

Dec. 6, 1966

B. E. STEVENS

3,290,634

MAGNETICALLY SHIELDED TRANSFORMER

Filed Oct. 31, 1963

FIG. 1

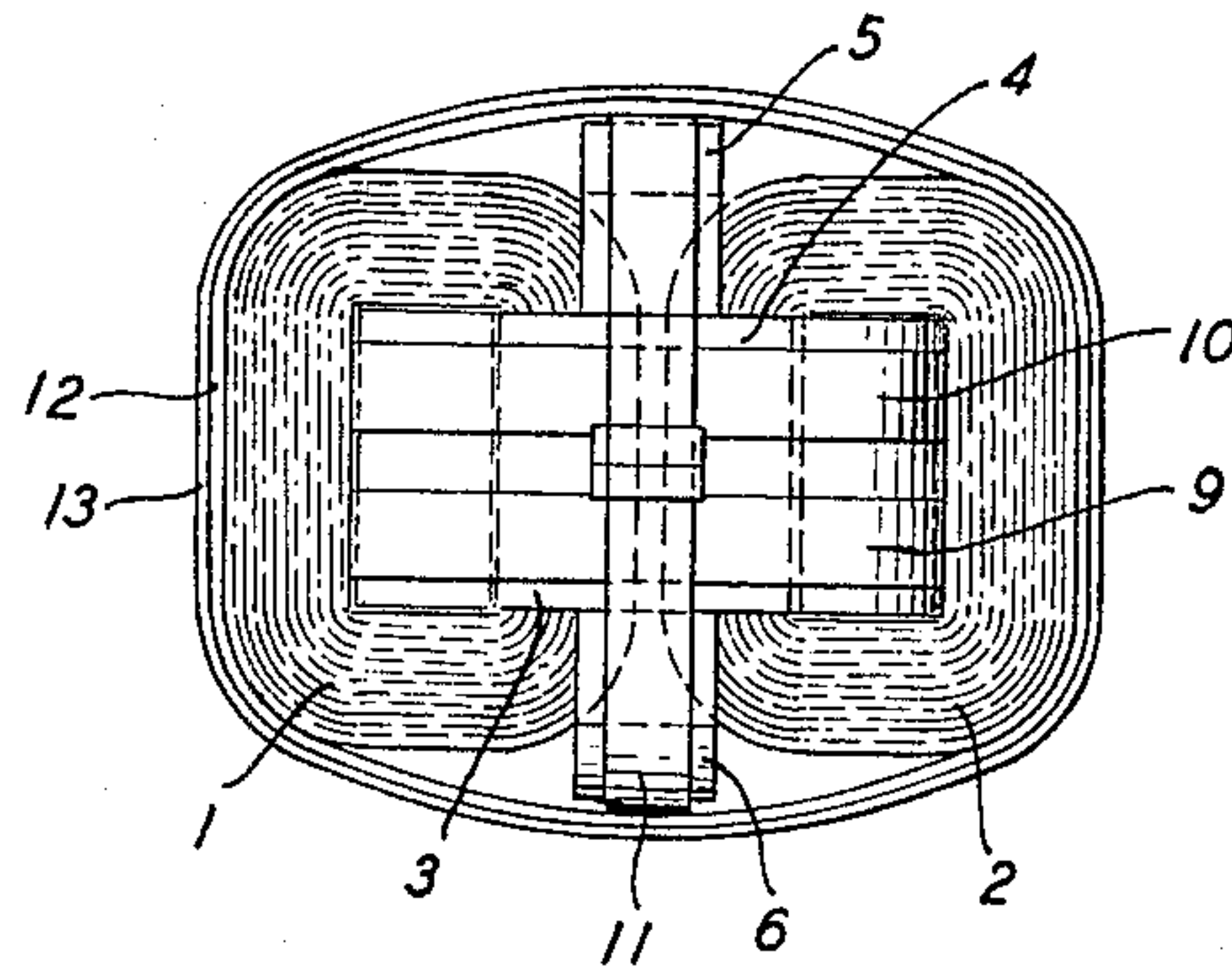


FIG. 2

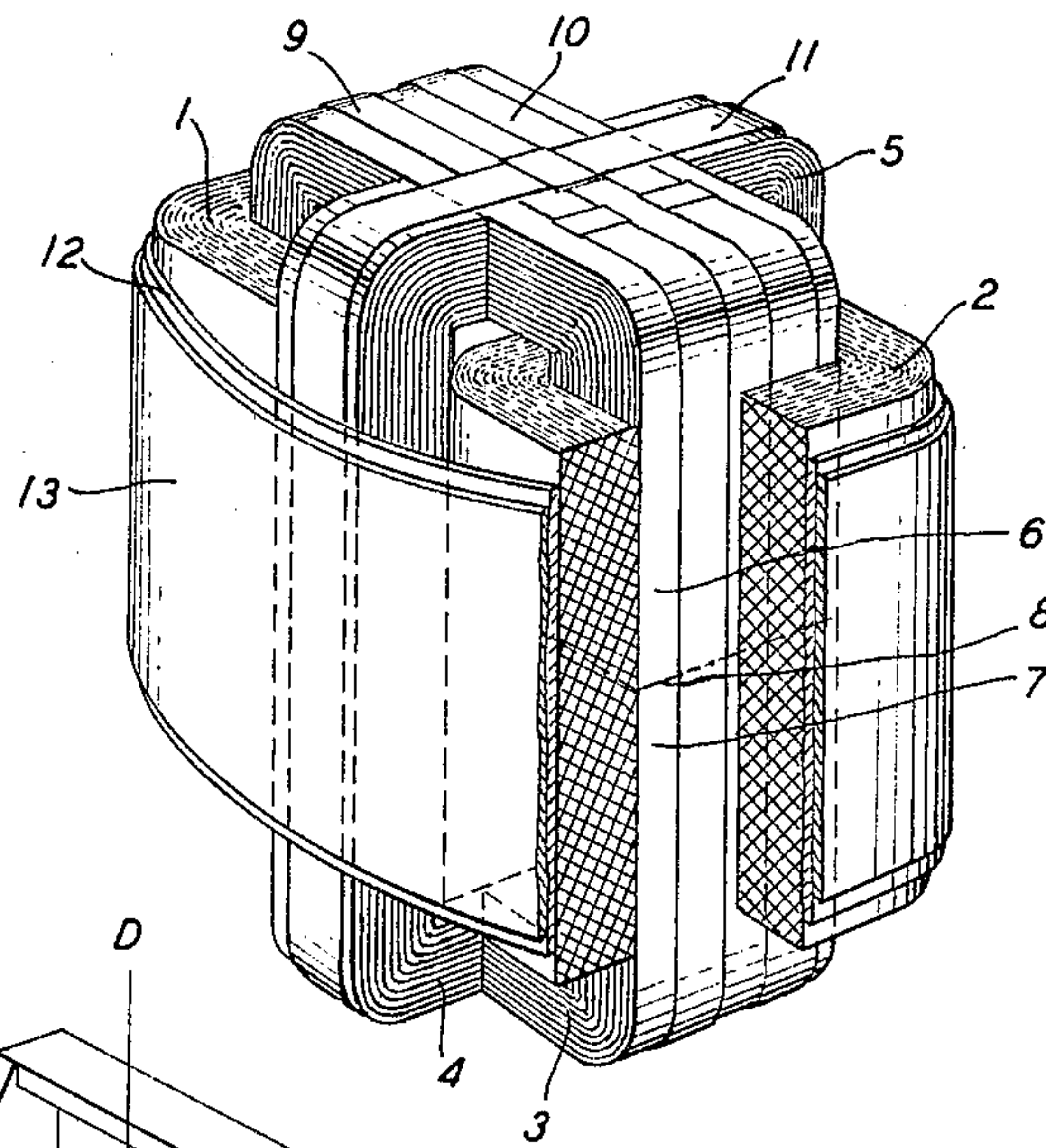
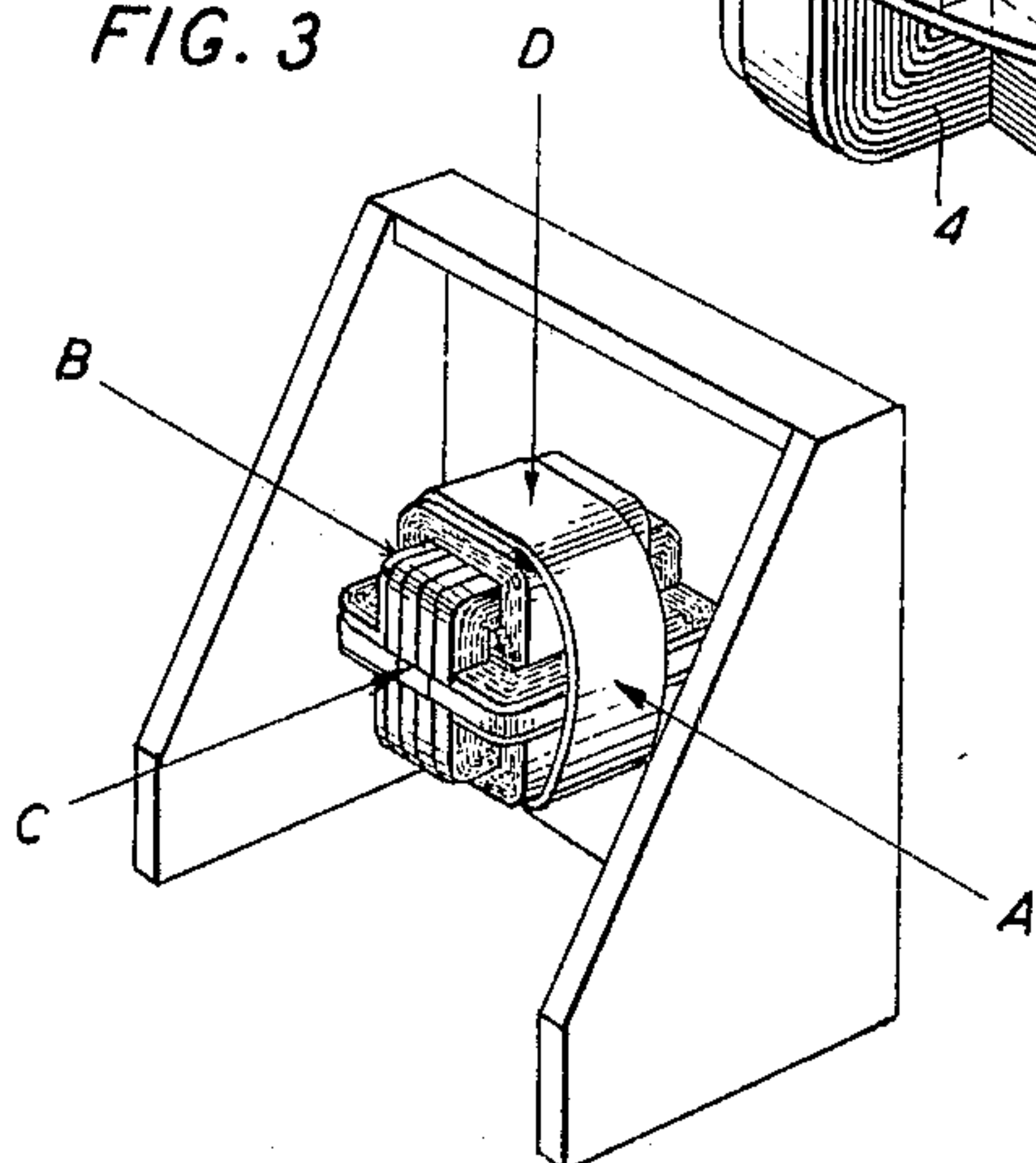


FIG. 3



INVENTOR  
B. E. STEVENS  
BY *John C. Morris*

ATTORNEY



1

3,290,634

MAGNETICALLY SHIELDED TRANSFORMER

Bruce E. Stevens, Closter, N.J., assignor to Bell Telephone Laboratories, Incorporated, New York, N.Y., a corporation of New York

Filed Oct. 31, 1963, Ser. No. 320,403

1 Claim. (Cl. 336—84)

This invention relates to inductor devices and more especially to transformers which utilize electric or magnetic shielding means to control the external field emanating from the transformer.

Transformers of the type pertinent to this invention are used principally in voltage regulators which are required to provide an output potential that is substantially independent of variations in the input potential. In meeting the foregoing requirement, designers of voltage regulators commonly specify the so-called ferroresonant type of transformer. An example of such a transformer, together with the principles of operation, are disclosed in United States Patent 2,143,745 issued to J. G. Sola on Jan. 10, 1939.

While ferroresonant transformers successfully provide a suitably constant voltage output which is substantially independent of voltage input variations, they exhibit a troublesome characteristic in that a large external field is generated during operation. As a consequence, magnetically sensitive components located adjacent to the transformer are subject to potentially disruptive magnetic interference.

It is, therefore, an object of this invention to reduce the large external field associated with ferroresonant transformers.

One method of reducing the external field is to encircle the entire transformer with a band of copper. A reduction in external field occurs when the external field of the transformer links the copper band whereby currents are caused to flow therein. The induced currents produce a field opposing that of the transformer. As a consequence, the external field is reduced. However, since the copper band is a short-circuited winding, currents of large magnitude are readily induced therein. As a result, the copper band is subject to overheating.

Although overheating can be controlled by increasing the quantity of copper in the band, economic considerations in many instances make such a solution prohibitive. Other materials such as steel have been tried in attempting to improve the band's field reducing capacity, but no single material has been found to surpass copper in efficiency. According to this invention, however, a band comprising an inner layer of steel and an outer layer of copper produces a reduction of external field exceeding that which can be obtained by a band of the same thickness made of copper or steel alone. Data illustrating this discovery are tabulated below.

2

TABLE

| I                                                                         | II                      | III                                                                                                        | IV                                                             |
|---------------------------------------------------------------------------|-------------------------|------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|
| Shield Material                                                           | Shield Thickness (mils) | Average Field Intensity Calculated From Measurements Taken at Points A, B, C, and D of Fig. 3 (millivolts) | Reduction in Average Field Intensity (10.17, III) (millivolts) |
| Grain-Oriented Silicon Steel-----                                         | 0                       | 10.17                                                                                                      | -----                                                          |
|                                                                           | 8                       | 8.75                                                                                                       | 1.42                                                           |
|                                                                           | 16                      | 7.07                                                                                                       | 3.10                                                           |
|                                                                           | 40                      | 5.13                                                                                                       | 5.04                                                           |
|                                                                           | 56                      | 4.68                                                                                                       | 5.49                                                           |
|                                                                           | 80                      | 4.65                                                                                                       | 5.52                                                           |
|                                                                           | 96                      | 4.53                                                                                                       | 5.64                                                           |
| Copper-----                                                               | 120                     | 4.33                                                                                                       | 5.84                                                           |
|                                                                           | 0                       | 10.17                                                                                                      | -----                                                          |
|                                                                           | 20                      | 5.45                                                                                                       | 4.72                                                           |
|                                                                           | 40                      | 3.32                                                                                                       | 6.85                                                           |
|                                                                           | 60                      | 2.42                                                                                                       | 7.75                                                           |
|                                                                           | 80                      | 2.02                                                                                                       | 8.15                                                           |
|                                                                           | 120                     | 1.50                                                                                                       | 8.67                                                           |
| Grain-Oriented Silicon Steel (40 mils) and Copper (80 mils) Combined----- | 500                     | .55                                                                                                        | 9.62                                                           |
|                                                                           | 120                     | .55                                                                                                        | 9.62                                                           |

<sup>1</sup> Approximate.

All measurements were made at a distance of two feet with an input of 129 volts, 60 cycles per second, a load current of 25 amperes, and a recorded external field frequency of 180 cycles.

The following detailed specification will aid in a fuller understanding of this invention when taken in conjunction with the appended drawing in which:

FIG. 1 discloses an elevation view of an illustrative embodiment of the invention;

FIG. 2 discloses a perspective view of the embodiment shown in FIG. 1 with parts broken away; and

FIG. 3 shows the embodiment illustrated in FIG. 2 mounted on a panel in a test set-up used to obtain data regarding field reducing capacity of bands made of various materials.

Referring to FIG. 2, the transformer consists of windings or primary and secondary coils 1 and 2 each encircling a leg of a core 3, and a pair of flux shunting yoke members 4 and 5. The core 3 comprises two C-shaped sections 6 and 7. Each section is preferably made from layers of grain-oriented silicon steel tape. The ends of the C-shaped sections 6 and 7 are lapped smooth and inserted in the coils 1 and 2 so as to abut one another at two places, one which is designated by the numeral 8. The sections 6 and 7 are held firmly together by a pair of straps 9 and 10. The straps 9 and 10 may conveniently be made from steel tape.

The two flux shunting yoke members 4 and 5 are C-shaped and complete the transformer by interconnecting the two sections 6 and 7 of the core 3. The yoke members 4 and 5 are preferably made of a grain-oriented sili-



3

con steel in a manner similar to that in which the sections 6 and 7 are made. The yoke members 4 and 5 are held firmly in place against the core 3 by a strap 11 which may also be made of steel.

Surrounding the completed transformer are two bands 12 and 13; one of which is preferably made from windings of grain-oriented silicon steel tape, while the other is made of copper. In the illustrated embodiment, the band 12 is 40 mils thick and made of steel, while the band 13 is 80 mils thick and made of copper.

Although only one specific embodiment of the invention has been shown and described, it will be apparent that various modifications of the component parts may readily be made without departing from the scope and spirit of the invention.

What is claimed is:

A transformer comprising: a primary coil wound around a central axis; a secondary coil wound around a central axis, said secondary coil and said primary coil being disposed with their central axes in parallel and being wound so that the stray fields generated by each

4

are aiding; a main core for magnetically coupling said primary and secondary coils; a pair of yokes for magnetically shunting said primary and said secondary coils; and a single band encircling said primary and said secondary coil, said main core, and said yokes for reducing the magnitude of said stray fields, said band having a height less than the height of said primary and said secondary coils and comprising an inner layer of grain-oriented silicon steel 40 mils thick and an outer layer of copper 80 mils thick.

#### References Cited by the Examiner

##### UNITED STATES PATENTS

|           |         |           |         |   |
|-----------|---------|-----------|---------|---|
| 2,526,977 | 10/1950 | Smith     | 336—84  | X |
| 2,771,587 | 11/1956 | Henderson | 336—160 |   |
| 2,826,748 | 3/1958  | Newton    | 336—155 |   |

LEWIS H. MYERS, *Primary Examiner*.

ROBERT K. SCHAEFER, *Examiner*.

W. M. ASBURY, T. J. KOZMA, *Assistant Examiners*.