June 27, 1939. P. WARE 2,163,645

INDUCTIVE TUNER

Filed Aug. 8, 1936 3 Sheets-Sheet 1

Fig. 1

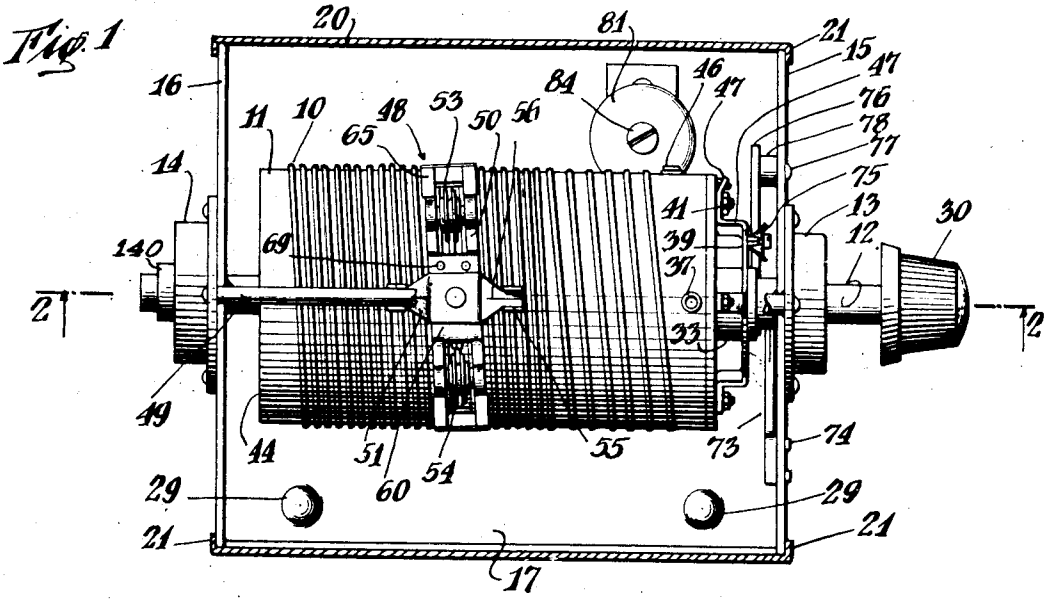
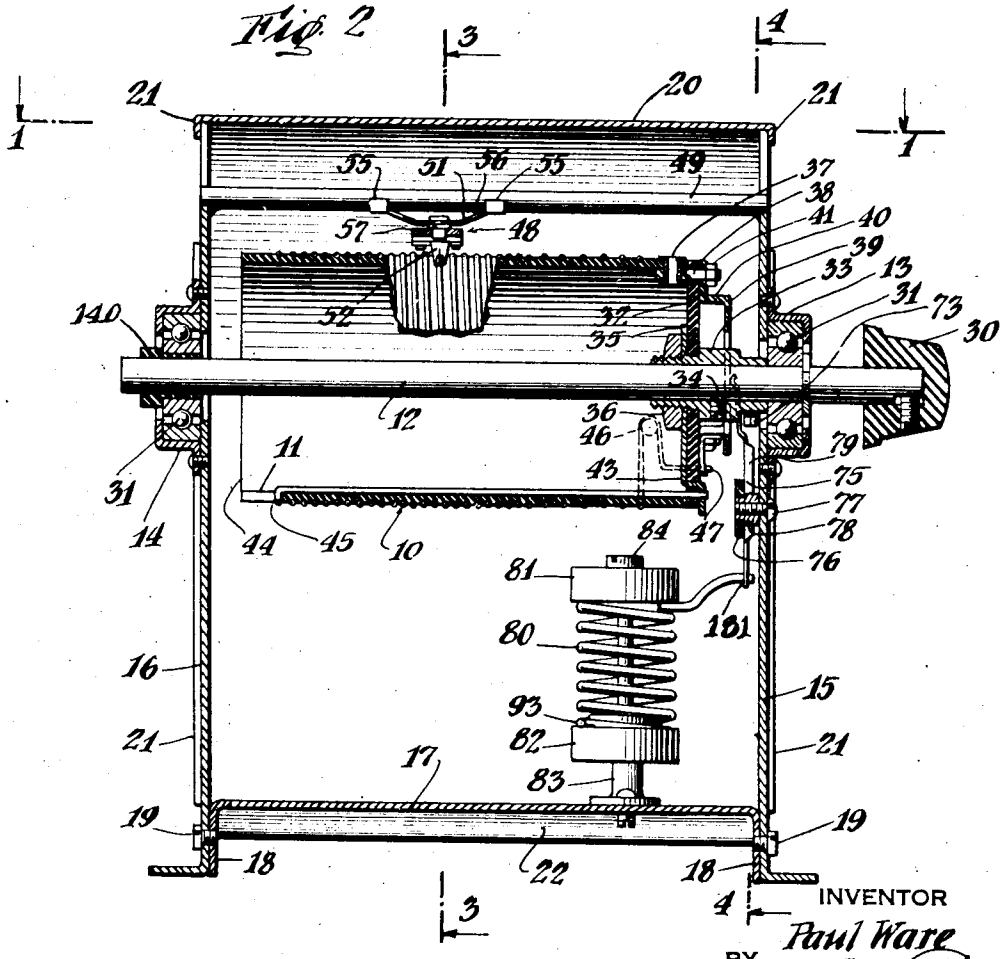


Fig. 2



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Fig. 3

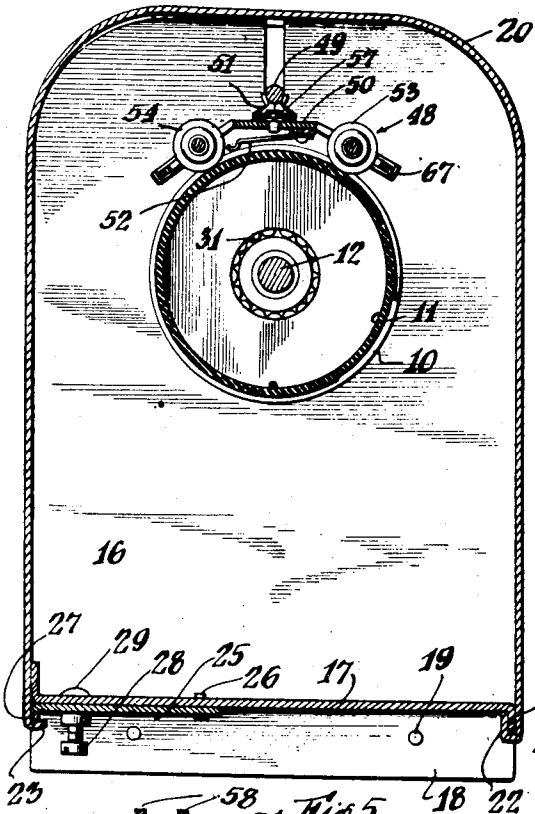


Fig. 4

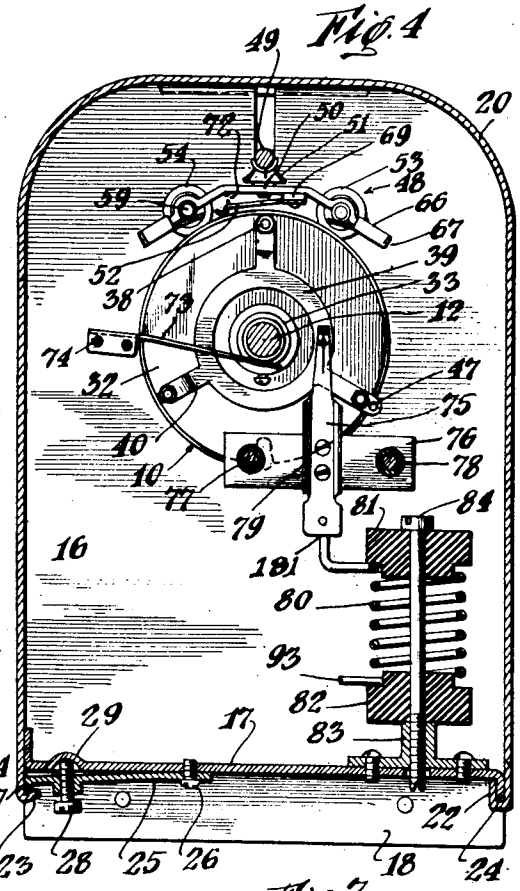


Fig. 5

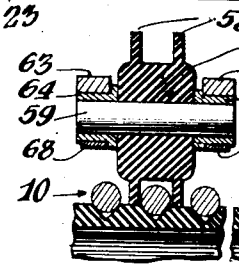


Fig. 6

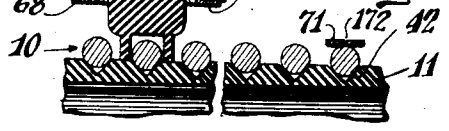
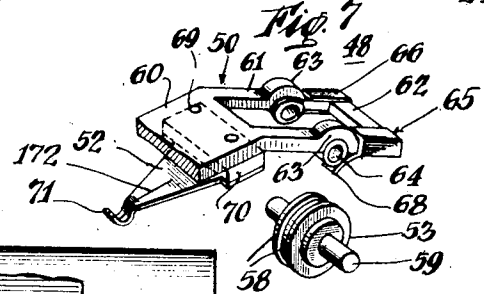


Fig. 7



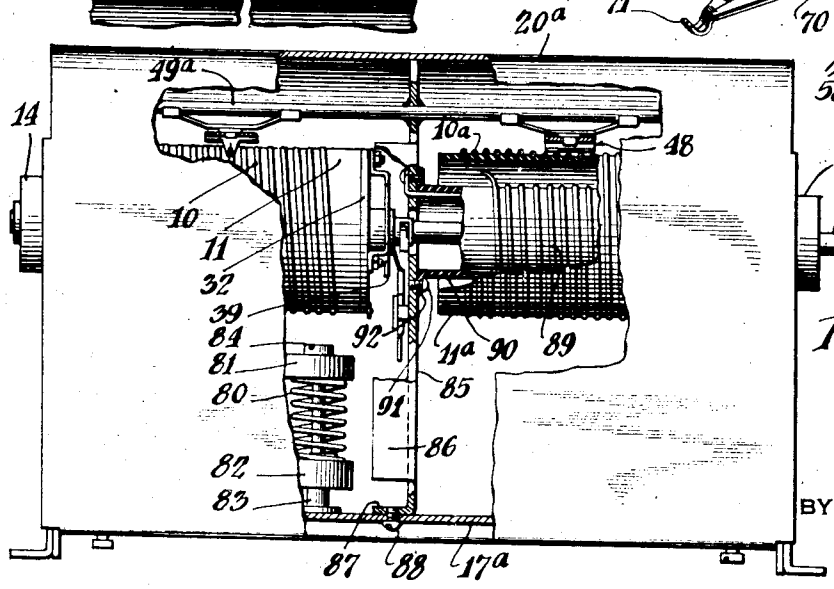


Fig. 8

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Fig. 9

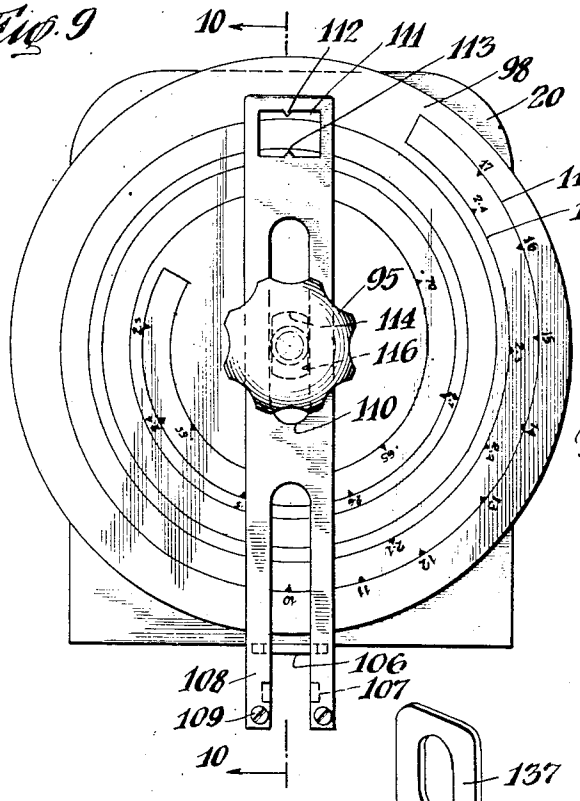


Fig. 10

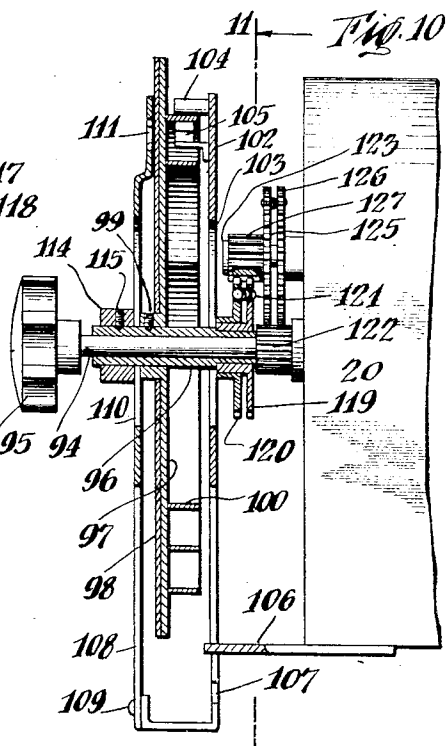


Fig. 12

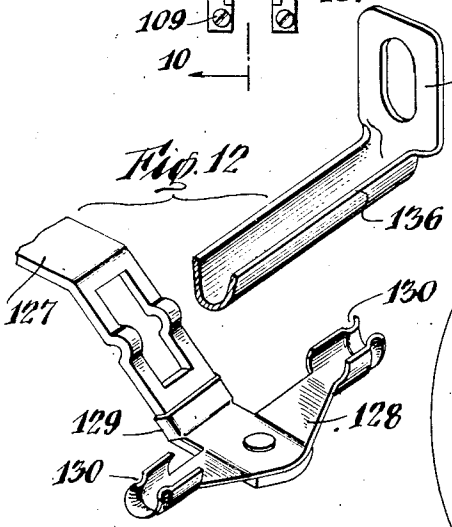


Fig. 11

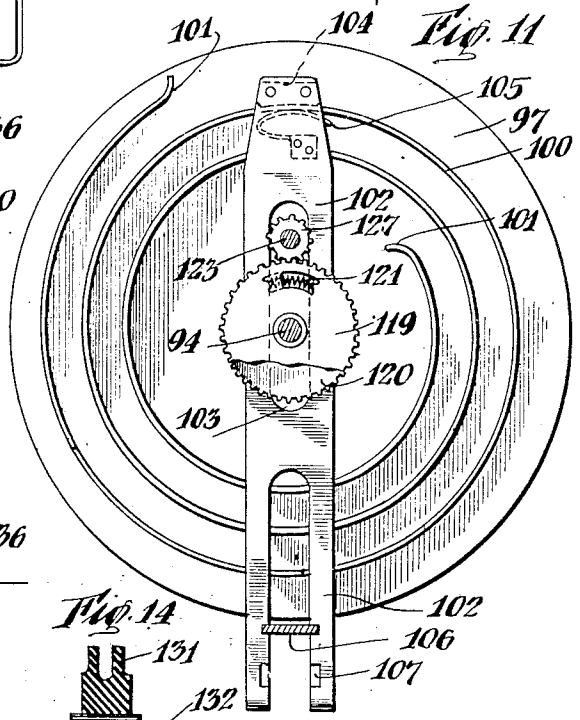


Fig. 13

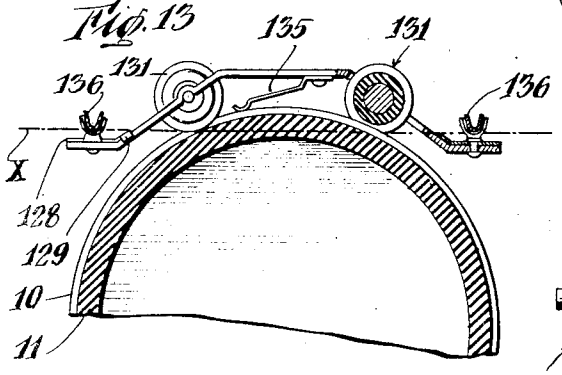
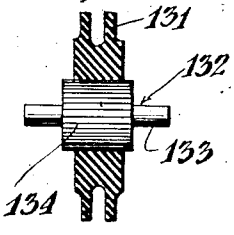


Fig. 14



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Patented June 27, 1939 2,163,645

UNITED STATES PATENT OFFICE

2,163,645

INDUCTIVE TUNER

Paul Ware, Indianapolis, Ind., assignor to P. R. Mallory & Co., Inc., Indianapolis, Ind., a corporation of Delaware

Application August 8, 1936, Serial No. 94,927

17 Claims. (Cl. 171—119)

This invention relates to tuning devices and more particularly to variable inductances for tuning radio receivers and the like.

This application comprises a continuation in part of my application for Radio apparatus Serial No. 31,823, filed July 17, 1935.

An object of the invention is to provide an improved tuning device.

Another object is to improve the structure of a variable inductance device.

A further object is the provision of a tuning arrangement and apparatus for radio receivers which will allow stepless tuning over an extensive frequency range.

Other objects of the invention will be apparent from the following description and accompanying drawings taken in connection with the appended claims.

The invention comprises the features of construction, combination of elements, arrangement of parts, and methods of manufacture and operation referred to above or which will be brought out and exemplified in the disclosure hereinafter set forth, including the illustrations in the drawings, the scope of the invention being indicated in the appended claims.

For a fuller understanding of the nature and objects of the invention as well as for specific fulfillment thereof, reference should be had to the following detailed description taken in connection with the accompanying drawings, in which:

Figure 1 is a top view, partly in section, of a tuning device arranged according to one form of the present invention;

Figure 2 is a section on the line 2—2 of Figure 1;

Figure 3 is a section on the line 3—3 of Figure 2;

Figure 4 is a section on the line 4—4 of Figure 2;

Figure 5 is a detailed view illustrating the guide trolley for the slide contact and also illustrating an improved means of making the coil form;

Figure 6 is a detail view illustrating the contact between the slide and the wire coil;

Figure 7 is a detailed exploded view of the contact carriage with parts broken away;

Figure 8 shows a modification of the tuning device comprising two ganged variable inductances;

Figure 9 is a face view of a dial arrangement adapted for use with the tuning device;

Figure 10 is a section on the line 10—10 of Figure 9;

Figure 11 is a section on the line 11—11 of Figure 10;

Figure 12 is a detail view of certain parts of a modified contactor structure;

Figure 13 is another detail view of the modified structure; and

Figure 14 is a section through a modified trolley wheel.

While a preferred embodiment of the invention is described herein, it is contemplated that considerable variation may be made in the method of procedure and the construction of parts without departing from the spirit of the invention. In the following description and in the claims, parts will be identified by specific names for convenience, but they are intended to be as generic in their application to similar parts as the art will permit.

In providing a variable inductance device which will operate satisfactorily for low and high frequencies, a number of problems are encountered, some of a mechanical nature and others principally electrical in nature. For instance, shielding of parts is important, both from an electrical standpoint and as structural protection for the unit against dirt, dust and moisture. The apparatus must be so constructed as to insure satisfactorily long life. Also of importance is the requirement that the device be easy of manipulation, constant in response and capable of satisfactory operation even when used by a person entirely unfamiliar with the apparatus.

The present invention not only meets the above requirements but provides a greater frequency tuning range than that obtainable by prior methods such as by the use of variable condensers, without extensive switching from one frequency band to another. The structure employed makes possible the tuning of a radio receiving set to any frequency in present day broadcast and short wave bands without the requirement of more than two switching positions. It is possible, in fact, to obtain a frequency tuning ratio of 11 to 1 without switching. The structures herein described are suitable, for example, for use in circuits such as those disclosed in my application Serial No. 94,928 for Tuning circuit filed concurrently herewith.

Referring to the drawings, the variable inductance device of the present invention may comprise an inductance coil 10 mounted on a rotatable form 11 of insulating material. The coil 10 and the form 11 upon which it is mounted are supported for rotation by a rotatable shaft 12

which is rotated in bearings 13 and 14 mounted in end plates 15 and 16 of the unit.

The case of the unit, which also serves as an electrical shield, comprises a bottom plate 17 having turned down edges and parallel upstanding end plates 15 and 16 which are secured to the end flanges 18 of the bottom plate 17 by machine screws 19. The upper corners of end plates 15 and 16 are rounded off and a correspondingly rounded cover 20 fits over the edges of end plates 15 and 16 to provide a top and side wall for the unit. Cover 20 is provided with flanges 21 which press against the outer faces of end plates 15 and 16 and is also provided with a pair of hook flanges 22 and 23 adapted to hook under the side flanges on bottom plate 17.

The cover 20 is secured in position in the following manner: Hook flange 22 on cover 20 is first hooked under flange 24 on bottom plate 17 and the rest of cover 20 is fitted over the edges of end walls 15 and 16. Bottom plate 17 is provided with an anchoring plate 25 secured along one edge of its lower surface by screws 26. Rivets can, of course, be used in place of the screws. Plate 25 is provided with a down turned flange 27 along its outer edge and flush with the edge of plate 17. Plate 25 is provided, near its outer edge, with a pair of tightening screws 28, the ends of which rest in recesses 29 in bottom plate 17. After cover 20 has been fitted over the unit, flange 23 is hooked under the edge of flange 27 on anchoring plate 25 as indicated in Figure 3. Screws 26 may then be tightened so as to spread plates 17 and 25 apart as indicated in Figure 4. This results in a tightening of cover 20 over the unit and it will thereby be held securely in place and can only be removed by loosening screws 28. The tightening insures a good, permanent electrical contact between the shield parts 17 and 20 and also renders the mechanism dust proof.

The shaft 12, upon which coil form 11 is supported for rotation, passes through end plates 15 and 16 and may extend beyond them at each end. A knob 30 may be secured to one end of shaft 12 so that it may be rotated manually or other rotating means may be provided. In a radio set knob 30 may be the control knob provided on the panel of the radio set for tuning to the various frequencies at which signals are received. The bearings 13 and 14 for shaft 12, secured to plate 15 and 16, respectively, may comprise ball bearing assemblies having ball bearings 31. The shaft is of hard copper. An insulating sleeve 40 may be provided at one end of the shaft, as shown to insulate it from the bearing and thus prevent any electrical noise which might otherwise be caused due to slight potential differences induced by the radio frequencies.

Coil form 11 is a hollow cylinder of insulating material, such as Bakelite or ceramic. It is rigidly secured for rotation with shaft 12 by end disc 32 of insulating material. A threaded sleeve 33 is secured to shaft 12 by set screws 34. End disc 32 is clamped between a shoulder on sleeve 33 and a metal ring 35 by nut 36. Form 11 is tightly secured against the face of disc 32 by a plurality of eyelets 37 and spade bolts 38 held by nuts 41 as indicated in Figure 2.

A slip ring 39 is mounted on the outer face of disc 32 and supported in spaced relation thereto by a plurality of legs 40 on ring 39. Legs 40 are held on spade bolts 38 by nuts 41.

A V-shaped groove is cut in form 11 in which the wire is tightly wound. The shape of the groove 42 is shown in Figure 6. It will be noted that the angle between the two sides of the groove is 90°. The groove has been cut to have a constant distance from the axis of the form 11. The wire rests on the sides of the groove. By this arrangement any eccentricity in the form will not result in eccentricity in the coil and hence more uniform coils may be constructed.

In the preferred method of applying the wire to the form it is preferably first attached at one end to lug 43 on ring 35. The wire is carried through the inside of cylindrical form 11 to its open end 44 where it is passed through nick 45 to the outside of the form and is there wound in groove 42 machined in the outside surface of form 11. Care is exercised to wind coil 11 tightly in place and when the coil has been completely wound it is looped around eyelet (or rivet) 46 located near the end of form 11 and the free end of the wire is then soldered to one of the legs 40 of slip ring 39 as indicated at 47.

It will be noted that the pitch of coil winding 10 is not constant but is greater at the right-hand end of the coil as shown in Figure 1 than at the left-hand end. With a coil 3 inches long and 1¼ inches in diameter approximately 36 turns may be provided, for example, of which 7 or 8 turns may have a pitch of ⅛ inch and the remainder of the turns a pitch of $\frac{1}{16}$ inch. Thus, slightly more than one-third of the coil may have a wide pitch and the remainder a narrow pitch. The variation in pitch of the coil enables easier tuning of the inductance when only a very few turns at the right-hand or high frequency end are in the circuit and tends to equalize the percentage change in inductance for a given rotation of the coil over its length.

The coil 10 is preferably formed of hard drawn copper wire of circular cross section plated with a smooth uniform closely adherent layer of silver. It is possible, however, to use other base metals such as hardened copper alloys or other highly conductive metals and other platings may be substituted for the silver such as for example rhodium plating. When silver plating is used, it is processed with a thin lanum oil solution to retard sulfiding and oxidation. This insures a permanent bright and untarnishable conducting surface on the wire over which the contactor may slide. By applying the silver plating to a hard wire base, such as hard drawn copper wire the tendency toward working and cracking of the silver is reduced to a material extent so that a considerably longer life is obtained.

The number of turns of coil 10 which are connected in the tuning circuit is controlled by contactor 48 which makes sliding contact with coil 10 and contact bar 49 parallel to a side of coil 10. Contactor 48 comprises metal frame 50, spring contactor 51 for making contact with contact bar 49, spring contactor 52 for making contact with coil 10 and trolley wheels 53 and 54 of insulating material, for guiding contactor 52 along wire of coil 10. Metal frame 50 comprises a central table portion 60 extending from which are a pair of angularly disposed portions integral with its two ends. These portions each comprise a pair of side arms 61 connected integrally to table portion 60 and a cross arm 62 connecting the extremities of the side arms. Each pair of side arms 61 are stamped up into aligned U-shaped portions 63 to provide for mounting the trolley wheels 53 and 54.

Contact spring 51 which makes sliding contact with contact bar 49 is an elongated piece of spring metal such as phosphor bronze riveted at

its center to the upper face of mid-portion 60 of contactor frame 50. The two arms of spring contactor 51 normally extend upward and outward from the mid-portion and rest against the under surface of contact bar 49. These arms are tapered toward their ends to a width approximately equal to the diameter of the contact bar and are each provided with a pair of ears 55 which are bent around the sides of contact bar 49 and serve to guide the contact tips along the surface of the bar. The two arms are split along their center as indicated at 56 to provide bifurcated contact tips. This insures uniform contact at all times. However, the contact tips of spring 51 are sufficiently yieldable to allow the contactor 48 to adjust itself to the variations in pitch of the coil 10. Lock washer 57 is interposed between spring contact member 51 and table 60. It will be noted that there are, in effect, four individual contact surfaces between spring 51 and contact bar 49.

Trolley wheels 53 and 54 may be of molded Bakelite. Each wheel has a pair of spaced flanges 58 as seen most clearly in Figure 5. Flanges 58 are spaced apart by a distance slightly greater than the diameter of the wire of coil 10. The depth of the grooves between flanges 58 is greater than the height of the wire of coil 10 above the surface of coil form 11. By this arrangement the trolley wheels will clear the top surface of the wire and they are are thus prevented from disturbing the wire surface and its coating along the path travelled by sliding contact 52. Thus wheels 53 and 54 may rest on the coil form with the edges of flanges 58 against the surface of the form as indicated in Figure 5 and the trolley wheels 53 and 54 will be guided by the wire.

The trolley wheels are each provided with a metal spindle 59 which may be molded into the insulating material of the wheel; the wheels are each mounted in the aligned grooves formed by U-shaped portions 63 in side arms 61 of frame 50. The ends of spindles 59 are inserted in pairs of bushings 64 which are held in the U-shaped portions 63 of the frame by spring clips 65.

Spring clips 65 are each provided with flanges 66 and 67 bent into a box-like form so as to be adapted to receive an end of frame 50. The spring clips are also each provided with a pair of integral leaf spring arms 68 which extend along the lower faces of arms 61 of the frame and retain bushings 64 in U-shaped portion 63 by spring action. Trolley wheels 53 and 54 are thus mounted for rotation in frame 50 and held in position by spring clips 65. Bushings 64 are adjusted to prevent excessive end play in the trolley wheels but to allow them to turn freely. In some instances spring clips 65 and bushings 64 may be dispensed with so that the spindles of the trolley wheels rest directly in grooves 63, held in position due to the relationship between the frame 50 and coil form 11.

Contactor spring 52 is riveted to the underside of table portion 60 by rivets 69 which pass through the spring, the table portion and an interposed spacer plate 70. Spring 52 may be of phosphor bronze or other metallic spring material and is tapered to a bifurcated point 71, slightly wider than the diameter of the wire of coil 10. Point 71 is bent into a U-shaped form so as to provide a convex surface in contact with the wire. The main body of contactor spring 52 is preferably tangent to the coil 10 at the point of contact. The end 71 of contactor 52 is split along its center line at 172 for a short distance back from the point of contact to provide parallel, semi-independent contacting portions pressing against the surface of the wire of coil 10 (see Figure 6). The trolley wheel groove width and bearings are held to such maximum additive tolerances that contactor 52 is held in contact with an individual turn of the coil with both nibs riding thereon and in no instance is there contact to two succeeding turns at one time.

The double nibbed design of spring contactor 52 greatly minimizes the possibility of noise introduced into the circuit by irregularities on the surface of the coil 10. With a single contacting surface a slight hump or depression in the surface of the wire may frequently result in momentarily breaking the contact between the end of the spring and the wire at the moment the end jumps over the irregularity in the wire during tuning. With two parallel contact surfaces resting side by side on the wire as provided by the arrangement described the probability of a momentary break in the contact is very greatly reduced since two parallel irregularities in the wire surface are not encountered in first-class plated and processed wire. If a minute surface irregularity causes a break in the contact between one of the nibs and the wire the other nib will serve to maintain the circuit closed. The two contacting nibs of spring 52 must slide in parallel along the length of the wire since they determine the amount of wire of coil 10 that is in the tuning circuit and hence the frequency of the circuit. With this arrangement therefore one nib may be raised without altering the tuning, whereas if the points of contact of the nibs were arranged sequentially along the wire only the one nearer the right end of coil 10 would determine the tuning frequency and the other nib would be inoperative.

The multiple contact advantage is also present in the contacts between spring 51 and track 49 as previously mentioned.

The stiffness and biasing of spring 52 are preferably so adjusted as to give a total contact pressure between the spring 52 and the wire of coil 10 of approximately 50 grams, or 25 grams for each contact tip. This low pressure is made feasible by the uniform position in which the contactor spring is held relative to the wire. This pressure is found to be sufficient to insure a reliable contact with two sliding nibs and yet be well under a value that will cause excessive wear or siezing. As compared with the roller contact described in my application Serial No. 31,823, the sliding contact has the advantage of tending to clean itself and the wire surface of minute irregularities as dust or chemical formations, whereas, the roller contact may often ride over them and cause noise.

In tests made with a coil of hard drawn copper wire plated with silver and a phosphor bronze double-nibbed contact spring I have discovered that a pressure of 50 grams per nib causes excessive wear of the surfaces of the conductors resulting in a tearing loose of particles of metal and rapid destruction of the unit. On the other hand a pressure of 10 grams per nib was insufficient to maintain reliable contact and tended to cause excessive noise. With pressures in the order of 25 grams per nib reliable contact was obtained and after 25,000 round trip operations of the device wherein the contactor travelled from end to end the device still functioned as intended and did not show excessive wear.

The thickness of spacer 70 is so chosen as to

make spring 52 substantially tangent with coil 10 in the vicinity of the contact, in order that the contact pressure shall be independent of the direction of rotation of the coil and that no danger of mechanical oscillation of the contact spring during rotation of the coil shall be possible. By the arrangement shown the distance 72 between the bifurcated tip 71 of spring 52 and table 60 will remain substantially constant during tuning. Otherwise there would exist the possibility of undue mechanical working of the spring metal resulting eventually in failure and breakage of the spring and excessive wear in the wire plating. Any eccentricity in the running of coil form 11 is compensated for by the flexing of spring 51 and not by flexing of spring 52. Only slight flexing of spring 52 is needed due to the small eccentricity existing between form 11 and coil 10. Whereas considerable variations in pressure between spring 51 and the contact bar 49 are not detrimental because spring 51 slides a comparatively short distance along bar 49, it would result in rapid failure of the contact and the wire of coil 10 if the pressure of spring 52 were to vary to any great extent. The pressure of spring 52 against the coil 10 must be relatively light in order to prevent excessive wear and disruptive action between the contact spring and the wire during use which may involve a total contact travel of several hundred miles. In order to keep down wear the spring pressure must be lighter than would normally produce reliability if the sliding contact were not accurately positioned by the trolley wheels with respect to the wire at all times and were not bifurcated so that one contact nib will remain in contact even if the other is momentarily lifted off.

Any slight tendencies of motion of the contactor assembly 48, other than that required for operation, are largely confined to slight rotation of the contactor assembly about an axis located approximately at the center of the wire over which the trolleys and the tips of spring 52 are pressing. Such motion as may take place in this manner, however, is insufficient to permit either of the contact nibs to leave the wire or to cause a "short" with an adjacent turn of the wire coil 10. By positioning contact tips 71 between the two trolleys 53 and 54 the variation and vibration of each is transmitted to the contact only in reduced amount.

One end of the coil 10 is grounded to shaft 12 through lug 43 on ring 35. Shaft 12 is positively grounded through bifurcated contact spring 73 which is secured to end plate 15 by screws 74. The split end of spring 73 makes contact with sleeve 33 which is secured to shaft 12. The other end of coil 10 is soldered to one of the lugs 40 of slip ring 39. Bifurcated spring 75 makes sliding contact with the circular face of slip ring 39. Spring 75 is supported by strip 76 of sheet insulating material supported on plate 15 in spaced relation thereto by screws 77 and sleeves 78. Spring 75 is positioned between insulating strip 76 and end wall 15. Capacity losses between spring 75 and plate 15 are reduced by thus providing an air dielectric between the two parts. Slip ring 39 is spaced away from end disc 32 for the same reason. Spring 75 is provided with a pair of angular flanges 79 for stiffening purposes.

Adjustable end inductance coil 80 is connected to the end of coil 10 through spring 75 to which one of the ends of coil 80 is soldered at 181. Coil 80 is preferably formed of hard drawn copper wire of sufficient stiffness and resiliency to return to its original shape if compressed or extended. Coil 80 is held between two buttons 81 and 82 of insulating material, each button being provided with a shoulder, as indicated, for receiving an end of the coil. The coil assembly is supported by a bracket 83 attached to the bottom 17 of the metal case and a long brass screw 84 extends through the entire assembly and bottom 17 of the case. Bracket 83 is internally threaded so that screw 84 may be tightened against the spring pressure of coil 80 by turning it with a screw driver. Both ends of screw 84 may preferably be provided with screw driver slots so that adjustment may be made from either end. In this way it is possible to delicately adjust the inductance of coil 80 by merely turning screw 84 to bring the adjacent turns of the coil into closer or more widely spaced relationship. The flexibility of the end of coil 80 which connects to the spring at 181 is sufficient to accommodate adjustment of the coil as described. End inductance coil 80 is preferably made to have a higher Q than an equivalent inductive part of coil 10 and it is thereby possible to improve the tuning characteristics of the unit at the high frequency end.

Figure 8 shows a modified tuning unit in which two coils 10 and 10*a* are mounted for rotation on a single long shaft 12*a*. The arrangement of parts is generally similar for each section of the unit shown in Figure 8 as for the single section unit shown in the preceding figures. With this unit, however, the base plate 17*a* and cover 20*a* of the case are extended over the length of the combined unit and a partition 85 is interposed between the units. Partition 85 is provided with flanges 86 which rest against the sides of cover 20*a*, and is secured to base plate 17*a*, by flange 87 and screws 88. The bearings 13 and 14 for shaft 12*a* are located at the two ends of the unit, the shaft passing through a clearance hole in partition 85 without support at this central point. Figure 8 also shows a stationary coil 89 supported on coil form 90 within and co-axial with coil 10*a*. Coil form 90 may be supported from partition 85 by screws 91 passing through flange 92 on the end of coil form 90. One end of coil 89 is shown grounded to the partition 85 and the other end free to be connected as desired into the circuit. However, other types of coil connections may be provided, depending upon the circuit requirements. Coil 89, for example, may be the mutual coil referred to in my copending application 94,928, filed August 8, 1936.

Coils 10 and 10*a* in Figure 8 are each provided with an individual contactor 48 similar to that illustrated in the preceding figures. In this case both contactors slide along contact bar 49*a* which extends the entire length of the case and is soldered or welded in position to the two end plates and the partition.

A three or four section unit may be made by extending the construction just described.

In the tuning of short-wave circuits it is desirable to employ a dial scale as long as possible for the reason that in the shorter wave length regions the stations are easily passed and, hence, a lengthening in the dial scale to facilitate observation of the wave lengths being tuned and a step-down mechanical arrangement between the primary tuning mechanism and the tuning knob is desirable. As variable condensers employed as tuning mechanisms are usually limited to about 180 degrees of rotation it will be apparent that involved and costly step-down and dial ex-

pansion mechanism would be required to achieve accurate tuning. Compared with this, the inductive tuning system described herein, affords a primary tuning mechanism passing through several complete revolutions so that where a direct drive is employed between the tuner and the dial a longer scale can be obtained than could under any reasonable circumstances be devised for a condenser tuning arrangement. In fact, it becomes necessary with such an inductive tuning system to employ a step-up mechanism to reduce the dial scale length to a reasonable dimension.

Figures 9, 10 and 11 show details of a dial assembly suitable for use in an inductive tuning system of the type just described. Referring to the figures tuning knob **95** is attached directly to the shaft **94** which may be the operating shaft of the device, such as shaft **12** in Figure 1. Pinion gear **122** is keyed to shaft **94** and drives gear pair **125**, **126** which, with pinion **127**, are attached together to rotate on shaft **123**. In turn pinion **127** drives gear pair **119**, **120** which are attached to sleeve **96** which has a running fit on drive shaft **94**. Dial **97** is attached to the sleeve **96** by set screw **99** through the hub. On the back of dial **97** is attached a spiral track **100** of approximately three full turns as shown in Figure 11. The vertical frame **102** shown in Figures 10 and 11 is provided with slot **103** so that frame **102** may slide vertically over sleeve **96**, and is additionally provided with a central slot at the bottom where it may likewise readily slide over guide **106**. At the top of member **102** there is provided a shoe **104** and a leaf spring **105** which co-operatively engage and slide along the spiral track **100**. It will be seen from Fig. 10 that the bottom of member **102** is bent forward and then upward to provide an attachment at **109** for a front vertical member **108** in whose center is a slot **110** which may slide over sleeve **96** guided by collar **114**. The top of vertical member **108** is disposed close to facing **98** of the dial and is provided with a window **111** and opposed indexing points **112** and **113**. Facing **98** is of paper or other suitable material on which are scales **117** and **118** calibrated to indicate the tuning frequency or wave length. The collar **114** is attached to sleeve **96** by means of set screw **115**. The spacing between the front end of sleeve **96** and the rear of knob **95** is such as to allow reasonable play between the parts but may constrain the moving parts of the assembly from being thrust too far forward. It will be seen that the two connected vertical members **102** and **108** provide a yoke which moves up and down actuated by spiral guide **100** which is rotated to the right or left whenever the knob is turned for tuning. The combined ratio of the two gear pairs **125**, **126** and **119**, **120** is such that for full motion of the dial spiral the contactor co-operating with the inductive tuner coil attached directly to shaft **94** will move from one end of the coil to the other. Curved portions **101**, **101** at the extremities of spiral guide **100** serve as mechanical stops to the entire mechanism. The gear pairs **119**, **120** and **125**, **126** are of such construction as to minimize backlash in operation. In this construction the front gear of each pair is designed to have a floating fit on the respective sleeves to which their companion gears are fixed and is spring coupled to its respective fixed gear by coil springs **121** held under tension therebetween in a well-known manner. It will be seen that with such a mechanism the scale may be viewed through window **111** and that the mechanism, in cooperation with the inductive tuner previously described enable accurate calibration and easy tuning to the exact frequency desired. In fact the greater the number of spiral turns on the dial the less can be the gear ratio between the dial and primary actuating shaft **94** and, consequently, the longer the scale and the greater its accuracy of calibration. In some instances the number of turns on the dial may be sufficient so that the gear ratio may become 1:1 and hence dispensed with, and the number of dial spirals equal the number of turns on the inductive tuner.

Figures 12 and 13 show an alternative method of axially guiding the contacting member along the coil **10** on form **11**. Instead of the single contact bar **49** shown in Fig. 2, there are provided two contact bars **136**, **136** positioned with their contact edges on the straight line (marked "X" in Fig. 13) which runs through the points of mechanical contact of the insulating trolley wheels **131**, **131** with the coil form **11**. By this arrangement it is apparent that the axial thrust on the contact assembly (i. e., parallel to the axis of form **11**) caused by the screw action of coil **10** when the coil form **11** is rotated is in the same plane as the frictional resistance components resulting from the light operating friction of springs **128**, **128** sliding on contact bars **136**, **136**. Thus this double contact bar arrangement makes it possible to eliminate any turning moment tending to rotate the contactor around line X. In other words the arm of moment of the frictional component about the line joining the points of contact of the flanges of wheels **131** with the coil form is reduced to zero. This advantage becomes of greater importance when larger structural units are made or when wheels **131** are of increased size. Since only limited end clearance is available the length of springs **128** must be kept at a minimum. In larger units, therefore, springs **128** cannot be correspondingly increased and the resistance offered by springs **128** to rotation about the line X is less. The use of double contact bars also further insures good contact and increases the mechanical strength.

The upper part of Fig. 12 shows the details of the contactor bar **136**. The end flanges **137**, one of which is not shown, may be pressed in one operation from sheet material. Bar **136** is silver plated and processed with lanum oil solution to retard sulfiding and oxidizing.

The contactor assembly shown in part in the lower part of Fig. 12 comprises frame **127** having grooved openings for mounting wheels **131** and springs **128** mounted on its ends. Ears **129** of spring **128**, determine the proper position of spring **128** with respect to member **127** in assembly and additionally tend to prevent any rotation of the spring member. The channelled extremes of spring **128** are beaded as at **130**, **130** to provide short, low friction contact portions with the smooth bottom of bar **136**.

It will be noted that in the arrangement of Figure 13 the separate bushings as well as the retaining clips have been omitted as the member **127** has been formed directly to act as a bearing for the spindle ends **133** of the trolley wheels. It is found that the pressure exerted by the springs **128** on the contact bars **136**, while light, is sufficient to hold the contactor assembly trolley wheels **131**, **131** properly in their bearings. It will be noted also that in Fig. 13 the double nib

contact of spring member 135 is provided with an offset portion at its upper extremity which obviates the necessity of a spacer such as shown in Fig. 7.

Fig. 14 shows a detail of one of the insulated wheel assemblies having a metal pinion 132 with large cylindrical central portion 134, around which the grooved wheel 131 of insulating material is pressed or moulded and turned-down pinion ends 133. The insulating material may either be pressed or moulded onto the central portion 134 and a preferred mode of construction is to knurl the cylindrical part 134 and mould Bakelite or other insulating material onto it. The desired groove is preferably cut in the periphery of wheel 131 after molding to insure a smooth groove although in some instances the groove may be moulded. Contact spring 135 has its main body portion substantially in the line tangent of coil 10 at the point of sliding contact.

The device described above is suitable for use as a variable inductance tuner in a radio set and in such an application may be used in any of a wide variety of circuits. The free end of the variable coil may be connected to a suitable terminal in a radio circuit and the metal case of the device may be grounded (or connected to another terminal) to provide a variable element in the circuit. The inductance in the circuit can then be varied by rotating the coil by the control knob. This varies the position of the contactor assembly with respect to the coil thus varying the inductance of the coil in the circuit.

The unused turns of coil 10 at the left of contactor 48 as seen in Figures 1 and 2 are short-circuited, i. e., grounded to the case as follows: From the left-hand end of coil 10, through lug 43, ring 35, bushing 33, shaft 12, contact 73 to the metal case.

A modified method of forming coil 10 comprises first winding form 11 with the hard metal wire, such as hardened copper, and then plating the wire with silver or the like by immersing the assembly in a plating bath.

While the present invention, as to its objects and advantages, has been described herein as carried out in specific embodiments thereof, it is not desired to be limited thereby but it is intended to cover the invention broadly within the spirit and scope of the appended claims.

What is claimed is:

1. A slide-wire variable inductance device wherein a bare helical coil is mounted for rotation about its longitudinal axis and a contact bar is mounted parallel to a side of the coil and spaced therefrom, characterized by the fact that there is combined with said coil and bar a moving contactor assembly, said contactor assembly comprising a frame, non-resilient means spacing said frame from said coil, a contact member on said frame and in contact with said coil and another contact member on said frame and engaging said bar, the contact member engaging said bar comprising spring means urging said frame away from said contact bar and toward said coil.

2. A slide-wire variable inductance device comprising a rotatable inductance coil member, a contactor carriage, a guide bar along-side said coil member guiding said carriage therealong, said carriage comprising a frame, a guide member supported thereon and guiding said carriage along the conductor of said coil member, and a contact on said frame guided thereby along said conductor in contact therewith, said frame following the inherent eccentricities in said coil member during rotation of said coil member, whereby the distance of said carriage from said bar is varied by said inherent eccentricities in said coil member during rotation thereof.

3. A slide-wire variable inductance device comprising a rotatable inductive coil member, a contactor carriage, a guide bar alongside said coil member guiding said carriage therealong, said carriage comprising a frame, a guide member supported thereon and guiding said carriage along the conductor of said coil member, and a contact on said frame guided thereby along said conductor in contact therewith, said frame following the inherent eccentricities in said coil member during rotation of said coil member, whereby the distance of said carriage from said bar is varied by said inherent eccentricities in said coil member during rotation thereof, the sole function of said carriage supported contact being to make contact with said wire.

4. A variable inductance device comprising a bare helical coil, means mounting said coil for rotation about its longitudinal axis, a contact bar parallel to a side of said coil and spaced therefrom, and a moving contactor carriage interposed directly between said coil and said contact bar, said contactor carriage comprising a frame, a guide member thereon engaging said coil so as to guide said carriage along the conductor of said coil during rotation thereof, a contact thereon engaging said coil and held to slide thereon by said guide and frame, and contact spring means mounted on said carriage frame and compressed between said carriage and said contact bar and comprising the sole engagement between said carriage and said bar, said contact spring means making electrical contact between said bar and carriage and guiding said carriage axially along sid coil.

5. A variable inductance device comprising an inductance coil of bare wire, a contactor assembly movable along the side of said coil, said assembly comprising an insulating trolley wheel and a sliding resilient metal contact, means for rotating said coil and means to guide said assembly along the side of said coil, said wire serving to guide said wheel and said wheel constraining said contact to slide along said wire, said contact serving solely to make continuous sliding contact with said conductor.

6. A slide-wire variable inductance device wherein the useful inductance of a bare inductive coil is varied by moving a contact along the conductor of the coil, characterized by the fact that there is combined with said coil and contact a moving contactor carriage having a pair of insulating trolleys thereon guided by said conductor, said carriage holding said contact on said conductor and guiding said contact therealong.

7. A slide-wire variable inductance device wherein the useful inductance of a bare inductive coil is varied by moving a contact along the conductor of the coil, characterized by the fact that there is combined with said coil and contact a moving contactor carriage having a pair of spaced insulating trolleys thereon guided by said conductor, said carriage holding said contact on said conductor at a point between said trolleys and guiding said contact therealong.

8. A variable inductance device comprising a cylindrical form and a bare conductor wound thereon to provide a helical coil, means supporting said form for rotation about its axis, a guide bar mounted parallel to the side of said form and a contactor carriage assembly mounted be-

tween said form and said bar, said contactor carriage assembly comprising an elongate frame extending parallel to the conductor of said helix and transverse to said bar, a pair of spring fingers secured to said elongate frame at an intermediate point and extending to spaced points of engagement with said bar whereby to make contact therewith and whereby to urge said carriage assembly away from said bar and toward said form, a pair of insulating trolley wheels pinioned at the ends of said elongate frame and grooved to said helical conductor whereby to travel along said conductor as a track when said coil and its form are rotated, and a sliding contact member secured to said elongate frame and having a bifurcated contacting portion thereof sliding along the conductor of said helical coil guided by said trolley wheels, said sliding contact member engaging said conductor along a path which is not touched by said trolley wheels in their travel along said conductor, said trolley wheels serving to determine the spacing between said carriage and said coil independent of eccentricity between said form and said guide bar, whereby substantially uniform contact pressure with said helical conductor is maintained.

9. A variable inductance device comprising a coil form of insulating material and a bare conductor wound thereon to form a coil unit, means to vary the inductance thereof comprising a contactor assembly to travel along said conductor as a track, said contactor assembly comprising a frame, two insulating trolley wheels pinioned therein and rollable on and guided by said coil unit, one of said wheels preceding the other along the length of said conductor, and a resilient contact secured to said frame and slidable along said conductor, said trolley wheels thereby maintaining constant spacing between said frame and coil unit and serving to guide said contact along said conductor, a guide track positioned parallel to the side of said coil unit and in spaced relation thereto, said guide track and said coil unit being rotatable relative to each other about the axis of the coil unit, said contactor assembly being positioned between said guide track and the side of said coil unit, and resilient means engaging said contactor assembly and guide track and urging said contactor assembly against the side of said coil unit whereby said resilient means serves to absorb any variations in the spacing of said guide track and side of said coil unit due to eccentricities in the coil unit during relative rotation of the guide track and coil unit.

10. A variable inductance device comprising an inductance coil rotatable about its longitudinal axis, means for rotating said coil, a guide track positioned parallel to a side thereof, a contactor assembly comprising a frame, two insulating trolley wheels pinioned therein, and a bifurcated end contact spring attached to said frame, and a resilient spring attached to said frame and engaging said guide track, said assembly being interposed between said guide track and coil, the said wheels running on a turn of said coil as a track, said contact spring slidably pressing on said turn at a point adjacent said wheels and guided therealong by said wheels, said resilient spring being in compression between said frame and the guide track whereby to hold the contactor assembly against the side of said coil, the pressure exerted on said turn by said bifurcated end contact spring being sufficient to prevent both nibs jumping from said turn at the same time during travel of said contact along the coil and less than the pressure which would cause seizing.

11. A variable inductance device comprising an inductance coil rotatable about its longitudinal axis, means for rotating said coil, a guide track positioned parallel to a side thereof, a contactor assembly comprising a frame, two insulating trolley wheels pinioned therein, and a bifurcated end contact spring attached to said frame, and a resilient spring attached to said frame and engaging said guide track, said assembly being interposed between said guide track and coil, the said wheels running on a turn of said coil as a track, said contact spring slidably pressing on said turn at a point adjacent said wheels and guided therealong by said wheels, said resilient spring being in compression between said frame and the guide track whereby to hold the contactor assembly against the side of said coil, the spacing between the turns of the coil differing for different sections of the coil.

12. A variable inductance device comprising a coil form of insulating material, an inductance coil of bare wire wound thereon, a contactor engaging the conductor of said coil, a guide for said contactor comprising an insulating wheel rolling directly on said insulating form, means holding said contactor and wheel, said coil providing a guide for said trolley wheel, and means for moving said contactor and trolley wheel in unison along said conductor.

13. A variable inductance device comprising a coil form of insulating material, an inductive coil wound thereon, a contactor carriage, means to move said carriage along the conductor of said coil, said carriage comprising a frame, a wheel thereon rolling on said form and a contact resiliently supported thereon arranged to travel along said coil in contact therewith, whereby said wheel will follow any inundations and eccentricities in said form and said contact will follow the inundations and eccentricities in said conductor during travel of said carriage along said coil conductor.

14. A variable inductance device comprising a cylindrical form and a bare conductor wound thereon as a helical coil, means supporting said form for rotation about its axis, a pair of guide bars mounted parallel to the sides of said form and a contactor assembly mounted between said form and said bars, said contactor assembly comprising an elongate frame having a pair of sliding contacts at its ends bearing against contacting surfaces of said bars, a pair of trolley wheels riding pivoted to said frame and riding on said form guided by said conductor and a sliding contact member sliding along the length of said coil conductor.

15. A slide-wire variable inductance device wherein a coil unit made up of a form of circular cross section and an inductive coil of bare wire wound thereon is mounted for rotation about a longitudinal axis and a pair of spaced guide tracks are mounted parallel to the side of said coil unit in spaced relation thereto, characterized by the fact that there is combined with said coil unit and guide tracks a contactor assembly comprising an elongate frame member having a pair of trolleys longitudinally spaced thereon and engaging said coil unit and guided along said wire when said coil unit is rotated and a pair of spaced guide members on said frame engaging said guide tracks and guided therealong

when said coil unit is rotated, the points of engagement of said guide members with said tracks and of said trolleys with said coil unit being aligned.

16. A slide-wire variable inductance device wherein a coil unit made up of a form of circular cross section and an inductive coil of bare wire wound thereon is mounted for rotation about a longitudinal axis and a pair of spaced guide tracks are mounted parallel to the side of said coil unit in spaced relation thereto, characterized by the fact that there is combined with said coil unit and guide tracks a contactor carriage assembly comprising an elongate frame member having a pair of guide members at its ends bearing against said guide tracks, at least one of said guide members comprising a resilient member under compression between said frame and its respective guide track whereby to urge said carriage assembly away from said guide track and toward said coil unit, and at least one insulating trolley wheel pinioned at an intermediate point in said elongate frame and grooved to said wire whereby to travel along said wire as a track when said coil unit is rotated, and a sliding contact member secured to said elongate frame and having a contacting portion thereof sliding along the wire of said coil when said coil unit is rotated, said trolley wheel guiding said sliding contact along said wire and determining the spacing between said carriage frame and said coil unit whereby the pressure of said contact on said wire is substantially independent of inherent eccentricity between said coil unit and said guide tracks.

17. A slide-wire variable inductance device for tuning a radio frequency circuit comprising a bare conductor formed into a coil, a contactor assembly, means to move said contactor assembly along the conductor of said coil to vary the amount of said coil in the circuit being tuned, the sole contacting means between said contactor assembly and said conductor being a spring finger, said contactor assembly comprising means maintaining uniform spacing with said coil and thereby maintaining uniform pressure between said spring finger and said conductor, the part of said spring finger slidably engaging said conductor comprising a pair of contact nibs sliding in parallel along the length of the conductor whereby the length of said conductor in the circuit at any setting of the device is the same with either nib in contact with the conductor and the other nib lifted off.

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