

Sept. 20, 1960

C. J. YARRICK ET AL

2,953,757

MOLDED EPOXY CURRENT TRANSFORMER

Filed June 4, 1956

FIG. 1

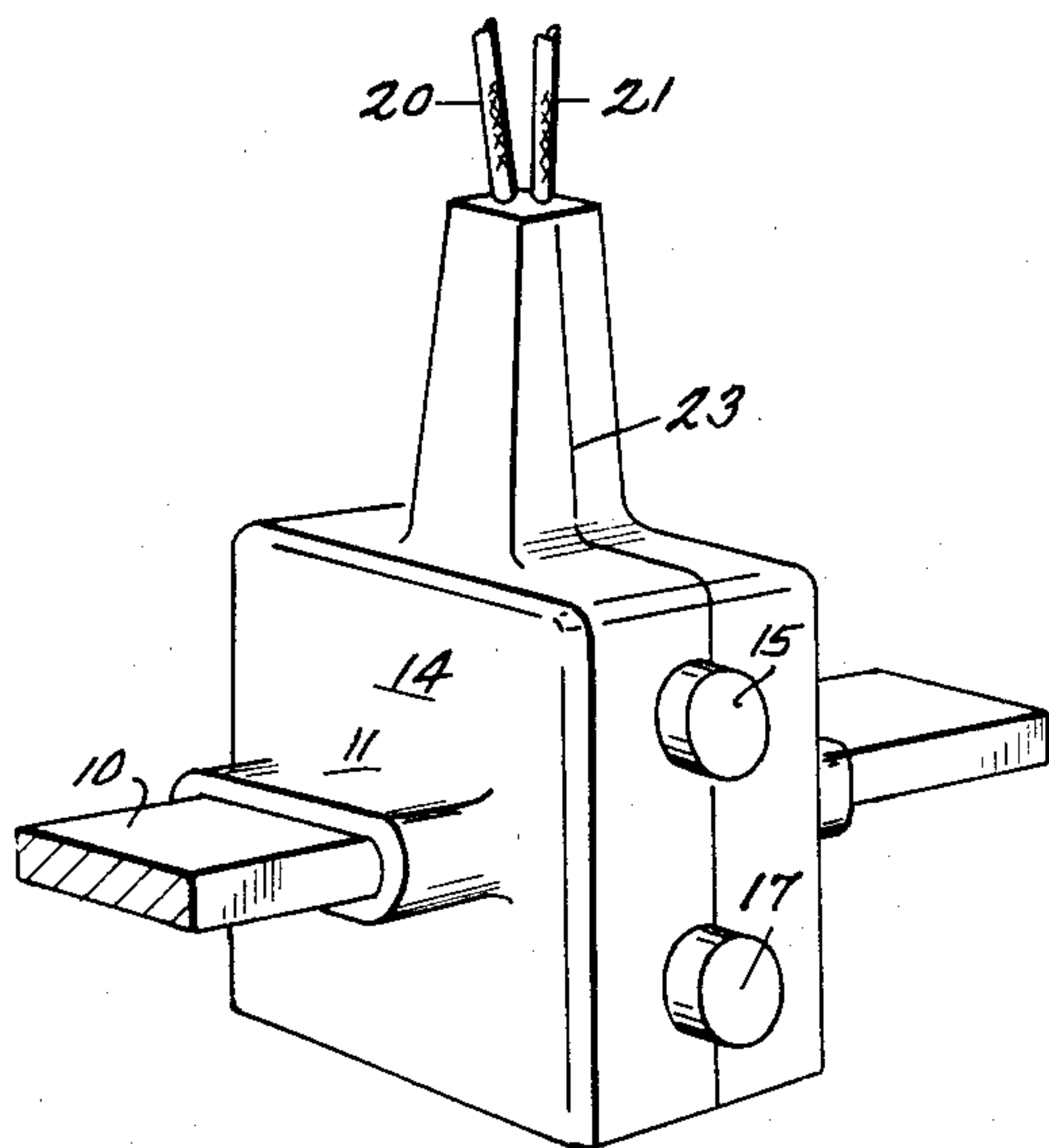


FIG. 2

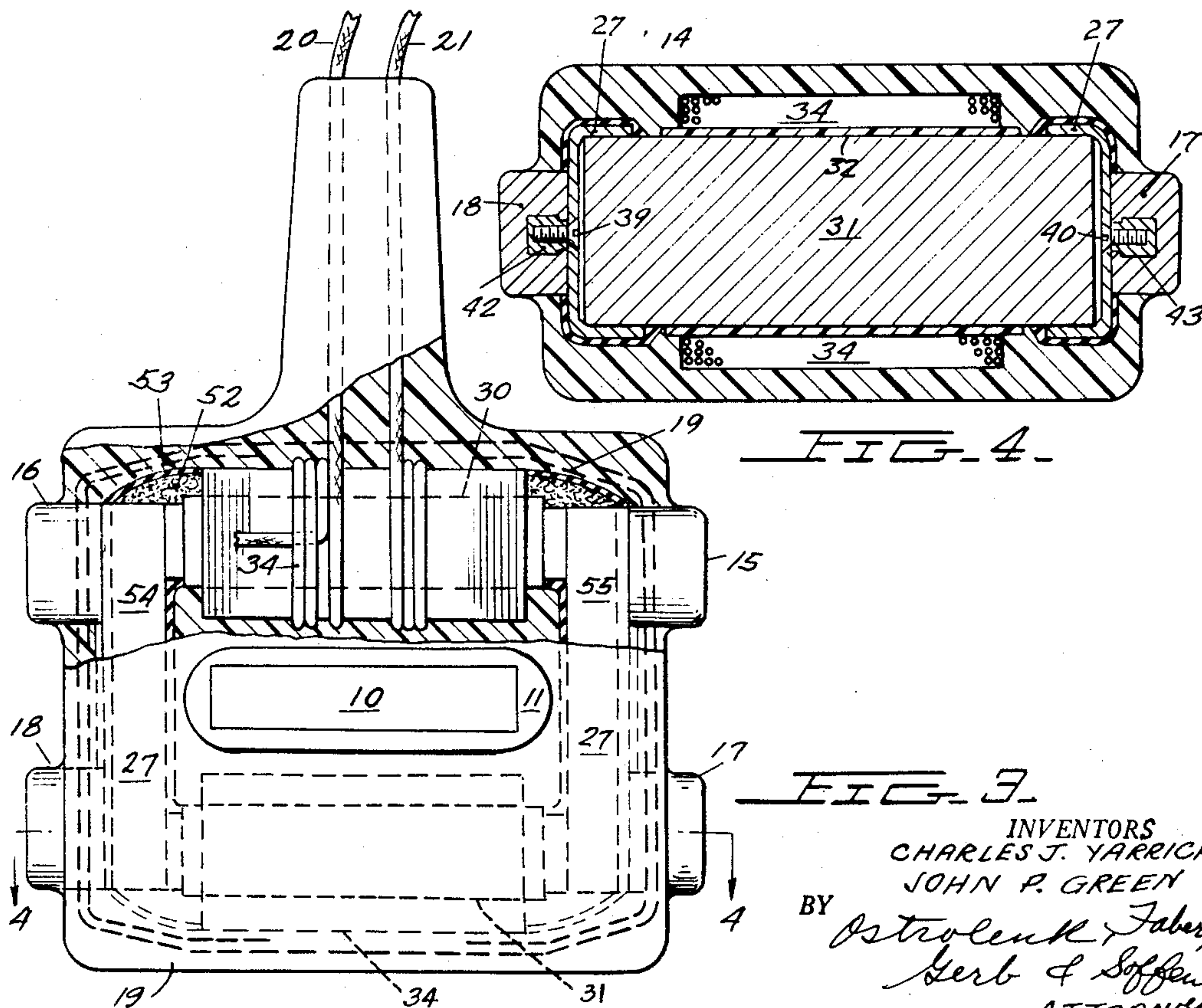
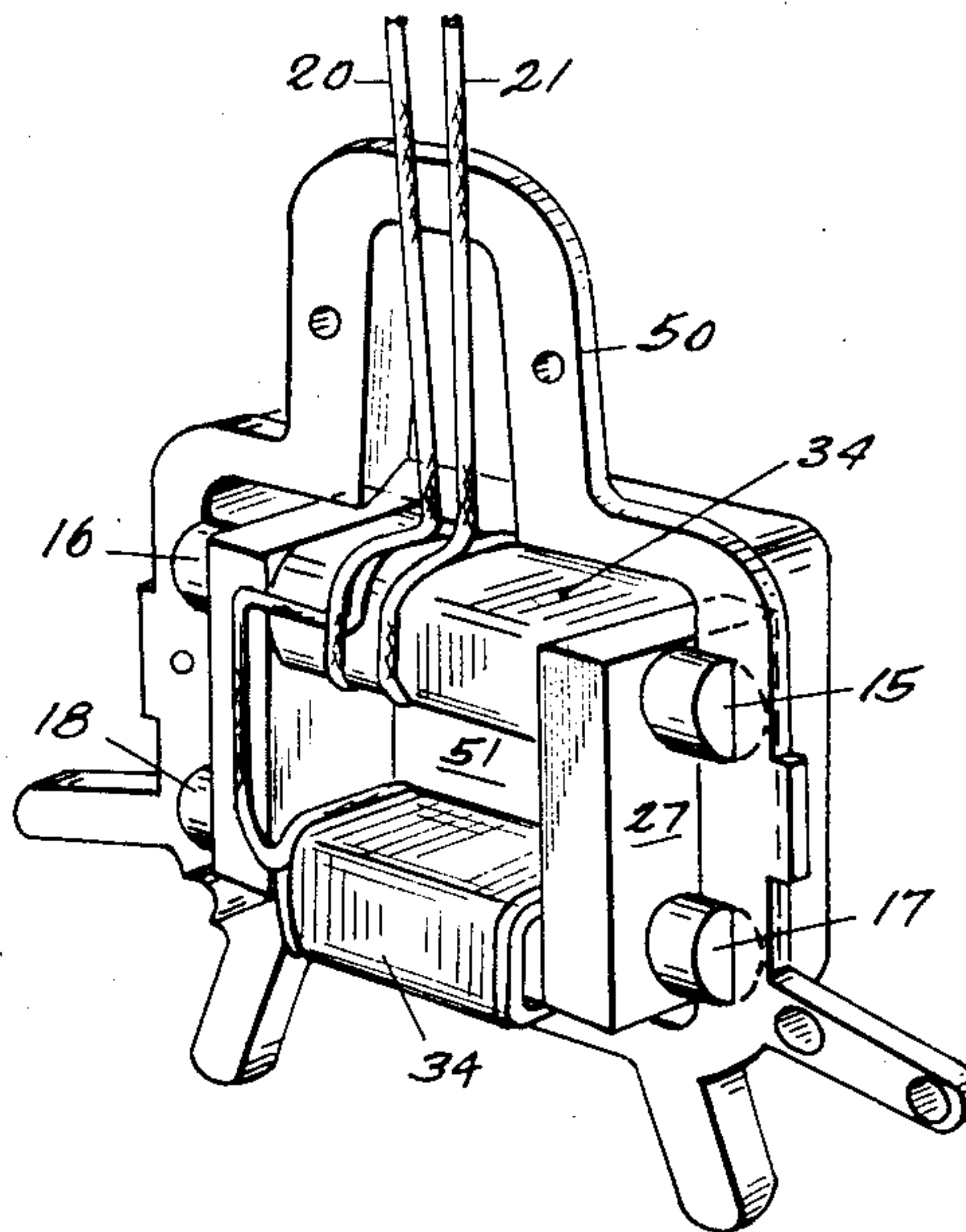


FIG. 4

FIG. 3

INVENTORS
CHARLES J. YARRICK
JOHN P. GREEN
BY *Ostrolenk, Faber,
Gerb & Soffen*
ATTORNEYS

1

2,953,757

MOLDED EPOXY CURRENT TRANSFORMER

Charles J. Yarrick, Haddonfield, N.J., and John P. Green, Philadelphia, Pa., assignors to I-T-E Circuit Breaker Company, Philadelphia, Pa., a corporation of Pennsylvania

Filed June 4, 1956, Ser. No. 589,256

2 Claims. (Cl. 336—65)

Our invention relates to a current transformer suitable for high voltage uses and the method of making such a transformer. More particularly, it relates to a current transformer, the secondary winding and magnetic core of which are completely insulated by encapsulation in an epoxy resin, and to the method of making such a transformer.

In the present method of constructing current transformers, it is the practice to insulate between primary and secondary windings and to insulate both windings from the core. Means for mounting the transformer are provided by metallic members attached to accessible parts of the core. The terminals are brought out of the transformer by suitable insulators. The magnetic core is available for grounding.

We have provided in the present invention a simplified method for making a completely insulated self-supporting transformer having no metallic parts exposed. Through the use of casting resins, we have overcome the relatively expensive and complicated procedures of the prior art and are able to economically make a compact transformer having good mechanical and electrical properties. The transformer of the present invention requires less space for mounting, has excellent resistance to moisture and chemically polluted atmospheres, and is of consistently good quality and dimensional uniformity. These advantages are made possible by providing a construction in which the transformer, except for the primary winding, is completely sealed in cast epoxy resin.

We have also provided in the present invention cushioning means designed to avoid or greatly minimize any thermal stresses set up in the transformer core during the casting operation which would otherwise tend to reduce its permeability.

Accordingly it is an object of our invention to provide a current transformer which has excellent insulating properties, resistance to humid and chemical atmospheres, and is economical to manufacture.

Another object of our invention is to provide a current transformer having a secondary assembly which is a completely insulated self-supporting unit having no metallic parts exposed.

Still another object of our invention is to provide a novel and economical method for providing a current transformer with a cast or molded epoxy insulation.

Another object is to provide cushioning means for avoiding stresses in the magnetic core of a cast epoxy current transformer.

These and other objects of our invention will become apparent when taken in connection with the drawings in which:

Figure 1 shows how the molded epoxy transformer of the present invention would appear when assembled.

Figure 2 shows the secondary and core of the transformer as it would appear just after being placed in the mold half.

Figure 3 is a side view of the present transformer par-

2

tially cut away so that a portion of the secondary assembly is illustrated in cross-section.

Figure 4 is a sectional view of a secondary winding and core section taken along the line 4—4 of Figure 3 and looking in the direction of the arrows.

Essentially, the present invention relates to a completely insulated self-supporting current transformer having no metallic parts exposed. The transformer is of the "window" or "through" type, comprising a single turn primary conductor which passes through a secondary winding and core assembly. The secondary in this instance is wound around a rectangular iron core, each corner of which is supported by a pre-cast epoxy mounting boss. The core corners are cushioned by means of crumpled aluminum foil provided with a coating of silicone rubber. Layers of glass mat are lashed to the winding as reinforcement at locations having abrupt changes in resin thickness. The entire transformer is encapsulated in epoxy resin.

The secondary core legs are mounted in metallic supporting frames prior to the casting step to which are attached the pre-cast epoxy mounting bosses. Also, prior to the casting step the core corners are provided with a cushioning of crumpled aluminum foil having thereon a coating of silicone rubber. The secondary assembly is then placed into a mold which is then completely filled with liquified epoxy casting resin. The surface of the transformer after casting then consists of this cast resin along with the pre-cast mounting bosses. No metallic parts of the secondary assembly are exposed and only the single turn primary bus bar and the secondary wiring extends from the molding.

Referring now to the drawings in more detail, the transformer is of the "window" type and has a bus bar or single turn primary 10 passing therethrough. The window 11 may be of any desired shape to accommodate the bus bar. The surface of the secondary comprises cast epoxy resin 14 and extending therefrom the four mounting bosses 15, 16, 17 and 18. The resin is preferably reinforced by glass mat 19.

The insulated wire terminals 20 and 21 also protrude from the secondary. Aside from these elements, all that is exposed to the atmosphere is the cast epoxy insulating resin. The line 23 is merely excess epoxy resin which may be present on the surface at the point where the two halves of the mold were joined.

As can be more clearly seen from Figures 2 and 3, the secondary comprises a metallic frame 27 from which extend a pair of core sections 30 and 31 around which the secondary winding 34 is wound. The core section 30 is supported at either end by mounting bosses 15 and 16 while the core section 31 is supported by mounting bosses 17 and 18. The bosses fit into both sections of the metallic frames by holes provided therein. Thus, the secondary and core assembly has a generally rectangular shape, having on opposite sides thereof a pair of parallel core sections upon which the secondary winding is wound, the core legs 54 and 55 being supported in metallic frames comprising a pair of parallel sections carrying suitable mounting holes for the bosses.

In Figure 4 a detailed section of a secondary and core is shown. Thus, the core section 31 is partially encased in a thermosetting resin bobbin 32. This resin bobbin, which may, for example, be made of Bakelite, serves as a support and as insulation from the core for the secondary winding 34. The secondary contains a predetermined number of turns and may comprise a plurality of layers of secondary wire.

Each leg 54 and 55 of the core carries an aluminum core clamp or frame 27. These clamps support screws 39 and 40 which are threaded into their respective brass inserts 42 and 43. Thus the mounting bosses are se-

3

cured to the core prior to the molding process during which the entire unit is encapsulated in the epoxy resin 14.

The secondary assembly having the cast epoxy mounting bosses secured thereto is placed in a mold 50, a half section of which is shown in Figure 2. Although not shown, it is to be understood that the mold is supplied with a rectangular core for casting the window for the primary winding. The mounting bosses rest on a recessed portion of the mold designed to accommodate the same and after the mold is filled with casting epoxy resin, the mounting bosses remain exposed, and are an integral part of the molded transformer.

Referring again to Figures 3 and 4, it is seen that the secondary core is provided with cushioning means comprising pieces of crumpled aluminum foil 52 which are coated with a silicone rubber 53. The foil is positioned as a pad on the indicated end sections of the four core corners.

Unvulcanized silicone rubber (for example Dow Corning's "Silastic—S-2007") is applied to the outside surfaces of the foil and adjacent core areas. The rubber thereby seals air spaces in the foil. By this means, we avoid stresses in the magnetic core which would otherwise be set up during the epoxy casting operation or subsequent temperature changes. Such stresses would decrease the permeability of the core and would have deleterious effects on the accuracy of the molded transformer.

These stresses are normally due to the fact that the steel in the core will expand and contract at rates different from that of the resin envelope as temperature changes take place in the molded transformer.

While it might be supposed that the problem could be solved by providing a resin formulation matching the thermal rate of the steel, this is not practicable because (1) thermal expansion rates are discontinuous functions for all common materials, particularly for epoxy resins, and (2) to reduce the thermal coefficient of the epoxy would require the addition of fillers which would raise the viscosity of the uncured resin to unworkable limits.

The present provision utilizing aluminum foil and silicone rubber which is vulcanized after the cushioning is in place avoids these problems and at the same time virtually eliminates the setting up of stresses in the core during the casting operation, and subsequent use of the transformer.

In applying the cushioning, it is also desirable to provide the other surfaces of the core with a raw rubber coating of about one-thirty second of an inch and then vulcanizing the rubber at about 330° F. for one hour. The winding is then molded in the manner hereinafter described.

The epoxy resins herein referred to are of the type comprising the resinous produce of reaction between an epihalohydrin such as epichlorohydrin and a polyhydroxyphenol such as bis-phenol-A. Resins of this type are referred to in United States Patents Nos. 2,324,483, 2,444,333 and 2,458,796. These resins have been found to possess excellent mechanical resistance, resistance to water and alkali and outstanding electrical insulation properties. Depending upon the desired physical properties, various fillers such as slate, quartz, flint and clays may be incorporated with the epoxy resins.

An example of a formulation of a casting resin which has been found to be particularly suitable is as follows:

29.2 percent by weight unmodified epoxy resin of the type suitable for acid catalysis. See for example, United States Patent No. 2,712,535. This resin goes under such trade names as "Araldite 6060" and "Epon 1001."

6.0 percent by weight of plasticizer such as a long-chain carboxylic acid of the type described in United States Patent No. 2,712,535 for adding flexibility and re-

4

silience to the epoxy resin. 7.80 percent by weight of phthalic anhydride as hardening or cross-linking agent. 57.0 percent by weight electrical grade flint (98 percent through 200 mesh screen, 99.8 percent pure silicon dioxide).

A similar formulation is used for the mounting bosses, except that they are made to have a higher heat distortion rating and the plasticizer is omitted so that the formulation is as follows:

34 percent by weight unmodified epoxy resin.
10 percent by weight phthalic anhydride.
66 percent by weight flint.

The epoxy resin is melted and heated to 300° F. Then the plasticizer is melted and heated to 300° F. and added to the epoxy. Predried flint, as above indicated, is added to the mix, after which phthalic anhydride hardener is added. The whole is then thoroughly mixed for five minutes, the temperature being maintained at 300° F.

The mold 50 may be of any metal such as aluminum or brass which has dimensional stability at the molding temperature of about 300° F. The inside surface 51 of the mold should be polished. Moreover, it is generally desirable to provide the mold with a silicone release agent. Such agents are well known in the art. One example would be the silicone going under the name of DC 7 made by the Dow Corning Corporation. As a substitute for the silicone release agents, standard hard and polished silver plating may also be used.

Prior to the molding operation, the mold is coated with the release agent. The assembled secondary after being provided with the cushioning means hereinabove referred to is dried for two hours at 320° F., in a forced circulation oven. The assembled mold is then placed in a heated vacuum tank which is then evacuated to 29 to 29.5 inches of mercury and between 300° F. and 320° F. The casting resin mix is poured slowly into the mold at 300° F. and the entire assembly is cured at atmospheric pressure for about sixteen hours at between 200° F. and 260° F. After release from the mold, the cast unit is further cured for four hours at between 250° F. and 260° F. As the unit is cooled the contracting resin compresses the rubber which being resilient, will transmit the pressure from all core surfaces to the aluminum cushion thereby compressing the air contained therein. In any subsequent heating of the transformer the air expands and the motion is reversed. After the unit is completed, the "window" for the primary may be painted with a carbonaceous conductive paint of a type well known in the art.

Although we have described preferred embodiments of our invention, many modifications and variations will now be apparent to those skilled in the art, and we prefer therefore, to be limited not by the specific disclosure herein, but only the appended claims.

We claim:

1. A completely insulated, self-supporting current transformer having no metallic parts exposed comprising a core structure carrying a secondary winding; a first and second portion of said core structure having a first and second frame member secured thereto; said first and second frame members having a respective extending boss of insulating material; said core structure, said secondary winding and a portion of said bosses being encapsulated in an epoxy resin; said encapsulated core structure having an opening therein for receiving a single turn primary conductor; said bosses being at least partially exposed for mounting said current transformer.

2. The device substantially as claimed in claim 1 wherein said core has a square configuration; the corners of said square configuration being cushioned by a cushion of crumpled aluminum foil having a coating of silicone rubber to absorb stress during cooling of said encapsulating epoxy resin.

(References on following page)

5

References Cited in the file of this patent

UNITED STATES PATENTS

2,175,934	Wentz -----	Oct. 10, 1939	
2,382,199	Brink -----	Aug. 14, 1945	5
2,414,525	Hill et al. -----	Jan. 21, 1947	
2,632,211	Trigg -----	Mar. 24, 1953	

2,731,607
2,756,399
2,785,383

6

Gould et al. -----	Jan. 17, 1956
August et al. -----	July 24, 1956
Foster -----	Mar. 12, 1957

OTHER REFERENCES

"Ethoxylines," by Prieswerk, Electrical Manufacturing, July 1949, pp. 78 through 81.