

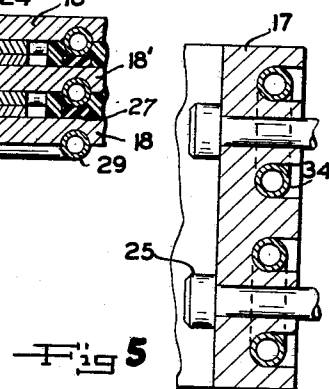
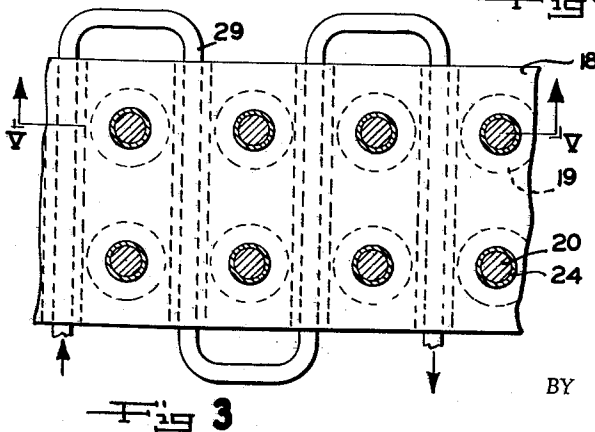
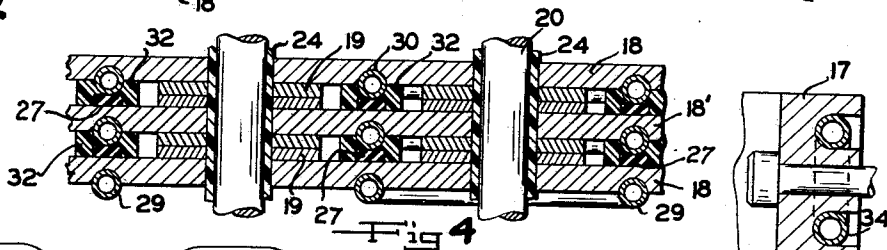
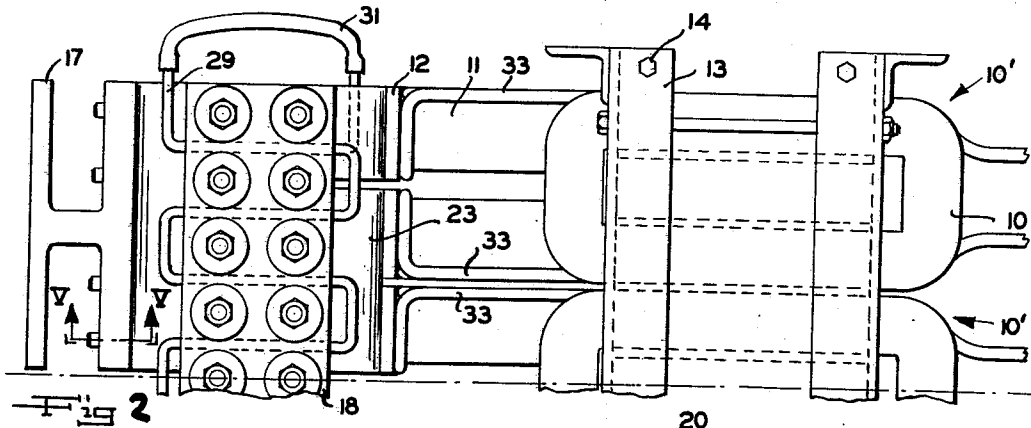
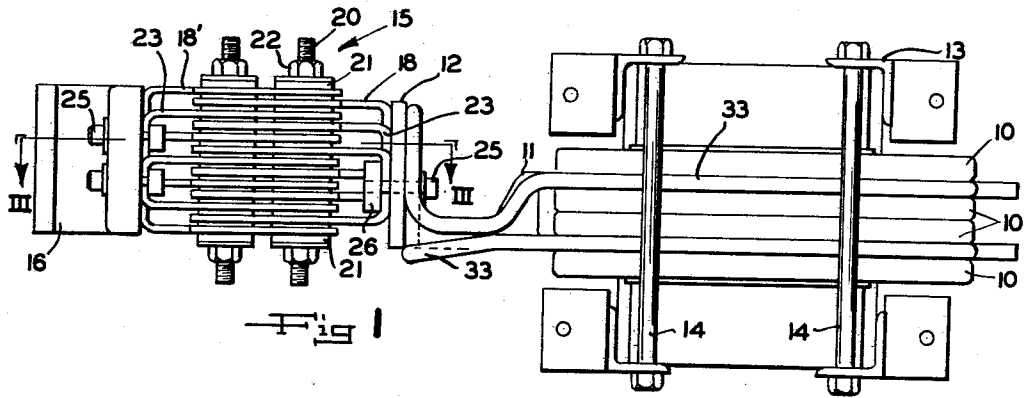
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LIQUID COOLING OF DRY DISC RECTIFIERS

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LIQUID COOLING OF DRY DISC RECTIFIERS

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The present invention relates to improvements in rectifier assemblies of the dry disc type, and more particularly to an improved construction of and cooling facilities for dry disc type rectifiers whereby the same may be adapted to continuously furnish uni-directional current of high magnitudes from standard commercial alternating current sources. Such apparatus finds common application in the electric resistance welding art, for example.

As is well known, the power output obtainable from dry disc rectifier assemblies is in a large measure dependent upon the ability of the assembly to dissipate internally generated heat. In the electric resistance welding art, for example, where unusually high load currents must be conducted by the rectifying apparatus, dissipation of heat is a problem of major importance, and accordingly it has heretofore been proposed to provide for the circulation through and/or about the rectifying apparatus of a cooling medium such as water or air or the like.

Water as a cooling medium has been found to be particularly desirable due to its inherent favorable heat transfer characteristics and its ready availability, and therefore many attempts have been made to provide a practical and satisfactory dry disc rectifier design incorporating means for circulating water in heat exchange relation to the apparatus. However, while I am aware that several types of rectifier constructions provide means of satisfactorily cooling and regulating the rectifier apparatus with a water medium, I have found that this has been accomplished at a sacrifice to the commercial practicability of the apparatus. That is, heretofore such cooling provisions have been accompanied by substantial increases in costs of manufacture and difficulty in assembly and maintenance of the apparatus. Accordingly, it is the ultimate object of this invention to provide a dry disc rectifier assembly of improved design whereby the provision of satisfactory arrangement for cooling by water or other liquid medium is rendered consistent with other general objectives of ease and simplicity of construction and satisfactory electrical performance.

More specifically, it is an object of the present invention to provide improvements in heretofore known general types of dry disc rectifier assemblies whereby more adequate cooling may be obtained with a minimum increase in the mechanical complexity of the apparatus.

To accomplish the above the invention seeks to provide a practical rectifier construction utilizing a plurality of conductor plates "stacked" in spaced relation, and including in the interstices between such plates, in heat exchange relation therewith, one or more heat conductive tubular members arranged to form a tortuous path through the interstices for water or other liquid cooling medium.

A further object of my invention resides in the provision of a rectifier assembly as set forth above wherein satisfactory heat exchange between the conductor plates and cooling tubes of the apparatus may be obtained without brazing or otherwise bonding the tubes to the con-

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ductor plates with a heat conductive agent. By the teachings of my invention the cooling tubes may be retained solely by mechanical pressure and may be readily assembled into the apparatus during assembly of the stacked conductor plates.

The above and other objects and advantages of my invention will become apparent upon full consideration of the following detailed specification and accompanying drawing wherein is disclosed a certain preferred embodiment of the invention.

In the drawing:

Figure 1 is a side elevation of a multi-phase transformer-rectifier power pack assembly, of the type utilized in electric resistance welding for example, wherein are incorporated the various teachings of my invention;

Figure 2 is a fragmentary plan view of the assembly of Figure 1;

Figure 3 is an enlarged fragmentary section view of my rectifier apparatus taken generally along line III—III of Figure 1;

Figure 4 is a fragmentary section view taken along line IV—IV of Figure 3; and

Figure 5 is an enlarged fragmentary section view taken along line V—V of Figure 2.

Figures 1 and 2 illustrate a common application of rectifying apparatus of my invention wherein a unitary multiple-phase rectifying device 15 is rigidly connected to a multiple-phase bank of high ratio step-down transformers 10' arranged in side-by-side relation as shown in Figure 2. Conventionally the transformers 10' comprise a plurality of primary windings 10 between which is sandwiched a pair of integrally connected secondary loops 11. Loops 11 are preferably U-shaped and of flat cast construction having flat right-angularly disposed terminal pads 12 with machined outwardly facing contact surfaces. Suitable structural means such as angle members 13 and tie rods 14 may be utilized to secure the transformers 10' in the relation shown. And it will be understood that the arrangement is such that the outwardly facing contact surfaces of terminal pads 12 are substantially in planar alignment.

Rectifying device 15 in the present illustration comprises a plurality of elongated flat input and output conductor plates 18 and 18' which in accordance with known principles of rectifier construction are stacked in alternate relation. Each of the conductor plates comprises an elongated substantially rectangular body portion and an integrally extending contact tab 23 having a right-angularly disposed flat contact portion 24 adapted in the manner shown in Figure 1 to contact terminal pads 12 of output terminals 16 and 17; the connections to the latter being such that one terminal is at all times of positive polarity with respect to the other. Suitable bolts 25 and clamping bars 26 may be used to effect uniform and adequate clamping pressure between contact portions 24 and terminals 16 and 17 or terminal pads 12.

Interposed between the input and output conductor plates are a plurality of disc-like rectifying elements 19 which are preferably all oriented in the same direction whereby to readily pass current in one direction while substantially impeding the flow of the same in the other direction. Rectifying elements of copper sulfide and magnesium have been found to be most desirable for such applications as electric resistance welding.

In carrying out the invention the rectifier discs 19 are arranged into a plurality of axially aligned stacks, which stacks are uniformly spaced across the body portion area of conductor plates 18 and 18' and are aligned in rows extending both longitudinally and laterally of the conductor plates. Elongated bolts 20 are received in aligned apertures in both the rectifying elements 19 and the conductor plates 18 and 18'. And by means of washers

21 and nuts 22 at both ends of bolts 20 the conductor plates and rectifier elements may be tightly compressed to insure adequate electrical contact therebetween and to mechanically secure the parts into a unitary and structurally rigid assembly. Suitable insulating means 24 is of course interposed between bolts 20 and the conductor plates and rectifying elements to prevent shorting the apparatus through the bolts 20.

According to the teachings of the invention the plates 18 and 18' are provided intermediate the laterally aligned stacks of rectifying elements 19 with semi-circular recesses 30 which are preferably straight so as to be readily formed by milling, for example. The recesses 30 are adapted in the manner shown in Figure 4 to receive tubular conduit members 29 which prior to assembly of the apparatus may be bent into wave-like form having a plurality of spaced straight transverse reaches substantially as shown in Figures 2 and 3. Conduit members 29 are preferably of highly heat conductive material, such as copper for example, whereby the same may be utilized to cause water or other cooling medium to pass back and forth in heat exchange relation to the conductor plates 18 and 18'.

In the preferred embodiment of the invention a wave-like conduit member 29 is provided for each interstice between the conductor plates 18 and 18', and the plurality of such conduit members 29 may be connected in series relation by means of tubular connectors 31 of rubber or other suitable insulating material. Alternatively the plurality of tubular conduit members 29 may be connected in parallel relation by suitable fluid circuitry, not shown, and it is contemplated that such modification may be readily effected by a skilled artisan. In the particular arrangement shown, cooling medium will progress longitudinally from one end to the other of the rectifier apparatus while moving tortuously back and forth between lateral rows of rectifying elements. After a complete pass through a first conduit member 29 the fluid is directed by insulating connector 31 into a second conduit member 29 whereupon the cooling medium moves in a similar tortuous path to the other longitudinal end of the rectifier assembly. This is continued until the cooling medium has passed through each interstice between conductor plates 18 and 18', whereupon the cooling medium is discharged or returned to its source, not shown.

The choice of cooling medium used will depend, among other factors, upon the magnitude of the voltage applied to the rectifier device. Thus, where relatively high voltages may be passed through the device the cooling medium should be substantially non-conducting to avoid short circuiting the apparatus. However, where low voltages are utilized, as for example in many applications of electric resistance welding, water may be conveniently used as the cooling medium.

It is in accordance with the objects of this invention that the conduit members 29 be readily assembled into the rectifying apparatus, and accordingly I have provided an arrangement whereby brazing or other bonding of the conduit members 29 to the conductor plates may be eliminated. This is accomplished by positioning flat strips 27 of plastic or other non-conductive material of equivalent strength between the exposed surface portions of the conduit members 29 and the next adjacent conductor plate. This arrangement is clearly illustrated in Figure 4. The physical dimensions of the flat strips 32 are such that upon assembly of the rectifier components and subsequent tightening of nuts 22, conduits 29 will be mechanically forced into intimate pressure contact with the conductor plates 18 and 18'. I have found that no additional means are required to insure rigid retention of the conduit members 29 in the arcuate recesses 30.

Where it is desired to increase the effective heat exchange area of the conduit members 29 a suitable heat

conductive but electrically non-conductive pitch compound may be applied about the conduit members 29 as illustrated at 32 in Figure 4. It will be understood that such compound may be readily applied during normal assembly of the apparatus.

If still additional cooling capacity is desired, I may provide heat exchange means at the terminal pads 12 and at the output terminals 16 and 17. In the illustrated apparatus I have provided cooling conduits 33 which are positioned in heat exchange relation to secondary windings 11 of the transformer bank in addition to being looped in heat exchange relation about the right-angularly disposed terminal pads 12. Similarly, conduits 34 may be provided in heat exchange relation with terminals 16 and 17 as suggested in Figure 5.

The advantages of the invention should now be manifest. I have disclosed a novel arrangement for internally cooling rectifier assemblies of the dry disc type which is wholly consistent with commercially and electrically sound rectifier construction. Whereas heretofore various elaborate and expensive arrangements have been required to provide internal liquid cooling of dry disc rectifiers, my invention illustrates the provision of advantageously positioned heat exchange conduit members which may be readily assembled and retained in place solely by mechanical pressure. Difficult and time consuming brazing operations are thereby eliminated, as is straightening and aligning of the conductor plates necessitated by warpage during such brazing operations.

Adequate heat exchange contact between conduit members 29 and conductor plates 18 and 18', heretofore obtained by brazing or otherwise bonding the parts in intimate relation, is accomplished in accordance with my invention by providing arcuate grooves 30 in the conductor plates. These grooves may be straight and parallel, and hence readily formed by milling, for example.

My arrangement comprises substantially standardized components which may be readily manufactured, and it will be apparent that the number and size of the conductor plates and stacks of rectifying elements may be varied to suit expected load requirements without impairing the ease of assembly and mechanical simplicity of the internal cooling means.

Having thus described a preferred embodiment of my invention, what I claim as new and desire to secure by Letters Patent is:

1. In a dry disc rectifying device a plurality of spaced parallel flat input and output conductor plates, a plurality of disc-like rectifying elements interposed between each of said input and output conductor plates, said rectifying elements being arranged in a plurality of axially aligned stacks, said stacks being relatively spaced and arranged in rows extending longitudinally and laterally of said conductor plates, certain of said conductor plates having laterally disposed straight arcuate grooves therein positioned substantially between laterally extending rows of said stacks, tubular conduit members for said certain of said conductor plates, said tubular conduit members being of heat conductive material and being of wave-like form having spaced straight transverse reaches adapted to be received in said arcuate grooves, and means to retain said tubular conduit members in intimate pressure contact with said arcuate grooves.

2. Apparatus according to claim 1 further characterized by said last mentioned means comprising electrically non-conductive compression members interposed between each of said tubular members and the conductor plate next adjacent thereto, and means for compressing said conductor plates and said rectifying elements whereby said non-conductive members urge said tubular members into said arcuate recesses.

3. In a dry disc type rectifying device a plurality of spaced parallel flat input and output conductor plates, a plurality of rectifying elements interposed between each

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of said input and output conductor plates, said rectifying elements being arranged in a plurality of axially aligned stacks, said stacks being relatively spaced and arranged in rows extending longitudinally and laterally of said conductor plates, certain of said conductor plates having arcuate grooves therein positioned adjacent certain of said stacks, tubular conduit members for said certain of said conductor plates, said tubular conduit members being of heat conductive material and being adapted to be received in said grooves to define tortuous paths along said certain of said conductor plates adjacent said certain of said stacks, and means to retain said tubular conduit members in intimate pressure contact with said arcuate grooves.

4. In a dry disc type rectifying device a pair of spaced parallel flat input and output conductor plates, a plurality of rectifying elements interposed between said conductor plates, said rectifying elements being arranged in laterally and longitudinally extending rows, one of said conductor plates having an arcuate groove therein positioned adjacent certain of said rectifying elements, a tubular conduit member adapted for reception in said groove, and means for urging said conduit member into intimate pressure contact with said groove.

5. Apparatus according to claim 4 further characterized by said last mentioned means including a non-conductive member interposed between said conduit member and the other of said conductor plates.

6. In a dry disc type rectifying device a pair of spaced parallel flat input and output conductor plates, a plurality of rectifying elements interposed between said conductor plates, said rectifying elements being arranged in straight rows, one of said conductor plates having a plurality of straight spaced arcuate grooves therein extending from side to side of said one of said conductor plates adjacent certain of said rows, a tubular conduit member of wave-like form having straight spaced trans-

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verse reaches adapted for reception in said arcuate grooves, and means to retain said conduit member in said grooves in heat exchange relation with said one of said conductor plates.

7. In a dry disc type rectifying device a pair of spaced parallel flat input and output conductor plates, a plurality of rectifying elements interposed between said conductor plates, said rectifying elements being arranged in straight spaced rows, one of said conductor plates having a plurality of straight spaced arcuate grooves therein extending from side to side of said one of said conductor plates adjacent certain of said rows, tubular conduit means received in each of said grooves, and means to retain said conduit means in said grooves in heat exchange relation with said one of said conductor plates.

8. In a dry disc type rectifying device a pair of spaced parallel flat input and output conductor plates, a plurality of rectifying elements interposed between said conductor plates, said rectifying elements being arranged in spaced relation, tubular conduit means positioned between said conductor plates adjacent certain of said rectifying elements and arranged to define a path between said plates for a cooling medium, and electrically non-conductive means acting on one of said conductor plates and said tubular conduit means for urging said conduit means into intimate heat exchange contact with the other of said conductor plates.

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