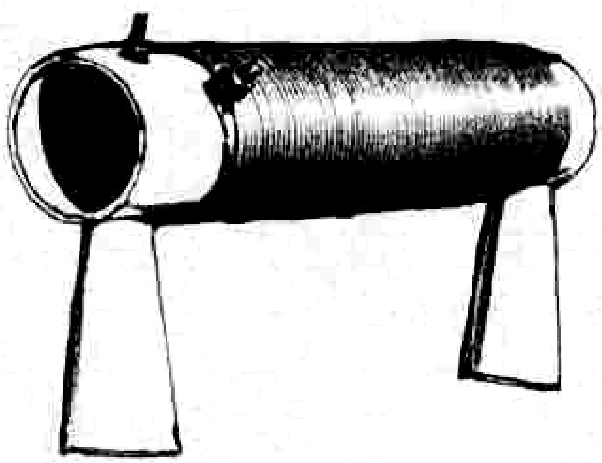
COIL WINDING

SECRETS



COIL WINDING SECRETS

In the world of coil winding, there are many commercially acceptable means which can be used to make quality coils. The large coils required in Broadcast Transmitters used for Short Wave or Standard Broadcast are extremely expensive. This is because these transmitters are required to operate in a very stable manner for up to 24 hours per day, 365 days per year, and up to 25 years without any major problems except tube replacements and normal maintenance. The coils we will show here are not of that quality, but due to their low cost can be replaced easily after five or six years of normal heavy duty use. They will serve just as well, but for less time under normal circumstances.

In the world of Commercial Coil Winding, machines do all the work of winding - in this Book, you will do it yourself. The Commercial coils are usually wound using flat wire. This can be purchased the same as round wire, but is harder to obtain and more costly. The flat wire has the advantage of allowing more surface area in each turn, providing for smaller coils in length and diameter. These coils tend to be extremely heavy, which I find much to my disliking. The insulating materials used by Commercial Winders sell for high prices but last for a long time. The materials used here are cheap in cost but high in quality, but last only 6 or 7 years under normal conditions. After that time, another PVC Form can be put inside the same wire and you can keep broadcasting. The plastic PVC material used here has been tested over a ten year period and continues to work in some cases. The problem is that PVC sometimes cracks or becomes brittle after a number of years, but these days a five year life expectancy is not bad for anything we buy, especially considering the low cost of the PVC used here.

Strips of Formica, Teflon, Plexiglas, or plastic may be used instead of PVC for the forms on which coils are made with great results. If used Commercial type insulation is available from a motor rebuilding shop, it should be used for greater life. I often hear the concern expressed about heat problems with coils, and most people think that coils get hot and may melt PVC or plastic. This is not valid in most cases, for a properly tuned coil does **not** get hot. If there is heat buildup, something must be wrong.

There are various ways in which coils are created. The most common in Broadcast Transmitters is the coil wound on a frame of three strips of insulating material arranged in a triangle. The coil itself is round with a spacing of 1/8 to 1/4 inch between turns. The greater spacing is for higher energy demands, preventing arc-over. In high power installations of over 10,000 watts, coils may take on enormous proportions, amounting to several yards in diameter and as tall as a house! Here we are dealing in powers under 10,000 watts, which can be made in the traditional sizes and shapes. Most coils are now wound **inside** the frame because this gives more control against movement of the winding. This is very difficult to do by hand and should only be done by a patient, experienced person. For our use, the coil wound on the outside of the frame is best.

Examples of coils are shown so that construction details can be observed. Coil forms are **notched** in a predetermined way so that windings will stay in place. A saw or file can be used to make the notches. Marks are laid out with a ruler and cut to the desired depth. This is usually at least equal to the radius of the coil wire size. Metal braces hold the coil forms together and are insulated from each other using insulated washers to prevent R.F. currents causing heat build-up, corrosion, and harmonics. If the metal end-braces form a complete circuit, they represent a separate coil in themselves, thus affecting the tuning of the coil and circulating large currents of R.F. within themselves. A triangular end-brace is made of **three pieces of metal, each insulated from the other.** The three plastic strips which support the coil must be very strong or they will bend out of shape. For most coils, they should be at least 1/4 inch thick and 3/4 inch wide or greater. Simple hand tools will make all the cuts, angles, and holes. When winding the coils, be sure to make them round and not **triangular.** One transmitter which we used in El Salvador had home-made coils, made by an engineer lacking skills, which were **triangles.** They did not work well, especially since they were wound on forms made of **wood!** This is about the worse thing you can do. **Never** make any coils on a wood form and then expect it to remain tuned!! Wood is famous for absorbing moisture, thus **de-tuning** the circuit with each change in moisture content. By the way, this is about the most common of all mistakes made by even experienced Amateurs. **DON'T USE WOOD for any tuning circuits** even if it has 100 coats of varnish, plastic, tape or teflon unless you like solving mysteries as to what went wrong with a perfectly good circuit!

COIL FORMULA

The Coil Formula is given below. It is used to determine any value of coil you may wish to figure, and is quite accurate for most applications. It is not needed if you wish to build standard coils commonly used in AM Standard Broadcast use; but if you want a fixed coil of a specific value, this will give the number of turns needed and the other necessary information.

COIL FORMULA: $L = \frac{R^2 N^2}{9R+10l}$

L = inductance in Microhenries
R = Radius of coil
l = length of coil in inches
N = number of turns in coil

Usually, the desired inductance is known and the diameter. Diameter is almost always determined by space limitations, but if various diameters are an option, they may be tried in the formula until a suitable result is obtained. The number of turns may be obtained by winding a few turns on a form and measuring the turns per inch. Then the formula may be tried for an even number of inches, and the inductance per inch figured. This is divided into the desired inductance and the total length of the coil is found. The other factors of the formula may be used in a similar manner to obtain needed estimates on diameter, etc.

In the case of coils with a predetermined number of turns per inch, the formula should be even simpler. Coil forms usually have notches pre-cut into the insulated supports every fraction of an inch. These can be measured to determined turns per inch. Coils wound on solid forms will have grooves if bare wire is to be used, but insulated wire may be used on a smooth form.

THE TUNING COIL

This coil is needed for tuning the antenna to match the transmission line. Two of these are used at each tower and sometimes a third one in series with the tuning capacitor for the purpose of making it adjustable. This same coil is used inside the transmitter in order to match the output with the transmission line. For 1000 watt transmitters, this same coil is just right for the tank coil. You may build them yourself and save about a thousand dollars on this one item alone in the course of building the transmitter and antenna system.

PARTS LIST

1. Three strips of insulating material measuring 1/4 inch thick by 1 inch wide by 13 inches long. These can be made of plastic, fiberglas or other suitable material.

2. Six one inch long brass screws approximately 1/8 inch diameter with nuts and 12 brass washers.

3. 50 feet # 10 solid copper wire.

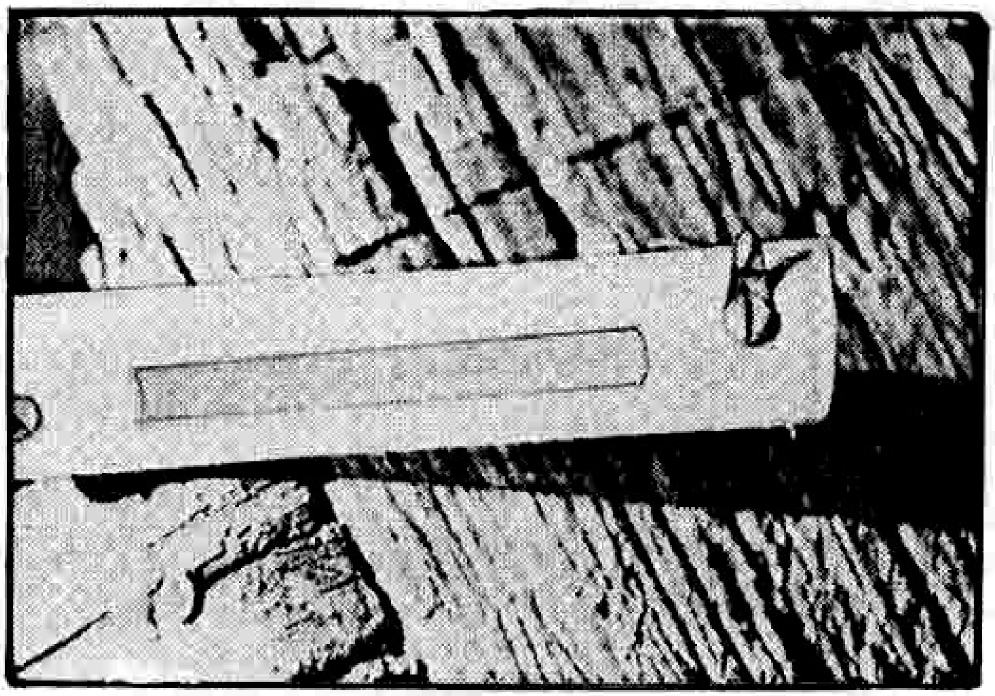
4. Two pieces 1/2 inch wide by 1/16th inch thick copper or aluminum for making a wire clip to adjust the coil.

5. One 1/8 inch by 3/4 inch screw with nut and two washers for wire clip adjuster.

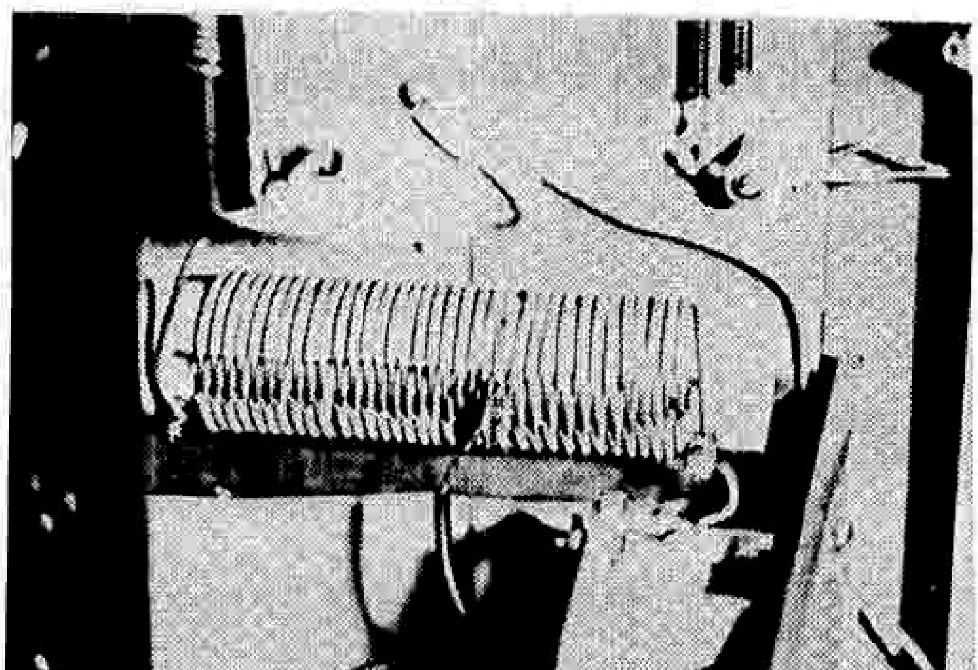
6. One piece of wire braid 13 inches long by 1/4 to 3/8 inches wide. This can be made from stripping the braided shield from a short piece of C.B. Coax or microphone cable.

7. Four 1-1/2 to 2 inch by 3/4 inch ceramic or plastic standoff insulators for the base of the coil. These can be made from PCV Pipe. See the Chapter explaining the uses of PVC.

PVC PIPE "FLUTED" COILS

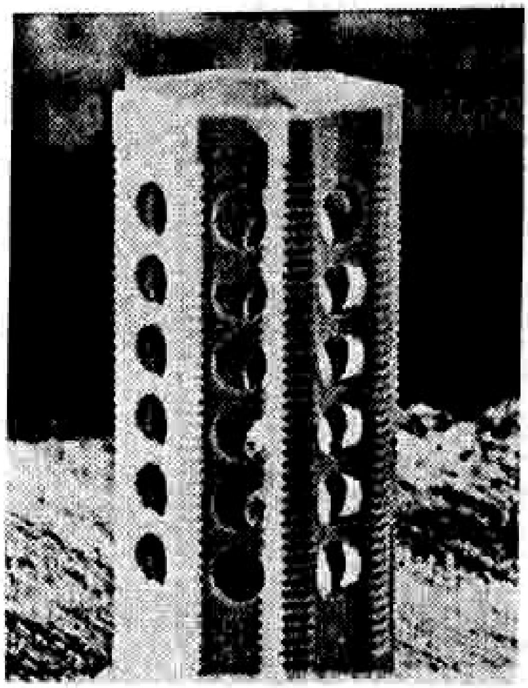


"FLUTED" AREA IS CUT OUT WITH A SMALL SAW
THIS ASSURES ROOM FOR INSERTING R.F. CLIP AFTER
COIL IS WOUND.



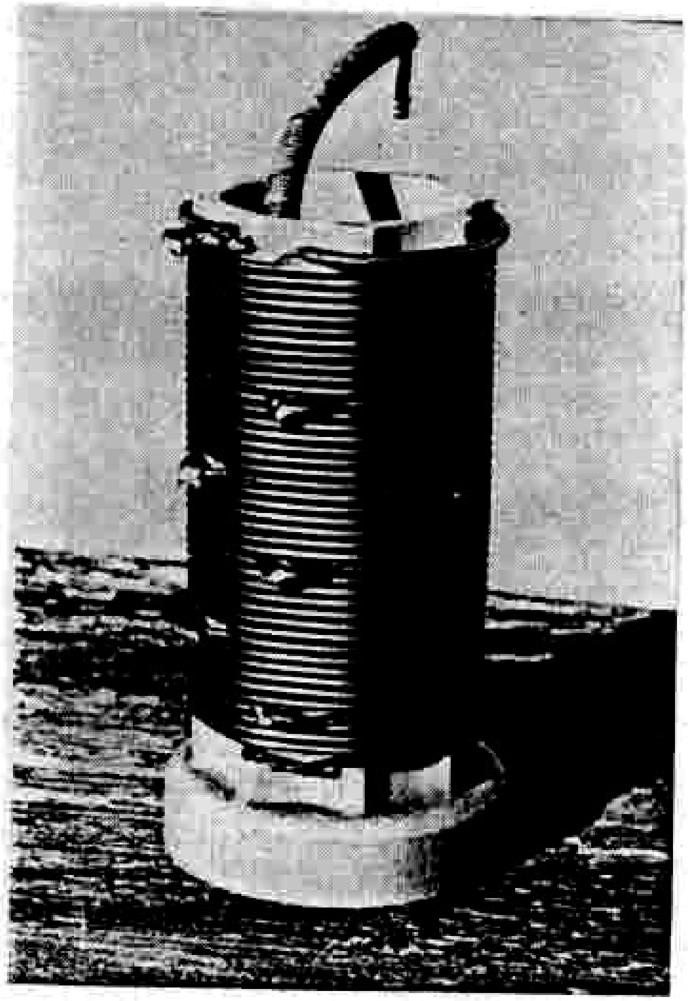
THE INSULATED WIRE IS BARED ACROSS THE "FLUTE"
FOR INSERTION OF THE R.F. CLIP. (#10 WIRE SHOWN)

MORE COIL SECRETS



COMMERCIAL FORM

YOU CAN DO IT YOURSELF AND SAVE



THE FINISHED PRODUCT

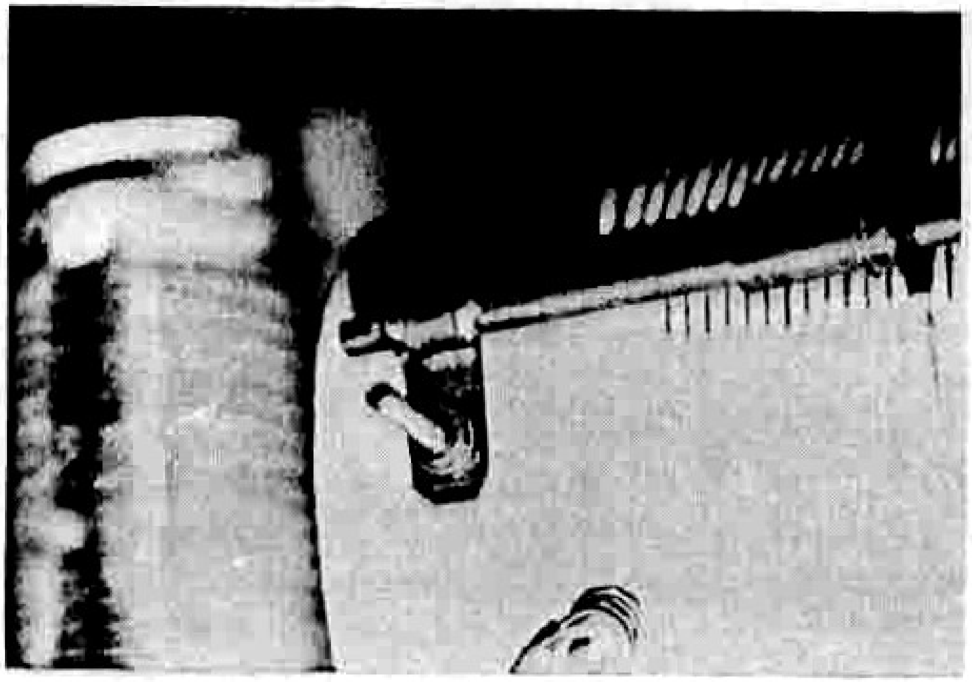
Commercially made coil forms are available (as shown) for those who do not like the "messy look" of coils like the "fluted" type. The fluted style is used by myself quite a lot, but is really hard to make look pretty, but it really does perform beautifully. The coil form shown is designed for bare wire up to #12 in size. It is really handy for building coils for short wave and broadcast purposes. The stiffer wire can be patiently shaped to achieve the results shown in the picture. It can have as many taps at various inductances as you feel you will need. The total inductance of the one shown is 60 Uh. This is perfect for A.M. Tuning at powers up to 100 watts continuous. It will handle safely 2000 volts and 1000 watts of R.F. in intermittent service such as required by Ham operators.

MAKING IT SIMPLE

The basic description has been given, and can be seen from studying the pictures of coils. Many high quality coils are custom made on a **SOLID** form. These are easiest to make and can be wound directly onto PVC PIPE of the right diameter. The inductance of the coil is the most important point, then power handling ability and size. PVC pipe comes in diameters suitable for coil forms, and is one of the best insulators in existence, and it costs very little in comparison to other materials. I have made critical tuning coils, tank coils, and antenna tuners in this manner and none of them have ever malfunctioned. These PVC Pipe Coils all use **INSULATED WIRE** instead of the usual bare wire. It is wound tightly along the PVC Pipe until the estimated inductance is reached(the right number of turns). The insulation is removed through **CAREFUL CUTTING** WITH A SHARP KNIFE BLADE and then a sliding contactor is made which is capable of a full range of adjustments. If the coil does not need to be adjusted, it can be wound solid and the ends terminated in brass screws set in the PVC Pipe ends. Connection is made to these screws and brought out to the circuit.

When the PVC Pipe Coil is going to be adjustable, a narrow strip of insulation is removed along the path of the adjuster. If too much insulation is removed, you will ruin the coil. The bar for the adjuster is made of 3/16th inch brass welding rod obtainable at any welding supply. Two brass washers of about 3/4 inch diameter are soldered together with a copper or brass washer between them as a spacer. The result is a device that slides freely along the distance of the brass rod, contacting both the rod and the individual turns of wire as desired. A single turn can be contacted at any desired location along the entire distance of the coil. The brass rod assembly is spring loaded and pressures against the wire where the washers set. The spring material is cut from heavy "shim stock" obtainable from auto parts dealers. This material must be made of brass or other metal which is a good conductor in order to work well. The brass "shim stock" spring material is wrapped around the brass rod and soldered in place after the washers have been put on the rod. I have made many of these, and they perform well at almost no cost. For Standard Broadcast purposes, the close contact between the insulated turns of wire poses no problem whatever. This style can be used to 30 mhz. but works best at lower frequencies.

HOW IT'S DONE



This close-up shows several things about the making of coils. I built this one on a hefty PVC high pressure pipe section. The wire is #12 plastic covered and is sufficient for 500 watts continuous use. The wire is tightly wound on the form and produces 150 Uh. inductance for tuning throughout the entire A.M. Band. The transmitter is designed to serve in Third World Countries where availability of units made by high priced manufacturers is limited. The tank coil is adjustable by sliding the wheel to the point on the wire where the inductance is right and leaving it there. The shorting bar itself is 1/4 inch brass welding rod. The wheel is made of two brass washers on a copper tube. The spacing between the two washers is made right for contacting by placing a third smaller washer between the two outer washers and soldering the whole washer assembly to the copper tube. The copper tube is chosen in size for easy sliding down the brass shorting bar. The close-up shows how the spring pressure is obtained and how the shorting bar is held in place. The pressure comes from the brass "shim stock" (heavy) wrapped around the ends of the shorting bar. This is chosen to give 3/8 to 1/2 inch spring action. As can be seen in the picture, the brass spring is wrapped around the bar at the ends and soldered in place. It is shaped first as shown, and when you know it is right, **then** solder it.

The two springs together give about 50 lbs. pressure against the copper wire in the coil. This has to be stiff, otherwise the contact pressure will not hold well enough to prevent arcing or poor contact. The covered wire is bared along the slider's path - nowhere else. The baring of this wire requires patience. I have found the right tool for the job is a moon-shaped woodcarving tool of the miniature variety. The sharper the better the job and the safer the user against accidents. When you must put too much pressure on the knife, when it slips, (and it will) something or someone will be hurt! The sharp tool is the safest tool for the job.

Brass screws are used to make the terminations of the wires and slider bar. These are 3/16 inch diameter and however long needed. A good hardware store will have bins full of these. I recommend looking for the older establishments as the new "QUICKIE" Hardware dealers have only what sells fast and in volume. NEVER lower yourself to use aluminum screws for this purpose. They simply are not strong enough to hold the pressure over a period of years. They will stretch in two over a period of time.

The entire PVC Coil Assembly is mounted on two stand-off insulators. The coil operates on the shorting principle with the wanted (active) turns un-shorted. As explained earlier in the Book, when cutting the insulation off the wire, the insulation on top is cut off, but that on the bottom of the wire remains so as to prevent shifting of the wire or shorting of turns. I have used this system for years, and never had a problem if the coil is done carefully.

Some have expressed concern over the insulation causing capacitance effect in the coils. I have not encountered any problems in actual use at powers up to 1000 watts. I am not prepared to say what effect it could have at 10,000 or 50,000 watts. I suppose that at those powers, commercialy made coils would be relied on anyway - not to say that insulated wire coils could not be built and used successfully.

Back to the subject of screws. Steel screws work until they rust. Then problems arise which are not easy to resolve. Avoid trouble by using only brass or stainless steel screws in your projects.

R.F. TUNING COIL

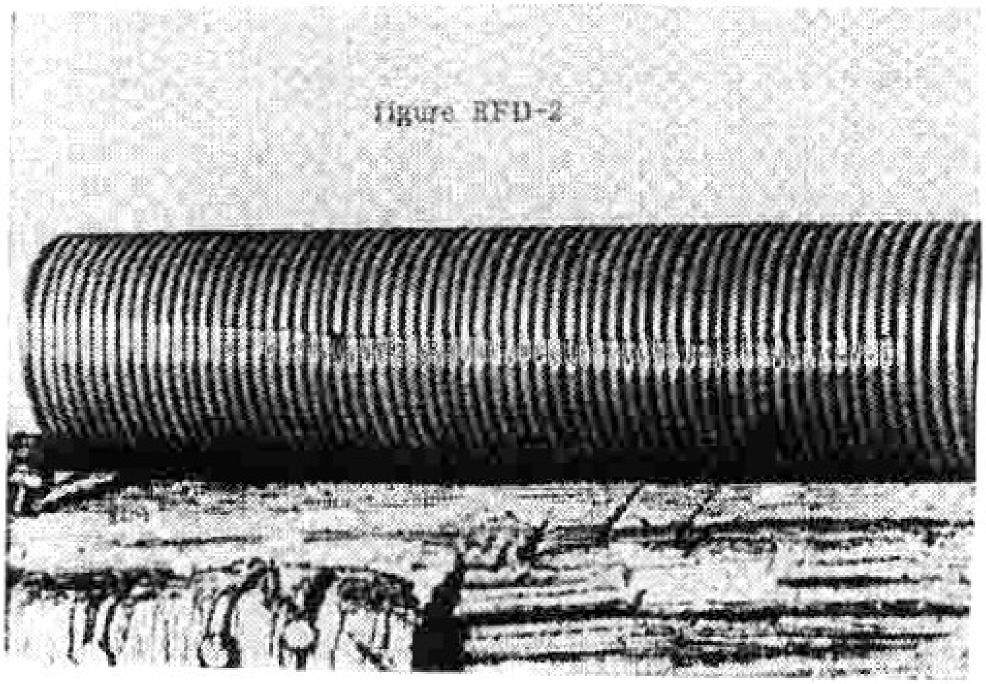


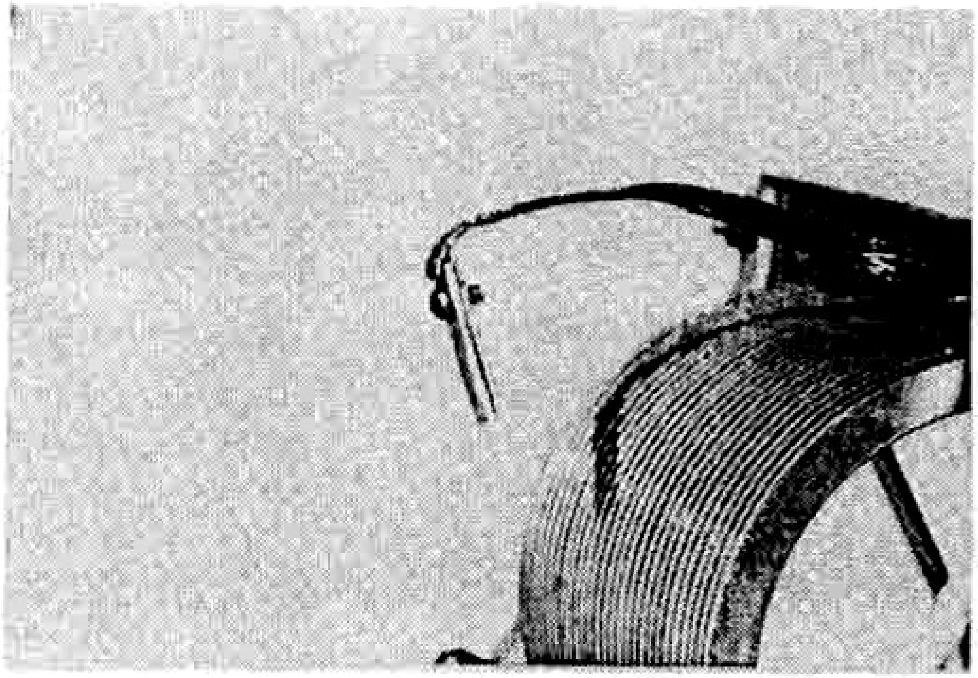
figure RFD-2

This picture shows what happens when the coil is prepared for the shorting bar "slider" by using a pocket knife on the insulation. The coil is still usable, but the job is a little messy. The tuning coil is for a 1000 watt A.M. Transmitter in the driver stage. Two 833-A tubes are driven successfully with this coil. The R.F. Energy developed across this coil is fairly strong, enough to burn a person quite severely if contacted by accident. Once the slider is in place, it is never "slid" anywhere. It is **lifted** into position and set on the individual turn where it is to be used. This prevents any wear on the winding by the rough sliding of the contactor. The contactor "wheel" does not roll in this case, but serves to make a positive contact on any desired turn. I have used a number of systems, but the contactor "wheel" does a really fine job and is inexpensive to build. As I previously stated, moisture from condensation due to overnight temperature changes does not seem to affect the tuning on coils made using these methods. The only danger real to this coil is the point of contact. It must be firm enough through sufficient spring pressure to assure solid contact. If too weak of "shim" material is used, there will be problems with poor contact. In my transmitter design, the bias supply will prevent any burn-outs due to loss of grid drive, but R.F. drop out will occur and the Station will be off the air until the problem is corrected. In cases where this style of contact is used in the tank coil, the problem is even more critical and should not be used unless you are sure your coil is "up to par." The heaviest wire for the job is a safer way to go, as too small of wire diameter will cause difficulty in making a good contact with the contactor wheel. While this coil is reliable if made properly, it should only be used where change of setting may be necessary from time to time. Other coil types will give even less trouble if there is an even more positive contact system devised, such as in conventional coils which use "pressure clips."

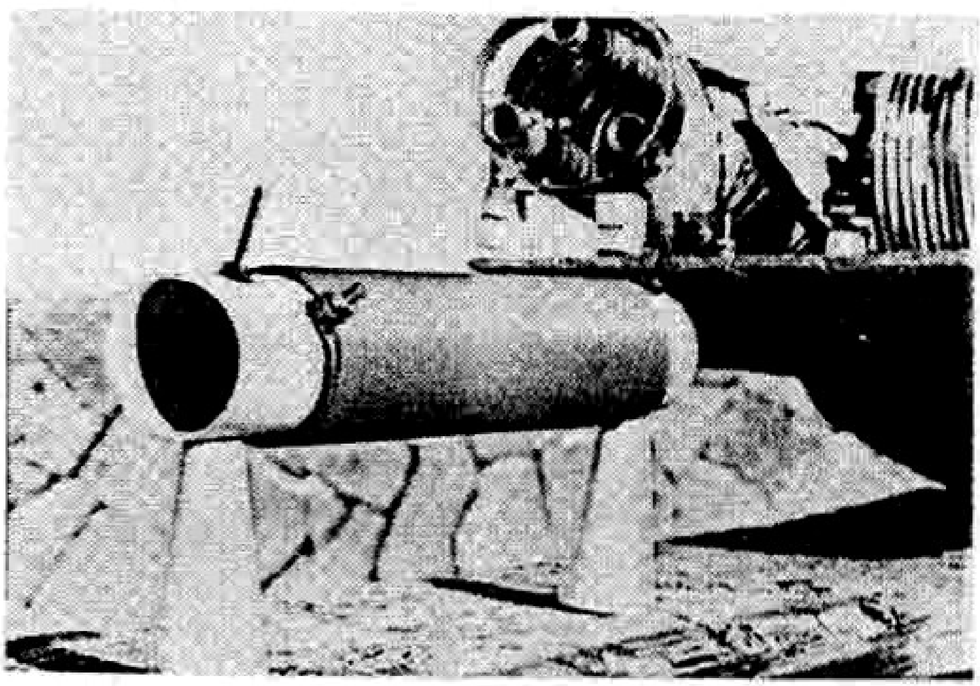
A good quality pressure clip can be made of two pieces of aluminum sheet metal shaped as shown on the following page. The pieces of metal are actually 1/16 inch or thicker and are formed by sawing to the right size and then drilled for the screw adjuster. The screw puts the right amount of pressure for a positive contact. The metal pieces are formed by putting enough bend in the two pieces to where the ends separate enough to accommodate the width of the coil winding. This makes it easy to slip on, then, the screw is tightened enough to hold well. Aluminum works well for this purpose if it is at least 1/16 inch thick. Copper is a better material for this purpose, but it may be a little more costly.

Flat wound wire is easy to obtain if you wish to build a flat wound inductor. Most large motor rebuilding shops have several sizes to chose from. You will have to chose what is best for your purposes and form the coil with a jig. The jig should have the size diameter desired and have narrow slots to hold the wire as it is formed in a circular motion. This is very hard to do without special equipment, but you can make a home-made jig from wood with the proper width slots cut in with a saw. Once the coil is released, it will spring out into a slightly larger diameter, so these primitive methods require experimentation until a form size for each coil diameter is reached. The larger widths of flat wire will be harder to work with, so if you decide to try this, start with the narrow widths and work upwards as your skill increases. A very small diameter coil will be virtually impossible to build due to the tight bends necessary. Larger diameter coils will be more practical to make. Most commercial transmitter builders use flat copper straps for making R.F. lines. These can be made of flat copper wire of 3/8 inch width or better, or of copper braid from coaxial cable.

HOME MADE RIBBON CLIP



Two pieces of heavy sheet aluminum shaped as shown and held together with a screw make a good reliable ribbon clip for R.F.
HEAVY COPPER ALSO SERVES WELL.



THIS HOME MADE CHOKE COIL USES #12 WIRE
AVAILABLE IN ANY ELECTRICAL SHOP