grid clip to the grid of the preceding r.f. stage. If condition of zero beat is not maintained in this stage adjust trimmer condenser until it is. Proceed in this manner with remaining stages. The alignment may be checked at any other setting of the tuning condensers without disturbing the trimmers as would have been necessary using an ordinary oscillator and output meter. Intermediate amplifiers in superheterodyne receivers are aligned in the same way.

To determine if a set of coils is properly matched, simply clip the test leads across one of them and tune the resonance indicator to zero beat. Upon connection to any of the other coils zero beat should be obtained at the same setting. If zero beat is obtained at a lower dial setting, the inductance is too low. If at a higher dial setting the inductance is too high. (Providing, of course, that the dial reads 100 when the condenser is closed.) Ganged condensers may be checked in the same way.

In the year or so during which the designer has used this device it has proven to be of inestimable value, and the fact that it is powered from the light mains seems to have no bearing on the results of which it is capable. But remember, it is not a frequency meter, it can be used only to indicate a condition of resonance when the values are approximately the same.

List of Parts

1 2.5 volt filament transformer. (1100 turns No. 32 DCC wire as primary, and 25 turns No. 16 enameled wire as secondary wound over an old audio transformer core at least ½ sq. in. cross section will suffice.)
1 filter choke (may be the primary of small audio transformer)
Sw, power switch
3 wafer type sockets, 5 prong
2 oscillator coils (as specified)
1 20 in. shield lead (shield itself may be used as one conductor)
1 vernier dial, 1 phone jack
Condensers and resistors of values shown in Figure 108
Wire, hardware, etc.
The constructor may use his own judgment in building a suitable case.

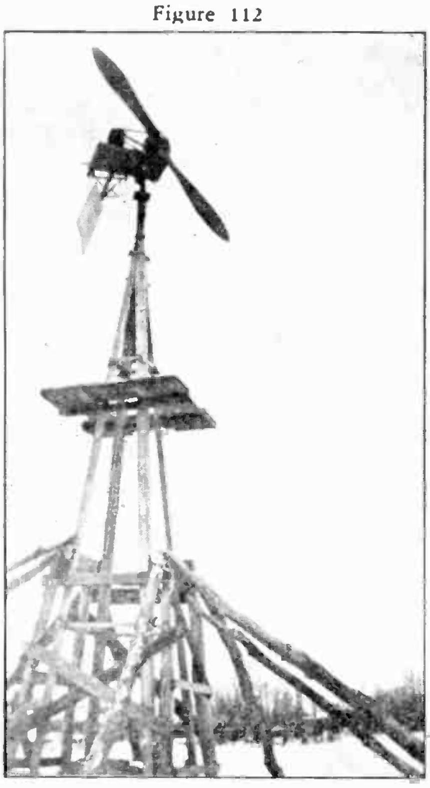
Service Hints

Windmill Power

With several manufacturers putting out Wind-Mill Power Plants and receivers designed especially for use with them both the farmer and the rural serviceman are getting a new "break." Some servicemen are jacking up their profits by constructing the wind-mill and charging unit themselves.

The accompanying photograph (Figure 112) shows an improved power plant. The model is mounted on a standard steel windmill tower. A 6-foot airplane-type propeller is mounted on the front-wheel assembly of a Model T Ford, and drives a 6-volt automobile generator at a 3-1 ratio by means of the conventional V-shaped fan belt. Sliding contacts on the platform permit it to turn with the wind. The propeller is offset 3½ inches from the turntable pivot, providing a tendency to turn away from a strong wind, with the effect of a governor.

Figure 112



Obviously, as high a position as possible, within reasonable distance from the receiver location, should be chosen for the windmill. The charger should be positioned at least 10 feet above the ground, and be sure that no obstructions, such as trees, silos and large buildings, are close enough to obstruct the wind. In almost every location there is a prevailing wind, and the tower should be erected in such a spot as to take full advantage of it.

All connections must be well soldered—excepting, of course, such as are made to posts. These latter should be made with soldered lugs. Be sure the ammeter, relay and battery connections are tight. In other words, watch out for high-resistance contacts. In running the wire from the wind charger to the battery, number 12 B. & S. gauge copper wire can be used on distances up to 50 feet. From 50 to 75 feet, number 8 is in order. From 75 to 200 feet, number 6 or 4 B. & S. must be employed. In cases where the receiver draws less current than the average charging rate, it will be more economical to house the battery as close to the wind-mill as possible—rather than alongside the set, which, however, is usually the more convenient location. (Many farmers, though in the habit of milking at 4 A.M., balk at the idea of trudging through sub-zero snow to put electrolyte in the battery!)

A Universal Plug For "Blanked Out" Sockets

A group of radio manufacturers have recently agreed to discontinue the use of "blanked out" octal sockets. But the radio serviceman for many years to come will be confronted with the problem encountered in testing such receivers. Boring through the blanked holes, or carrying along a truck-load of adapters have been alternative solutions to the difficulty. Figure 111 shows two universal plugs.

Both bases are drilled for the full complement of octal pins. Base number 1 is the easier to construct. Threaded sleeves are inserted into the holes, and the required number of pins are screwed into the correct holes. Base 2 presents a some-

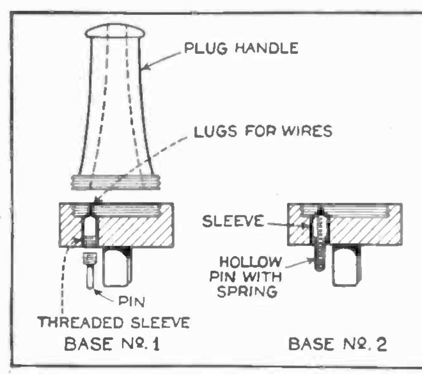


Figure 111

what more complicated construction, but its use is simplified. Hollow pins, with internal springs, are inserted in each hole. Pins hitting the blanks are forced up into the base, while those over the socket holes insert themselves to make contact. Fairly strong springs should be used.

New Use For Dental Mirror

In trying to look around a corner in a periscopic fashion to see the end color of a resistor, a dental mirror works out quite nicely. It is also a great help in tracing circuits through a maze of half-hidden wires.

The magnification afforded by such mirrors relieves eye strain and contributes to the speed and accuracy of many a service job. Try it on some tubular condenser with the capacity marked on the side you can't see!

SOUND EQUIPMENT

Radio News 20-Watt Amplifier

THE amplifier shown in Figure 113 features the superior quality of reproduction obtainable with Class A power amplification and resistance-coupled voltage amplification, both in push-pull. A new non-distorting phase-inverting circuit voids the use of transformers or chokes for this purpose, eliminating one source of induction hum and possible distortion. Resistance-capacity filters of unusual size insure complete absence of "motor-boating" and reduce hum to a negligible quantity. Absolute stability with high gain is attained through careful design and selection of the components used.

The input circuit employs a dual-triode 6A6 as an electronic mixer and amplifier, permitting the use of two microphones simultaneously with independent control of each one by the two volume controls R1 and R2 (Figure 114). A switch, SW1, is provided so phonograph pickup amplification is accomplished without using the additional gain provided by the 6A6, affording a smoother and wider range of control. A tone control is also provided (not shown in the diagram), which may be employed to minimize needle scratch when using records, reduce microphone hiss, etc., when required. In spite of its high-gain and power output of full 20 watts, the amplifier is perfectly stable even when operated at full sensitivity. It may be used without a pre-amplifier, with either carbon or crystal microphones. Velocity mikes may also be used, but while good volume is obtained, the usual pre-amplifier should be used for maximum output.

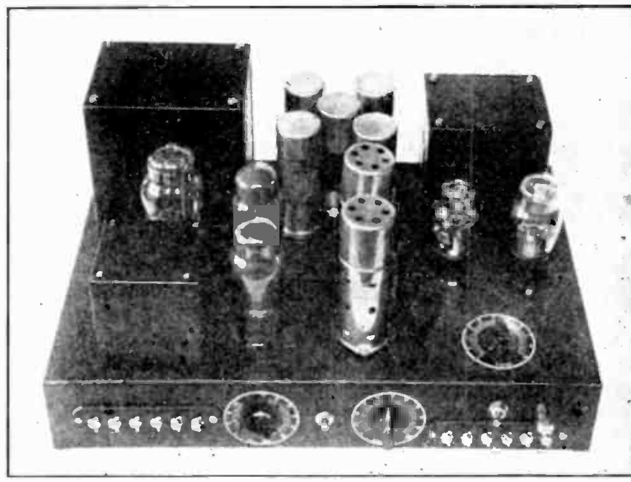


Figure 113—

An entirely new Class A amplifier which incorporates a new foolproof and distortionless method of phase inversion. A combination of resistance and direct coupling is employed.

Drawbacks of Earlier Circuits

The usual phase inverter consists of two triodes and rests on the principle that the signal in the plate circuit is 180 degrees out of phase with the signal in the grid circuit. The phase is then reversed by applying a part of the output of the first tube to the grid of the second tube and taking the signals from the plate circuit of the two tubes. The system is imperfect because due to the capacity coupling the two sides are not exactly in opposite phase, although the difference is small. Furthermore, if one tube changes its characteristics through ageing, the balance is lost and the two sides will have unequal amplitude.

1-Tube Inverter

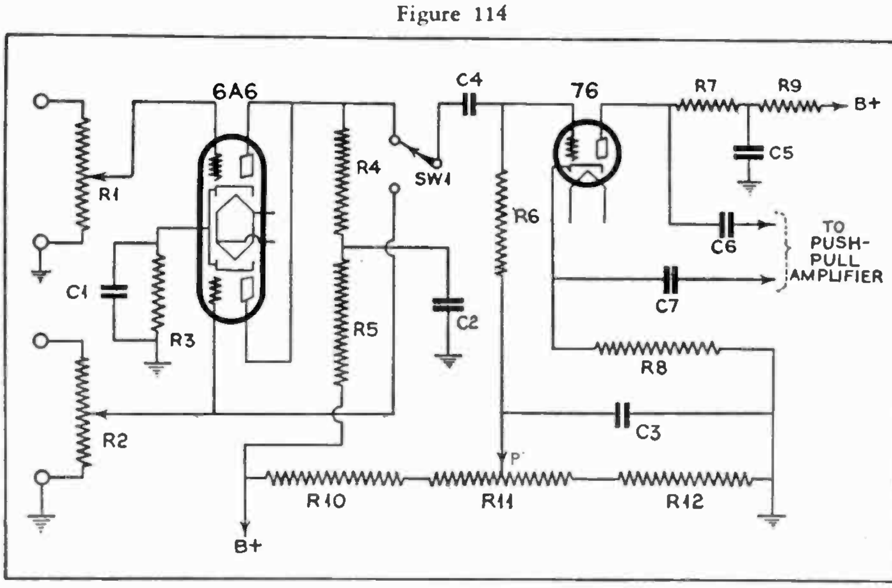
In this new system only one tube is used and the two sides of the signal are perfectly in phase and of equal amplitude. When a resistor is in the plate circuit, during the positive half cycle of the input signal, the current increases and the voltage across the plate load increases, so the plate voltage drops. If the plate load is put in the cathode side, when the current increases the cathode voltage goes up. So, if the load is divided equally between the plate and cathode circuit (R7 and R8, Figure 114), the drops across these load resistors will be equal and opposite and the inversion is complete. There are no condensers to shift the phase and variations in the mu of the tube will have no effect.

The big problem, however, is to supply the correct bias to the grid without spoiling the balance. One solution to this was given by Mr. W. Richter in Electronics for October 1935. The grid return is brought to a point on a voltage divider, R10-R11-R12, which is negative with respect to the cathode thereby placing the correct bias on the tube. Under these conditions the variation in voltage across the cathode resistor, R8, reacts on the grid bias so as to cause degeneration. Consequently there can be no gain in the stage. The output of one side of the push-pull arrangement is about .8 of the input signal voltage. The degeneration does not affect the desired phase inversion in any way, it just does not deliver any large output.

The voltage amplifier is resistance coupled to the push-pull power stage. The plate and grid resistor values have been conservatively chosen, not to provide the utmost in gain but rather to assure reliable operation with tubes of varying gas content.

The power stage consists of two 6B5's, a type of tube whch is coming into wide use in sound system amplifiers. Essentially, it

Figure 114



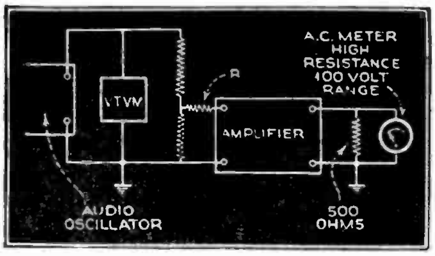


Figure 115

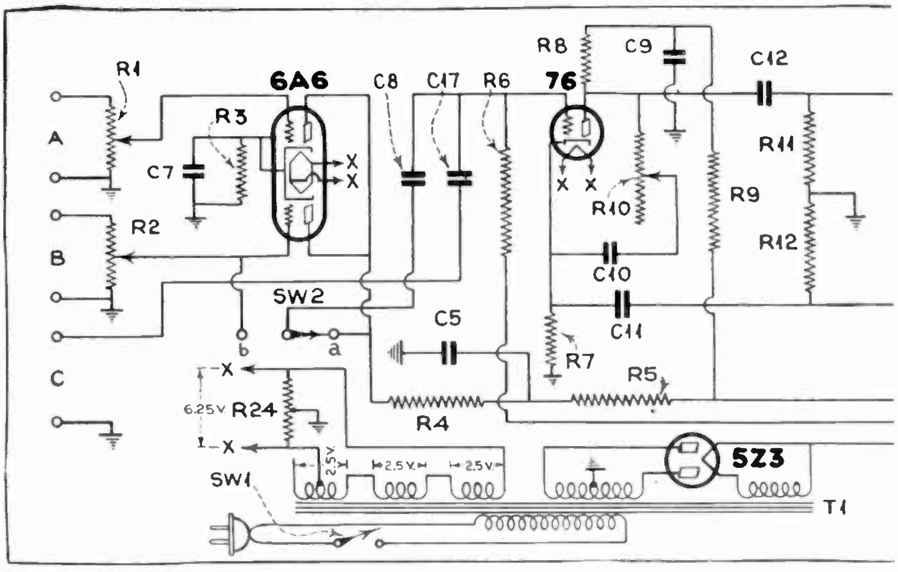


Figure 116—The complete circuit

consists of two tubes in a single glass envelope with the second section direct-coupled to the first or input section. Through its use a full 20 watts of undistorted power is obtained with Class A operation with economy and simplicity of circuit design not obtainable with other types of power tubes.

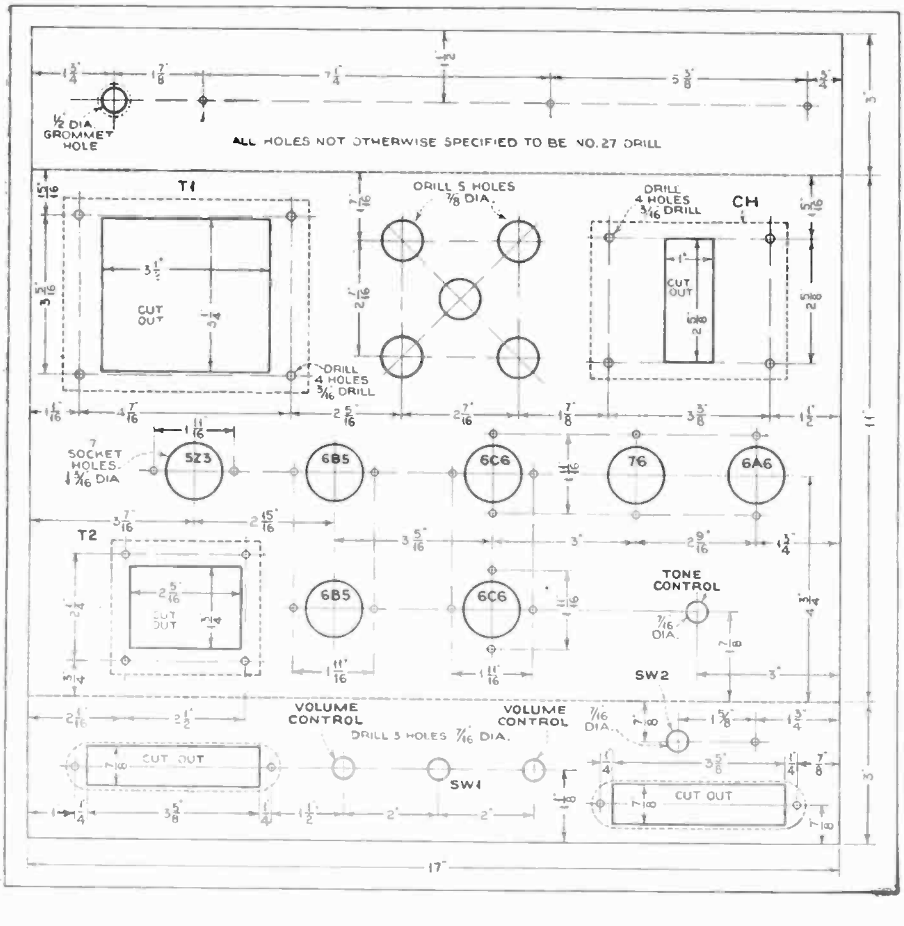
The complete schematic circuit of this new 20-watt P.A. amplifier for amateurs or servicemen to build themselves is shown in Figure 116 and indicates the simplicity of the design. Three individual input channels are provided, two of which may be used for microphones and the third for a phonograph pick-up or pre-amplifier. Convenience and ease of connection are assured through the use of a 6-contact input terminal strip.

Flexible Input Circuits

Since the 6A6 is composed of two similar high-mu triodes, provision has been made to connect channels A and B simultaneously, to each input section. As the output plates of this tube are wired in parallel, sounds picked up by microphones connected to these channels are amplified and mixed in the plate circuit before passing on to the phase-inverter tube. Separate gain controls are provided for both channels A and B to facilitate proper mixing. In addition, for phonograph pick-up amplification, where the increased gain of the 6A6 is not required, channel B and its associated volume control may be transferred directly to the phase-inverter tube by simply throwing switch 2 to point b.

Channel C connects directly to the phase inverter circuit and is intended for use with an external pre-amplifier, but may likewise be used for pick-up work when the turntable is already fitted with a volume control. Switch 2 must be on point a when using this channel.

Figure 117



The tone control is connected from the plate to cathode of the phase-inverter tube and is therefore effective, regardless of which channel is used.

High Stability

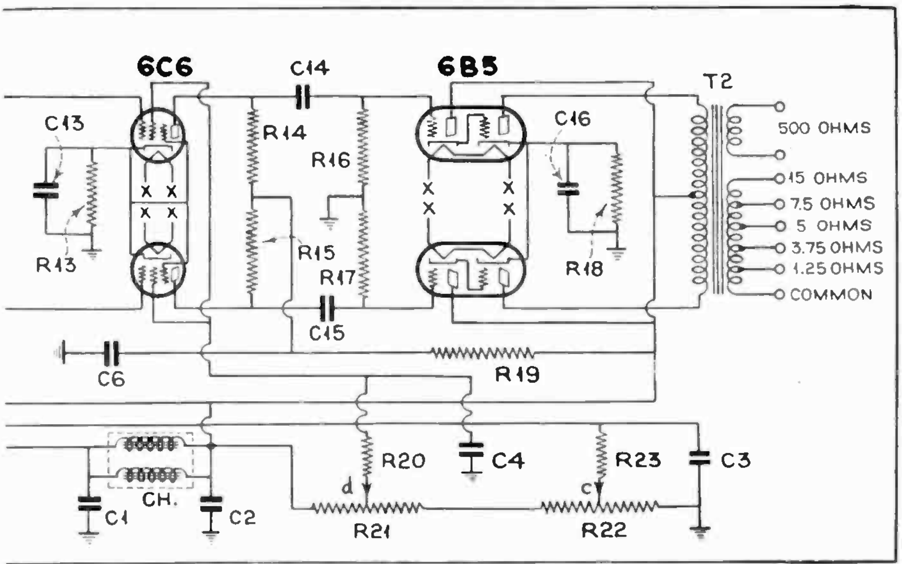
Freedom from motor-boating and other forms of instability is obtained through the liberal use of resistance-capacity filtering. In all circuits, except the screen supply to the 6C6 tubes, considerable capacity has been used. The screen filter circuit, consisting of a 1-megohm resistor and a .1 mfd. condenser, has a time constant of 1/10th second which is sufficiently fast to eliminate motor-boating under these design conditions, without affecting the fidelity characteristic over the useful range. It is important that no larger capacity be used at this point.

The chassis employed is of standard size, using heavy No. 16-gauge steel, and is fitted with a bottom cover. Drilling is done in accordance with the layout shown in Figure 117. The two gain controls are located in the front of the amplifier, with the power switch S1 in the center. Above the input terminal strip is located the channel switch S2 and the ground binding post. The tone control is on the top portion of the chassis. Provision is made for five output channels. The output transformer is designed to match 15-, 7.5-, 5-, 3.75- and 1.25-ohm loads in addition to a standard 500-ohm transmission line.

Wiring Suggestions

In wiring, the leads in the input circuits should be kept well separated to reduce stray coupling. The filament circuits should be wired in first. The filter circuit wiring may then be completed. Finally, the resistors and by-pass condensers are wired in, using small terminal strips located close to the sockets. After the wiring is completed, the voltage adjustment of the phase-inverter tube may be undertaken. The slide on R22 should be adjusted until the voltage between point C and ground is approximately 26 volts. Next, put a milliammeter in the plate circuit of the 76 and readjust the slide until the meter reads 1.4 ma., approximately. Point D, for the screen voltage, is taken at 250 volts.

If the amplifier is to be operated over long periods, longer tube life, particularly of the 6B5's, may be obtained by using less



of the RADIO NEWS **amplifier**

than the maximum plate voltage of 400 volts. A reduction to approximately 350 volts is accomplished by simply omitting C1. The power output will, of course, drop slightly but will be sufficient for practically all purposes.

Measured Characteristics

The amplifier's performance was measured in the RADIO NEWS Laboratory in the usual way. The gain of the amplifier was 102 db. In practical language, this means that it takes .025 volt at the input terminals to deliver full output.

The frequency characteristic was measured with the same set-up, shown in Figure 115. This was taken also at full gain and with the amplifier delivering 20 watts to a 500-ohm load.

The frequency characteristic is essentially flat throughout the audible range. At 18,000 cycles it was .7 db. down, at 10,000 cycles .4 db. down. On low notes good response is obtained; at 80 cycles it is .9 db. down, at 50 cycles 3 db. down and at 30 cycles 6.7 db. down. When the first stage is cut out, the voltage gain is reduced 10 times, so the total gain of the amplifier is then 82 db.; it takes .25 volt at the input terminals for full 20-watt output. This arrangement will generally be preferred with the average phonograph pick-up.

One should be careful to shield input wires and to ground the shields of input transformers, etc., to eliminate any possibility of hum pick-up by induction.

Finally, some cathode-ray tests were made. The first one was a test for harmonic distortion. It was made by applying the input signal to one set of deflecting plates and the output signal to the other set of deflecting plates. When proper phase relations exist, the trace should be a straight line. If it curves at the ends, third harmonic distortion is present. While there was a slight curvature at the ends at full output, the line was perfectly straight at slightly reduced levels. Another cathode-ray test was made to establish the action of the inverter tube. After measuring the voltage across resistors, R11 and R17 with a vacuum tube voltmeter, to be sure that they were equal, the deflecting plates were connected so that one side of the signal sweeps horizontally, the other vertically. The resultant trace must be a straight line and at 45 degrees to the axis—nearly, because the two sets of plates are not equally sensitive. The experiment proved that this was the case. Reversing the connections to the input grids of the 6C6's did not change the trace. This was a proof that the inverter delivers a symmetrical signal to the push-pull circuit.

Parts List

C1—Cornell-Dubilier PE-B6808 paper filter condenser, replacement for 8 mfd. 800 volts peak
C2—Two, Cornell-Dubilier EB8800 dual electrolytic condensers 8-8 mfd. each, 525 peak
C3—Cornell-Dubilier electrolytic condenser 25 mfd. 50 volts

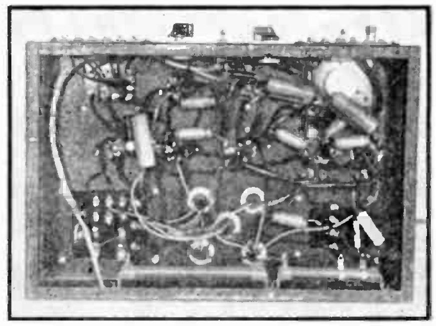


Figure 118

C4. C10, C11, C12, C14, C15, C17—Cornell-Dubilier tubular paper condenser, .1 mfd., 400 v. type DT-4P1
C5, C6—Cornell-Dubilier dual electrolytic condenser 8-8 mfd., 525 volt peak
C7. C13. C16—Cornell-Dubilier electrolytic condenser 25 mfd., 25 v. ED-2250
C8—Cornell-Dubilier tubular paper condenser type DT-4P1, .1 400 volt
C9—Cornell-Dubilier electrolytic condenser 8-8 mfd., 525 volts peak
Ch—Amertran filter choke, Z-913, dual sections in parallel, 8 henries, 200 ma.
R1. R2, R10—Electrad potentiometers, 500,000 ohms
R3—IRC carbon resistor, 1250 ohms, 1 watt
R4—IRC carbon resistor, 50,000 ohms, 1 watt
R5, R9. R19—IRC carbon resistor, 100,000 ohms, 1 watt
R6. R11, R12, R16, R17—IRC carbon resistor, .5 meg., ½ watt
R7. R8—IRC carbon resistor, 25,000 ohms, ½ watt
R13—IRC carbon resistor, 1500 ohms, 1 watt
R14, R15—IRC carbon resistor, ¼ meg., 1 watt
R18—IRC wire wound resistor, 150 ohms, 10 watts
R20—IRC carbon resistor, 1 meg., 1 watt
R21—Electrad Truvolt resistor, 50,000 ohms, 25 watts
R22—Electrad Truvolt resistor, 25,000 ohms, 50 watts
R23—IRC carbon resistor, 75,000 ohms, 1 watt
R24—Trutest, center-tapped resistor, 20 ohms
SW1—SPST toggle switch
SW2—SPDT toggle switch
T1—Amertran Power transformer, type U981, primary, 115 volts; secondaries, 425-0-425 volts, 160 ma.; 5 volt. 3A; 2½ volts, 5A; 2½ volts, 10A; 2½ volts CT, 5-A
T2—Amertram output transformer, type J874, primary 10,000 ohms CT, secondaries, 500 ohms and universal voice coil
1 4-prong wafer socket
1 5-prong wafer socket
1 large 7-prong wafer socket
4 6-prong wafer socket
1 chassis 17x11x3 with bottom cover
2 terminal strips, 6 terminals each
2 tube shields
3 V. C pointer knobs
2 indicator dials marked "Volume"
1 indicator dial marked "Tone"
4 terminal lug strips—2 terminals
1 line cord and plug
1 rubber grommet
1 binding post
2 6C5 Raytheon metal tubes
1 5Z4 Raytheon metal tubes
6 feet parallel or twisted pair, power cord
Hookup wire
1 dozen nickel plated brass screws—6/32—½" with nuts and lock washers
2 grid clips
2 6B5 tubes Triad or Sylvania
2 6C6. 1 523, 1 76 and 1 6A6 tube

Radio News A.C. Pre-Amplifier

MANY p. a. amplifiers and many of the speech amplifiers employed in "ham" transmitters have sufficient gain for operation with carbon mikes but not enough for the more modern crystal and velocity types. In any p. a. amplifier, if an attempt is made to concentrate too much amplification in a single unit, the problem of securing stable operation becomes exceedingly difficult. With resistance-coupled amplifiers, "motorboating" is likely to result if the amplifier is effective at low frequencies, due to coupling from a common power supply source. With transformer coupling, extreme shielding and balancing precautions must be taken to secure a low hum level. The simplest way out is to use a self-powered pre-amplifier. Pre-amplifiers are generally battery-operated. In the instrument shown in Figure 119, the hum level is so low as to be completely inaudible with phones connected to its output circuit. When connected to the main amplifier, with the overall gain adjusted to give full output the amplified hum level is still negligible.

The circuit diagram is shown in Figure 121. As indicated, it employs two resistance-coupled stages using 6C5 tubes. The overall gain is 58 db.

Metal tubes are used throughout, eliminating the need for tube shields which are so often a cause of noise due to poor contacts. The 5Z4 rectifier is slow heating, therefore no bleeder resister is required. This relieves the chokes of an added current burden and permits better filtration. In the plate circuit of the input tube, a resistance-capacity filter, R3-C2 gives the required additional smoothing to this circuit.

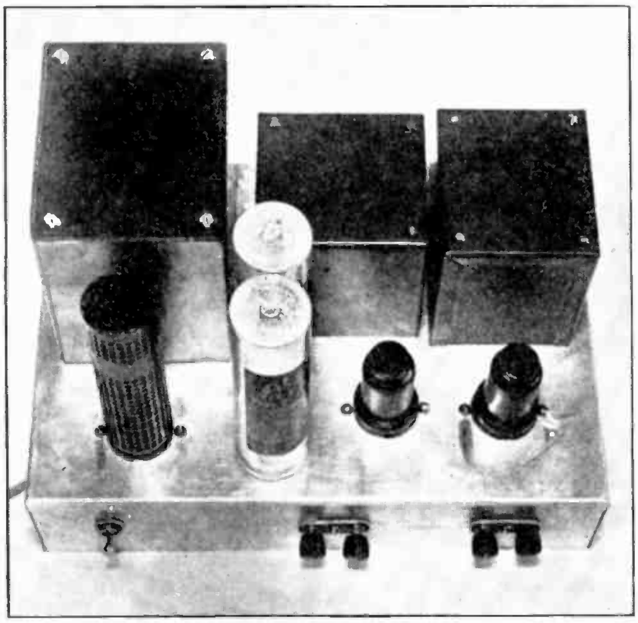


Figure 119—

A simple and straightforward layout in which every part is self-shielded; an aid in obtaining high stability and minimum hum.

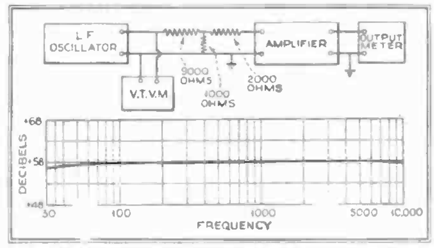


Figure 120

In this design, the output circuit has a relatively low impedance. The usual plate-to-line and line-to-grid transformers are therefore not required. This results in a considerable saving in cost. The plate load resistor of the 6C5 output tube is 20,000 ohms. Using this value, 7 or 8 feet of low-capacity shielded cable may be employed to join the amplifiers with a loss of less than .5 db. at 10,000 cycles. While higher gain may be obtained by using a 50,000 or 100,000 ohm plate load, the present gain of 58 db. is more than adequate for p. a. work and avoids complications.

Fidelity Curve

The fidelity curve is shown in Figure 120. This was obtained using the set-up indicated. A General Radio type 377-B low frequency oscillator is employed with a General Radio vacuum-tube voltmeter across its output.

The output voltmeter is a Radio News multimeter using a copper oxide rectifier and Weston meter. The 100 volt scale was employed and the output voltage kept constant at 20 volts. The v.t. voltmeter and output meter were checked against each other and a correction factor used to compensate for the slight frequency error in the output meter .

Calculating Amplification

The db. gain was calculated by the usual method, multiplying by 10 the logarithm of the ratio of the power in the output circuit under load to that of the input circuit. The output meter load is 100,000 ohms, which introduces more loss at low frequencies than will occur with the usual amplifier input circuit load. Nevertheless, it is down only .5 db. at 50 cycles and but .13 db. at 10,000 cycles. Even at 20,000 cycles, it is down only .3 db. It should be pointed out, however, that db. ratings for overall gain of amplifiers with resistance input may be confusing. If the input resistance were 5 megohms instead of .5 megohms, the voltage amplification would still be the same though the rating would be 10 db. higher.

Overall Gain

The overall gain of the Radio News 20-watt amplifier (described in the preceding pages) is 108 db. reckoned on the basis of the input resistance of 500,000 ohms. With a transformer secondary connected, rated at 150,000 ohms, it would be 102 db. When we connect the pre-amplifier, we do not get 108 db. plus 58 db. because the output impedance of the pre-amplifier is 20,000 ohms. This will cause a loss of approximately 14 db. From the input of the pre-amplifier to the output of the main amplifier, the overall gain is therefore 108 db. plus 58 db. minus 14 db., or 152 db. If we connect a 2000 ohm velocity mike to the pre-amplifier the input will then be 2000 ohms instead of 500,000 ohms. This will reduce the effective gain 24 db. making 128 db. overall.

It is rather difficult to express the sensitivity of crystal mikes in terms of db. since they are designed to work into a very high impedance and their own impedance takes the form of a capacitive reactance which varies with frequency Methods of rating these microphones now include the output in millivolts at average speech levels. From this information, the voltage gain required to deliver the desired output may be readily computed.

There are two types of crystal mikes, the sound cell and diaphragm models. The former can be designed to give exceptionally fine fidelity while the latter gives good fidelity and high sensitivity at somewhat lower cost.

Manufacturers of crystal mikes recommend using a 2 to 5 megohm grid resistor to assure best low-frequency response.

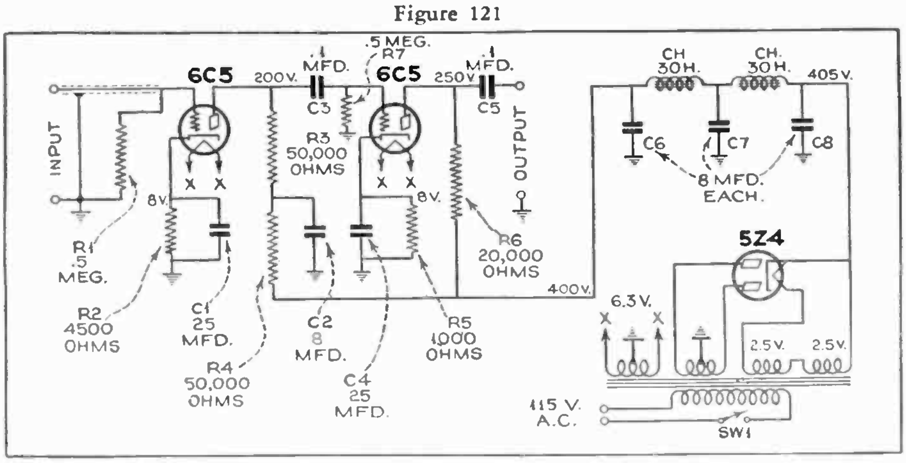
How much gain do we actually require? Figuring on a basis of .006 watts at zero level, 15 watts is plus 33 db. If the microphone is rated at -70 db. we require 103 db. overall gain to get this output. For 20 watts, we require 2 db. more, or 105 db.

The filter chokes are laid out with their centers on a line with that of the power transformer and with their cores mutually at right angles. The input tube is opposite choke 2, which will have the smallest external field. The terminal blocks are arranged to give the shortest possible leads. The input grid lead should be shielded.

In wiring, the heater leads should be twisted and kept close to the chassis and well away from grid and plate leads. This also applies to the power cord. The tube shield prong on each octal socket should be grounded directly to the chassis. The filament supply for the 5Z4 is obtained by connecting the two 2.5 volt power transformer windings in series-aiding If connected in series-bucking, no voltage will result.

In operation, care should be taken to use only shielded cable to the microphone. The shielding should extend right up to the input to the pre-amplifier, in order to prevent pickup of extraneous voltages.

Figure 121



Parts List

C1, C4—Aerovox electrolytic condensers, type PR-25, 25 mfd., 25 volts
C2, 6, 7, 8—Aerovox electrolytic condensers, type GG-5, 8-8 mfd., 450 volts
C3, C5—Aerovox tubular paper condensers, type 484, .1 mfd., 400 volts
Chl, 2—Amertran filter chokes, 30 henry, type Z-904
R1—I.R.C. carbon resistor, 500,000 ohms, 1 watt
R2—I.R.C. carbon resistor, 4500 ohms, 1 watt
R3, R4—I.R.C. carbon resistor, 50,000 ohms, 1 watt
R5—I.R.C. carbon resistor, 1,000 ohms, 1 watt
R6—I.R.C. carbon resistor, 20,000 ohms, 1 watt
1—S.P.S.T. toggle switch
T1—Amertran power transformer, type U-971, 600 v., c.t., 2.5/2.5/6.3 c.t.
1—Cadmium-plated steel chassis—7½ x 11 x 2½ inches, not drilled
2 double binding post strips
3 octal wafer sockets

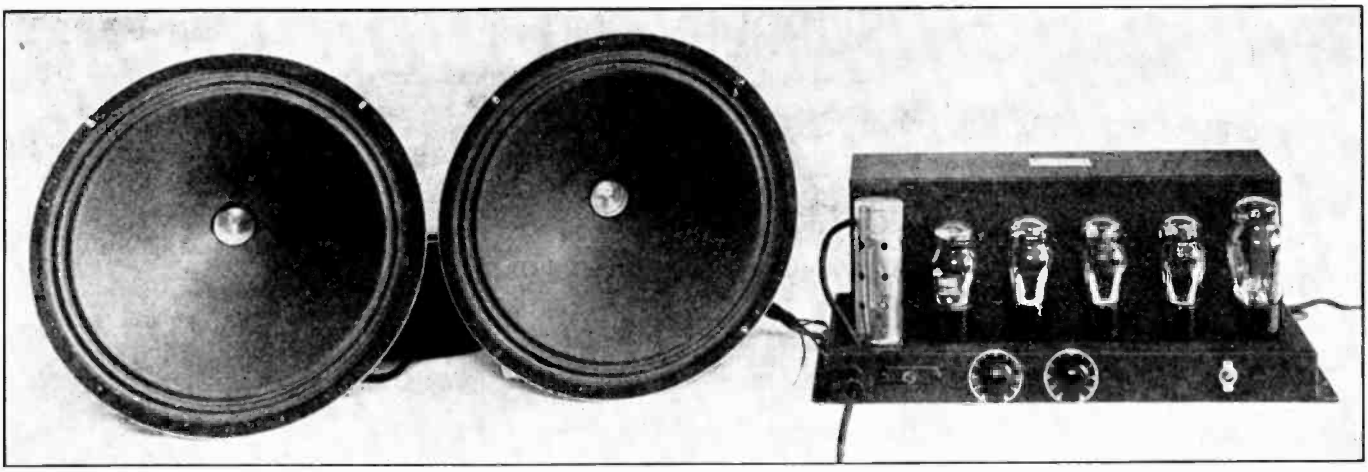


Figure 122

A 15-Watt High-Gain Amplifier

AN unusually successful high gain amplifier is represented by the 15-watt unit shown in Figure 122 which is especially designed for use with either crystal or high impedance type velocity microphones.

The output stage uses two 2A5 tubes connected as push-pull triodes, self-biased, in a class AB circuit. The rating given by tube manufacturers to this type of 2A5 arrangement is 15 watts and the preceding stages employed in this design are ample to fully excite the output stage with the microphones mentioned. The amplifier has an extraordinarily low hum level, at all times better than 25 db. below zero level.

In designing the system, special attention was given to making it versatile in application. The input of the amplifier is arranged for ribbon-velocity or crystal microphones, and may be easily adapted for carbon microphone use. Almost any type of phonograph pickup may be employed and radio input may also be used. The output transformer has taps at 4, 8, 16 or 500 ohms. The lower output impedances may be used in various combinations with a number of standard dynamic speakers. The 500 ohm output is employed for coupling to a line when the speakers are placed some distance away from the amplifier. It is evident that these flexible input and output provisions will meet practically all low-power public address requirements that may arise.

It provides an unusually high gain of 104 decibels to insure more than enough gain to permit the direct use of a crystal or a high impedance velocity microphone without a pre-amplifier.

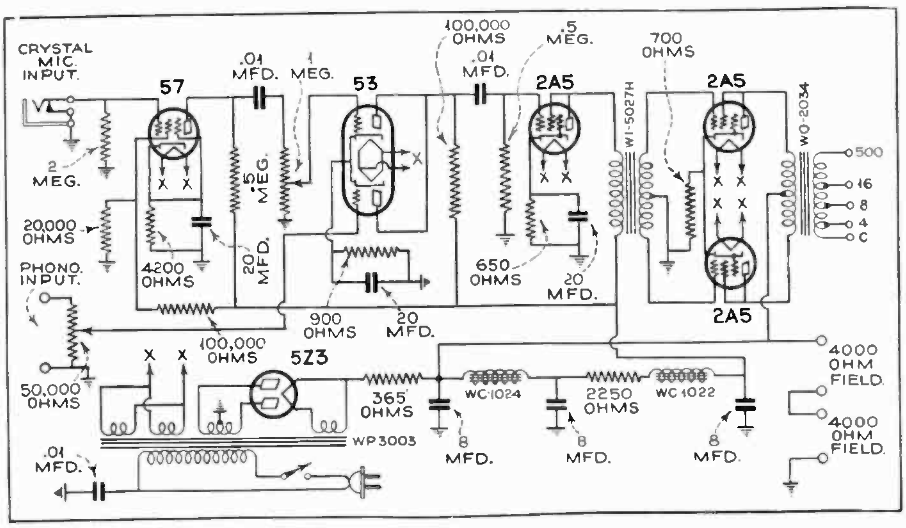


Figure 123

In looking over the schematic circuit diagram, (Figure 123), it will be noted that four audio stages are employed. A type 57 tube is used in a high-gain microphone pre-amplifier stage. A type 53 tube is used as a voltage amplifier and a novel electronic mixer. For this application the plates of the two triode sections are tied together, while the grids are coupled to two dissimilar sources. The grid of one section is connected to the output of the 57 stage and the input voltage is controlled by means of a one-megohm potentiometer. The second grid is connected to the phonograph pickup input terminals. By means of these two potentiometer controls the microphone and phono inputs may be mixed and blended in any desired proportion.

The next stage is used as a voltage amplifier and driver and employs a 2A5 tube connected as a triode. This tube in turn is coupled through a specially designed transformer to a pair of 2A5's in a class AB arrangement. The plate voltages and field current are obtained from a conventional, well filtered full-wave rectification circuit using one 5Z3 tube. The fields are connected in series across the high voltage, acting as a bleeder and stabilizing the output voltage.

Free Information Service

If you require any further information regarding parts, wiring or operating data on the radio apparatus described in this book, mail us a postcard with your questions. The information will be furnished promptly — absolutely free of charge.

RADIO NEWS 461 EIGHTH AVENUE NEW YORK, N. Y.

SUPPLEMENT I

Ten Lessons In Radio

LESSON ONE

Radio Waves—How A Radio Station Works—Detection

THIS first lesson presents a simplified discussion of the theory of operation and of the functions of the various parts of a receiver.

Readers who wish to take maximum advantage of these lessons will want to build most of the units to be described. If parts from earlier units are again used wherever possible in building subsequent units, the cost can be held to a low figure.

It is recommend that you study up on radio fundamentals as you go along. Reading of radio books and periodicals will help materially, or enrollment in a regular radio school or correspondence course will result in a well rounded out training in which are combined both theory and practice.

Radio Waves

Radio stations all over the world are sending out radio waves. Just what these waves are, we do not know. We do know, however, that a radio waves has the power to create an electrical pressure in any electrical conductor (such as wire) and this electrical pressure will cause a current to flow in the conductor. Thus the wave from a radio transmitter causes a minute electric current in any receiving antenna (or other conductor) within its path. The strength of this current will depend on the power of the station, the distance from the station and the length, location and direction of the receiving antenna.

This tiny electric current flows down to the receiver which must convert it back into the original speech, morse code, music, picture, etc., being conveyed by the radio waves. Note that there is no difference in the transmission of telegraph, telephone messages, music or picture. The nature of the wave, the transmitter or the receiver is the same, it is just the translating device (microphone, key, televisor) which differs.

Duties of the Receiver

The duties of the receiver are: first, to pick up the small electrical pressures or voltages; second, select the desired signal excluding all others; third, translate the signal into sound (or picture or code message, but in this lesson let us consider sound only). Before the latter can be accomplished a process, called "detection" must take place.

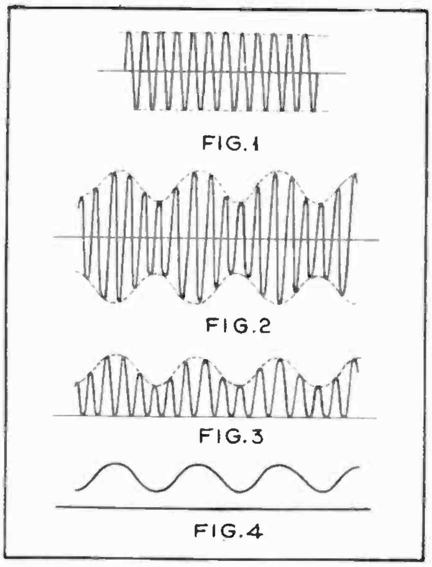


FIG.1

FIG.2

FIG.3

FIG.4

The natural question will be—what is detection and why is it necessary? Why can't we connect the headphones to antenna and ground and listen for stations? The answer is not so simple.

How A Radio Station Works

It is necessary to consider briefly how a radio station works. Most of us are familiar with alternation current or A.C. Any electrical current flowing through a conductor creates an electro-magnetic field around the conductor. If the conductor is coiled up, the field can be concentrated so that the coil will attract iron, nickel or cobalt. This electro-magnetic field represents energy. The energy was supplied by the electrical circuit and now resides in the space surrounding the coil. When the circuit is opened, the field disappears and returns the energy to the circuit by *creating a voltage* or electrical pressure in the coil.

The electro-magnetic field around a conductor which carries alternating current, is constantly collapsing and reversing in direction. It will return its energy to the wire as long as the reversing process is not too rapid. If the reversal occurs frequently enough, or the *frequency* (number of cycles or vibrations per second) becomes high enough, some of the energy in the electro-magnetic field travels away—is radiated. Therefore, the name radio-frequency. There is no sharply defined limit of radio frequency, but generally it is assumed to be from 25,000 cycles per second up. Frequencies lower than this, when sent through a loudspeaker, are translated into *audible* tones hence the term "audio-frequ

Each broadcasting station, when it is "on the air," is sending out a steady wave at some particular radio frequency, and this is called the carrier wave. As a performer in the broadcast studio speaks into the microphone this carrier wave *varies in amplitude or strength* in accordance with the movements of the microphone diaphragm and the carrier is then said to be "modulated." Figure 1 graphically portrays the carrier wave at a moment when no sound reaches the microphone. Figure 2 shows the carrier wave when "modulated" by speech or other sound at the microphone.

Detection

An exact replica of this wave will reach the radio receiver and must there be converted back into sound. The first step in this conversion process is called detection. A perfect detector is nothing but a device which will permit electrical current to flow in one direction only and not in the reverse direction. When the received signal passes through this detector, it may be represented as in Figure 3. When such a current as that of Figure 3 flows through an electrical device which does not permit the fast variations of the individual radio frequency pulses (the headphone is such a device), the result is an average current, as shown in Figure 4.

LESSON TWO

Constructing A Simple Diode (or Crystal) Receiver

THE simplest receiver that could be made would consist of a headphone and a detector connected between aerial and ground.

It is more satisfactory and more reliable to use a vacuum tube as a detector as it requires no adjustments of any kind, and so the receiver described here employs a type 30 tube.

This tube contains a filament, a grid and a plate. When the filament is heated, electrons will flow from the filament to the plate and grid (which is connected to the plate externally) but not vice versa.

The tuned circuit consists of the usual coil and condenser and in order to keep the condenser capacity small and still cover the required broadcast range, it is necessary to tap the coil and use a switch to employ any desired part of it. The next problem is to collect the signals and bring them to the tuned circuit. This could be done by running the received currents, on their way from aerial to ground, through another coil on the same form as the tuning coil, as shown in Figure 5. The combination would work as a transformer, the antenna winding being the primary and the tuned winding the secondary. The winding which serves as primary had better be variable, too, because the smaller this part, the better the ability of the tuned circuit to separate the signals but the more turns there are in it the louder the signals.

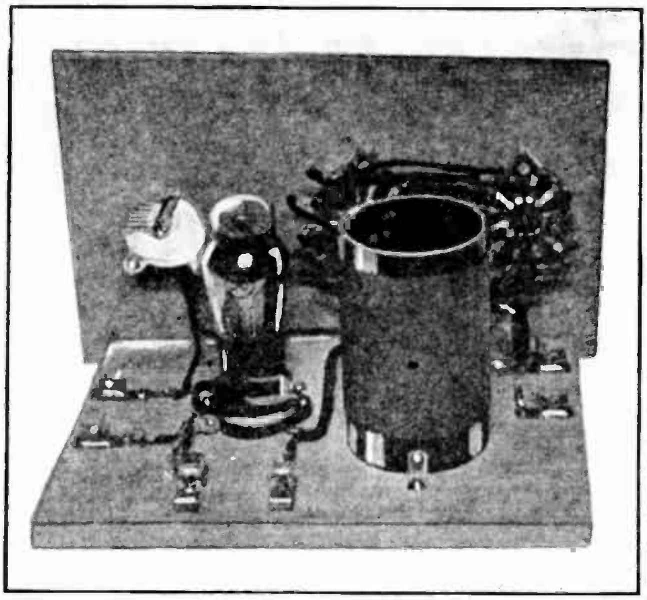


Figure 10—(Left)—Rear view of the simple diode receiver. Figures 11 and 12 (Lower right-hand corner) front and top view showing placement of parts.

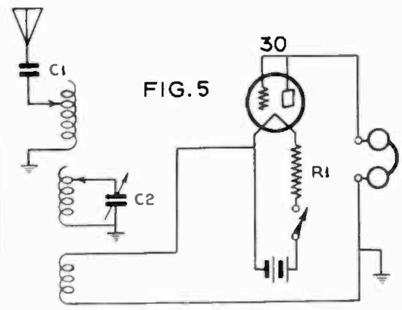


FIG. 5

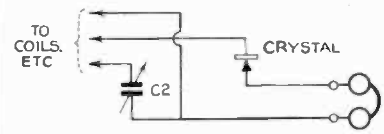


FIG. 7

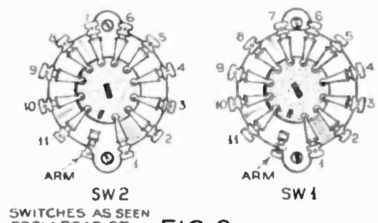


FIG. 8

When a crystal detector is used, the detector circuit becomes as shown in Figure 7.

Instead of using the three coils as in Figure 5, it is possible to make a single coil do the work of three by means of taps. This system is employed in Figure 6 which is the diagram of the diode receiver to be built.

When all the parts have been procured, construction may proceed in the following order:

Beginning with the panel, the centers for the holes should be marked off.

The screws for joining baseboard and panel should be ¼ inch from the bottom edge of the panel. The hole for switch 3 is located 3 inches from the left edge and 1½ inches from the bottom. Drill the holes to fit the various parts.

The panel may now be screwed to the baseboard and all other parts except the coil mounted on the baseboard, as shown in the photographs, Figures 10, 11 and 12. The tube socket should be turned so as to have the large holes towards the back of the baseboard.

After all parts except the coil are mounted, as much as possible of the wiring should be completed. A study of Figures 6 and 8 and the photographs will help. The middle lug of C2 should be the grounded side while one of outer lugs is connected to the moving arm of SW2.

When looking at the back of the panel the switches appear as in Figure 8. Connect point 1 of SW1 to point 1 of SW2, point 2 of SW1 to point 2 of SW2, etc. At the same time solder a few inches of wire to each point of SW2 except to point 11. These wires will later be connected to taps on the coil.

Figure 9 and the pictures show the proper location of the taps with reference to the mounting brackets. First drill the holes for the mounting brackets at such a distance from the lower edge that the brackets will be level with the edge of the tubing. Then drill two holes for fastening the beginning of the winding.

When taking off a tap, twist a little loop in the wire, but be careful not to break the wire. The taps of the coil in the illustration are in two vertical rows, making it much easier to make connections as the taps are spaced well apart. When the coil is finished, scrape the insulation from the taps and tin the exposed wire loops. Mount the coil in the proper position and solder the wires from SW2 to the proper taps. From point 1 on SW2 to tap 1, from point 2 to tap 2, etc.

In operating the receiver remember that the right-hand switch, SW2, and the dial both control the frequency of the tuned circuit. For the lowest frequency use the highest taps. The condenser in itself has not enough range to cover the whole broadcast band, so it will be necessary to go to lower taps for higher frequency. The condenser allows you to make finer adjustments.

Switch 1 adjusts the coupling of the an-

TAPS	TURNS
1	11
2	22
3	33
4	44
5	55
6	66
7	77
8	88
9	99
10	110
FINISH	125

USE NO. 24 D.S.C. WIRE

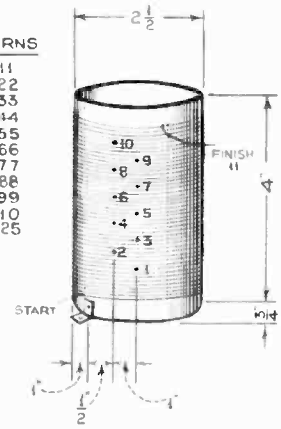
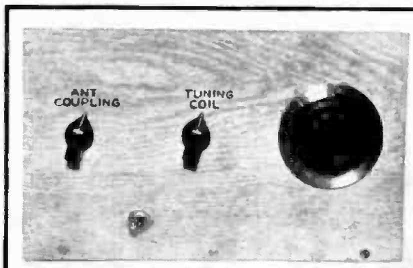
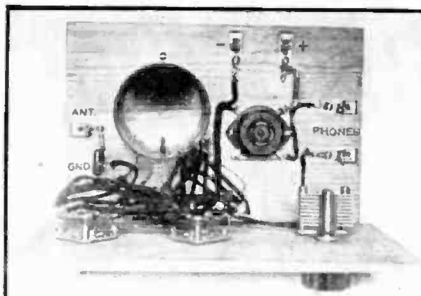


FIG. 9





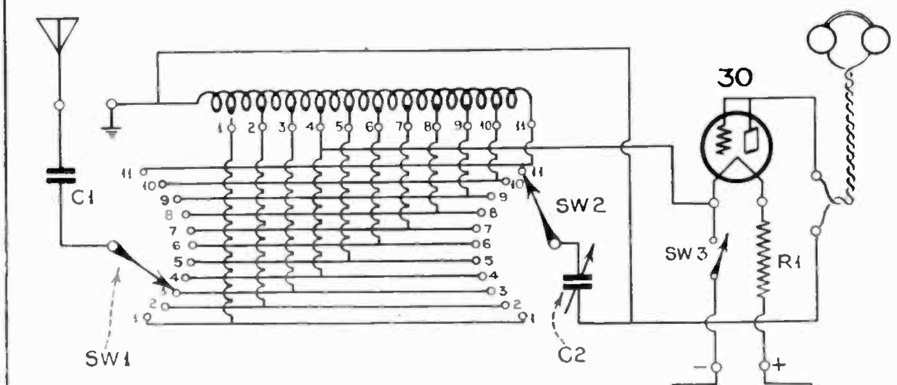


FIG. 6

tenna. The set will be more selective if the switch is set on the lower taps On the other hand, the higher taps make the stations come in stronger. The best compromise has to be found.

Parts List

C1—Aerovox mica condenser type 1467, .00025 mfd.
C2—Hammarlund "Star" midget variable condenser, 140 mmfd.
SW1, SW2, Yaxley one-gang 11 point switches, non-shorting, type 1211
Bud 2¾ inch dial
Bakelite coil form, 2½ inches in diameter, 4 inches in length
¼ lb. magnet wire, number 24, d.s.c.
4 Fahnestock clips, 1 inch overall
2 small angle brackets (for mounting the coil)
1 baseboard, wood, 6x9x½ inch thick
1 panel, wood, 10x6x¼ inch thick
1 pair of Acme headphones, 2000 ohms

When using tube as detector, add:

1 Eby basemount socket, 4 prong
R1—15 ohm filament resistor
SW3 s.p.s.t. toggle switch
2 Fahnestock clips, 1 inch overall
2 Burgess "Little six" dry cells
1 type 30 tube

When using crystal detector, add:

1 crystal with holder

LESSON THREE

Operation of Vacuum Tubes — Plate and Grid Detection

THE little receiver described in Lesson Two employed a vacuum tube as a diode detector. Lesson Four will be devoted to describing minor changes in this receiver so as to employ the same tube as a much more efficient detector, providing louder signals and reception from greater distances. Before proceeding it will be best to review briefly the action of a vacuum tube.

A vacuum tube consists of a closed bulb of glass or metal wherein several metallic elements are placed. The simplest type ("diode") has two such metallic elements, a filament and a metal plate. When the filament is heated, electrons—the smallest known negatively charged particles—will be thrown off the filament wire. The heating of the filament is for no other purpose than to obtain a source of free electrons in this manner.

What happens to the electrons? When enough of these negative particles leave the filament, the filament itself becomes positive. When this occurs the electrons tend to rush back to the filament unless a stronger attraction is provided elsewhere in the tube. The entire action of a vacuum tube hinges on the controlled movement of these electrons. The presence of air hampers this movement and for that reason the air is pumped out of the tube during manufacture, hence the name "vacuum" tube.

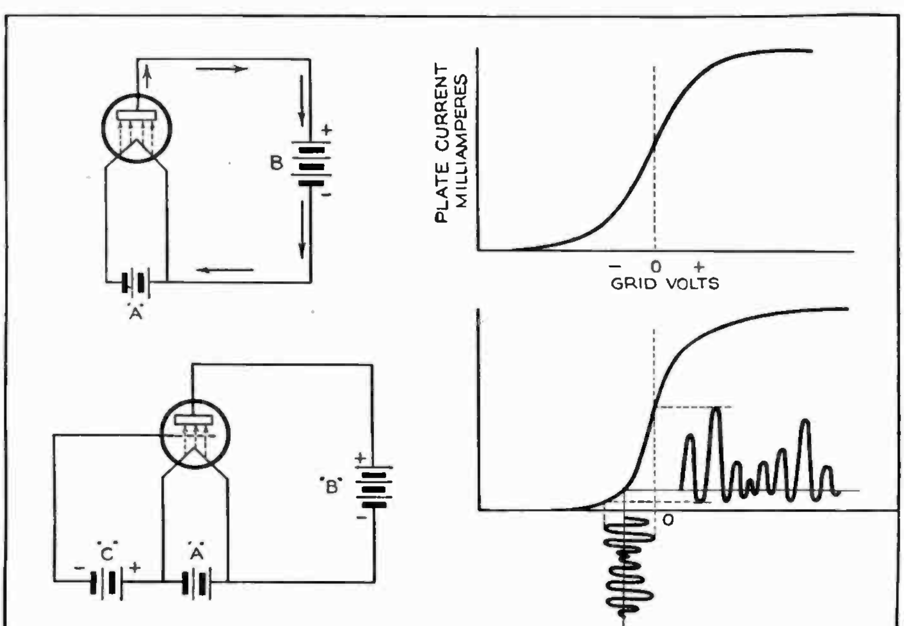
The Diode Tube

When a metal plate is nearby, and the metal plate is insulated, some of the electrons will settle down on the plate until it becomes negatively charged, in which condition it will repel other electrons. If the metal plate is connected to the filament, the electrons which went to the plate will return to the filament through the wire because the filament is positive (lacking in negative electrons). Thus an electric current will flow from the filament, through the vacuum to the plate and then through the wire back to the filament.

Suppose we go a step further and by inserting a battery, "B," between the plate and filament, make the plate positive with respect to the filament (Figure 13). Then the electrons will be attracted to the plate and pass through the battery and back to the filament. The current obtained in this way is much larger than without a battery, the amount depending on the voltage between plate and filament. If, on the other hand, the plate were made negative with respect to the filament (by reversing the battery connections), the plate would repel the electrons and practically no current would flow in the plate circuit. This type of tube is called a "diode" and is a device which conducts electricity in one direction only.

The first property is utilized in the use of such a tube as a detector (or rectifier). Since it conducts in one direction only, the negative half of an alternating voltage does not produce any current and alternating currents are therefore converted into direct current.

Fig. 13—Top, left; Fig. 14—Bottom, left; Fig. 15—Top, right; Fig. 16—Bottom, right



The Triode Tube

Introduction of a third element (making the tube a "triode") opens up new possibilities for the tube. When a "grid," consisting of a metal spiral or a mesh of wires, is placed between the plate and filament and the plate is made positive, it is possible to control the plate current by applying small voltages on the grid. This works as follows: Since the grid is much closer to the filament than is the plate, it has a greater effect on the electrons which are just emerging from the filament. When the grid is made negative, even a few volts, it may completely cancel the attracting power of the positive plate. On the other hand, reducing the negative voltage applied to the grid, will allow electrons to pass through the grid on their way to the plate. As long as the grid does not become positive, there will be no current in the grid circuit and it will take no power to control the larger power in the plate circuit.

To illustrate a tube's properties or characteristics the radio man resorts to the use of curves. One such curve showing the plate current for different grid voltages while the plate voltage is constant, is shown in Figure 15. Note that there are two bends in the curve. The upper bend is present because there is a maximum "saturation" current which exists when all the electrons emitted by the filament are travelling to the plate. There is a different saturation current for each plate voltage and each filament voltage, because a higher filament voltage will cause a greater emission and a higher plate voltage will exert a greater pull on the electrons, which is necessary to overcome the "space charge," which is a charge of the cloud of electrons themselves. This charge also limits the maximum plate current.

Plate Detection

There are several ways in which a tube can be made to detect (rectify). In Lesson One we said that an ideal detector would be a device which is conductive only in one direction. However, a perfect detector has not been developed to date. Nevertheless this rectifying action can be performed and utilized even though the rectifier is not perfect.

The most simple way to use a tube as a rectifier or detector would seem to be to give the grid a steady negative voltage (as in Figure 14) so that the operating point is on a sharp bend of the curve. Figure 16 illustrates what happens when a signal voltage is applied to the grid. While the grid voltage varies up and down, the plate current will go up and down too but it responds much better in one direction than in the other because of the bend in the characteristic. The plate current now closely resembles the rectified current shown in

Figure 3, and this current when passing through the phones will reproduce the original sound which first entered into the microphone at the transmitter.

The difference between the above described system and diode detection is that it is much more sensitive because the tube when used as a triode, serves as an amplifier as well as a detector. The increased power is supplied by the B-battery with the grid acting as a valve to control it, while in the diode system the received signal itself must supply the power for the phones. A triode receiver is described in Lesson Four.

LESSON FOUR

Building A Simple Triode V. T. Receiver

THERE are several reasons why the method of operation described in Lesson Three, (Figure 14), is not popular for small sets. In the first place it requires an extra "C" battery and it is necessary to know the exact location of the sharpest point of the bend for a given plate voltage, so as to get most efficient detection.

A More Practical System

A second system which does not require a "C" battery is more practical for a simple receiver. This makes use of a grid condenser and a grid leak. The circuit is shown in Figure 18. The grid-leak resistor, R2, is connected to the positive side of the filament, making the grid slightly positive and as a result a considerable plate current will flow when no signal is coming in. When the grid is driven more positive by a signal (the positive half of a cycle), electrons will be attracted by the grid itself and will charge the grid-condenser C3, the grid side of it becoming negative. During the next half-cycle (negative) no electrons can be attracted and the grid cannot get rid of its charge except through the grid leak R2. This takes a relatively long time and while a current is flowing through the resistor, there is a voltage drop across it making the grid negative except at the peak of the positive half cycle. In this way the bias adjusts itself to a point where detection takes place.

Proper proportioning of the grid condenser and grid leak are necessary, so the charge will leak off at the required rate. Suppose, for instance, that the grid resistor has a very high value, it will take very long before the charge leaks off and during that time, the grid may stay so far negative that the tube is inoperative. On the other hand, if the resistance is too small there may not be enough bias and the tube will be insensitive.

The Revised Receiver

This circuit is used in the revised receiver and makes the signals much louder. For detection purposes a rather low plate voltage ("B" battery) will be satisfactory. It works well with only 22.5 volts. Since a standard 45-volt "B" battery is required for use with units to be described in other lessons of this series, the parts list shows such a battery rather than the 22.5-volt type. There is, of course, no objection to using a smaller capacity battery with 22.5 volts maximum for this receiver.

The complete circuit of the new unit is shown in Figure 18.

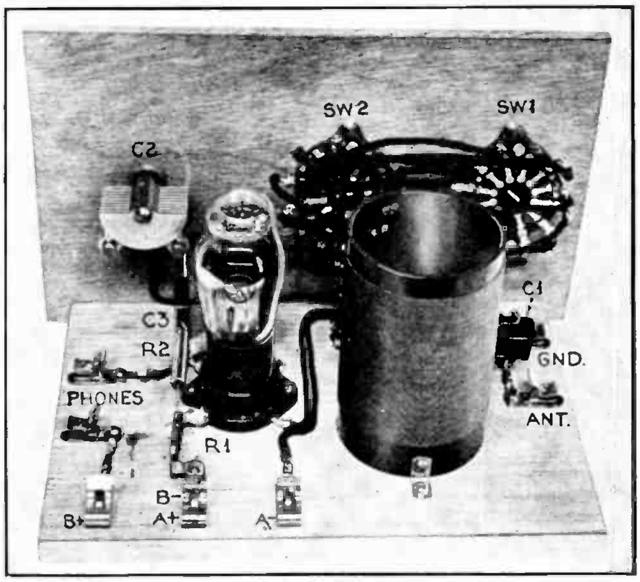


Figure 17—

Rear view of the triode receiver showing placement of the various parts, etc. Note the additional clip, resistor and mica condenser.

Changing The Old Circuit

Changing the old circuit to the new one is simple. The connections to the coil and the tap switches remain the same; nearly all changes are made at the tube socket. First mount another Fahnstock clip at the right-hand back corner of the baseboard. This will become the B plus terminal. Disconnect and remove the leads to the phone jacks and to the plate and grid of the tube.

There is a wire which runs from the filament switch to tap 3 or 4 of the coil. Disconnect this wire from the coil and connect it to the ground wire. This connects the negative side of the filament to ground.

Connect the B plus Fahnestock clip to the nearest phone clip. The other phone clip is connected to the plate terminal of the socket. The grid condenser, C3, is connected from the stationary plates of the tuning condenser (one of the outside terminals) to the grid terminal of the tube socket. Then connect the grid leak, R2, from the grid terminal to the positive filament terminal. The photographs, Figures 17 and 19, will aid in making these changes.

When hooking up the set, note the correct polarity of the batteries and connect them as shown in Figure 18.

Additional Parts List

(for change over to triode detection)

C3—Aerovox, type 1467 mica condenser, .0001 mfd.
R2—IRC carbon resistor, 2 megohms.
1 Fahnestock clip
1 Burgess standard 45-volt B-battery, tapped at 22½ volts.

Figure 18

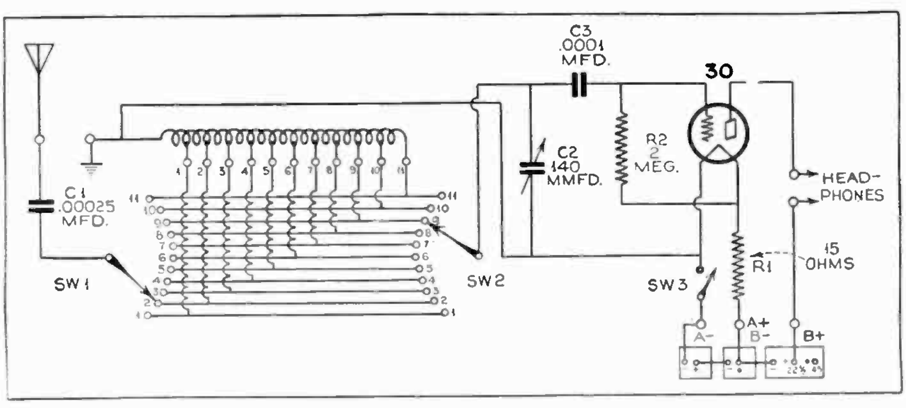
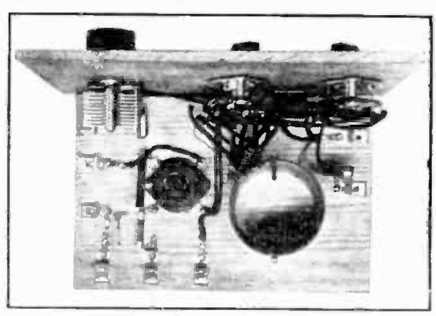


Figure 19



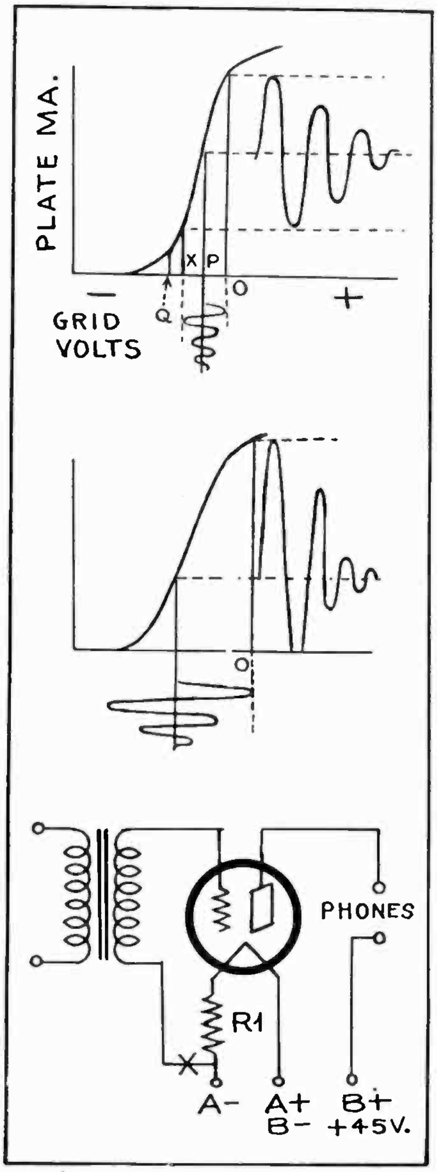
LESSON FIVE

R. F. and Audio Amplification—Versatility of Tubes

BESIDES performing all the functions described in the previous lessons, the modern radio receiver *amplifies* the signal (multiplies its strength or intensity) many thousands of times.

Amplification can be accomplished either before or after the detector of a receiver or both before and after. An amplifier ahead of the detector must operate at the original frequency of the incoming signal; it is called a radio-frequency amplifier. An amplifier stage after the detector is called an audio-frequency amplifier. The difference in results obtained is that an audio-frequency amplifier is intended primarily to make received stations come in louder. If the signal from a distant station is too weak to be detected, no amount of audio-frequency amplification can bring it in. Radio-frequency amplification increase sensitivity and will add new stations. It also provides the opportunity for additional tuned circuits and therefore sharper tuning.

Figure 20—Top; Figure 21—center; Figure 22—Bottom.



Tubes Are Versatile

Why is it that the same tube can work as a detector or as an amplifier? This brings us back to the theory of tubes.

An amplifying stage consists of a tube and some means of coupling it to the previous tube. First let us confine our attention to the tube itself. In Figure 15 we showed a so-called "static characteristic," which illustrates the variation in plate current due to changes in grid voltage while the plate voltage remains fixed. Actually the plate voltage does not remain fixed during operation because the phone or transformer in the plate circuit has resistance and inductance which cause a voltage drop across it when the tube plate current flows. This voltage drop will change when the plate current changes, which results in a change of plate voltage. Curves which take these things into consideration are called "dynamic characteristics." These enable the radio man to determine the best plate and grid voltages, etc., and to find the other necessary constants of the circuit. However, these curves do not lend themselves to an easy explanation of the tube's functions. Therefore, we are sticking to the static characteristic which better illustrates what happens.

Used as Amplifier

The coupling device usually consists of a transformer or a network of resistors and condensers. It is important to prevent the plate voltage of the previous tube from reaching the grid of the next one. A transformer does this, generates a signal voltage in the secondary and gives some amount of step-up. The voltage in the secondary would be three times the voltage in the primary if a 3-1 ratio transformer were used, for instance. Of course this adds to the amplification.

Figure 20 illustrates the characteristics of a tube and shows the way it amplifies. The grid is given a fixed negative voltage so as to bring the operating point to the center of the straight portion of the curve. The detector utilizes the bend of the curve, as explained in Lesson Three, but the amplifier must work on the straight part. The way to make the tube do the required work is to give it the correct fixed negative voltage or "bias" also called "C-bias" because it would require a third or C-battery. So in the case of Figure 20 if the fixed bias is equal to OP, the tube is an amplifier, if it is equal to OQ it is a detector.

When working a tube as an amplifier, there are two things to look out for. The first one is to keep the variation of grid-voltage due to the signal within the limits of the straight part of the "curve," and never to let it run over a bent part. As long as the straight portion of the characteristic is utilized, the plate current will vary in exact proportion to the grid voltage. As soon as the grid-voltage becomes too large so that the tube works on a bend during a part of the cycle, the plate-current variations no longer correspond to the grid-voltage variations, in other words there is distortion. This is illustrated in Figure 21. It is seen that the tops have been cut off the highest peaks. For this reason, it is essential that the applied signal volatge should never exceed OP or PX. In a good arrangement OP should equal PX.

Grid Always Negative

The second limitation is that the grid should never be allowed to go positive. As soon as this happens grid current will flow and the grid current will cause a voltage drop in the grid circuit which usually has a high resistance. This voltage drop subtracts from the signal voltage and therefore is another cause for distortion. In practice then, it is only possible to use that part of the straight portion of the characteristic which is situated to the left of the zero line.

The fixed grid voltage or bias should then be chosen at the center of this straight portion.

The manufacturers have listed the proper grid bias for different plate voltages, so it is not necessary to make a curve (they are made by measurements). But this explanation should clarify the meaning of these figures. It should also be clear now that if the recommended grid bias is 2 volts, the peak of the signal voltage on the grid should never exceed 2 volts. This is equal to 1.4 volts as shown by an A.C. voltmeter as only the peaks reach 2 volts, whereas the voltmeter shows an average rather than peaks. If the signal is likely to exceed this value, one must look for another tube which has a larger fixed bias. Sometimes the same tube with a higher plate voltage will need the larger bias and would then be suitable. the very strongest stations could just reach the maximum signal allowable of 1 volt peak.

LESSON SIX

A One-Stage Audio Amplifier

NOW, we will employ a 30 tube with a plate voltage of 45 volts and build an amplifier unit for the receiver described in Lesson Four. Since the plate voltage is so low and our signal is rather weak, we need a grid bias of about one volt. This can be obtained without the use of an extra battery. The filament requires but two volts while the battery supplies 3 volts, the extra volt is lost in the resistor R1 If we place this resistor in the negative leg of the filament circuit, the negative side of the battery will be 1 volt negative with respect to the negative side of the filament. All we have to do is to connect the lead marked "F" of the transformer to the negative A terminal and 1 volt bias results. See the circuit of Figure 22. In our model,

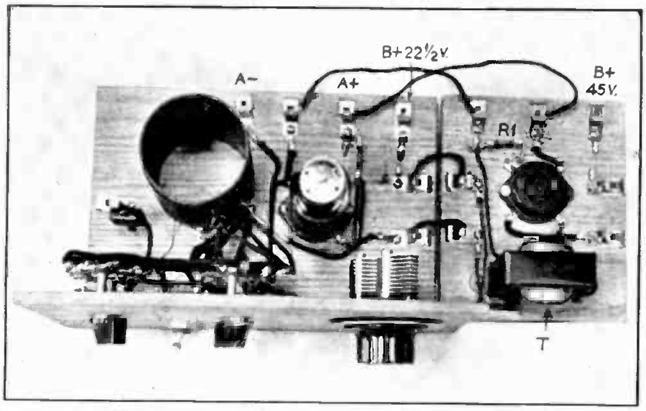
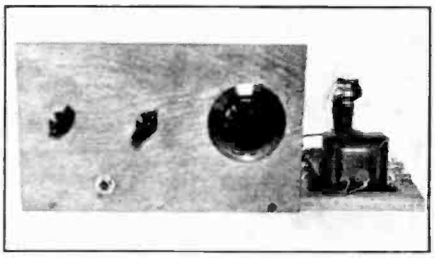
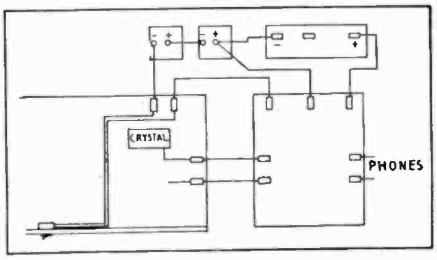


Figure 23—

(Right) shows front view of receiver and amplifier; Figure 26 (lower right) shows battery connections; Figure 27 (left) shows top view of both units.





Constructional Details

The illustrations, (Figures 23 and 27), clearly show the layout and construction of the unit. The Fahnestock clips are so arranged that it is easy to connect the two units together, or to operate either one separately. It was found necessary to make a small change in the unit described in Lesson Four in order to have the original switch control the filament of both tubes. This is done by adding a Fahnestock clip and connecting it to the negative filament terminal of the detector socket. The original A— clip is moved over towards the left and the new one put in its place; then both are connected as shown in Figure 24.

The amplifier is built on a ½-inch baseboard 5 inches wide and 6 inches deep (the same depth as the old unit). Mount the parts as shown in Figure 27. The transformer has its wires marked; the side which has the plate (P) and B plus wires coming out should be turned towards the front. The socket is mounted with the filament terminals towards the back.

The Fahnestock clips on the left edge of the baseboard should be placed so that they come exactly opposite the phone terminals of the one-tube set. Soldering lugs should be employed at each Fahnestock clip. You should also use a small drill to make holes for all screws to avoid splitting the baseboard.

The wiring is simple. Be sure to connect the transformer wires right. The red wire, marked G, goes to the grid terminal of the socket, while the one marked F should go to the A-Fahnestock clip, the one which has the resistor connected to it. This is important for obtaining the right negative bias on the grid.

Operation

Connect the two units together as shown in the top view, keeping in mind the polarity of the A terminals. Then connect the batteries as shown in Figure 25. A 45-volt B battery is employed, the same one as used with the original set. Those who wish may try higher voltages, but then a 3-volt battery should be inserted at X, (in Figure 22), with the negative side connected to the transformer the positive side to A—. The actual operation and tuning remain the same as described in Lesson Four, because the addition of the amplifier stage does not add any controls.

Readers who made the crystal set described in Lesson Two can also employ this amplifier unit. The two units can be connected up without any further changes except that there is no filament switch. You would have to take the tube out or disconnect one of the filament wires to turn off the amplifier. The remedy is to put a switch on the main panel and place two Fahnestock clips at the back of the baseboard, the connections are then as shown in Figure 26.

It is possible to use this amplifier with the diode detector described in Lesson Two, but this would be rather impractical and wasteful. It is therefore recommended that those having the diode receiver convert it for triode operation as described in Lesson Four. In this way greater sensitivity and output volume will be obtained. Then the one-stage audio amplifier described in the present lesson can be added as explained above.

Figure 24

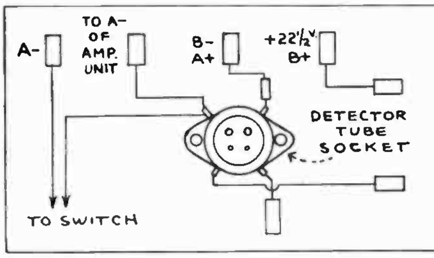
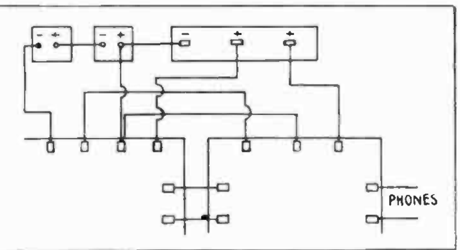


Figure 25



Parts List for Amplifier Unit

R1—15-ohm wire-wound filament resistor
T—United Transformer Co. interstage transformer, type U31
1 Eby base mount socket, four-prong
8 Fahnstock clips, 1 inch overall
Baseboard, 5 inches by 6 inches by ½ inch thick
Lugs, screws, push-back wire

LESSON SEVEN

How A Power Supply Works

THE first six lessons have covered battery-operated equipment, but from now on the equipment to be described will be for operation from 60-cycle, 110-volt A.C. lighting lines.

All but the most simple radio receivers require direct current of several different voltages up to 300 volts and current values so large as to make batteries impractical. In order to meet this demand, the modern receiver includes a "power supply"—which turns the 110-volt A.C. into higher D.C. voltage and at the same time delivers A.C. of a few volts for the tube filaments.

This and the next three lessons will describe a general utility power supply and audio amplifier in one unit which can be used with the several tuning units to be described later. This unit is also an excellent audio amplifier for phonograph reproduction and it can be used Lesson Six's battery set to obtain high-volume loudspeaker reception. Lessons Seven and Eight will describe how the apparatus works and the constructional details will be given in Lessons Nine and Ten.

Obtaining D.C. from A.C. is accomplished by means of a "rectifier"—a device which conducts electricity in one direction only and was described in Lesson One. For several reasons it is necessary in the case of a power supply to utilize both halves of the wave and to arrange two diode rectifiers to provide "full-wave" rectification.

Referring to Figure 28, the 5Z4 tube has been drawn upside down for convenience. The transformer winding, B, serves to heat the filament of this tube. This particular rectifier is one of the "indirectly heated" type. Its cathode consists of a tiny cylinder which is a good electron emitter when heated. The filament is inside of and heats the cathode but does not touch it—therefore the term "indirectly heated."

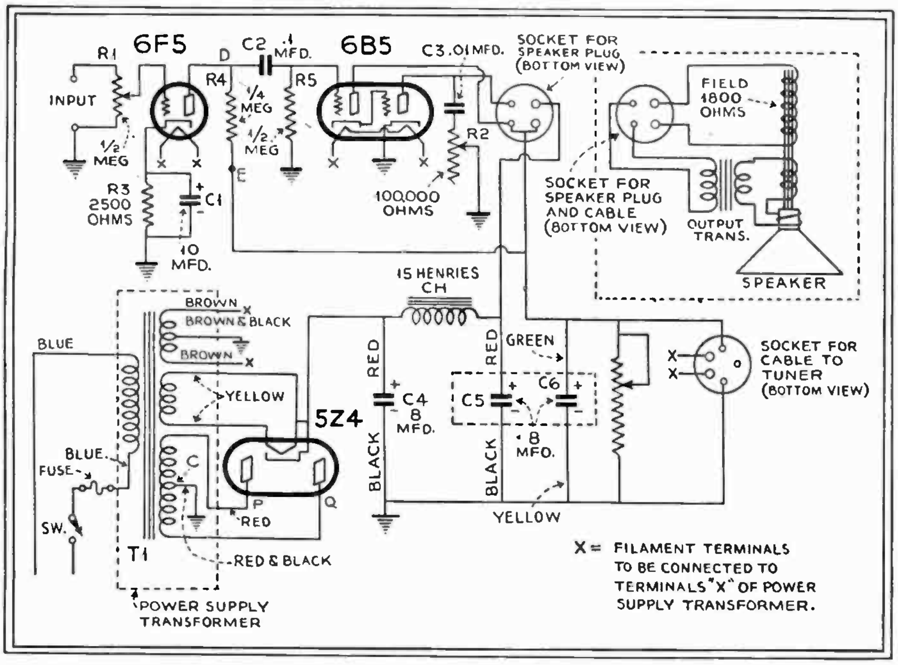


Figure 28

Transformer winding C delivers 375 volts A.C. each side of the center tap. On one-half of each cycle the plate P becomes positive with respect to the ground, or center-tap. A diode conducts only when the plate is positive; therefore, during this half cycle, electrons will flow from the cathode to plate P, through the upper part of winding C to ground and from ground through the resistor, the speaker field and the choke back to the cathode. Meanwhile, the lower half of winding C is not conducting any current.

During the next half cycle, the conditions are reversed and Q becomes positive. Consequently, electrons will flow from cathode to plate Q, through the lower half of winding C to ground and back again through R6 and the chokes. The direction of the electron flow through the resistor and the chokes is the same in both cases and the result is 120 pulses of D.C. per second. If this pulsating voltage were applied to the plates of the amplifier tubes, a loud 120-cycle *hum* would be heard in the speaker. To smooth out the pulsating voltage and remove the hum, a filter must be used.

The power supply filter generally consists of one or more sections, each section consisting of a choke in series with the rectifier output and one or two condensers across the output. The first condenser C4 serves as a reservoir. At the peak of each voltage impulse the condenser charges up to that peak, but as the voltage subsides the condenser discharges through the chokes and the resistor. The net result is a partial smoothing out of the impulses as well as the raising of the average voltage.

The choke, CH, tends to oppose any change in current and therefore helps also in smoothing out the impulses. The function of condenser C5 might best be explained by considering that the current passing through the choke consists of the desired direct current plus some undesirable 120-cycle A.C. It is the purpose of C5 to remove the alternating current by providing an easy path to ground for it. The D.C. cannot, of course, pass through a condenser. In this filter the hum has been cut down about sixty times in the first section. In the next section the hum is cut down again about 200 or 300 times. These effects multiply so that the total reduction of hum in both sections is 60 x 300 or 18,000 times. Such a reduction is more than enough. Measurements have shown that the hum voltage across the primary of the output transformer is less than .1 volt, while the maximum signal voltage across this primary is nearly 200 volts.

A further explanation of the speaker field is needed. This and all other "electrodynamic" speakers require that a current be sent through the magnet or "field" windings. At the same time the field can serve as a choke in the filter, thus killing two birds with one stone. There are, however, complications to this arrangement. The field requires a certain minimum power to be properly magnetized and consequently the number of turns of the field must be just right for the total current flowing through it. These fields are usually specified by their resistance as well as the power consumption. When designing the power supply, the designer must arrange the circuit so that he makes best use of the field's filtering property without losing too much voltage in it.

More or less standard field resistances are 1000, 1800 and 2500 ohms, which usually require currents of 100 ma., 70 ma. and 45 ma. respectively. In our case, the power supply unit is designed to provide a maximum direct current of 85 ma. and so the 1800-ohm field was most suitable. During the employment of smaller tuning units with a total drain of only 50 ma., including the amplifier, extra current can be drawn through the bleeder resistor R6 by decreasing its resistance, in order to bring up the total current drain, if this is found necessary.

A 5-prong socket is provided for carrying the power to a tuner unit, although only 4 prongs are used. The extra prong is to prevent the error of plugging this cable into the 4-prong speaker socket.

LESSON EIGHT

How An Amplifier Works

THE amplifier in the circuit shown in Figure 28 employs two tubes, but it really includes three stages, because the 6B5 consists of two tubes and the coupling means, all within a single bulb.

The first tube, a 6F5, is an indirectly heated triode employing "automatic bias" or "self-bias." The plate current on its way to "ground" through the cathode circuit passes through a resistor, R3, with the result that a voltage drop is developed across it and the cathode is positive with respect to ground by the amount of this voltage.

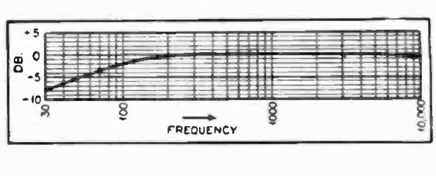
Since the grid is connected to ground, the grid is thus made negative with respect to the cathode.

The cathode resistor must be "by-passed;" that is, an easy path for alternating or voice currents must be provided by a condenser in parallel with it. If this were not done, the amplified signal would pass through the cathode resistor, causing alternating voltages across it, and the grid voltage would vary accordingly. This variation in cathode volatge would be in such a direction as to oppose the original signal and amnlification would be reduced. The large by-pass condenser, C1, provides a very easy path for alternating currents and so practicallv nothing will be fed back to the grid.

The resistance coupling consists of the combination R4, C2, and R5. The plate current of the 6F5 passes through R4 and causes alternating voltages across it. Since the point E is held at a fixed potential (plus 300 volts), the voltage at D fluctuates. The ideal way of coupling would be to connect the grid of the next tube to D and the cathode to E, but unfortunately this is impractical, because the high plate voltage at D would likewise be applied to the 6B5 grid. C2, R4 and C6 may be considered in parallel with R5, with the result that the greater part of the signal voltage is also across R5. There is not much lost in the condenser coupling through C2 and C6 if the condensers are large enough. C6 is always large enough, but C2 has to be chosen so that its reactance is low compared to the resistance of R5. The reactance varies with frequency, so the calculation has to be made for the lowest frequency which has to be amplified.

On the other hand, C2 cannot be too large or a loud signal may make the grid of the 6B5 positive for a very short time. When this happens, the condenser C2 will be charged, making the grid negative and "blocking" the tube. The charge leaks off through the resistor R5. The larger C2

Figure 29



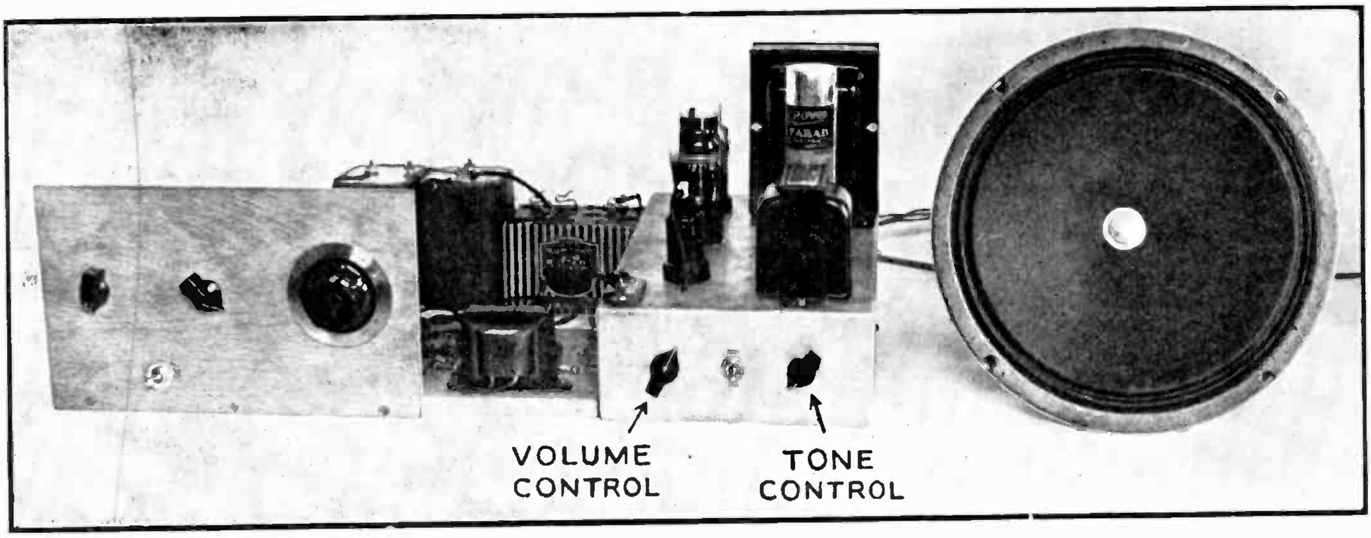


Figure 30

and the larger R5, the longer it will take before the charge has disappeared and the tube is working again. The values must be chosen so as to make the blocking time very short. In the example of Figure 28, it will be one-twentieth of a second.

The story of the 6B5 is much too long to be told in this lesson. The tube was chosen because it does its work well and because it requires the simplest circuit. It is best to consider that it consists of two coupled triodes. The bias for the tubes is developed automatically inside the tube.

The power tube drives the speaker voice coil through a transformer. The voice coil consists of a few turns of heavy wire and therefore offers a relatively low resistance. For efficient operation this must be matched to the higher output resistance of the tube. The output transformer, included in the speaker, performs this function.

LESSON NINE

Discussion On Volume Controls

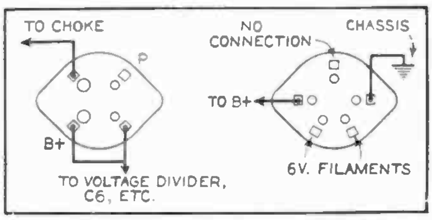
In the previous lessons the discussion on the amplifier and power pack wasn't quite completed. Therefore the remainder will be covered in this lesson.

The tone control has been added because one or more of the tuners to be described in later articles will be of the all-wave type. Such reception often requires that interfering noise be reduced and since most such noise consists of high-pitched sounds, a tone control which reduces high notes is helpful.

The ordinary type of control depends on the fact that a condenser offers an easy path for high frequencies and not for low frequencies, its "impedance" becoming lower and lower as the frequency increases. Thus a condenser placed across the circuit by-passes some of the audio currents, particularly those of higher frequencies. A variable resistor in series with the condenser will regulate this action, the adjustment of the resistance value varying the degree of tone control. When the series resistance is large enough there will be no tone control action. In Figure 28, the tone control consists of C3 and R2.

Whenever the best quality is desired the tone control should be adjusted for maximum resistance by turning the control R2 all the way to the left. Maximum noise reduction, on the other hand, is obtained with R2 turned to the opposite extreme.

Figure 32



If a greater degree of tone control is required it can be obtained by changing C3 from .01 to .05 mfd.

In order to judge the performance of an amplifier the radio man makes curves showing the variation in output for different frequencies while the input is held constant. This is called the "fidelity curve" and in its most perfect form it should be a straight line. Figure 29 shows the curve of the amplifier as it was measured in the RADIO NEWS Laboratory. It was measured with the amplifier connected to a resistance load instead of the speaker. Therefore, it does not include the characteristics of the speaker.

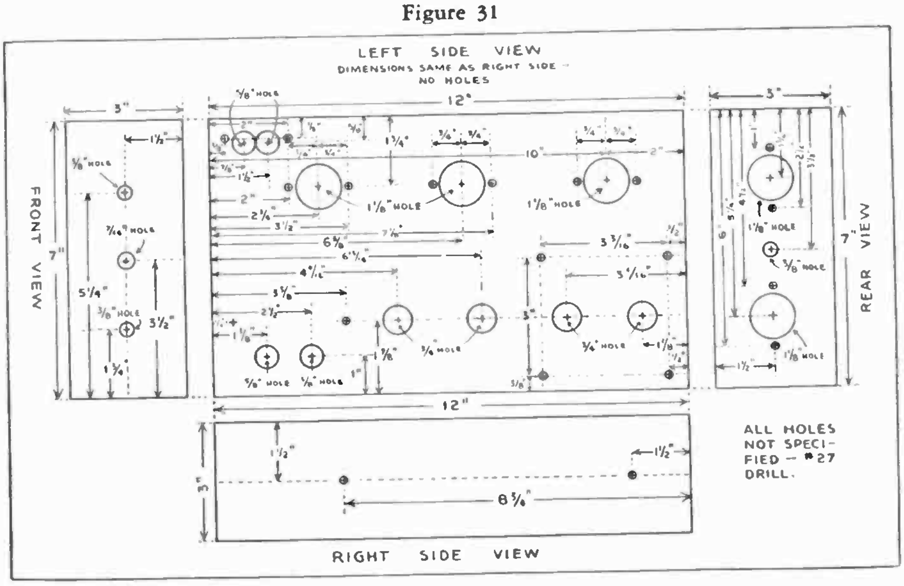
The gain or amplification of the amplifier is 77 decibels. It is not possible here to go into an explanation of the decibel as a unit. One might think of a decible as representing a change in sound level just sufficient to be noticeable to the ear. In practical language a 77 db. gain means that it takes .25 volts at the input terminals of the amplifier to obtain 4 watts output (the maximum output for the 6B5). The signal across the output transformer primary is then 170 volts approximately.

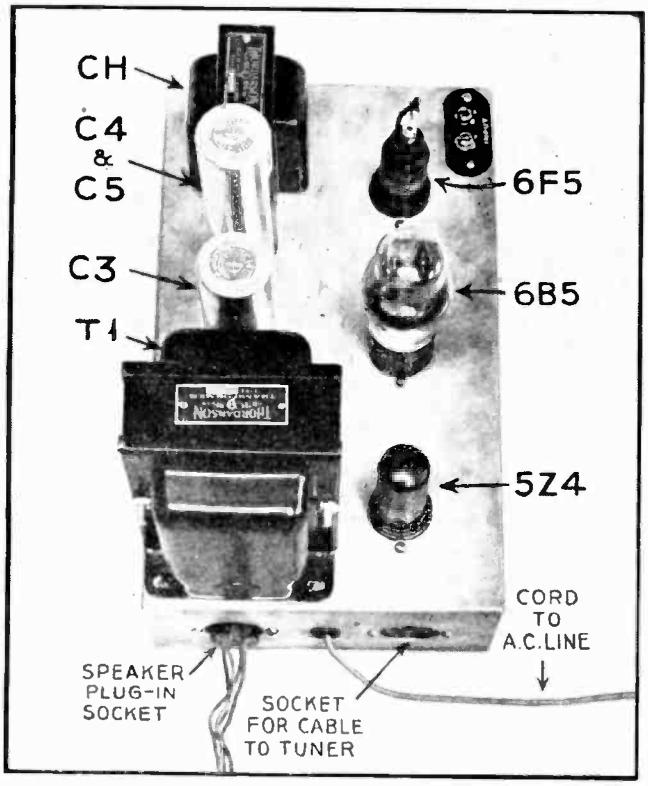
For those who wish to acquire the parts for this combination A. F. Amplifier and Power Supply Unit, a parts list follows. The drilling specifications of the chassis are given in Figure 31.

Parts List

C1—Aerovox electrolytic condenser, type PR50, 10 mfd., 50 volts

Figure 31





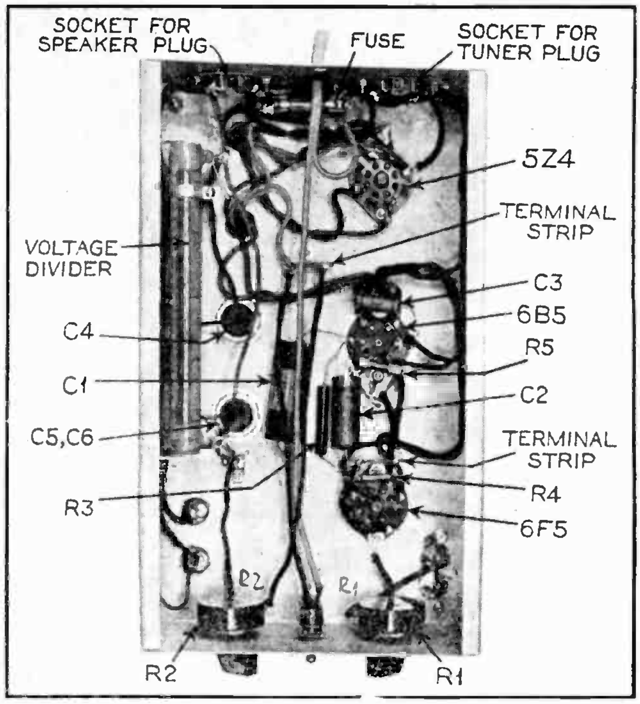


Figure 33—Left

Figure 33A—Above

C2—Aerovox tubular paper condenser, type 484, .01 mfd., 400 volts.
C3—Aerovox tubular paper condenser, type 484, .01 mfd., 400 volts.
C4—Aerovox dry electrolytic condenser, type GL, 8 mfd., 525 volts
C5, C6—Aerovox dual dry electrolytic condenser, type GGL, 8-8 mfd., 525 volts.
R1—Electrad volume control, type 203, 500,000 ohms
R2—Electrad tone control, type 242, 100,000 ohms
R3—IRC carbon resistor, 2500 ohms, ½ watt
R4—IRC carbon resistor, ¼ megohm, ½ watt
R5—IRC carbon resistor, ½ megohm, ½ watt
R6—Electrad variohm, 25,000 ohms, 75 watts
T1—Thordarson power transformer, type T7062
CH—Thordarson power choke, type T1607, 15 henries, 85 ma.
Wright-DeCoster 10-inch dynamic speaker, model 820-B (speaker field 1800 ohms, transformer primary 7000 ohms)
1 four-prong, 1 five-prong, 1 six-prong and 2 octal wafer type sockets. Mounting centers 1½ inch
ICA cadmium-plated steel chasssis 12x7x3 inches high, type 1527, blank or drilled
SW1—ICA toggle switch, type 1230
2 ICA bakelite pointer knobs, type 1155
1 ICA terminal strip marked "INPUT," type 2417
E ICA fuse mounting, type 2340
1 Littelfuse 2 amp. fuse
2 lug terminal strips, each having 2 terminals
1 rubber grommet for ⅜-inch hole
1 small grid-clip (for metal tubes)
1 line plug and 5 feet of line cord
Bolts, nuts, washers, soldering lugs, push-back wire
1 6F5 tube
1 6B5 tube
1 5Z4 tube

LESSON TEN

Constructing the A. F. Amplifier and Power Unit

IN selecting the parts employed in the model discussed in this lesson, every effort was made to keep the cost as low as possible, consistent with the required quality. It is not imperative that the parts employed by the constructor be of the exact makes and type numbers shown in the list of parts in Lesson Nine, but it is important that the quality and electrical values be the same if results are to equal those provided by the model. If stubstitions are made they may in some cases require some alteration in the drilling layout.

The first thing to do is to prepare the chassis. The socket holes can be made easiest with a punch as as the Livermore Five-In-One Punch on sale at many radio stores. Holes of five different sizes can be made with this tool. The holes for the socket mounting screws should be laid out after the large holes are punched, thus allowing for any slight error in placement of the large holes.

All except the socket holes can be made with ordinary twist drills. Start the larger holes with a small drill, then use a larger one of the required size.

The centers of the tube sockets mounting screw holes are shown 1½ inches apart in Figure 31. There are three standard spacings of these mounting centers: 1½ inches. 1 11/16 inches and 1 27/32 inches. At present the smallest size is the most often used. If sockets with the wider spacing are used the holes in the chassis should be spaced accordingly.

All sockets on the chassis are to be placed with the filament terminals towards the rear; that is, the notches in the central hole of the metal tube socket should point towards the rear and the large holes of the middle socket should be at the rear. (See Figure 34). The sockets for the cables should be placed as shown in Figure 32.

When mounting the choke and the input terminals, care should be taken to prevent short circuits. The lugs stick through the holes and no part of the lug or any metal connected to it should touch the chassis. This is so important that a special test is recommended. This is done by connecting one terminal of a voltmeter to a battery, and the other terminals of the voltmeter and battery to the lug and the chassis respectively. If the meter shows a voltage reading it indicates a short circuit.

After all the parts have been mounted, the terminal lug strips are mounted with screws as shown in the bottom view, also the fuse holder.

Beginning with the wiring it is pernaps easiest to begin with the transformer connections. The wires are distinguished by their color. A paper comes with the transformer which explains the color code; they are also shown in Figure 28.

The electroylytic condensers must be connected with due regard to their polarity. The electroylytic condenser consists of two aluminum foils separated by an electrolyte (a solution which conducts electricity and is decomposed by the current). The current causes an extremely thin film to form on one of the foils. This film being non-conductive, the whole becomes a condenser. Due to the fact that the film is extremely thin, the capacity can be made large in relatively small space. This type of condenser will be ruined if the polarity is reversed; they are good only in D.C. circuits, or when A.C. is superimposed on D. C. as in the power pack. In our case, all the negative terminals should be connected to the chassis. The condensers are marked and color coded; the colors are also shown in Figure 28.

The proper connections to the sockets are shown in Figures 34 and 32. Figure 34 shows the sockets on the chassis as they look from the bottom. Figure 32 gives the bottom views of the sockets at the rear of the chassis.

The terminal lug strips serve as a support for connections which would otherwise

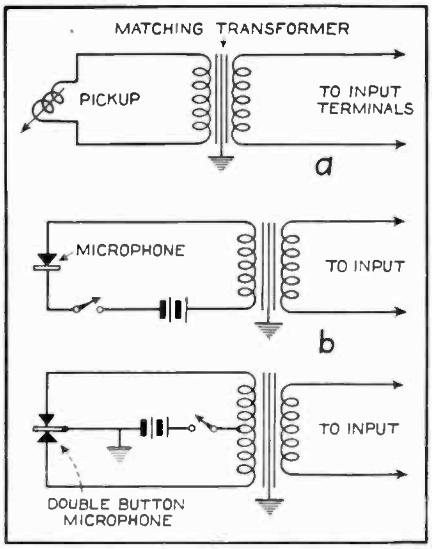


Figure 35

hang in the air. The first one serves to support R4 while the other one is used to support one side of the line and the junction between C3 and R2 of the tone control.

The volume control and tone control are wired as in Figure 36. This is a view of the bottom of the chassis looking from the rear.

The constructor might first complete the power pack and then test it by turning it on, seeing that all the tubes light and (with due caution) measuring the high-voltage.

With the voltage divider in the circuit as the only drain, there will be about 430 volts.

When the other tubes have been connected, the plate voltage will be dropped to approximately 310 volts.

With the power turned off, the slider on the voltage divider can be connected to the high side and adjusted until the total current is 70 ma. The slider will then be less than an inch from the high end. The plate voltages will be slightly over 300 volts.

Use of the Amplifier

The input of the amplifier can be connected to the two-tube receiver described in Lesson Six. Remove the audio tube of the battery set and connect the input term-

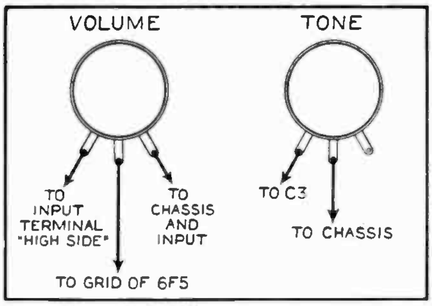


Figure 36

inals of the amplifier across the secondary of the transformer being sure that the grounded side of the transformer connects to the chassis. If the set has a tendency to squeal it can be cured by a .00025 mfd. condenser across the primary of the transformer. It may also be useful to ground the speaker chassis.

If it is desired to use a phonograph pick-up of the "high-impedance" type it is simply connected to the input terminals direct. With a pick-up of the low-impedance type a suitable matching transformer is required, as shown in Figure 35a. The amplifier can also be employed with a carbon microphone, either single button or double button, as shown in Figures 35b and 35c. The other types of microphones such as the crystal, velocity, etc., are too low in output for use with this amplifier. In all these cases it is important to keep the leads in the amplifier input circuit short. Where a transformer is used with microphone input, etc., its case should be grounded and it may be necessary to shield the leads from it to the amplifier input in order to prevent instability and pick-up of hum.

The Speaker

The Wright De Coster Model 820B dynamic speaker used with this amplifier was selected for this use because it offers the attractive combination of good quality and low cost. Another advantage is that its 1800-ohm field is just right to permit the field to function as one of the chokes in the power-supply filter, thus insuring freedom from hum and saving the cost of an extra choke. Also it comes equipped with a cable and plug, thus simplifying the program of making connections to the main unit.

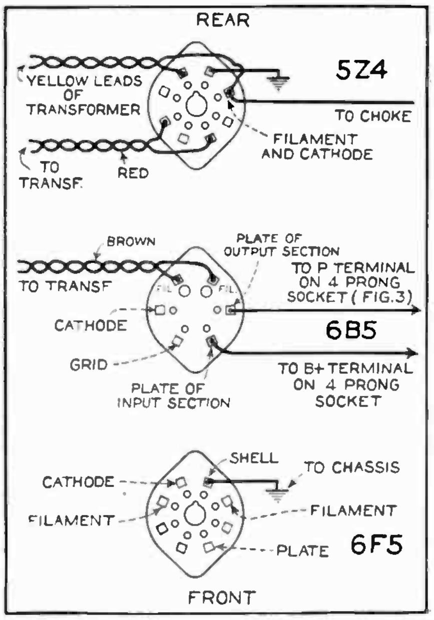


Figure 34

Without a baffle, which may be a flat board or a cabinet, a dynamic speaker will not properly reproduce low notes because in the case of low frequencies the sound from the back of the cone tends to cancel that from the front. The remedy is to make the path from front to back rather long by mounting the speaker on a baffle. The lower the note the larger this baffle should be. In order to fully reproduce a 50 cycle note, for example, the baffle would have to be 22 feet square. Of course, no one would care to make so large a baffle. For practical purposes a baffle three or four feet square gives very good results. Placing the baffle on the floor, extends its size at least in one direction.

When a speaker is placed in a cabinet, the sides of the cabinet constitute an effective part of the baffle. A smaller baffle or cabinet does not bring out the low notes fully but is better than none at all.

Additional lessons in radio are appearing in Radio News. The next lesson appears in the October, 1936, issue and more will follow. They will provide instructions for building various types of tuners, both t.r.f. and superheterodyne, which may be used with this amplifier-power supply unit.

Television Opportunity

(*Continued from Page 2*)

for men who are already familiar with the technical complications of modern radio, and have, in addition, an understanding of branches of electronics which have thus far not been of great importance to those engaged in the radio industry.

Along what lines preparation should follow depends upon previous training and experience and upon the branch of the new industry in which the individual is most interested. Television operation will definitely be limited to the ultra high-frequency ranges; the cathode-ray tube, the photocell, and other electronic devices will play an essential role and television will have much in common with moving picture photography, projection and sound reproduction. All of these therefore represent logical and helpful lines of study. The oscillograph, for instance, involves all the features of the television image reproducer. Plenty of information is available on oscillographs and a thorough study of this will provide an excellent foundation for more detailed study of the television processes.

Ultra high-frequency transmission and reception introduce new phenomena and new problems. The construction and operation of a 5-meter amateur station will provide excellent practical study and training—or at least the construction of a receiver capable of listening in on the 5-meter "ham" band and the experimental broadcasting on the adjacent television channels.

Radio News will present constructional data on television receivers — and transmitters as well — just as rapidly as satisfactory designs permit. It may seem a bit far-fetched to recommend that those interested in television occupations actually construct their own equipment but the fact remains that many of the most important figures in radio today gained their early knowledge by building their own radio sets in the early days of radio.

A study of motion-picture operations will prove extremely helpful. Television pick-up technique will follow closely along lines of movie photography—and even the direction of players and planning of programs will closely parallel those of the movies. Technically, they have much in common also—optically and electrically.

Obviously the important feature in preparing for television is to read everything dependable that one can find on the subject, not only technical literature but articles pertaining to the commercial angles as well.

There are now a number of well qualified schools offering courses in television. For those who can take advantage of such training it is invaluable as it provides the necessary knowledge in concentrated form. Moreover most students find it more beneficial to follow a regular prescribed routine of study, and in almost every case this method will provide better results, when combined with outside reading and practice, than the more haphazard methods of self-training.

To anyone desirous of making a future for himself in television it cannot be too strongly stressed that now is the time to prepare. Hours intelligently spent now in preparation are sure to pay big dividends in years to come.

SUPPLEMENT 2

U. S. Broadcasting Stations

Call	Location	Kc.	Kw.
KABC	San Antonio, Texas	1420	0.1
KABR	Aberdeen, S. Dak	1420	0.1
KADA	Ada, Okla.	1200	0.1
KALB	Alexandria, La.	1420	0.1
KALE	Portland, Ore.	1300	0.5
KANS	Wichita, Kans.	1210	0.1
KARK	Little Rock, Ark.	890	0.25
KASA	Elk City, Okla.	1210	0.1
KAST	Astoria, Ore.	1370	0.1
KBHB	Rapid City, S. Dak.	1370	0.1
KBIX	Muskogee, Okla.	1500	0.1
KBPS	Portland, Ore.	1420	0.1
KBST	Big Spring, Texas	1500	0.1
KBTM	Jonesboro, Ark.	1200	0.1
KCMC	Texarkana, Ark.	1420	0.1
KCMO	Kansas City, Mo.	1370	0.1
KCRC	Enid, Okla.	1360	0.25
KCRJ	Jerome, Ariz.	1310	0.1
KDB	Santa Barbara, Calif.	1500	0.1
KDFN	Casper, Wyo.	1440	0.5
KDKA	Pittsburgh, Pa.	980	50.0
KDLR	Devils Lake, N. Dak.	1210	0.1
KDNC	Lewistown, Mont.	1200	0.1
KDON	Del Monte, Calif.	1210	0.1
KDYL	Salt Lake City, Utah	1290	1.0
KECA	Los Angeles, Calif.	1430	1.0
KEHE	Los Angeles, Calif.	780	0.5
KELD	El Dorado, Ark.	1370	0.1
KERN	Bakersfield, Calif.	1370	0.1
KEUB	Price, Utah	1420	0.1
KEX	Portland, Ore.	1180	5.0
KFAB	Lincoln, Neb.	770	10.0
KFAC	Los Angeles, Calif.	1300	1.0
KFBB	Great Falls, Mont.	1280	1.0
KFBI	Abilene, Kans.	1050	5.0
KFBK	Sacramento, Calif.	1490	5.0
KFDM	Beaumont, Texas	560	0.5
KFDY	Brookings, S. Dak.	780	1.0
KFEL	Denver, Colo.	920	0.5
KFEQ	St. Joseph, Mo.	680	2.5
KFGQ	Boone, Iowa	1370	0.1
KFH	Wichita, Kans.	1300	1.0
KFI	Los Angeles, Calif.	640	50.0
KFIO	Spokane, Wash.	1120	0.1
KFIZ	Fond du Lac, Wis.	1420	0.1
KFJB	Marshalltown, Iowa	1200	0.1
KFJI	Klamath Falls, Ore.	1210	0.1
KFJM	Grand Forks, N. Dak.	1370	0.1
KFJR	Portland, Ore.	1300	0.5
KFJZ	Fort Worth, Texas	1370	0.1
KFKA	Greeley, Colo.	880	0.5
KFKU	Lawrence, Kans.	1220	1.0
KFNF	Shenandoah, Iowa	890	0.5
KFOR	Lincoln, Neb.	1210	0.1
KFOX	Long Beach, Calif.	1250	1.0
KFPL	Dublin, Texas	1310	0.1
KFPW	Fort Smith, Ark.	1210	0.1
KFPY	Spokane, Wash.	890	1.0
KFQD	Anchorage, Alaska	780	0.25
KFRC	San Francisco, Calif.	610	1.0
KFRO	Longview, Texas	1370	0.1
KFRU	Columbia, Mo.	630	0.5
KFSD	San Diego, Calif.	600	1.0
KFSG	Los Angeles, Calif.	1120	0.5
KFUO	St. Louis, Mo.	550	0.5
KFVD	Los Angeles, Calif.	1000	0.25
KFVS	Cape Girardeau, Mo.	1210	0.1
KFWB	Hollywood, Calif.	950	1.0
KFXD	Nampa, Idaho	1200	0.1
KFXJ	Grand Junction, Colo.	1200	0.1
KFXM	San Bernardino, Calif.	1210	0.1
KFXR	Oklahoma City, Okla.	1310	0.1
KFYO	Lubbock, Texas	1310	0.1
KFYR	Bismarck, N. Dak.	550	1.0
KGA	Spokane, Wash.	1470	5.0
KGAR	Tucson, Ariz.	1370	0.1
KGB	San Diego, Calif.	1330	1.0
KGBU	Ketchikan, Alaska	900	0.5
KGBX	Springfield, Mo.	1230	0.5
KGCA	Decorah, Iowa	1270	0.1
KGCU	Mandan, N. Dak.	1240	0.25
KGCX	Wolf Point, Mont.	1310	0.1
KGDE	Fergus Falls, Minn.	1200	0.1
KGDM	Stockton, Calif.	1100	1.0
KGDY	Huron, S. Dak.	1340	0.25
KGEK	Sterling, Colo.	1200	0.1
KGER	Long Beach, Calif.	1360	1.0
KGEZ	Kalispell, Mont.	1310	0.1
KGFF	Shawnee, Okla.	1420	0.1
KGFG	Oklahoma City, Okla.	1370	0.1
KGFI	Corpus Christi, Texas	1500	0.1
KGFJ	Los Angeles, Calif.	1200	0.1
KGFK	Moorhead, Minn.	1500	0.1
KGFL	Roswell, N. M.	1370	0.1
KGFW	Kearney, Neb.	1310	0.1
KGFX	Pierre, S. Dak.	630	0.2
KGGC	San Francisco, Calif.	1420	0.1
KGGF	Coffeyville, Kans.	1010	1.0
KGGM	Albuquerque, N. M.	1230	0.25
KGHF	Pueblo, Colo.	1320	0.5
KGHI	Little Rock, Ark.	1200	0.1
KGHL	Billings, Mont.	780	1.0
KGIR	Butte, Mont.	1340	1.0
KGIW	Alamosa, Colo.	1420	0.1
KGKB	Tyler, Texas	1500	0.1
KGKL	San Angelo, Texas	1370	0.1
KGKO	Wichita Falls, Texas	570	0.25
KGKY	Scottsbluff, Neb.	1500	0.1
KGLO	Mason City, Iowa	1210	0.1
KGMB	Honolulu, T. H.	1320	1.0
KGNC	Amarillo, Texas	1410	1.0
KGNF	North Platte, Neb.	1430	1.0
KGNO	Dodge City, Kans.	1340	0.25
KGO	San Francisco, Calif.	790	7.5
KGU	Honolulu, T. H.	750	2.5
KGVO	Missoula, Mont.	1260	1.0
KGW	Portland, Ore.	620	1.0
KGY	Olympia, Wash.	1210	0.1
KHBC	Hilo, T. H.	1400	0.25
KHJ	Los Angeles, Calif.	900	1.0
KHQ	Spokane, Wash.	590	1.0
KHSL	Chico, Calif.	950	0.25
KICA	Clovis, N. M.	1370	0.1
KID	Idaho Falls, Idaho	1320	0.5
KIDO	Boise, Idaho	1350	1.0
KIDW	Lamar, Colo.	1420	0.1
KIEM	Eureka, Calif.	1450	0.5
KIEV	Glendale, Calif.	850	0.25
KINY	Juneau, Alaska	1310	0.1
KIRO	Seattle, Wash.	710	1.0
KIT	Yakima, Wash.	1310	0.1
KIUJ	Santa Fe, N. M.	1310	0.1
KIUL	Garden City, Kans.	1210	0.1
KIUN	Pecos, Texas	1420	0.1
KIUP	Durango, Colo.	1370	0.1
KJBS	San Francisco, Calif.	1070	0.5
KJR	Seattle, Wash.	970	5.0
KLCN	Blytheville, Ark.	1290	0.1
KLO	Ogden, Utah	1400	0.5
KLPM	Minot, N. Dak.	1240	0.25
KLRA	Little Rock, Ark.	1390	1.0
KLS	Oakland, Calif.	1440	0.25
KLUF	Galveston, Texas	1370	0.1
KLX	Oakland, Calif.	880	1.0
KLZ	Denver, Colo.	560	1.0
KMA	Shenandoah, Iowa	930	1.0
KMAC	San Antonio, Texas	1370	0.1
KMBC	Kansas City, Mo.	950	1.0
KMED	Medford, Ore.	1310	0.1
KMJ	Fresno, Calif.	580	1.0
KMLB	Monroe, La.	1200	0.1
KMMJ	Clay Center, Neb.	740	1.0
KMO	Tacoma, Wash.	1330	0.25
KMOX	St. Louis, Mo.	1090	50.0
KMPC	Beverly Hills, Calif.	710	0.5
KMTR	Hollywood, Caif.	570	1.0
KNEL	Brady, Texas	1500	0.1
KNET	Palestine, Texas	1420	0.1
KNOW	Austin, Texas	1500	0.1
KNX	Hollywood, Calif.	1050	50.0
KOA	Denver, Colo.	830	50.0
KOAC	Corvallis, Ore.	550	1.0
KOB	Albuquerque, N. M.	1180	10.0
KOCA	Kilgore, Texas	1210	0.1
KOH	Reno, Nev.	1380	0.5
KOIL	Council Bluffs, Iowa	1260	1.0
KOIN	Portland, Ore.	940	1.0
KOL	Seattle, Wash.	1270	1.0
KOMA	Oklahoma City, Okla.	1480	5.0
KOMO	Seattle, Wash.	920	1.0
KONO	San Antonio, Texas	1370	0.1
KOOS	Marshfield, Ore.	1390	0.25
KORE	Eugene, Ore.	1420	0.1
KOTN	Pine Bluffs, Ark.	1500	0.1
KOY	Phoenix, Ariz.	1390	0.5
KPAC	Port Arthur, Texas	1260	0.5
KPDN	Pampa, Texas	1310	0.1
KPLC	Lake Charles, La.	1500	0.1
KPLT	Paris, Texas	1500	0.1
KPO	San Francisco, Calif.	680	50.0
KPOF	Denver, Colo.	880	0.5
KPPC	Pasadena, Calif.	1210	0.1
KPQ	Wenatchee, Wash.	1500	0.1
KPRC	Houston, Texas	920	1.0
KQV	Pittsburgh, Pa.	1380	0.5
KQW	San Jose, Calif.	1010	1.0
KRBC	Abilene, Texas	1420	0.1
KRE	Berkeley, Calif.	1370	0.1
KRGV	Weslaco, Texas	1260	0.5
KRKD	Los Angeles, Calif.	1120	0.5
KRKO	Everett, Wash.	1370	0.05
KRLC	Lewiston, Idaho	1420	0.1
KRLD	Dallas, Texas	1040	10.0
KRLH	Midland, Texas	1420	0.1
KRMD	Shreveport, La.	1310	0.1
KRNR	Roseburg, Ore.	1500	0.1
KRNT	Des Moines, Iowa	1320	0.5
KROC	Rochester, Minn.	1310	0.1
KROW	Oakland, Calif.	930	1.0
KROY	Sacramento, Calif.	1310	0.1
KRRV	Sherman, Texas	1310	0.1
KRSC	Seattle, Wash.	1120	0.1
KSAC	Manhattan, Kans.	580	0.5
KSCJ	Sioux City, Iowa	1330	1.0
KSD	St. Louis, Mo.	550	1.0
KSEI	Pocatello, Idaho	900	0.25
KSFO	San Francisco, Calif.	560	1.0
KSL	Salem, Ore.	1370	0.1
KSLM	Salt Lake City, Utah	1130	50.0
KSO	Des Moines, Iowa	1430	0.5
KSOO	Sioux Falls, S. Dak.	1110	2.5
KSTP	St. Paul, Minn.	1460	25.0
KSUN	Lowell, Ariz.	1200	0.1
KTAR	Phoenix, Arix.	620	1.0
KTAT	Fort Worth, Texas	1240	1.0
KTBS	Shreveport, La.	1450	1.0
KTEM	Temple, Texas	1370	0.1
KTEP	El Paso, Texas	1500	0.1
KTFI	Twin Falls, Idaho	1240	1.0
KTHS	Hot Springs, Ark.	1060	10.0
KTRB	Modesto, Calif.	740	0.25
KTRH	Houston, Texas	1290	1.0
KTSA	San Antonio, Texas	550	1.0
KTSM	El Paso, Texas	1310	0.1
KTUL	Tulsa, Okla.	1400	0.5
KTW	Seattle, Wash.	1220	1.0
KUJ	Walla Walla, Wash.	1370	1.0
KUMA	Yuma, Ariz.	1420	0.1
KUOA	Fayetteville, Ark.	1260	1.0
KUSD	Vermillion, S. Dak.	890	0.5
KUTA	Salt Lake City, Utah	1500	0.1
KVCV	Redding, Calif.	1200	0.1
KVEC	San Luis Obispo, Calif.	1200	0.25
KVI	Tacoma, Wash.	570	1.0
KVL	Seattle, Wash.	1370	0.1
KVOA	Tucson, Ariz.	1260	0.5
KVOD	Denver, Colo.	920	0.5
KVOE	Santa Ana, Calif.	1500	0.1
KVOL	Lafayette, La.	1310	0.1
KVOO	Tulsa, Okla.	1140	25.0
KVOR	Colorado Springs, Colo.	1270	1.0
KVOS	Bellingham, Wash.	1200	0.1
KVSO	Ardmore, Okla.	1210	0.1
KWAT	Watsonville, Calif.	1310	0.25
KWBG	Hutchinson, Kans.	1420	0.1
KWG	Stockton, Calif.	1200	0.1
KWJJ	Portland, Ore.	1040	0.5
KWK	St. Louis, Mo.	1350	1.0
KWKH	Shreveport, La.	1100	10.0
KWLC	Decorah, Iowa	1270	0.1
KWSC	Pullman, Wash.	1220	1.0
KWTN	Watertown, S. Dak.	1210	0.1
KWTO	Springfield, Mo.	560	5.0
KWYO	Sheridan, Wyo.	1370	0.1
KXA	Seattle, Wash.	760	0.25
KXL	Portland, Ore.	1420	0.1
KXO	El Centro, Calif.	1500	0.1
KXRO	Aberdeen, Wash.	1310	0.1
KXYZ	Houston, Texas	1440	1.0
KYA	San Francisco, Calif.	1230	1.0
KYOS	Merced, Calif.	1040	0.25
KYW	Philadelphia, Pa.	1020	10.0
WAAB	Boston, Mass.	1410	0.5
WAAF	Chicago, Ill.	920	1.0
WAAT	Jersey City, N. J.	940	0.5
WAAW	Omaha, Neb.	660	0.5
WABC	New York, N. Y.	860	50.0
WABI	Bangor, Maine	1200	0.1
WABY	Albany, N. Y.	1370	0.1
WACO	Waco, Texas	1420	0.1
WADC	Akron, Ohio	1320	1.0
WAGF	Dothan, Ala.	1370	0.25
WAGM	Presque Isle, Me.	1420	0.1
WAIM	Anderson, S. C.	1200	0.1
WALA	Mobile, Ala.	1380	0.5
WALR	Zanesville, Ohio	1210	0.1
WAML	Laurel, Miss.	1310	0.1
WAPI	Birmingham, Ala.	1140	5.0
WAPO	Chattanooga, Tenn.	1420	0.1
WARD	Brooklyn, N. Y.	1400	0.5
WASH	Grand Rapids, Mich.	1270	0.5
WATL	Atlanta, Ga.	1370	0.1

Call	Location	Kc.	Kw.
WATR	Waterbury, Conn.	1190	0.1
WAVE	Louisville, Ky.	940	1.0
WAWZ	Zarephath, N. J.	1350	0.5
WAYX	Waycross, Ga.	1200	0.1
WAZL	Hazleton, Pa.	1420	0.1
WBBA	West Lafayette, Ind.	890	0.5
WBAL	Baltimore, Md.	760	2.5
WBAL	Baltimore, Md.	1060	10.0
WBAP	Fort Worth, Texas	800	50.0
WBAX	Wilkes-Barre, Pa.	1210	0.1
WBBC	Brooklyn, N. Y.	1400	0.5
WBBL	Richmond, Va.	1210	0.1
WBBM	Chicago, Ill.	770	50.0
WBBR	Brooklyn, N. Y.	1300	1.0
WBBZ	Ponca City, Okla.	1200	0.1
WBCM	Bay City, Mich.	1410	0.5
WBEN	Buffalo, N. Y.	900	1.0
WBEO	Marquette, Mich.	1310	0.1
WBIG	Greensboro, N. C.	1440	0.5
WBLY	Lima, Ohio	1210	0.1
WBNO	New Orleans, La.	1200	0.1
WBNS	Columbus, Ohio	1430	0.5
WBNX	New York, N. Y.	1350	0.25
WBNY	Buffalo, N. Y.	1370	0.1
WBOQ	New York, N. Y.	860	50.0
WBOW	Terre Haute, Ind.	1310	0.1
WBRB	Red Bank, N. J.	1210	0.1
WBRC	Birmingham, Ala.	930	1.0
WBRE	Wilkes-Barre, Pa.	1310	0.1
WBT	Charlotte, N. C.	1080	50.0
WBTM	Danville, Va.	1370	0.1
WBZ	Boston, Mass.	990	50.0
WBZA	Springfield, Mass.	990	1.0
WCAD	Canton, N. Y.	1220	0.5
WCAE	Pittsburgh, Pa.	1220	1.0
WCAL	Northfield, Minn.	1250	1.0
WCAM	Camden, N. J.	1280	0.5
WCAO	Baltimore, Md.	600	0.5
WCAP	Asbury Park, N. J.	1280	0.5
WCAT	Rapid City, S. Dak.	1200	0.1
WCAU	Philadelphia, Pa.	1170	50.0
WCAX	Burlington, Vt.	1200	0.1
WCAZ	Carthage, Ill.	1070	0.1
WCBA	Allentown, Pa.	1440	0.5
WCBD	Waukegan, Ill.	1080	5.0
WCBM	Batimore, Md.	1370	0.1
WCBS	Springfield, Ill.	1420	0.1
WCCO	Minneapolis, Minn.	810	50.0
WCFL	Chicago, Ill.	970	5.0
WCHS	Charleston, W. Va.	580	0.5
WCHV	Charlottesville, Va.	1420	0.1
WCKY	Covington, Ky.	1490	5.0
WCLO	Janesville, Wis.	1200	0.1
WCLS	Joliet, Ill.	1310	0.1
WCMI	Ashland, Ky.	1310	0.1
WCNW	Brookyn, N. Y.	1500	0.1
WCOA	Pensacola, Fla.	1340	0.5
WCOC	Meridian, Miss.	880	0.5
WCOL	Columbus, Ohio	1210	0.1
WCOP	Boston, Mass.	1120	0.5
WCPO	Cincinnati, Ohio	1200	0.1
WCRW	Chicago, Ill.	1210	0.1
WCSC	Charleston, S. C.	1360	0.5
WCSH	Portland, Me.	940	1.0
WDAE	Tampa, Fla.	1220	1.0
WDAF	Kansas City, Mo.	610	1.0
WDAH	El Paso, Texas	1310	0.1
WDAS	Philadelphia, Pa	1370	0.1
WDAY	Fargo, N. Dak.	940	1.0
WDBJ	Roanoke, Va.	930	1.0
WDBO	Orlando, Fla.	580	1.0
WDEL	Wilmington, Del.	1120	0.25
WDEV	Waterbury, Vt.	550	0.5
WDGY	Minneapolis, Minn.	1180	1.0
WDNC	Durham, N. C.	1500	0.1
WDOD	Chattanooga, Tenn.	1280	1.0
WDRC	Hartford, Conn.	1330	1.0
WDSU	New Orleans, La.	1250	1.0
WDWS	Champaign, Ill.	1370	0.1
WDZ	Tuscola, Ill.	1020	0.25
WEAF	New York, N. Y.	660	50.0
WEAN	Providence, R. I.	780	0.5
WEBC	Superior, Wis.	1290	1.0
WEBQ	Harrisburg, Ill.	1210	0.1
WEBR	Buffalo, N. Y.	1310	0.1
WEDC	Chicago, Ill.	1210	0.1
WEED	Rocky Mount, N. C.	1420	0.1
WEEI	Boston, Mass.	590	1.0
WEEU	Reading, Pa.	830	1.0
WEGL	Brooklyn, N. Y.	1400	0.5
WEHS	Cicero, Ill.	1420	0.1
WELI	New Haven, Conn.	900	0.5
WELL	Battle Creek, Mich.	1420	0.1
WEMP	Milwaukee, Wis.	1310	0.1
WENR	Chicago, Ill.	870	50.0
WEOA	Evansville, Ind.	1370	0.1
WESG	Elmira, N. Y.	850	1.0
WEST	Easton, Pa.	1200	0.1
WEVD	New York, N. Y.	1300	1.0
WEW	St. Louis, Mo.	760	1.0
WEXL	Royal Oak, Mich.	1310	0.05
WEXP	Clarksburg, W. Va.	1370	0.1
WFAA	Dallas, Texas	800	50.0
WFAB	New York, N. Y.	1300	1.0
WFAM	South Bend, Ind.	1200	0.1
WFAS	White Plains, N. Y.	1210	0.1
WFBC	Greenville, S. C.	1300	1.0
WFBG	Altoona, Pa.	1310	0.1
WFBL	Syracuse, N. Y.	1360	1.0
WFBM	Indianapolis, Ind.	1230	1.0
WFBR	Baltimore, Md.	1270	0.5
WFDF	Flint, Mich.	1310	0.1
WFEA	Manchester, N. H.	1340	0.5
WFIL	Philadelphia, Pa.	560	1.0
WFLA	Clearwater, Fla.	620	1.0
WFMD	Frederick, Md.	900	0.5
WFOY	St. Augustine, Fla.	1210	0.1
WGAL	Lancaster, Pa.	1500	0.1
WGAR	Ceveland, Ohio	1450	0.5
WGBB	Freeport, N. Y.	1210	0.1
WGBF	Evansville, Ind.	630	0.5
WGBI	Scranton, Pa.	880	0.5
WGCM	Gulfport, Miss.	1210	0.1
WGES	Chicago, Ill.	1360	0.5
WGH	Newport News, Va.	1310	0.1
WGL	Fort Wayne, Ind.	1370	0.1
WGN	Chicago, Ill.	720	50.0
WGNY	Chester, N. Y.	1210	0.1
WGPC	Albany, Ga.	1420	0.1
WGR	Buffalo, N. Y.	550	1.0
WGRC	New Albany, Ind.	1370	0.25
WGST	Atlanta, Ga.	890	1.0
WGY	Schenectady, N. Y.	790	50.0
WHA	Madison, Wis.	940	2.5
WHAM	Rochester, N. Y.	1150	50.0
WHAS	Louisville, Ky.	820	50.0
WHAT	Philadelphia, Pa.	1310	0.1
WHAZ	Troy, N. Y.	1300	0.5
WHB	Kansas City, Mo	860	1.0
WHBB	Selma, Ala.	1500	0.1
WHBC	Canton, Ohio	1200	0.1
WHBF	Rock Island, Ill.	1210	0.1
WHBI	Newark, N. J.	1250	1.0
WHBL	Sheboygan, Wis.	1300	0.5
WHBQ	Memphis, Tenn.	1370	0.1
WHBU	Anderson, Ind.	1210	0.1
WHBY	Green Bay, Wis.	1200	0.1
WHDF	Calumet, Mich.	1370	0.1
WHDH	Boston, Mass.	830	1.0
WHDL	Olean, N. Y.	1420	0.1
WHEB	Portsmouth, N. H.	740	0.25
WHEC	Rochester, N. Y.	1430	0.5
WHEF	Kosciusko, Miss.	1500	0.1
WHFC	Cicero, Ill.	1420	0.1
WHIO	Dayton, Ohio	1260	1.0
WHIS	Bluefield, W. Va.	1410	0.5
WHJB	Greensburg, Pa.	620	0.25
WHK	Cleveland, Ohio	1390	1.0
WHKC	Columbus, Ohio	640	0.5
WHLB	Virginia, Minn.	1370	0.1
WHN	New York, N. Y.	1010	1.0
WHO	Des Moines, Iowa	1000	50.0
WHOM	Jersey City, N. J.	1450	0.25
WHP	Harrisburg, Pa.	1430	0.5
WIBA	Madison, Wis.	1280	1.0
WIBG	Glenside, Pa.	970	0.1
WIBM	Jackson, Mich.	1370	0.1
WIBU	Poynette, Wis.	1210	0.1
WIBW	Topeka, Kans.	580	1.0
WIBX	Utica, N. Y.	1200	0.1
WICC	Bridgeport, Conn.	600	0.5
WIL	St. Louis, Mo.	1200	0.1
WILL	Urbana, Ill.	580	1.0
WILM	Wilmington, Del.	1420	0.1
WIND	Gary, Ind.	560	1.0
WINS	New York, N. Y.	1180	1.0
WIOD	Miami, Fla.	1300	1.0
WIP	Philadelphia, Pa.	610	1.0
WIRE	Indianapolis, Ind.	1400	0.5
WIS	Columbia, S. C.	56	1.0
WISN	Milwaukee, Wis.	1120	0.25
WJAC	Johnstown, Pa.	1310	0.1
WJAG	Norfolk, Neb.	1060	1.0
WJAR	Providence, R. I.	890	1.0
WJAS	Pittsburgh, Pa	1290	1.0
WJAX	Jacksonville, Fla.	900	1.0
WJAY	Cleveland, Ohio	610	0.5
WJBC	Bloomington, Ill.	1200	0.1
WJBK	Detroit, Mich.	1500	0.1
WJBL	Decatur, Ill.	1200	0.1
WJBO	Baton Rouge, La.	1420	0.1
WJBR	Gastonia, N. C.	1420	0.1
WJBW	New Oreans, La.	1200	0.1
WJBY	Gadsden, Aa.	1210	0.1
WJDX	Jackson, Miss.	1270	1.0
WJEJ	Hagerstown, Md.	1210	0.1
WJIM	Lansing, Mich.	1210	0.1
WJJD	Chicago, Ill.	1130	20.0
WJMS	Ironwood, Mich.	1420	0.1
WJNO	W. Palm Beach, Fla.	1200	0.1
WJR	Detroit, Mich.	750	50.0
WJRD	Tuscaloosa, Ala.	1200	0.1
WJSV	Washington, D. C.	1460	10.0
WJW	Akron, Ohio	1210	0.1
WJZ	New York, N. Y.	760	50.0
WKAQ	San Juan, P. R.	1240	1.0
WKAR	East Lansing, Mich.	850	1.0
WKBB	East Dubuque, Ill.	1500	0.1
WKBH	LaCrosse, Wis.	1380	1.0
WKBI	Cicero, Ill.	1420	0.1
WKBN	Youngstown, Ohio	570	0.5
WKBO	Harrisburg, Pa.	1200	0.1
WKBV	Richmond, Ind.	1500	0.1
WKBW	Buffalo, N. Y.	1480	5.0
WKBZ	Muskegon, Mich.	1500	0.1
WKEU	Griffin, Ga.	1500	0.1
WKOK	Sunbury, Pa.	1210	0.1
WKRC	Cincinnati, Ohio	550	1.0
WKY	Oklahoma City, Okla.	900	1.0
WKZO	Kalamazoo, Mich.	590	1.0
WLAC	Nashville, Tenn.	1470	5.0
WLAK	Lakeland, Fla.	1310	0.1
WLAP	Lexington, Ky.	1420	0.1
WLB	Minneapolis, Minn.	1250	1.0
WLBC	Muncie, Ind.	1310	0.1
WLBF	Kansas City, Kans.	1420	0.1
WLBL	Stevens Point, Wis.	900	2.5
WLBZ	Bangor, Me.	620	0.5
WLEU	Erie, Pa.	1420	0.1
WLLH	Lowell, Mass.	1370	0.1
WLMU	Middlesboro, Ky.	1210	0.1
WLNH	Laconia, N. H.	1310	0.1
WLS	Chicago, Ill.	870	50.0
WLTH	Brooklyn, N. Y.	1400	0.5
WLVA	Lynchburg, Va.	1200	0.1
WLW	Cincinnati, Ohio	700	500.0
WLWL	New York, N. Y.	1100	5.0
WMAL	Washington, D. C.	630	0.25
WMAQ	Chicago, Ill.	670	50.0
WMAS	Springfield, Mass.	1420	0.1
WMAZ	Macon, Ga.	1180	1.0
WMBC	Detroit, Mich.	1420	0.1
WMBD	Peoria, Ill.	1440	0.5
WMBG	Richmond, Va.	1210	0.1
WMBH	Joplin, Mo.	1420	0.1
WMBI	Chicago, Ill.	1080	5.0
WMBO	Auburn, N. Y.	1310	0.1
WMBQ	Brooklyn, N. Y.	1500	0.1
WMBR	Jacksonville, Fla.	1370	0.1
WMC	Memphis, Tenn.	780	1.0
WMCA	New York, N. Y.	570	0.5
WMEX	Boston, Mass.	1500	0.1
WMFD	Wilmington, N. C.	1370	0.1
WMFF	Plattsburg, N. Y.	1310	0.25
WMFG	Hibbing, Minn.	1210	0.1
WMFJ	Daytona Beach, Fla.	1420	0.1
WMFN	Clarksdale, Miss.	1210	0.1
WMFO	Decatur, Ala.	1370	0.1
WMFR	High Point, N. C.	1200	0.1
WMIN	St. Paul, Minn.	1370	0.1
WMMN	Fairmont, W. Va.	890	0.25
WMPC	Lapeer, Mich.	1200	0.1
WMSD	Sheffield, Ala.	1420	0.1
WMT	Cedar Rapids, Iowa	600	1.0
WNAC	Boston, Mass.	1230	1.0
WNAD	Norman, Okla.	1010	1.0
WNAX	Yankton, S. Dak.	570	1.0
WNBC	New Britain, Conn.	1380	0.25
WNBF	Binghamton, N. Y.	1500	0.1
WNBH	New Bedford, Mass.	1310	0.1
WNB	Memphis, Tenn.	1430	0.5
WNBX	Springfield, Vt.	1260	1.0
WNBZ	Saranac Lake, N. Y.	1290	0.1
WNEL	San Juan, P. R.	1290	1.0
WNEW	Newark, N. J.	1250	1.0
WNLC	New London, Conn.	1500	0.1
WNOX	Knoxville, Tenn.	1010	1.0
WNRI	Newport, R. I.	1200	0.1
WNYC	New York, N. Y.	810	1.0
WOAI	San Antonio, Texas	1190	50.0
WOC	Davenport, Iowa	1370	0.1
WOCL	Jamestown, N. Y.	1210	0.05
WOI	Ames, Iowa	640	5.0
WOKO	Albany, N. Y.	1430	0.5
WOL	Washington, D. C.	1310	0.1
WOLS	Florence, S. C.	1200	0.1
WOMT	Manitowoc, Wis.	1210	0.1
WOOD	Grand Rapids, Mich.	1270	0.5
WOPI	Bristol, Tenn.	1500	0.1
WOR	Newark, N. J.	710	50.0
WORC	Worcester, Mass.	1280	0.5
WORK	York, Pa.	1320	1.0
WORL	Boston, Mass.	920	0.5
WOS	Jefferson City, Mo.	630	0.5
WOSU	Columbus, Ohio	570	0.75
WOV	New York, N. Y.	1130	1.0
WOW	Omaha, Neb.	590	5.0
WOWO	Fort Wayne, Ind.	1160	10.0
WPAD	Paducah, Ky.	1420	0.1
WPAR	Parkersburg, W. Va.	1420	0.1
WPAX	Thomasville, Ga.	1210	0.1
WPAY	Portsmouth, Ohio	1370	0.1
WPEN	Philadelphia, Pa.	920	0.25
WPFB	Hattlesburg, Miss.	1370	0.1
WPG	Atlantic City, N. J.	1100	5.0
WPHR	Petersburg, Va.	880	0.5
WPRO	Providence, R. I.	630	0.25
WPRP	Ponce, P. R.	1420	0.1
WPTF	Raleigh, N. C.	680	5.0
WQAM	Miami, Fla.	560	1.0
WQAN	Scranton, Pa.	880	0.25
WQBC	Vicksburg, Miss.	1360	1.0
WQDM	St. Albans, Vt.	1370	0.1
WRAK	Williamsport, Pa.	1370	0.1
WRAW	Reading, Pa.	1310	0.1
WRAX	Philadelphia, Pa.	920	0.25
WRBL	Columbus, Ga.	1200	0.1
WRC	Washington, D. C.	950	0.5
WRDO	Augusta, Me.	1370	0.1
WRDW	Augusta, Ga.	1500	0.1
WREC	Memphis, Tenn.	600	1.0
WREN	Lawrence, Kans.	1220	1.0
WRGA	Rome, Ga.	1500	0.1
WRJN	Racine, Wis.	1370	0.1
WROK	Rockford, Ill.	1410	0.5
WROL	Knoxville, Tenn.	1310	0.1
WRR	Dallas, Texas	1280	0.5
WRUF	Gainesville, Fla.	830	5.0
WRVA	Richmond, Va.	1110	5.0
WSAI	Cincinnati, Ohio	1330	1.0
WSAJ	Grove City, Pa.	1310	0.1

Call	Location	Kc.	Kw.
WSAN	Allentown, Pa.	1440	0.5
WSAR	Fall River, Mass.	1350	1.0
WSAY	Rochester, N. Y.	1210	0.1
WSAZ	Huntington, W. Va.	1190	1.0
WSB	Atlanta, Ga.	740	50.0
WSBC	Chicago, Ill.	1210	0.1
WSBT	South Bend, Ind.	1360	0.5
WSFA	Montgomery, Ala.	1410	0.5
WSGN	Birmingham, Ala.	1310	0.1
WSIX	Springfield, Tenn.	1210	0.1
WSJS	Winston-Salem, N. C.	1310	0.1
WSM	Nashville, Tenn.	650	50.0
WSMB	New Orleans, La.	1320	0.5
WSMK	Dayton, Ohio	1380	0.2
WSOC	Charlotte, N. C.	1210	0.1
WSPA	Spartanburg, S. C.	920	1.0
WSPD	Toledo, Ohio	1340	1.0
WSPG	Portland, Me.	640	0.5
WSPR	Springfield, Mass.	1140	0.5
WSUI	Iowa City, Iowa	880	0.5
WSUN	St. Petersburg, Fla.	620	1.0
WSVA	Harrisonburg, Va.	550	0.5
WSVS	Buffalo, N. Y.	1370	0.05
WSYB	Rutland, Vt.	1500	0.1
WSYR	Syracuse, N. Y.	570	0.25
WTAD	Quincy, Ill.	900	0.5
WTAG	Worcester, Mass.	580	0.5
WTAL	Tallahassee, Fla.	1310	0.1
WTAM	Cleveland, Ohio	1070	50.0
WTAQ	Green Bay, Wis.	1330	1.0
WTAR	Norfolk, Va.	780	0.5
WTAW	College Station, Texas	1120	0.5
WTAX	Springfield, Ill.	1210	0.1
WTBO	Cumberland, Md.	800	0.25
WTCN	Minneapolis, Minn.	1250	1.0
WTEL	Philadelphia, Pa.	1310	0.1
WTFI	Athens, Ga.	1450	0.5
WTHT	Hartford, Conn.	1200	0.1
WTIC	Hartford, Conn.	1040	50.0
WTJS	Jackson, Tenn.	1310	0.1
WTMJ	Milwaukee, Wis.	620	1.0
WTMV	East St. Louis, Ill.	1500	0.1
WTNJ	Trenton, N. J.	1280	0.5
WTOC	Savannah, Ga.	1260	1.0
WTRC	Elkhart, Ind.	1310	0.1
WVFW	Brooklyn, N. Y.	1400	0.5
WWAE	Hammond, Ind.	1200	0.1
WWJ	Detroit, Mich.	920	1.0
WWL	New Orleans, La.	850	10.0
WWNC	Asheville, N. C.	570	1.0
WWRL	Woodside, N. Y.	1500	0.1
WWSW	Pittsburgh, Pa.	1500	0.1
WWVA	Wheeling, W. Va.	1160	5.0
WXYZ	Detroit, Mich.	1240	1.0
W1XBS	Waterbury, Conn.	1530	1.0
W2XR	Long Island City, N. Y.	1550	1.0
W6XAI	Bakersfield, Calif.	1550	1.0
W9XBY	Kansas City, Mo.	1530	1.0

World's Leading Short-Wave Stations

Meters	Call Letters	Frequency Kc.	City Country
13.93	W8XK	21540	Pittsburgh, Pa.
13.94	W2XE	21520	New York, N. Y.
13.97	GSH	21470	Daventry, England
16.87	W3XAL	17780	Bound Brook, N. J.
16.89	DJE	17760	Zeesen, Germany
19.56	DJR	15340	Zeesen, Germany
19.57	W2XAD	15330	Schenectady, N. Y.
19.60	GSP	15310	Daventry, England
19.62	LRU	15290	Buenos Aires, Arg.
19.63	DJQ	15280	Zeesen, Germany
19.66	GSI	15260	Daventry, England
19.68	TPA2	15244	Pontiose, France
19.69	OLR	15230	Podebrady, Czech.
19.71	PCJ	15220	Eindhoven, Holland
19.72	W8XK	15210	Pittsburgh, Pa.
19.74	DJB	15200	Zeesen, Germany
19.76	RV96	15180	Moscow, U.S.S.R.
19.76	GSO	15180	Daventry, England
19.81	RKI	15140	Moscow, U.S.S.R.
19.82	GSF	15140	Daventry, England
19.84	HVJ	15121	Vatican City
19.85	DJL	15110	Zeesen, Germany
20.00	SV1KI	15000	Athens, Greece
20.04	LZA	14970	Sofia, Bulgaria
20.55	JVH	14600	Nazaki, Japan
22.16	SPW	13653	Warsaw, Poland
22.95	VPD	13075	Suva, Fiji Islands
24.52	TFJ	12235	Reykjavik, Iceland
25.00	RV59(RNE)	12000	Moscow, U.S.S.R.
25.24	TPA3	11885	Pontoise, France
25.27	W8XK	11870	Pittsburgh, Pa.
25.36	W2XE	11830	New York, N. Y.
25.36	W9XAA	11830	Chicago, Ill.
25.40	I2RO	11810	Rome, Italy
25.49	DJD	11770	Zeesen, Germany
25.53	GSD	11750	Daventry, England
25.58	PHI	11730	Huizen, Holland
25.58	CJRX	11730	Winnipeg, Canada
25.60	TPA4	11720	Pontoise, France
25.62	HJ4ABA	11710	Medellin, Col.
26.24	COCX	11435	Havana, Cuba
26.60	HIN	11280	Trujillo, D. R.
27.35	HS8PJ	10955	Bangkok, Siam
27.93	JVM	10740	Nazaki, Japan
28.14	JVN	10660	Nazaki, Japan
29.04	ORK	10330	Ruysselede, Belgium
30.43	EAQ	9860	Madrid, Spain
30.75	COCQ	9750	Havana, Cuba
31.00	CQN	9677	Macao, Asia
31.07	YNLF	9655	Managua, Nicaragua
31.09	CT1AA	9650	Lisbon, Portugal
31.14	I2RO	9635	Rome, Italy
31.25	RAN	9600	Moscow, U.S.S.R.
31.25	HJ1ABP	9600	Cartagena, Col.
31.27	HH3W	9595	Port-au-Prince, Haiti
31.27	HBL	9595	Geneva, Switzerland
31.28	W3XAU	9590	Philadelphia, Pa.
31.28	VK2ME	9590	Sydney, Australia
31.28	PCJ	9590	Eindhoven, Holland
31.28	HP5J	9590	Panama City, Pana.
31.30	HJ2ABC	9585	Cucuta, Colombia
31.32	VK3LR	9580	Lyndhurst, Australia
31.32	GSC	9580	Daventry, England
31.35	W1XK	9570	Millis, Mass.
31.38	DJA	9560	Zeesen, Germany
31.40	TIPG	9559	San Jose, C. R.
31.45	DJN	9540	Zeesen, Germany
31.48	W2XAF	9530	Schenectady, N. Y.
31.48	LKJ1	9530	Jeloy, Norway
31.55	GSB	9510	Daventry, England
31.55	HJU	9510	Buenaventura, Colom.
31.55	VK3ME	9510	Melbourne, Australia
31.56	XEFT	9505	Veracruz, Mex.
31.58	HJ1ABE	9500	Cartagena, Col.
31.75	TGWA	9450	Guatemala City
31.82	COCH	9428	Havana, Cuba
31.35	HS8PJ	9350	Bangkok, Siam
32.88	HAT4	9125	Budapest, Hungary
33.53	HCJB	8948	Quito, Ecuador
34.29	ZBW	8750	Hong Kong, China
34.62	CO9JQ	8665	Camaguey, Cuba
38.48	HBP	7797	Geneva, Switzerland
39.95	JVP	7510	Nazaki, Japan
41.80	CR6AA	7177	Lobito, Angola, Africa
42.80	EA8AB	7010	Tenerife, C. I.
43.48	HI3C	6900	La Romana, D. R.
43.99	XGOX	6820	Nanking, China
44.14	HIH	6796	San Pedro, D. R.
44.44	JVT	6750	Nazaki, Japan
44.71	TIEP	6710	San Jose, Costa Rica
45.00	HC2RL	6667	Guayaquil, Ecuador
45.25	HIT	6630	Trujillo, D. R.
45.34	PRADO	6618	Riobamba, Ecuador
45.38	RV72	6611	Moscow, U.S.S.R.
45.80	HI4D	6550	Trujillo, D. R.
46.01	YV6RV	6520	Valencia, Venezuela
46.08	HIL	6510	Trujillo, D. R.
46.66	HI1S	6430	Puerto Plata, D. R.
46.91	HI8Q	6395	Trujillo, D. R.
47.06	YV4RC	6375	Caracas, Venezuela
47.24	HRP1	6350	San Pedro Sula, Hond.
47.54	HIZ	6310	Trujillo, D. R.
47.62	YV12RM	6300	Maracay, Venezuela
47.77	HIG	6280	Trujillo, D. R.
47.77	CO9WR	6280	Sancti Spiritus, Cuba
48.05	HIN	6243	Trujillo, D. R.
48.11	HRD	6235	La Ceiba, Hond.
48.15	OAX4G	6230	Lima, Peru
48.19	HJ1ABH	6225	Cienaga, Colombia
48.50	HI1A	6185	Santiago, D. R.
48.70	VPB	6160	Colombo, Ceylon
48.70	CJRO	6160	Winnipeg, Canada
48.78	VE9CL	6150	Winnipeg, Canada
48.78	HJ2ABA	6150	Tunja, Colombia
48.78	YV3RC	6150	Caracas, Venezuela
48.78	HJ5ABC	6150	Cali, Colombia
48.78	COKG	6150	Santiago, Cuba
48.86	W8XK	6140	Pittsburgh, Pa.
48.88	CR7AA	6137	Lourenzo Marques, A.
48.94	XEXA	6130	Mexico, D. F.
48.94	COCD	6130	Havana, Cuba
48.96	HJ3ABX	6128	Bogota, Col.
49.02	HJ1ABB	6120	Barranquilla, Col.
49.02	W2XE	6120	New York, N. Y.
49.10	CHNX	6110	Halifax, N. S.
49.18	"Beograde"	6100	Belgrade, Yugoslavia
49.18	W3XAL	6100	Bound Brook, N. J.
49.18	W9XF	6100	Chicago, Ill.
49.20	ZTJ (JB)	6098	Johannesburg, Africa
49.22	HJ4ABE	6095	Medellin, Col.
49.26	CRCX	6090	Toronto, Canada
49.30	HJ5ABD	6085	Cali, Col.
49.31	HJ3ABF	6084	Bogota, Col.
49.32	VQ7LO	6083	Nairobi, Kenya, Afr.
49.34	HP5F	6080	Colon, Panama
49.34	W9XAA	6080	Chicago, Ill.
49.34	ZHJ	6080	Penang, S. S.
49.40	OER2	6072	Vienna, Austria
49.42	YV7RMO	6070	Maracaibo, Ven.
49.50	W8XAL	6060	Cincinnati, Ohio
49.50	W3XAU	6060	Philadelphia, Pa.
49.50	OXY	6060	Skamlebaek, Denmark
49.59	HJ3ABD	6050	Bogota, Col.
49.59	HI9B	6050	Trujillo, D. R.
49.63	HJ3ABI	6045	Bogota, Colombia
49.65	HJ1ABG	6042	Barranquilla, Col.
49.67	YDA	6040	Tandjong Priok, Java
49.67	W1XAL	6040	Boston, Mass.
49.75	HP5B	6030	Panama City, Pana.
49.83	DJC	6020	Zeesen, Germany
49.83	XEUW	6020	Veracruz, Mex.
49.85	ZHI	6018	Singapore, Malaya
49.90	HJ3ABH	6012	Bogota, Colombia
49.92	COCO	6010	Havana, Cuba
49.95	HJ1ABJ	6006	Santa Marta, Col.
49.96	CFCX	6005	Montreal, Can.
49.96	HP5K	6005	Colon, Panama
49.96	VE9DN	6005	Montreal, Canada
50.00	XEBT	6000	Mexico City, Mex.
50.00	RV59	6000	Moscow, U.S.S.R.
50.17	HIX	5980	Trujillo, D. R.
50.21	XECW	5975	Xantocam, Mexico
50.25	HJN	5970	Bogota, Colombia
50.25	XEWI	5970	Mex. D. F.
50.26	HVJ	5969	Vatican City
50.50	TG2X	5940	Guatamala City
50.72	HH2S	5915	Port-au-Prince, Haiti
50.76	HRN	5910	Tegucigalpa, Hond.
50.85	YV8RB	5900	Barquisimeto, Ven.
51.15	HI1J	5865	San Pedro, D. R.
51.46	TIGPH	5830	Alma Tica, Costa Rica
51.72	YV2RC	5800	Caracas, Venezuela
51.90	OAX4D	5780	Lima, Peru
55.45	ZBW	5410	Hong Kong, China
70.21	RV15	4273	Khabarovsk, Siberia