Aug. 25, 1959 H. HARTMANN 2,901,713

HIGH CURRENT TRANSFORMER

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Fig. 1.

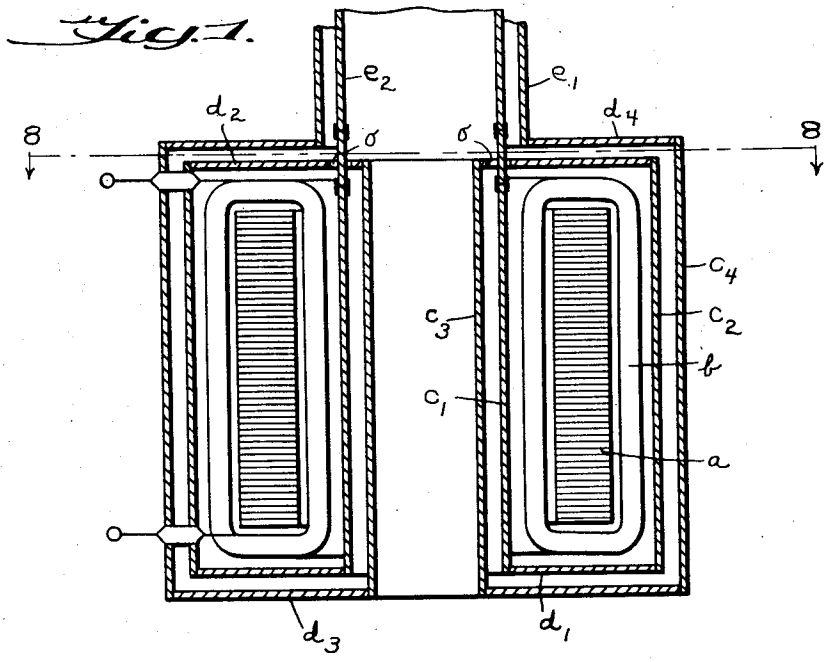
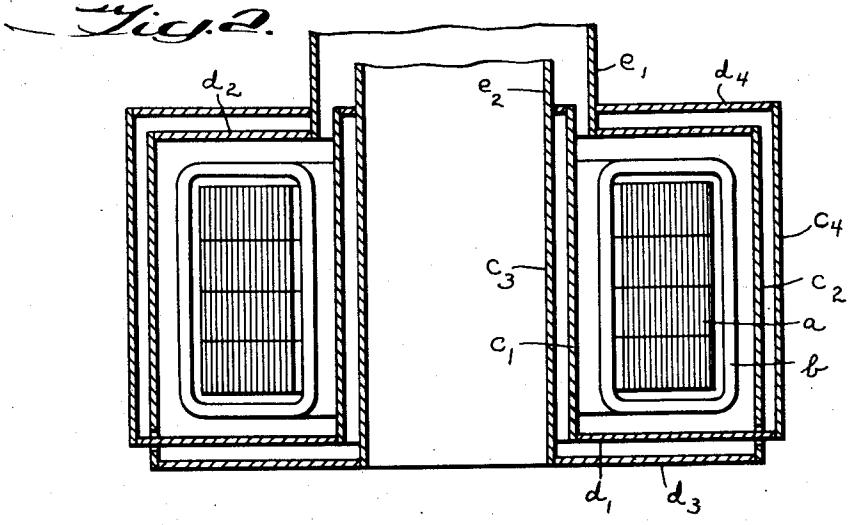


Fig. 2.



INVENTOR

Hans Hartmann

BY Pierce, Scheffler & Parker

ATTORNEYS

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Fig. 3.

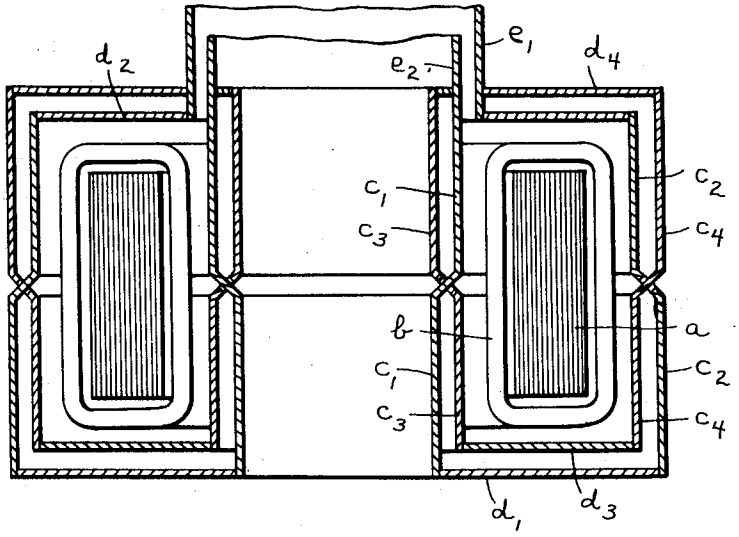
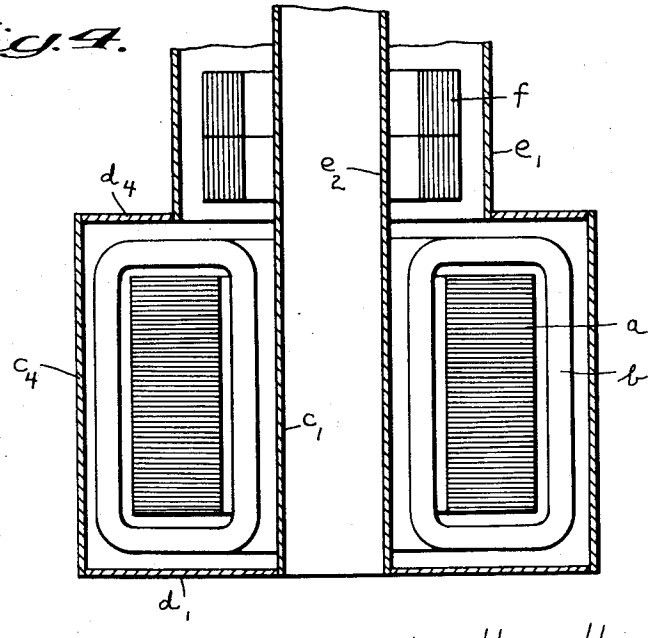


Fig. 4.



INVENTOR

Hans Hartmann

BY Pierce, Scheffler & Parker

ATTORNEYS

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Fig. 5.

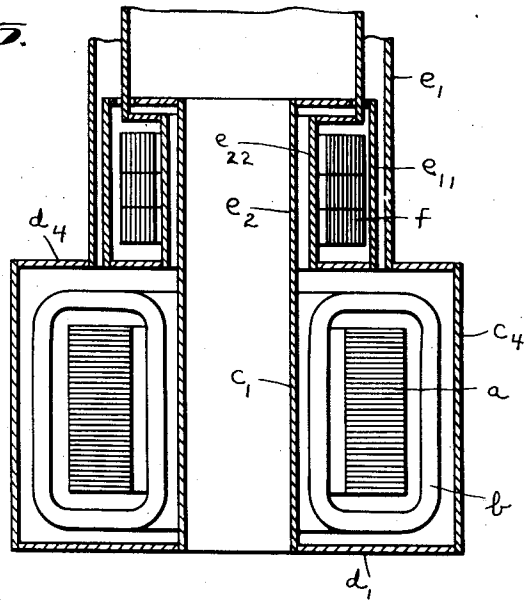
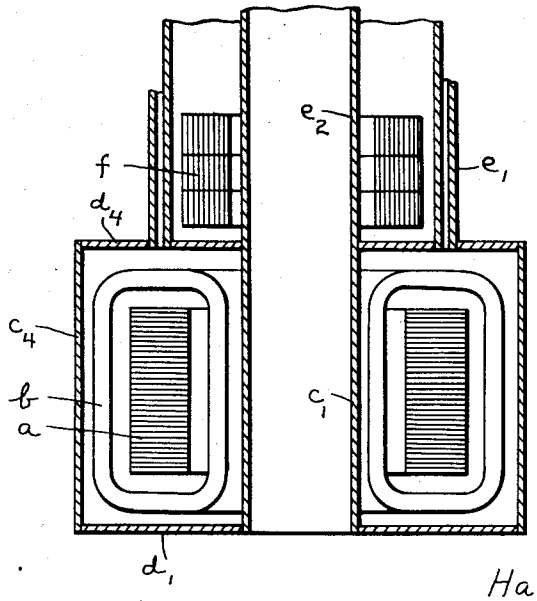


Fig. 6.



INVENTOR

Hans Hartmann

BY Pierce, Scheffler & Parker

ATTORNEYS

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Fig. 7.

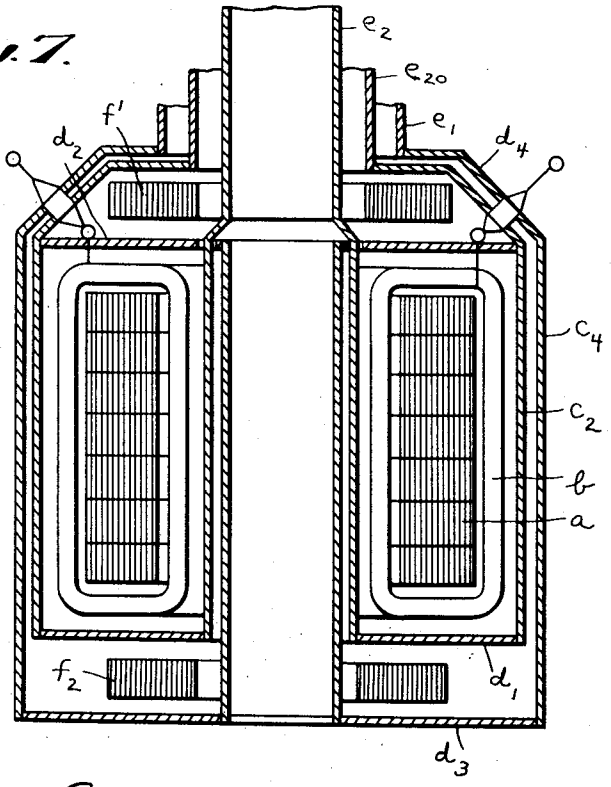
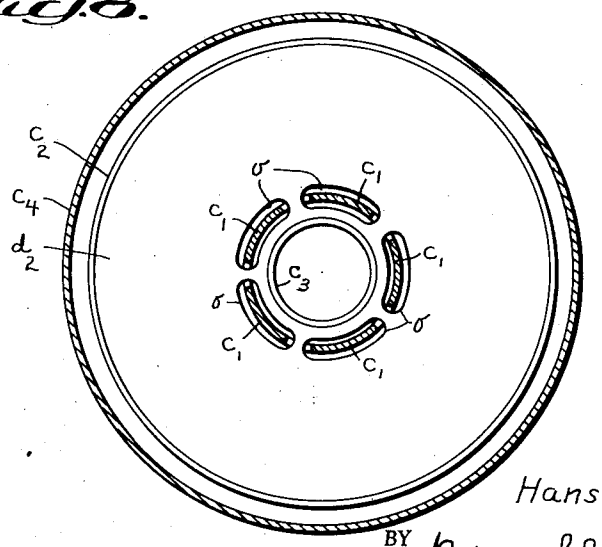


Fig. 8.



INVENTOR

Hans Hartmann

BY Pierce, Scheffler & Parker

ATTORNEYS

United States Patent Office 2,901,713
Patented Aug. 25, 1959

2,901,713

HIGH CURRENT TRANSFORMER

Hans Hartmann, Baden, Switzerland, assignor to Aktiengesellschaft Brown, Boveri & Cie, Baden, Switzerland, a joint-stock company

Application May 6, 1953, Serial No. 353,395

Claims priority, application Switzerland May 10, 1952

6 Claims. (Cl. 336—82)

In the construction of heavy-current transformers, in particular for the feeding of current converters of the mechanical switching type, the following difficulties arise. The heavy currents require a very large conductor cross-section. For the coil windings conventional in transformer construction, made of wire, many coils of small wire diameter must be connected in parallel, because excessive wire cross-sections can no longer be bent because of their stiffness in order to wind coils out of them. The parallel connection of individual coils is difficult and time-consuming. When sheetmetal windings are used, the customary design of core transformers and cylindrical windings leads to increased losses at the edges through the wide-side penetration of the bulging stray field into the sheets. Also the current derivations to be connected to the sheetmetal winding cause difficulties and additional losses. The junctions of the transformers and the connections between coil groups and the coil, however, are not only difficult to produce technologically, they also are the seat of additional losses. These losses are by no means limited to the connections themselves, but their intensive fields produce losses in neighboring metallic structural parts. The intensive stray fields of the heavy-current winding and of the derivations, moreover, bring about undesired inductive voltage drops, which are the more serious as the customary voltages are small at heavy currents. The result of this is that transformers of high output can no longer be built with good efficiency for the very small voltages of a few volts, as they are often desired, because the voltage induced in the transformer would already be consumed to a large extent before reaching the terminals by the total voltage drops.

The subject of the invention is a heavy-current transformer with annular iron core and with a heavy-current winding formed by tubular conductors, wherein the said difficulties are eliminated in that according to the invention the heavy-current winding forms a covering for the transformer core including the primary winding and consists of stationary, cylindrical conductors arranged concentrically to each other and co-axially with the core axis, and of conductor parts, bridging the annular spaces between said conductors at the front ends of the tubular conductors, the connections of the heavy-current winding being led out concentrically with each other in the direction of the core axis as tubes at at least one front end.

The use of cylindrical structural elements for the heavy-current winding of transformers has the result that the core window can be made smaller than in the hitherto customary winding set-up; the losses become smaller. The magnetic lines of force, which the heavy-current winding produces, strike the latter only at the narrow front edges of the tubular conductors, as these conductors are circular.

Due to the concentric covering of the primary winding and of the iron core of the transformer, the leakage between both is reduced and the space outside the secondary winding remains completely without a field. The stray inductivity of the entire arrangement therefore presents a minimum, and losses in surrounding structural parts due to the effect of stray fields are completely eliminated.

The circular ring shape for the transformer and the heavy-current winding results in a completely axial-symmetrical design, and the ampere-turns to the connection points of the transformer are directly compensated at every point.

In the drawing, examples of the possible construction and utilization of the transformer according to the invention are illustrated diagrammatically in longitudinal section in Figures 1 to 7, the specifically mechanical set-up and wiring details not needed for the comprehension of the invention being omitted. Fig. 8 is a transverse section on line 8—8 of Fig. 1 showing the manner in which cross-connections are made between certain of the cylindrical secondary conductors which lie respectively within and without the annular core.

In all figures, the iron core of the transformer is denoted as a; it carries the primary winding b. The transformer core is an annular core which is either a stack of core parts wound of iron strips or it may be wound from a strip whose width corresponds to the core height. However, the core may be built up by stratification of parts stamped out of sheetmetal plates. The secondary or heavy-current winding for the feeding of a current consumer, not shown, surrounds the transformer core including the primary winding, as a cover. This cover is composed of stationary tubular conductors arranged concentrically with each other and with the core axis, as well as of conductor parts, bridging the annular spaces between them at the front ends of the tubular conductors.

In the transformer according to Fig. 1, the cover is double-sheathed; it consists of two concentric tubular conductors c_1, c_3, which lie in the interior of the annular core a, the two concentric tubular conductors c_2, c_4 extending outside the annular core co-axially with it, and the conductor parts d_1 to d_4 bridging these tubular conductors at their front ends. The tubular conductors c_1 to c_4 are connected in series by means of the conductors d_1 to d_4 and can be traced as follows: from conductor sleeve c_1 through d_1 to conductor sleeve c_2, from sleeve c_2 through conductor d_2 to sleeve c_3, and from sleeve c_3 through conductor d_3 to sleeve c_4. The winding connections are concentric tubular conductors e_1, e_2, which are led out in the direction of the core axis and arranged at the outermost tubular conductor c_4, on the one hand, and at the inner tubular conductor c_1 adjacent to the transformer core, on the other. The tubular conductors may be wound from sheetmetal.

In order that the winding connection may be led out from the tubular conductor c_1 present inside the iron core out of the covering, the bridging annular conductor d_2 which connects conductor c_2 with conductor c_3 must be provided at the upper front end of the tubular conductors c_1, c_2 with penetration apertures o as shown in Fig. 8, in order to permit passage upward through bridging conductor d_2 of correspondingly positioned peripheral parts of tubular conductor c_1 which lies intermediate tubular conductors c_2 and c_3 and which connects with terminal conductor e_2. The same purpose can be achieved by bridging the annular space between the tubular conductors by conductor parts in spoke-type arrangement at this point.

For liquid-insulated transformers it is possible to use the heavy-current winding or parts thereof as containers for the oil not shown. The innermost tube c_3 in the core window can then be made use of as a container wall, or the outermost tube c_4 surrounding the core, provided with a bottom plate, may serve as container.

Instead of connecting in series, pairs of concentric tubular conductors inside and outside the core of the transformer according to Fig. 1, it is possible also to connect the tubular conductors in parallel, as shown in Figures

2 and 3, crossings of the inner and of the outer tubular conductors being easy to carry out.

Transformers according to the invention are particularly valuable in plants for the generation of high-ampere direct current with the aid of a contact transformer i.e. mechanical switching converter which is combined with a reversing choke with annular core for the production of low current intervals in the contact period. Examples of this kind are shown in Figures 4 to 7, where the annular core f of the reversing choke is provided co-axially with the transformer core a. The choke core is permeated by the current of the heavy-current winding at least in part. The secondary winding surrounding the transformer core including the primary winding as a cover may here again consist only of one tubular conductor c_1, c_4 inside and outside the transformer core having concentric connections e_1, e_2 led out in the core axis (see Figs. 4 to 6), or it may be double-sheathed (see Fig. 7). The covering of the transformer is so designed that it surrounds the core of the reversing choke, and it is then composed of the concentric tubular conductors c_1, c_4, the bridging conductor parts d_1, d_4 and the concentric connections e_1, e_2. And this covering may be so designed that it surrounds at least the reversing choke coil as a double sheath, as is seen from Fig. 5. The cover of the choke will then consist of two concentric tubular conductors e_1, e_{11} outside the choke core and two concentric tubular conductors e_2, e_{22} inside the core window of the reversing choke, as well as of the bridging conductors on the front side.

Fig. 6 shows as a further example the use of a transformer designed according to the invention, having a reversing choke for contact transformers with open Graetz wiring of the type shown generally in Fig. 4 of U.S. Patent No. 2,441,484, issued May 11, 1948, and assigned to the same assignee as is this application. The tubular conductor c_1, e_2, which lies inside the core of the transformer and reversing choke and which belongs to the cover formed by the heavy-current winding, leads in this case to the one current system of the one phase, while a connection derived from this tubular conductor leads to the other current system of the open Graetz wiring, and the tubular conductor e_1 of the cover lying outside the core is connected to the star point of the transformer.

Finally there is shown in Fig. 7 a transformer combined with reversing chokes according to the invention for the operation of a contact transformer in pushpull arrangement. Here, the reversing chokes f_1, f_2 are arranged on both front sides of the transformer core coaxially with the annular core a of the transformer inside the cover formed by the heavy-current winding. The current conductors of the heavy-current windings c_1, c_2, and c_3, c_4 respectively, feeding the phase and counterphase, are arranged for push-pull operation. From terminal e_1 the secondary circuit is constituted by tubular conductors c_4 and c_3 in series to terminal e_{20} which leads to the transformer star point. Similarly, from terminal e_2 the secondary circuit is constituted by tubular conductors c_1 and c_2 in series to terminal e_{20}. For the rest, the transformer according to Fig. 7, exhibits the same structural elements as Fig. 1 with respect to the cover, and identical parts bear identical reference symbols. The choke cores f_1, f_2 may, if desired, be enclosed on all sides by the heavy-current winding in the manner shown in Fig. 5. The arrangement of Fig. 7 can also be used without choke.

In all examples, the cores of the reversing choke coils are wound from sheetmetal strip. The annular cores may either be made from a sheet of a width equal to the core height or as shown in Fig. 7 be composed of several axially aligned partial cores of small height. The magnetic characteristic of the core material for the transformer and reversing choke must be adapted to the requirements for the latter. The transformer cores may consist of silicon iron, the reversing choke cores, of nickel iron.

Transformers according to the invention can be used in series as well as in parallel connection. It is possible without difficulty to use monophase combinations of transformer and reversing choke for three or multiple-phase contact transformers. The individual transformers may be arranged alongside each other or in superposition.

The cores may also be produced from stamped disks or otherwise, for example, as powder cores.

At variance with the arrangement according to Fig. 1 the winding connections may be arranged at the tubular conductors external to the transformer core, an inner tubular conductor adjacent to the transformer core being connected with one of the outer tubular conductors by crossing of the bridging conductors at one front end.

I claim:

1. A heavy-current transformer for supplying current converters of the mechanical switching type comprising an annular iron core, a primary winding on said core and a heavy-current secondary winding comprising a first pair of radially spaced tubular conductors disposed within said core, a second pair of radially spaced tubular conductors disposed outside of said core, the outermost of said tubular conductors of second pair forming a cover for said transformer, secondary terminal means connected respectively to one conductor of said first pair and to one conductor of said second pair and means connecting said conductors of said first pair with said conductors of said second pair at the ends thereof comprising bridging conductors extending therebetween, one of said bridging conductors being passed through one of said tubular conductors in order to interconnect a conductor of said first pair with a conductor of said second pair.

2. Transformer according to claim 1, characterized in that all of said secondary tubular conductors are connected across their ends by said bridging conductors to form a series arrangement.

3. Transformer according to claim 1, characterized in that said bridging conductors interconnect said pairs of tubular conductors to establish two secondary circuits in parallel, each said secondary circuit being constituted by a tubular conductor of said first pair series connected to a tubular conductor of said second pair.

4. Transformer according to claim 1 and which further includes an annular choke core surrounding one of said first pair of tubular conductors in axial spaced relation to said core for said primary winding.

5. Transformer according to claim 4, characterized in that said cover of the transformer surrounds the said annular choke core.

6. Transformer according to claim 1, characterized in that said bridging conductor which passes through one of said tubular conductors is constituted by a disc-shaped member having an arcuate array of slots therein through which parts of said tubular conductor are passed.

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