Nov. 18, 1952 C. D. COOK, JR 2,618,689

ELECTROMAGNETIC INDUCTION APPARATUS

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Fig. 1.

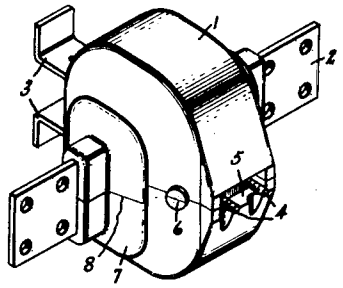



Fig. 2.

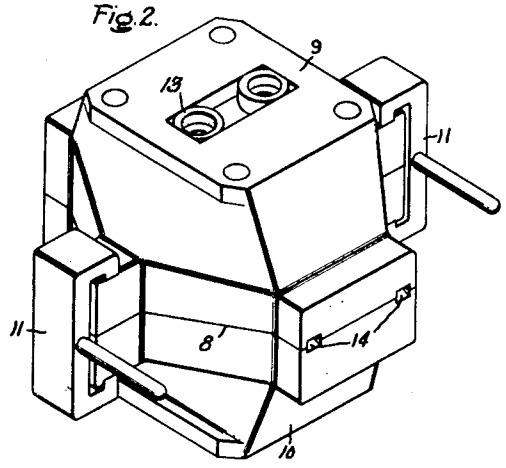



Fig. 3.

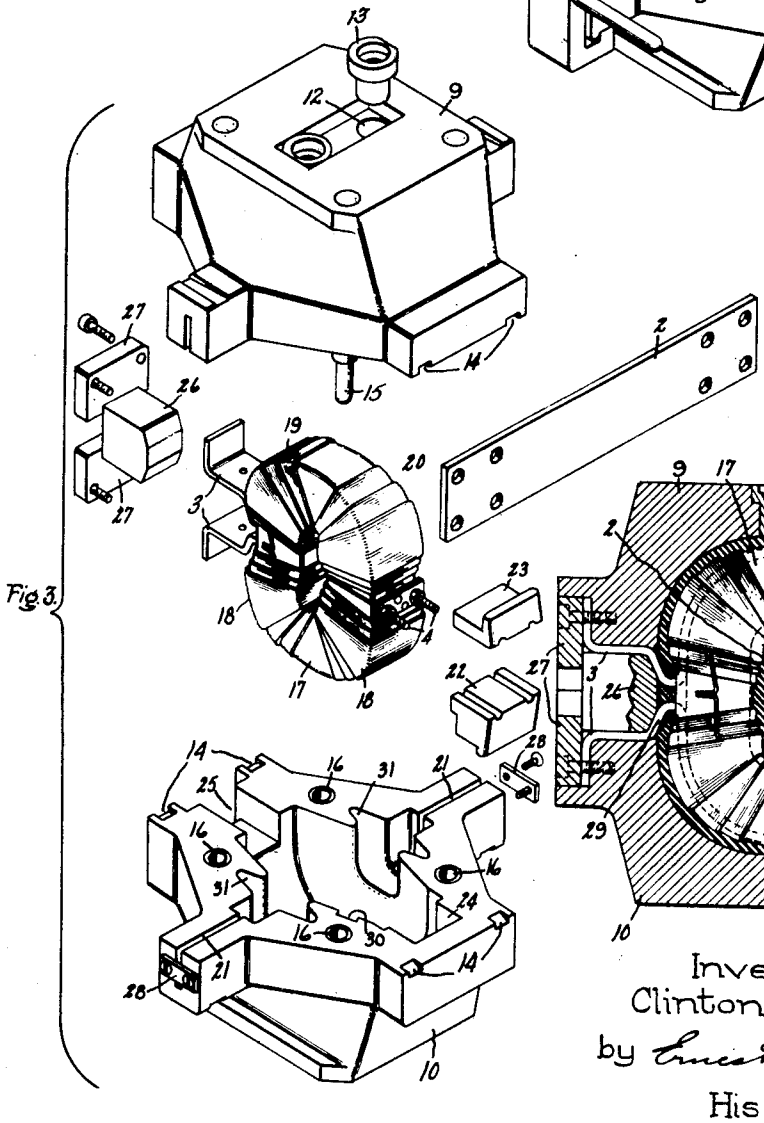
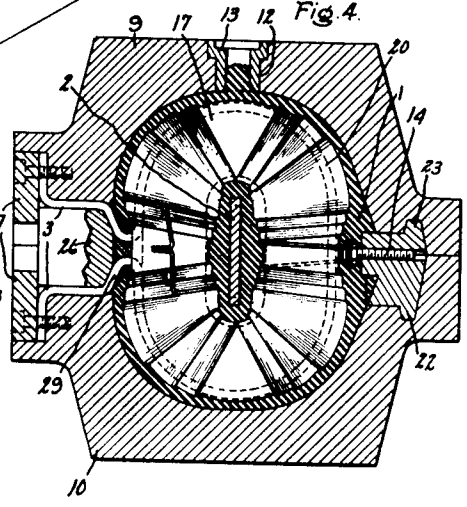



Fig. 4.




Inventor:
Clinton D. Cook, Jr.,
by Ernest H. Britton
His Attorney.

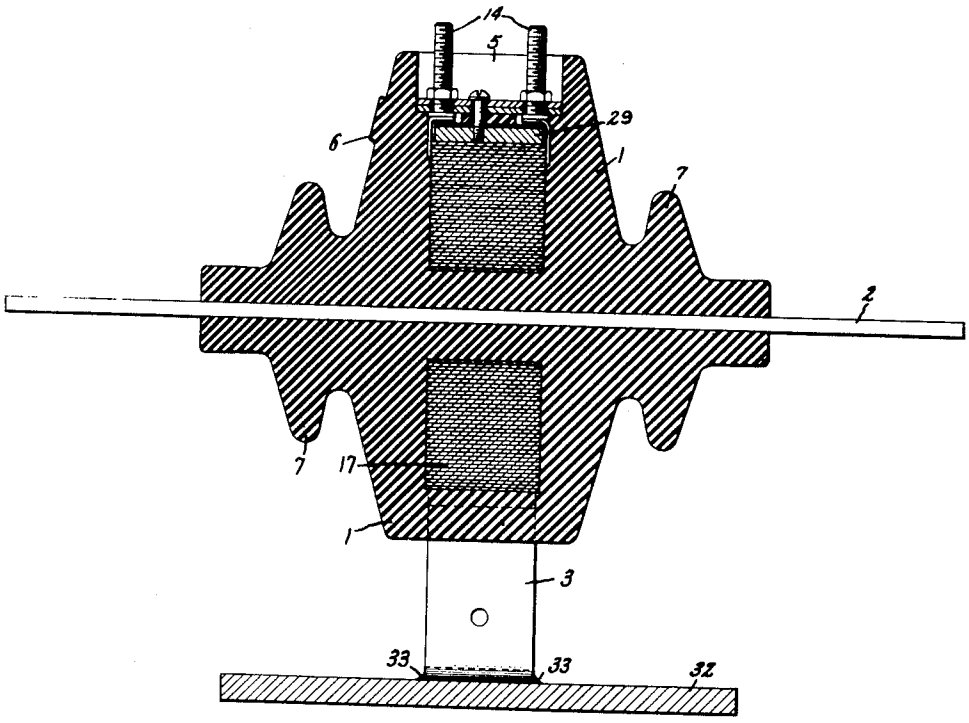
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Fig. 5.




Inventor:
Clinton D. Cook, Jr.,
by Ernest C. Britton
His Attorney.

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ELECTROMAGNETIC INDUCTION APPARATUS

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Fig. 6.

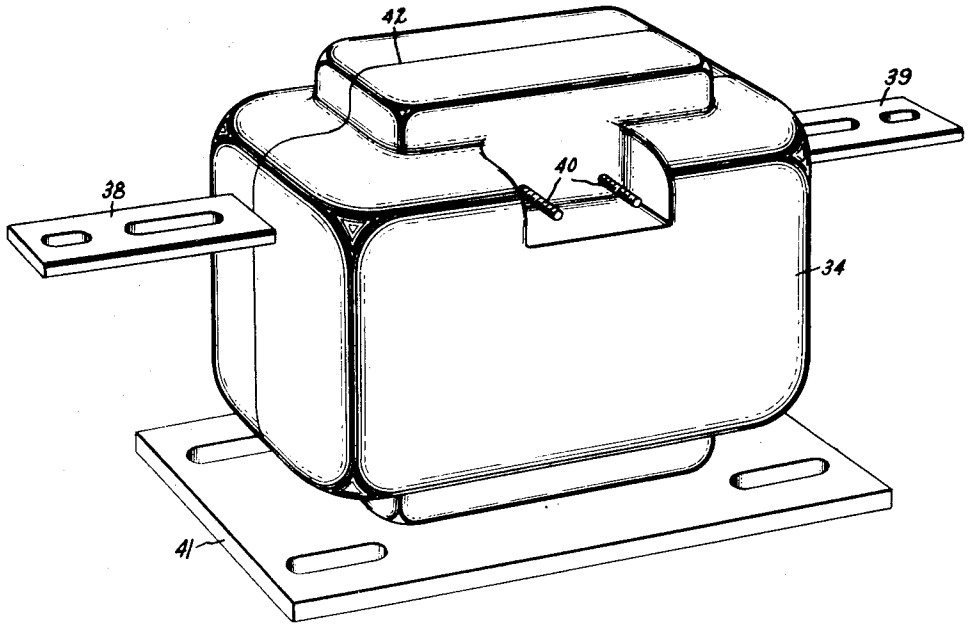
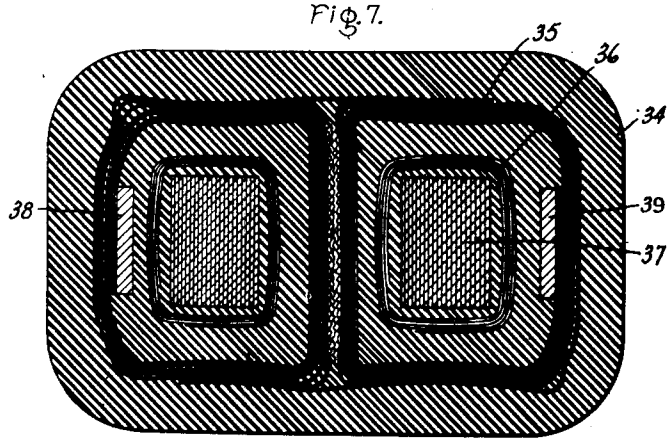



Fig. 7.




Inventor:
Clinton D. Cook, Jr.,
by Ernest C. Britton
His Attorney.

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2,618,689

# UNITED STATES PATENT OFFICE

2,618,689

## ELECTROMAGNETIC INDUCTION APPARATUS

Clinton D. Cook, Jr., Shelburne, Vt., assignor to General Electric Company, a corporation of New York

Application January 13, 1948, Serial No. 1,935

2 Claims. (Cl. 175—358)

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This invention relates to an electromagnetic induction apparatus and more particu'arly to improvements in transformers and to their method of construction.

Heretofore, electromagnetic induction apparatus such as transformers have been provided with molded casings of various materials such as Portland cement or concrete or various synthetic resins and solventless varnishes. However, none of these constructions has been satisfactory because the various materials which have been used have had one or more of the following defects, namely: they have been hydroscopic; or have had low insulation value; or they crack during the initial curing period; or they crack during aging at or above normal operating temperatures; or they crack as a result of hot and cold cycles; or they require excessive molding pressure which distorts the coils, cores, and windings; or they are difficult to cure; or they form voids in the material; or they have excessive shrinkage with low impact strength and modulus elasticity; or they attack the copper from which the coils are made; or they stick to the mold; or, in general, they have poor moldability.

I have discovered, however, that the material known as GR–I (Government rubber isobutylene) is a nearly perfect material for forming both the major insulation between the windings of such apparatus themselves, between the core and the windings, and for forming the outer casing of the apparatus. The raw material, which is cured in a manner similar to the vulcanization of rubber during the molding operation, is a copolymer of a high proportion of isobutylene and a low proportion of isoprene. It has a dielectric strength of at least 150 volts per mil at continuous temperatures of 85° C. with part time temperatures of 95° C. and short time temperatures (1 second) of 150° C. It has a power factor lower than 3%, is not affected by corona and has good surface arcing characteristics. Furthermore, it has a relatively high heat transfer ability of .1 B. t. u. through a cubic foot per hour per degree Fahrenheit temperature difference between opposite faces. It is tough and resilient and will not crack due to expansion of embedded copper coils throughout a temperature range of −40° C. to +100° C. and tests indicate an outdoor life of 25 years.

However, I do not wish to be limited to butyl rubber and I comprehend the use of all rubber-like materials which may be thermoplastic, or thermoplastic, and thermosetting, which are at least somewhat fluid before curing and which result in a firm resilient insulating structure similar in characteristics to that produced by butyl rubber. For example, I have in mind plastesol type materials composed of modified vinyl chloride formulations.

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An object of the invention is to provide an electromagnetic induction apparatus having a resilient molded casing which also provides the major insulation and mechanical support of the transformer parts.

Another object of the invention is to reduce the size and cost of electromagnetic induction apparatus.

A further object of the invention is to provide a transformer casing which is equally suitable for indoor and outdoor use.

An additional object of the invention is to improve the appearance and durability of electromagnetic induction apparatus.

An added object of the invention is to provide electromagnetic induction apparatus with a homogeneous resilient molded casing and insulation which has high dielectric strength and low power factor over high temperature ranges which is substantially unaffected by corona and surface arcing, which has good heat transfer properties and long weather-resistant outdoor life.

The invention will be better understood from the following description taken in connection with the accompanying drawing and its scope will be pointed out in the appended claims.

In the drawing, Fig. 1 is a perspective view of a high voltage current transformer embodying the invention, Fig. 2 is a perspective view of a mold for making the transformer shown in Fig. 1, Fig. 3 is an exploded perspective view showing the top and bottom halves of the mold separated and with the parts of the transformer also separated, Fig. 4 is a transverse sectional view through the mold and transformer, Fig. 5 is an enlarged vertical section through the transformer shown in Fig. 1, Fig. 6 is a perspective view of a modification and Fig. 7 is a horizontal sectional view through the modification shown in Fig. 6.

Referring now to the drawing and more particularly to Fig. 1, the current transformer comprises a resilient molded dielectric body or casing 1 through the center of which passes a heavy conducting bar 2, which is preferably made of copper and which constitutes the primary winding and its terminals. The transformer is provided with mounting feet 3 and with secondary winding terminals 4 which are recessed in a cavity 5 in the insulating body 1. A polarity marker 6 is molded directly into the body 1. Between

the ends of the primary bar 2, which are normally at the same relatively high line potential, and the parts 3 and 4, which are normally near ground potential, the main body 1 is fluted or provided with one or more integral ridges or petticoats 7 for increasing the creepage distance along the surface of the body 1. A line 8 on the surface of the body 1 corresponds with the plane of separation of the two halves of a mold in which the body 1 is formed.

The above-mentioned mold is shown in Fig. 2 as comprising what may be referred to as a top half 9 and a bottom half 10, whose plane of juncture or separation is also represented by the line 8. The two halves of the mold are held tightly together by any suitable means such as C clamps 11 which cooperate with complementary integral sidewise extensions on the two halves of the mold. A suitable material for the mold is cast steel, and it has been found that a cast inner surface is suitable for and gives good molding results and good appearance of the molded product without the necessity of machining of the inner surface of the mold. The top half 9 of the mold is provided with a filler opening 12 in which is inserted a bushing or coupler 13 for making tight connections to the reservoir (not shown) for the material which is to be molded. As suitable places around the mold, the two adjoining faces are provided with complementary recesses or notches 14 for making it easier to pry the two halves of the mold apart after the transformer body 1 has been cured and the C clamps 11 have been removed.

In Fig. 3 the two halves of the mold are shown separated and it will be seen that the top part 9 carries dowel pins 15 for insertion in holes 16 in the bottom part 10 so as to assure proper alignment of the two parts of the mold when they are brought together. Between the two halves of the mold is shown a core and coil assembly comprising a generally oval-shaped magnetic core 17 on which are wrapped a number of coils of wire 18, 19 and 20 which are interconnected to form the secondary winding of the transformer.

In assembling the parts shown in Fig. 3, preparatory to molding the main body 1, the primary bar 2 is inserted in the center opening through the core and coil assembly and its edges are fitted into slots 21 in the lower half of the mold. The core and coil assembly is centered on the bar 2 and spaced therefrom by suitable supporting blocks on opposite sides. Two of these blocks are shown at 22 and 23 and they are provided with grooves which embrace the secondary terminals 4. These blocks 22 and 23 fit snugly into a cavity 24 in the mold and they thus cause the formation of the secondary terminal cavity or recess 5 in the main body 1 as shown in Fig. 1. The mounting feet 3 are supported in notches 25 in the mold parts. The proper spacing of the mounting feet 3 is obtained by means of a spacing block 26 and the ends of the feet and the spacing block 26 are in turn securely held in position by plates 27 which are screwed into the two halves of the mold.

The primary bar 2 is properly centered lengthwise in the mold by means of end plates 28 which are attached to the lower half of the mold across the outer open ends of slots 21.

Fig. 4 clearly shows how the main body 1 is not only molded around the primary bar 2 but is also formed between the primary bar or winding 2 and the core and coil assembly so that the same material which forms the outer surface or housing for the apparatus also serves as its major insulation between its different voltage parts.



Fig. 4 also shows how the mounting feet 3 are formed from the ends of a strap 29 which is wrapped around the core underneath the secondary winding.

The reason the boundary plane between two halves of the mold is perpendicular to the plane of the primary bar 2 is to make it easier to separate the two halves of the mold after the main body 1 has been cured and also so as to prevent separation of the material of the main body 1 from the primary bar 2.

In the molding operation, the raw material known as GR–I is compounded with various suitable ingredients, such as are used in vulcanization of rubber, to form a molding compound which is vulcanizable at elevated temperatures to form a good ozone and oxygen resistant material which is particularly suitable for use as a dielectric having exceptional aging properties. The molding compound is forced into the mold through the bushing 13 at a suitable pressure, such as 600–1000 pounds per square inch, so as to entirely fill the free spaces in the mold. The material is then cured for a suitable length of time at elevated temperatures; this curing or vulcanization being essentially a thermosetting phenomenon caused by polymerization.

Returning briefly to Fig. 3, the parts of the mold which form the polarity mark are indicated at 30 and the parts of the mold which form the integral fluted portions or ridges on the main body 1 are indicated at 31.

The sectional view shown in Fig. 5 illustrates more clearly the unitary or integral nature of the main body 1 as an outer housing, as the major insulation between the primary bar 2 and the core 17, and as the ridge members 7 for increasing the creepage distance between the bar 2 and the mounting feet 3, and between the bar 2 and the secondary terminals. In this figure the secondary coils are not visible because the section is taken through the front vertical center line.

A supporting plate 32 to which the turned over ends of the mounting feet 3 have been attached in any suitable manner such as by welds 33 has been illustrated in Fig. 5.

In the modification shown in Figs. 6 and 7, there is a molded main body 34 which, unlike body 1 in Figs. 1 to 5, serves as the protective covering or housing of the apparatus and also as the major insulation between a multiturn primary winding 35 on the one hand, and a multiturn secondary winding 36 and a magnetic core 37 on the other hand. The primary winding 35 has oppositely extending terminals 38 and 39 whose inner ends are bent at right angles and are permanently attached to the opposite ends of the primary winding in any suitable manner such as by brazing. The secondary winding terminals are shown at 40 in Fig. 6. A suitable mounting or base plate 41, preferably of metal, is provided.

Due to the resilient properties of the bodies 1 and 34, the transformers are exceptionally sturdy and they will stand very rough treatment without chipping or cracking or otherwise injuring them.

As shown in Fig. 6, around the main body 34, there is an equitorial line 42 which indicates the plane of juncture of the two halves of the mold (not shown) in which the body 34 is formed, and it will be seen that the plane of this line bears the same relation to the plane of the terminals

39 and 40 as exists between the plane of the line 8 and the plane of the primary bar 2 in Fig. 1.

While there have been shown and described particular embodiments of the invention, it will be obvious to those skilled in the art that changes and modifications can be made without departing from the invention and, therefore, it is aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An outdoor bar type current transformer, comprising, in combination, a closed magnetic core, a low voltage secondary winding surrounding said core, a straight conducting primary bar extending through said core, and a resilient body of isobutylene copolymerized with isoprene in which said core and secondary winding and the center of said bar embedded, the ends of said bar extending out beyond said body and constituting high voltage terminals for said transformer, said body having integral ridges surrounding said bar for increasing the electrical creepage distance of the surface of said body relative to its overall outside dimensions.

2. The method of making a high voltage current transformer which comprises, equipping a magnetic core with an inner low voltage secondary and an outer high voltage primary winding, said windings being spaced apart from each other, said high voltage primary winding having a pair of rectangular cross section bar type bare metal terminals extending in opposite directions in the same plane from the ends of said primary winding, placing said core and winding in a mold having two halves which are separable along a plane which bisects said terminals perpendicular to their plane of extension, said mold halves having registering grooves which closely receive said terminals, forcing a plastic molding compound of a copolymer having a high proportion of isobutylene and a low proportion of isoprene into said mold under a pressure of 600 to 1000 pounds per square inch until all the space in said mold not occupied by said core, said windings and said terminals is filled with said compound, elevating the temperature of said mold substantially above room temperature for a predetermined length of time so as to cure said compound by thermosetting it, separating the two halves of said mold along said plane of separation so as to place minimum strain on the molded material adjacent the surface of said terminals, and removing the molded transformer from said divided mold.



CLINTON D. COOK, JR.


## REFERENCES CITED

The following references are of record in the file of this patent:

### UNITED STATES PATENTS

| Number | Name | Date |
|---|---|---|
| 894,620 | Frank | July 28, 1908 |
| 1,333,004 | Vaughn | Mar. 9, 1920 |
| 1,790,981 | Fischer | Feb. 3, 1931 |
| 2,065,934 | Deutschmann | Dec. 29, 1936 |
| 2,163,798 | Mucher | June 27, 1939 |
| 2,246,167 | D'Entremont | June 17, 1941 |
| 2,251,351 | Cooper | Aug. 5, 1941 |
| 2,297,605 | Camilli | Sept. 29, 1942 |
| 2,329,346 | Goff | Sept. 14, 1943 |
| 2,382,199 | Brink | Aug. 14, 1945 |
| 2,385,460 | Omansky | Sept. 25, 1945 |
| 2,391,038 | Rifenbergh | Dec. 18, 1945 |
| 2,428,275 | Frankwich et al. | Sept. 30, 1947 |
| 2,436,636 | D'Entremont | Feb. 24, 1948 |
| 2,456,219 | Shaheen | Dec. 14, 1948 |
| 2,464,029 | Ehrman | Mar. 8, 1949 |

### FOREIGN PATENTS

| Number | Country | Date |
|---|---|---|
| 426,324 | Great Britain | Jan. 1, 1934 |

### OTHER REFERENCES

Article: Some Recent Advances in Industrial Plastics, Journal of Scientific Instruments, pages 129–136, vol. 19, September 1942.

General Electric Review, April 1943, pages 215–217.