Sept. 14, 1965 B. BERGER ETAL 3,206,630

COOLED BRUSH HOLDER FOR CARRYING CURRENT IN DYNAMO-ELECTRIC MACHINES

Filed May 29, 1961 6 Sheets-Sheet 1

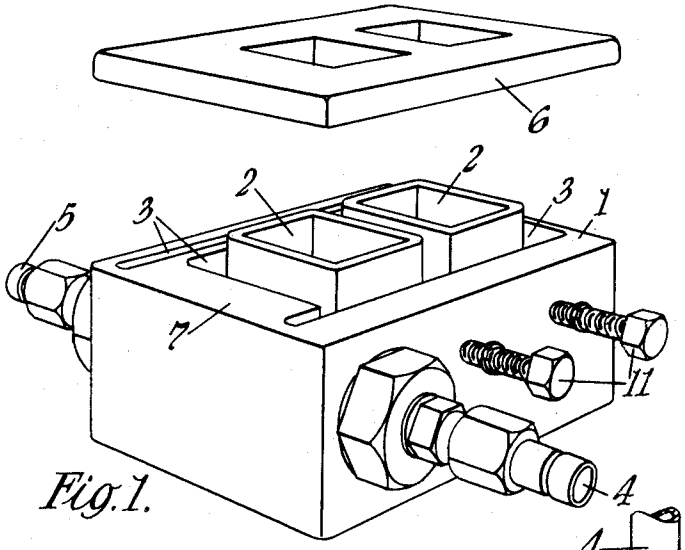


Fig. 1.

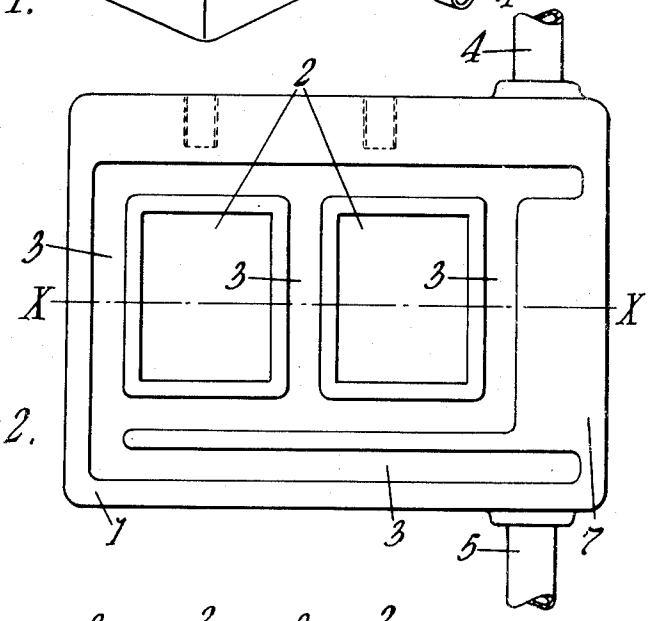


Fig. 2.

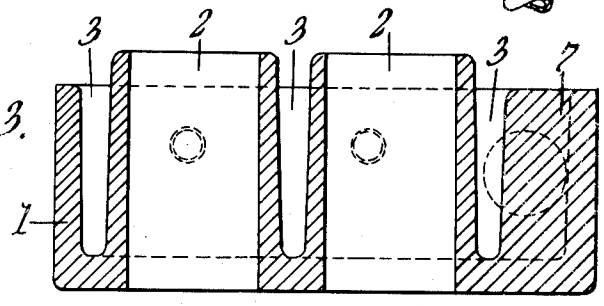


Fig. 3.

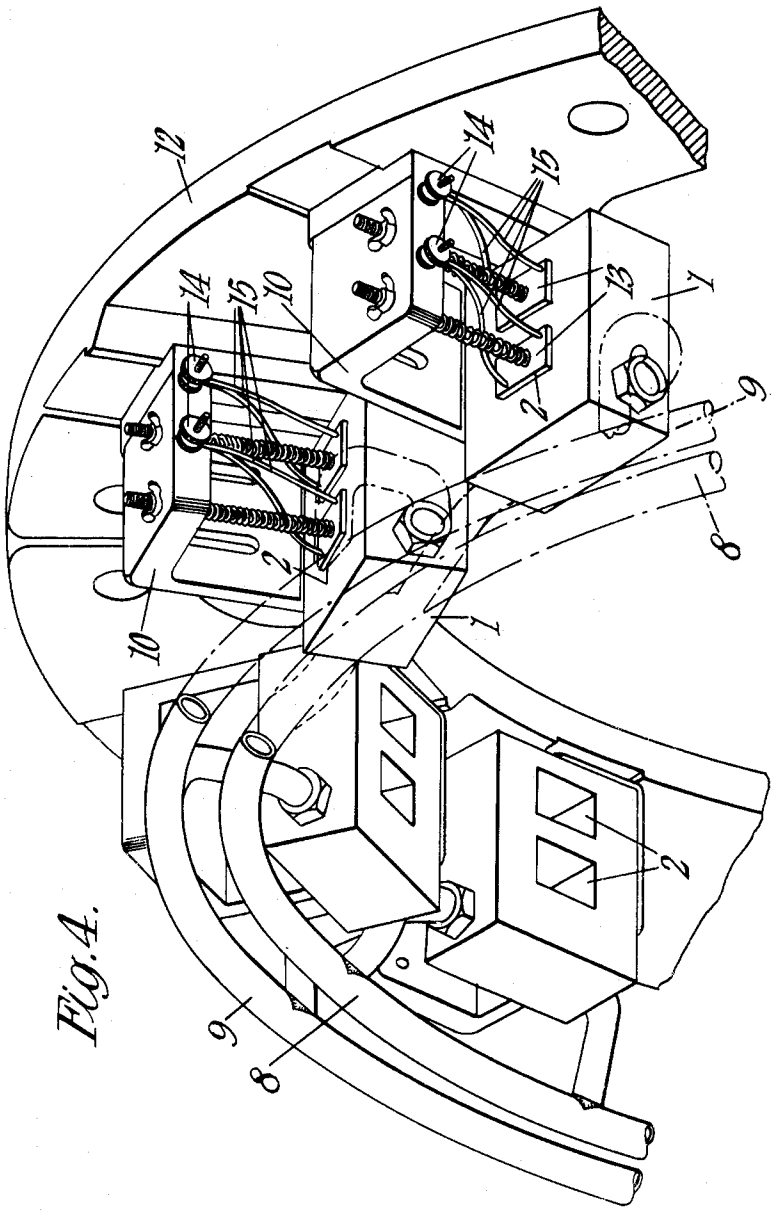


Fig. 4.

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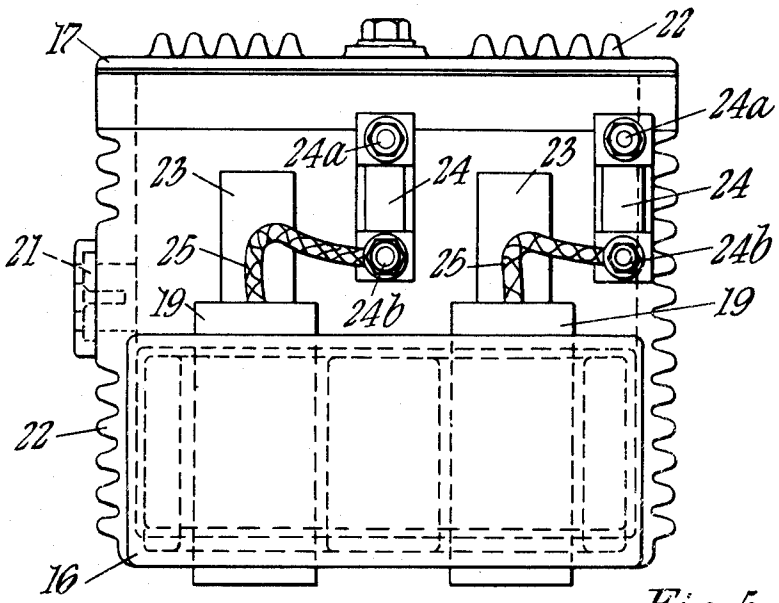


Fig. 5.

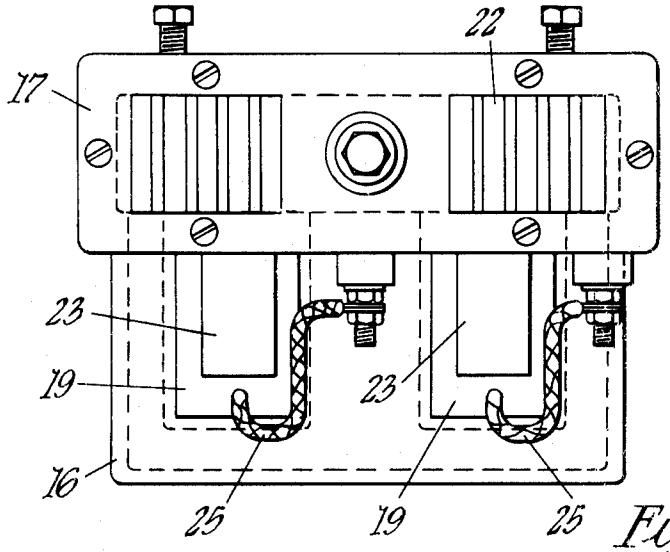


Fig. 6.

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COOLED BRUSH HOLDER FOR CARRYING CURRENT
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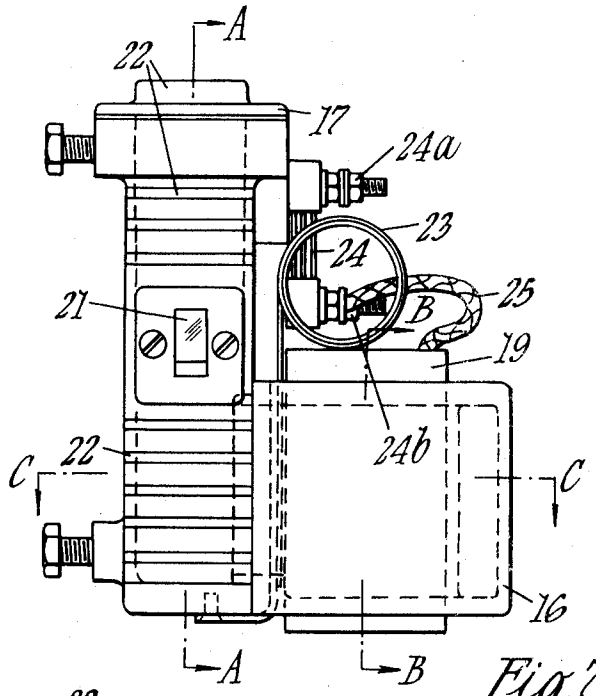


Fig. 7.

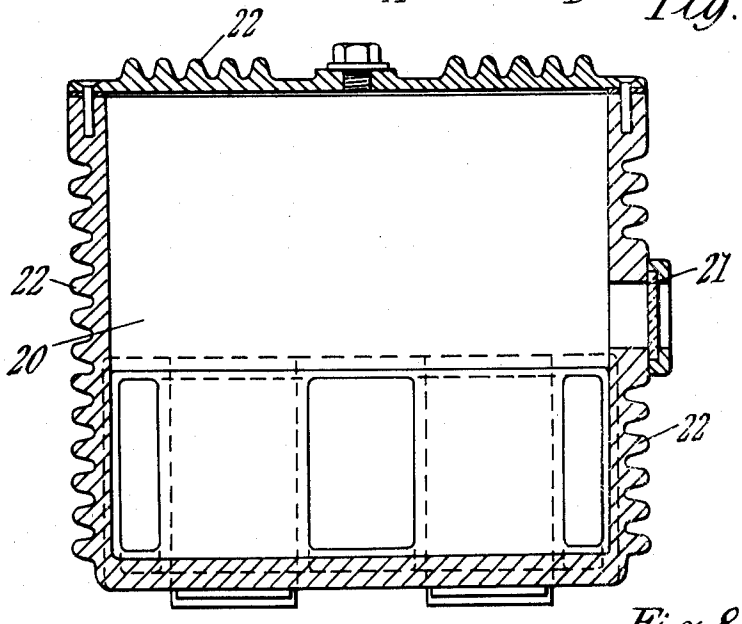


Fig. 8.

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COOLED BRUSH HOLDER FOR CARRYING CURRENT
IN DYNAMO-ELECTRIC MACHINES
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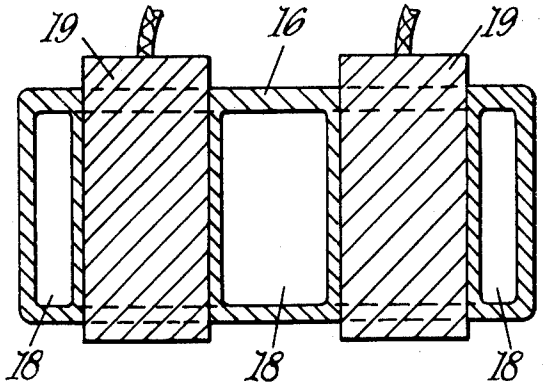


Fig. 9.

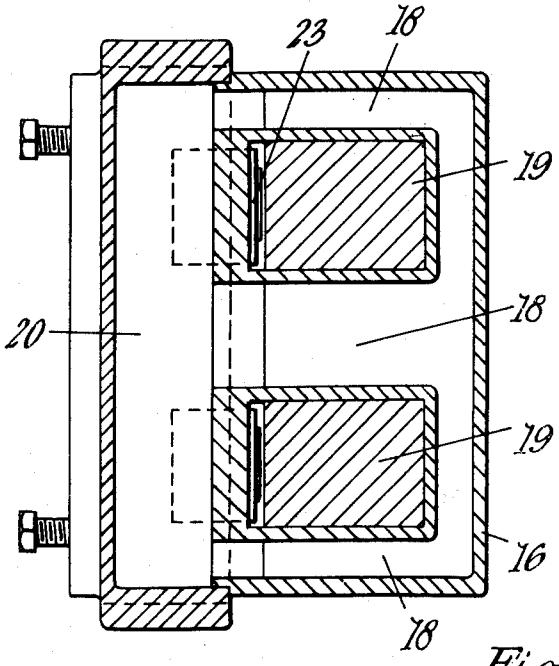


Fig. 10.

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COOLED BRUSH HOLDER FOR CARRYING CURRENT IN DYNAMO-ELECTRIC MACHINES

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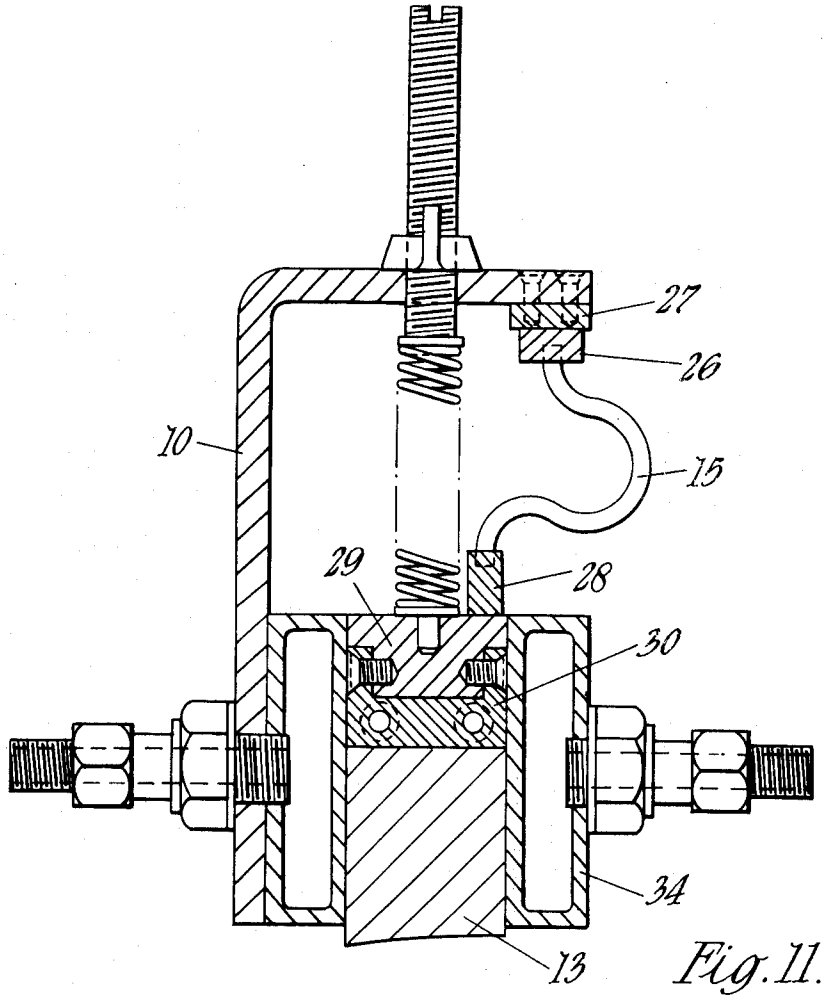


Fig. 11.

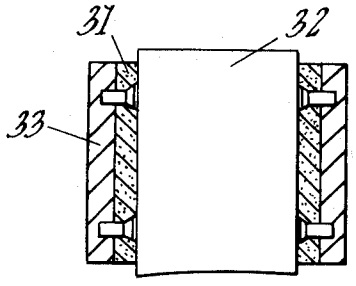


Fig. 12.

United States Patent Office

3,206,630
Patented Sept. 14, 1965

3,206,630

COOLED BRUSH HOLDER FOR CARRYING CURRENT IN DYNAMO-ELECTRIC MACHINES

Bruno Berger and Norman E. Gatiss, Newcastle-upon-Tyne, England, assignors to C. A. Parsons & Company Limited, Newcastle-upon-Tyne, England

Filed May 29, 1961, Ser. No. 113,523
Claims priority, application Great Britain, May 31, 1960, 19,189/60
8 Claims. (Cl. 310—227)

This invention relates to brush gear for carrying current in dynamo-electric machines especially slip ring brush gear of the kind commonly used with large turbo-generators for power station use.

As the current rating of such machines increases complications arise as a result of the large number of brushes required to carry the rotor current. If the diameter of the slip ring is increased to accommodate the extra brushes the rate of wear is increased and current sharing difficulties are enhanced because of resulting higher rubbing speeds. On the other hand if the rows or number of brushes is increased the length of the machine is increased or routine inspection and maintenance is complicated. If the current is increased without raising the number of brushes, resulting brush temperature rises would not be permissible.

The object of the present invention is to provide improved brush gear for current carrying in dynamo-electric machines in which the above complications are substantially reduced.

The invention consists in brush gear for current carrying in dynamo-electric machines in which the brush gear is liquid cooled as specifically defined in the appended claims.

Referring to the accompanying drawings.

FIGURE 1 shows an "exploded" perspective view of a brush box of brush gear in accordance with one form of the present invention;

FIGURE 2 is a plan view of the brush box of FIGURE 1.

FIGURE 3 is a section on line XX of FIGURE 2.

FIGURE 4 shows a perspective view of part of a brush gear assembly in accordance with one form of the invention.

FIGURE 5 is a front elevation of a brush box and bracket for use with vaporised liquid cooling.

FIGURE 6 is a plan view of FIGURE 5.

FIGURE 7 is an end elevation of FIGURE 5.

FIGURE 8 is a section on line AA of FIGURE 7.

FIGURE 9 is a section on line BB of FIGURE 7.

FIGURE 10 is a section on line CC of FIGURE 7.

FIGURE 11 shows a brush box and bracket of the kind illustrated in FIGURE 4 adapted for thermo-electric cooling of the brush flexible lead.

FIGURE 12 shows a section through a brush and associated brush box in an arrangement which dispenses with the need for flexible leads for the brushes.

In carrying the invention into effect in the forms illustrated by way of example and referring first to FIGURE 1, a brush box **1** is formed with openings **2** in which brushes are housed. A channel **3** surrounds the openings **2** and a cooling liquid such as water is circulated, for example by means of a pump, through the channel **3** to cool four sides of the brushes. Inlet and outlet connections for the cooling liquid are shown at **4** and **5** respectively.

A cover plate **6** fits over the box and is welded or otherwise joined thereto.

The brush box may be cast in a material such as aluminium and whilst two openings for brushes have been shown the invention is not limited to this number.

Referring to FIGURES 2 and 3 the shape of the channel **3** can be more clearly seen.

Cooling liquid entering through inlet **4** is deflected by a wall **7** to ensure that the liquid circulates around the brushes and not directly from the inlet **4** to the outlet **5**. If necessary the inner surface of the box **1** in contact with the cooling liquid may be finned to improve heat transfer.

An assembly of a number of such boxes on a dynamo-electric machine is shown in FIGURE 4, the boxes being connected in parallel with supply and discharge pipes **8** and **9** respectively for the cooling liquid.

Each brush box is attached to a bracket **10** by means of bolts **11** (see FIGURE 1) and the brackets are in turn fixed to a brush gear support plate **12** on the machine. Brushes **13** are shown in position in two of the boxes and are connected to terminals **14** by current carrying flexible leads **15** in conventional manner. These flexible leads must be rated at the brush operating current and this will require an increased copper section and generally four flexible leads instead of the two normally used.

With the arrangement described the current density for each brush can be increased four of five times without damage or increase in temperature or undue increase in the rate of wear of the brushes.

Whilst in the form described the boxes are forced-cooled by a liquid which is circulated, for example by means of a pump, through each box from common inlet pipes **8**, a vaporisable liquid can be used within the scope of the invention. In such a case each brush box would be individually sealed and natural circulation of the liquid and vapour would take place within the box; for example a brush box and bracket could be a single hollow casting with the liquid forming a reservoir around the brushes and the vapour rising into the space in the bracket above the brushes, condensing and running back into the reservoir of liquid surrounding the brushes. This arrangement would necessitate all the brush boxes being above the centre line of the machine so that the required circulation could take place.

FIGURES 5–10 show a sealed brush box suitable for use with vaporisation cooling. The brush box **16** and bracket **17** are hollow and the cavities or channels **18** surrounding the brushes **19** open into the cavity **20** of the bracket.

The cavities **18**, **20** are filled with a vaporisable liquid, such as Freon, to a level, in the bracket cavity **20**, which is above the brushes. The remainder of the space in the cavity **20** above the liquid is the space into which the vapour rises and is condensed to flow, under gravity, back into the liquid. An inspection window **21** is provided to check the liquid level.

To produce condensation in the upper part of cavity **20** the brush box and bracket are cooled by a gas circulating over the outside surfaces thereof. Fins **22** may be provided, as shown, to assist transfer of heat to the cooling gas. The use of a gas, such as nitrogen, hydrogen or argon or other gas without free oxygen content, reduces oxidation of the brushes and hence increases brush life.

The use of a gas such as nitrogen, hydrogen or argon as coolant means that the brush gear covers cannot be

removed for spring pressure adjustments or brush changes unless the gas is first removed or unless it is allowed to escape to atmosphere. It is preferable, therefore, to eliminate as far as possible the need for access to the brush gear during the running period of the machine between routine overhauls or shut-down periods. To these ends long brushes up to at least 6" and conventional constant tension springs **23** which apply a pressure which is independent of the brush length, may be used.

Instead of using sealed brush boxes as described in FIGURES 5–10 with condensation taking place within the box, the vaporised liquid can be taken to a condenser separate and if desired some distance from the brush gear. This separate condenser can then be used for condensing vapour from all the brush boxes. The condensate may return to the boxes by gravity or be circulated by means of a pump.

If a separate condenser is used the heat passing to the cooling gas is substantially reduced and such heat can be disispated by the brush gear enclosure, assisted by the circulation produced by the rotating slip rings. If a separate condenser is not used and the system of FIGURES 5–10 is used, it may be necessary to force-circulate the gas round a circuit including a cooler for the gas.

Whilst the use of a cooling gas has been described with particular reference to its use when vaporisable liquids are used for cooling the brushes, such a gas could also be used to surround the brush gear of FIGURES 1–4.

Instead of having hollow boxes the brushes may be cooled by brazing cooling pipes to solid brush boxes and connecting the pipes to the pipes **8** and **9** of FIGURE 1, for example, to permit ingress and egress of coolant. The tubes may be flattened tubes to give a good surface area of contact with the brush box.

As a consequence of the increased current capacity of the brushes due to improved brush cooling devices as described above, the number of brushes required for a machine can be reduced. This in turn means that as each brush is carrying a greater proportion of the total current it is important to know when a brush is being overloaded. To keep a check on the current being carried by any given brush, a resistance **24** may be incorporated in the current path between the brush flexible leads **25** and the bracket **17** as shown in FIGURES 5 and 7. Leads can be taken from terminals **24***a*, **24***b* at each end of the resistance and taken to a selector switch which in turn is connected to a voltmeter for recording the voltage drop across any given resistance to determine the current passing therethrough. The current carried by each brush can therefore be determined and if one or more brushes are seriously overloaded remedial action can be taken before damage to any part of the brush gear occurs. An alarm contact can be incorporated in the voltmeter and the selector switch can be motorised, for remote indication of overload for example in a control room. To keep the heat generated in the brush flexible leads small, with increased current flowing in the leads, the cross-sectional area of the lead is increased. A limit is reached, however, when the lead presents appreciable restraint to the free movement of the brush and it may be necessary to increase and direct the flow of cooling gas or use other cooling means. For example, the flexible lead may be cooled by making use of the well known thermoelectric cooling effect of P and N-type thermoelements interposed in the electrical circuit at each end of the brush flexible lead.

FIGURE 11 shows how such a cooling device can be applied to a brush box and bracket of the type shown in FIGURE 4. Because of the improved cooling only one flexible lead is normally required. Assuming that the current is flowing from the brush **13** to the bracket **10**, a P-type thermo-element **26** is joined to a copper heat sink **27** at the end of the flexible lead **15** remote from the brush **13**. The N-type thermo-element **28** is joined to a copper heat sink **29**. The heat sink **27** plugs into or is otherwise fastened to the bracket **10** and the heat sink **29** is plugged into or otherwise fastened to copper extension **30** of the brush **13**. The flexible lead with its thermo-elements and heat sinks thus forms a detachable connection, which allows the brush to be renewed without renewing the flexible lead. Some of the heat developed in the flexible lead **15** is absorbed at the junctions of the thermo-elements **26** and **28** and the flexible lead **15**. Additional heat due to the Peltier effect is generated at the junction of the thermo-elements **26** and **28** and the heat sinks **27** and **29** respectively. The total heat appearing at these latter junctions is absorbed by the cooling liquid and the bracket. Some heat will also be dissipated to the gas surrounding the brush boxes and brackets.

If the current flow is from bracket to brushes the positions of the P and N-type elements would be reversed.

The need for removing heat developed in the flexible leads can be avoided by dispensing with the flexible leads altogether. Such an arrangement is illustrated in FIGURE 12 in which a graphite or copper-graphite sleeve **31** is interposed between a brush **32** and the wall of the brush box **33**. Current then passes from the brush through the sleeve to the brush box or vice versa and the need for brush flexible leads is avoided. The heat developed at the junction between sleeve and brush is readily removed by the cooling fluid.

We claim:

1. Brush gear for carrying current in dynamo-electric machines which brush gear is vaporisable-liquid cooled, and in which the brushes are housed in boxes attached to brackets which are in turn attached to a brush gear supporting ring, each bracket and associated brush boxes being hollow with connected cavities therein surrounding the brushes and in the bracket, said cavities being filled to a level above the brushes with the vaporisable liquid, a space being formed in the bracket cavity above the liquid level into which vapour may rise and be condensed.

2. Brush gear for carrying current in dynamo-electric machines which brush gear is vaporisable-liquid cooled, and in which flexible leads connected to the brushes and carrying current to or from the brushes are cooled by connecting to one end of the lead a thermo-element of the P-type and connecting to the other end a thermo-element of the N-type each thermo-element being joined to a metal member acting as a heat sink from which heat is dissipated to the liquid cooling the brushes and to the gas surrounding the brush gear.

3. Brush gear for carrying current in dynamo-electric machines which brush gear is vaporisable-liquid cooled, and in which flexible leads connected to the brushes and carrying current to or from the brushes each have a resistance in series therewith the voltage drop across which resistance is measured to provide an indication of the current flowing through the flexible lead.

4. Brush gear for carrying current in dynamo-electric machines which brush gear is vaporisable-liquid cooled, and in which inside the brush box a sleeve of high electrical and thermal conductivity acts as the current transfer contact between box and brush, thereby dispensing with flexible leads.

5. Brush gear for dynamo-electric machines comprising hollow brush boxes, brushes located in said boxes, said brush boxes having connected cavities therein surrounding the brushes, the cavities containing a vaporisable liquid and means connected with the liquid space in said boxes for condensing vapour produced from said liquid.

6. Brush gear as claimed in claim **5** in which each brush box is self contained and the means connected to the liquid space for condensing the vapour comprise a space in the box above the liquid level into which the vapour

may rise and be condensed by cooling fluid circulating over the boxes.

7. Brush gear as claimed in claim 5 in which the means connected to the liquid space of each box for condensing vapour is a separate condenser located remote from said brush gear and connected thereto by conduits for the passage of vapour and condensate.

8. Brush gear for dynamo-electric machines comprising hollow brush boxes for housing brushes and means for liquid cooling the brushes in said boxes and brush leads conveying current to or from said brushes in which the brush leads comprise a sleeve of high electrical and thermal conductivity interposed between a brush and its brush box, which sleeve acts to transfer current from the brush to the box or vice-versa and is cooled by the liquid in the said boxes.

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