

Sept. 13, 1955

S. G. HALE ET AL
ADJUSTABLE INDUCTANCE DEVICE

2,717,984

Filed Dec. 27, 1951

FIG. 1

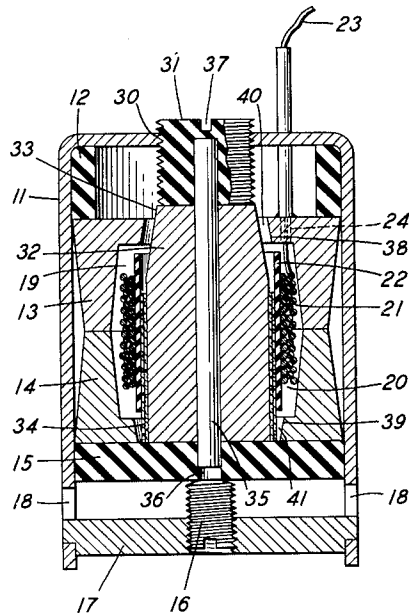
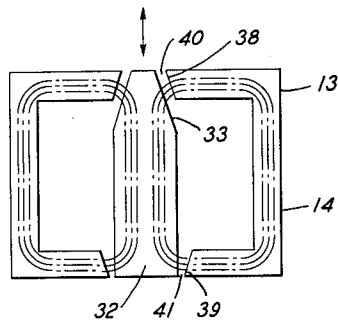


FIG. 2



INVENTORS: S. G. HALE
C. W. NUTTMAN

BY

[Signature]

ATTORNEY

1

2,717,984

ADJUSTABLE INDUCTANCE DEVICE

Stuart G. Hale, Chatham, and Charles W. Nuttman, East Orange, N. J., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application December 27, 1951, Serial No. 263,564

10 Claims. (Cl. 336—134)

This invention relates to inductance devices and more particularly to adjustable closed-core inductors.

In numerous applications including tuned circuits having a low-current level, it is highly desirable to employ high Q inductors which are accurately adjustable over a wide range of inductance values. The variation in inductance should advantageously be linear with respect to the movement of the adjusting means in order to insure accuracy in tuning. It is further desirable that the adjusting means be simple and rugged yet allowing fine adjustment of the inductor.

In the past, inductors have been made which employ various methods of adjustment. One such method is to vary the number of windings in the coil, as by moving the entire coil in relation to the core members or by adding or removing windings from the coil. This general method of adjusting inductors, however, is not readily adaptable to use in closed-core inductors.

A second method of adjusting inductors is to vary the reluctance of the magnetic circuit by changes in the length of air gaps in the circuit. It is familiar to those skilled in the art that adjusting may be accomplished by inserting a magnetic member into a fixed air gap. This type of adjustment, however, requires precise movement of a small magnetic member in the confined space of the air gap. The variation of inductance with respect to travel of the magnetic member tends to be exponential rather than linear as is desired where accurate adjustment throughout the entire range of magnetic member displacement is sought. Also flux concentrations in the member may greatly reduce the Q of the inductor. If the length of the air gap is varied by moving the surfaces defining the air gap in relation to each other, the adjustment must again be precise for the total movement of the surfaces is small and the change in inductance with respect to the mechanical adjustment is definitely exponential.

One general object of this invention is to improve the performance characteristics of adjustable inductance devices. More specific objects of this invention are to increase the inductance range of such devices, to obtain a substantially linear relationship between the variation of inductance and the adjusting member displacement, and to enable fine accurate adjustment of closed-core inductors.

In one specific embodiment illustrative of this invention, an inductor comprises an outer frame or shell of magnetic material with beveled apertures located at each end. This outer member may advantageously be made of the crystalline ferromagnetic material known as ferrite. Contained within the frame or shell is a movable member, also of magnetic material, which is adjustable in relation thereto and has a tapered portion adjacent one end. A coil is mounted on an insulating tube through which may be adjusted the movable member, and an adjusting element such as a positioning screw is attached to one end of the movable member and engages the threads of a support for the inductor. By operating the adjusting element, the movable member may be moved within the outer frame or shell. The tapered surface at one end of the movable member and the surface of one beveled aperture in the outer member define a variable air gap, and the opposite end of the movable member and the surface of the beveled aperture of the other end of the outer member define a

2

second variable air gap in series with the first air gap in the magnetic circuit of the inductor. Actuation of the movable member simultaneously increases the length of one air gap and decreases the length of the other so that the over-all change in reluctance of the magnetic circuit of the inductor and consequently the change in inductance of the device depends upon the differential effect of relatively large changes in the two opposing air gaps.

A feature of this invention involves the provision of a magnetic circuit having in series two air gaps which are oppositely variable whereby a gradual variation in inductance may be achieved.

A further feature of this invention pertains to the combination of a single adjustable member with an enclosing shell and defining two variable air gaps therewith, the member and shell being relatively movable to effect simultaneous variation of the two gaps in opposite sense.

Another feature of this invention involves the correlation of the bounding faces of the two air gaps so that adjustment of the movable member effects a prescribed differential variation in the net reluctance of the two air gaps. More specifically, another feature involves the taper of the surface of the movable member at one end whereby the two air gaps have different proportions and rates of change in reluctance.

A more complete understanding of this invention may be had by reference to the following detailed description and the accompanying drawings in which:

Fig. 1 is a longitudinal section of an inductor illustrative of one embodiment of this invention; and

Fig. 2 is a diagrammatic illustration of the magnetic circuit in the embodiment of this invention shown in Fig. 1.

The inductor illustrated in Fig. 1 comprises a U-shaped frame 11, advantageously of non-magnetic metal, with an apertured insulating spacer 12 positioned inside of the base of the U. Two cylindrical, magnetic, cup-shaped core members 13 and 14 are positioned in opposed relation to each other between the legs of the frame 11 and constitute a magnetic frame or casing. An insulating plate 15, which is located between the legs of the frame 11 and towards its open end, acts as a retaining member for the cup-shaped core members 13 and 14. The spacer 12, the core members 13 and 14, and the plate 15 are maintained in fixed relation to the frame 11 by means of a set screw 16 and a retainer bar 17, the ends of which rest on the edges of two slots 18 in the frame 11.

The opposed cup-shaped core members 13 and 14 bound a chamber 19 in which is located a coil assembly 20 comprising windings 21 mounted on an insulating tube 22. Two leads 23 for the windings 21, only one of which is shown in Fig. 1, pass through aperture 24 in core member 13 and then through an opening in frame 11.

Threaded opening 30 is located in the center of the base of the U of frame 11. Engaging the threads of opening 30 is adjusting screw 31 to which is attached, as by cementing, a movable member 32 of right circular cylindrical shape except for a tapered portion 33 at the end adjacent adjusting screw 31. The cylindrical portion of movable member 32 is covered by insulating tape 34 while an aligning rod 35 penetrates the center of the movable member 32 and the adjusting screw 31. The end of the aligning rod 35 extends beyond the movable member 32 and into a guide hole 36 in the center of the plate 15. By rotating a screwdriver in a slot 37 of adjusting screw 31, movable member 32 with the insulating tape 34 and aligning rod 35 may be moved axially in relation to the cup-shaped core members 13 and 14 and coil assembly 20.

The tapered portion 33 of the movable member 32 defines an air gap 40 with the beveled annular surface 38 of core member 13. The cylindrical surface of the mov-

able member 32 defines a second air gap 41 with beveled annular surface 39 of core member 14. The lengths of both air gaps are opposingly variable with the movement of member 32. That is, as adjusting screw 31 is rotated in one direction, member 32 will tend to be withdrawn from chamber 19 and this movement will shorten air gap 40. At the same time, its movement will increase the length of air gap 41. The combination of the decrease in reluctance of the air gap 40 and the increase in reluctance of air gap 41 will cause an over-all change in inductance of the device.

The magnetic circuit of the inductor and the proportions of the series air gaps may be seen more clearly by reference to Fig. 2, which shows the inductor in diagrammatic form with the beveled surfaces 38 and 39 and the tapered surface 33 shown in exaggerated detail.

Differential tuning is accomplished by incorporating the two air gaps of different configuration into the series magnetic circuit so that each changes in reluctance at a different rate. The net effect of movement of the adjustable member is to gradually change the inductance of the unit at a rate less than that due to the change in each taken separately. In the specific embodiment of this invention shown in Fig. 1, the rate of variation of inductance is nearly uniform 0.24 per cent per mil of linear travel of the tuning member 32 and is accomplished by employing a 5 degree bevel on openings 38 and 39, as well as a 5 degree taper on movable member 32. It is understood, of course, that differently proportioned air gaps may be utilized to obtain a different rate of change of inductance as may be desired.

The substantially uniform variation in inductance with movable member displacement makes the entire range of displacement available for accurate adjusting of the inductor with a resultant increase in useful tuning range over inductors with a more or less exponential inductance variation.

It is understood that the above described arrangements are 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.

Reference is hereby made to the application, Serial No. 262,248 of R. S. Duncan and H. A. Stone Jr., filed December 18, 1951, wherein a related invention is disclosed.

What is claimed is:

1. An inductance device comprising a hollow casing of magnetic material, an adjustable member of magnetic material within said hollow casing, a coil within said hollow casing surrounding said adjustable member, said adjustable member defining an air gap with each of two opposite ends of said hollow casing, said air gaps being of different proportions and means for displacing said adjustable member within said hollow casing to vary opposingly the magnetic reluctance of the air gaps simultaneously.

2. An inductance device comprising a hollow casing of magnetic material, a coil enclosed within said hollow casing, an adjustable member of magnetic material within said hollow casing, said adjustable member defining an air gap with each of two opposite ends of said hollow casing, said air gaps having different rates of change in reluctance, with movement of the adjustable member and means for displacing said adjustable member in relation to said hollow casing to lengthen one of said air gaps and to shorten the other of said air gaps simultaneously.

3. An inductance device comprising a hollow shell of magnetic material, said shell having apertures at opposite ends, a coil within said shell, and a movable member of magnetic material within said shell and defining air gaps of different proportions therewith at each of said apertures, and means for adjusting the position of said movable member to opposingly vary the lengths of said air gaps simultaneously.

4. An inductance device comprising an enclosed casing of magnetic material having a beveled aperture located centrally at each end, a coil situated within said casing, and a movable member insertable through said beveled apertures and into said coil, said movable member defining an air gap with said casing at each of said beveled apertures, and means for adjusting the position of said movable member to opposingly vary the lengths of said air gaps simultaneously.

5. An inductance device in accordance with claim 4 wherein each of said beveled apertures is larger toward the interior of said casing.

6. An inductance device comprising an enclosed casing of magnetic material, said casing having inwardly beveled apertures at each end, a coil contained within said casing, and a movable member of magnetic material insertable through said apertures and into said coil, the ends of said movable member each defining an air gap with said casing at each of said apertures, the air gaps being of different proportions.

7. An inductance device comprising an enclosed casing of magnetic material, said casing having beveled surfaces bounding apertures at each end, a coil within said casing, and an adjustable member of magnetic material having portions adjacent said apertures in said casing, said adjustable member defining an air gap with said casing at each of said apertures, said adjustable member being cylindrical and having a taper at one end to define an air gap of different proportion at each end, and means for relatively displacing said casing and said adjustable member.

8. An inductance device comprising a first magnetic member having a pair of spaced faces of the same configuration, a second magnetic member having a pair of spaced portions of dissimilar configurations each in juxtaposition to a respective one of said faces and defining an air gap therewith, said members and air gaps constituting a magnetic circuit, a coil in electromagnetic coupling relation to said circuit, and means for adjustably moving one of said members relative to the other to vary the reluctance of the two air gaps in an opposite sense.

9. An inductance device comprising a first magnetic member having a pair of spaced beveled surfaces, a second magnetic member having a pair of spaced surfaces each in juxtaposition to a respective one of said spaced surfaces of said first magnetic member and defining an air gap therewith, one of the surfaces of said second magnetic member being tapered conforming to the juxtaposed beveled surfaces in the first magnetic member, said members and air gaps constituting a closed magnetic circuit, a coil in electromagnetic coupling relation to said circuit, and means for adjustably moving one of said members relative to the other to vary the lengths of the two air gaps opposingly.

10. An inductance device comprising a first magnetic member having a pair of spaced faces, a second magnetic member having a pair of spaced portions each in juxtaposition to a respective one of said faces and defining an air gap therewith, the face and portion defining one air gap being of different relative configurations than the face and portion defining the other air gap, said members and air gaps constituting a closed magnetic circuit, a coil in electromagnetic coupling relation with said circuit, and means for adjustably moving one of said members relative to the other to vary the reluctance of the two air gaps in opposite sense.

References Cited in the file of this patent

UNITED STATES PATENTS

2,437,345	Bell	Mar. 9, 1948
2,494,579	Pimlott et al.	Jan. 17, 1950
2,646,552	Shingledecker et al.	July 21, 1953

FOREIGN PATENTS

676,673	France	May 20, 1930
---------	--------	--------------