another MRL Handbook...

5½ x 8½
24 pages
10 drawings

HB-3. CRYSTAL DETECTORS.

CONTENTS

A FEW OF THE QUESTIONS ANSWERED IN HANDBOOK 3. Pages given.

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7000 miles on a Crystal set in the 20's, with poor transmitters - see page 23.

This is a complete revision of our original Handbook, published in 1938. Lots of material has been added, and the book brought up-to-date in many ways.

Detailed data is given on most minerals used as detectors. This includes formulae, source, description, commercial uses, best methods of operation, use of the battery, and many other items of interest to the Experimenter.

On page 19 all 31 minerals are classified for easy reference. This shows formula, active element, battery use, if any.

On the same page is a classification by trade names, so you will know what you're buying.

Crystal diodes and Transistors are well covered. As most material on them is highly technical, we have brought it down in an easy-to-read manner, to make it more usable.

From the general outline of the Handbook, the Fan may be able to try other minerals in his experiments. Many hints are given that will help him along the way to proper manipulation.

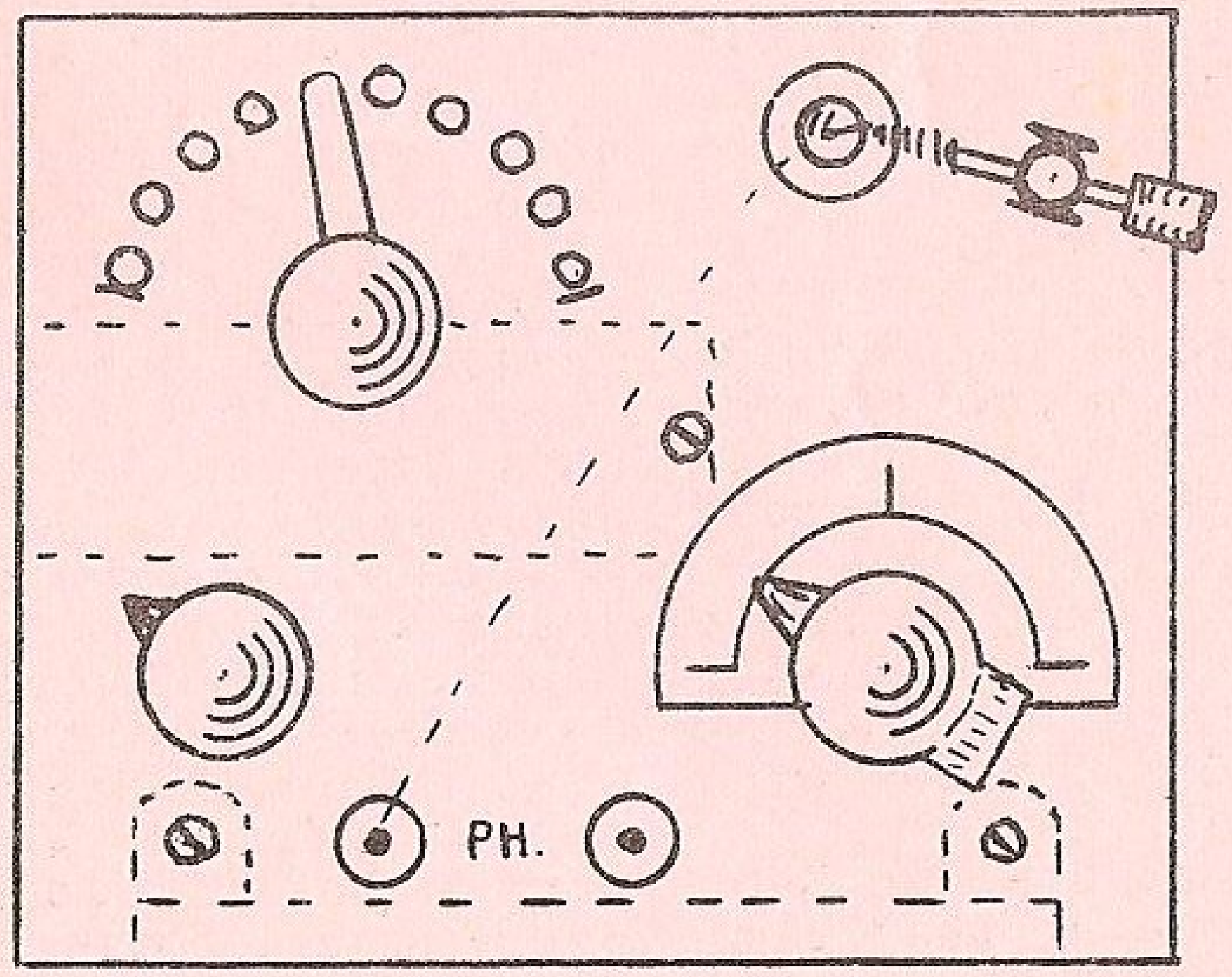
HB-3 is as complete as we can make it. Be sure to add it to your library. Same size as this Handbook - same price & source.

MRL HB-5. Crystal Set Construction.

another MRL Handbook... HB-5

Crystal Set Construction

By Elmer G. Osterhoudt



CONTENTS

by

Elmer G. Osterhoudt

'With Radio Since 1915,' including:

Radio Operator, R.C.A. Marine Service
Radio Mechanic, Maximum, U.S.N.
Technician, Electrical Products Corporation
Southern California Edison Company
Majestic Electrical Products
U.S. Motor Company
Manchester Radio Electric Shop
Modern Radio Laboratories
Amateur and Radio Service
6NW (1919)

Litho. in U.S.A. by Modern Radio Laboratories.

FOREWORD.

For many years I have spent a lot of time on Crystal set problems. It began in the broomstick coil days of 1915. During this period few books were available on Amateur Wireless, but we would grab copies of "Electrical Experimenter" and "QST" off the newsstands and go to it. Wm. B. Duck catalogs gave no coil data, but we'd try to figure it out. Wireless was really "in the raw" in those days.

During 1920-23 I went to Sea & standard equipment was a semi-fixed Crystal receiver, altho most of us lugged a 1-tuber with us to get the Arcs, etc.

1924 we went into a Radio Shop in Los Angeles. During that time we contacted hundreds of Crystal Fans who did nothing else.

In 1932 Modern Radio Labs. was established as a medium for the Experimenter. Maybe we haven't solved all the Crystal set Makers' problems but we've tried.

Most current literature for a Beginner "doesn't begin" - but jumps to Ham sets, Geiger counters and Atomic terminology. A Chief operator friend of mine, who manages a Coastal station, says most of his men never worked a Crystal set. In his category it is no longer required. Most large Handbooks seldom mention the Crystal set any more.

It seems that many tube circuits may be adapted to Crystal detector operation, as the principle is the same. Our stronger transmitters more than give the Crystal operator a chance at Dx.

By this Handbook it is hoped many Fans can get started in Radio. Likewise, Old Timers may get back into this interesting field if they see how easily it can be done. Everything nowadays has been simplified and most rules of Radio have become cut and dried. No need to dig thru a lot of old books like we used to do. Then, when you did find a fact - the next writer disagreed with it completely.

We have tried to make an easier path - with a few of our pet hints thrown in. Our hope is that you'll get more of our Handbooks - as others do. Much of our material comes from our own notes and not available in Libraries. We are always open to any suggestions as to titles and the betterment of these publications for you. Begin with Crystal sets and go up the ladder to Engineering - and interesting life.!

1. INTRODUCTION.

In building Crystal sets there are many peculiarities we must take into consideration. They cannot be built like a tube set, so most information found in a library doesn't help much.

A Crystal set uses as its power only the current it receives thru the air to activate it. The losses, therefore, must be kept to a minimum. One must keep most metals away from the coil fields in order to conserve all the energy to go into the crystal. In the 1920's - which is considered the Crystal set era - principles of low-loss were worked out to the "nth" degree.

The various losses encountered in metal-built sets is overcome by the strong tube amplifiers now in use. All you have to do is to "soup up" the volume - and the signal comes thru anyway. With a Crystal set there is no means of increasing volume unless you build it by low-loss principles, use a bigger Aerial, or a more sensitive crystal and phones. With a tube set one may add tuned Radio frequency stages ahead of the detector to boost the volume. This is not possible at the present using the regular crystal detector. No doubt soon the Transistor may be able to do this for us.

We will attempt to explain many of our pet principles that have been found best - and the numerous questions - over a period of 40 years of Crystal set building.

2. PANELS.

In Crystal set construction there are usually three methods of layout. First, a panel, with all parts mounted on it, and wired up as a unit. Second, with a panel and some of the parts mounted onto the base. Third, with just a base, which is usually called a "breadboard" layout - or mounting.

Metal panels may be alright in some cases, but it is best to keep away from metal as much as possible. Conserve all energy from the air and put it into the crystal circuit. It is harder, and more expensive to build them on a metal panel. One must use an expensive single-hole coil switch as switch points will be shorted on the metal panel. Also other parts as phone jacks, Xtal stand, and sometimes the variable condenser must be insulated from the metal panel with bushings and washers. Then a short may occur from a burr or poor insulation between parts.

As Bakelite, and many other plastics are very expensive, we will stick to wood or Compo.(we usually call Masonite). Compo. is made from dry, pressed sawdust and impregnated with a very tough binder, and therefore is equivalent to dry wood as a good insulator. When wood is wet it's a poor insulator, as you've seen when standing on a wet floor and working with the 110!

Plywood is good, but the ¼" standard thickness makes a clumsy job. If one gets hold of some 1/8" stock it will be alright, but it is apt to splinter. Also, when using wood for a panel the heat on the switch points may burn the holes - enlarging them so they become loose and sloppy. Compo. works as easily and is hard enough to hold parts solidly in place.

It is always a good idea to drill the panel first and then cover the surface with a finish, if you'd like to cover up those scratches. Compo. has a neat appearance, and when clear lacquer is applied, the grain is brought out for a more pleasing dress for your set. It may be lacquered to any desired color, preferably with a spray gun. However, it may also be varnished, but the latter dries slowly - and we usually want to get our rig going. Stay away from stain, paint or other lead-bearing materials that help to short the parts. We do not recommend Shellac because it tends to short circuits at Hi frequency as it absorbs moisture - so lacquer is best. For the technical minded Fan Celluloid has a power factor (pf) of about 2.8 while Shellac is about 7.

3. BASES.

Here we can best use our regular Plywood. Most sets mount entirely on the panel, but if you must have a base - this is OK.

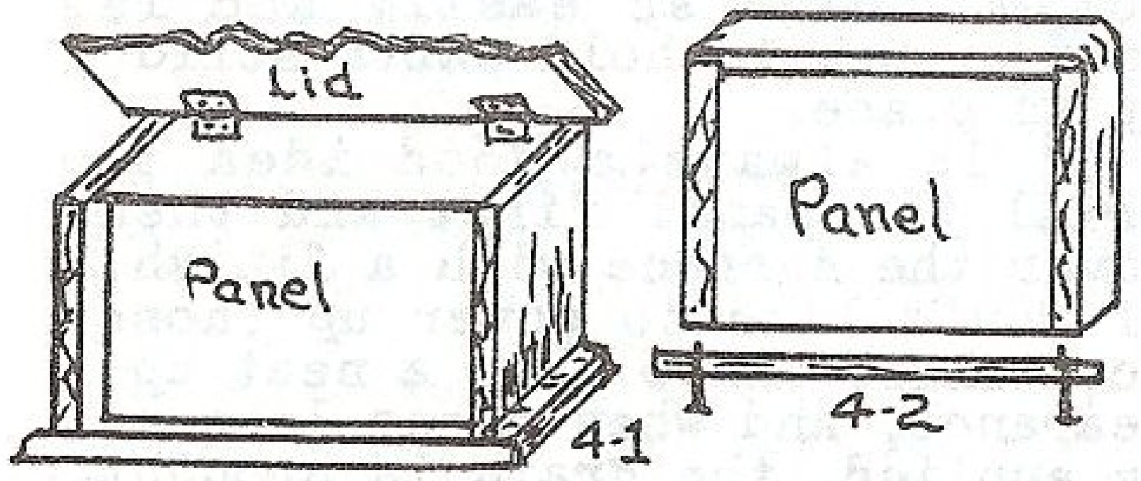
You may varnish or lacquer it if you wish. If no wires touch it you may use paint, varnish, shellac or stain on the base.

One may screw the panel onto the base directly, but we prefer ½" x ½" steel brackets. This will hold the panel in a steady, upright position better than the use of wood screws thru front.

It is easier to use small wood screws to hold parts to base, but if you want to be a little more classy - then countersink flathead machine screws thru the base, with nuts on top.

4. CABINETS.

One may rig up any number of types of boxes for a Crystal, or other set. It is possible to get nice plastic boxes in the Dime Store for some more elaborate tiny sets. But, to be efficient, a Crystal set cannot be made so small - as the coil should be about 2" in diameter.



For years cabinets were built with an open front and a lid. It was usual to groove the front to hold the panel. Tiny strips may be used instead of the slot. It is still a good type of cabinet because the panel may be removed at will. See Fig. 4-1.

Fig. 4-2 shows a more modernistic type that we used to sell. We dadoed the front and halved in the joints, which were glued and nailed. Corners were then rounded off with a sanding wheel and then painted two coats. We left the box open in the back, but it may be closed to make it more rigid. When set and panel were slipped in - the bottom was screwed on.

Cabinets may be finished with oil stain, shellac and then varnish. Or, it may be painted with a flat coat, sanded and one of the fast-drying enamels put on. Sandpaper between all coats and remove dust with oiled rag.

5. COILS.

Various types of coils are used in Crystal sets. However, there are three good rules that must be followed for best reception. (1) The form must be as low-loss as possible; (2) the diameter must be at least 1½" & preferably 2" for best results; and (3) the wire must be as big as #24, and preferably Double cotton covered. While coils will be treated in a different Handbook, we'll give the points most important to Crystal set builders here.

The form, on which a coil is wound, is an important as the size of the wire. Most of our coils are wound on .015" Celluloid, with formers in the ends. Celluloid, when made into a very thick form, is inefficient. But, when made into a thin form it becomes an exceptionally good one - in fact, next to air itself, which is considered "zero loss."

A similar method is to lay Celluloid strips over a collapsible form and wind on your wire which is cemented to the strips. When dry it is removed. While it isn't a very rigid form - it is very efficient. You can see it used in transmitting set coils.

Bakelite, or other plastic may work very well, but is higher in price. The 1/16" wall thickness is most used. If thicker it adds loss to the circuit.

Cardboard is good for a form if dry and stiff. It may be lacquered to stiffen it up. Crystal sets and mush boxes used to be associated in the 1920's. Surely many boxes of mush were bought just to get the box for a Crystal set.

Fibre is paper that is vulcanized by chemically treating, pressing and baking it into a form. It has high-loss properties at high-frequencies, so is used mostly in magnets, motors, and other low-frequency electrical parts. It is not good for a Crystal set coil usually. However, a funny thing happens - it works best for our QRM Wave trap coils. We have tried Celluloid but Fibre is best. Possibly because it adds the right amount of resistance to the circuit. If you just want local reception it may be alright to use.

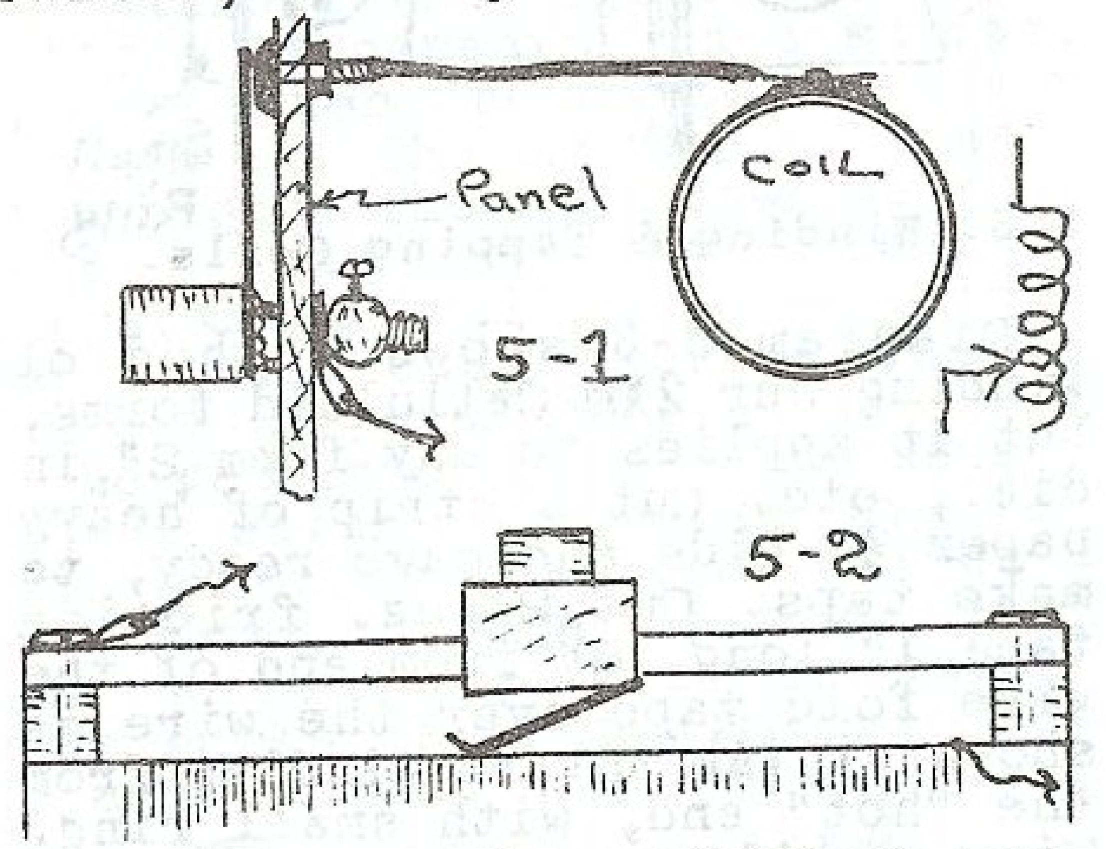
Crystal sets cannot be made tiny and still be efficient- regardless of all the advertising on Pocket Crystal sets. A perfect coil is called a "square coil" - that is, the diameter is about equal to the length of the winding on the form. When lots of wire is needed - the wire is to be smaller. Coils don't have to be perfect in this ratio but it all helps. Likewise, when we wind a 20 meter plug-in coil on 1½" form we spread it out to run ¼" long for 4 turns - instead of closewound. If spread too much it will not oscillate- so a happy medium must be found.

When you cut the diameter of a coil to say 1" - and the wire to around #34 enameled - you have a lot of things working against the long distance capabilities of the coil. (1) The diameter is too small and offers resistance to the signal; (2) it lessens the size of the coil field; (3) smaller wire offers less surface path for the signal to travel on; (4) due to more turns per inch there is more distributed capacity between turns, which in turn offers resistance to A.C.; (5) and they are harder to build and make taps. You may make up a small coil like this and then a larger one with larger wire- but the same length of wire, and compare them for volume, selectivity, etc.

However, the small coil also has its good qualities. As its field is smaller - it doesn't pick up those hi-powered local BC stations as does a larger one. It is more selective than a larger coil because the capacity between turns is the same as adding another condenser across your tuning condenser. Also the smaller coil is cheaper to make.

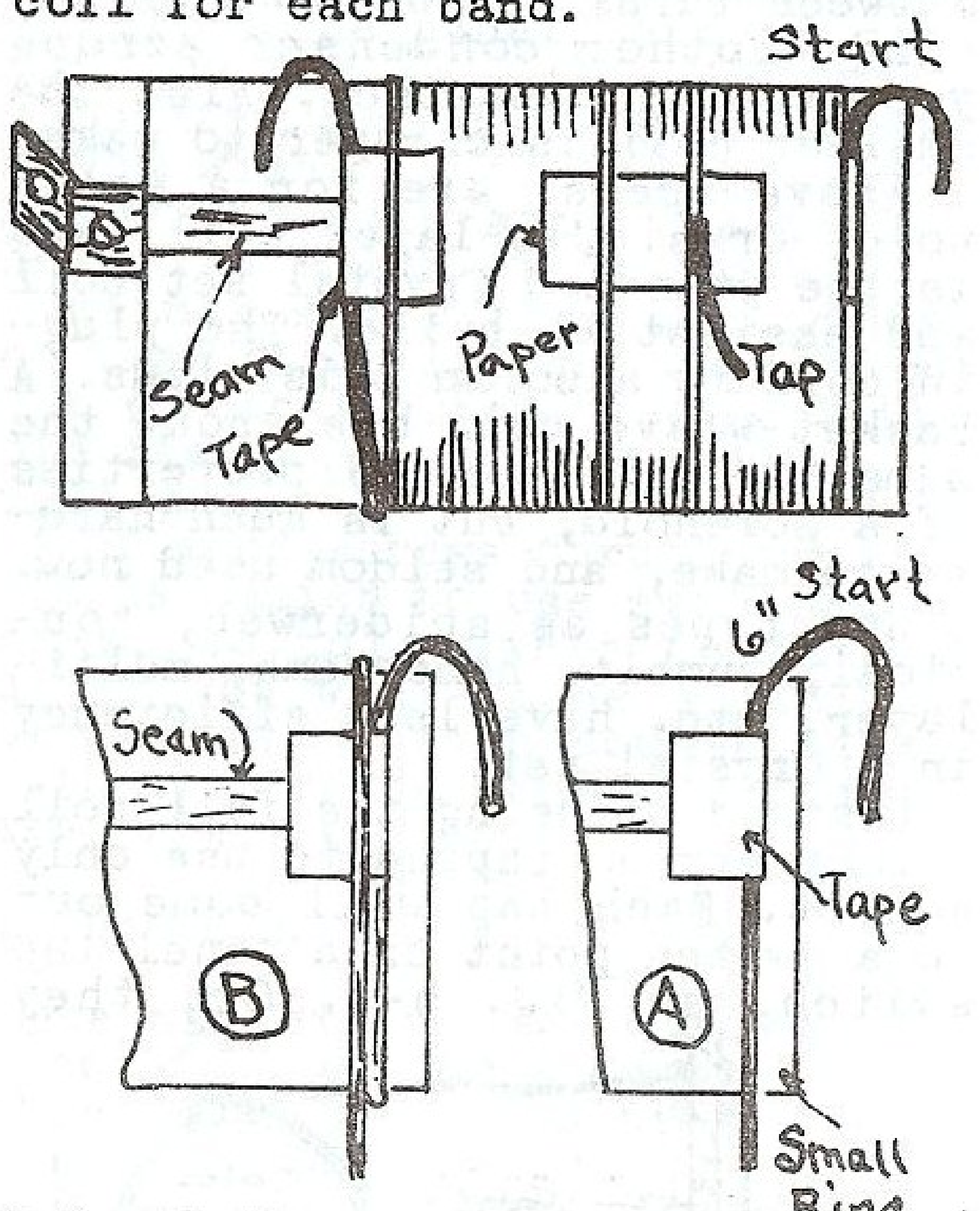
Above specs. are for a Solenoid, or single-layer coil, and is the standard Crystal set coil and easiest to build. The plug-in coil is also in this class. A basket-weave coil has about the same "Q" (efficiency) properties of a Solenoid, but is much harder to make, and seldom used now. Other types as spiderweb, toroidal, jumble, honeycomb, multilayer, etc. have less efficiency in a Crystal set.

Instead of using the full coil - they may be tapped to use only a part. Each tap will come out to a switch point on a panel tap switch, as Fig. 5-1. Or, they



may also be made variable by using a slider that runs on a rod over a bare coil path. Fig 5-2.

Tapped coils have an unused portion that has a deadening effect on the rest of the coil. It is called the "dead-end effect." It is similar to an obstruction of the signal. For a BC coil the Short wave stations are cut in volume due to this dead-end effect. You can make a test of this effect by jumble-winding some wire and slipping it inside a coil when it is operating. Note the difference in tuning, etc. It may be further demonstrated if you short the ends of the added coil. To get away from this phenomenon we may use plug-in coils that have no dead-end part not in use. In the larger all-wave sets they use a separate coil for each band.



5-3. Winding & Tapping Coils.

Diagram 5-3 shows method of winding our 2XM Celluloid forms, but it applies to any form 2" in dia., etc. Cut a strip of heavy paper ½" wide and have ready, to make taps. Cut 2 pcs. friction tape 1" long. 6" from end of the wire fold tape over the wire as shown at (A). Start winding from the "hot" end, with small ring. Wind until you want a tap and slip paper under, and continue. Finish winding, cut wire 6" long and then back off one turn. As at (B) make a loop in tape and push under next to last turn and cinch up. Pull last turn around again thru loop of tape and secure flap of tape with Cellophane tape. Paint all edges with Light Coil Cement.

Use a ½" x ½" bracket to mount coils upright on base. If on a panel, hold out by 6-32 x 1¼" BH screw and nuts, far as possible.

Mount switch points good and solid. Tin ends of them with a touch of soldering paste and a good solder. Mount the coil last as it's easier to wire. We prefer #22 stranded hookup wire for switch leads. Flexible wire prevents breaking off at points.

5-4

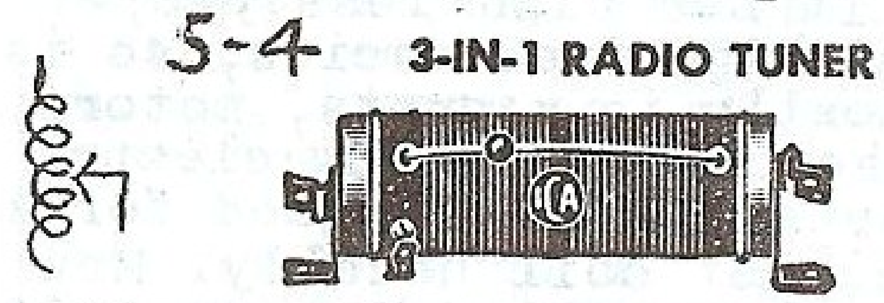
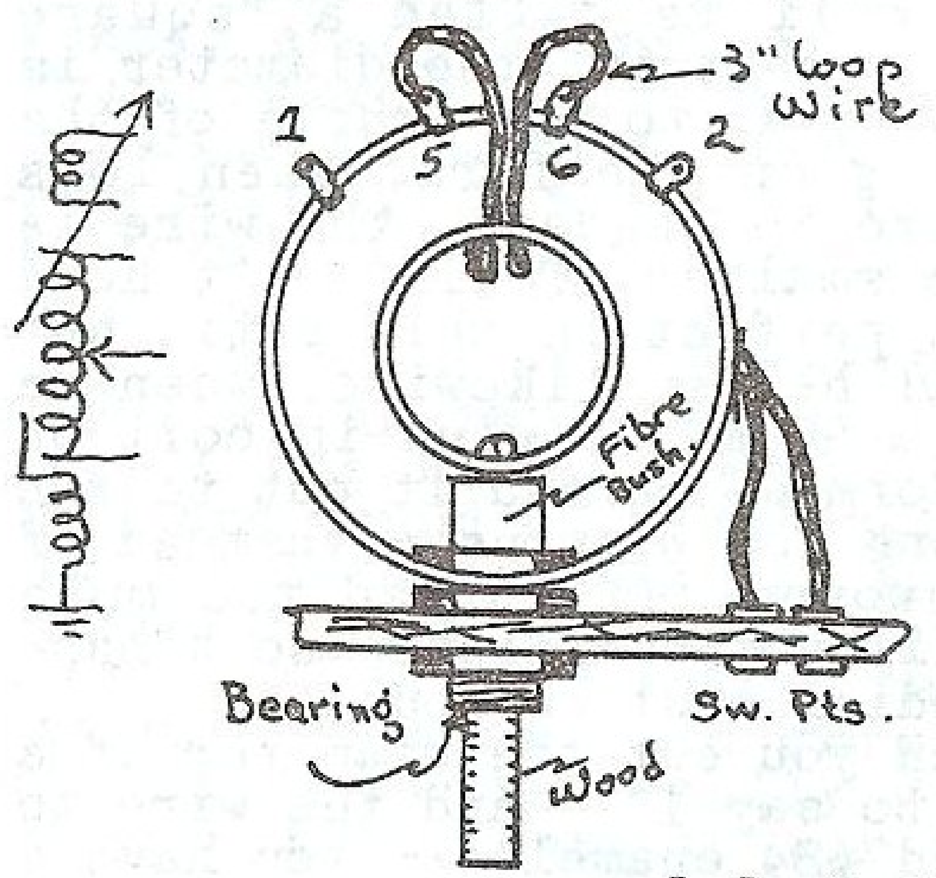


Diagram shows use of sliders & rods - instead of switch points. Some of the cheaper sets on the market use this method of tuning - which was much in usage in early Radio days. One may use several sliders on one coil, as will be shown in Circuit section. On a tube set the length of a turn may skip some stations that you'd get if you used taps and a variable condenser.



5-5. Rotor of Coupler or Variometer.

Other constructional features of coils are the variable coupling types, or relation between one coil and adjacent one. One may be a rotor working inside another - and working as secondary, primary or tickler. Changing position, or angles of the coils produces changes in tuning and selectivity and volume. You may do the same thing by winding the other coil on tubing that slips loosely over the other.

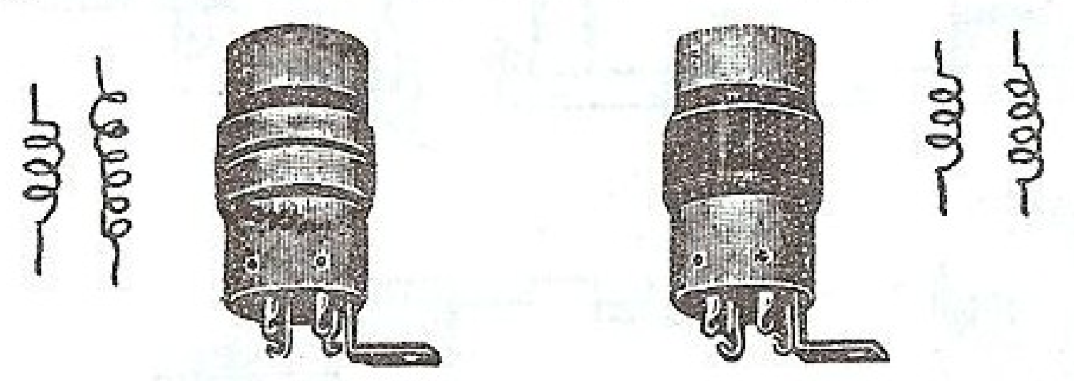
Loopsticks (5-6) are a recent addition to the Crystal set Fan. They are a bank-wound coil with

5-6. Loopstick Coil.

a slug that works back and forth inside. The slug contains finely ground iron in a binder - each ground particle being a magnet itself. It adds to the total inductance of the coil. Tuning is obtained by sliding the slug. A loose wire is used for a Hi-gain pickup of the signal. There are now several types of these Loopsticks - some 12" long.

5-7. Radio Frequency Chokes.

Radio frequency chokes may be used in some Crystal circuits, - mostly for building up an inductive load. They may be sectional - or Pi-wound. They may also be jumble, or scramble wound.



5-8. AC-DC RF and Detector Coils.

This type is a Hi-gain RF and Detector coil, using a hi-gain primary. In this case, it is a large number of turns to build up the inductive effect on the next coil.

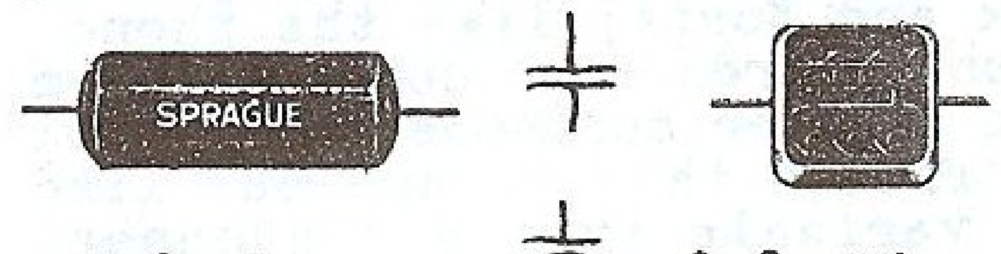
Never use Shellac on your Radio coils, as it adds loss to them. Light coil cements derived from Cellulose bases often increase the efficiency of coils.

We have attempted to go over lightly - the various types of coils used in Crystal sets only. More details will be found in another Handbook on Coils.

Don't pass up any MRL Handbooks!

6. CONDENSERS.

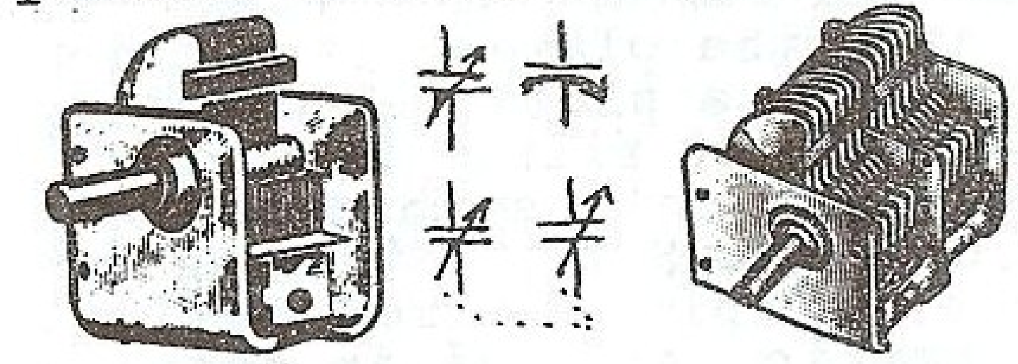
The original condenser was a Leyden jar. It was coated inside and out with tinfoil - with the inside usually connected by a metal chain to a brass ball on top. It was charged by a battery and held its charge over a long period of time.



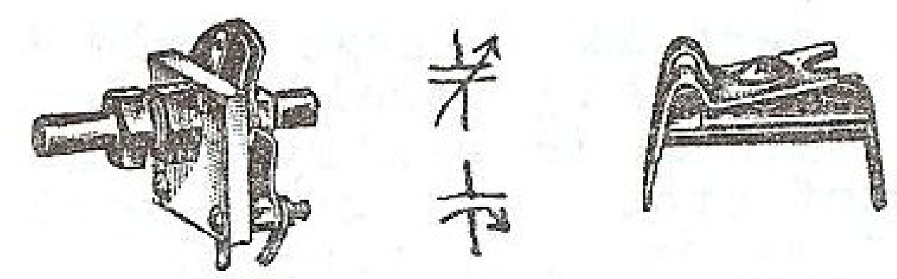
6-1. Bypass Condenser. 6-2. Mica Condenser.

Later several sheets of tinfoil were laid out and separated by sheets of wax paper. They were then rolled up - the same way it is done today with bypass condensers (6-1). It was soon found that moisture in the ends caused them to break down so they were dunked in wax. The more sheets of tinfoil the higher the capacity - as capacity is a surface proposition, no matter how you obtain it. The thicker the paper the higher the breakdown voltage - but this isn't important in Crystal set building. This type of bypass condenser is seldom used in Crystal sets.

We get into the Mica condenser (6-2) which is another type of fixed condenser. Metal plates R separated by mica which increases the capacity more than paper. The works is then moulded in a plastic to moisture proof it.



Single .00035. 2-gang .00035.



Midget Trimmer. Padder.

6-3. Variable Condensers.

Fig. 6-3 shows variable condensers- of which there are many types in use. In early days we used to glue tinfoil to 2 phonograph records and slide them back and forth for tuning. Students of High frequency know about sliding box sides back and forth for HF tuning.

The main condensers are those for tuning. You can slide plates back and forth, like the phonograph records - or compress them like trimmer condensers. Or, you may rotate them in and out like the variable tuning condenser. The most used variable in Crystal set construction is the 350 micro-microfarad (.00035 mfd.). It usually has about 17 plates on a side - and closely spaced. The rotating plates are called Rotors and the stationary ones Stators - easy to remember. The Rotors and shaft are usually grounded.

Along this order we may have tiny trimmer condensers or often called midgets - of 2 or more plates. Maximum capacity may run as low as 5 mmfd. (.000005 mfd.)

In early days the most sold was .001 mfd. or what we usually called a 43-plate condenser, but they are seldom seen now.

Ganged condensers are two or more, working on the same shaft. They are often used in Crystal sets - and may tune two circuits at once - or hooked in parallel they double the capacity up to .0007 mfd.

Test variable condensers by a phone and battery in series - as you turn the plates. If a click is heard - a plate is touching, or a piece of filing is there.

Capacity may be changed in a lot of ways. Size, thickness and number of plates; separation; dielectric material in between as paper, mica, air, plastic, gas, etc.

Condensers is a large field & may be treated by itself.

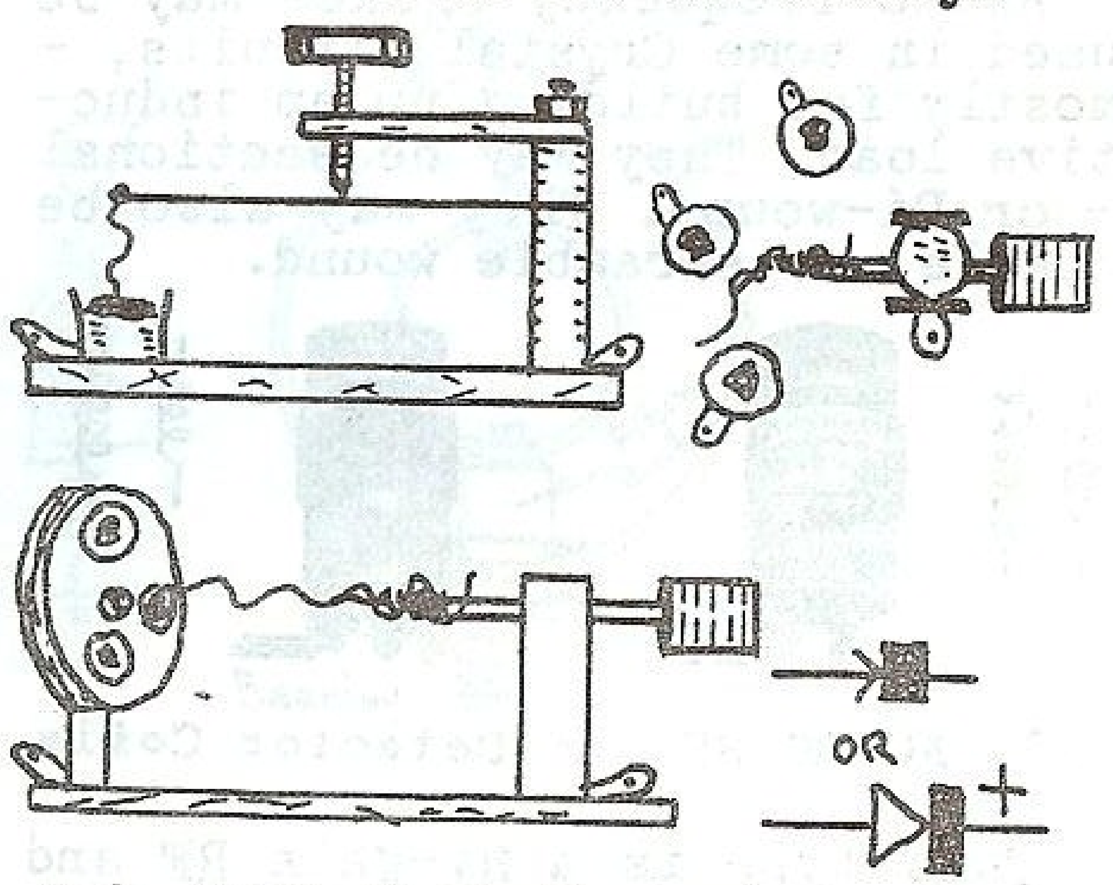
A condenser is really a collector of static charges - with a positive and negative plate. It holds its charge until it is shorted (discharged) or it leaks off between the plates.

7. CRYSTAL STANDS & CATWHISKERS.

There is no symbol for a crystal stand - just for the crystal detector itself.

Since the early 1900's there have been a great variety of crystal stands thought up - made and junked. Everyone came up with a new gadget to suit his preference. Much could be written on this subject.

To our knowledge there is only one crystal stand made now - the Philmore. They are not the best that can be made, but we can get along with them nicely. They are sold in the knocked/down type, assembled on a fibre base, or mounted inside a celluloid cover to keep out dust. Keeping out the dust is a good idea - but it would be better if the cover was independent of the stand so it wouldn't knock out as easily.

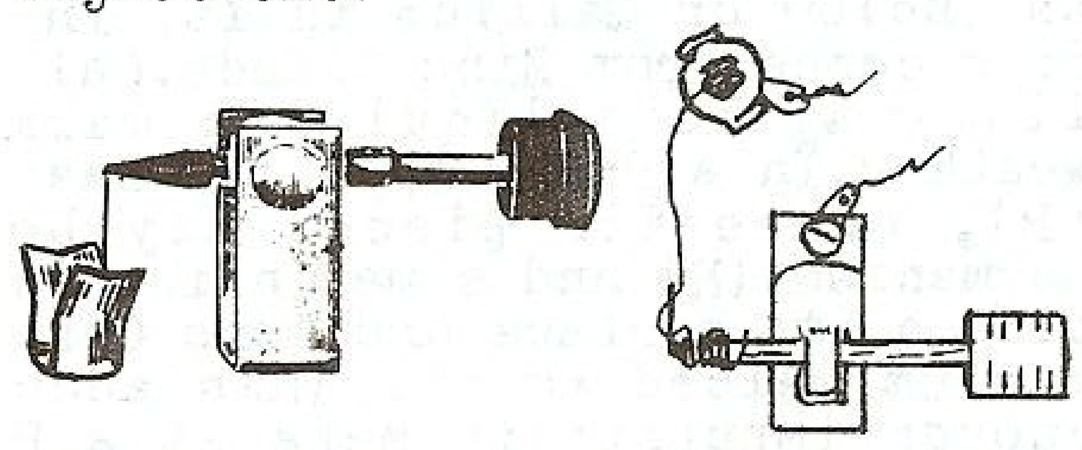


7-1. Some Varieties of Stands.

Various systems were used- and in all kinds of positions. Like the Philmore- many worked up and down. Others worked endwise. One type had several crystal cups so any crystal could be used at the Operator's pleasure. Another excellent one was re-adjusted by pressing on a button on the top of the Bakelite case. This actuated an eccentric that slid the crystal around for a new spot. The ingenious Experimenter may think of a lot of ideas along this line.

Crystals, using a heavy contact like Carborundum, Perikons, and others, used a spring that forced a contact. These were hard to jar out. (See "Crystal Detectors" Handbook).

The best operating position for a crystal stand is in the upper right hand side of the panel. For a left-hander - put it on the left. Mount the cup a little higher for best operation - or to suit yourself. Shift the shaft and clip a little to one side and you'll have a longer catwhisker to work with. This is better when using Steel galena, or other fine-point crystals. You can then get an up-and-down and a sidewise motion during an adjustment.



7-2. A simple but efficient Crystal Stand.

A good idea is to take a Philmore knocked/down stand and remove the ball. Mount a 1" Fahnstock clip and a cup on your base or panel. Tin the end of the shaft and drive on the knob. You then slip the shaft thru Fahnstock clip and solder on the heavy catwhisker. You do not use this catwhisker for contact, but wrap the tiny catwhisker around it to find a better point. These fine points are the ones that get the real distance with Steel galena and others. Once a long distance station has been gotten - re-adjust the catwhisker for a louder position.

For mounting Crystal diodes, with pigtails, use ½" or 3/4" Fahnstock clips on the back of the panel. Diodes may then be slipped in or out at will without soldering. Always try reversing a Diode on distant stations for most volume. Each circuit has its own polarity when it works best.

Fixed crystals, or Diodes, may be mounted anywhere. If one of the semi-adjustable type mount it so you can get at it easily. If adjustable type, use a piece of #14 busbar to keep it rigid.

In making Diodes the manufacturers found that a catwhisker worked better when formed like a wave. The pressure was better and it held the contact better. We have found that a 1-turn loop on a fine catwhisker was better for fixed Silicon and Pyrites crystals where a finer point was required.

When spark transmitters were used the spark would burn off, or knock out the contact. A copper blade was added to the Ant. switch to short the crystal circuit. Otherwise the Operator may miss several words before he got back "on" again. During 1920-23, when I was an Operator, we used a Perikon or Carborundum with a battery, as standard equipment. These didn't knock out easily, but just required a tap on the knob to set them back again.

It is a good idea to try different catwhiskers and see which combination works best with your particular crystal. Try them on weak stations because you can't see any difference on locals. If you can obtain an 0-50 micro-ammeter, and hook it across where the phones are - you can get a much more accurate test. The big Aerial will give more pickup and volume - and will result in a much more accurate test.

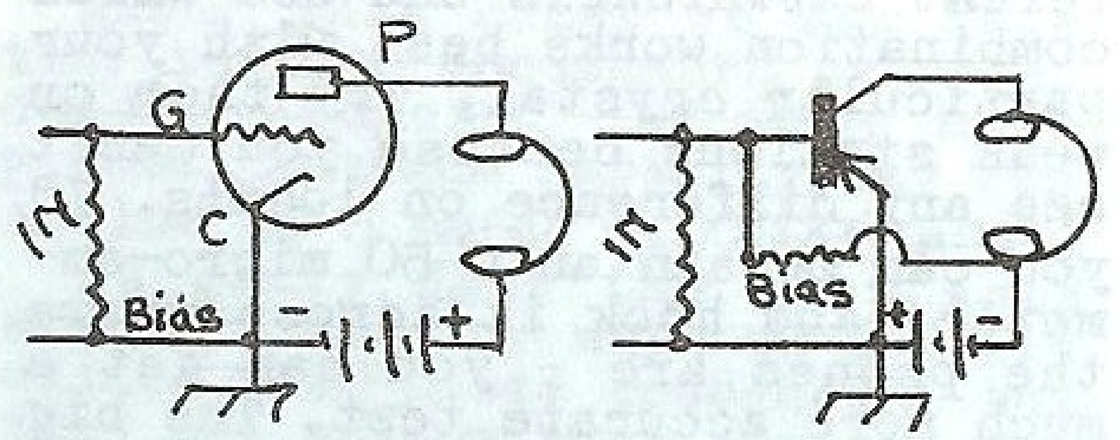
8. SEMI-CONDUCTORS.

Crystal detectors, Diodes, Transistors, etc. are now termed Semi-conductors. This is a class of solids that offers high resistance to the current flowing in one direction but almost completely opposes it in the opposite direction. In other words, they act as rectifiers of current. Selenium, Copper oxide, & other rectifiers also come under this class, altho not used as detectors of signals. Tubes rectify the current more than semi-conductors as the latter let a little current thru in one direction that isn't supposed to be. The English name of "valves" is a good word for tubes.

Our Handbook "Crystal Detectors" goes well into this study of the varieties that may be used for detecting signals.

For long distance reception the Steel galena is still superior.Many sensitive Iron pyrites, Silicon, etc. have been found also.However, a very light touch of the catwhisker is essential if good distance is to be had.

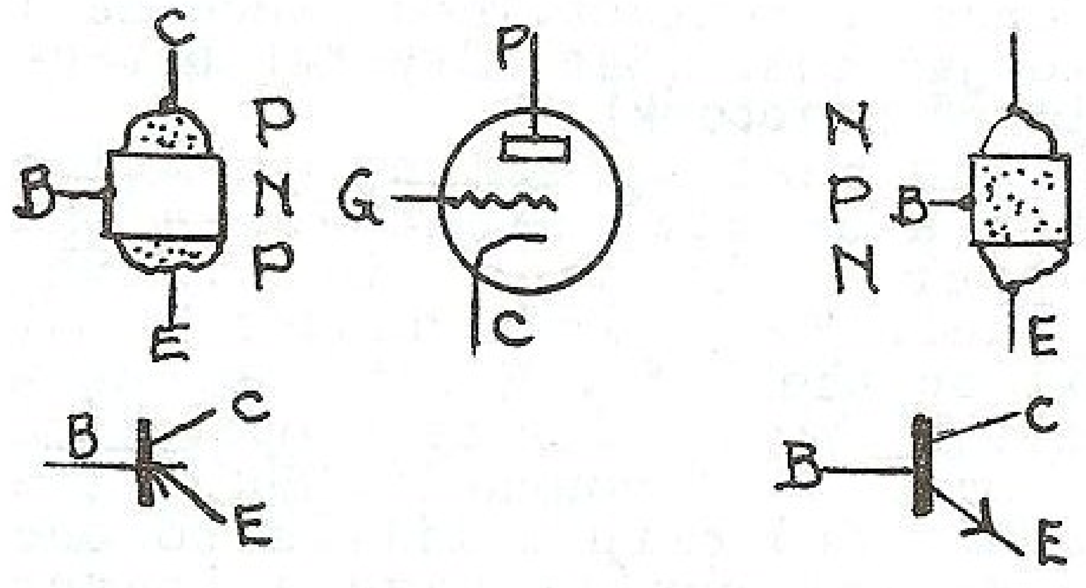
The ordinary Crystal detector is the same as the Diode - inasmuch as both have two elements, the crystal and one catwhisker. The commercial Diodes are usually sealed in a plastic case, and the catwhisker spot-welded so it won't jump off. The sealed catwhisker is the reason for the Diodes not being recommended for distant reception. As said, a light, adjustable catwhisker is necessary. Some manufacturers mix their Diodes up with their tube lists, so you have to know what you are buying!



8-1. Relation of a Tube to a Transistor.

The original Transistor was called a point-contact type and had one element Germanium for the crystal and two catwhiskers spaced .002" apart. The crystal is called the Base (B). One of the catwhiskers is called the Emitter (E) and the other the Collector (C). A newer one has three catwhiskers. Point-contact Transistors have been operated at hundreds of megacycles of frequency.

Later they found that three pieces of Transistor material could be placed alongside and act similarly to the catwhisker type. They are called Junction Transistors. However, the adjoining pieces must be a little different in molecular construction. We have two types P-N-P &



8-2. P-N-P and N-P-N Transistors & Symbols.

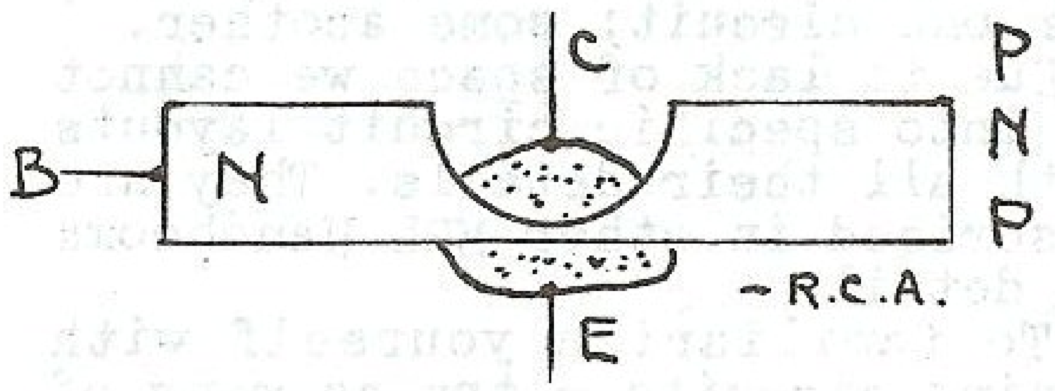
N-P-N. N is the Germanium. P is Germanium with a little impurity as Indium or Gallium in it. Indium comes from Zinc blende.Gallium may be a liquid in warm weather.In a P-N-P type the base (B), or center piece, may be Germanium (N) and some Indium is put on its surface and more Germanium welded to it. This adds enough impurity to make it a P type. So, one of the P's is called Collector (C) and the other the Emitter (E). But if Indium-rich Germanium (P) is used in the center and pure Germanium (N) is used on the two outside pieces, it is called an N-P-N type.We usually think of a Junction Transistor as being made of three flat plates, but only the center is flat. They are "blobbed" onto the edge and leads are welded to them.

In the circuits it is just a matter of reversing the battery polarity between a P-N-P and an N-P-N. Never change the polarity on a Transistor or it may be ruined. High surges may also fix them for good.Be sure to cut off the batteries when altering your circuits. We prefer to use a red wire for positive (carbon) and a black wire for negative (zinc). They are then less liable to get crossed. Transistors may operate on 1½ to 12 volts - the higher the voltage the greater the amplification.

Transistor hearing aids are getting smaller every year. We have seen them put into the ear pieces of glasses. At a fair, this year, we saw one 1½" x 2" that used 4 Transistors operat-

ing on a 1.4 Mallory mercury cell. Due to such a small battery it lasted but 35 hours and cost about $4 per month.

The common Junction Transistor is presently not efficient above Broadcast frequencies, due to the resistance-capacity-leakage effect on the input signal. But they are fine for small Crystal and 1-tube rigs. We can operate a PM speaker using 1½ volts of battery, after a crystal set.



8-3. Adapting a Junction Transistor to High frequency Operation.

However, now they drill a hole into a piece of Germanium from both sides. Separation between the holes is approximately .0005 inches. Blobs for the Collector and Emitter are welded to each side. They have attained a frequency of 75 megacycles by this method. Even so, they still do not make good detectors for signals at a long distance.

9. HEADPHONES.

Our Handbook "Headphones: Operation & Repair" gives all the average Fan wants to know about Earphones and how to fix them. However, a few details will be given here that may help.

Naturally the more sensitive a phone - the more it will pick up weak signals. Phones with a high resistance and impedance are to be preferred to those around 1000 ohms D.C. resistance.

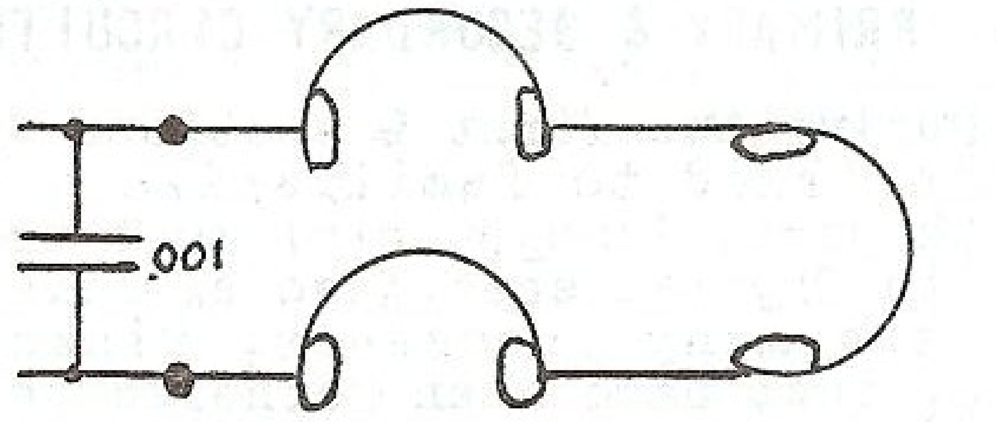
Impedance is roughly 5 times the DC resistance in ohms.If you have a phone with 5000 ohms DC resistance it will approximate 24,000 ohms AC impedance. Resistance is usually measured by direct current; impedance with alternating, or fluctuating as the incoming signal.

The Iron in cheaper phones is softer and of a poorer grade. Tungsten, and other ingredients are added to Iron to make it a lot harder. The harder it is the longer and better it holds its magnetism. You may make a test by removing the phone cap and pulling on the diaphragm. On one Permalloy magnet the phones will pull 4 ounces.

Tube sets may de-magnetize the phones, especially if hooked up the wrong direction. However, as Crystal sets use such little power you need not worry about this. The Handbook tells how to re-magnetize a phone if there is no pull on the diaphragm.

Another thing in favor of high resistance phones on a Crystal set is that it helps selectivity - and makes for smoother operation of your rig. Because phones are hooked around (shunted across) the crystal, tuning condenser and coil they tend to short the circuit.If your phones have high resistance they offer a longer, and harder path for the electricity to travel - with less shorting effect.

Phones are usually hooked to the circuit thru Phone tip jacks - or even by a Phone plug and a Phone jack. For a cheaper method 1" spring Fahnstock clips may work very well. The older method was by using Binding posts.



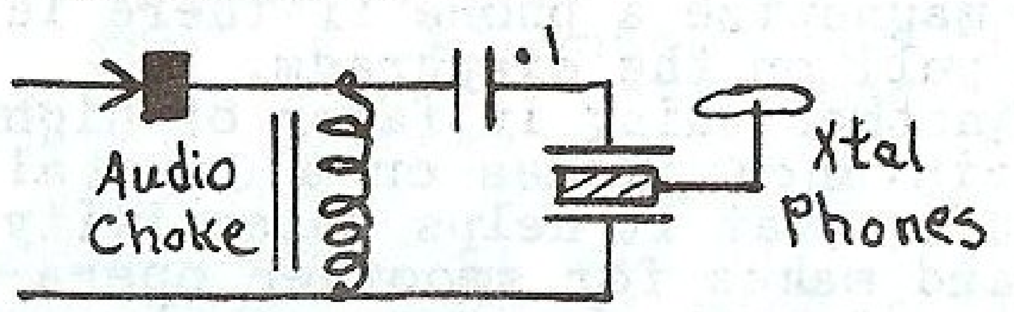
9-1. Several phones in series. Also with tone condenser.

Several phones may be hooked in series, that is, from one to the other like "Ring around Rosie!" Hi. The volume is cut less this way than if they were hooked in parallel where each phone tends to short the rest.

Adjust the headband so phones are not too tight on your head. Sponge rubber ear cushions are often used to avoid "cauliflower ears."

If your phone cords rasp when you move them - you need a new phone cord. Hook them across a flashlite battery and work the cords around until you find the spot. Often it is a poor connection to the tip - that is about ready to break off. **Handbook** shows how to repair it.

Take good care of your phones. Under normal conditions they'll last a lifetime. Buy a good pair when you decide. Have a coathook handy on the wall to keep them on when not in use.



9-2. Hooking Crystal Phones.

You cannot use Crystal phones on a Crystal set unless you use a special hookup as Fig. 9-2. The crystal does not offer a direct path like the windings in the phone coils.

The tone of phones may be regulated by hooking a fixed condenser across them as Fig. 9-1. The larger the condenser you use the lower the tone - and also the less volume.

10. PRIMARY & SECONDARY CIRCUITS

During the first 9 sections we have tried to familiarize you with parts (components) most used in Crystal sets.Also explained are many processes, kinks, etc. that have been gathered together to make it easier and more interesting to build Crystal sets. By pictures and diagrams an attempt has been made to show what they look like on the shelf - as well as in a regular schematic diagram.

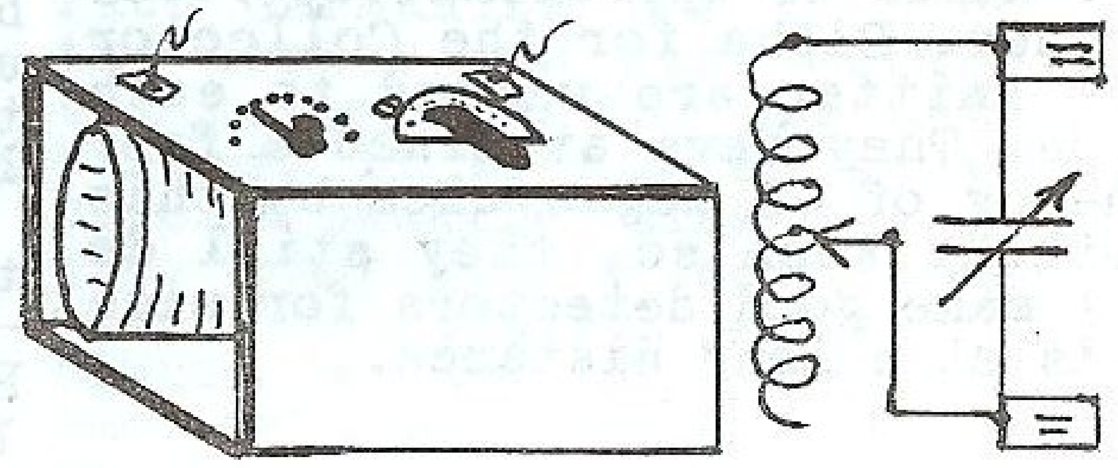
Schematics are used by all Radio men - so it is up to you to learn to read them at once. Get a good list of Radio symbols and study them as you go along. You will soon associate each part with a certain symbol.

In this section will be shown a lot of tricks of the trade. You'll probably see combinations new to you. Experimenting with Crystal sets is very enlightening and not at all expensive. Many parts may be used again in the next project to come.

Each circuit has its own advantages. However, few can say which is the best, in most cases - as many methods are equal in good performance. Some may prefer one circuit; some another.

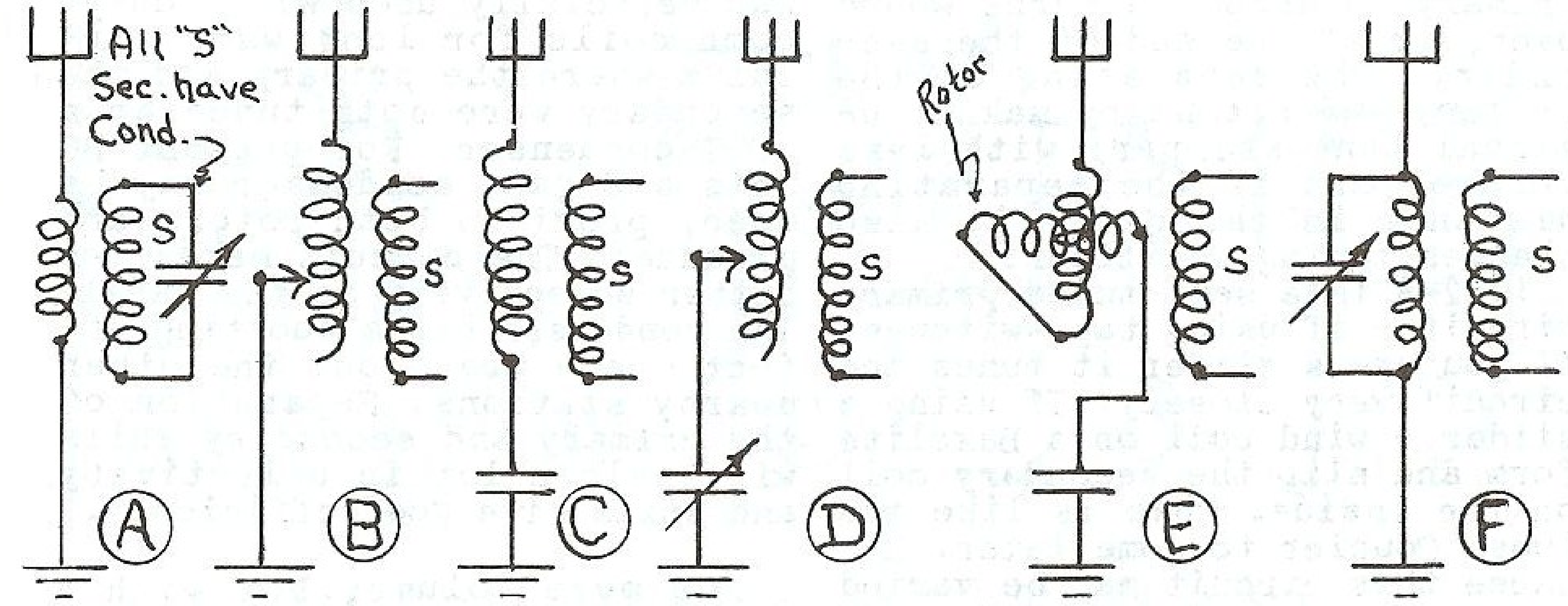
Due to lack of space we cannot go into specific circuit layouts with all their details. They are described in other MRL Handbooks in detail.

To familiarize yourself with tuning circuits - try as many of them as possible. Note the many tricks they perform. Combine them in dozens of different ways - maybe you'll come up with a new circuit - who knows? Only a few of the many combinations are shown here.



10-1. Heart of the Crystal Set - the Tuning Coil and Condenser.

Secondaries. Because this is the standard tapped coil secondary and variable condenser circuit for most sets- it is a good idea to build one or more permanently.On a 2" x 4½" Celluloid or Bakelite form wind 90 turns #22 DCC wire with 10 taps as 5-10-16-23-31-40-50-61-73-90. You may mount it on a Compo. panel. If put into a box, leave the end open that has the 5-turn tap on it - so a primary may be slipped inside. Below it mount your switch lever with 10 switch pts. and also a .00035 variable condenser. Below these mount two Fahnstock clips for connections.



10-2. Aerial & Ground Primary Circuits.

Keep this unit to experiment on as it is more or less standard.

On 1" coils - you may use 110 turns #32 enameled wire - for a small secondary tuned with a .00035 variable condenser. Various other coils may be made at will. You will find that a 4" in diameter coil doesn't take half as many turns as a 2" one. Instead of being in a ratio of 1:2 it will be 12:27. But, you may add or subtract a few turns to make it come out alright. This is due to the difference in resistance, capacity between turns and other causes. Some secondaries are **Aperiodic** tuned - that is, they are not tuned to any particular frequency. Any near tuning circuit will affect them and cause them to follow. In the case of the Aperiodic secondary, the tuned primary does the tuning for the secondary.

As to wire you may use Enameled, Single or Double Cotton, or Single Cotton Enameled. You will use more turns if using Double Cotton as Enameled is closer together. This closeness builds up capacity between turns that adds to the total capacity. This is called distributed capacity. It is easier to tap DCC wire and make a nice job. The Enameled is used more for tight places where space is limited. The DCC has a little less loss than Enameled, which absorbs some moisture.

Primaries may vary a lot more in construction than secondaries - depending on what you want to do with them. The idea is to get as much energy from the Aerial-ground circuit into the secondary as possible. Most primaries in AC-DC commercial sets are detuned. This makes them easier to build and also improves selectivity. Also, if the AC-DC primary is tuned correctly it will overload the grid of the first tube and make it hard to control - so it is de-tuned. However, in a Crystal set this is much to be desired as we need all the energy we can get. If you have a short Aerial you will need more primary turns. These may be added by a Loading coil in series, which may be 100 turns tapped about every 10.

At 10-2-A you have an Aperiodic primary that is semi-automatic in tuning the incoming signal to volume. If the secondary is tuned to, say 1000 kc., then the primary circuit automatically tunes to 1000 kc. However, it still isn't as efficient as the tuning of both circuits with variable condensers. In midget AC-DC sets the primary is usually large because they are often operated with little or no Aerial. Therefore, this larger primary coil "loads" the circuit up to near the broadcast band. For the usual tuning circuits the primary is about 15 turns wound over, or at the end of the secondary. The separating of the primary and secondary makes the signal tune sharper; with less volume; and if the separating distance is changed - it also changes tuning positions.

10-2-B is a semi-tuned primary circuit - if using tap switches. If you use a slider it tunes the circuit very closely. If using a slider - wind coil on a Bakelite form and slip the secondary coil on the inside. This is like the Loose Coupler to come later. Because this circuit may be varied - you may use from 15 to 150 turns on the primary coil.

10-2-C. This is a capacity tuned primary using a fixed mica condenser. If a bypass condenser of about .1 mfd. is used it may become more Aperiodic as the condenser is made larger. It usually tunes best to one frequency, or an octave of the same frequency, if using a mica. These octaves are called harmonics.

10-2-D. This tunes the incoming signal with a .00035 variable condenser. If the coil is made larger - say 150 turns of #28 DCC wire - and tapped in about 4 places - it will tune to the exact frequency. This will result in a big increase in volume and efficiency. It will help boost the long distance stations considerably. If you are near strong broadcast stations, you may have to separate primary from secondary a little to keep stations from mixing up. But, it can be made into a very efficient circuit.

10-2-E. This is a variometer-tuned circuit. The secondary may be wound on the form first. Then half of the primary is wound over it. The rotor is placed inside, using half of the primary. Rotor controls from the front of the panel with a wooden shaft. The addition of the fixed mica condenser, in the ground circuit will help sharpen it up.

10-2-F. This is a shunt, or parallel-tuned circuit that used to be used in many circuits. It was especially used with Honeycomb coils for long wave circuits where the primary and the secondary were both tuned by a .001 condenser. For present BC sets a 2-gang condenser may be used, provided both rotors are grounded. The circuit makes for better selectivity as the parallel condenser has a boosting effect - and traps out the other nearby stations. Separation of the primary and secondary coils will help a lot in selectivity and still give good efficiency.

For more volume, but with a lot less selectivity, you may couple your secondary, or Crystal tuning circuit direct to the Aerial and ground circuit.

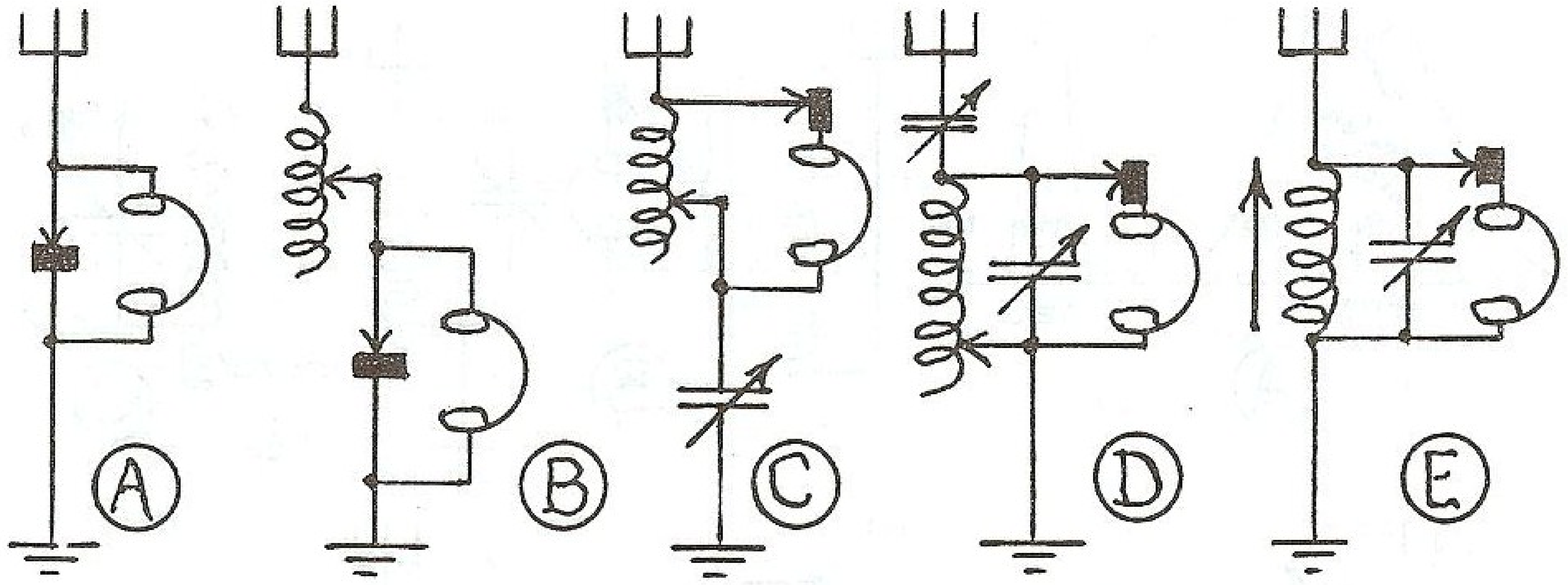
10-3-A shows a circuit where one buys an assembled Crystal stand and hooks phones and the Aerial and ground around it. It is as direct as possible. The loudest station usually predominates, with the weaker ones in the background. Outside of being the simplest set- it isn't worth rigging up.

10-3-B. This goes a couple of steps farther and has a 100 turn 2" loading coil with 10 taps, in series with set and Aerial. The mica condenser tends to make it a little more selective. Both A and B are usually very noisy and may pick up power line noises.

10-3-C. This gets more into a Crystal set circuit that is appreciated. The coil is series-tuned by a .00035 variable condenser. The coil may be twice the size of the standard secondary above, as the condenser cuts the coil in half. This is a little sharper than one at B.

10-3-D. This is a standard secondary circuit - but sharpened up with a 3 or 5 plate midget trimmer condenser in series with the Aerial and coil. It is often more effective on Short waves. Less capacity on it will sharpen up the broadcast stations.

10-3-E. This is a Loopstick with a .00035 variable condenser around it. It is used with a short Aerial which is necessary if selectivity is to be desired.



10-3. Direct Coupling to Aerial-Ground Circuit.

11. LOOSE COUPLED CIRCUITS AND SELECTIVITY.

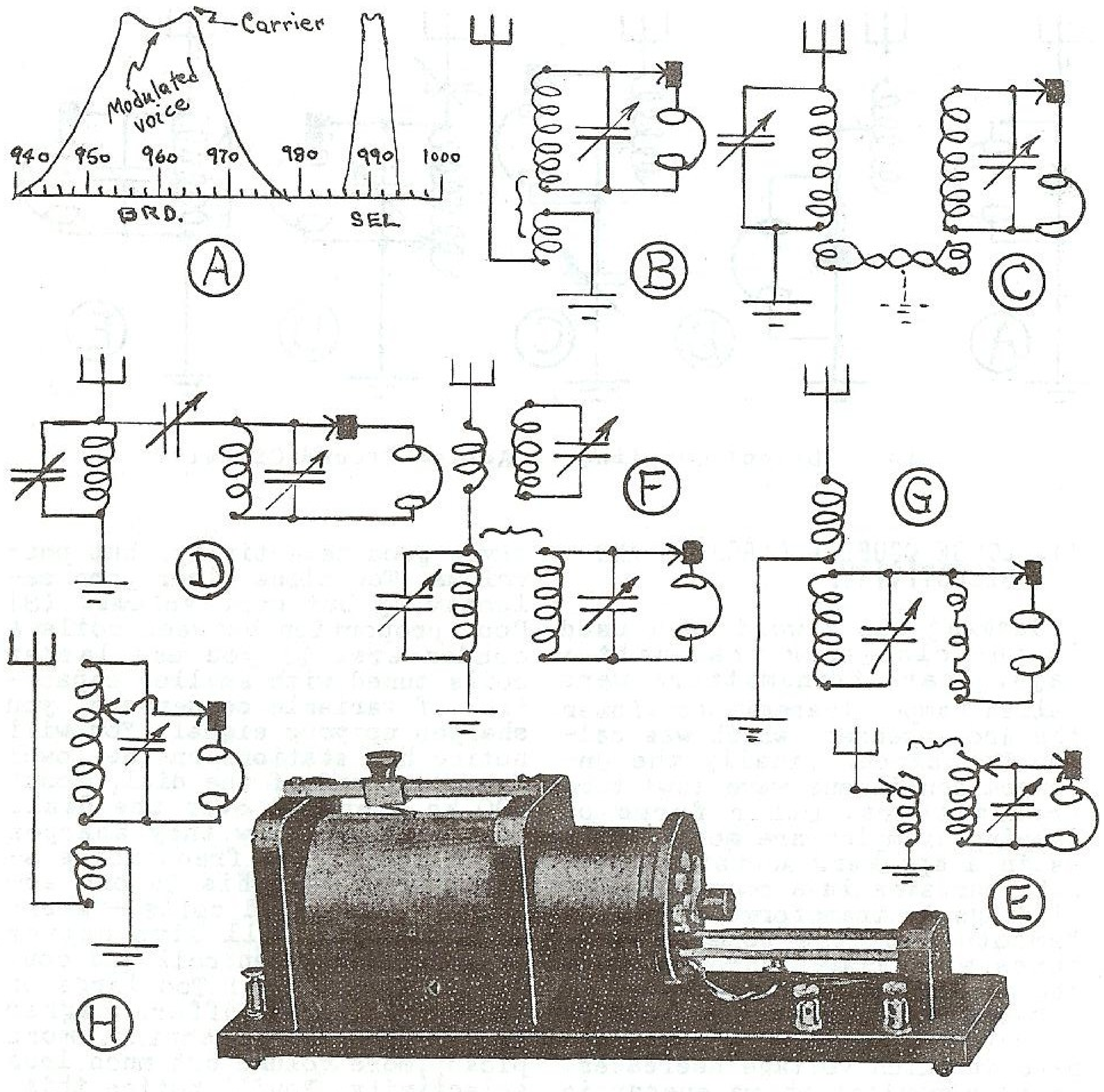
Damping was a word much used in the old Spark transmitter days. Spark transmitters were called Damped transmitters. Later the Arc appeared, which was called Un-damped. Finally the Undamped continuous wave (cw) tube transmitters. Other forms of damping examples are mechanical, as in a speaker. Acoustical, as with curtains in a room. Damping windings in transformers tend to "smooth out" the tones so all notes will come in - not just the ones in medium range.

Damping in an oscillating Electrical circuit determines the rate at which voltage decreases. In cw circuits, where energy is being constantly fed, there is no damping. Where energy is subtracted from a circuit, it is said to introduce damping. All forms of losses in coils, condensers, wiring, etc. increases the damping in the circuit. This damping effect increases at the higher frequencies.

The lack of selectivity in a circuit is usually caused by one or more of these 4 causes, as (1) Losses and resistance in the circuit as poor construction, coil form losses, wrong size of wire, condenser losses and poor wiring, etc. (2) Mistakes in the coupling, as too loose coupling gives good selectivity, but poor volume. Too close gives poor selectivity but more volume. (3) Poor proportion between coils & condensers. If you use larger coils tuned with smaller capacities of variable condensers, you sharpen up your signal. You will notice how stations on the lower frequency end of the dial, about 600 kc., spread over the dial. Contrariwise, how they sharpen up on the higher frequencies around 1500 kc. This is one advantage of tapped coils - where certain taps will give better proportion between coil and condenser tuning. (4) Too large an Antenna - which offers higher resistance, more damping, more pickup, more volume but much less selectivity, You'll notice this on a 150 ft. Aerial compared to an inside one of 25 feet.

At 11-A you will see a couple of curves showing a broad and a selective signal. Dial markings are at the bottom. The first one shows a signal with close coupling between primary and secondary. See how it spreads over the dial. The second curve shows how it looks when sharpened up. Long distance stations will show a curve like the second- loud ones like the first curve.

In Fig. 10-3 you will see some direct-coupled circuits - hooked right to the Aerial. They usual-



11-1. Variable Selectivity Circuits.

ly have a tendency to spread as the first part of 11-A.

At 11-B you will see the usual way to give a set more selectivity - is to pull the primary away from the secondary. This may be done in one of several ways. (1) Primary winding, on the same form as secondary, may be moved away from the secondary about ½" - the farther the more selective. The primary may be wound on another form and slipped over or inside the secondary. Or the primary may be wound on a rotor and turned inside the secondary. Or, the primary may even be made with less turns. Any way you may change the coupling values between primary and secondary will automatically change setting of the tuning condenser.

At 11-C we pull the secondary entirely away from the primary and couple it by link coupling. A few turns of wire are wound around both primary and secondary and then coupled by a twisted pair of leads.If one side of the link is grounded it will in-

crease the volume. For the advanced Technician this is the best way to couple a signal generator to coils - where de-tuning effects are encountered.

11-D accomplishes the same result by capacity means. The less capacity, the less volume and coupling, but the greater amount of selectivity.

11-E. Last, but most important, is the old time Ancient Loose-coupler. This is still one of the most effective means we have of studying tuning, range, selectivity, volume, etc. Years ago they ate up all our old Salt boxes - so many were made.

Make two end pieces of soft wood. Make a solid block to fit inside a 2" Bakelite form 4" in length. Cut a hole in the other piece to take the other end of form. Wind the form full of #22 Enameled wire and cement the edges. Mount the form - and then screw the end pieces to a base. Mount slider and sandpaper path for it to make contact.

For the secondary, wind a 1½" x 4" Bakelite tube full of #26 DCC wire - and tap at 5-10-20-50 100, etc. as desired. Mount a switch lever and points on an end piece of the secondary as shown and solder taps. Fit wooden plug to other end - making 2 ends take 2 brass rods. Fasten rods into end piece of primary & outside block as shown. This cut shows flexible Loop wire going out to Binding posts.

To operate - push the secondary in and run slider until you hear a station. Adjust secondary points and variable condenser for best settings. Then position of coil. You will find that the settings are very definite. I'd advise making a paper scale for logging of the coil position, on the base.You will be able to cut out almost any station with the proper setting. After you get a good setting, go back and recheck for best positions. Log all the settings down. It is a most interesting piece of equipment. With a tube detector you can work wonders with it. With a tube you may wind 10-15 turns loosely around the secondary for a tickler coil.

11-F. Here we have a tuned primary and secondary, with variable coupling in between. Also, to trap out some of those "Meanies" insert a wave trap in the Aerial. The wave trap is tuned to the unwanted station and then left there. Balance of set is then tuned to best point. Coupling may be varied by making the primary on another form to slide over the secondary. Proper coupling, etc. here is similar in operation to the Loose Coupler shown at (11-E).

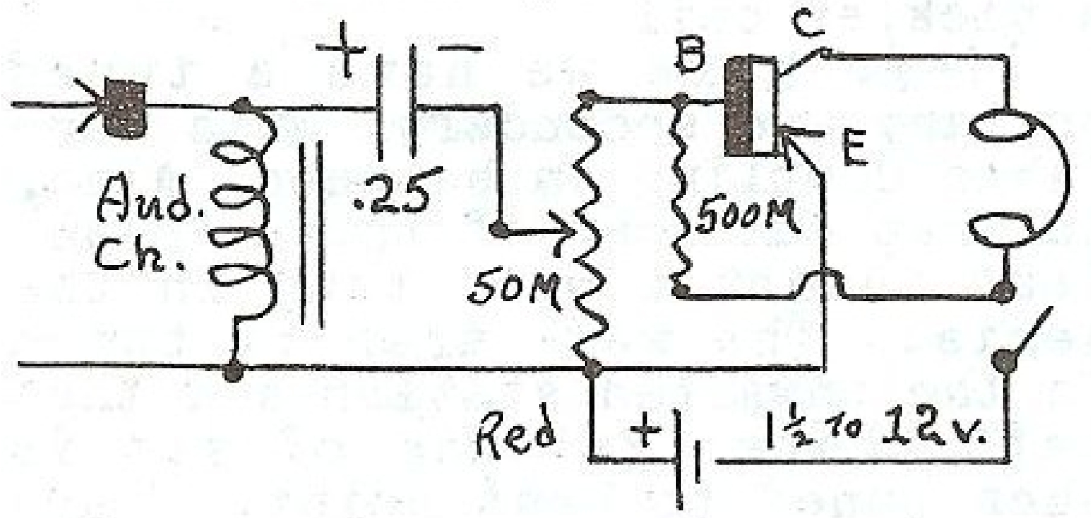
11-G. This is the standard close-coupled primary and secondary as the first unit. This couples by only one lead to the crystal-phone circuit. To build up an Aperiodic inductance, we insert a Radio frequency choke (5-7) in the circuit, to build up an inductance. The larger the choke - the more volume. The secret of this circuit's selectivity is that there is nothing across the tuning condenser and coil to cause the RF to leak off - like the crystal and phones.

11-H. Using the standard primary and secondary again- we use a slider - or taps at every 10, on the secondary. As in 11-G we raise the condenser and coil up so there is less leakage. As the crystal is worked toward the ground - it makes the set more selective - but less volume.

There are many other ways one may juggle the circuits around to get selectivity. But, these will illustrate the point.

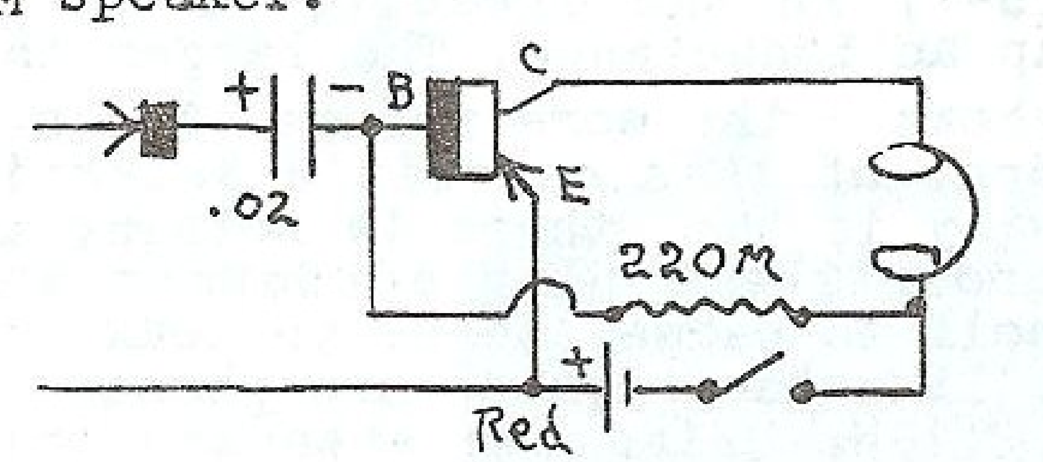
12. TRANSISTOR AMPLIFIER CIRCUITS.

At present there are quite a few good amplifier circuits using Junction Transistors. Will give a couple that are easy to make - and with plenty of power. About the only difference in the small Transistor circuits is the method of feeding the signal into it. The rest of the circuit is more or less conventional. Be sure to read section 8 before you build one up.



12-1. Choke input with Volume Control and Switch.

This is a favorite one of ours - and very efficient. It may be used on the phone connections of Crystal sets or 1-tube sets to operate a speaker. It will operate on a 1½ volt flashlite cell, but can use up to 12 volts with increasing power. You may use an Output transformer, where the phones connect, and match up a PM speaker.



12-2. Condenser input and Switch.

This is another simple circuit but instead of using an Audio choke input, it uses condenser. The only control is a SPST panel switch to cut off battery when not in use. It will work on from 1½ to 12 volts. However, the one above has a volume control in case you get too much signal on a loud local station.

Both circuits have a splendid tone - especially after a Crystal set - which tone has never been surpassed. If you can almost hear those weak stations - one of these rigs will bring 'em in alive! Values in a Transistor circuit are not too critical. If you will get the bias resistor right - the circuit will work at maximum efficiency. This runs from the Base (B) back to negative of battery. The secret of the amplification is to have a very small input voltage against a comparatively large output v. For best volume - we suggest you substitute a 1 meg. volume control for the resistor. Run it around until you get best volume. Then, disconnect one side and test the resistance. Replace the volume control with the new resistor. If you wish, you may leave the volume control in.

Any P-N-P Junction Transistor is alright, as CK-721, CK-722, CK-768. GT-34, 2N107, etc.

If you want to use an N-P-N, just reverse battery polarity. Always be sure battery is hooked up right - and try to use a RED wire for the positive Carbon. Be sure to disconnect battery when not in use- altho the Transistor does not draw much current.

13. PANEL & BASE LAYOUTS.

Here are some suggestions on panel and base layouts. As most Crystal sets are operated at the Broadcast frequencies - too much attention need not be given to short leads.

Most sets are assembled and wired up right on the panel, so do not require baseboards. The 2" x 4½" coils are usually fastened to the panel last as this makes assembly easier. Switch points are the last to wire up. The coil is mounted back from the panel by 1½" screws and nuts - far enough to clear the moving condenser parts, etc. Section 5.

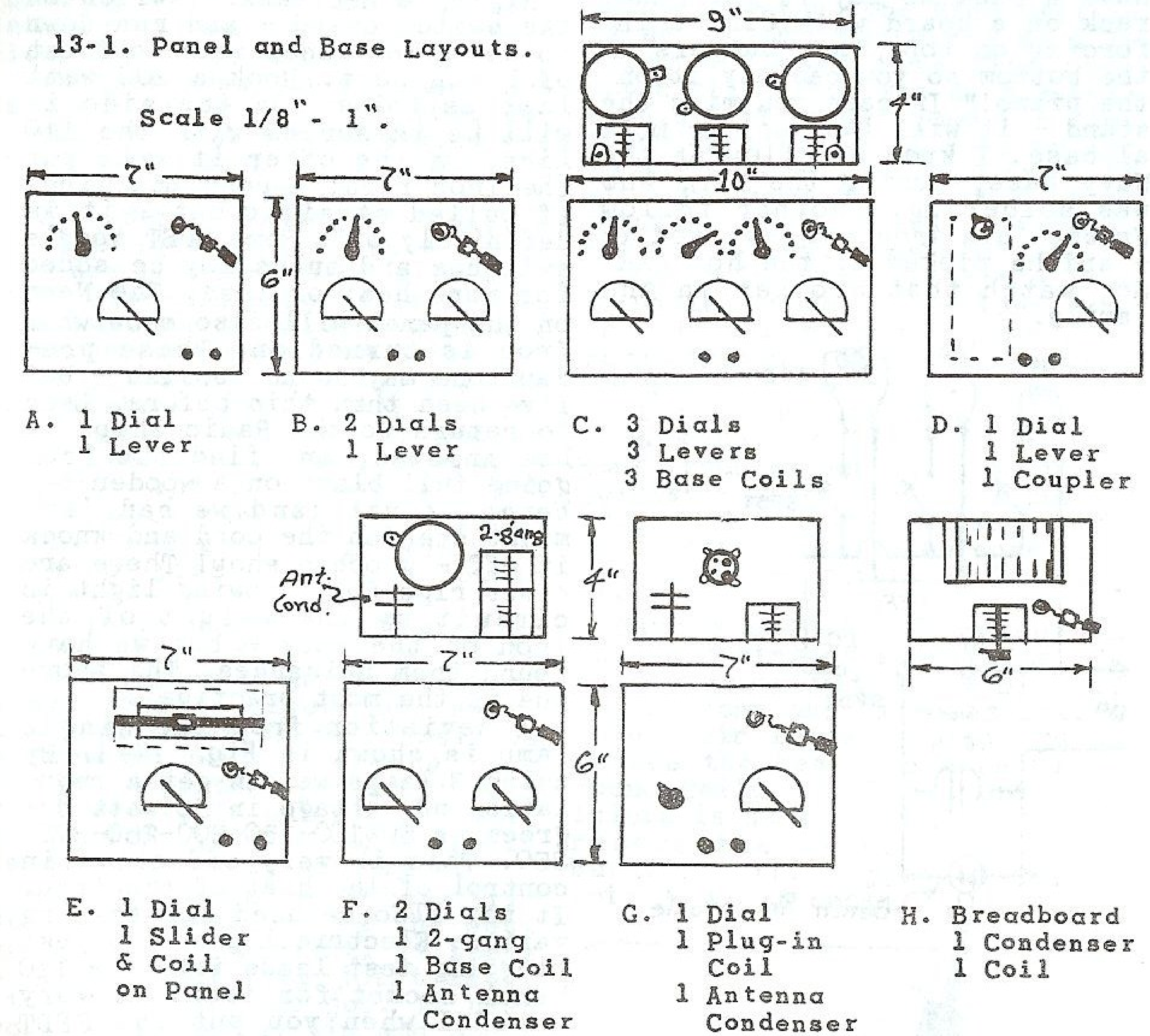
Base layouts are employed only when coils are to be mounted on the base - with no room on the panel for them. Also, if you use plug-in coil sockets, 2 or 3-gang condensers, audio chokes, Antenna trimmer condensers, batteries, binding posts, etc.

See SEC. 2 & 3 for more Panel and Base data. Appearance is very important in Panel layout. It is a good idea to work from a vertical center line or Panel.

Do not crowd parts so they'll be hard to assemble or operate: Mount main tuning dial conveniently. Controls, you use least, should be placed at the top, bottom or at the left.

13-1. Panel and Base Layouts.

Scale 1/8" - 1".



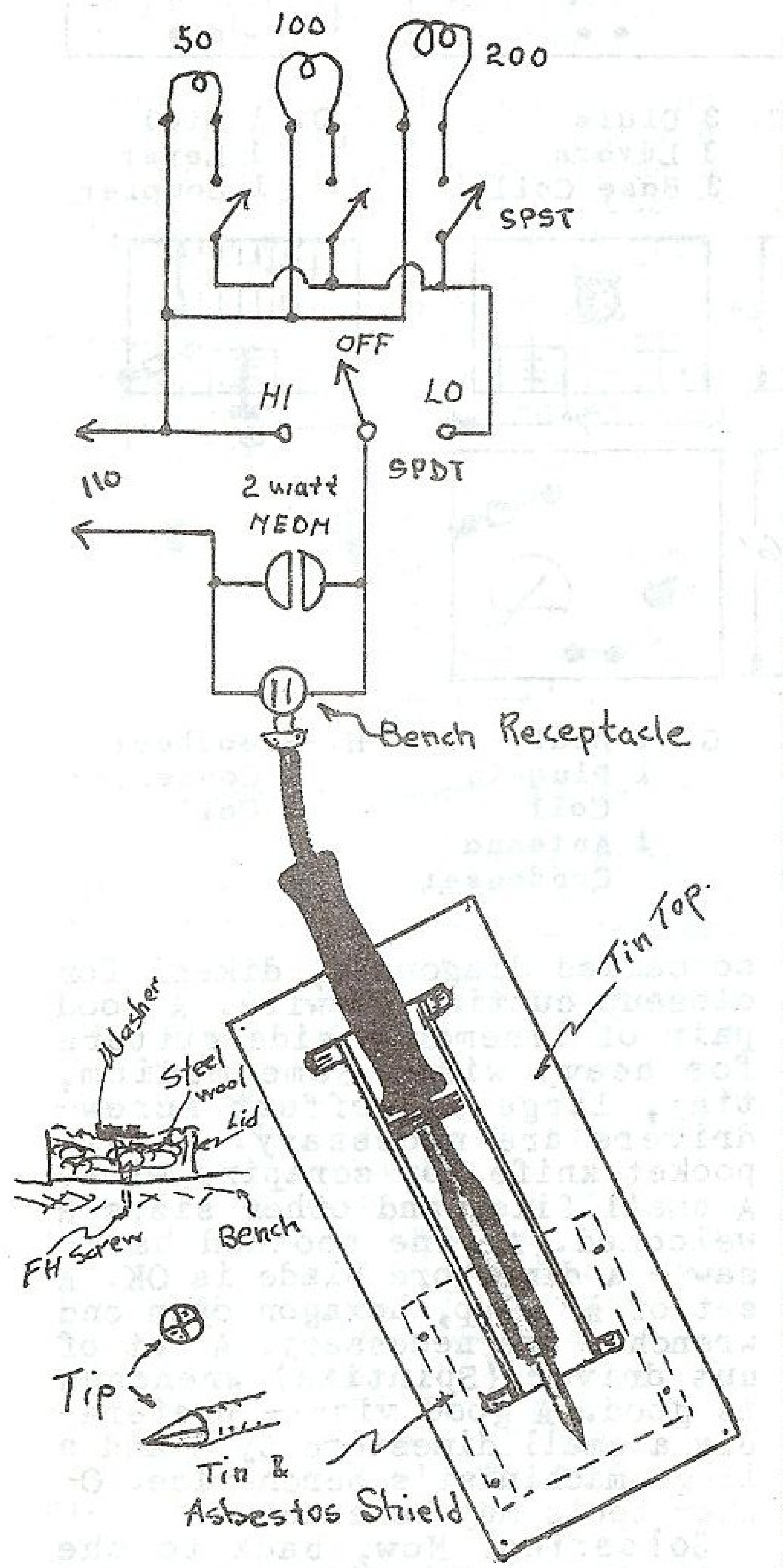
14. ASSEMBLING & WIRING NOTES.

Tools. If you're going to become a good mechanic, you will never get thru buying tools because you can always find a good use for them. No article pays for itself more than a tool.

The most important for the Radio man is a good soldering iron setup. A 100 watt iron will usually fill the bill. The soldering guns are excellent. Do not buy the so-called Soldering pencils or dimestore irons- as they soon burn out. We have used two 100 watt American Beauty Irons for over 30 years- and they cost over $5 wholesale at that time.

Other essential tools, to start with are small Side cutters (also called diagonals, dikes) for closeup cutting of wire. A good pair of lineman's side cutters for heavy wire. Some medium, tiny, large and offset screwdrivers are necessary. A dull pocket knife for scraping wire. A small file, and other sizes R welcomed. A fine toothed hacksaw - a dimestore blade is OK. A set of ¼" - up, hexagon open end wrenches are necessary. A set of nut driver (Spintite) wrenches is good. A good vise - preferably a small dimestore type and a large machinist's bench vise. Other tools may be added.

Soldering. Now, back to the Iron. This, with sidecutters and screwdrivers - will be used most in your work. It is assumed you have a rack to lay it on. Mount rack on a board with tin re-inforc'ng on top. Tack bumpers on the bottom so you can "lay it on the piano!" In case you miss the stand - it will land on the metal base. I knew a fellow at the Navy base, during the War, who was soldering. Another fellow grabbed his iron and reversed it - and he picked up the hot end! So, watch that brother in the family.



14-1. Soldering Iron Setup.

Rig up a SPDT knife switch on the switch board - and run down to an outlet receptacle to front of bench post. Hook a 200 watt lamp as shown. On one side it will be in series with the 110 line. On the other it will put the Iron right across the line. If pulled straight out - it is definitely off. Some SPST toggle switches and bulbs may be added for more heat or less. The Neon on the panel will also show when Iron is turned on. These precautions may sound foolish - but I've been thru this before. Used to return to the Radio shop, in Los Angeles, and find the Iron going full blast on a wooden top bench. A rat (and we had 'em) might step on the cord and knock it off - goodbye shop! There are other rigs for throwing light in circuit by the weight of the Iron on the rack - but we have found them nuisances. The above one is the most practical.

A deviation from the single lamp is shown in Fig. 14-1. By using 3 lamps we can get a regulation of wattage in 50 watt degrees as 50-100-150-200-250-300-350. This is very effective in control of the heat of the iron. It may also be used for testing various Electrical parts by just plugging test leads into the 110 bench socket for iron. Be very careful when you put the SPDT switch on HI as it is directly across the 110.

One of our pet ideas, to keep the Soldering iron in good condition - is to get a Mayonnaise lid. Drill a hole in the center. Grab some Steel wool and hold it down with a washer and a flat-head wood screw - to the bench. Smear some soldering paste on the steel wool. Run the Iron over it - and keep adding a little solder to the iron. This will tin your iron first class. Each time you solder - run the tip over the steel wool. Occasionally add a little more paste. Later when you replace the dirty steel wool - you'll find a lot of debris in the bottom, that came from the iron.

File the soldering iron tip as

drawing - if pits occur. Pits R caused by too much heat over a long time - so watch it.

Another idea you may use. Get a piece of tin and fit some Asbestos inside. Fit it around the iron tip - when in the rack. It will conserve heat.

A soldering Paste, or flux, is a substance applied to a metal surface to make solder flow easily. Its main purpose is to rid the surface of Oxides. Even so, your surface should be clean before you start. You may make an interesting test of this process by cleaning a piece of Copper with steel wool. Hold it over a flame - and it will turn dark brown with tarnish from oxidation. Drop a piece of Rosin on this hot piece - and see how it clears up.

Rosin is used in most good Electrical soldering pastes. It's held together with some form of starch paste, glycerine, vaseline, or other binder. Rosin is a form of resin - coming from sap of Turpentine pines. It will not dissolve in water - but will in Alcohol. In this condition it is sometimes used as a flux.

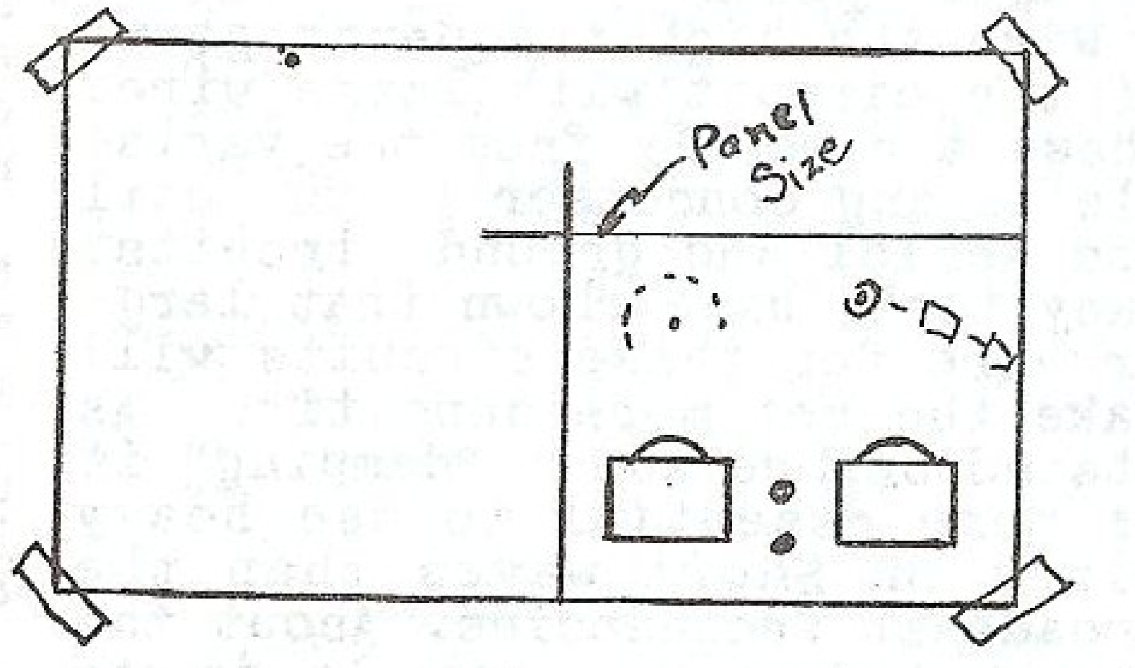
The English solder Dubois Trisol 60-40 seems to be the best we can get at present. It seems to "grab" onto the joint as if it wants to do the job. It uses rosin flux; Malay tin and Spanish lead. Its walls are to thin that it works easily.

Companies, that build high-frequency parts, are much against the use of soldering Paste (a good way to get canned!). However, we have always been in favor of using it - in moderation, of course. It is almost impossible to tin an iron without it. If you have a joint that doesn't stick - apply a little with a toothpick. It is not detrimental for most joints. I wouldn't use it for coil taps, however.

Whatever you do, never use Zinc chloride (killed spirits) for soldering Radio parts of any kind. It is OK for rough soldering for tinsmiths, etc. It is made by throwing pieces of Zinc into equal parts of Hydrochloric acid and water. The Zinc will be eaten up. One Fan wired up a 1-tuber and used this flux, because his father was an Electrician, and it worked good for him. After cleaning it up - by golly, he went home and re-wired it with the same flux again! It is dynamite around a set - as high-frequency current is shorted.

When soldering - hold the iron on until you see the solder run. Hold the joint with pliers, or screwdriver, until the color changes. It has then cooled. It will soon be easy. Give a joint a yank to see if it holds OK. Many troubles result from "rosin joints" - where the rosin holds, but not the lead. It isn't confind to beginners - because the factories are guilty of it many times.

Care should be exercised in the soldering of some parts. In this class - watch the Diodes, Transistors and fixed crystals. Hold their leads with pliers to reduce the heat. Be careful around Celluloid forms. Our Celluloid is slow-burning. When you remove the flame - it stops burning. Other types of Celluloid go up in smoke.



14-2. Panel & Base Planning.

Layout. What size panel shall I use? This is the question that comes up first, when getting all ready to build. Fasten a sheet of paper on your bench with Cellophane tape. Working from the lower right-hand corner - lay out the parts in the best position. Open up the condensers so they can't touch. See if everything else clears. But don't put them too close together. Draw a border for your panel, leaving ½" clear all around for mounting in a cabinet.

If using breadboard, or base mounting, do the same with it. However, for the base, draw the connecting wires on the paper. U can then turn sockets around to get the shortest distance.Otherwise, some lead may crawl over the whole rig. It isn't essential that all Crystal set leads be short - but let's make them that way for theory alone. Maybe it will prove up on that real long distant station.

One of the worst troubles, besides sloppy soldering and assembly jobs - with kits returned to us - is wrong position of the parts. Be sure to check socket connections as well as connections on coils for proper points for terminals. Many get sockets switched around on tube sets. If parts are not screwed down good, they get sloppy and jump around. On octal sockets check position on the pin. On 4-prong sockets check the two large prongs.

Once the base parts are laid out correctly you may transfer the mounting holes to the base with carbon paper or by means of a center punch.

Wire the high-frequency parts of the circuit with large wire. These are mostly from the variable tuning condenser to the coil and Aerial and ground circuits. Many tests have shown that larger wire for these circuits will make the set more sensitive. As stated before about "damping" it is more essential to use heavy wires on Short waves than the broadcast frequencies. About the worst thing you can do is to wire the set up with small magnet wire - unless you just want local stations. If you wire the set with #14 busbar- so much the better. But with this, be sure the joint gets hot - and sticks well. If not, any advantage you gain will be offset by resistance in the joint. #18 stranded or solid hookup wires is preferred for RF wiring. Use solid if set is permanently fixed.

If set is portable, or it is to be used around coils or moving parts, be sure to use only stranded. When using stranded wire - push the insulation back a little and twist the wires. Tin them before attempting to solder them down. If they fray out they may cause a short or make a sloppy job.

When wiring coil taps it is best to use #22 stranded. It has plenty of flexibility and also a lot of surface for such a small wire. Before you wire up the taps, sandpaper lengthwise with the coil tap wires. Tin them a little with the iron before you solder them. Also tin each end of the wires to switch points before soldering them up. Leave a little play in case the coil jumps around.

These are just a few of the details that may help. You will run onto a lot more with each set you build. Most circuits may emphasize the essential details in wiring it. Get yourself a good circuit and start in!

15. LONG DISTANCE RECEPTION (DX)

Two things are most important for DX reception, e.g., a good set and Aerial-ground system and a good location. We may improve on the first but the location may have us stumped.

A set must be made as low-loss as possible. Variable condensers must be well built, clean and plates not touching. They may be helped by cleaning in Acetone or Carbon tet. for very bad ones. Be sure all connections are secure and not corroded.

Coils should be wound on Celluloid or other good low-loss forms. Wire should be of sufficient size, insulation and number of turns for best tuning. Tuning coils are best wound with DCC on Celluloid forms. Coils should be spaced so their fields aren't affected by condensers or other metal parts. The field usually runs ½ the diameter, so if a coil is 2" in diameter - keep it at least 1" away from parts.

Good crystals are most important. Try to have several good

ones around. Also, small, fine catwhiskers of various types. Be patient in the adjustment of the catwhisker for DX stations. The Diodes are not usually too good on weak stations.The pressure on the catwhisker may be too heavy. No doubt some Diodes have the right pressure and may work OK. You must try them for your particular setup. The advantage is they don't need adjusting. Most crystals that use battery power are not usually best for DX.

A good sensitive pair of Earphones is necessary if you want to recognize those weaker stations.They should be around 5000 ohms DC resistance. Take good care of your phones - they can last a lifetime. Buy a good pair when you do.

The Aerial and ground are important - and are considered a part of your receiver. The higher Antenna is always the best regardless of length. Use good heavy #12 or #14 Enameled or a stranded tinned or enameled. But never use galvanized or baling wire. Small magnet wire should never be used as surface is too small. #12-14 magnet is OK. The use of several wires will give more pickup than a single. Put them on a spreader with wires at least 30" apart.

Use good glass insulators. Use a good flexible Leadin wire and keep it insulated to the set. If going under a window use a Window leadin strip. But, solder to each end, including the rivet.

Keep Aerial away from trees, poles, lite lines, chimneys, gutters, etc. far as possible.

Several types of Aerials may be tried. The "T" has the most pickup. You'll find one you like best. Direction of Ant. may help some, but is most noticeable on Short waves. We always prefer to have several different Aerials, with each hooked to its SPST knife switch. You may then use one, none or several at once.You will find certain combinations to work the best.

The ground is very important as much energy comes thru it.Use all the grounds you can. Galvanized pipes in wetted flower beds are good. All water pipes are OK and use a "C" clamp to hook on. Wires and pipes placed in stream beds or wells are excellent. The best ground is salt water.Always use as large ground wire as possible even if it requires twisting several together. Some use a SPST knife switch for each Gnd.

If on the second floor you'll not fare as well. Ground may be too long.A baseboard wire may be substituted. Hook to any water system. Electrical fixtures are OK if no shorts, or you will get fireworks. No doubt you'll discover a lot more kinks.

Location. Very little is accomplished in DX operation geographically if next to bad local interference (QRN). Leaky power lines, motors, Neon signs, etc. raise havoc with DX. Long lines may help to pick up more DX so if they are quiet you're Ok.

Tall buildings will absorb a lot of energy. Under trees is also bad. Many conditions in the City will cause trouble.

Deep valleys are bad, even if receiving lengthwise. Signals do not jump hills good- for someone closeup. Get 25-50 miles away & reception comes back. On top of the hill is the best.

Large broad valleys are superb and Crystal sets in the Miss. valley often hit 1000 miles the first nite in many directions.

Deserts are poor due to poor ground and static.A counterpoise may be used here for ground.

Time of day and year is also important. Most Ham magazines give you a good forecast.

Direction also makes a difference. It is harder to receive North than South in the U.S.A. East Coast Crystal sets often pull in Europe, etc. Strong Moscow is picked up frequently on Crystal sets in the U.S. and in Canada.

After rain storms the air is very conductive and DX is there. During hot,dry weather reception is usually at its worst.

We hope this Handbook has aided in your Radio hobby. You may now go on to more advanced parts.