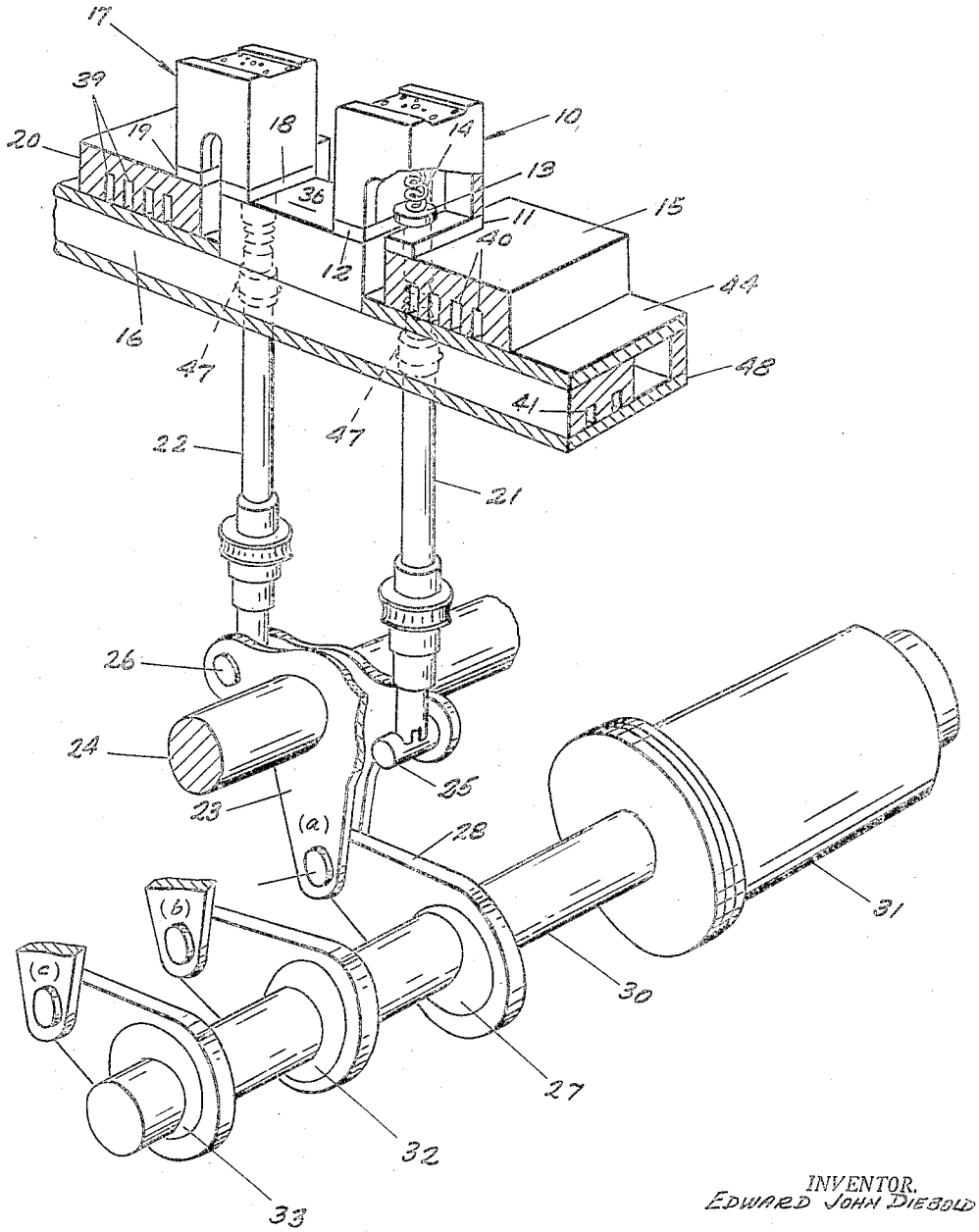
April 14, 1959 E. J. DIEBOLD 2,882,479

COOLING SYSTEM FOR MECHANICAL RECTIFIERS

Filed May 6, 1955

4 Sheets-Sheet 1

FIG. 1



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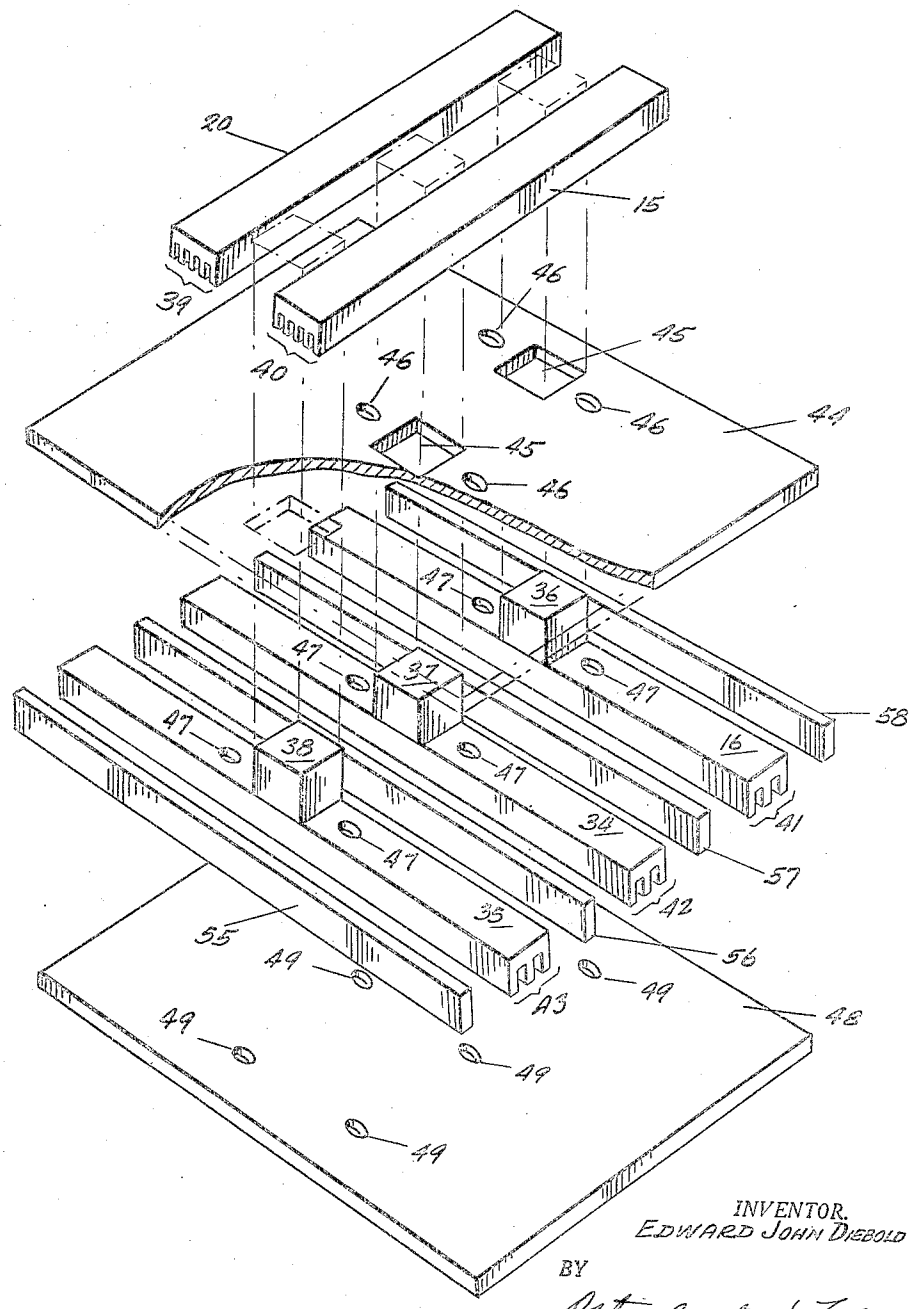
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COOLING SYSTEM FOR MECHANICAL RECTIFIERS

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4 Sheets-Sheet 2

FIG. 2



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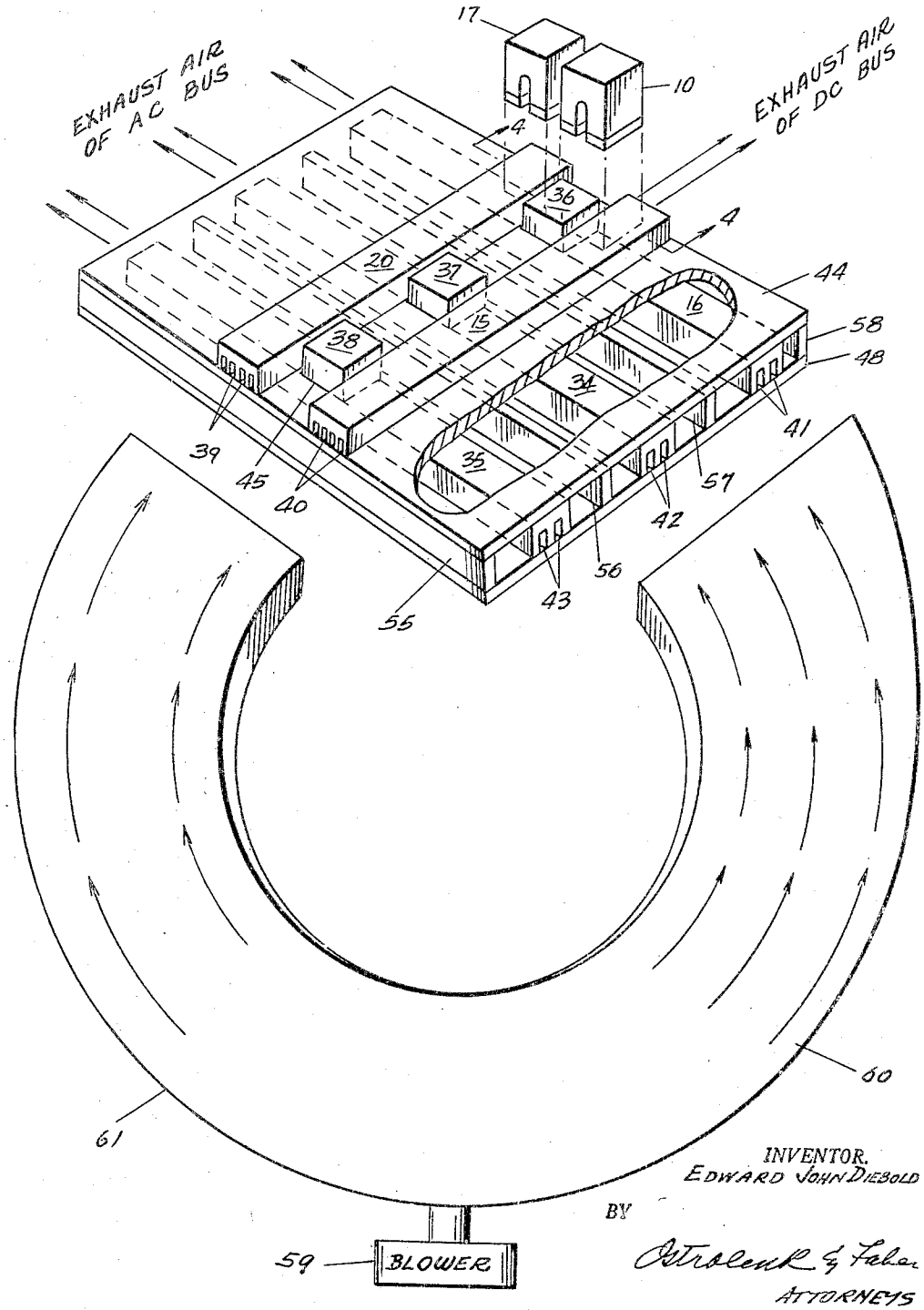
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COOLING SYSTEM FOR MECHANICAL RECTIFIERS

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4 Sheets-Sheet 3

FIG. 3.



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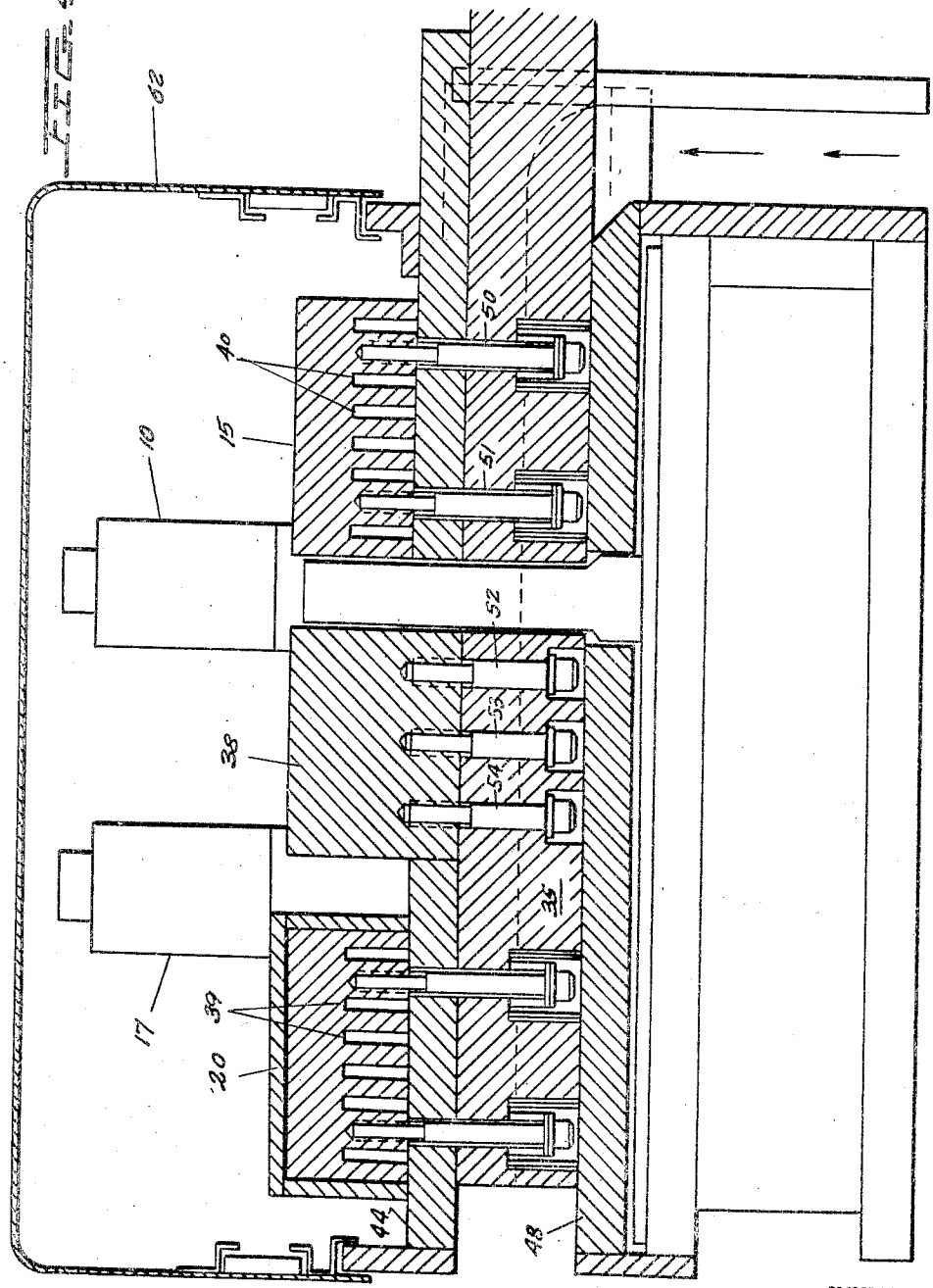
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COOLING SYSTEM FOR MECHANICAL RECTIFIERS

Filed May 6, 1955

4 Sheets-Sheet 4

FIG. 4



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United States Patent Office 2,882,479 Patented Apr. 14, 1959

2,882,479

COOLING SYSTEM FOR MECHANICAL RECTIFIERS

Edward John Diebold, Ardmore, Pa., assignor to I-T-E Circuit Breaker Company, Philadelphia Pa., a corporation of Pennsylvania

Application May 6, 1955, Serial No. 506,542

16 Claims. (Cl. 321—48)

My invention relates to a cooling system for cooling the contacts of a mechanical rectifier and more specifically to a cooling system in which the A.-C. and D.-C. bus structure leading to the contacts is cooled and the cooling medium is isolated from the cooperating contacts.

A mechanical rectifier is a mechanically operated switch which works in conjunction with commutating reactors. The switch or contact is usually of the type having a pair of stationary contacts and contact engagement and disengagement is then effected by a bridging contact. Contacts of the type used in mechanical rectifiers are clearly shown in copending application Serial No. 307,067 filed August 29, 1952, and assigned to the assignee of the present invention, now Patent No. 2,798,909.

The commutating reactor which is placed in series with the contact is of the type shown in U.S. Patent No. 2,693,569 assigned to the assignee of the instant application, and is used to provide a low current step in which the contact may be engaged or disengaged. Details of mechanical rectifier operation and the operation of the contacts in conjunction with the commutating reactors is clearly described in both of the above mentioned cases.

In order to obtain the switching of large currents at a high repetition rate with accuracy and without damage to the parts involved, the moving conductors of the contact such as the bridging contact are made very small. Therefore the current density in the contact material attains values of 15,000 to 20,000 amperes per square inch. This current density is more than ten times higher than the current density used in other electrical conductors such as the A.-C. bus and D.-C. bus which are synchronously connected by the above mentioned bridging contact. This high current density together with the appreciable resistance of the contact points between the movable conductors and the fixed conductors of the switch mechanism cause an appreciable amount of heat within a relatively small volume.

For instance, in a practical contact there is approximately two hundred watts per cubic inch of material. The fixed conductors which are the A.-C. and D.-C. bus leading to the contact mechanism are of very large cross section which can be as much as forty to fifty times the cross section of the movable or bridging contact and permit an easy heat flow away from the small concentrated heat source by conduction. However, the problem still remains to cool these large volume fixed conductors to a relatively low temperature to thereby assure that the actual contact pieces will not get too hot.

The operation of contact elements under high temperature offers many disadvantages. The first disadvantage would be that the unequal expansion due to heat of the metallic bus structure which can be of copper, the insulators which can be of porcelain, and the frame which can be of steel and fasteners which can be steel bolts, as compared to the length of the operation, push rods which are usually constructed of steel and steatite cause appreciable difference in contact timing and therefore interfere with the electrical operation. If, for instance,

there is only $\frac{1}{1000}$ of an inch expansion difference in the above mentioned elements, the contact timing would be changed by $1\frac{3}{4}$ electrical degrees.

A second disadvantage of contacts running under high temperature is that the excessive heat will cause deterioration of springs which are used to bias the movable contact to the engaged position.

A third disadvantage is that metallic contacts working at high velocity impact are subjected to high stresses. Furthermore, since they work at a high repetition rate which would be 216,000 operations per hour when rectifying a sixty-cycle source, the high stresses at this high repetition rate promotes serious mechanical wear. Practical experience has shown that this mechanical wear increases tremendously when the temperature of the contacts exceed approximately 100° C.

Electrical contacts also present problems which are not connected with heat but are caused by contact operation in a corrosive atmosphere. Contacts are metallic bodies which are separated by a layer of gas or air when they are opened and directly touching when closed. The active surface of the contacts is therefore alternately submitted to the influence of the atmosphere and the action of a strong electric current flowing across this surface from one body to another.

Since practical contacts are made of pure silver or alloy containing silver, such as silver-nickel, silver-copper, they are very little affected by pure air or pure air containing humidity. However, traces of sulphur, chlorine or their compounds such as H_2S, SO_2, HCl, HClO, are extremely harmful. Furthermore, corrosive or insulating dust creates a similar problem to that of the above mentioned chemical corrosion.

As mentioned above, cooling of the contacts is essential but cooling the contacts of a mechanical rectifier mechanism requires tons of air per day and it is obvious that if this amount of air is permitted to come in direct contact with the active contact surfaces, a minute fraction of a percent of the above mentioned dangerous compounds in the air will be extremely detrimental to the contact life.

In summary, we are presented with the problem of first cooling an electrical contact and secondly of cooling the electrical contact in such a way as to isolate the cooling medium from the active contact surfaces or the surfaces which come into electrical contact.

In the past, mechanical rectifier contacts have been cooled by a strong air blast which is introduced into the rectifier through various air canals and is impinged directly on the contacts. More specifically, in this system the air flows through holes across the bus bars, then circulates around the movable conductors and between the contact surfaces. The use of this type system provides effective cooling of the contacts themselves and since the cooling medium is an insulator, no leaks or other obstructions will harm the operation. However, as mentioned above, due to the danger of corrosive chemicals or insulating dust entering between the contact surfaces, the cooling air requires a very large air filter. The use of a filter of this type first introduces a pressure drop, thereby requiring increased power in the circulating mechanism of the cooling system and secondly, the use of filters increases maintenance of the rectifier. However, the use of these filters still does not eliminate the chemically active gases as above noted which will thereby make the rectifier inoperative in certain locations.

For instance, a system as mentioned above wherein the cooling air is blown directly on the cooperating contacts of the rectifiers can only be used in locations such as Switzerland where the air is exceedingly pure due to the lack of heavy industry. Since, however, rectifiers of this type are mainly used in electrochemical plants

and plants requiring large amounts of D.-C. power, the atmosphere in these locations is inherently impure in that it contains traces of various harmful chemicals and dust.

Another system which has been used to overcome the above mentioned problems of cooling the contacts and at the same time isolating the cooling medium from the contacts has been a water cooling system wherein distilled water is forced through a closed circuit. In this system, distilled water was forced through longitudinal holes drilled in the A.-C. and D.-C. bus. The holes of the A.-C. and D.-C. bus are then interconnected by insulating plastic or rubber tubing to provide the closed circuit for the distilled water. The heat absorbed by the distilled water was then dissipated in a radiator which was of the automobile type and this radiator was in turn cooled by an air blast. The use of distilled water in this system is necessary to obtain a high resistance connection since the distilled water completes a circuit between the various bus bars through which it flows. Since the corrosive atmosphere of the air blast now is impinged only upon the automobile radiator, it is completely isolated from the mechanical rectifier itself in which the contacts operate within an air tight hood.

However, this type of water cooled systems presents many inherent disadvantages. The first is that water leaks due to corrosion of the cooling system occur often, and immediately cause a short circuit and hence a shutdown of the rectifier. This problem is inherent in any fluid system due to the imperfection in gasketing. Furthermore, the fluid conductors such as the plastic or rubber tubing are subject to deterioration.

A further disadvantage and a very severe one is that obstructions of the cooling system due to the products of corrosion accumulating in the cooling canals lead to dangerous overheating of the rectifier. Furthermore, due to the nature of these canals, cleaning to remove the obstructions is difficult and time-consuming.

Still another disadvantage of this system is that there will be an inherent double temperature drop which will lead to high temperatures on the cooled bus bars. The double temperature drop is present since the temperature of the cooled bus bar is necessarily higher than that of the cooling water and the temperature of the cooling water is necessarily higher than the temperature of the cooling air.

Still another disadvantage connected with this system lies in the difficulty of drilling the required cooling canals which are longitudinal holes throughout the length of the A.-C. and D.-C. bus bars.

It should be noted that the rectifier contacts can be placed under a common hood to provide a certain measure of protection from the ambient air. Although it would be desirable to seal each contact individually, this is impractical since the push rod which drives the movable contact into and out of engagement 216,000 times per hour would have to be gasketed to prevent leakage through the enclosed contact.

It is the principle of my invention to cool the bus bars leading to the mechanical rectifier contacts with a gas cooling medium which is isolated from the contacts. I first increase the effective cooling surface of the A.-C. and D.-C. bus bars by providing longitudinal cooling canals which are slots milled on one surface of the above mentioned bus bars, to enclose these slots with an insulating medium and to then force a strong gas blast through the enclosed slots. Since the cooling canals are longitudinal in both the A.-C. and D.-C. bus and are further enclosed by an insulating medium, effective cooling of the bus is caused by convection and no cooling gas will reach the switching contacts of the rectifier.

By providing the above-mentioned common hood for all of the contacts, the contacts can operate in clean, stagnant air or can be made to operate in a pressurized

compartment under any desired protective gas without affecting the cooling system.

It should be clearly noted that the cooling area of the bus bars is considerably increased by providing the above mentioned longitudinal slots and the area can be made large enough to provide heat exchange without undue temperature drop. More specifically, the slots will provide an extremely large heat exchange area while sacrificing only a very small cross sectional area of copper.

For example, in a bus bar having a cross-sectional area of two inches by four inches and a length of three feet, assume that four slots each having an area of one inch by one-eighth of an inch are cut in the longitudinal length of the bus. In this case, the current density will be increased by only six percent whereas the additional cooling surface provided will be 288 square inches.

A very important advantage is gained with the use of slots since they can be easily milled along one surface of the bus bars by conventional machinery. This is in contradistinction to the complex machining of a longitudinal hole through the length of the bus bar as was used in the prior art water cooling system.

A further advantage presented by my novel invention is that the cooling gas flows axially along the bus bars and through the adjoining canals at high velocity to thereby cause excellent heat dissipation by forced convection between the copper and the cooling gas.

It should be noted that the total temperature rise of the contact temperature over the ambient temperature will with my novel cooling system consist of:

(1) The temperature drop due to heat conduction in the bus bar;

(2) Temperature drop due to convection between the bus bar and the air;

(3) Increase of temperature in the air due to the heat to be evacuated.

By using the above-mentioned forced convection, the temperature drop of item 2 is reduced to approximately the same amount as the temperature drop of both 1 and 3. This is in opposition to the most practical cases where the heat dissipation by convection and radiation require the highest temperature drop.

A further and obvious advantage is that the cooling medium can now be an unfiltered gas which is only used once and not recirculated in a closed circuit. This clearly eliminates the use of a filter which presents a large pressure drop and the heat exchanger which presents a large temperature drop. Furthermore, since the cooling medium is now an electrical insulator, leaks in the circulating system are unimportant.

Still another advantage is that a high velocity air blast can be obtained with a relatively low power cooling fan. This is due to the use of straight canals with smooth surfaces in which the gas travel is short, and that the highest gas velocity is obtained only at the place where it is actually required. Therefore, the high turbulence which is required for good cooling but undesirable in that it causes a substantial pressure drop which must be overcome by a fan is present only where it is needed and nowhere else in the system. Furthermore, no gas can escape without going through one of the cooling canals, thereby increasing the cooling system efficiency.

Another important advantage is in the decreased maintenance required for this gas cooling system. That is, since the cooling canals are straight and open to the outside, they can be periodically cleaned, merely by inserting an ordinary pipe cleaner.

Accordingly, it is a primary object of my invention to provide a gas cooling system for mechanical rectifier contacts in which the bus bars leading to the rectifier contacts are cooled by a cooling gas and the cooling gas is isolated from the cooperating contacts.

Another object of my invention is to provide longitudinal cooling canals in the A.-C. and D.-C. bus bars which comprise longitudinal slots that are so enclosed

that the cooling medium will be isolated from the switching contacts of the rectifier.

Still another object of my invention is to provide longitudinal slots in the A.-C. and D.-C. bus bars of a mechanical rectifier in which the slots will be used to conduct a cooling medium to thereby cool the bus and subsequently cool the contact which makes electrical engagement between the A.-C. and D.-C. bus.

Still another object of my invention is to provide longitudinal slots in the A.-C. and D.-C. bus of a mechanical rectifier, said slots to have a small cross sectional area but provide a large area for heat exchange.

Yet another object of my invention is to provide cooling canals in the A.-C. and D.-C. bus of a mechanical rectifier which comprise slots which can be easily milled into one surface of the bus and then enclosed by an insulating body.

These and many other objects of my invention will become apparent from the following description taken in connection with the figures in which:

Figure 1 shows a perspective view of the D.-C. bus and one phase of an incoming A.-C. bus of a mechanical rectifier in conjunction with the mechanically operated contacts and the contact driving mechanism.

Figure 2 shows an exploded perspective view of the complete bus structure of a mechanical rectifier and clearly shows the cooling slots and canals of my invention. This figure is similar to Figure 1 and shows the complete three A.-C. phases, but does not show the contacts or driving structure.

Figure 3 is a perspective view of the assembled bus structure shown in Figure 2 in conjunction with a blower system which will force gas through the above-mentioned cooling canals and slots.

Figure 4 is similar to Figure 3 as seen when looking directly into the D.-C. bus and specifically shows the method of fastening the A.-C. and D.-C. bus work together.

Referring now to Figure 1, a contact assembly **10** is shown as comprising a pair of fixed contacts **11** and **12** which are synchronously connected by a movable bridging contact **13**. The bridging contact **13** is biased to be in engagement with fixed contacts **11** and **12** by means of a spring **14**. When bridging contact **13** places the fixed contacts **11** and **12** in electrical contact, it is clear that D.-C. bus **15** will then be in electrical contact with the A.-C. bus **16**.

A second contact **17** is shown as having similar components of contact assembly **10**, that is, fixed contacts **18** and **19** and a biasing spring and movable contact which are not seen is then operated to engage and disengage 180° out of phase with the contact assembly **10** to thereby connect D.-C. bus bar **20** to the A.-C. bus **16**.

The mechanism causing engagement and disengagement of contact assemblies **10** and **17** is shown as push rods **21** and **22** respectively which are in turn connected to a connecting link **23**. Connecting link **23** is pivotally connected to a shaft **24** and the push rods **21** and **22** are pivotally fastened at pivot points **25** and **26** respectively.

Connecting link **23** is then driven with an oscillatory motion by means of the eccentric **27** which drives link **28** which is then attached to connecting link **23** at the pin **29**. The eccentric **27** is fastened to shaft **30** which is energized by means of the synchronous motor **31**. It is now clear that the synchronous motor **31** which rotates in synchronism with the A.-C. input of the rectifier will impart an oscillatory motion to the push rods **21** and **22** which will in turn cause engagement and disengagement of D.-C. bus bar **15** and A.-C. bus bar **16** and a similar engagement and disengagement of D.-C. bus **20** and A.-C. bus **16** with a 180° phase displacement between the engagement and disengagement of the alternate D.-C. bus bars **15** and **20**.

In Figure 1, only one A.-C. phase **16** has been shown. However, eccentrics **32** and **33** are shown which will subsequently drive cooperating contacts similar to **10** and **17** to engage and disengage a second and third A.-C. phase to the D.-C. bus bars **15** and **20**.

It should be noted that the eccentrics **32** and **33** are so displaced from one another and from eccentric **27** that all the contacts engaging the positive D.-C. bus will engage at a phase displacement of 120° and the contacts on the negative bus will engage at a phase displacement of 120°. Their displacement is again such that for a given A.-C. bus bar, the two associated contacts will have a 180° phase displacement.

It is to this type of mechanism that my invention can be applied. The problem as above stated is to cool the cooperating contacts such as contacts **11**, **12** and **13** of contact assembly **10** and at the same time prevent the cooling medium from contaminating the above mentioned contact surfaces.

My novel invention is specifically shown in conjunction with Figures 2 and 3 which show the A.-C. and D.-C. bus work in conjunction with the contacts that will place them in electrical engagement as described in connection with Figure 1.

In Figures 2 and 3, the D.-C. buses **15** and **20** are shown as being positioned with respect to the A.-C. bus bars shown as **16**, **34** and **35**. Stubs **36**, **37** and **39** are associated with the A.-C. bus bars **16**, **34** and **35** in such a way as to bring the A.-C. bus bars into the plane of the surface of the D.-C. bus bars **15** and **20**. The fixed contacts of their associated contact assemblies then straddle this common surface from a D.-C. bus to an A.-C. bus as shown more specifically in Figure 3.

It should be noted that in Figure 3 only two contact assemblies **10** and **17** have been shown in conjunction with the D.-C. bus bars **15** and **20** and A.-C. bus **16** and stub **36**. However, a pair of cooperating contacts will also be associated with stub **37** and D.-C. bus bars **15** and **20** and sub **38** with D.-C. bus bars **15** and **20**. However, these additional contact assemblies have not been shown in an effort to simplify the diagrams.

In order to provide effective cooling of all the bus work, Figures 2 and 3 clearly show the plurality of longitudinal slots to which my novel invention is directed as extending along the bottom of D.-C. bus bars **15** and **20** and similarly along the bottom of A.-C. bus bars **16**, **34** and **35**.

That is, a plurality of slots **39** is associated with the D.-C. bus bar **15**; a second plurality of slots **40** is associated with the D.-C. bus bar **20**; slots **41** are associated with the A.-C. bus bar **16**, slots **42** are associated with the A.-C. bus bar **34** and slots **43** are associated with the A.-C. bus bar **35**. A.-C. bus bars **16**, **34** and **35** are insulated from the D.-C. bus bars **15** and **20** by an insulating sheet **44**. As clearly shown in Figure 2, this insulating sheet has windows **45** and **46** and a window which is not shown which are so dimensioned as to fit over the stubs **36**, **37** and **38** respectively. Insulating sheet **44** also contains holes **46** which will cooperate with holes **47** which are in each A.-C. bus bar in order to allow the push rod access to its corresponding movable contact.

A second insulating sheet **48** is then provided having another plurality of holes **49** which will again cooperate with holes **47** and the A.-C. bus bars to allow the push rod access to the movable contact.

As shown more specifically in Figure 4 which shows a cross section taken through bus bar **35** and looking directly into the D.-C. buses **15** and **20**, the A.-C. bus bars are then clamped to the D.-C. bus bars by means of bolts **50** and **51** and the stubs such as stub **38** is fastened to the A.-C. bus bar **35** by means of bolts **52**, **53** and **54**.

The bottom insulation sheet **48** is then fastened to be flush with the bottom of the A.-C. bus bars **16**, **34** and **35** and the A.-C. bus bars are then insulated from

one another by insulating pieces 55, 56, 57 and 58. It should now be clearly noted that the construction of the above mentioned insulating pieces 55 through 58 and the top and bottom insulating sheets 44 and 45 provide electrical insulation of the A.-C. bus bars 16, 34 and 35 from one another as well as electrical insulation of the A.-C. bus bars from the D.-C. bus bars 15 and 20. Furthermore, as well as forming the electrical insulation, they also provide an enclosed channel through which cooling gas may be forced to cool the sides of the A.-C. bus bars 16, 34 and 35 without the cooling gas having access to the contacts.

Referring now more specifically to the cooling system shown in Figure 3, a blower or any gas circulating means shown as 59 in Figure 3 forces the gas through vents 60 and 61 in the direction shown by the arrows into slots 39 and 40 of the D.-C. bus bars 15 and 20, slots 41, 42 and 43 of the A.-C. bus bars 16, 34 and 35 and into the channels along each side of the above mentioned A.-C. bus bars.

It should be clearly noted that there is no possible way for this cooling gas to reach the contact surface area. The air exhaust coming out at the other end of each set of bus bars cannot reach the contacts if an air tight hood shown as hood 62 in Figure 4 is used.

The hood 64 of Figure 4 can also enclose a protective atmosphere within which the contacts can operate since they are now cooled indirectly and the cooling medium does not impinge upon the contact surfaces.

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 therefore to be limited, not by the specific disclosure herein, but only by the appended claims.

I claim:

1. In a rectifier, a first bus; a second bus; contact means to electrically connect said first and second buses; said first and second buses containing a longitudinal slot; said longitudinal slot extending from one bus surface to the interior of the bus; enclosing means to enclose said longitudinal slot; and means to force cooling gas through said enclosed slots and in contact with the walls of said slots to provide cooling for said contact means.

2. In a rectifier, a first bus; a second bus; contact means to electrically connect said first and second buses; said first and second buses containing a longitudinal slot; said longitudinal slot extending from one bus surface to the interior of the bus; enclosing means to enclose said longitudinal slot along said bus surface containing said slot; and means to force cooling gas through said enclosed slots and in contact with the walls of said slots to provide cooling for said contact means.

3. In a rectifier, a first bus; a second bus; contact means to electrically connect said first and second buses; said first and second buses containing a longitudinal slot for at least a portion of their length; said longitudinal slot extending from one bus surface to the interior of the bus; enclosing means to enclose said longitudinal slot along said bus surface containing said slot; means to force gas through said enclosed slots and in contact with the walls of said slots to provide cooling for said contact means and isolating means to isolate said contact from said cooling gas.

4. In a rectifier, a first plurality of buses; a second plurality of buses; contact means to electrically connect buses of said first plurality of buses to buses of said second plurality of buses to one another in a predetermined synchronous manner; at least a portion of the buses of said first and second plurality of buses containing a longitudinal slot; said longitudinal slot extending from one bus surface to the interior of the bus; enclosing means to enclose said longitudinal slot; means to electrically insulate said first and second plurality of buses and forming enclosed ducts parallel to the electrically insulated bus; and means to force gas through said enclosed slots and said enclosed ducts to provide cooling for said contacts; said cooling gas being physically isolated from said contact means by said enclosed slots and ducts.

5. In a polyphase rectifier, a pair of D.-C. bus bars and a plurality of A.-C. bus bars; contact means to electrically connect buses of said plurality of A.-C. bus bars to either of said pair of D.-C. bus bars in a predetermined synchronous manner; each of said buses containing a longitudinal slot; said longitudinal slot extending from one bus surface to the interior of the bus; enclosing means to enclose said longitudinal slot; means to electrically insulate said A.-C. and D.-C. buses from one another; and forming closed ducts along either side of said A.-C. bus; and means to force gas through said enclosed slots and said enclosed ducts to provide cooling for said contacts through said bus; said cooling gas being isolated from said contact means by said enclosed slots and ducts.

6. In a rectifier, a first bus; a second bus; contact means to electrically connect said first and second buses; said first and second buses containing a longitudinal slot; said longitudinal slot extending from one bus surface to the interior of the bus; the surface area formed by each of said slots being large compared to the volume of the space formed by each slot to provide maximum heat transfer area in comparison to the decrease in current conducting area; enclosing means to enclose said longitudinal slot along said bus surface containing said slot and means to force cooling gas through said enclosed slots and in contact with the walls of said slots to provide cooling for said contact means.

7. In a rectifier, a first bus; a second bus; a reciprocating contact for transferring energy from said first to said second bus; said buses crossing each other at right angles; said first bus having a stub extending therefrom and terminating at a region substantially in the same plane as one surface of said second bus; means for operating said contact intermittently to simultaneously engage said second and first bus for transferring electrical energy from one of said buses to the other of said buses; said buses being spaced from each other to form an insulation barrier between adjacent crossing surfaces of said buses; said buses each having elongated slots extending from one end to the opposite end of each of said buses and forming air ducts therein; the surface area formed by each of said slots being large compared to the volume of the space formed by each slot to provide maximum heat transfer areas in comparison to the decrease in electric-conducting area and a source of air supply connectible to one end of each of said buses for conducting air thereto for transmission through said slots, said slots at the opposite end of said buses being arranged to permit exhaust of the air flow therethrough, and means for preventing air from said source from reaching said contact engaging surfaces.

8. In an electrical transfer circuit for transferring energy from a first bus to a second bus, said buses crossing each other at right angles; said first bus having a stub extending therefrom and terminating at a region substantially in the same plane as one surface of said second bus; a contact member for engaging said second and first bus at said common plane for transferring electrical energy from one of said buses to the other of said buses; an insulation barrier between adjacent crossing surfaces of said buses for electrically isolating said buses from each other at said crossing surfaces; said buses each having elongated slots extending from one end of the opposite end of each of said buses and forming air ducts therein; the surface area formed by each of said slots being large compared to the volume of the space formed by each slot to provide maximum heat transfer areas in comparison to the decrease in electric-conduct-

ing area and an air system connectible to one open end of each of said slots for conducting air thereto for transmission through said slots; said slots at the opposite end of said buses being arranged to permit exhaust of the air flow therethrough.

9. In a rectifier, a first plurality of buses; a second plurality of buses; said first buses being arranged at right angles to said second buses; said first buses each having a stub extending away from their rectifier buses and terminating at regions substantially in the same plane as one of the surfaces of said second buses; a contact member; means for operating said contact member to intermittently engage respective ones of said first buses to associated ones of said second buses for transferring electrical energy from said first to said second buses; an insulation barrier between adjacent crossing surfaces of said buses; said buses each having elongated slots extending throughout the lengths of said buses and forming air ducts therein; the surface area formed by each of said slots being large compared to the volume of the space formed by each slot to provide maximum heat transfer areas in comparison to the decrease in electric-conducting area and a source of air connectible to one end of each of said buses for conducting air thereto for transmission through said slots; said slots at the opposite end of said buses being arranged to permit exhaust of the air flow therethrough; and means for confining said air flow to the slots to prevent air from said source from reaching said contacts.

10. In a rectifier, a first plurality of buses; a second plurality of associated buses; a plurality of reciprocating contacts for transferring energy from said first to said second buses; said first buses crossing said second buses; said first buses each having a stub extending therefrom and terminating at a region substantially in the same plane as one surface of said second buses; means for operating said contacts intermittently to effect simultaneous engagement of respective ones of said first to associated second buses for transferring electrical energy from said one set of buses to the other set of buses; said buses being spaced from each other to form an insulation barrier between adjacent crossing surfaces of said buses; said buses each having elongated slots extending from one end to the opposite end of each of said buses and forming air ducts therein; the surface area formed by each of said slots being large compared to the volume of the space formed by each slot to provide maximum heat transfer areas in comparison to the decrease in electric-conducting area; and a source of air supply connectible to one end of each of said buses for conducting air thereto for transmission through said slots; said slots at the opposite end of said buses being arranged to permit exhaust of the air flow therethrough; and means for preventing air from said source from reaching said contact engaging surfaces.

11. In a rectifier, a first plurality of buses; a second plurality of associated buses; a plurality of reciprocating contacts for transferring energy from said first to said second buses; said first buses crossing said second buses; said first buses each having a stub extending therefrom and terminating at a region substantially in the same plane as one surface of said second buses; means for operating said contact intermittently to effect a simultaneous engagement of respective ones of said first to associated second buses for transferring electrical energy from said one set of buses to the other set of buses; an insulation housing for said first buses to form an insulation barrier between adjacent crossing surfaces of said buses and having an open end; said stubs extending through said housing; said buses each having elongated slots extending from one end to the opposite end of each of said buses and forming air ducts therein; the surface area formed by each of said slots being large compared to the volume of the space formed by each slot to provide maximum heat transfer areas in comparison to the decrease in electric-conducting area; and a source of air supply connectible to one end of said second and to the open end of said housing for conducting air thereto for transmission through said slots of said buses and between said first buses; said slots at the opposite end of said buses being arranged to permit exhaust of the air flow therethrough; said connection being arranged to prevent air from said source from reaching said contact engaging surfaces.

12. In a rectifier, a first polyphase system of buses; a second pair of D.C. buses; a plurality of reciprocating contacts for transferring energy from said first system of buses to said second pair of buses; said first system of buses crossing said second pair of buses; said first buses each having a stub extending therefrom and terminating at a region substantially in the same plane as one surface of said second buses; means for operating said contacts intermittently to effect simultaneous engagement of respective ones of said first buses to associated second buses for transferring electrical energy from said polyphase system to said D.C. buses; an insulation housing enclosing said polyphase buses and forming an insulation barrier between adjacent crossing surfaces of said buses; said housing being open at its ends; said buses each having elongated slots extending from one end to the opposite end of each of said buses and forming air ducts therein; the surface area formed by each of said slots being large compared to the volume of the space formed by each slot to provide maximum heat transfer areas in comparison to the decrease in electric-conducting area and a source of air supply connectible to one end of each of said D.C. buses and to the open end of said housing for conducting air thereto for transmission through said slots; said slots at the opposite end of said buses being arranged to permit exhaust of the airflow therethrough; said connection preventing air from said source from reaching said contact engaging surfaces.

13. In a rectifier, a first polyphase system of buses; a second pair of D.C. buses; a plurality of reciprocating contacts for transferring energy from said first system of buses to said second pair of buses; said first system of buses crossing said second pair of buses; said first buses each having a stub extending therefrom and terminating at a region substantially in the same plane as one surface of said second buses; means for operating said contacts intermittently to effect simultaneous engagement of respective ones of said first buses to associated second buses for transferring electrical energy from said polyphase system to said D.C. buses; an insulation housing enclosing said polyphase buses and forming an insulation barrier between adjacent crossing surfaces of said buses; said housing being open at its ends; said buses each having openings extending from one end to the opposite end of each of said buses and forming air ducts therein; the surface area formed by each of said openings being large compared to the volume of the space formed by each opening to provide maximum heat transfer areas in comparison to the decrease in electric-conducting area; and a source of air supply connectible to one end of each of said D.C. buses and to the open end of said housing for conducting air thereto for transmission through said openings; said openings at the opposite end of said buses being arranged to permit exhaust of the air flow therethrough; said connection preventing air from said source from reaching said contact engaging surfaces.

14. In a rectifier, a polyphase system of buses; a second pair of D.-C. buses; a plurality of reciprocating contacts for transferring energy from said first system of buses to said second pair of buses; said first system of buses crossing said second pair of buses; said first buses each having a stub extending therefrom and terminating at a region substantially in the same plane as one surface of said second buses; means for operating said contacts intermittently to effect simultaneous engagement of respective ones of said first buses to associated second buses for transferring electrical energy from said polyphase system to said D.-C. buses; an insulation housing enclosing said polyphase buses and forming an insula-

tion barrier between adjacent crossing surfaces of said buses; said housing being open at its ends; means for conducting cooling air to said buses at said contacting surfaces to conduct away heat generated thereat; and means for isolating the contacting surfaces from said air.

15. In a rectifier, a polyphase system of buses; a second pair of D.-C. buses; a plurality of reciprocating contacts for transferring energy from said first system of buses to said second pair of buses; said first system of buses crossing said second pair of buses; said first buses each having a stub extending therefrom and terminating at a region substantially in the same plane as one surface of said second buses; means for operating said contacts intermittently to effect simultaneous engagement of respective ones of said first buses to associated second buses for transferring electrical energy from said polyphase system to said D.-C. buses; an insulation housing enclosing said polyphase buses and forming an insulation barrier between adjacent crossing surfaces of said buses; said housing being open at its ends; said buses being constructed to conduct air to the contacting surfaces and to the surfaces between buses to conduct away heat generated thereat; and means for isolating the contact engaging surfaces from said air.

16. In a rectifier, a polyphase system of buses; a sec-

ond pair of D.-C. buses; a plurality of reciprocating contacts for transferring energy from said first system of buses to said second pair of buses; said first system of buses crossing said second pair of buses; said first buses each having a stub extending therefrom and terminating at a region substantially in the same plane as one surface of said second buses; means for operating said contacts intermittently to effect simultaneous engagement of respective ones of said first buses to associated second buses for transferring electrical eneregy from said polyphase system to said D.-C. buses; an insulation housing enclosing said polyphase buses and forming an insulation barrier between adjacent crossing surfaces of said buses; said housing being open at its ends; a source of air supply; air ducts associated with each bus for conducting away heat generated at said contacts engaging surfaces; said air source, bus and air duct being constructed to isolate said contacts from the air of said source.

References Cited in the file of this patent

UNITED STATES PATENTS

2,230,427	Frank	Feb. 4, 1941
2,497,516	Phelps	Feb. 14, 1950
2,741,735	Wasserrab	Apr. 10, 1956