United States Patent [19]

Haddock, Jr. et al.

[11] **3,708,775**

[45] **Jan. 2, 1973**

[54] **ADJUSTABLE IMPEDANCE REGULATING TRANSFORMER**

[76] Inventors: **Asa H. Haddock, Jr.; Jay W. Howard,** both of c/o ESB Incorporated, P.O. Box 8109, Philadelphia, Pa. 19101

[22] Filed: **Aug. 6, 1971**

[21] Appl. No.: **169,639**

[52] **U.S. Cl.** **336/155,** 336/212, 336/215

[51] **Int. Cl.**.....**H01f 21/08**

[58] **Field of Search**.....336/155, 160, 170, 184, 212, 336/214, 215, 234

[56] **References Cited**

UNITED STATES PATENTS

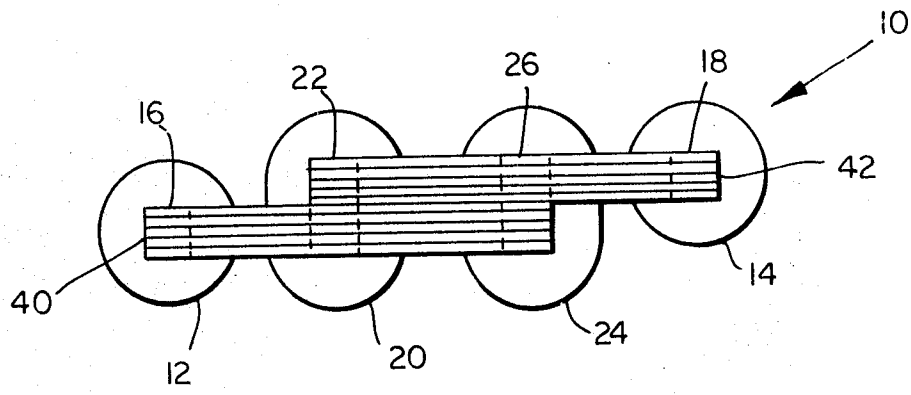
3,395,373	7/1968	Stephens	336/215 X
1,662,132	3/1928	Simmons	336/215 X
3,454,867	7/1969	Dinger	336/155 X
2,991,437	7/1961	Kreuzer et al.	336/215 X
1,606,761	11/1926	Guilbaud	336/214 X
1,606,755	11/1926	Field	336/215 X

Primary Examiner—Thomas J. Kozma
Attorney—Robert H. Robinson et al.

[57] **ABSTRACT**

An adjustable impedance regulating transformer of the type having four windings including a primary winding, a secondary winding and two control windings wound on four legs of a transformer core. The core comprises in sequence a first leg of a first cross section, two legs of twice the first cross section and a fourth leg of the first cross section. The two control windings are located on the two legs of first cross section and the primary and secondary windings are located, respectively, on the two legs of twice the first cross section. The core can utilize standard transformer laminations.

3 Claims, 4 Drawing Figures



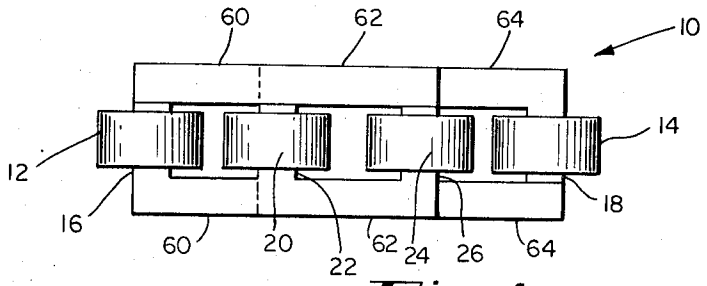


Fig. 1

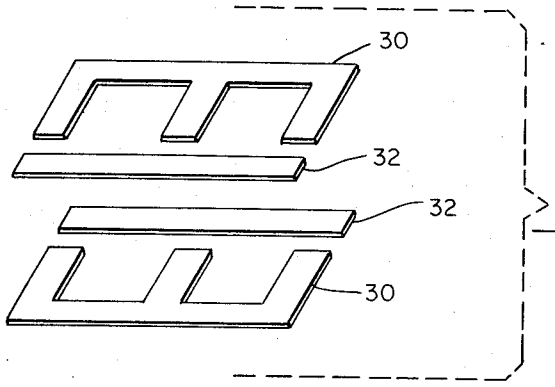


Fig. 2

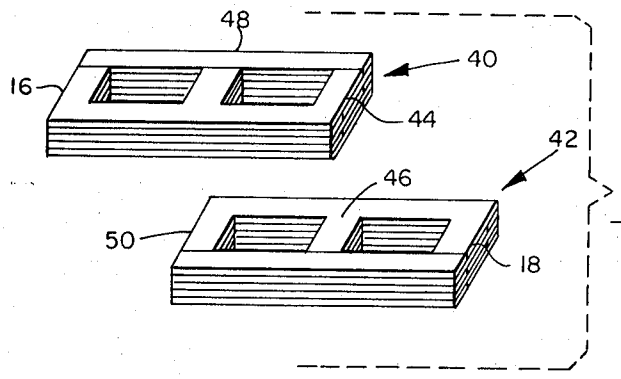


Fig. 3

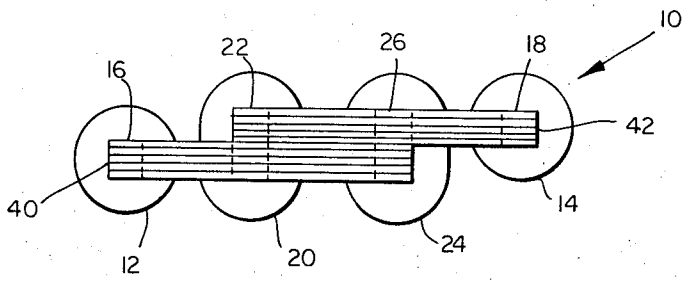


Fig. 4

INVENTORS.
ASA H. HADDOCK, JR.
JAY W. HOWARD

ADJUSTABLE IMPEDANCE REGULATING TRANSFORMER

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to adjustable impedance regulating transformers of the type having four legs and four windings.

2. Description of the Prior Art

The utility of a four-legged, four-winding, adjustable impedance regulating transformer has been known for many years. Circuits embodying such devices have been described for use as on welding control, current control, voltage control, AC regulation, etc. Similar devices have been described for storage battery charge control. Particularly in storage battery charger field, there is a custom business with short runs of many types and sizes. Any one particular size charger does not warrant the purchase of expensive tools, particularly transformer core punches, as would be necessary to construct the cores of the adjustable impedance regulating transformers that have been described.

SUMMARY OF THE INVENTION

Briefly, and in accordance with the invention, there is provided a four-legged, adjustable impedance regulating transformer. Two of the core legs of the transformer have twice the cross section of the remaining two legs. Control windings are provided on the core legs of small size and primary and secondary windings, respectively, are provided on the two core legs of larger size. The magnetic core of the transformer may be assembled from standard E and I core punchings or stampings by laying up one-half the core stampings in offset relation to the remaining core punchings. A more complete understanding of the invention may be had from the following description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows in elevation a transformer made in accordance with the invention;

FIG. 2 shows some standard transformer core punchings;

FIG. 3 shows two juxtaposed core stacks; and

FIG. 4 shows in plan the transformer of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

It is well known in the transformer art that transformer cores should be discontinuous in paths at right angles to the magnetic path. If this is not done, eddy currents will flow in the cores causing loss of efficiency and excess heating of the core. For this reason, transformer cores are normally made from compressed powders or are built up from thin laminations of sheet metal. For low volume custom transformer work, the laminated construction offers the lowest cost assembly consistent with a high quality product. For purposes of example, an adjustable impedance regulating transformer will be described below making use of a laminated core structure, however, it is to be understood that other core construction methods such as molded powder techniques can be used to embody the present invention.

In FIG. 1, 10 represents a transformer made in accordance with the invention using the lamination technique. Windings 12 and 14 located on legs 16 and 18 are the control windings; winding 20 on leg 22 is the primary winding and winding 24 on leg 26 is the secondary winding. The several core legs are connected together to form a magnetic circuit by the several connecting arms 60, 62 and 64. In FIG. 2, for example, a transformer core punching or lamination of a shape 30 that has become standardized and designated as an E punching is shown. A further standardized shape known as an I punching or lamination is shown at 32. E and I laminations are used in great quantity for the cores of many types of transformers. They are readily available and can be obtained in a great many sizes and dimensions. There are also other standard lamination shapes in general use. The invention is not suited to E and I laminations only. It is usual practice when assembling a core to lay a first pair of laminations with the legs of the E lamination as shown in the bottom portion of FIG. 2. The next pair of laminations are laid down with the legs of the E lamination and the I lamination as shown in the upper portion of FIG. 2. By so alternating the laminations, the effect of the discontinuity in the magnetic path between the E lamination and the I lamination is minimized. The laminations are stacked up until a core of a desired size has been made.

In FIG. 3, two stacks of laminations 40 and 42 are shown. To produce a core suitable for the regulating transformer shown as 10, FIG. 1, two equal stacks of laminations are prepared (FIG. 3, 40 and 42). One stack 40 is set against the other 42 in a partially overlapping position so that a first end leg 44 of the first stack overlies the middle leg 46 of the second stack and the middle leg 48 of the first stack overlies the second end leg 50 of the second stack. The second end leg of the first stack 16 and the first end leg 18 of the second stack are each clear of the opposing stack. This results in a core having four legs, a first end leg of unity thickness, two central legs of double unity thickness and a second end leg of unity thickness.

A first pair of arms 60, FIG. 1, connects the primary leg 22 to the first control leg 16, a second pair of arms 62 connects the secondary leg 26 to the primary leg 22, and a third pair of arms 64 connects the second control leg 18 to the secondary leg 26.

FIG. 4 is a top view of transformer 10 showing the two core stacks 40 and 42 in a partially overlapping position. Control coils 12 and 14 are shown wound around the two end legs 16 and 18. The primary coil 20 is wound around one of the central legs 22 and the secondary coil 24 is wound around the remaining central leg 26. In the regulating transformers of the present invention, it is desirable that the control legs have just one-half the cross section of the primary and secondary legs in order to get maximum control range. If a lesser control range is satisfactory, the control legs may be smaller than the above stated ratio. As shown in FIG. 4 taken with FIG. 1, the cross sectional area of each arm of arms 60 and 64 connecting the control leg cores 16 and 18 to the main portion of the core 22, 62, 26 is approximately equal to the cross sectional area of the control leg cores 16 or 18. The cross sectional area of each of the main connecting arms 62 is approximately equal to the cross sectional area of the primary and secondary leg cores 22 and 26 respectfully.

The sizing of transformer parts such as windings, cores, etc., is well known in the art and well documented. In generalities, it can be stated that the core size and windings for the primary and secondary of the regulating transformer of the invention are chosen in the same manner and according to the same rules as are used in normal transformer art. The control windings desirably have the same ampere turns as the primary winding although this is not mandatory. Also, when used in the battery charging circuit referred to above, it is customary to have the control windings electrically interconnected and to pass direct current through the control coils. Further, when direct current is used for control, it is usual practice to have the field of one of the control coils in opposition to the other.

Although the manner in which the regulating transformer operates is well documented, it can be stated that the control windings are used to saturate or partially saturate the core legs passing therethrough. This, in turn, controls the magnetic flux which is forced to pass from the primary through the secondary core legs and this, in turn, controls the output of the regulator.

Other ways of assembling standard core forms may be used to produce a four-legged core having two small area end legs and two large area central legs. For example, a core may be laid up in which the individual laminations are alternately arranged in the positions of the stacks shown by **40** and **42**. This gives a better core magnetically than the core of transformer FIG. 4 and might also be used with closed H laminations. However, because the end legs tend to be thicker (because of the air spaces in the cores) than the end legs of FIG. 4, more wire will be needed to form the control coils than in the design of FIG. **4** and, hence, the transformer will probably be more costly.

Having described my invention and given a detailed description of a typical embodiment, I hereby claim:

1. An adjustable impedance regulating transformer having a magnetic core which comprises:

a. a first control leg having a first control winding thereon;

b. a primary leg having a primary winding thereon, the primary leg having approximately twice the cross sectional area of the first control leg and being structurally and magnetically connected to the first control leg by a first pair of connecting arms; the cross sectional area of each arm of the first pair of connecting arms being approximately equal to the cross sectional area of the first control leg;

c. a secondary leg having a secondary winding thereon, the secondary leg having approximately the same cross sectional area as the primary leg and being structurally and magnetically connected to the primary leg by a second pair of connecting arms; the cross sectional area of each arm of the second pair of connecting arms being approximately equal to the cross sectional area of the primary leg; and,

d. a second control leg having a second control winding thereon, the cross sectional area of the second control leg being approximately equal to the cross sectional area of the first control leg and being structurally and magnetically connected to the secondary leg by a third pair of connecting arms; the cross sectional area of each arm of the third pair of connecting arms being approximately equal to the cross sectional area of the first control leg.

2. An adjustable impedance regulating transformer which comprises:

a. a first stack and a second stack of transformer core laminations, each stack of laminations comprising a first end leg, a middle leg and a second end leg with the first end leg being interconnected with the middle leg by a first pair of connecting arms and with the middle leg being interconnected to the second end leg by a second pair of connecting arms, the second stack of laminations located adjacent to the first stack of laminations in partial overlapping relationship so that the first end leg of the first stack overlies the middle leg of the second stack and the middle leg of the first stack overlies the second end leg of the second stack;

b. a first control winding being disposed about the second end leg of the first stack;

c. a primary winding being disposed about the middle leg of the first stack and the second end leg of the second stack;

d. a secondary winding being disposed about the first end leg of the first stack and the middle leg of the second stack; and

e. a second control winding being disposed about the first end leg of the second stack.

3. An adjustable impedance transformer as described in claim **2** in which the first and second control windings are electrically interconnected.

* * * * *