July 22, 1952 E. J. MACKERETH 2,604,519

TRANSFORMER

Filed March 23, 1949

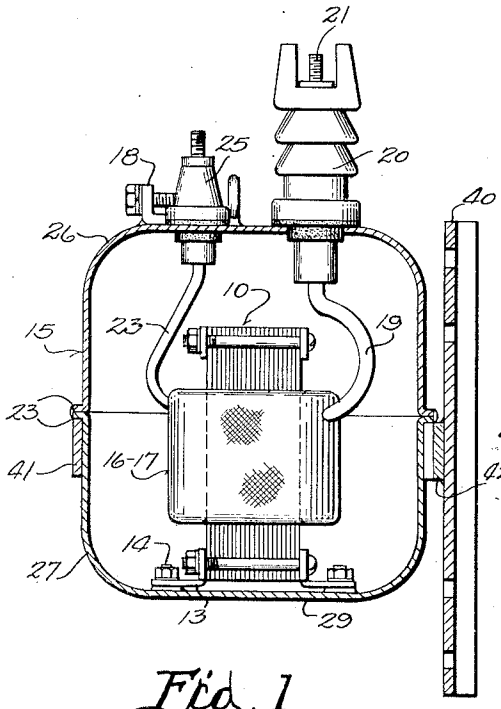



Fig. 1

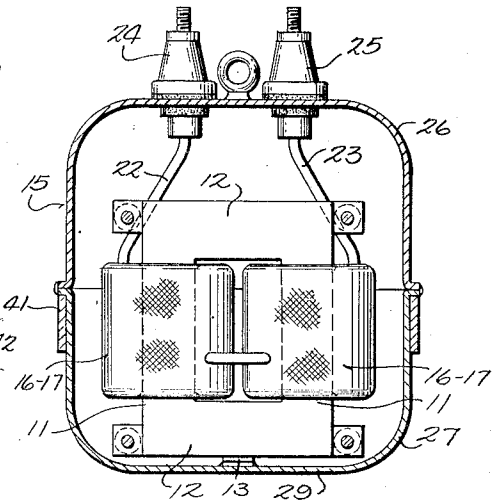



Fig. 2

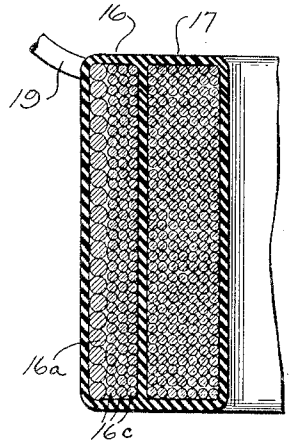



Fig. 3

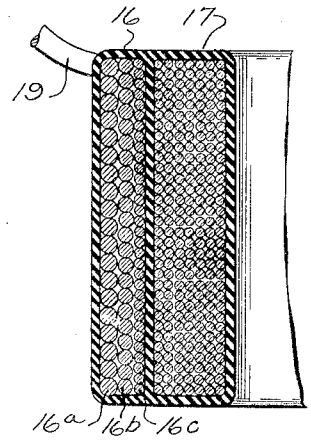



Fig. 4

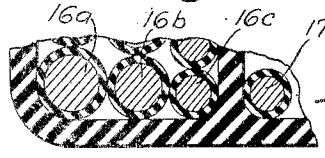



Fig. 5

Inventor

EDWARD J. MACKERETH

By Miles Kenninger

Attorney

Patented July 22, 1952 2,604,519

# UNITED STATES PATENT OFFICE

2,604,519

## TRANSFORMER

Edward J. Mackereth, Toronto, Ontario, Canada

Application March 23, 1949, Serial No. 83,009

8 Claims. (Cl. 175—361)

1

This invention relates to improvements in electricity distributing transformers and, while not limited thereto, is particularly applicable to weatherproof transformers mounted on poles such as are employed for the distribution of energy in rural areas.

The present application is a continuation-in-part of my copending application, Serial Number 22,400, filed April 21, 1948, now abandoned.

An object of the invention is to provide a transformer of simple and durable construction, which is not easily damaged in handling and which is reliable in operation.

Another object is to provide a transformer of small overall size for its normal and also for its overload capacity.

Another object is to reduce the temperature differential between different parts of the transformer and between such parts and the enclosing tank.

Another object is to provide a transformer which withstands high surges of voltage and current.

A further object of the invention is to provide a transformer in which the several turns of the primary winding are loaded substantially simultaneously due to the capacity effect thereof and in which the potential between the turns of the winding is reduced.

Another object of the invention is to provide a transformer in which the primary winding has a graded or varying capacitance to ground to reduce steep wave front surges entering the primary winding and thus avoids danger to the winding due to such surges.

Another object of the invention is to provide a transformer in which all of the windings have substantially the same surge impedance to avoid setting up of dangerous oscillations in the windings, due to line transients.

Other objects and advantages will hereinafter appear.

The accompanying drawing is illustrative of an embodiment of the invention. In the drawing,

Fig. 1 is a sectional view of a transformer embodying the invention.

Fig. 2 is a sectional view on a plane at right angles to the section shown in Fig. 1.

Fig. 3 is a vertical section of a fragment of windings embodying the present invention.

Fig. 4 is a fragmentary section of another embodiment of transformer winding including the present invention; and

Fig. 5 is an enlarged fragment of Fig. 4 to show the progressive variation in insulation as the cross sectional size of the conductor progressively varies.

2

Referring to the drawing, the transformer has a rectangular laminated iron core 10 with two vertical legs 11, 11, joined at their end by cross members 12, 12, completing the closed iron magnetic circuit. The laminations of the core are clamped together by suitable bolts in any conventional manner. Attached to each lower corner of the core is an angle bracket 13 fastened by a bolt 14 to the bottom of an enclosing tank 15.

Each core leg 11 is provided with a primary winding 16 and a secondary winding 17 concentric with the primary winding. Both windings are suitably insulated from the core and from each other and suitable means (not shown) may be provided to support the windings rigidly on the core. The inner end (not shown) of the primary winding 16 may be connected to the transformer core and thus to the tank 15, while the latter in turn may be connected to ground by a wire attached to a lug 18 on the tank. The outer end of the primary winding is connected to a lead-in wire 19, which passes through an insulating bushing 20, and terminates at a terminal 21, mounted on the upper end of the bushing.

By reference to Fig. 3, it will be seen that the primary lead-in wire 19 is larger than any of the turns of the primary winding 16 and that such primary winding is composed of conductors of two different sizes, the turns 16*a* being materially larger than the turns 16*c*. For example, layer 16*a* may be as large as No. 6 B. & S. gauge while winding layers 16*c* may be as small as number 24 conductor on the same gauge. Only one layer of turns 16*a* and several layers of turns 16*c* are shown, but it will be understood that the two or more layers of the heavier turns may be used with a corresponding reduction in the number of turns of conductor 16*c*. The heavier turns 16*a* of the primary winding 16 have heavier insulation than the rest of the winding to absorb the extra potential strain thereon due to voltage surges on the transmission line. When in addition to the foregoing strengthening of the insulation of the end turns, their cross section is also increased, the tendency of short circuiting due to voltage surges on the line is greatly reduced. This may be due to the fact that a surge current which is impressed on these turns, due to a steep wave front, flows largely on the surface of the wire, resulting in high momentary current density which causes melting of the surface metal and short circuits between turns and burn-outs. Furthermore, and in addition to greater momentary current-carrying capacity, a larger cross section of the wires reduces the maximum potential gradient between adjacent wires and this in

itself reduces the strain on their insulation and thus the tendency to cause short circuits.

The maximum graded capacitance effect would be obtained if it were practically possible to make a conductor of a constantly decreasing size and to use such conductor for the primary winding, the smallest size of the conductor being equal to the size of the conductor in the secondary winding. A close approximation of the maximum effect can be obtained if the primary winding is made with turns 16*a*, turns 16*b* and turns 16*c* of progressively smaller size and down to the size of the conductor of secondary winding 17. It will be understood that any number of sizes of conductors may be used in the primary winding so long as the first turns are substantially the size of the lead-in wire 19 and the last turns are substantially the size of the conductor of the secondary winding.

It has been found that even the construction of Fig. 3 will resist breakdown at surges of up to 50,000 amperes per micro second and the structure of Fig. 4 will withstand surges of even higher values. Hence, it is possible to obtain a transformer winding resistant to all of the average lightening surges and at a reasonable cost. The best result is obtained by the use of a large conductor at the line-connected end of the primary winding, by providing sufficient capacitance to reduce the steep wave fronts and by varying the capacitance to ground. The potential between larger size turns is reduced and all of the windings have substantially the same surge impedance.

The secondary winding is arranged in two sections or coils 17, one on each leg of the frame as is common practice. The two coils may be connected in series or parallel. In the present case the two coils are usually connected in series to afford a 3-wire current supply. The common center tap of the two coils is grounded to the tank 15, while the outer taps are connected by wires 22 and 23, respectively, to the terminal bushings 24 and 25, on top of the tank 15.

The tank 15 consists of two similar relatively shallow cups 26 and 27 drawn or spun from sheet steel and provided at their edge with a short transverse flange 28. The bottoms 29 of the cups are relatively flat and merge into the cylindrical sides in a curve of relatively large radius.

In assembling the apparatus the transformer core and windings are assembled in the usual manner. Thereafter the assembled transformer is fastened inside of the lower cup in the manner described. The bushings 20, 24 and 25 are attached in any suitable manner to the top cup 27 of the tank 15. Thereafter the top cup 27 is put in position, while the lead wires 19, 22 and 23 are simultaneously threaded through their respective insulating bushings and sealed therein in an air and moisture tight manner. The ground wires are then connected to the inside of the lower cup 26. The bottom and top cups 26 and 27 of the casing are now welded together along the flanges 28. The welded flange forms a perimetrical bead, which serves as the support of the assembled transformer as will be pointed out hereinafter. Thereafter the tank is filled with a suitable insulating liquid and may then be heated or treated otherwise so as to drive out air and moisture entrapped in the liquid or in the transformer coils.

The finished transformer may be mounted on a transmission pole or other supporting structure by means of a bracket assembly arranged to embrace the tank and permit its rotation to bring the terminals of the transformer into the most advantageous position relative to the line wires to which they are connected. The assembly comprises a length of vertically extending channel iron or the like 40 provided with suitable holes for fastening to a supporting pole or wall. A circular iron ring 41 of strap iron and of a diameter about equal to the outer diameter of the tank 15, has its two adjacent ends welded together and bridged by a U-shaped strap 42 of rectangular section whose intermediate and end portions are welded to the ring 41 and also to the channel 40, thus joining the former and the latter to form a rigid support.

Various other modifications within the scope of the present invention will be apparent to those skilled in the art.

What I claim as new and desire to secure by Letters Patent is:

1. In an electrical transformer, an electrically conductive case, a lead-in conductor extending into the case in insulated relation therewith, a primary winding connected at one end with the case and at the other end with the lead-in, the primary winding being formed of portions of conductor of progressively decreasing cross-section from a winding end connected with the lead-in to a winding end connected with the case, the conductor of the portion connected with the lead-in being of larger size than the conductor of the portion connected with the case for varying the capacitance of the winding from a large value in the portion connected with the lead-in to a lesser value in the portion connected with the case, a secondary winding comprising a conductor inductively related to the primary winding, and terminals extending from the secondary winding exteriorly of the case and in insulated relation therewith.

2. In an electrical transformer, an electrically conductive case, a lead-in conductor extending into the case in insulated relation therewith, a primary winding connected at one end with the case and at the other end with the lead-in, the primary winding being formed of portions of conductor of progressively decreasing cross-section from a winding end connected with the lead-in to the winding end connected with the case, a secondary winding conductor inductively related to the primary winding, and terminals extending from the secondary winding exteriorly of the case and in insulated relation therewith, the portion of the primary winding conductor connected with the lead-in being of substantially the size of the lead-in and the portion of the primary winding conductor connected with the case being substantially the size of the secondary winding conductor for varying the capacitance of the primary winding in its length from a large value at the lead-in connection to a lesser value at the connection thereof with the case.

3. In an electrical transformer, an electrically conductive case, a lead-in conductor extending into the case in insulated relation therewith, a primary winding connected at one end with the case and at the other end with the lead-in, the primary winding being formed of portions of conductor of progressively decreasing cross-section from a winding end connected with the lead-in to the winding end connected with the case, a secondary winding conductor inductively related to the primary winding, and terminals extending from the secondary winding exteriorly of the case and in insulated relation therewith, the pri-

mary winding conductor comprising a portion connected with the lead-in and of substantially the size thereof, a portion connected with the case and of substantially the size of the secondary winding conductor and a portion intermediate said primary winding portions and of a size between the sizes of the first said two of the primary conductor portions whereby the capacitance of the primary winding is reduced in its length from the lead-in connection to the connection thereof with the case.

4. In an electrical transformer, an electrically conductive case, a lead-in conductor extending into the case in insulated relation therewith, a primary winding connected at one end with the case and at the other end with the lead-in, the primary winding being formed of portions of conductor of progressively decreasing cross-section from a winding end connected with the lead-in to the winding end connected with the case, a secondary winding conductor inductively related to the primary winding and of the same cross-sectional size throughout its length, terminals extending from the secondary winding outside of the case and in insulated relation therewith, and insulation on the primary and secondary windings, the primary winding insulation progressively decreasing in insulating value as the conductor size decreases, the primary winding conductor comprising a portion connected with the lead-in and of substantially the size thereof, a portion connected with the case and of substantially the size of the secondary winding conductor and a portion intermediate said primary winding portions and of a size between the sizes of the first said two of the primary conductor portions whereby the capacitance of the primary winding progressively decreases along its length from the lead-in connection to the connection thereof with the case.

5. In an electrical transformer, an electrically conductive case, a lead-in conductor extending into the case in insulated relation therewith, a primary winding conductor connected at one end with the case and at the other end with the lead-in, the primary winding being substantially of hollow cylindrical shape and being formed of portions of conductor of progressively decreasing cross-section and wound in layers and connected at the ends respectively with the case and with the lead-in conductor, the layer of primary winding conductor connected at one end with the lead-in being of larger cross-sectional size than the layer of conductor connected at one end with the case for varying the capacitance of the primary winding from a larger value in the portion connected with the lead-in to a smaller value in the portion connected with the case, a secondary winding conductor inductively related to the primary winding, and terminals extending from the secondary winding exteriorly of the case and in insulated relation therewith.

6. In an electrical transformer, an electrically conductive case, a lead-in conductor extending into the case in insulated relation therewith, a primary winding comprising a conductor with portions of progressively decreasing cross-section from a winding end connected with the lead-in to a winding end connected with the case and being wound in layers of substantially hollow cylindrical shape, secondary winding conductor inductively related to the primary winding, and terminals extending from the secondary winding outside of the case and in insulated relation therewith, the outer peripheral layer of the primary winding conductor being connected at one end with and being of substantially the size of the lead-in and the inner peripheral layer of the primary winding conductor being connected at one end with the case and being substantially of the size of the secondary winding conductor for reducing the capacitance of the primary winding from a large value for the outer peripheral layer to a smaller value for the inner peripheral layer of the primary winding.



7. In an electrical transformer, an electrically conductive case, a lead-in conductor extending into the case in insulated relation therewith, a primary winding comprising a conductor with portions of progressively decreasing cross-section from a winding end connected with the lead-in to a winding end connected with the case, a secondary winding conductor inductively related to the primary winding and terminals extending from the secondary winding outside of the case and in insulated relation therewith, the primary winding being of substantially hollow cylindrical shape and comprising a layer connected at one end with and of substantially the cross-sectional size of the lead-in conductor and a layer connected at one end with the case and of substantially the cross-sectional size of the secondary winding conductor for progressively decreasing the capacitance of the primary winding from the end connected with the lead-in conductor to the end connected with the case.

8. In an electrical transformer, an electrically conductive case, a lead-in conductor extending into the case in insulated relation therewith, a primary winding comprising a conductor with portions of progressively decreasing cross-section from a winding end connected with the lead-in to a winding end connected with the case, a secondary winding conductor inductively related to the primary winding, terminals extending from the secondary winding outside of the case and in insulated relation therewith, and insulation on the primary and secondary winding conductors proportional in insulating value to the size of the conductors, the primary winding being of substantially hollow cylindrical shape and comprising an outer peripheral layer of conductor connected at one end with and of substantially the cross-sectional size of the lead-in conductor, an inner peripheral layer of conductor connected at one end with the case and of substantially the cross-sectional size of the secondary winding and an intermediate layer of conductor of a cross-sectional size between the sizes of the conductor of the peripheral layers of the primary winding for progressively decreasing the capacitance of the primary winding in steps from the lead-in connection therewith to the case connection therewith.

EDWARD J. MACKERETH.

## REFERENCES CITED

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

UNITED STATES PATENTS

| Number | Name | Date |
|---|---|---|
| 714,934 | Moody | Dec. 2, 1902 |
| 783,802 | Shoemaker | Feb. 28, 1905 |
| 854,774 | Taylor | May 28, 1907 |
| 1,872,369 | Van Sickle | Aug. 16, 1932 |
| 1,940,840 | Bellaschi | Dec. 26, 1933 |
| 2,519,224 | Chiles, Jr. | Aug. 15, 1950 |