Dec. 18, 1962 O. JENSEN 3,069,615

UNITARY COOLING TANK FOR RECTIFIERS

Original Filed Dec. 8, 1955 6 Sheets-Sheet 1

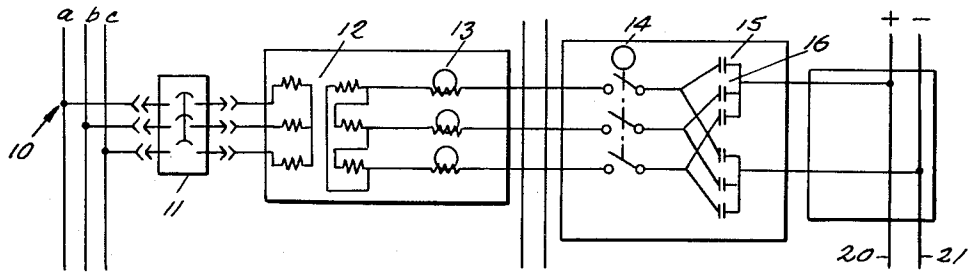


FIG. 1

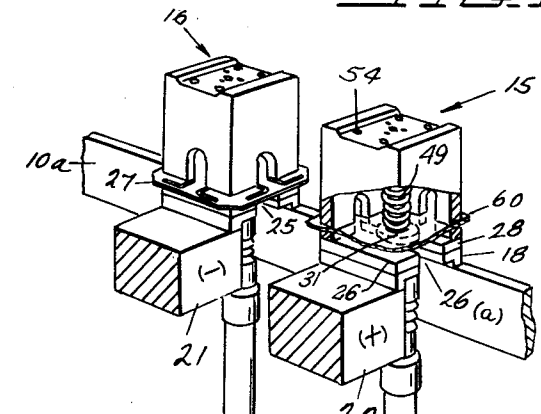
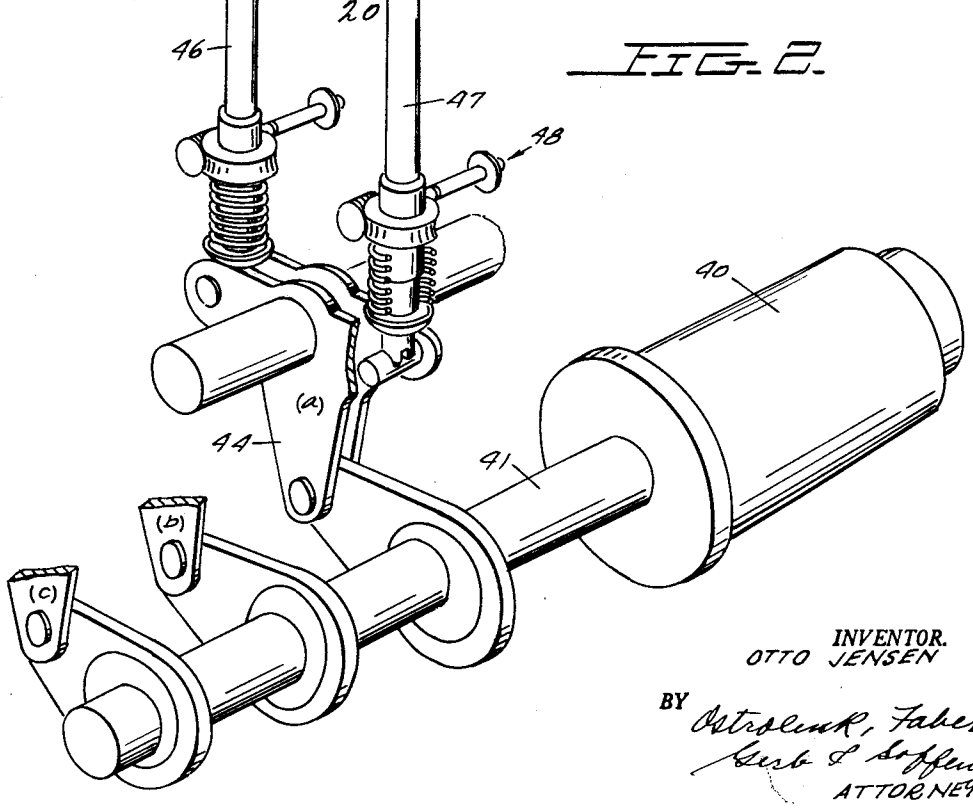


FIG. 2



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FIG. 3.

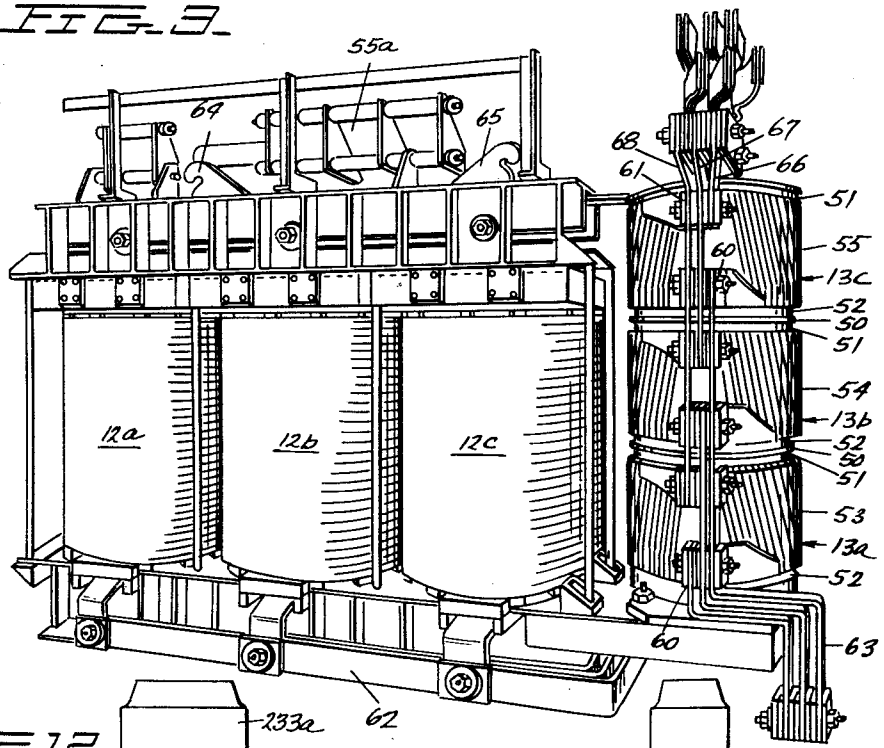
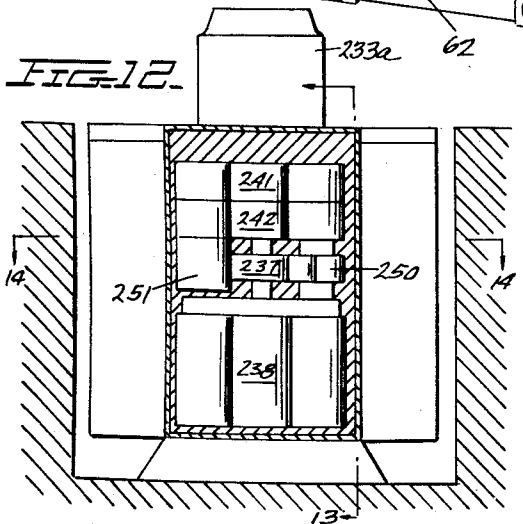


FIG. 12.



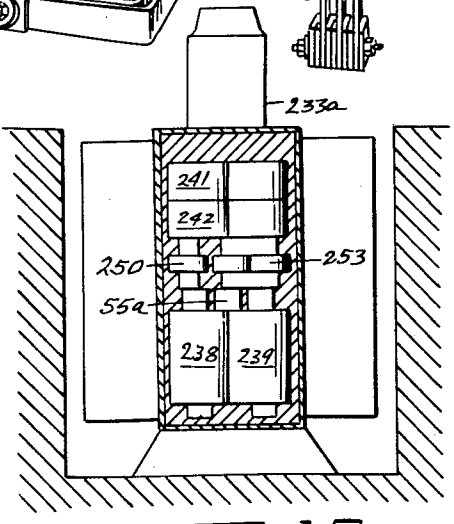


FIG. 13.

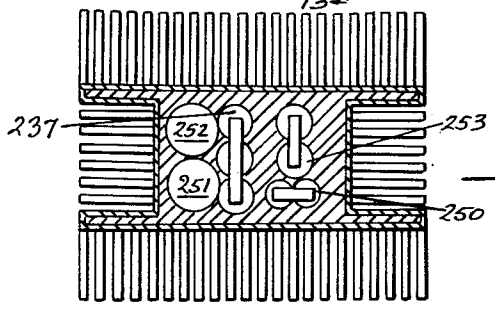


FIG. 14.

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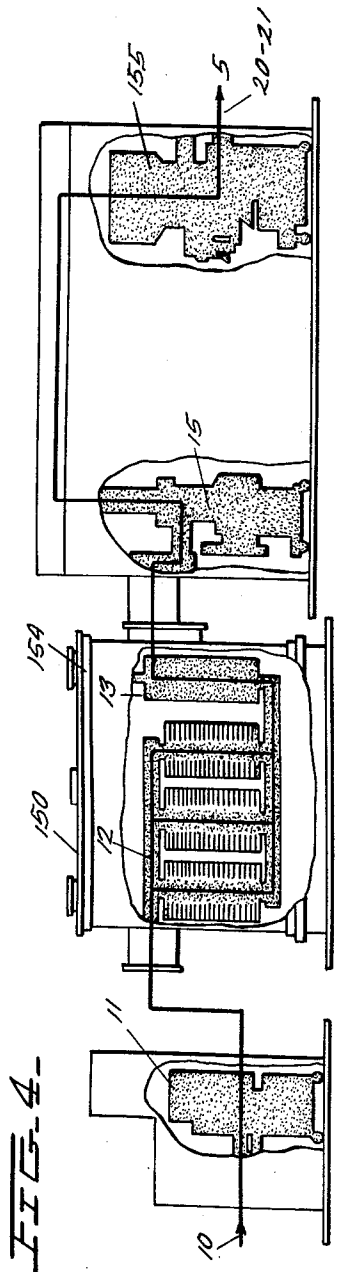


FIG. 4.

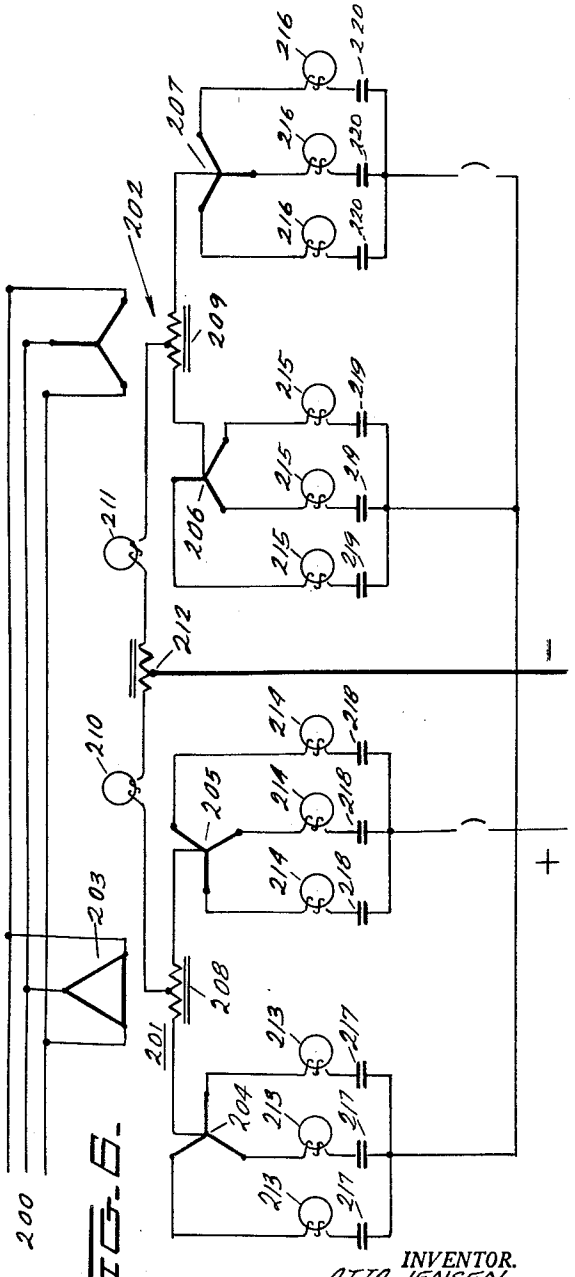


FIG. 6.

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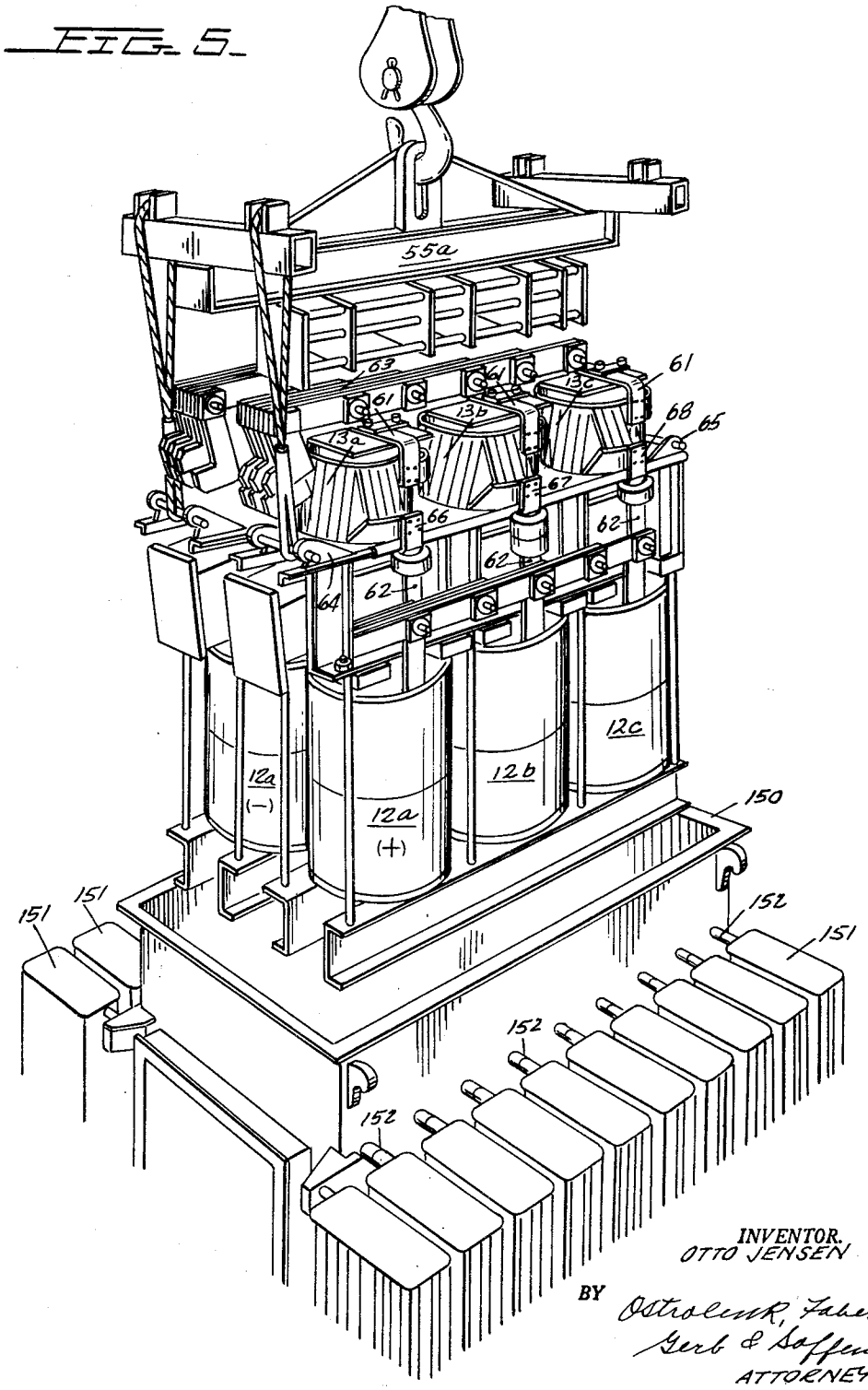
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FIG. 5



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FIG. 7

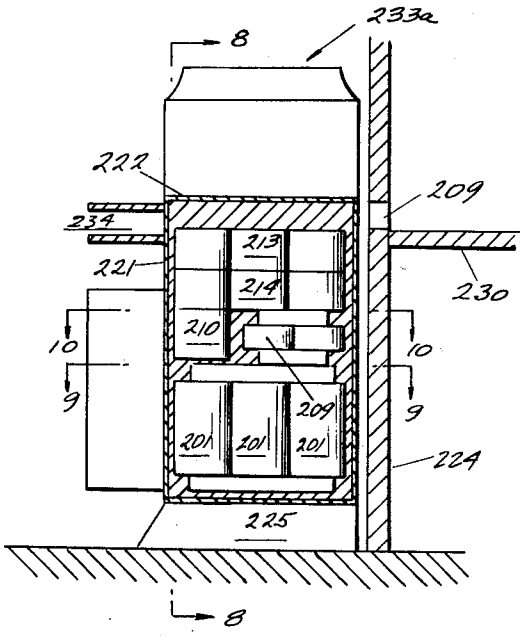
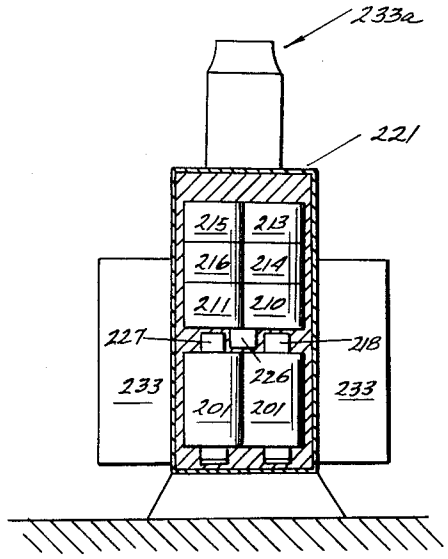


FIG. 8



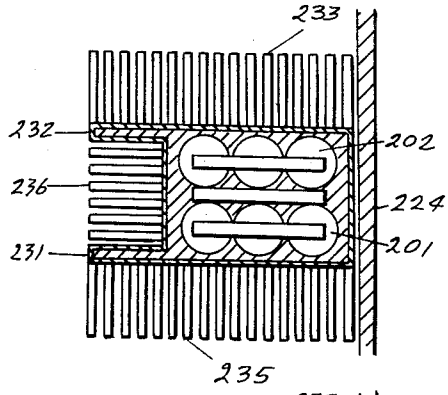


FIG. 9

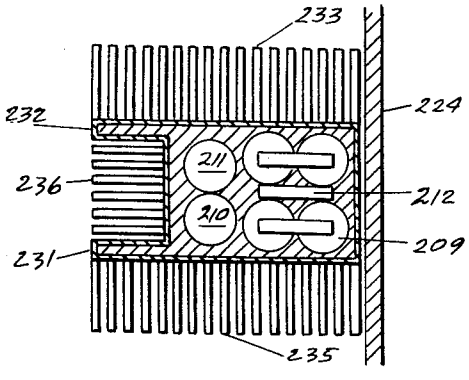


FIG. 10

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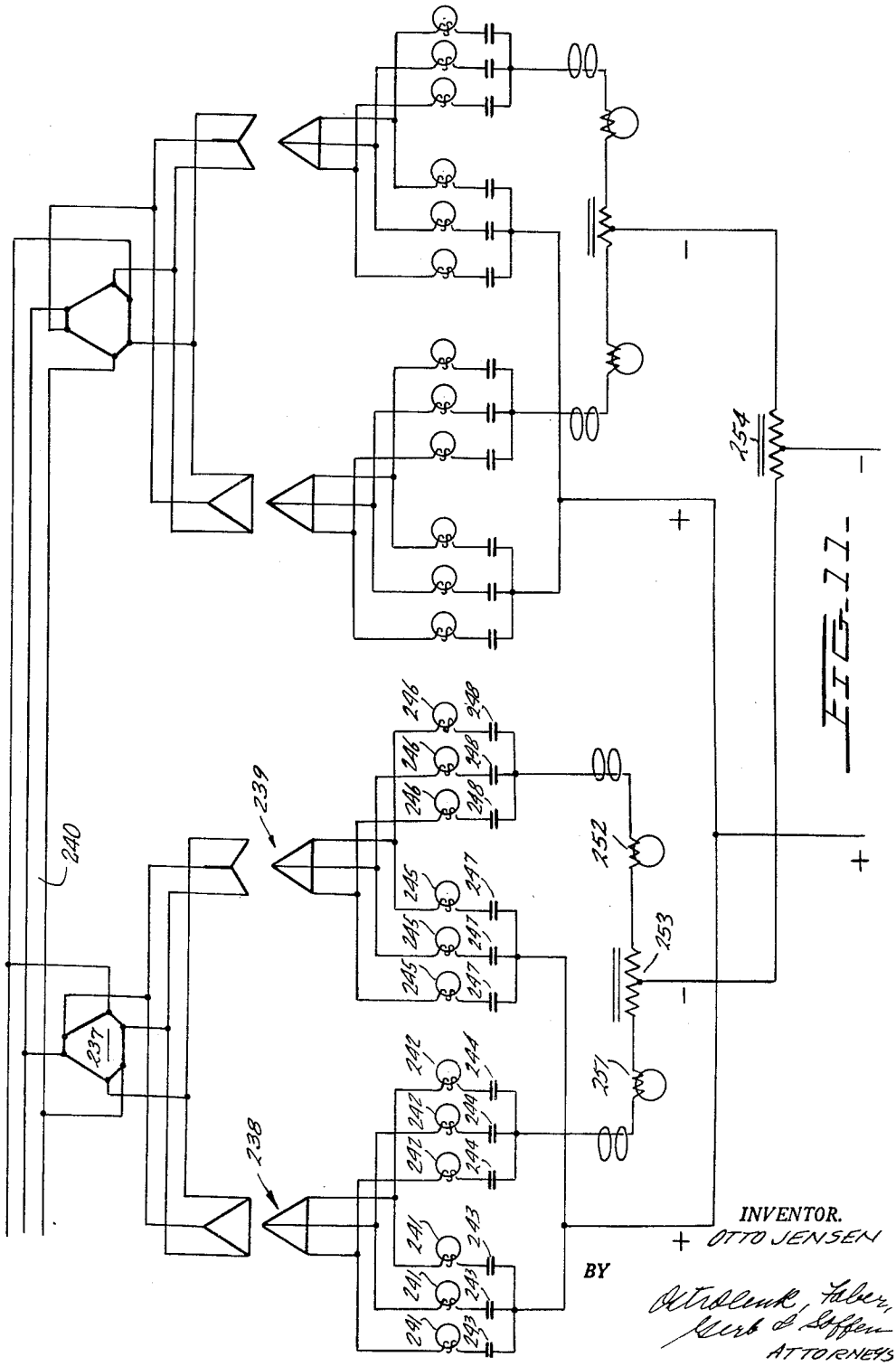


FIG. 11

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United States Patent Office 3,069,615 Patented Dec. 18, 1962

3,069,615

UNITARY COOLING TANK FOR RECTIFIERS

Otto Jensen, Malvern, Pa., assignor to I-T-E Circuit Breaker Company, Philadelphia, Pa., a corporation of Pennsylvania

Continuation of application Ser. No. 551,807, Dec. 8, 1955. This application Dec. 24, 1959, Ser. No. 861,987
3 Claims. (Cl. 321—48)

My invention relates to an arrangement of equipment for high current capacity mechanical rectifiers and more specifically to an arrangement wherein all of the high current carrying components of a mechanical rectifier are placed in the closest possible relationship with one another, and are assembled in a unitary tank. This is a continuation application of my copending application Serial No. 551,807, filed December 8, 1955, assigned to the assignee of the present application.

Mechanical converters of the type described in copending applications Serial No. 212,017, filed February 21, 1951, now Patent No. 2,693,569, and Serial No. 201,880, filed July 31, 1952, now Patent No. 2,759,128, and assigned to the assignee of the instant application, require power transformers to provide the proper secondary voltage for D.-C. utilization. The circuit from the transformer secondaries are connected in series with the main windings of commutating reactors. Heretofore a separate and independent tank unit was provided to house the power transformers with the commutating reactors positioned outside the tank.

With this prior art arrangement the commutating reactors were mounted inside the building and were provided with an enclosure on top of which was mounted a fan which forced air in through the bottom of the stack of reactors and out the top. However, a considerable amount of dirt was blown into the reactor windings. Due to this undesirable condition, it was considered desirable to treat the commutating reactor in the same manner as a transformer to obtain better and cleaner cooling by providing the reactor with a tank arrangement similar to that used for the power transformer.

However, this arrangement has many of the disadvantages encountered in previous arrangement plus other disadvantages. For example, when the reactor is mounted in a separate tank the plurality of connections between the power transformer secondaries and the reactor main windings must be made through external bushings and leads. Thus, this arrangement increases the number of bushings required and also takes up considerably more space. Furthermore, this arrangement still has the disadvantage of requiring two separate and independent cooling systems, one for the transformer and another for the reactor. Also the length of the bus lines between the two components of the separately mounted transformer and reactor resulted in insertion of from 3 to 3½% reactance in the circuit resulting in the deterioration of the contacts.

With the arrangement of my invention all of the above disadvantages are overcome. With my novel arrangement of providing a unitary housing or tank for the commutating reactors and the power transformers, it is possible to obtain

(1) Shorter length of bus leads between the transformer secondaries and the main winding of the reactors to thereby reduce the reactance to less than one half of one percent and thereby prevent deterioration of the contacts;

(2) A single cooling system to cool both the transformer and commutating reactors to thereby eliminate the necessity of an extra cooling unit;

(3) Material reduction in the number of tank bushings required since all the connections between the transformer

secondaries and the main winding of the commutating reactors can be made within the unitary tank for the combination of the two circuit units;

(4) Economy by requiring a single large tank for the combination rather than separate independent tanks;

(5) Considerable saving in space;

(6) Better and cleaner cooling of the reactor and prevents dirt from being blown into the windings.

It will be apparent that all of the above problems are common to any type of high current low voltage rectifier system and the invention, which solves these problems, is applicable regardless of the rectifier element used, whether it be of the contact type, semi-conductor type, or the like, wherein saturable reactors or other reactors such as commutating reactors are necessary in some function.

Two embodiments of my novel arrangement are set forth in the appending disclosure. In the first embodiment the commutating reactor stacks are mounted on the side of power supply transformers and hence are cooled by oil which has not passed through the transformer means. In the second embodiment the individual commutating reactors are mounted on top of their respective power supply transformers. Although this latter embodiment has the disadvantage of having the reactors cooled by the oil which has passed through the transformer, it has the added advantage of providing a more compact unit with shorter lead length between the transformers and reactors.

Accordingly, an object of my invention is to provide a unitary tank to house the combination of power transformers and commutating reactors.

Another object of my invention is to provide a novel structural arrangement for a mechanical converter which introduces less than one half of one percent reactance into the circuit.

Another object of my invention is to provide a combination transformer and commutating reactor housing which requires a single cooling system.

Still another object of my invention is to provide a mechanical converter with a novel combination arrangement for the transformers and reactors which will prevent deterioration to the switching contact.

Another object of my invention is to provide a novel arrangement for a mechanical converter which will substantially reduce the required number of bushings required for the connection between the transformers and reactors.

A further object of my invention is to provide a novel combination tank for transformer and reactor which results in economy and saving of space.

A further object of my invention is to provide a novel combination transformer and commutating reactor unit with the latter unit aligned on the side of the former.

A further object of my invention is to provide a novel combination arrangement for a transformer and commutating reactor with the reactor for each phase mounted on top of its respective transformer.

My novel invention may be further extended to provide a unitary housing for extremely high current capacity mechanical rectifiers, wherein phase shifters, step reactors (as described in copending application Serial 541,709, filed October 20, 1955, now abandoned) and interphase transformers may be housed in the same tank as is the commutating reactor and main power transformer. If desired, this type of unitary tank may then be so constructed as to have the contact mechanism positioned immediately on top of the tank to thereby appreciably shorten the length of the bus required to connect the contact mechanism to the other high current carrying components within the tank.

The requirement for extremely high current capacity

rectifying equipment is typified in the aluminum industry. It has been found that for more efficient production of aluminum that larger ports be used having an overall capacity of 150,000 amperes at 300 volts, whereas the previous rating for aluminum pots has been 60,000 amperes at 900 volts. In aluminum manufacture, it is seen that by increasing the current rating of a pot from 60,000 to 150,000 amperes, a larger pot could be used, thereby allowing the use of fewer auxiliaries per pound of aluminum manufactured.

However, this changing trend in current and voltage ratings for aluminum manufacture requires that the current conversion equipment supplying this D.-C. power must supply a much greater current, thereby leading to higher resistance losses in the bus, and a lower voltage, which means that a voltage drop in the conversion unit due to reactance or resistance losses will result in a much greater loss in efficiency than would be had in the higher voltage units.

It is therefore essential for an economically desirable conversion unit that the A.-C. voltage drop and the copper losses be as small as possible and be compatible with an economical use of the copper. That is to say, copper losses may be decreased by vastly increasing the cross-sectional area of the copper conductors but the cost in doing so may be prohibitive.

The principle of my invention is to overcome the above mentioned problems by placing each of the components which carry this high current in as close a proximity as possible, thus leading to a decreased length of copper bus, which in turn leads to a small copper loss by cutting down the resistance as well as a smaller reactive loss, thereby maintaining efficiency and power factor at a desirable level.

It is to be seen that by applying my novel invention to decrease both copper losses and inductive voltage drop I inherently provide a single cooling system with which each of the high current carrying components of the rectifier unit are cooled. Similarly, there is a material reduction in the number of tank bushings required since all of the interconnections between the components take place within the unitary tank structure.

Accordingly another object of my invention is to provide a unitary tank structure for a mechanical rectifier which contains power transformers, commutating reactors, phase shifters, interphase transformers and step reactors.

Another object of my invention is to substantially decrease copper losses and inductive voltage drop in a mechanical converter by providing a unitary tank structure for the housing and cooling each of the high current carrying components, and to thereafter mount the contact mechanism on top of the enclosed tank.

These and other objects of my invention will be apparent from the following description when taken in connection with the drawings in which:

FIGURE 1 is a schematic electrical connection diagram of a mechanical converter to which my invention may be applied.

FIGURE 2 is a perspective view of the contact mechanism of the mechanical converter.

FIGURE 3 is a perspective view of the mounting and arrangement for combining the transformer assembly and commutating reactor assembly which are to be placed within a unitary tank.

FIGURE 4 is a cross-sectional schematic view of my novel combination transformer and commutating reactor unit in connection with an entire rectification circuit.

FIGURE 5 is a perspective view of a second embodiment of my novel combination transformer and commutating reactor when positioned in a unitary tank.

FIGURE 6 is a circuit diagram of a high current capacity mechanical rectifier unit having a 12 phase output voltage ripple.

FIGURE 7 is a cross-sectional schematic view of a unitary tank structure containing the high current carrying components of the circuit of FIGURE 6.

FIGURE 8 shows a sectional view of FIGURE 7, taken along the lines 8—8 of FIGURE 7.

FIGURE 9 is a sectional view of FIGURE 7 when taken along the lines 9—9 of FIGURE 7.

FIGURE 10 is a sectional view of FIGURE 7 when taken along the lines 10—10 of FIGURE 7.

FIGURE 11 shows still another circuit diagram for a mechanical rectifier having a high current capacity and an output voltage having a 24 phase ripple.

FIGURE 12 is a sectional view of a unitary tank structure containing the components of the circuit diagram of FIGURE 11.

FIGURE 13 is a sectional view of FIGURE 12 taken along the lines 13—13 of FIGURE 12.

FIGURE 14 is a sectional view of FIGURE 12 when taken along the lines 14—14 of FIGURE 12.

In FIGURE 1 the source of alternating current is derived from an A.-C. voltage source which energizes the conductors **10** and passes through the circuit breakers **11** to the step down transformer **12**. The current is subsequently passed through commutating reactors **13** to step the current for commutating purposes as set forth in United States Patent 2,693,569 assigned to the assignee of the instant application. The construction of the commutating reactor is described in copending application Serial No. 301,880, filed July 31, 1952, now Patent No. 2,759,128, and assigned to the assignee of the instant application.

The current then passes through the disconnect switches **14** to the contact assemblies **15** and **16**. The contact assemblies **15** and **16**, which are sequentially operated in synchronism with the frequency of the source, are connected to the alternating source buses **10***a*, *b* and *c* to the direct current load buses **20** and **21**.

For purposes of simplification, I have shown in FIGURE 2 the mechanical switching arrangement which is utilized for phases A of FIGURE 1, it being understood that the switching apparatus for phases B and C are identical in construction.

A synchronous motor **40** drives the shaft **41** which in turn operates the eccentric member **43** to thereby alternately drive the push rods **46** and **47** upwardly through the bell cranks **44**. A detailed explanation of the construction of the adjustment and control by means **48** is set forth in copending application Serial No. 307,024, filed August 29, 1952, and now Patent No. 2,845,592.

The upward movement of the push rod **47** will urge the disc shaped bridging contact **31** upward against the bias of the helical spring **49** and thereby disengage it from engagement with the stationary A.-C. contact **28** and the positive D.C. stationary contact **26**. During this period of time the push rod **46** is in its lowermost position and hence the bridging contact associated with the structure **16** is biased into contact engagement by the helical spring associated with the contact assembly **16**.

On the next half cycle, the position of the push rods **46** and **47** will be reversed by the bell crank **44** so that the push rod **47** will be in its lowermost position and the push rod **46** will be in its uppermost position. Hence at this time the bridging contact **31** associated with the contact block assembly **15** will be in engagement with its associated stationary contacts **23** and **26** and the bridging contact associated with the contact block assembly **16** will be disengaged from its associated contacts **25** and **27**.

Thus throughout a complete cycle of operation the bridging contacts will also complete a mechanical cycle of operation.

The tank unit of FIGURE 3 shows the arrangement of components for the rectification system of FIGURE 1. Thus it is necessary to provide the mechanical converter with three commutating reactors, each corresponding to one of the three phases. To achieve a compact arrange-

ment, the commutating reactors 13*a*, 13*b* and 13*c* of FIGURE 3 are placed on top of one another to form a stack and are supported by aluminum spiders 50 which are in turn supported from a center column which is not seen in the drawing.

The commutating reactors are then insulated from the supporting spiders 50 by the phenolic base members 51 and 52.

A detailed description of the commutating reactors shown in FIGURE 3 may be had with reference to my copending application Serial No. 301,880, filed July 31, 1952, now Patent No. 2,759,128.

As further seen in FIGURE 3, the input terminals 60 and 61 of the reactors 13 are connected by means of the plurality of vertical bus bars 66, 67 and 68, respectively.

The power supply transformer 12 has windings 12*a*, 12*b* and 12*c* for phases which correspond to lines *a*, *b* and *c* of power line 10 of FIGURE 1 which are positioned to the left of the commutating reactor stacks 13*a*, 13*b* and 13*c* and are supported from the common base construction. The primary windings of the transformer coils 12*a*, 12*b* and 12*c* are energized from primary leads (not shown) which are connected to the unit at the upper left hand corner.

Energy from the secondary windings of the transformer 12 is fed to commutating reactor windings 53, 54 and 55 by means of secondary bus bars 62 and is taken from the commutating reactors by the bus bars 63. It is to be noted that the connection between bus bars 90 and 91 takes place within the tank unit thereby avoiding gaskets and that the length of the bus run is very short to thereby reduce bus resistance and inductance.

A tap changing means shown generally at 55*a* is then positioned above the transformer assembly. The assembly is then provided with hook means 64, 65 for easy removal from the tank as seen in FIGURE 5.

Another embodiment for a compact arrangement for the commutating reactors 13*a*, 13*b* and 13*c* and power supply transformer coils 12*a*, 12*b* and 12*c* is shown in FIGURE 5. In this embodiment, in which like numerals have been assigned to parts similar to the embodiment of FIGURE 3, the commutating reactors 13 are positioned on top of the power supply transformer 12.

As can be clearly seen in FIGURE 5, the bus bars 62 which connect the secondary coils 12*a*, 12*b* and 12*c* of transformer 12 to the main winding of the reactors 13*a*, 13*b* and 13*c* are considerably shorter than as shown in FIGURE 3 and therefore present a greatly decreased resistance and reactance.

As further seen in FIGURE 5, the entire combination of the power supply transformers and commutating reactors are positioned in a tank 150. The tank 150 is provided with a plurality of radiator cooling fins 151 which are connected to the tank 150 by tubing 152 at their top and are similarly connected at their lower end (not shown). After the combined unit of transformers 12 and reactors 13 are positioned in tank 150, the entire unit is filled with an insulating and cooling oil such as pyranol.

The entire unit is then sealed closed by a cover 154 as may be seen in FIGURE 4 which shows the general schematic view of the system of FIGURE 1 and FIGURES 3 or 5. Hence, as the components within the tank 150 begin to warm up, heat will be transferred to the oil means by convection. As the hot oil has a lower density than the cold oil, it will raise in the tank 150 and pass through openings 152 into the radiator cooling fins 151.

The large exposed surfaces of the radiators 151 will ensure rapid cooling of the oil therein and pass it back into the tank through the lower openings (not shown) which are similar to opening 152. Hence, a single continuous closed oil cooled system is provided as a means to dissipate the heat generated by both the transformers 12 and commutating reactors 13.

It is to be noted in conjunction with FIGURE 4 that, as was shown in FIGURE 1, the input A.-C. power lines 10 are taken through the A.-C. switchgear 11 and then into the unitary tank 150 which contains the power transformer 12 and the commutating reactor 13. From the tank 150 the power is then passed to the contact mechanism 15 and thence to the D.-C. switchgear 155 and finally to the D.-C. buses 20—21.

FIGURE 6 shows a particular circuit diagram of a mechanical rectifier system which may be used for high current applications. In this figure it is seen that an input A.-C. power source 200 is connected to a first and second transformer 201 and 202, respectively. Transformer 201 is shown as comprising a primary winding 203 connected in delta and having two secondary windings 204 and 205 connected in Y. Similarly, the power transformer 202 is provided with two Y connected secondaries 206 and 207. The neutral point of the secondary windings 204 and 205 are brought out to an interphase transformer 208 and similarly the neutral points of windings 206 and 207 are connected to an interphase transformer 209.

A center tap is then taken from each of the interphase transformers 208 and 209 and are connected through two step reactors 210 and 211, respectively, to still another interphase transformer 212. A center tap is then made at the interphase transformer 212 and the negative D.-C. bus bar of the rectifier unit is taken therefrom. The secondary windings 204, 205, 206 and 207, respectively, are then shown as having each phase connected in series with the commutating reactors 213, 214, 215 and 216, respectively, and the contacts 217, 218, 219 and 220, respectively. Each of these assemblies are then connected together to provide the positive output bus of the rectifier system of FIGURE 6.

It is to be noted that in the case of FIGURE 6 the output voltage will have a 12 phase ripple. This is of great importance in many applications since by increasing the ripple frequency, telephone interference is decreased. In the case of 12 phases with its associated increase in power capacity, it is of interest to note that for the same power per phase as the circuit of FIGURE 1, that the circuit of FIGURE 6 although doubling the power output, appreciably decreases telephonic interference.

Since the power requirements of the circuit of FIGURE 6 are drawn to extremely high current capacities at relatively low voltages, it is essential that the length of copper conductors connecting the various current carrying components of the system be as short as possible.

FIGURE 7 shows the arrangement of the components of FIGURE 6 in a unitary tank structure shown generally by the walls 221, cover 222 and base 223. The tank structure is shown as being placed adjacent to the building wall 224. The building wall 224 has an aperture 229 therein above the floor level 230 which is positioned to receive the D.-C. bus bars coming out of the unitary tank structure. The unitary tank structure of FIGURE 7 is further constructed to have a throat 234 which is adapted to bring input A.-C. leads into the tank structure. It is seen that the unitary tank which is positioned on the concrete cushion 225 has the two power transformers 201 and 202, as seen more specifically in FIGURES 8 and 9 which are sectional views through the lines 8—8 and 9—9 respectively of FIGURE 7, positioned at the base thereof.

As seen in FIGURE 8, the tap changing equipment 226 is positioned between the iron cores 227 and 228 of the transformers 201 and 202 respectively. Immediately on top of the transformers 201 and 202, the step reactors 210 and 211 are positioned as seen with reference to FIGURES 7, 8 and 9. The interphase transformers 208, 209 and 211 are, as shown in FIGURES 7 and 10 where FIGURE 10 is a sectional view of FIGURE 7 taken along lines 10—10, positioned at one side of the step reactors 210 and 211. The unitary tank structure is then completed by the assembly of the commutating reactors 213, 214, 215 and 216, as seen in FIGURES 7 and 8.

With the tank thus completed and circuit connections made between the various components, the tank is filled with a cooling oil and then covered. As shown specifically in FIGURE 9, the tank wall is provided with extensions 231 and 232, so that cooling fins or radiators 233, 235 and 236 may surround the transformer tank.

The contact mechanism 233*a* is then positioned on top of the unitary tank structure using the cover 222 of the tank as a support means. The tank cover 222 is more specifically a heavy steel plate with appropriate bushings and connectors therein for connecting the mechanism contacts to the appropriate circuit components within the tank. The rectifier mechanism 233*a* may be provided with a weatherproof hood whereby moisture is kept away from the electrical contact structure. Clearly, it is the mechanism 233*a* of FIGURES 7 and 8 which contains the contact structures 217, 218, 219 and 220 of FIGURE 6. By placing this mechanism on top of the unitary tank structure, the contacts are placed in their closest proximity with respect to the commutating reactors.

It is seen that in general all current connections will be as short as possible with the construction shown in FIGURES 7 through 10, whereby copper losses in the connecting conductors and inductive voltage drops will be held to a minimum value.

A second high current capacity rectifier is shown in FIGURE 11, in which two 12 phase rectifiers have been combined to give a 24 phase output voltage ripple. In the case of FIGURE 11, it is seen that the two 12 phase units are phase shifted from one another by means of the phase shifter 237. The 12 phase units fed by the phase shifter 237 are identical and only one will be described herein.

The phase shifter 237 energizes power transformer 238 and 239 respectively from the A.-C. line 240. The power transformer 238 is connected then to the commutating reactors 241 and 242 respectively and the contact structures 243 and 244 respectively. Here the contacts 243 will pass a positive potential, whereas the contacts 244 will pass a negative potential. In a like manner, power transformer 239 energizes the commutating reactors 245 and 246 respectively and the contact structures 247 and 248 respectively. The output of contacts 243 and 247 are combined in a single bus and the outputs of contacts 244 and 248 are interconnected through the interphase transformer 253.

Step reactors 251 and 252 are then provided to protect the rectifier unit supplied by transformer 238 and 239 respectively, as set forth in copending application Serial No. 541,709, filed October 20, 1955, now abandoned.

It is then seen that the combined positive outputs of the unit supplied by phase shifter 237 and the unit supplied by the other similar phase shifter are combined in a common bus and the negative outputs are combined in a phase shifter 254.

In view of the extremely high current values carried in the D.-C. bus bars, the current is measured best by means of the D.-C. transductors in a manner well known in the art.

If the phase shifter 237 effects a phase shift of minus 7½ degrees with respect to the input power and the other phase shifter effects a phase shift of plus 7½ degrees with respect to the input power, the output will have an extremely high current value and the output voltage will have a 24 phase ripple.

In view of the extremely high current capacity which could be obtained with the circuit of FIGURE 11, it is of utmost importance that the current carrying components be in as close a physical proximity as possible in order to maintain low copper losses and low inductive voltage drops. This may be done in accordance with my novel invention as seen with reference to FIGURES 12, 13 and 14, where the circuit components of FIGURE 11 energized by the phase shifter 237 are placed in a unitary tank.

Similarly, the circuit energized by the other phase shifter may be placed in an identically constructed unitary tank where the output leads are taken out of their corresponding unitary tanks and brought to the load circuit.

It is seen that the unitary tank structure of FIGURE 12 is almost exactly the same as that of FIGURE 7, where in the case of FIGURE 10 the unit is positioned in a pit. However, in the case of FIGURE 7 the step reactors 210 and 211 and the interphase transformers 208, 209 and 211 were positioned immediately above the power transformers. In the case of the circuit of FIGURE 11, it is seen that the step reactors 251 and 252 occupy the same layer as does the phase shifter 237 and interphase transformers 250 and 253. The power transformers 238 and 239 occupy the lower level and similarly as in FIGURE 7, the commutating reactors 241, 242, 245 and 246 are positioned in an uppermost layer and are directly connected to the contact mechanism 233*a*, which is positioned on top of the tank unit.

It is to be understood that the D.-C. transductors which are not shown in FIGURE 12 are to be positioned in any desirable manner with regard to the connecting bus configuration within the tank assembly.

While a particular arrangement of the various current carrying components has been set forth in FIGURES 7 through 10 for the circuit of FIGURE 6 and in FIGURES 12 through 14 for the circuit of FIGURE 11, it is to be realized that this physical arrangement could be varied and still come within the scope of my novel invention. In any case, the provision of the unitary tank would dictate the advantage of short interconnecting leads between the various components, as well as providing a single cooling system for the individual components. Similarly, an extremely compact system is provided which would lead to substantial savings in space.

Although I have shown a preferred embodiment of my invention, it will now be obvious that many variations and modifications will occur to those skilled in the art, and I prefer to be bound not by the specific disclosure herein but only by the appended claims.

I claim:

1. In a mechanical rectifier for providing unidirectional current from a multi-phase source to a direct current load comprising a plurality of commutating reactors and power supply transformers; each of said power transformers comprising primary and secondary windings; each of said commutating reactors being comprised of a magnetic core and a main winding wound thereon; said commutating reactors and said power transformers housed within a single tank unit; electrical conductors; said secondary windings of said power transformers being electrically connected within said tank to associated main windings of said commutating reactors by said electrical conductors; said electrical conductors being constructed to have a minimum length to thereby decrease their resistance and reactance; an oil cooling system in said tank unit; said oil cooling system comprising a means to circulate said oil within said single tank unit and a means to extract heat from said oil; said oil being circulated to absorb heat from said commutating reactors and power transformers, said heat absorbed by said oil being dissipated by said means to extract heat.

2. In a mechanical rectifier for providing unidirectional current from a multiphase source to a direct current load comprising a plurality of commutating reactors, power supply transformers, interphase transformers, phase shifter, step reactors, and a contact mechanism; each of said power transformers comprising primary and secondary windings; each of said commutating reactors being comprised of a magnetic core and winding; each of said commutating reactors being connected in series with a pair of contacts of said contact mechanism and one of said power transformer secondary windings; said contact mechanism being constructed to synchronously drive each pair of contacts into and out of engagement; said inter-

phase transformers being connected to combine contacts passing a positive unidirectional current into a single positive lead and to combine contacts passing a negative unidirectional current to a common negative lead; said phase shifter being connected to energize said power transformer primary winding from said multiphase source; said commutating reactors, interphase transformers, phase shifter, step reactors and power transformers being housed within a single tank unit; electrical conductors; said commutating reactors, power transformers, phase shifter, step reactors and interphase transformers being electrically connected within said tanks by said electrical conductors; said electrical conductors being constructed to have a minimum length to thereby decrease resistive losses and reactance; an oil cooling system in said tank unit; said oil cooling system comprising a means to circulate said oil within said single tank unit and a means to extract heat from said oil; said oil being circulated to absorb heat from said commutating reactors, power transformers and interphase transformers; said heat absorbed by said oil being dissipated by said means to extract heat; said contact mechanism being positioned and maintained on the cover of said single tank unit.

3. In a rectifier for providing unidirectional current from a multiphase source to a direct current load comprising a plurality of saturable reactors and power supply transformers; each of said power transformers comprising primary and secondary windings; each of said saturable reactors being comprised of a magnetic core and a main winding wound thereon; said saturable reactors and said power transformers housed within a single tank unit; electrical conductors; said secondary windings of said power transformers being electrically connected within said tank to associated main windings of said saturable reactors by said electrical conductors; said electrical conductors being constructed to have a minimum length to thereby decrease their resistance and reactance; an oil cooling system in said tank unit; said oil cooling system comprising a means to circulate said oil within said single tank unit and a means to extract heat from said oil; said oil being circulated to absorb heat from said saturable reactors and power transformers, said heat absorbed by said oil being dissipated by said means to extract heat.

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