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In This Issue

SHORT WAVE RECEIVER

BANKED WINDINGS

12,000-Ohm Resistance Unit

WHEN the Armstrong super-regenerative circuit made its appearance there was an immediate and large demand for 12,000 ohm resistances, two of which were required for each receiver. This demand is now met by our special resistance unit which replaces the two formerly required. Built in a form as simple as our fixed condenser, the resistance carries three brass eyelet terminals to take screws for mounting and connecting. The unit is essentially a 24,000 ohm resistance with a center tap, which solves the most difficult problem of the filter system in an ideal way.

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A Short Wave Receiver

A receiving outfit whose efficiency on continuous wave reception is responsible for its popularity among advanced radio enthusiasts.

The Reinartz Circuit

THE Reinartz circuit is a comparatively new system which does not greatly differ from the regenerative circuits familiar to all of us. It was first made public in the early summer of 1921 and since that time it has been adopted by a large number of the foremost amateurs of the country. Slight improvements and modifications have been made and varying interpretations of the circuit have been published denser permits a more accurate regulation of the regenerative state of the system. In spite of the impression gained from the number of controls on the front of the instrument, its operation is surprisingly simple. Generally but one knob will be used for tuning and one for obtaining regeneration. For this reason the Reinartz receiver is particularly well suited for short wave relay work, altho, unlike the super-regenerative receiver, it is not limited to short waves alone.

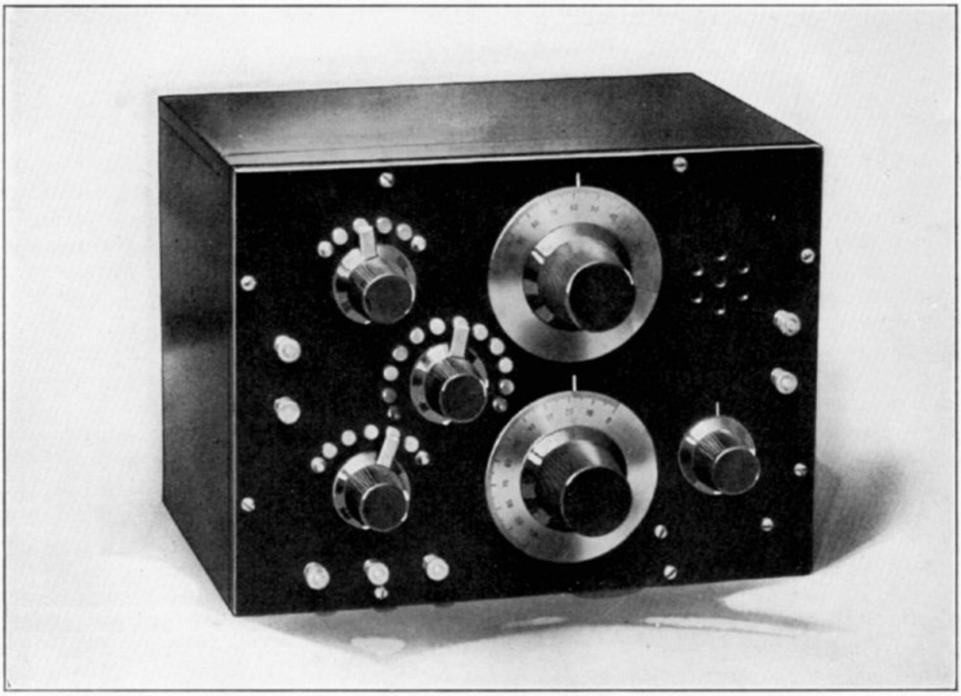

Fig. 1. A quick-action tuner for relay traffic which is also capable of long distance reception. The active controls are only two in number

in the best radio periodicals in America and abroad. The instrument described in this article differs in some respects from any that has previously been presented but the theory is exactly the same as that evolved by Mr. Reinartz.

The tuner is regenerative, employing both electrostatic and electro-magnetic feedback from the plate circuit. It is particularly well adapted for the reception of continuous waves since it oscillates freely, the degree of regeneration is not greatly affected by a change of wavelength, and there is but a single circuit to tune. The antenna circuit is supposed to function aperiodically. Relatively coarse adjustments of the feedback are provided by a tapped plate coil while a coupling con-

A Reinartz Receiver

As seen from Fig. 1 the Reinartz receiver here described takes up very little space. The front panel measures 7½ by 10 ins. and the cabinet enclosing the instrument is 6½ ins. deep. The arrangement of the controls on the front panel are unusually close but sufficient clearance is provided on both the front and rear. This compactness adds considerably to the appearance of the instrument and makes the construction relatively simple. The two dials and knobs at the center are 11-plate variable condenser controls, the upper being for feedback while the lower one is a tuning condenser. The four point switch at the left varies the inductance of the plate coil, the ten point switch at the center controls the inductance in the antenna circuit, while the lower or five-point switch is an inductance adjustment for the closed oscillating circuit. The knob in the lower right hand corner controls a rheostat for regulating the filament temperature of the detector tube mounted on a small panel in the rear. The two binding posts at the left of the panel are for the antenna and ground, the three at the lower edge take care of the A and B batteries, while the two at the right are telephone terminals. The latter two are located at a point the same height from the table as the input binding posts of the 2-stage amplifier which has previously been described. This makes it possible to use the two instruments together with the pleasing appearance revealed in Fig. 7. From the rear view, Fig. 3, the arrangement of the parts on the back of the panel may be clearly understood. Due to the limited space the variable condensers are turned at a 45° angle to clear the switch points and each other. Altho there are two inductances in the Reinartz circuit both are wound on the

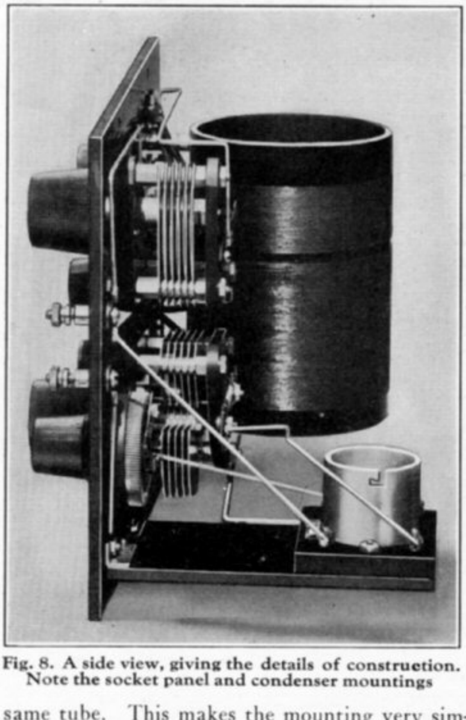

Fig. 8. A side view, giving the details of construction. Note the socket panel and condenser mountings

same tube. This makes the mounting very simple. The complete set of parts required for the construction of the receiver is shown in Fig. 2.

The cabinet which encloses the instrument is of ⅜ in. mahogany carrying a high polish on its outer surfaces. A hinged cover is provided to enable the operator to conveniently remove or replace the detector tube or do work of a minor nature without removing the instrument from the case. All joints are dadoed and glued and the edges of the cover are fitted with a cross grain strip to prevent warping. A cabinet of this quality is difficult to make unless the builder has a well equipped shop and is experienced in the use of woodworking tools. For those who are not so fortunate it is better to buy the cabinet already made.

Winding the Inductance

The inductance is wound upon a 5-in. length of L. P. F. tubing 3½ ins. in diameter. This has a ⅛ in. wall which makes it a very sturdy form for supporting the winding. Before starting

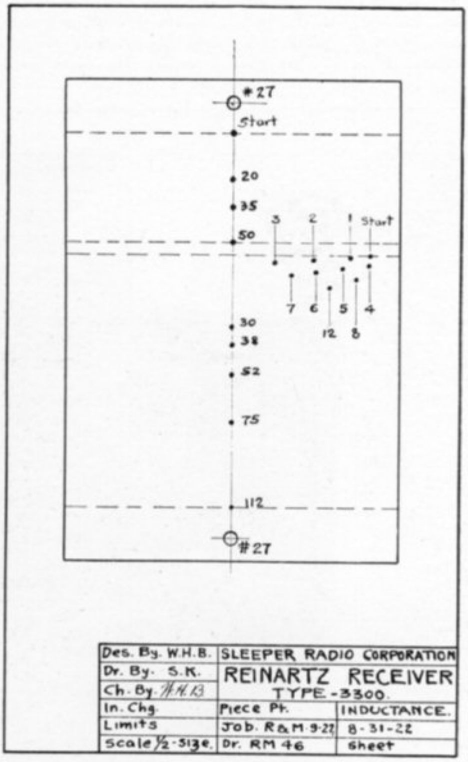

Fig. 4. One-half scale drawing of the inductance, showing the tapping points by numbered dots

the winding drill the tube with two No. 27 holes ¼ in. from each end of the tube. The position of these holes may be better understood by reference to the scale drawing, Fig. 4. At points where taps are to be taken off it is well to drill the tube with three small holes so that the end of the wire may be inserted in one and brought up through the next. This means that the wire has to be cut at each tap. Altho this method makes an exceptionally good job of the tapping, it is not at all necessary. No. 24 S. S. C. wire is used for the coil, a ¼ lb. spool being a sufficient quantity. Start the winding 9/16 in. down from the top of the tube and take off the first tap at the 20th turn. Another tap is made at the 35th turn while the coil is ended when the 50th is reached. Leave a space of ⅛ in. and begin the next section of the inductance. Taps are taken off at the turns indicated in the drawing Fig. 4. The first ten should be located to the right of a line connecting the No.

27 holes in order to bring the taps over the center switch for convenience in wiring.

A simple method for taking off the taps is to bend the wire back over the first part of the winding as soon as the tapping point is reached. One turn is wound around the coil and brought back to the tube at the place where it was taken from it. The winding is then continued in the usual manner. After all the wire is on, each loop about the coil is cut at a point diametrically opposite the place where the tap is to come, and the two ends twisted together to form a lead to a switch point. It is a commercial practice to first drill Determine the position of the holes by intersecting scriber lines on the reverse size of the stock and use a center punch before attemptng to drill. The size of drill to be used is indicated by numbers appearing beside the holes in the drawing. Concentric circles mean that the holes so marked are to be countersunk to take flat head screws. With all the holes located, the panel is placed face downward on a flat surface for drilling. Extreme care should be taken not to employ too great pressure on the drill when the hole is about to come thru for otherwise the panel may be chipped out on the front.

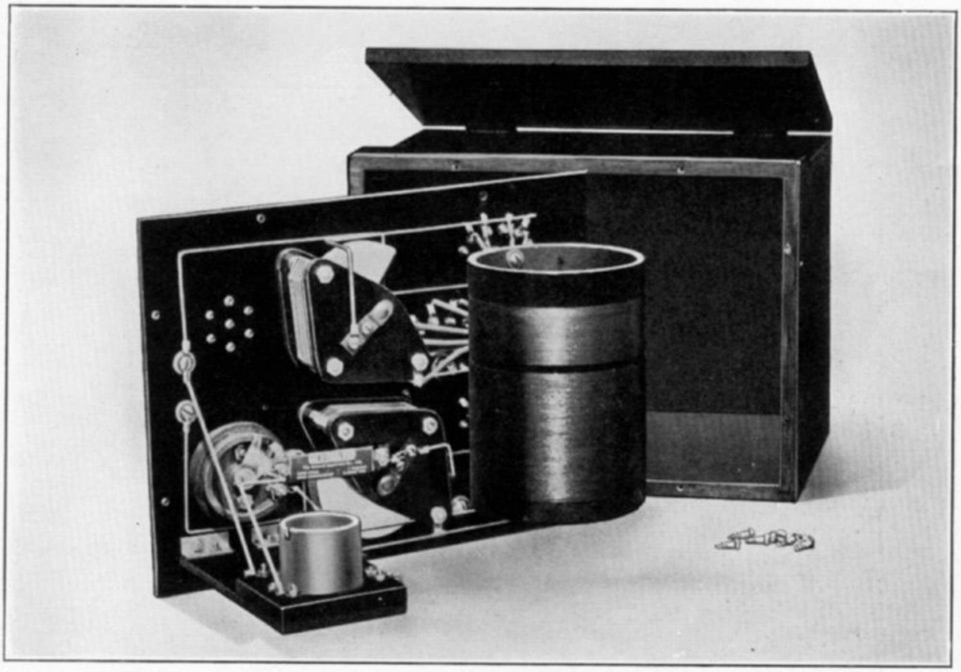

Fig. 3. Notice the small amount of hand work to be done in building the receiver. Connections, too, are simple

the tube with three small holes at the position of each tap and after the winding is put on as outlined above, the extra turns are cut and an end is inserted in the first and third holes and the two brought back together thru the second.

Drilling the Panel

The front panel is of 3/16-in. polished L. P. F. measuring 7½ by 10 ins., while a piece of the same material 2½ by 5 ins. is used to support the socket. Both panels are of standard sizes so that they may be obtained accurately cut and perfectly square. This is a less expensive way to buy the panels and it relieves the builder of considerable work on this part of the instrument. In Fig. 5 a scale drawing showing the location of all holes is given. This figure is exactly half size so that measurements made upon it must be multiplied by two before transferring to the work.

Assembling the Parts

The first step in the assembly operation is to secure the 6 stopping points and 19 switch points to the panel. A small copper soldering lug is fastened to each of the latter to accommodate the inductance taps. It will be found that some of the lugs will have to be turned inside the switch point arc to provide sufficient clearance for the condensers. Coil support pillars are next assembled to the panel where they are held in place by 3/8 in. 6-32 F. H. screws. These pillars are round nickel plated brass supports, 13/16 in. in length by 5/16 in. in diameter, tapped with a 6-32 thread in each end. The inductance tube is secured to them by 3/8 in. 6-32 R. H. screws which pass thru the No. 27 holes drilled for the purpose. The taps taken from the coil are enclosed in sections of empire tubing just long enough to reach from the coil to their respective

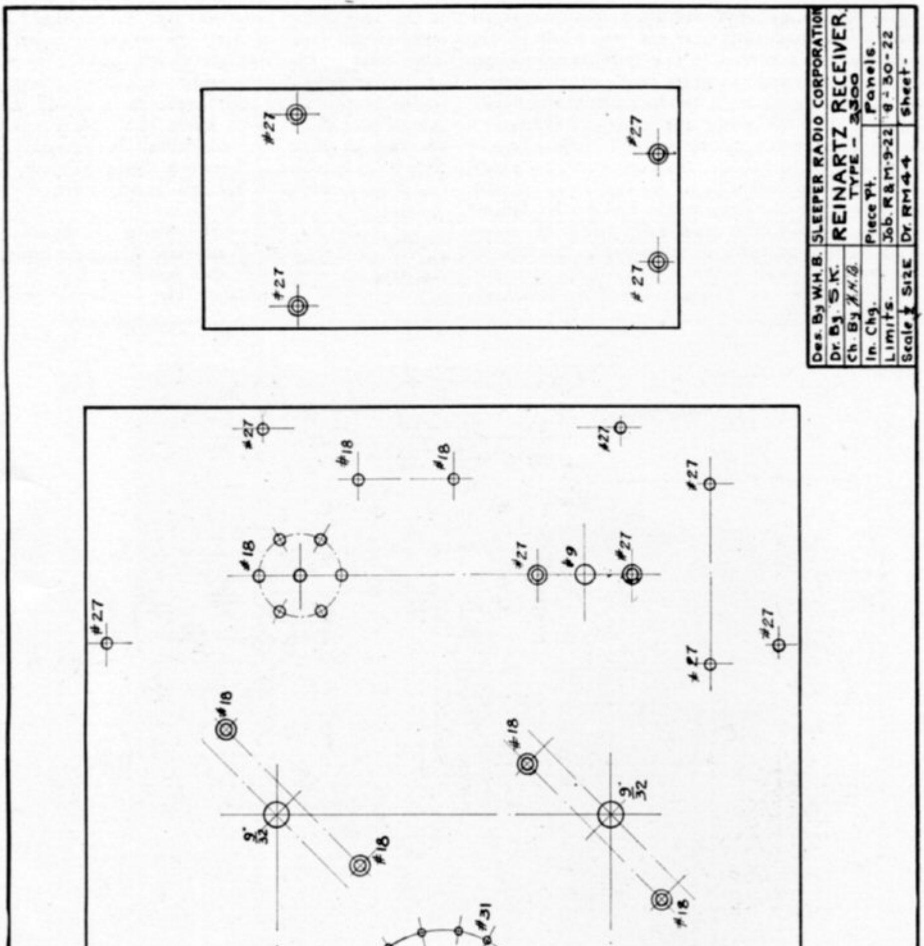

Fig. 5. A scale drawing, exactly one-half size, from which you can determine the location of the holes in the front panel

switch point lugs where soldered connections are made. The two taps and the two ends of the plate coil are soldered to the four switch points of the top switch, the start going to the switch point shown at the right on the front of the panel. The first ten taps of the next coil are soldered to the center switch with the start of the winding to the switch point nearest the center of the panel. The remaining taps lead to the lower switch with the end on the last point to the right. By following Figs. 4 and 6 it is practically out of the question to make an error in connecting the taps to their proper switch points.

Now put the two 11-plate variable condensers

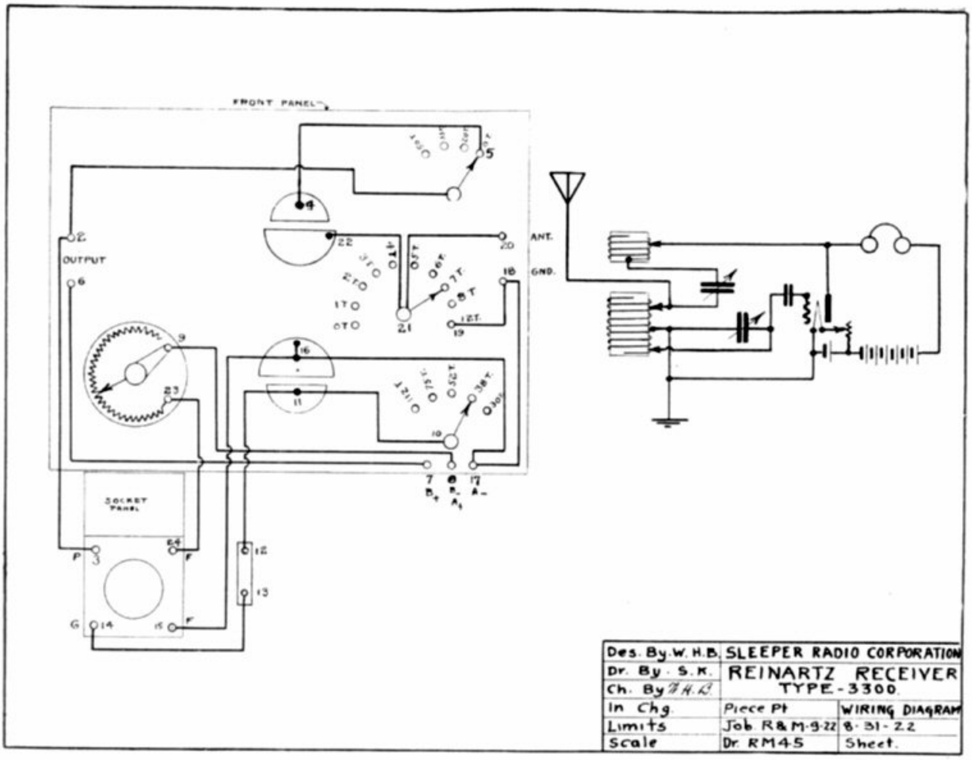

Fig. 6. A new system of showing the wiring is presented to the readers of R. & M. As long as you follow the numbers you can't make any mistakes

in place as shown in Fig. 3. The rheostat is held to the panel by means of two ½-in. 6-32 F. H. nickeled screws and nuts with which it is regularly supplied. A copper soldering lug should be placed under each resistance terminal and behind the seven binding posts before they are added. The socket panel is secured to the front panel by two nickel plated brass angle brackets 1 in. in length. These are held to both pieces by ⅜ in. 6-32 screws and nuts. Flat head screws are used on the small panel while round head screws are used on the front. The socket is fastened to the rear of its support by ⅝ in. F. H. screws and nuts. It is turned so that its filament terminals are toward the left of the instrument. A gridleak condenser is the only other unit that has to be added but since this is supported by the wiring it is left off until some of the connections are made. By way of preparing it for assembly a copper soldering lug is attached to each eyelet with R. H. 6-32 screws and nuts. This keeps the soldered joints far enough from the condenser to prevent the flux from running in between the paper and tinfoil sheets when the hot iron is applied.

Wiring the Receiver

All of the wiring is carried out using square tinned copper bus bar with copper soldering lugs at the terminals. The conductor should be kept perfectly straight except for right angle bends where the direction of the wire must be changed. Use a minimum amount of soldering flux, a hot soldering iron and not too much solder. This is important if neat joints are to be made. In Fig. 6 the wiring diagram of the receiver is given. At the right the theoretical circuit is shown while at the left the actual connections used in the instrument are drawn out. Proceed with the wiring in the order of the numbers given on the drawing, that is, first run a length of bus bar from point 1 to point 2 which is from the top switch blade to the top telephone terminal. A second conductor is soldered between points 2 and 3 while the third goes from 4 to 5. Points 6 and 7 are next joined and the wiring is continued by connecting the various units in the numerical order shown in the drawing. After all joints have been made they should be carefully wiped off to remove the excess soldering paste in order to make a clean job and prevent corrosion.

The instrument may now be placed in the cabinet and held there by means of ½ in. No. 6 R. H. nickeled wood screws. While this is a simple operation it requires care to avoid letting the screw driver slip and scratch the polished surface of the panel.

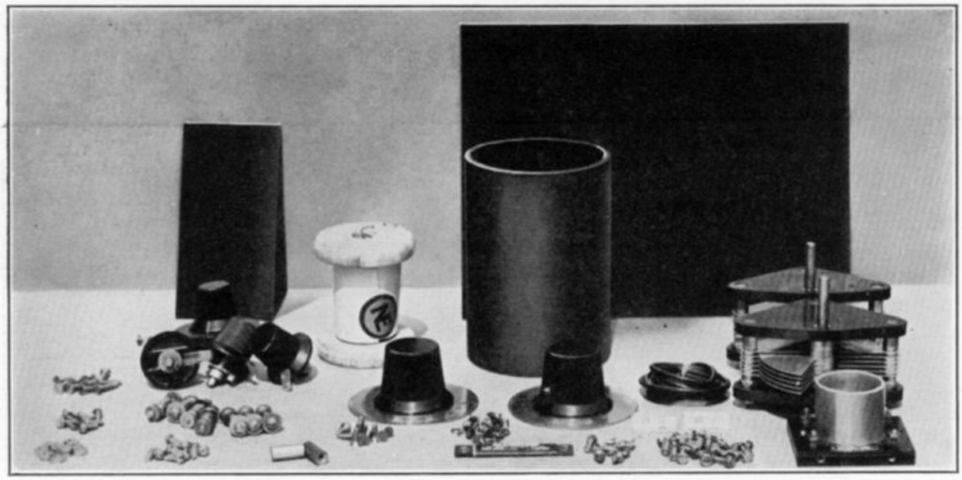

Fig. 2. All the unfinished parts are laid out to show you just what is required for the set

Notes on Operation

With the outfit completed, connect an antenna to the upper left hand binding post and the ground to the lower one. The positive of a 6 volt filament battery and the negative of a 22½ volt plate battery are connected together and led to the center of the three binding posts. The one at the left takes care of the negative side of the A battery while the positive of the B battery is wired to the right hand post. A pair of telephones or the input terminals of an amplifier are attached to the binding post at the right of the panel, a detector tube is placed in the socket and the outfit is ready for operation.

The lower switch and condenser control the wavelength of the system which with the inductance described covers a band of 130 to 750 meters. With the switch set at tap 1 wavelengths between 130 and 210 meters may be covered by a 180 degree rotation of the tuning condenser.

Fig. 7. In combination with the two-step amplifier this tuner makes a splendid outfit

The next tap covers 188 to 297, the third 267 to 419, the fourth 377 to 593, and the last 533 to 788. It will be noted that an overlap has been allowed between each tap sufficient to eliminate any possible difficulty in covering the entire range between the limits specified. Using this tabulation as a guide the point at which the tuning switch should be set for a desired signal may be determined. The center switch can be placed at point 6 and the plate inductance switch at point 2. To tune in the signal, set the coupling condenser at zero and adjust the tuning condenser for the desired wavelength. As soon as the signal is heard the coupling condenser should be increased to obtain regenerative amplification. If there is no point on its scale where the tube seems to oscillate or regenerate, increase the plate inductance by 1 or 2 taps and readjust the condenser. With this at its optimum value, vary the center or antenna switch for best signal response. It will usually be found that the adjustment of this switch is not critical and in most cases it will be used at its highest end.

In articles previously printed on the construction of Reinartz tuners a radio frequency choke coil has been recommended for use in the output circuit of the detector tube. This was tried in the instrument described but no improvement could be noted. The type 3100 amplifier was wired to the set and still the choke coil seemed unnecessary. However, it may be that such a coil will have to be used where amplifying transformers of a low primary impedance are used.

Additional Notes on the Laboratory Oscillator

A few extra notes on the Laboratory Oscillator, described in the August R. & M. may be helpful to those who have built the instrument.

With the oscillator connected and the variocoupler set at zero the filament temperature is increased until about half its normal brilliancy is reached when a low frequency buzz will be heard in the telephones. This indicates that the tube is oscillating at the low frequency. The coupling may now be closed and at a certain point a change in character of the note will be produced. When the windings are opposed, the outfit will oscillate well at low frequency alone, but when they are properly coupled a radio frequency period of oscillation will be produced as well. It will be found very interesting to note the changes in sound due to variations of the filament temperature, condenser capacity, and inductive coupling. Either an amplifier or a power tube may be used in the oscillator, depending upon the energy it is desired to radiate. Where a tube larger than the Radiotron amplifier is employed it may be found necessary to cut away a small portion of the L.P.F. tube of the variocoupler, since the clearance between it and the socket is very small.

An oscillator of this type has been used in the testing department of the Sleeper Radio Corporation for the past four months and has given complete satisfaction as a generator of signals of the exact character of those dealt with in actual receiving service. If the instrument is to be calibrated the chart should be made of the various condenser settings with the coupler at one definite adjustment, as a change in the mutual inductance between the two windings affects the wave length at which a signal is emitted.

The oscillator was given a test to determine its adaptability for short distance radio telegraph transmission one day during the unfavorable month of July. The duration of the test was less than two hours, but during this time telegraph signals were transmitted over a distance of two miles using a vacuum tube detector with no amplifiers at the receiving end. A plate potential of 45 volts was used with a telegraph key connected in series to break the circuit for forming dots and dashes. Considering the fact that this transmission was accomplished at a time when static prevented anything but local reception the results were extremely promising and the oscillator bids fair to replace the old time system of spark coil transmission.

Determining the Minimum Number of Taps for Units and Tens Switches

To find out the minimum number of taps for use with units and tens switches, by the ordinary cut and try method, is slow work. It is an easy matter, however to arrive at the correct number if the following method is employed:

Having decided upon the total number of turns in the coil, divide by the number of turns per unit tap. This is not necessary, of course, if the unit taps are to be brought off every turn. Take the square root of the number thus found. If the square root is not a whole number, discard the fraction and add 1 to it for both units and tens.

For example:—A coil has 213 turns, in three banks. It is possible to bring off unit taps only every third turn. Dividing, the answer is 71. The square root of 71 is 8.4. Discarding the fraction we have 8, adding 1 we get 9. Therefore, to give the least number of taps, there should be 9 points for each switch. The taps are then 0, 3, 6, 9, 12, 15, 18, 21, and 24 for units, and 24, 48, 72, 96, 120, 144, 168, 192, and 216 for the tens switch. Note that 3 turns must be added to the coil as an adjustment. The last units point and the first tens point are connected to the same inductance tap. Leads to the turning circuit are brought out from the switches.

Some Experimenters prefer to have the unused turns short circuited. This can be done by connecting the first units tap to the units switch and the last tens tap to the tens switch. Remember to solder in your taps in such a way that the inductance increases with a clock-wise rotation of the switch. It is rather confusing when two switches are used.

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EDITORIAL

HAVE you given your radio room its fall house cleaning too? If you let things slide a bit during the summer you'd better get out the old dust cloth and start to work. Throw all those odds and ends into the junk box, put the stuff that's good but of no immediate usefulness up on the shelf, arrange those books and magazines in an orderly fashion, clean up the tool box, and get things generally in spic and span condition.

I'm not telling any secrets when I say that there is really worth while work ahead for the winter. Probably you've felt it in the air. Aside from a few things I know about definitely, and others which will be disclosed by various sources, there must be dozens of new things worked out by the thousands of minds now busy experimenting with this or that.

In response to the editorial a few issues back, a number of Experimneters have submitted their ideas to the engineering staff of R & M. They have been given considerable assistance. To those with inventions of practical value advice concerning patent protection has been given, and aid in connecting with manufacturers able to make the greatest use of this idea. Obviously, an inventor prefers to market his product thru a concern able to provide national distribution rather than one able to make only local sales. Others, who have had ideas of too limited application have been saved from the expense and time they might have spent fruitlessly, and guided into channels of more productive thought.

Frequently the question is asked, "How can I disclose my invention for your report as to its value and patentability without hazard to my rights?" The answer is simple. Make up a rough sketch, accompanied by a very brief description. Sign it, and have the sheet stamped by a notary. In that way the date of conception is established. You will find that we can assist you greatly by giving advice about work already accomplished along lines you are pursuing. Patent searching and legal aid are for attorneys, whose fees are high. However, the familiarity of the engineering staff with American and foreign publications makes available, with no cost or obligation to you, much information that patent councellors do not have, and charge a great deal for if they are asked to get it.

Robert Gowan, the man who put Ossining on the radio map, has brought back an interesting story of his work in China. Because, altho he was treated royally by the Government officials, he didn't like the idea of staying permanently in the Orient, it was necessary to train a staff of Chinamen to handle a series of radio telephone stations he erected there. These men, unable to speak English, were taught by a series of lectures written by Mr. Gowan and translated by an assistant. In checking over the Chinese version, he found "armature" indicated by a word meaning "bundle of wires." Later on, the same word was used for "choke coil," "transformer," and "impedance coil." While they were all bundles of wire, they could not be indicated by the same term. Failing to discover more descriptive equivalents, he taught them the English words. It is very likely that Mr. Gowan's influence was in this way firmly implanted in the development of China's radio future.

I wish to take this opportunity to thank experimenters whose letters were not acknowledged individually for the suggestions sent in response to the editorial request for ideas on vacuum tube transmitters. The first set to be described is now under way. The data on it will probably appear in the coming number of R & M. The design may not be just the thing that every one wants but we have tried hard to meet the requirements of the majority as indicated by their letters.

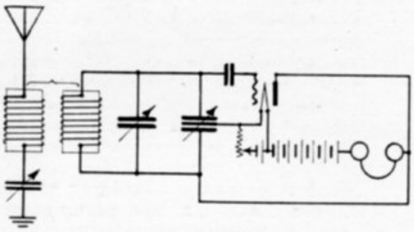
You will find quite a surprise in the next R & M, which we have worked hard to put in shape and I am sure it is something that you will be very glad to see. It is another step forward in the steady progress which we must maintain for R and M. Another announcement along this line will be made in the October issue. I want to demonstrate to you that the fundamental idea behind R and M—that of making radio work interesting to Experimenters—is not a mere slogan but an aggressive policy.

M. B. SLEEPER,
Editor.

REGARDING RENEWALS
All subscriptions are discontinued as they expire, and if you find a renewal blank in your copy of the magazine it indicates that your subscription expires with that number. Subscribers will please be prompt in sending in renewal remittance so that the next copy of the magazine will not be missed. Please sign your name exactly as it appears on your present address. If you have changed your address, give the old address as well as the new one so there will be no delay in locating your name and making the necessary change.

101 Receiving Circuits

Sixth Installment



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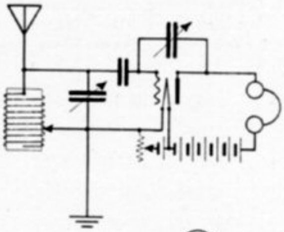

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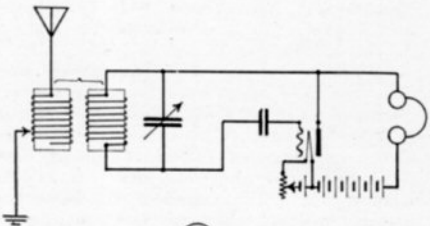
50. Electrostatic feed-back coupling between the grid and plate circuits of a detector tube is here accomplished by a condenser designed especially for the purpose. It consists of three plates or three sets of plates, two of which are fixed while the third is movable between them. When the center or variable plate is varied, the capacity between it and one stationary plate is increased and the capacity between it and the other is simultaneously decreased. It will be noted that the two plates which are connected to the secondary tuning condenser have a fixed separation so that the adjustment of the feed-back condenser does not affect the tuning of the receiver. The capacity between the fixed plates is so small that the wave length of the closed oscillatory circuit is not seriously increased by the use of this electrostatic feed-back. During the World War, this method of obtaining regeneration was employed in some of the best receivers in military and naval use. In some cases, it was used in conjunction with an inductive feed-back, while in others, the circuit was practically that shown in this diagram.

51. A condenser of relatively small capacity may be connected from the grid to the plate of a detector tube to cause the receiving system to oscillate. Such a circuit is shown in this diagram. The adjustment of the coupling condenser is usually very critical and it has some effect upon the wave length to which the set is tuned. The method is seldom used exception long wave reception.



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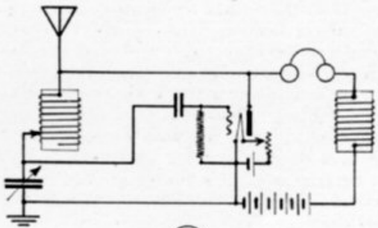

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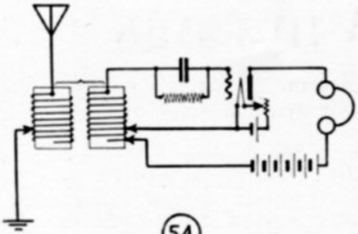
52. This diagram shows the ultra-audion circuit, an invention of De Forest. The circuit is a persistent oscillator adapted for use in undamped wave reception. The usual tuner is employed but instead of connecting to the grid and filament elements of the detector tube, the grid and plate are used. A circuit of this kind is not to be recommended for telephone or damped wave telegraph reception where the true tone of the transmitter is to be preserved.

53. While this type of circuit makes a good receiver for undamped or continuous waves, it is usually employed for transmission purposes. A variable inductance and capacity are wired in series between the antenna and ground for tuning the circuit, and connection is made to each of the three elements of the vacuum tube detector in the manner shown. Owing to the fact that the tuning system is in shunt with the plate circuit, it is necessary to place an inductance in the latter to prevent the currents of the frequency of the incoming wave, from taking this course from the antenna to ground. It should be noted that in this case the grid-leak resistance goes from the grid to the filament, rather than across the grid condenser. The reason for this is that the grid would otherwise be placed at nearly plate potential preventing the efficient operation of the set.



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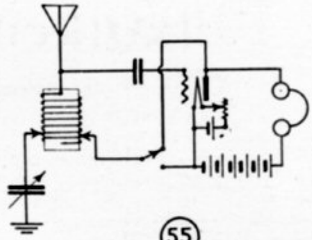
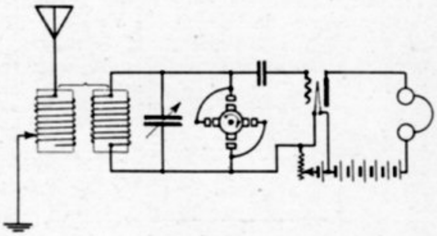


(55)

54. In this circuit feed-back is obtained through the proper selection of inductance in the secondary of a loose coupler. Two variable contacts are provided, one of which leads to the filament of the audion detector while the other goes to the negative side of the plate battery. In this way, portions of the same coil are included in the grid and plate circuits of the vacuum tube, thereby providing the necessary coupling for regeneration or oscillation. When the two variable contacts are placed on the same point of the inductance a non-regenerative circuit results, functioning exactly the same as circuit No. 36, but by increasing the distance between them, the circuit can be made to regenerate or oscillate.

55. A single pole double throw switch may be wired into a simple audion circuit in such a way that the set may be conveniently changed from a damped to an undamped wave receiver. This diagram illustrates the method. The blade of the switch is connected to the ground side of the tuner, while the plate and filament of the vacuum tube are each wired to a switch point. When the switch is thrown to the filament pole, a simple non-regenerative circuit is formed, but when in the other position, the circuit becomes an ultra-audion. This is a very practical arrangement, and is not only found in some makes of amateur and experimental equipment, but in apparatus for government use as well.



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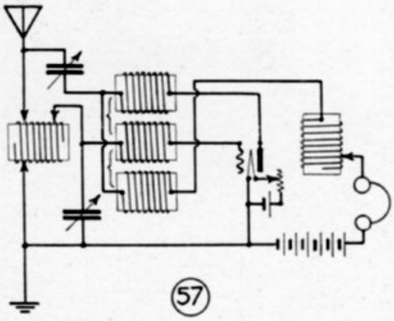

(57)

56. Although designed for continuous wave reception, this is a non-regenerative circuit. Undamped waves are made audible by alternately detuning and tuning the system to resonance with a desired transmitter at a frequency within the range of the ear. This rapid change in adjustment is accomplished through the use of a rotary tone condenser connected in parallel with the secondary tuning condenser. The device consists of a stationary and a rotary unit arranged so that the capacity between the two changes from minimum to maximum a number of times during a single revolution of the rotating member. The rotor is mechanically connected to the shaft of a small motor which drives it at a constant speed. The variation in wave length of the circuit due to the action of the rotary tone condenser is not sufficiently great to cause the receiver to respond to signals over too broad a band of frequencies.

57. This is one of the improved circuits of the Reinartz tuner. Although this receiver is a little more complicated than the sets previously discussed, it has become quite popular among amateurs in both America and England. It incorporates both electro-magnetic and electro-static methods of feed-back and possesses the advantage of not requiring a change in feed-back coupling for each variation in tuning. Two variable condensers are provided, one for tuning purposes and the other for regulating the degree of feed-back. To keep the radio frequency energy from passing through the telephone circuit, a variable inductance is used as a high frequency choke in the plate circuit. Owing to the fact that this does not exclude all of the energy which it is intended to keep out, a second coil is connected in series with it and coupled to the input side of the tube. While not necessary for efficient operation of the tuner, its addition improves receiving results considerably.

Banked Windings

Here are directions for bank windings so specific that you cannot make mistakes.

REFERENCE is frequently made in articles in R & M to bank windings. Altho it is possible, usually, to buy the coils all wound the real Experimenter wants to do this work himself. Directions have been given but apparently they are not sufficiently specific to enable many Experimenters to accomplish this work.

The first requisite for good results in coil winding is a simple rig to hold and turn the tube. Fig. 1 shows a winder that can be made at very little expense and, when used in our laboratory, gave such good results that it was universally adopted for our work. It meets the important requirements which are simplicity, sturdiness, easy access for coil changing, and a means for counting the number of turns.

The active part of the machine is simply a Goodell-Pratt buffing head, designed for round belt drive. The cost of this part is about three dollars. At one end is a disc clamped to the shaft by nuts provided, and fitted with a handle for turning. Opposite, is a wooden disc which you can turn yourself or have made up in a local carpenter shop. The diameter is smaller outside than the hole in the tube, and a little larger next to the shoulder. A similar disc turns freely on a pin set into the wooden upright corresponding to the tail stock. Because 5 inches is a standard tube length, the tail stock is fastened to the bench by a hinge secure with wood screws. The upright, however, might have been fastened to a grooved strip of wood, sliding along corresponding grooves in strips at each side. Then the tail stock could be adjusted to any length of tube and held in place by a single screw or nail in the bench.

The counter is of the ordinary Veeder type intended for fixed mounting and operation by a pin striking a wheel on the shaft. We found it easier, however, to remove the wheel and insert the shaft in a hole drilled into the handle end of the winder shaft. To keep the counter itself from rotating it was then necessary to secure a weight to thg under side of the counter. This probably sounds more difficult than it actually was in practice.

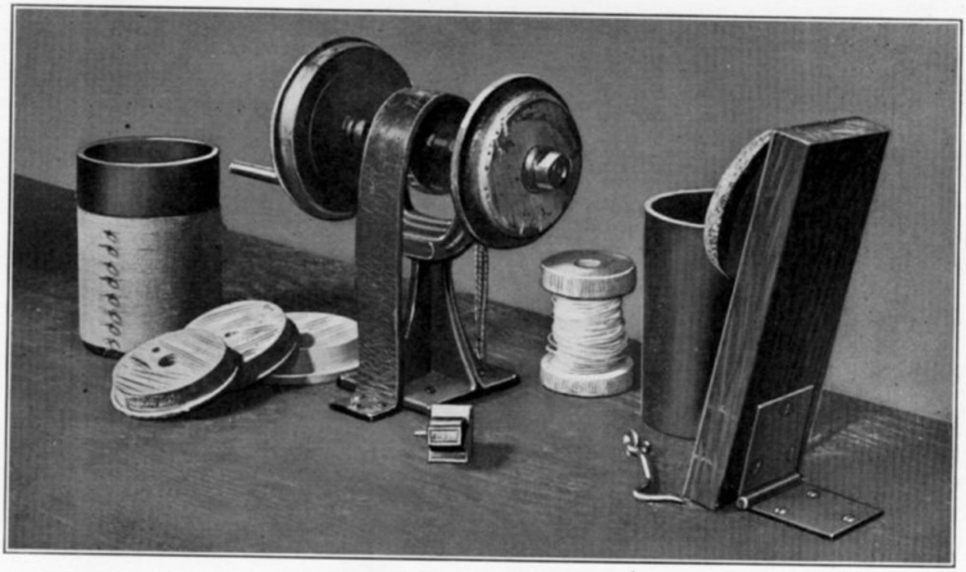

Fig. 1. Parts for the winding rig. Wooden discs for various coils are shown, and the revolution counter, with its compressed tinfoil weight. detached from the shaft

One of the great difficulties experienced in hand winding without a machine is that of keeping the coil from slipping backward. Therefore, a brake is necessary. This is merely a strip of leather belting fastened to the bench at one end and connected at the other by a strong rope running thru a hole to a foot-treadle. When the treadle is pressed the belt binds tightly on the pulley.

A series of illustrations in Fig. 2 show the successive steps for 3-bank winding. Very heavy wire was used to show plainly the exact steps followed. For clearness let us consider them by number.

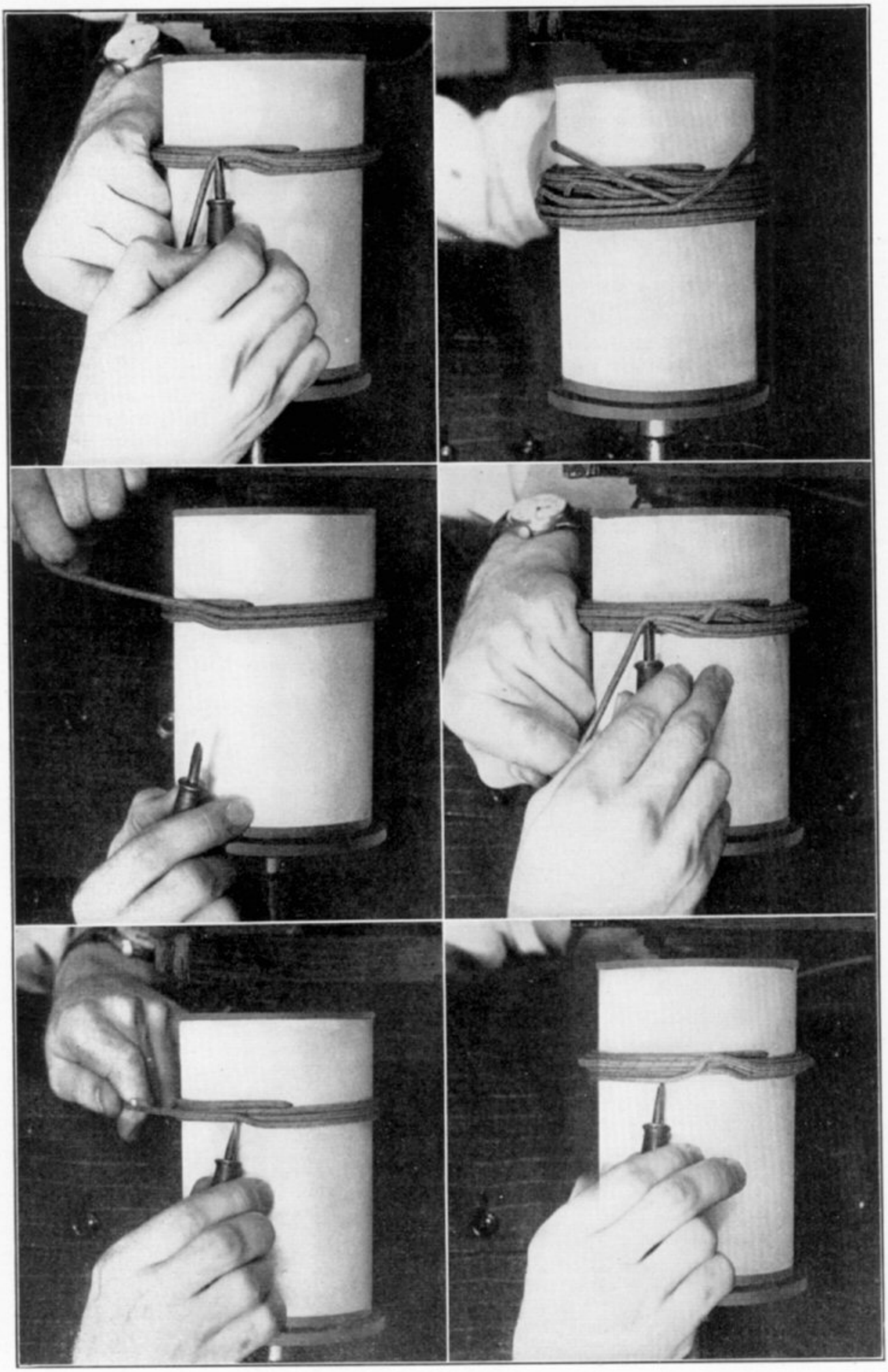

Fig. 2. Six views of the steps employed in winding and tapping a three banked inductance. Heavy wire is used to give a clear idea of the position of the wires

1. To overcome complications from slipping it is necessary to prepare the tube before the coil is wound so that each wire will stay in its place. Rather than put varnish on the wire while it is being wound, it is best to varnish the tube and permit it to dry for a few hours. That makes the tube just sticky enough to hold the wire in place. When permanence is of great importance, the best scheme is to varnish the tube and bake it, until perfectly dry, in a gentle heat. As soon as the coil is removed from the oven, it should be given another coat of varnish with the least possible amount on the brush. In this way the tube is shrunk properly after it has been slightly expanded by the first coat. Valspar varnish is one of the best coatings for inductances because it is entirely moisture proof.

2. Wind three complete turns around the tube. Hold the coil in position by pressure on the foot-brake. Opposite the start of the winding bend the wire toward the start and bring it up over the previous turn. Press the blunt screw driver against the wire right at the point where it comes up on the previous turn and bend it sharply toward the screw driver. Then bring it down between the wires as shown in the illustration of the 1st step. Now wind on two complete turns and your coil will look like the one in the second illustration.

3. Now you have five complete turns and your coil is two layers deep. Keep an even pull on the wire at all times. At the end of the fifth turn bring the wire up on the second layer between the two turns which comprise it.

4. Wind one turn more, completing six turns, the first section of the bank winding. You will be tempted, probably, to bring the wire down right at the end of the sixth turn but carry it along just a little bit, as in the third illustration so that the end of the sixth turn will hook over the start of it. That will keep the top turn in place. Bend the wire sharply against the screw driver and bring it down carefully on to the tube in preparation for the next set of banks.

5. The fourth illustration shows the appearance of the end of the sixth turn and the start of the seventh. It is very necessary to have the wires close together at the point where the screw driver is pressing against the wire.

6. After completing the seventh turn wind the eighth over it and also the ninth. The fourth picture shows the end of the ninth turn and the operator, as before, hooking the end of the turn over the beginning of it, ready to bring the wire down on to the tube and start another bank.

7. In the last illustration several banks have been completed and a tap taken off. This method of tapping single or multiple layer coils, originally shown in R & M, has not always been understood but, once grasped, it is clearly the most satisfactory way to tap any coil. You will see that, instead of continuing one of the top turns, the wire is carried to one side and one turn wound over the tube, ending right where it started. The winding is then continued as before. In the meantime a loop is left which, when the coil has been varnished and dried, can be cut and twisted at the point where the wires cross. If a lead of normal length is required, the loop can be cut diametrically opposite the start, in which case two wires of equal length will be provided to carry off to the switch point. If you want a single wire lead or a very long lead you can cut the loop right near the start, giving a long end and a short end. The two should then be twisted together and the shorter one soldered to the longer.

8. With the coil completed put on one very thin coat of varnish and dry it for a day or two in the open air or for eight hours in a very gentle heat. Then the taps may be cut without danger of loosening the wire.

The same scheme can be carried out for 2-bank coils or windings requiring more than three banks. In the case of the 2-bank coil it is started with two complete turns instead of three. The third turn is brought up and wound between the first and second, then brought down on the tube for the fourth turn and up on the fourth for the fifth. The whole secret of success comes in using the blunt screw driver to give sharp bends to the wire and hooking the end of a top turn over the beginning of it.

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