Dec. 29, 1942. H. C. DANIELS 2,306,527

ELECTRIC-POWER TRANSMISSION-SYSTEMS

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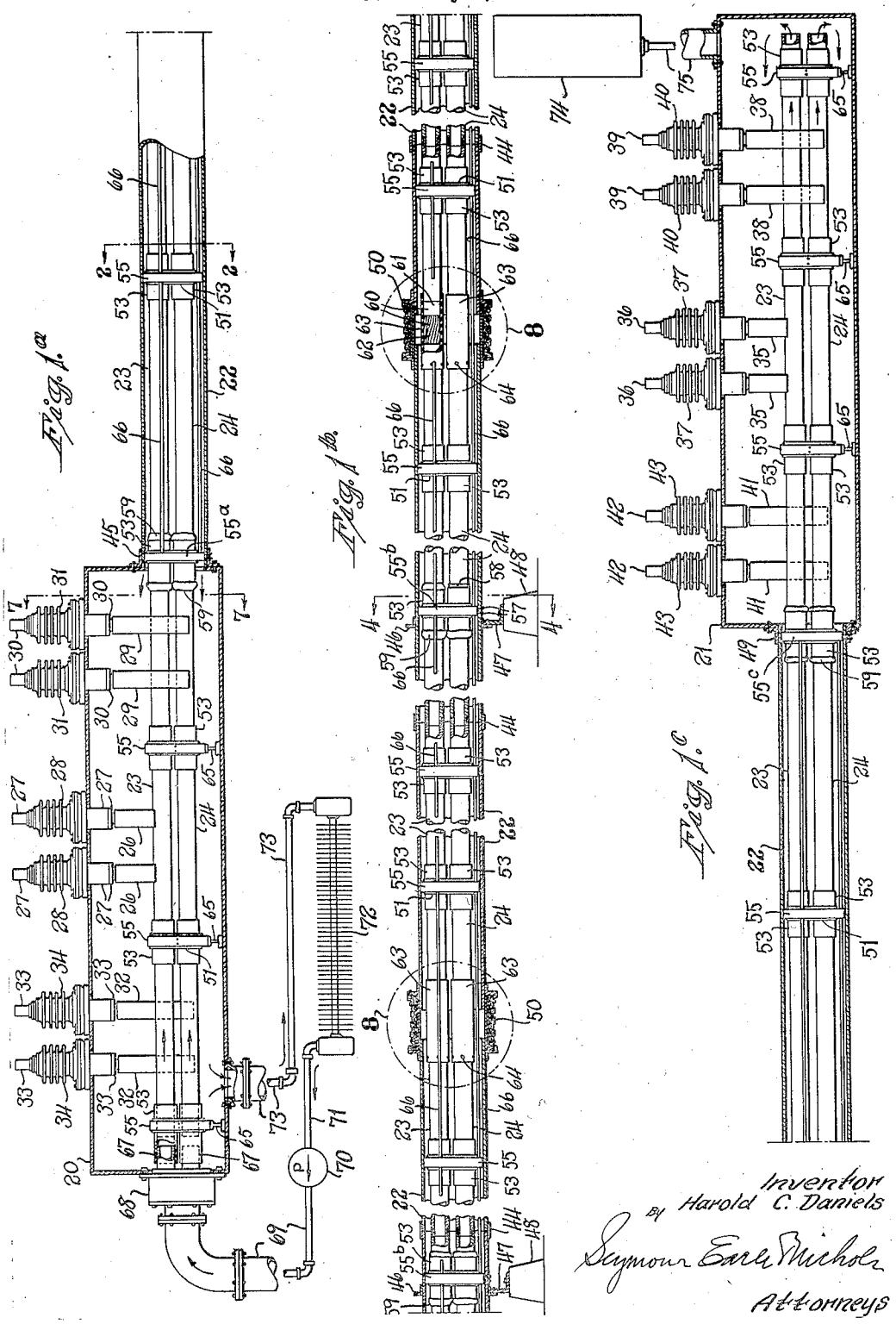


Fig. 1a.

Fig. 1b.

Fig. 1c.

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Fig. 2.

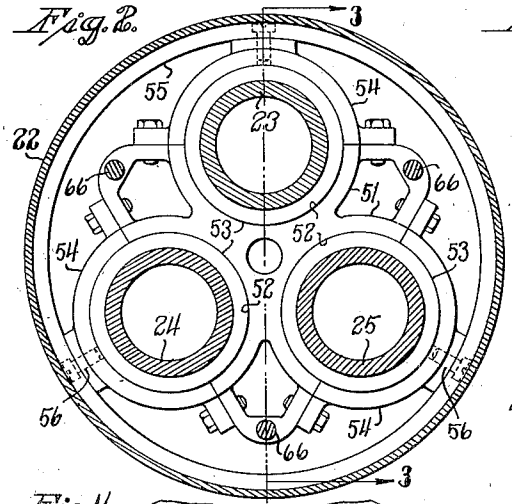


Fig. 3.

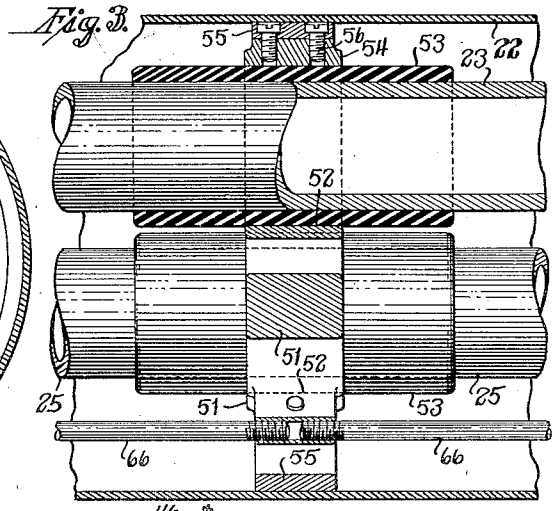


Fig. 4.

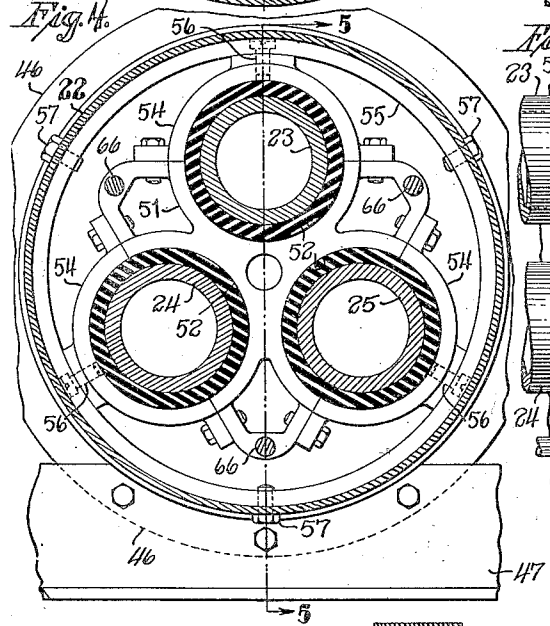


Fig. 5.

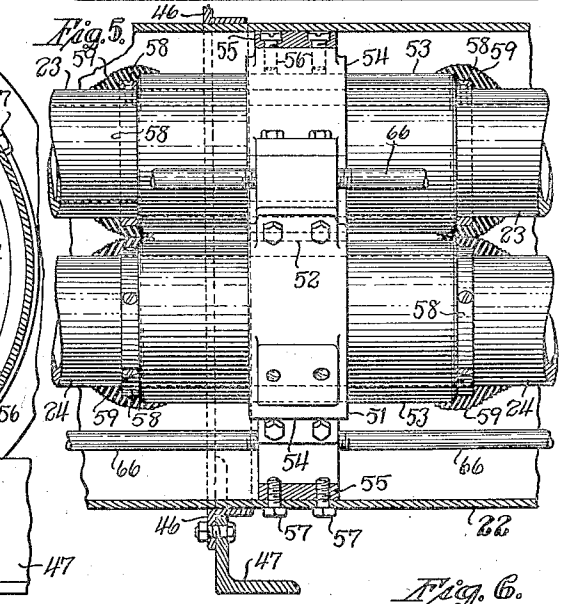
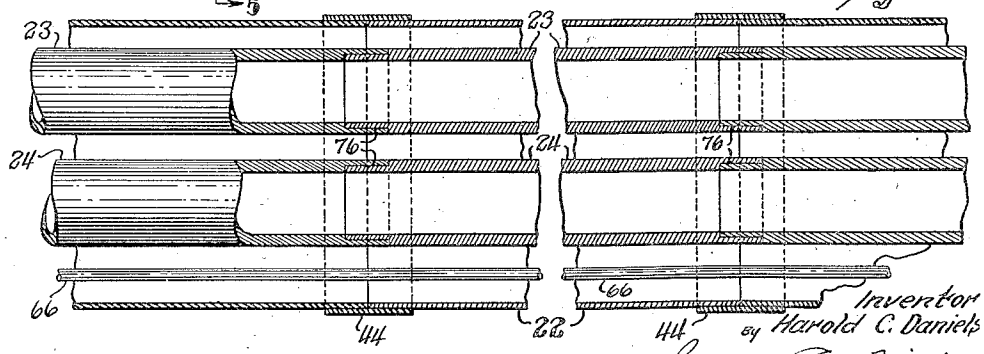


Fig. 6.



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Fig. 7.

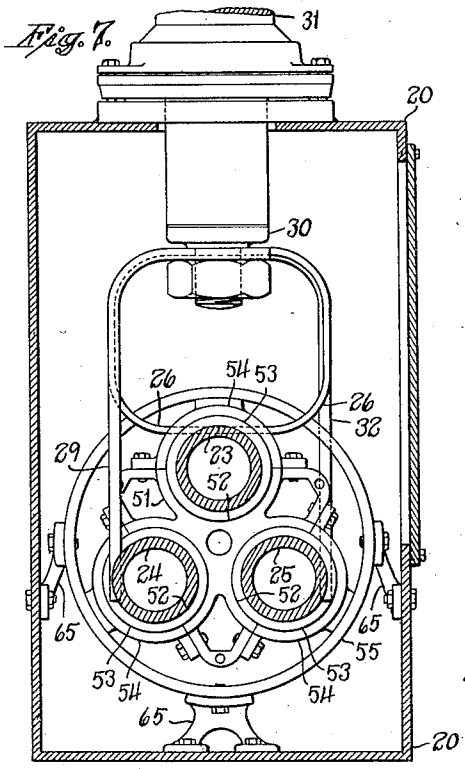


Fig. 10.

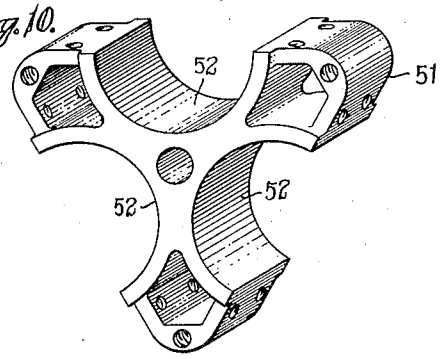


Fig. 11.

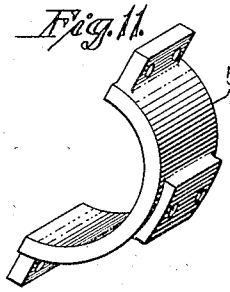


Fig. 9.

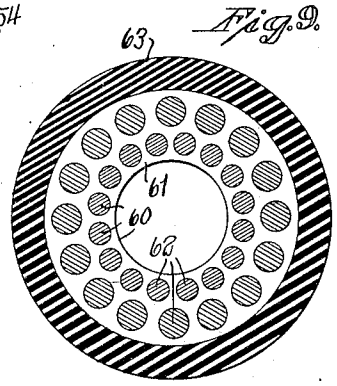
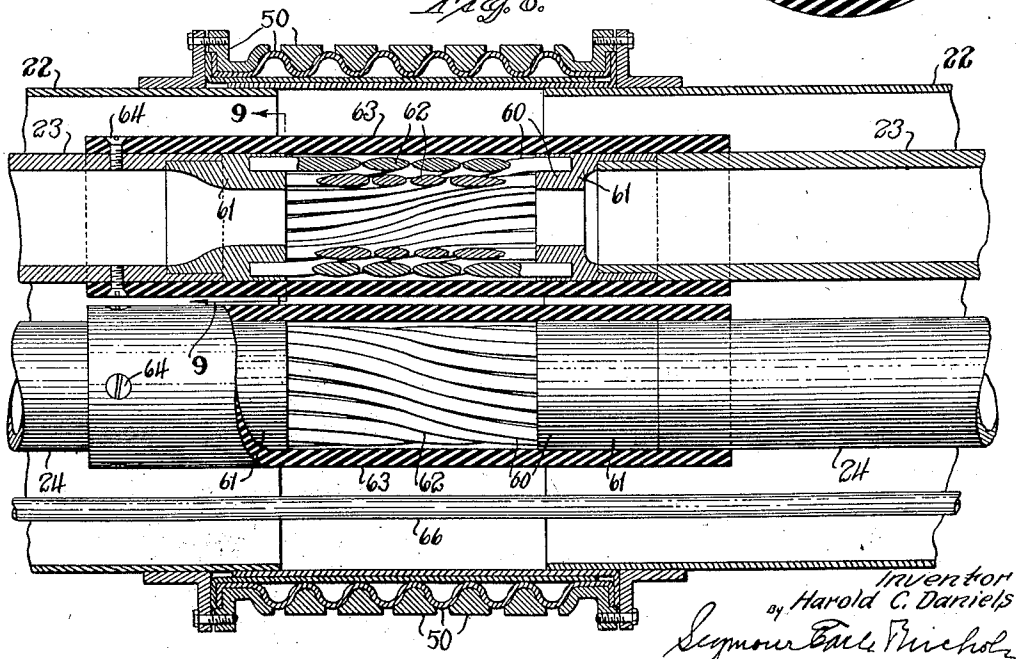


Fig. 8.



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UNITED STATES PATENT OFFICE

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ELECTRIC-POWER TRANSMISSION SYSTEM

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Application May 2, 1940, Serial No. 332,943

2 Claims. (Cl. 174—15)

The present invention relates to improvements in electric-power transmission-systems and relates more particularly to electric transmission-means for the transmission of electrical power of commercial frequencies and voltages.

More specifically the present invention relates to electric-power transmission-systems of the character wherein it is necessary for practical purposes to provide for the circulation of a cooling medium in order to avoid overheating of the elements of the system.

One of the objects of the present invention is to provide a superior electric-power transmission-system embodying low cost for manufacture with efficiency of service.

Another object of the present invention is to provide an electric-power transmission-system in which a fluid-cooling medium may be economically circulated in such manner as to carry off the undesired heat in an efficient and effective manner.

Still another object of the present invention is to provide a superior electric-power transmission-system combining maximum electric-power transmission capacity with minimum space requirements.

A still further object of the present invention is to provide a superior electric-power transmission-system in which a cooling-fluid may be effectively circulated at low power-cost.

With the above and other objects in view, as will appear to those skilled in the art from the present disclosure, this invention includes all features in the said disclosure which are novel over the prior art.

In the accompanying drawings, in which certain modes of carrying out the present invention are shown for illustrative purposes:

Fig. 1*a* is a schematic view partly in vertical central-longitudinal section and partly in side elevation of the left portion of an electric-power transmission-system embodying the present invention;

Fig. 1*b* is a similar view of the intermediate portion of the transmission-system;

Fig. 1*c* is a similar view of the right portion thereof;

Fig. 2 is a transverse sectional view taken on the line 2—2 of Fig. 1*a* but on a larger scale.

Fig. 3 is a broken view partly in side elevation and partly in central-longitudinal section taken on the line 3—3 of Fig. 2;

Fig. 4 is a transverse sectional view taken on the line 4—4 of Fig. 1*b* but on a larger scale;

Fig. 5 is a broken view partly in side elevation and partly in vertical central-longitudinal section taken on the line 5—5 of Fig. 4;

Fig. 6 is a fragmental view in vertical central-longitudinal section showing the rigid joints between individual sections of the tubular sheath and also the rigid joints between individual sections of the tubular electric-conductors;

Fig. 7 is a broken transverse sectional view taken on the line 7—7 of Fig. 1*a* but on a larger scale;

Fig. 8 is a fragmental view mainly in vertical central-longitudinal section and partly in side elevation of the portion of the system within the dotted line 8 of Fig. 1*b* but on a larger scale;

Fig. 9 is a transverse sectional view taken on the line 9—9 of Fig. 8;

Fig. 10 is a perspective view of one of the conductor-supporting spiders or frames; and

Fig. 11 is a perspective view of one of the conductor-clamping caps.

The electric-power transmission-system herein chosen for the purpose of illustrating the present invention includes two longitudinally-spaced-apart fluid-chambers 20 and 21 of rectangular form and connected together by a tubular sheath generally designated by the reference character 22 but which comprises several coaxial sections arranged end-to-end as will be more fully hereinafter described. The said sheath 22 is fluid-tight and is preferably formed of copper or the like not only to resist corrosion but also to provide an efficient thermal conductor for the dissipation of heat and an efficient electric-conductor as well.

Extending longitudinally through the sheath 22 and into both of the fluid-chambers 20 and 21 are three (more or less) hollow tubular electric-conductors 23, 24 and 25. The said electric-conductors are preferably formed of copper or other high electro-conductive material and extend in parallelism with each other in spaced-apart relationship both with respect to each other and with respect to the interior surfaces of the sheath 22. The hollow tubular electric-conductors such as 23, 24 and 25, and whatever their number, will always occupy but a part of the total cross-sectional area of the sheath 22 so as to provide a fluid-passage within the said sheath and exteriorly of the said electric-conductors. In other words, the cross-sectional area of the electric-conductor or electric-conductors within the sheath 22 or its equivalent will jointly and severally have a cross-sectional area less than the cross-sectional area of the interior of the said sheath 22.

The electric-conductor 23 has brazed or otherwise secured to its upper surface, two similar conducting-straps 26—26 located in the fluid-chamber 20 about midway the length thereof. The upper portions of each of the conducting-straps 26—26 extend into both mechanical and electrical engagement with the lower portion of the adjacent one of two vertical conducting-rods 27—27 each extending upwardly through one of two similar insulators 28—28 mounted upon the

upper surface of the fluid-chamber 20 and extending through the top wall thereof as is shown especially well in Fig. 1*a*. The upper ends of the conducting-rods 27—27 project upwardly beyond the upper surfaces of the respective insulators 28—28 and may be connected to a line-wire or to any desired electrical apparatus.

The outer side-face of the hollow tubular conducor 24 has two conducting-straps 29—29 brazed or otherwise secured to it at two spaced-apart points within the fluid chamber 20 and adjacent the point of connection of the sheath 22 therewith. Each conducting-strap 29—29 just referred to is connected at its upper end to the lower end of the adjacent one of two vertical conducting-rods 30—30 each of which is mounted in one of two corresponding insulators 31—31 mounted upon and in part extending downwardly through the top-wall of the fluid-chamber 20. The respective upper ends of the conducting-rods 30—30 extend upwardly beyond their respective insulators 31—31 for joint connection to a line-wire or any desired electrical apparatus.

Adjacent the outer end of the fluid-chamber 20 the hollow tubular electric-conductor 25 has brazed or otherwise secured to it at longitudinally-spaced-apart points two conducting-straps 32—32 each of which extends upwardly into electrical engagement with the lower portion of the adjacent one of two vertical conducting-rods 33—33. Each of the conducting-rods 33—33 is mounted in one of two similar insulators 34—34 which are mounted upon the upper wall of the fluid-chamber 20 and extend from the interior to the exterior thereof as do also the conducting-rods 33—33.

Adjacent their opposite ends, i. e., the ends within the right fluid-chamber 21, the three hollow tubular electric-conductors 23, 24 and 25 are also provided with electrical connections leading from the said electric-conductors outwardly to the exterior of the fluid-chamber 21 in a manner similar to that described in connection with the opposite or left end of the said electric-conductors.

About midway of the length of its portion extending within the fluid-chamber 21 the hollow tubular electric-conductor 23 has brazed or otherwise secured to it at spaced-apart points two conducting-straps 35—35 each of which extends into electrical engagement with the lower end of one of two vertical conducting-bars 36—36. Each of the said conducting-bars 36—36 extends from the interior to the exterior of the fluid-chamber 21 through the upper wall thereof and is mounted in one of two similar insulators 37—37 secured to the said upper wall and extending downwardly therethrough.

Adjacent its outer end the hollow tubular electric-conductor 24 has brazed or otherwise secured to it at longitudinally-spaced-apart points two conducting-straps 38—38 each of which extends upwardly into electrical connection with one of two vertical conducting-bars 39—39 both of which extend from the interior to the exterior of the fluid-chamber 21. Each of the said conducting-bars 39—39 is mounted in one of two insulators 40—40 mounted upon the upper wall of the fluid-chamber 21 and extending partly within the interior of the said fluid-chamber.

The portion of the hollow tubular electric-conductor 25 within the fluid-chamber 21 has brazed or otherwise connected to it at spaced-apart points adjacent the inner wall of the said fluid-chamber, one of two conducting-straps 41—41. The upper end of each of the conducting-straps 42—42 is electrically joined to the lower end of one of two similar vertical conducting-rods 42—42 extending from the interior to the exterior of the said fluid-chamber 21. Each conducting-rod 42—42 is mounted in one of two insulators 43—43 carried on the upper wall of the said fluid-chamber.

The sheath 22 is preferably formed of sections of copper tubing joined together in end-to-end relationship in any suitable manner to afford the desired total length of sheath. Over some of the joints between its abutting sections the said sheath has applied to its exterior a coupling-band 44 as is especially well shown in Figs. 1*b* and 6. The said coupling-bands are preferably brazed to each of the adjacent sections of the sheath 22 so as to, in effect, unite the said sections into a rigid unit.

The hollow tubular sheath 22 has its left end rigidly coupled to the adjacent or inner end-wall of the fluid-chamber 20 by means of a coupling-flange 45 of L-shaped form in cross-section and having one leg brazed or otherwise rigidly secured to the adjacent portion of the sheath 22 and having its other or radial leg bolted or otherwise secured to the inner end-wall of the fluid-chamber 20 as is shown in Fig. 1*a*.

At suitable intervals intermediate its respective opposite ends the tubular sheath 22 is anchored against longitudinal movement and supported against downward movement as is shown in the central portion of Fig. 1*b* and also in Figs. 4 and 5. For the purpose just described the sheath 22 has brazed or otherwise secured upon its periphery an annular coupling-flange 46 of L-shaped form in cross section and having the lower portion of its radial leg coupled to a supporting-bracket 47 mounted upon a supporting-block 48 of concrete or other suitable material.

The right end of the tubular sheath 22 is provided with a coupling-flange 49 brazed or otherwise secured thereto and in turn bolted or otherwise secured to the adjacent inner end-wall of the right fluid-chamber 21.

Inasmuch as the opposite ends of the sheath 22 are rigidly coupled respectively to the fluid-chambers 20 and 21 and the said sheath is held rigidly intermediate of its length upon the supporting-block 48, provision is made for allowing the necessary axial or lengthwise expansion and contraction of the sheath 22 to take place without damage to the structure. The expansion just referred to is provided for by interrupting the sheath 22 with suitable expansion-joints such as those indicated by the reference character 50. The expansion-joints 50 are of known construction and require no detailed description herein other than to say that they provide a fluid-tight joint between adjacent sections of the sheath 22 while still permitting the said sections to move axially with respect to each other.

The hollow tubular electric-conductors 23, 24 and 25 are supported within the sheath 22 and held in spaced relationship with respect to the inner surface of the said sheath and with respect to each other by a series of similar conductor-supporting spiders or frames 51. Each of the spiders or frames 51 just referred to is provided with three equidistant and outwardly-facing semicircular seats 52 each of which receives one of three adjacent insulating-tubes 53 one of which surrounds the adjacent portion of each of the said tubular electric-conductors 23, 24 and 25.

Secured to each of the three faces of each spider or frame 51 is a conductor-retaining cap 54 extending over the outer face of the adjacent insulating-tube 53 and firmly clamping the same in the complemental one of the seats 52 in the spider 51 in such manner that the said insulating-tube is held against axial movement with respect to the said spider. The fit of the insulating-tubes 53 upon the periphery of the respective tubular electric-conductors 23, 24 and 25 is such as to permit the said electric-conductors to slide through the said insulating-tubes without undue hindrance in order to compensate for expansion and contraction lengthwise of the said electric-conductors, save at special points as will hereinafter appear.

The outer portion of each of the three conductor-retaining caps 54 of each spider or frame 51 snugly engages the inner periphery of a spacing-ring 55. Save in special instances hereinafter mentioned each spacing-ring 55 snugly but slidably fits the inner periphery of the sheath 22. Substantially-radial screws 56 are employed for coupling each spacing-ring 55 to each of the adjacent set of three caps 54 and hence also to the adjacent spider or frame 51.

All but a minor number of the plurality of spacing-rings 55 are free to slide within the sheath 22 in a direction lengthwise thereof. In the construction shown the three spacing-rings designated 55*a*, 55*b*, 55*c* and respectively adjacent the inner end-wall of the fluid-chamber 20, adjacent the supporting-block 48 and adjacent the inner end-wall of the fluid-chamber 21 are held against sliding movement within the sheath 22 by screws 57. It follows from the foregoing that the three spiders or frames 51 associated with the three spacing-rings 55*a*, 55*b* and 55*c* are also held against axial movement with respect to the sheath 22.

For the purpose of anchoring each of the tubular electric-conductors 23, 24 and 25 against axial movement within such of their respective insulating sleeves 53 as are coupled to the aforesaid spacing-rings 55*a*, 55*b* and 55*c*, stop-collars 58 are employed. One of the stop-collars 58 is mounted in engagement with each of the respective opposite ends of each of the insulating-tubes 53 encompassed by the said spacing-rings 55*a*, 55*b* and 55*c* and the said stop-collars 58 are rigidly attached to the adjacent portions of whichever one of the electric-conductors 23, 24 or 25 may extend therethrough.

The stop-collars 58 above referred to are preferably made of metal and inasmuch as they in effect reduce the gap between the respective tubular electric-conductors 23, 24 and 25, it is preferable that each of the said collars be covered with a mass of insulating material 59.

To permit the hollow tubular electric-conductors 23, 24 and 25 to expand and contract lengthwise in response to temperature changes, each of the said electric-conductors has interposed in it at spaced-apart points intermediate its points of anchorage as above described, a series of corresponding expansion-joints generally designated by the reference character 60 and especially well shown in Figs. 8 and 9. Each of the said expansion-joints includes two spaced-apart tubular heads 61—61 brazed or sweat-soldered to the adjacent portions of the particular tubular electric-conductors 23, 24, or 25 of which it forms a feature. The heads 61—61 are electrically connected together by two or more layers of helically-inclined wires 62 preferably formed of soft copper or other suitable high electro-conductive material. Sleeved over each expansion-joint 60 and the adjacent portions of the tubular electric-conductors 23, 24 or 25 of which it forms a feature, is a sealing-tube 63 preferably formed of insulating material. Each of the said sealing-tubes is anchored by any suitable means such as screws 64 to one portion of the particular electric-conductor with which it is assembled and has sliding engagement with the portion of the conductor on the other side of the particular expansion-joint 60, as is especially well shown in Fig. 8. The sealing-tubes 63 serve to minimize the leakage of fluid between the hollow interior of each of the conductors 23, 24 and 25 and the space within the sheath 22 and exterior of the said conductors for purposes as will hereinafter appear, though it is not essential that leakage be more than minimized.

The portions of each of the hollow tubular electric-conductors 23, 24 and 25 which extend within the fluid-chambers 20 and 21 are also equipped and held in spaced relationship by spiders or frames 51 before described, together with their respective spacing-rings 55 and other features described, save that at these locations the said spacing-rings 55 instead of bearing within the interior of the sheath 22 are supported by suitable brackets such as 65.

For the purpose of preventing undue shifting of the various conduit-supporting spiders or frames 51 lengthwise of the sheath 22, it is preferred that the said spiders be interconnected by suitable tie-rods 66.

At their respective left ends the three hollow tubular electric-conductors 23, 24 and 25 do not open directly into the interior of the fluid-chamber 20, but are respectively sleeved-over one of a corresponding number of tubular bosses 67 projecting inwardly from a header 68 through the outer end-wall of the fluid-chamber 20 and into the interior thereof. The said header 68 is connected by suitable piping 69 to the outlet end of a fluid-circulating pump 70. The inlet end of the said pump 70 is connected by suitable piping 71 to one end of a heat-exchanger 72 of any suitable character and serving to cool such fluid as may be caused to pass therethrough in the usual manner of heat-exchangers. The opposite end of the heat-exchanger 72 is connected by suitable piping 73 to the interior of the fluid-chamber 20 as is shown in Fig. 1*a*.

The respective right ends of the three hollow tubular electric-conductors 23, 24 and 25 open into the interior of the fluid-chamber 21 adjacent the outer end thereof, as is shown especially well in Fig. 1*c*. Preferably an expansion-tank 74 is employed to provide for the expansion and contraction of the fluid contained in the system, and also to provide a reservoir of fluid to automatically replace such fluid as may leak from the system. Preferably the expansion-tank 74 is placed at a higher elevation than the highest portion of the system and is connected by suitable piping 75 to the outer end of the fluid-chamber 21, as shown in Fig. 1*c*.

When the hollow tubular electric-conductors 23, 24 and 25 or their equivalent have a considerable length between expansion-joints 60, it is desirable to braze or otherwise secure several sections of tubing together in end-to-end relationship. As shown in the drawings, sections of tubing composing the various hollow tubular electric-conductors 23, 24 and 25 have adjacent ends shaped to provide interfitting male and female

portions respectively, as shown at 76 in the drawings.

It is preferred that before the system is put into operation that it be filled with a suitable cooling-fluid having insulating properties. Many fluids are suitable for the purpose, among which may be mentioned non-inflammable oils such for instance as those on the market under the trade names Pyranol and Inerteen, high flash-point heavy cylinder-oils, transformer oils, carbon tetrachloride, etc., etc. It is preferred that the fluid in the system be maintained at high pressures in order to accentuate the insulating properties of the fluid, and such pressure may be in the order of several hundred pounds per square inch.

After the system including the fluid-chambers 20 and 21, the interior of the sheath 22, the interiors of the various hollow tubular electric-conductors 23, 24, 25, the various piping and at least a portion of the expansion-tank 74 have been suitably filled with a suitable cooling and insulating fluid, the pump 70 will be driven by any suitable prime-mover.

The starting of the pump 70 will cause an inflow of the fluid from the header 68 into the left ends of the respective hollow tubular electric-conductors 23, 24 and 25 for flow from left to right throughout the length of the said conductors. The fluid will emerge through the right ends of the electric-conductors 23, 24 and 25 into the outer end of the right fluid-chamber 21 and will then reverse its direction and circulate from right to left through the said fluid-chamber around the exteriors of the respective electric-conductors 23, 24 and 25.

After having flowed from right to left within the fluid-chamber 21 and over the exterior of the hollow tubular electric-conductors 23, 24 and 25, the cooling and insulating fluid will enter the adjacent right end of the tubular sheath 22 and flow therethrough around the exterior of the said electric-conductors back into the inner end of the left fluid-chamber 20. It is to be borne in mind, in this connection, that the skeletonized nature of the conductor-supporting spiders or frames 51 and their associated parts permits the passage of fluid through the said sheath exteriorly of the hollow electric-conductors 23, 24 and 25.

After having emerged into the inner end of the fluid-chamber 20 from the left end of the sheath 22, the cooling and insulating fluid will be drawn through the piping 73 into the heat-exchanger 72 where the said fluid will be cooled. The cooled fluid will emerge from the heat-exchanger 72 and pass through the piping 71 to the pump 70 and again will enter the interiors of all three of the hollow tubular electric-conductors 23, 24 and 25 for another cycle of circulation through the system.

Despite possible heavy pressures existing within the system, the load imposed upon the pump 70 or its equivalent in circulating the cooling and insulating fluid will amount to substantially only the frictional losses.

By providing an electric-power transmission-system such as has been above described, a free and effective flow of cooling fluid is provided both interiorly and exteriorly of the conductors 23, 24 and 25 or their equivalent without requiring external piping. It is possible by means of the present system to maintain the conductivity of the conductors at maximum efficiency by the effective cooling provided for as above described.

By the reverse flow of fluid in the manner described, the heat generated in the conductors 23, 24 and 25 is conducted away therefrom by fluid acting both interiorly and exteriorly thereof.

Under some conditions a large measure of the heat absorbed by the reversely flowing fluid may be dissipated through the sheath 22 and other surfaces of the system without requiring a special heat-exchanger 72. In instances where the system extends up a hill, for instance, it is possible to dispense with the pump 70 under some conditions and rely upon the well-known thermo-syphon action to effect the circulation of the cooling and insulating fluid.

The invention may be carried out in other specific ways than those herein set forth without departing from the spirit and essential characteristics of the invention, and the present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive, and all changes coming within the meaning and equivalency range of the appended claims are intended to be embraced therein.

I claim:

1. An electric-power transmission-system including in combination: a first fluid-chamber; a second fluid-chamber spaced from the said first fluid-chamber; a hollow tubular sheath interconnecting said fluid-chambers in fluid-conducting relation; a plurality of hollow tubular electrical-conductors extending longitudinally through the said sheath and into said fluid-chambers and each providing a flow-channel interiorly of itself, the said plurality of hollow tubular conductors occupying substantially less than the cross-sectional area of the interior of the said sheath to provide a flow-channel exteriorly of the said plurality of conductors and interiorly of the said sheath; a plurality of electrical tap-offs extending through the walls of said fluid-chambers and connected to said conductors; and means interconnecting said interior and exterior flow-channels constructed and arranged to cause insulating cooling-fluid to flow along said flow-channels and fluid-chambers and over and in contact with the portions of said tap-offs located in said fluid-chambers.

2. An electric-power transmission-system including in combination: a first fluid-chamber; a second fluid-chamber spaced from the said first fluid-chamber in fluid-conducting relation; a hollow tubular sheath interconnecting said fluid-chambers; a plurality of hollow tubular electrical-conductors extending longitudinally through the said sheath and into said fluid-chambers and each providing a flow-channel interiorly of itself, the said plurality of hollow tubular conductors occupying substantially less than the cross-sectional area of the interior of the said sheath to provide a flow-channel exteriorly of the said plurality of conductors and interiorly of the said sheath; a plurality of electrical tap-offs extending through the walls of said fluid-chambers and connected to said conductors; and means including a heat-exchanger exterior of said sheath interconnecting said interior and exterior flow-channels constructed and arranged to cause insulating cooling-fluid to flow along said flow-channels and fluid-chambers and over and in contact with the portions of said tap-offs located in said fluid-chambers.

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