Feb. 14, 1933. A. J. CHRISTOPHER 1,897,040

INDUCTIVE DEVICE

Filed March 8, 1932

FIG. 1

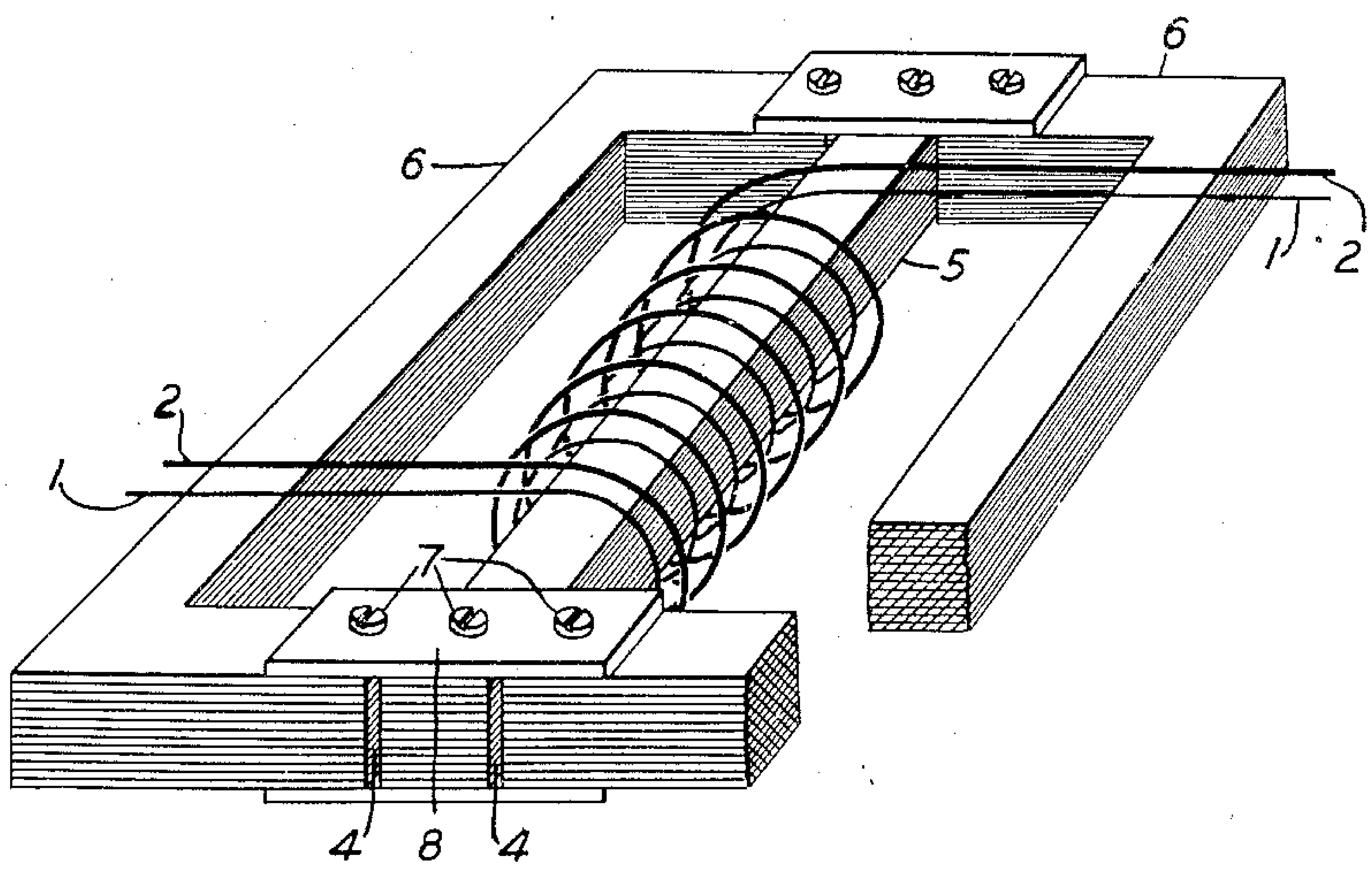
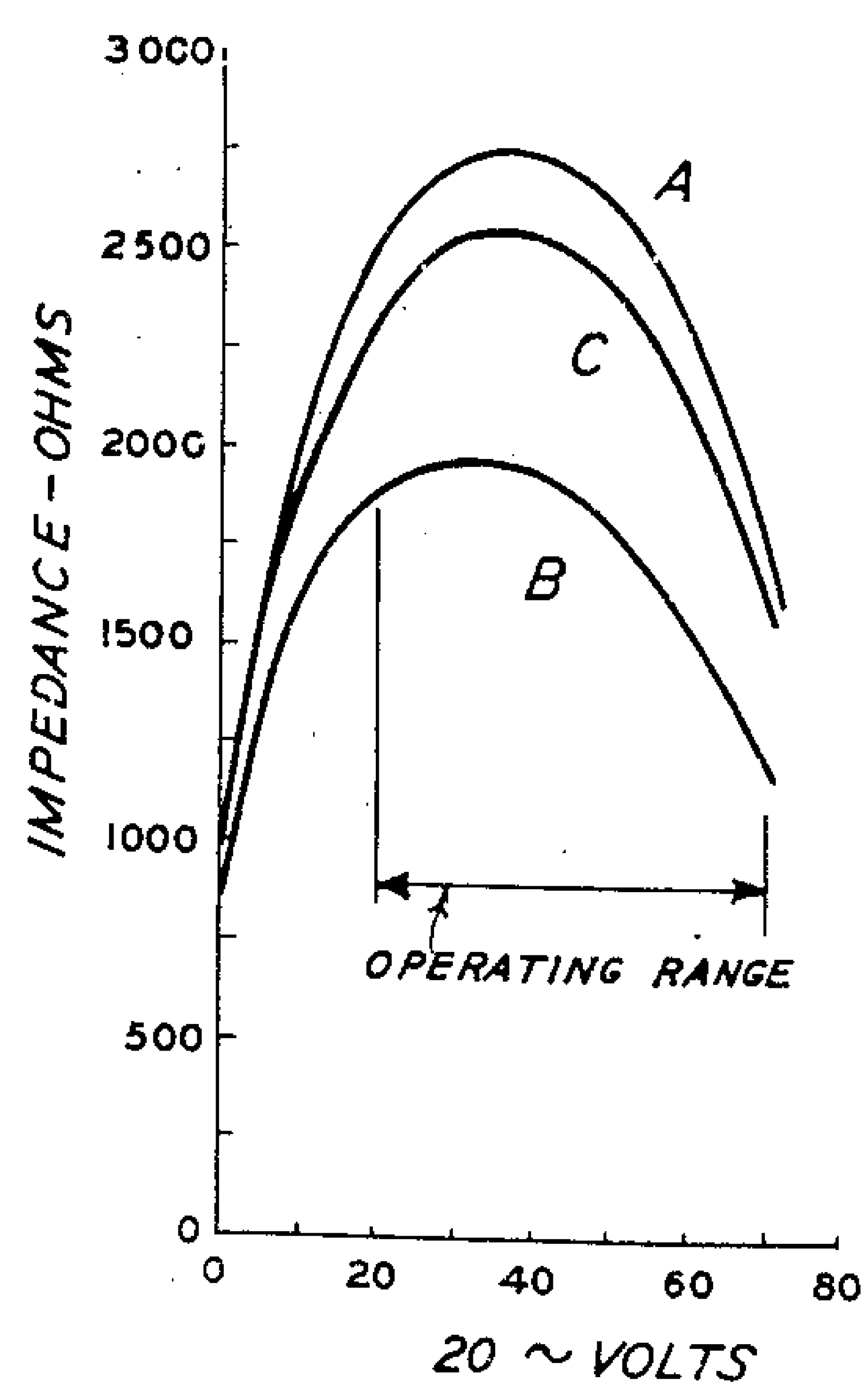


FIG. 2



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UNITED STATES PATENT OFFICE

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INDUCTIVE DEVICE

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This invention relates to electromagnetic inductive devices and more particularly to transformers and repeating coils such as are used in telephone communication circuits.

An object of this invention is to improve the efficiency of inductive devices and to make them uniformly effective over a wide range of current densities.

A more particular object is to provide transformers and repeating coils of inexpensive construction which transmit with high efficiency both speech frequency currents of low intensity and lower frequency signaling currents of high intensity.

Shell-type transformers constructed by the assembly of C and I shaped laminations have long been employed in the art. A characteristic of this construction is the presence of a small air gap between the junction point of the two different shaped laminations. This construction is especially advantageous as it affords a quick, convenient and cheap means of manufacturing the transformer. The different shaped laminations of the core are usually clamped together with brass or some other low cost material which possesses the required rigidity to hold the laminations together.

In addition to the manufacturing advantages which this structure yields, the small air gap effects an essential function in stabilizing the inductance of the coil at speech frequencies. For paired repeating coils having cores comprising laminations of silicon steel or iron-nickel alloys and employed with two-way repeaters, this factor is extremely important for the maintenance of high amplification of voice frequency currents. With no air gap or an air gap which is too small a tendency exists for one or both of the coils forming a pair after being subjected to the effect of heavy magnetizing currents (such as low frequency signaling currents) not to be self-restoring but on the contrary to operate with changed impedance characteristics. This condition reduces the impedance balance originally obtained. However, the air gap causes the magnetic path to present a considerably higher reluctance to high flux densities of sixteen to twenty cycles ringing current than if no air gap were present. Consequently, the efficiency of the device at these current densities is seriously impaired. It is therefore desirable that a repeating coil for this purpose be provided with a core which at sixteen to twenty cycles involving high alternating current saturation has an effective length of air gap as small as possible.

In accordance with this invention a coil is provided with a shell-type core with air gaps sufficient to cause the coil to function satisfactorily with currents of the frequencies and intensities employed in the operation of two-way voice frequency repeaters. In order that the coil may also efficiently transmit high intensity currents of sixteen to twenty cycles frequency the core is provided with end plates which overlap the air gap and consist of a material having a low reluctance at high flux densities. Certain heat treated alloys comprising cobalt and iron when employed as end plates have a relatively higher effective reluctance at low flux densities and a lower effective reluctance at high flux densities than that of the air gap. A small quantity of vanadium is usually added to these alloys to improve their working qualities. Plates of these alloys in addition to holding the laminations firmly together bridge the air gap. In a core of this construction the flux caused by the sixteen to twenty cycles ringing current at high flux densities passes largely through the end plates, which have a low reluctance under these conditions, and to a lesser extent through the air gap. As a consequence the effective impedance of the coil is increased at the low frequencies of the ringing current, thus resulting in improved transmission efficiency. With the low flux densities of the voice current, however, the reluctance of the end plates is relatively higher than that of the air gap and only a small percentage of the total flux in the core passes through the end plates. The shunting effect of these plates, therefore, has but little effect on the permeability and stability of the core under voice frequency conditions.

An embodiment of the present invention is illustrated in the accompanying drawing in which:

Fig. 1 represents in a diagrammatic manner a repeating coil having primary and secondary windings, the core of the coil being shell-type and consisting of I and C-shaped laminations;

Fig. 2 is a graph indicating the variation in mutual impedance which may be effected at high flux densities by the use of different end plates employed in the structure illustrated in Fig. 1.

In Fig. 1 the core comprises an I-shaped member 5 and two C-shaped members 6, 6. Each of these members is preferably constructed of a plurality of laminations, arranged in parallel. Each member 6 is positioned on one side of the member 5 such that the arms of members 6 are in spaced relation to the member 5 to form air gaps 4, 4 and are in alignment with the arms of the other member 6. The length of the air gaps between member 5 and the arms of members 6 is such as to insure the stability of the inductance of the core for the transmission of voice currents. While the air gap may be any distance, placing the arms of members 6 so that they abut the side of member 5 usually affords sufficient gap for this purpose, the distance between the members terminating in the air gap being approximately one mil. The primary 1 and secondary 2 of the coil are preferably wound around the member 5.

Although other magnetic alloys than those described here may be employed, materials having a high permeability at both low and high flux densities are preferred for the construction of members 5 and 6. Heat treated alloys comprising 44 to 46% nickel and the remainder chiefly iron and heat treated silicon steel comprising 3.5 to 4.5% silicon and the remainder chiefly iron, both of which exhibit this characteristic, are examples of materials which may be used for this purpose. The nickel-iron alloy is heat treated by placing it in a container which prevents oxidation and contamination and subjecting it to a temperature between 1050° C. and 1100° C. for a period of one hour. The container is then permitted to cool at a rate not exceeding 4° C. per minute. The silicon steel is heated for one hour at 760° C. to 830° C. and then cooled at a rate not exceeding 10° C. per minute between the annealing temperature and 500° C.

Extending between the oppositely disposed arms of members 6, 6 and bridging the air gaps 4 between the member 5 and the members 6, 6 are one or more strips 8, rods or other means comprising a material having a lower effective reluctance at high flux densities and a higher effective reluctance at low flux densities than the effective reluctances of the air gaps. The strips or other means of bridging the magnetic members of the core may be fastened to the members in any suitable manner, such as by screws or rivets. In Fig. 1 screws 7 are the fastening medium. A cobalt-vanadium-iron alloy comprising 49.5 to 50.5% cobalt, 1.75 to 2.25% vanadium and the remainder chiefly iron when properly heat treated has a low reluctance at high flux densities and a comparatively high reluctance at low flux densities. The presence of the vanadium in the alloy is to improve the working qualities of the metal. The heat treatment consists in placing the alloy in a container which insures its freedom from oxidation and contamination, subjecting it to a temperature of approximately 1000° C. for a period of one hour, and then permitting it to cool slowly in the furnace from that temperature. Bridging means comprising other magnetic materials which cause the bridge to exhibit a comparatively lower reluctance at high flux densities and higher reluctance at low flux densities than that of the air gap, such as ordinary sheet steels, may also be employed.

In Fig. 2 curve B shows a typical impedance characteristic at twenty cycles with various impressed voltages of a coil comprising a shell-type laminated core, the air gaps of which are bridged with brass. Curve A shows the impedance of the same coil with cobalt-vanadium-iron alloy as the clamping material, while curve C is that of the same coil, with sheet steel as the clamping material. In the operating range of signaling voltage the impedance of the brass bridged coil (curve B) varies from a maximum of approximately 1950 ohms at about 33 volts to a minimum of approximately 1200 ohms at 70 volts; whereas the impedance for the same coil with cobalt-vanadium-iron (curve A) as the bridging medium is 2750 ohms at 38 volts and 1800 ohms at 70 volts. The same coil using sheet steel as the bridging medium attains a maximum impedance of approximately 2550 ohms at 37 volts and a minimum within the operating range of about 1640 ohms at 70 volts. Although the impedance at the higher signaling voltages is increased above the brass bridged core by more than 45% with the vanadium-cobalt-iron alloy and 30% with sheet steel, it has been found that there is no appreciable difference in the inductive stability of the three cores.

It is to be understood that any magnetic material which when employed as the bridging means has a lower effective reluctance at high alternating current saturation conditions and higher effective reluctance at low flux densities than the effective reluctance of the air gaps, may be used for the end plates and that any efficient magnetic material may be used for the coil laminations. Likewise, although a shell-type core comprising C and I-shaped laminations is described in the specific embodiment, any other shell-type core comprising different shaped laminations, such as the T and U-shapes, or any core which has an air gap and with which the same result is effected is within the scope of this invention.

What is claimed is:

1. An inductive device comprising a core with windings thereon, said core comprising a magnetic material, the continuity thereof being broken by an air gap, the opposed portions of said material terminating in the air gap being bridged by means comprising a magnetic material having a lower reluctance at high flux densities and a higher reluctance at low flux densities than the first stated material.

2. An inductive device comprising a core with windings thereon, said core comprising a magnetic material having a high permeability at both high and low flux densities, the continuity of said material being broken by an air gap, the opposed portions of said material terminating in the air gap being bridged by means comprising a material having a low reluctance at high flux densities and high reluctance at low flux densities.

3. An inductive device in accordance with claim 2, in which the magnetic material having a high permeability at both high and low flux densities is silicon steel.

4. An inductive device in accordance with claim 2, in which the magnetic material having a high permeability at both high and low flux densities is an alloy comprising nickel and iron.

5. An inductive device in accordance with claim 2, in which the material having a low reluctance at high flux densities and a high reluctance at low flux densities comprises cobalt and iron.

6. An inductive device comprising a core with windings thereon, said core comprising a plurality of magnetic members, said members being separated from each other by an air gap, said air gap being bridged by means having a lower effective reluctance at high flux densities and a higher effective reluctance at low flux densities than that of said air gap.

7. An inductive device in accordance with claim 6 in which the means having a lower effective reluctance at high flux densities and a higher effective reluctance at low flux densities than that of said air gap is an alloy comprising cobalt and iron.

8. An inductive device in accordance with claim 6, in which the means having a lower effective reluctance at high flux densities and a higher effective reluctance at low flux densities than that of said air gap is sheet steel.

9. A transformer comprising a shell-type core with windings thereon, said core comprising a plurality of different shaped members of a magnetic material, said members being separated from each other by an air gap and joined to each other at the air gap by means having a lower effective reluctance at high flux densities and a higher effective reluctance at low flux densities than that of said air gap.

10. A transformer comprising a shell-type laminated core with windings thereon, said core comprising a plurality of different shaped members, said members comprising laminations of silicon steel, said members being separated from each other by an air gap and joined to each other at the air gap by means comprising an alloy comprising cobalt, vanadium and iron.

11. A transformer comprising a shell-type laminated core with windings thereon, said core comprising a plurality of different shaped members, said members comprising laminations of a nickel-iron alloy comprising 44 to 46% nickel and the remainder chiefly iron, said members being separated from each other by an air gap and joined to each other at the air gap by means comprising 49.5 to 50.5% cobalt, 1.75 to 2.25% vanadium and the remainder chiefly iron.

12. A transformer comprising a shell-type laminated core with windings thereon, said core comprising a plurality of different shaped members, said members comprising laminations of silicon steel, said members being separated from each other by an air gap and bridged to each other at the air gap by means comprising sheet steel, said means having a higher effective reluctance at low flux densities and a lower effective reluctance at high flux densities than that of said air gap.

In witness whereof, I hereunto subscribe my name this 4th day of March, 1932.

ARTHUR J. CHRISTOPHER.