June 2, 1959 D. R. SCHMITZ 2,889,524

MINIATURE INDUCTIVE ASSEMBLY

Filed Feb. 21, 1956

FIG. 1

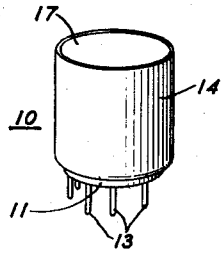


FIG. 2

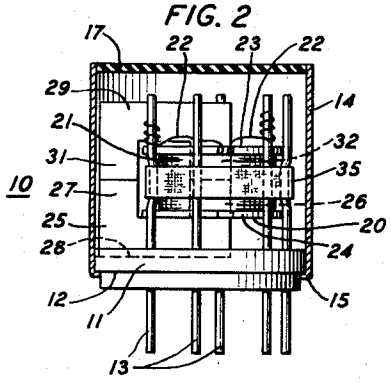
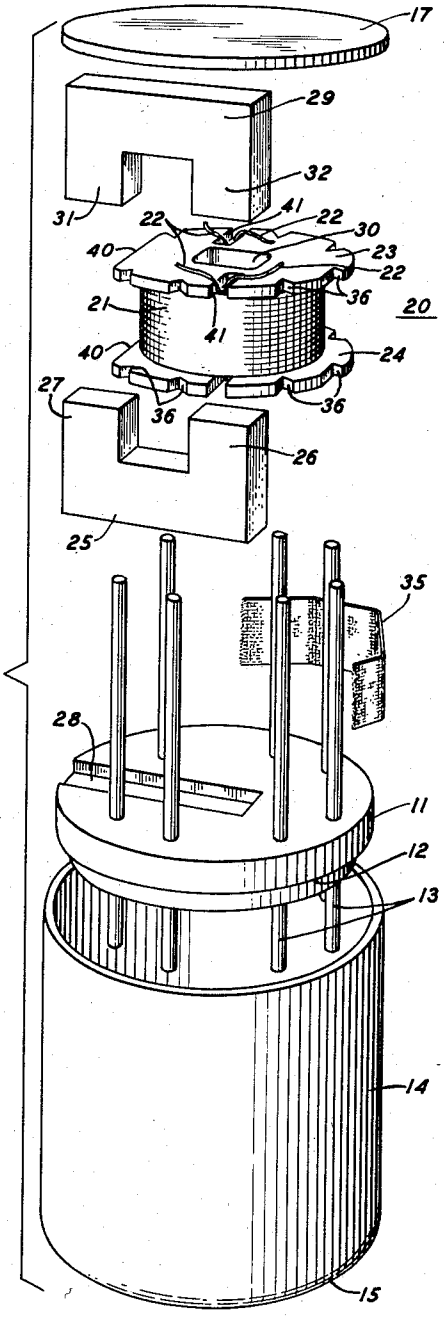


FIG. 3



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United States Patent Office 2,889,524 Patented June 2, 1959

2,889,524

MINIATURE INDUCTIVE ASSEMBLY

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Application February 21, 1956, Serial No. 566,835

10 Claims. (Cl. 336—192)

This invention relates to inductive devices and more particularly to miniaturized inductance devices, such as communication transformers.

In the design of communication transformers, for example, for use in carrier telephone systems, the comparatively recent development of high permeability magnetic core materials, such as the polycrystalline ceramic-like ferrites disclosed in the Patents 2,452,529, 2,452,530, and 2,452,531, to J. L. Snoek, allows marked reduction in the size of the magnetic core. In order to obtain the advantages of decreased size afforded by the use of ferrites, it is desirable to employ windings of fine wire. In low voltage applications, wire as fine as 46-gauge (0.0016 inch diameter) is desirable.

In attempting to attain a high degree of miniaturization in the past, it has been found that a limiting factor in the reliability of the devices has been the likelihood of breakage of the fine wire, particularly of the leads in the region of attachment to their terminals. Another factor of importance in the design of miniaturized inductive devices is, that with decreased size, when employing conventional designs, a high degree of skill and manual dexterity of the assembler is required. Primary causes of winding failures have been found to be improper manipulation during the assembly, in particular, the steps of securing the winding to the terminal, and because of stress applied to the windings due to relative movement of the winding assembly with respect to the terminals.

It is desirable for moisture and mechanical protection to encapsulate or pot devices of this type in catalyzed, thermosetting or thermoplastic sealing compounds. The failure of a winding or lead due to any cause results in a totally defective nonrepairable component owing to the extreme difficulty in removing the sealing compound. Therefore, the reliability of leads is of prime practical importance in the design of miniature inductive devices.

Accordingly, it is a general object of this invention to attain miniaturized inductive devices having a high degree of reliability.

More specific objects of this invention are to provide a miniature inductor or transformer of simple design and low cost in which the terminals constitute a protective enclosure for the winding assembly; to prevent relative movement of the winding assembly with respect to the terminals; and to enable the securing of all the fragile winding leads simultaneously to their respective terminals with a minimum of strain thereon and requiring a minimum of skill and mechanical dexterity of the assembling operator.

These objects are accomplished in accordance with one specific embodiment of this invention comprising an insulating terminal plate or button having a plurality of wire segments extending therethrough and arranged in a spaced or circular array to form a cage-like structure on at least one side of the terminal plate. A winding bobbin having notched flanges corresponding to the terminals is nested coaxially within the cage-like structure. One U-shaped magnetic core part is positioned between the terminal plate and one flange of the bobbin and extends into the cage-like structure. Overlying the outer flange of the bobbin is a second U-shaped magnetic core part the ends of which are cemented to the ends of the first core part. Wound upon the bobbin between the flanges are a plurality of turns of insulated wire comprising the winding or windings of the inductive device. The lead ends of the windings pass through openings in the outer bobbin flange, are fanned outward, and are secured to certain of the terminal wires.

As discussed above, it is necessary in miniature devices of this type to insure against relative motion of the winding, winding spool, terminals, and magnetic core. Particularly, it is important to prevent motion between the winding or windings and the terminals to which their ends are secured, which motion can introduce strains into the winding ends or rupture the electrical connection between the winding and the terminal. In accordance with one aspect of this invention, a tensioned insulating band encircles the terminals between the bobbin flanges mechanically biasing them by distorting them slightly against the bobbin flanges and thereby maintaining the bobbin immobile with respect to the terminals. Motion between other parts of the device is prevented by seating the base of the magnetic core in a depression in the insulating terminal plate through which the terminals extend and by proportioning the parts so that the lower notched flange of the winding spool rests on the upper surface of the base of the core.

An appreciation of the size of miniature inductors in accordance with this invention can be gained from the fact that the overall volume of one specific illustrative embodiment comprising a carrier frequency transformer is less than one-half cubic inch exclusive of external terminals. The attainment of such a degree of miniaturization by utilizing ferrite core material and exceedingly fine wire windings imposes severe requirements on the connections between the windings and the terminals and on the making of such connections. Specifically, not only must relative motion between the parts that would tend to rupture the very fine wire connections be prevented, but also, in accordance with another aspect of this invention, the structure must be such as to lend itself readily to fabrication without the introduction of strains or deleterious forces during the fabrication by relatively unskilled personnel.

One feature of this invention relates to the arrangement of terminals forming a protective cage for the winding assembly of the device.

Another feature involves the winding bobbin having discontinuities corresponding to the terminals whereby the bobbin and winding are positioned coaxially within the terminal cage.

Another feature relates to the terminals extending beyond the bobbin flange to afford a point for simultaneous attachment by dip soldering of all of the winding leads at a remote point on the terminal.

Another feature involves the employment of a tensioned band mechanically to bias the terminals in and about the winding bobbin to prevent movement of the bobbin parallel to the terminals.

Still another feature resides in the arrangement of the winding bobbin whereby it serves to clamp the magnetic core securely in position against the terminal plate.

These and other features of this invention may be understood by reference to the following detailed description and to the accompanying drawing, in which:

Fig. 1 is an exterior view of a completed assembly in accordance with this invention;

Fig. 2 is an elevational view of the device of Fig. 1 with the enclosure shown in section for clarity; and

Fig. 3 is an exploded and enlarged representation of the device of Fig. 1.

Referring now to Figs. 1 and 2, a transformer assembly **10** may be seen comprising generally a terminal plate **11** of insulation such as molded phenolic material in the form of a circular disk having a peripheral step **12** in one face. Passing through the terminal plate at right angles to its major faces are a plurality of wires **13** constituting the terminals of the transformer. Enclosing the assembly is a tubular housing **14** having a rolled-over lip **15** at one end corresponding to the peripheral step **12** in the terminal plate **11**. Enclosing the open end of the tubular member is an insulating disk **17**.

The terminal wires **13** are arranged in a circular array. Positioned within the cage-like structure formed by the terminal wires **13** on one side of the terminal plate is a coil bobbin **20** about which a plurality of turns **21** of insulated wire are wound. The winding terminations or leads **22** pass through openings or slots **41**, seen in Fig. 3, in a flange **23** of the bobbin **20** and are wound about certain terminal wires **13** near the adjacent end of the wires **13**.

Between the terminal plate **11** and the bobbin **20** is a U-shaped magnetic core part **25** of, for example, manganese zinc ferrite. The bottom surface of the core part **25** rests in a groove **28** in the terminal plate **11** and the legs **26** and **27** of the core part are upturned, the leg **26** being substantially on the common axis of the coil bobbin **20** and the terminal wires **13**. The leg **27** extends upward outside of the cage of terminal wires **13**. The core part leg **26** is positioned to extend through a lower flange **24** and into a central opening **30** in the coil bobbin **20**, best seen in Fig. 3. A core part **29** similarly of U configuration is positioned over the outer flange **23** of coil bobbin **20**, with legs **31** and **32** of core part **29** in juxtaposition with those of the core part **25**. The core parts **25** and **29** are cemented together and thereby define a closed rectangular magnetic core structure having one side passing through the central opening **30** in the coil bobbin **20** and an adjacent side clamped by the coil bobbin **20** against the terminal plate **11**.

Encompassing the terminals in the region intermediate the outer flange **23** and an inner flange **24** of the bobbin **20** is a tensioned insulating band **35**, for example, a plurality of turns of insulating pressure sensitive tape. The band is tightly wound around the terminal wires **13** and in so doing mechanically biases them into corresponding notches **36** in the bobbin flanges as is best seen in Fig. 2. The terminal wire sections between the flanges **23** and **24** are bowed inward slightly by the band **35** thereby preventing movement of the coil bobbin **20** along the terminal wires **13**. In Fig. 2, the bowing of the terminal wires **13** is exaggerated for the purposes of illustration. Several notches **36** in the bobbin flanges **23** and **24** prevent movement of the winding assembly perpendicular to the axis of the terminal array while the band **35** of insulating tape and bowed portion of the terminals effectively prevent movement of the bobbin **20** in a direction generally parallel to the terminal wires **13** and away from the terminal plate **11**. The core part **25**, clamped between flange **24** of bobbin **20** and terminal plate **11**, prevents movement of the bobbin **20** toward the terminal plate **11**. In this arrangement, the winding, although a separate assembly from the magnetic core and terminals, is positively fixed with respect to those elements in the transformer. The leads of the winding need traverse only the short distance from the bobbin **20** to the terminal wire ends within the protective cage thereby minimizing the likelihood of breakage.

The details of the transformer of Figs. 1 and 2 may be more clearly seen by reference to Fig. 3 which is an exploded view of the winding and core assembly. The tubular enclosure **14** is shown with the lip portion **15** at the bottom in position to receive the terminal plate **11** with embedded terminal wires **13**. The groove **28** in which the core part **25** rests is clearly shown extending into the circular array of terminal wires **13**. The terminal wires **13** may be unequally spaced in the array for identification purposes and to fit a particular mounting for the device. Positioned to encompass the cage structure of terminal wires **13** is tensioned band **35**, only a fragment of which is shown in Fig. 3. The core part **25**, as well as the core part **29**, includes legs **26** and **32**, respectively, which are arranged to extend into the substantially rectangular hole **30** in the winding bobbin **20**. Legs **27** and **31** fit along flattened edges **40** of the flanges **23** and **24** of the bobbin **20**. The winding leads **22** may be seen emerging from slots **41** in the flange **23** of the bobbin in a position convenient for attachment to the terminal ends. Uppermost in Fig. 3 is the insulating disk **17** which serves to complete the assembly after filling the enclosure **14** with a sealing compound having good insulating qualities.

In assembly, the core part **25** is positioned in groove **28** and bobbin **20** having turns **21** thereon is slid into the cage formed by terminals **13** coming to rest on core part **25**. Band **35** shown in Fig. 2 is placed about the terminals **13** between flanges **23** and **24** and is drawn up tight forcing the terminal wires **13** into notches **36** of bobbin **20**. The winding leads are drawn through the slots **41** in the winding flange **23**, are separated, stripped of insulation, if necessary, and wound about the correct terminal. The entire assembly then is inverted and the ends of the terminal wires **13** adjacent the bobbin **20** are immersed in a molten solder bath to secure all of the winding leads to their terminals simultaneously. After this step, the core part **29** is positioned over bobbin **20** and cemented to the core part **25**. After a dip coating of insulation or after vacuum impregnation with wax, the transformer assembly is complete and in usable form. To prevent obscuring the drawing, the wax or insulating coating on the assembly is not depicted in the drawing.

For more permanent protection, the assembly is enclosed in the tubular housing **14** which is subsequently filled with a sealing compound and closed with disk **17**; the sealing compound is also omitted from the drawing for clarity sake. In this form, the only exposed elements connected to the winding leads are the terminal ends which are the extreme opposite ends from the point of lead attachment. Therefore, movement of a terminal wire has virtually no chance of producing strain in its winding lead. Similarly, the leads during manufacture are subjected only to handling in being threaded through the bobbin slots and wound about the terminal wire. Soldering is accomplished with no physical contact to the lead except for the molten solder. These features, in addition to the arrangement for effectively securing the winding assembly as a whole from moving with respect to the terminal wires, practically eliminate the introduction of unwanted strain into the winding leads resulting in increased reliability in the transformer.

It is to be understood that the above described arrangements are merely illustrative of the application of the principles of this invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. An inductive assembly comprising an insulating terminal plate, a plurality of spaced terminals extending through said terminal plate and secured therein, the portions on one side of said terminal plate forming a cage-like structure and the portions on the opposite side of said terminal plate constituting the external connectors for the inductive assembly, an insulating winding bobbin including end flanges and a central opening extending through said bobbin positioned within said cage-like structure with the end flanges extending transverse to the terminals, a winding on said bobbin, a magnetic core for

said winding positioned at least partially within said cage-like structure and having a portion extending through said winding bobbin, the ends of said winding emerging from said bobbin and secured each to a respective terminal, and insulating means encompassing said terminals between the end flanges and mechanically biasing said terminals against said winding bobbin end flanges tending to bow said terminals in the region between the end flanges to secure said winding bobbin from movement.

2. An inductive assembly comprising an insulating terminal plate, a plurality of spaced terminals extending through said terminal plate and secured therein, the portions on one side of said terminal plate forming a generally circular cage-like structure and the portions on the opposite side of said terminal plate constituting the external connectors for the inductor assembly, an insulating winding bobbin including a central opening positioned within said cage-like structure, said bobbin including a pair of spaced end flanges in contact with said terminals and being positioned thereby substantially coaxially within said cage-like structure, a winding on said bobbin, a magnetic core for said winding including a portion extending through the opening in said winding bobbin, the ends of said winding emerging from said bobbin and secured each to a respective terminal, and insulating means encompassing said terminals between the end flanges of said winding bobbin and mechanically biasing said terminals against said winding bobbin tending to bow said terminals in the region between the end flanges to secure said winding bobbin from movement.

3. An inductive assembly comprising an insulating terminal plate, a plurality of spaced terminals extending through said terminal plate and secured therein, the portions on one side of said terminal plate forming a generally circular cage-like structure and the portions on the opposite side of said terminal plate constituting the external terminals for the inductive assembly, an insulating winding bobbin having a central opening therethrough positioned within said cage-like structure, said bobbin including a pair of spaced end flanges in contact with said terminals and being positioned thereby substantially coaxially within said cage-like structure, said flanges having peripheral notches therein coinciding with the terminals, a winding on said bobbin, a magnetic core for said winding including a portion extending through the opening in said winding bobbin, the ends of said winding emerging from said bobbin and secured each to a respective terminal, and insulating means encompassing said terminals between the end flanges of said winding bobbin and mechanically biasing said terminals against said winding bobbin at the peripheral notches tending to bow said terminals in the region between the end flanges to secure said winding bobbin from movement.

4. The inductive assembly in accordance with claim 3 wherein said insulating means comprises a closed tensioned band.

5. The inductive assembly in accordance with claim 3 wherein said insulating means comprises a band of pressure sensitive tape.

6. An inductive assembly comprising an insulating terminal plate, a plurality of spaced terminals extending through said terminal plate and secured therein, the portions on one side of said terminal plate forming a cage-like structure and the portions on the opposite side of said

terminal plate constituting the external connectors for the assembly, an insulating winding bobbin having a central opening therethrough positioned within said cage-like structure, said bobbin including end flanges having peripheral notches coinciding with the terminals, a winding on said bobbin, insulating means mechanically biasing said terminals into the peripheral notches of said bobbin end flanges and a magnetic core extending through said bobbin and said winding, said magnetic core including a portion extending between said terminal plate and one bobbin end flange and secured therebetween.

7. An inductive device comprising a terminal plate of insulation, a plurality of elongated terminals secured in spaced array through said plate with portions extending from opposite sides thereof, the terminal portions on one side of the plate defining a cage-like enclosure and those on the other side being the external connectors, an insulating winding form within the enclosure including extended portions in contact with said enclosure, a winding on the form, winding ends protruding from the form within the enclosure and secured to respective terminals only in a region of said terminals remote from said terminal plate, and a tensioned band of insulation encompassing the terminals in the region of said extended portions of said winding form to bias said terminals against the winding form tending to bow said terminals in the region between the extended portions of said winding form to inhibit relative movement between the form and the terminals.

8. An inductive device comprising a plurality of terminal conductors arranged in a cage-like array, an insulating winding spool including end flanges within said array, a winding on said spool having its ends connected to respective ones of said conductors, and means for preventing relative motion between said conductors and said winding spool, said means including a tensioned band of insulation encompassing said conductors mechanically to bias said conductors against the end flanges of said winding spool.

9. A miniature inductive device comprising an insulating terminal plate having a depression in one side thereof, a plurality of terminals extending through said plate and arranged in a cage-like array adjacent to said one side of said plate, an insulating winding spool within said array and having a central aperture and spaced flanges having peripheral notches therein, a winding on said spool having its ends connected to said terminals, a magnetic core having one arm extending through said aperture, said core having a portion positioned in said depression, and a tensioned band of insulation encompassing said terminals between the flanges of said winding spool and mechanically biasing said terminals within said notches in said flanges.

10. A miniature inductive device in accordance with claim 9 wherein one of said flanges rests on a portion of said core and secures said core in said depression.

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