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ABSORPTION DYNAMOMETER

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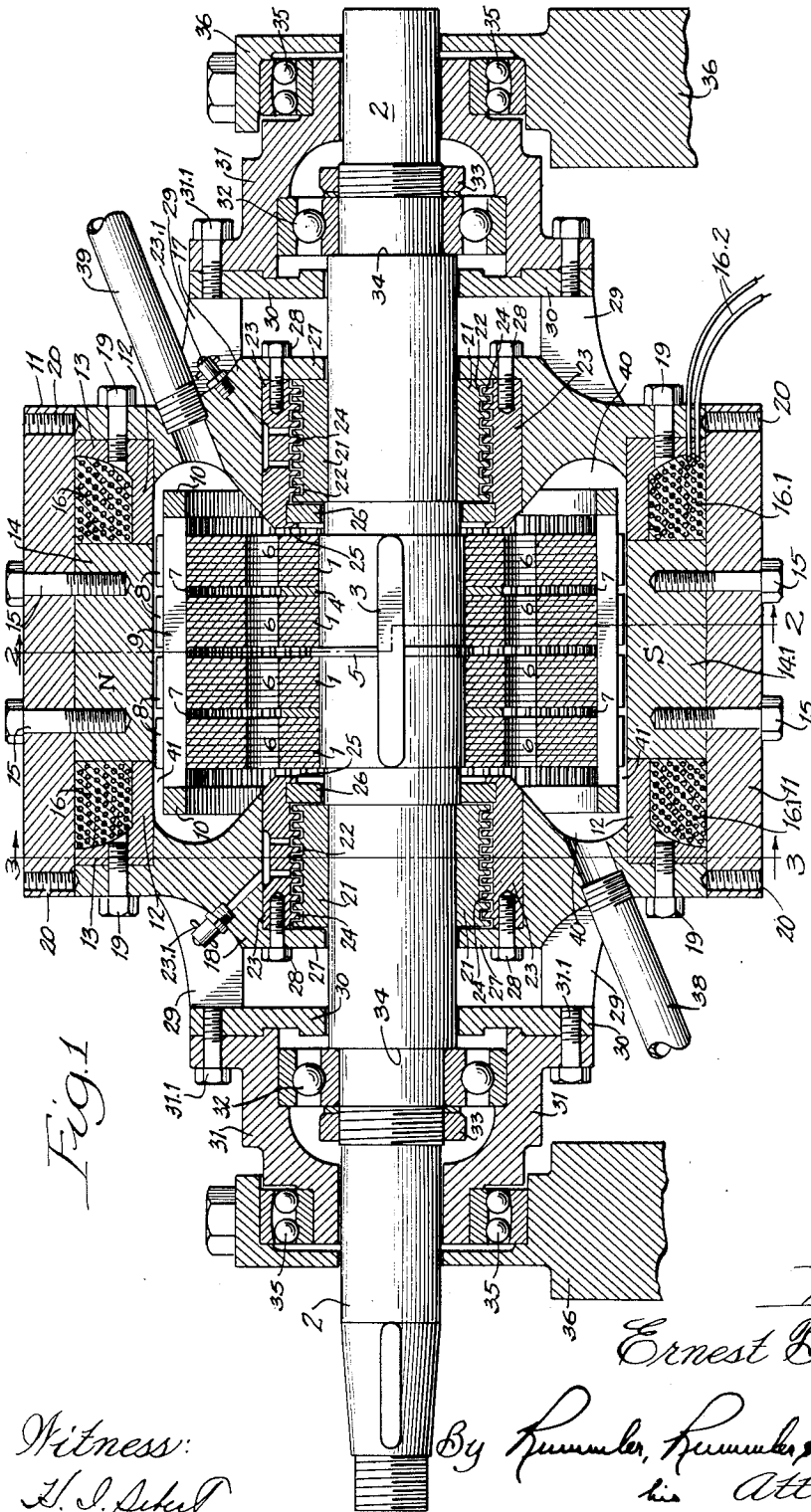


Fig. 1

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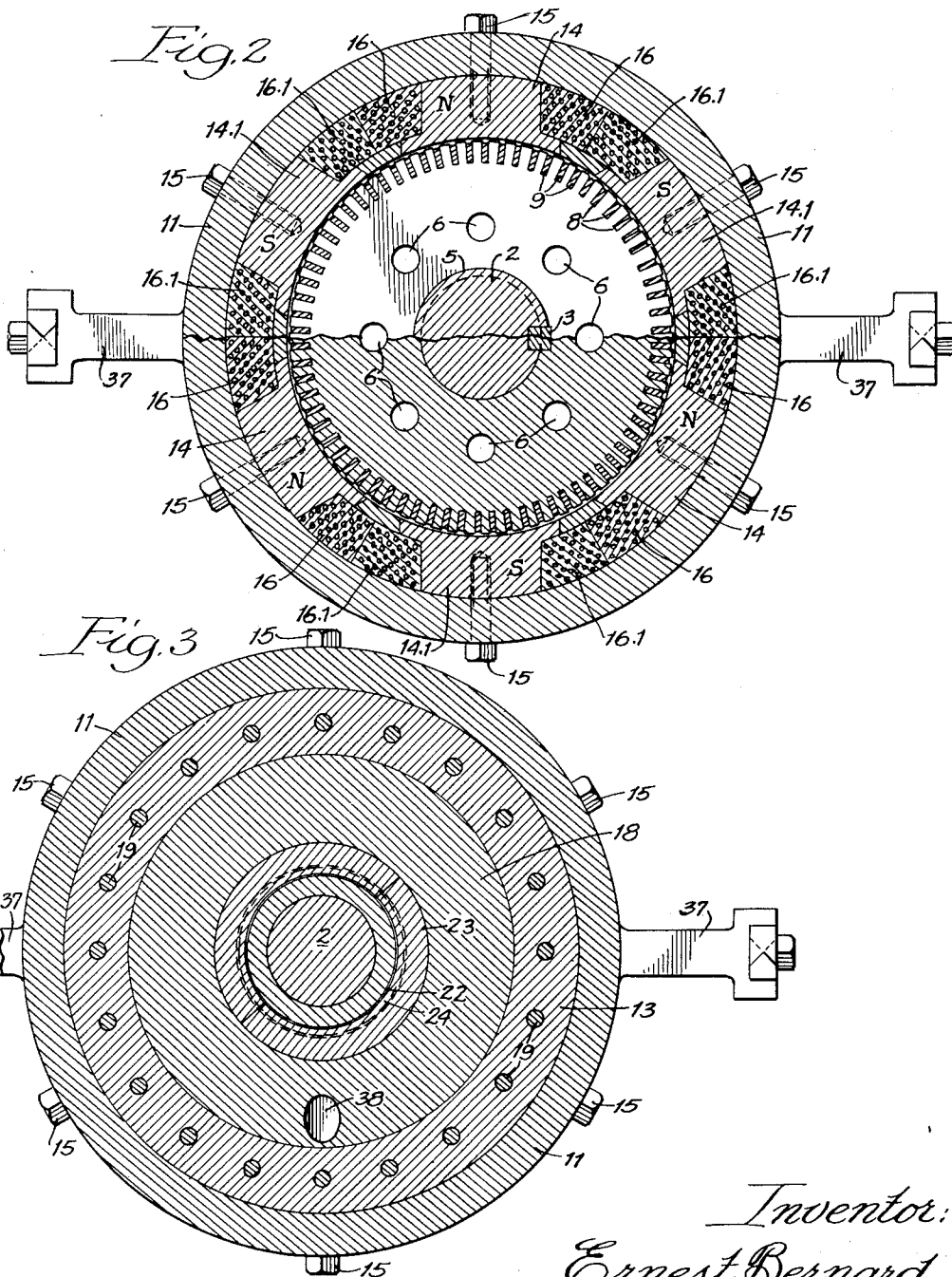
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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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ABSORPTION DYNAMOMETER

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8 Claims. (Cl. 188—104)

This invention relates to dynamometers, and particularly to absorption dynamometers of the electro-dynamic type.

The main objects of this invention are to provide an improved absorption dynamometer; to provide such a device having the superior operation characteristics of the electro-dynamic dynamometer but without the use of an external power absorbing rheostat; to provide an improved electro-dynamic absorption dynamometer having fluid cooling or power dissipating means; to provide such a device in which the cooling fluid is circulated through the power absorbing parts of the device by the integral fabricated structure of the rotating element thereof; to provide an improved absorption dynamometer which combines the operating characteristics of the hydraulic type and the electro-dynamic type of dynamometer; to provide an improved absorption dynamometer having less bulk and weight for any predetermined maximum load; to provide an improved absorption dynamometer capable of smooth, flexible and continuous full-load operation over a wide range of speed; and to provide electrical means in such a device to create a superior power-speed performance.

Heretofore it has been the practice in the art of electro-dynamic absorption dynamometers to generate power currents and, or, eddy currents in the power absorbing element without regard or consideration being given to the electrical conditions prevailing therein, such absorption dynamometers being invariably limited to one particular form of application.

It is, therefore, a further purpose of this invention to provide a device in which only the most efficient internal electrical conditions may be realized to obtain maximum power absorbing capacity and speed range for useful power absorption; and to provide such a device having the maximum power absorbing characteristics for all kinds of dynamometer applications.

A specific embodiment of this invention is shown in the accompanying drawings, in which:

Figure 1 is a longitudinal, sectional elevation of the device, showing its internal construction.

Fig. 2 is a sectional end elevation of the device as taken on line 2—2 of Fig. 1, and,

Fig. 3 is a similar view as taken on line 3—3 of Figure 1.

In the form shown in the drawings, the improved dynamometer consists essentially of two principal elements; namely, a rotor or armature and a stator or housing which serves as a field magnet frame, the rotor or armature comprising

a core made from a plurality of iron or steel discs 1 suitably fitted and attached to a shaft 2 by means of a key 3. As shown, the discs 1 are laminated units spaced from each other by means of spacing rings 4 and a centrally-located collar 5, which is integral on the shaft 2, and each of the rotor or armature discs 1 is provided with a series of angularly-spaced apertures 6, arranged in a circle just beyond the periphery of the spacing discs 4. Also, the several rotor discs 1 are positioned so that their respective apertures 6 are in registry or alignment with each other, whereby communication is had between the radially extending spaces 7 provided by the spacing rings 4 and 5 and the ends of the rotor by way of the apertures 6.

As shown in Figs. 1 and 2, the outer periphery of the rotor core is provided with angularly-spaced axially-extending slots 8, and a metal bar 9 of a conducting material having high electrical resistance, such as "Ni-Chrome" alloy, is set into each of the slots 8, which bars are of such length as to project somewhat beyond each end face of the rotor, where they are brazed or welded together so as to form respective annular end rings 10. The bars 9 are preferably insulated in any suitable manner from the core or rotor discs 1 and the end rings 10 are spaced from the ends of the rotor. Thus the axially-extending metal bars 9, together with the end rings 10, form a closed circuit, power generating, power absorbing, high resistance armature, winding on the rotor core exclusively, without any external connections whatsoever, when the bars 9 are acted upon by the main exciting field magnetic flux.

The stator or rotor housing which may also be termed the field magnet frame comprises an annular steel ring or pole yoke 11, which forms the outer shell or side wall of the dynamometer body, and within the steel ring or pole yoke 11 is fitted an annular non-magnetic bronze ring or inner shell 12 having peripheral end flanges 13, the edges of which bear against the inner surface of the steel ring or pole yoke 11. Thus, a space between the outer periphery of the bronze ring 12 and the inner periphery of the steel ring or pole yoke 11 is provided for exciting coils, as will be hereafter explained.

A plurality of centrally-located, angularly-spaced, alternate North and South pole pieces 14 and 14.1, respectively, are set into suitable slots or openings in the bronze ring 12 and secured to the pole yoke 11 by means of suitable bolts 15. As shown, the pole pieces 14 and 14.1 are formed

so that their inner surfaces will conform to the curvature of the inner surface of the bronze ring 12, and the pole pieces are set into the bronze ring 12 so that their inner surfaces will be substantially flush with the inner peripheral surface of the ring 12, the joints between the edges of each pole piece face and the bronze ring being brazed or welded to make a positively water-tight fitting.

Thus the annular non-magnetic bronze ring 12 with its peripheral end flanges and with the pole pieces 14 and 14.1 in place serves as the peripheral portion of an enclosed liquid-tight casing in which the armature is suitably contained and rotated and which positively prevents liquid from short circuiting or coming into contact with the field coils.

The pole pieces 14 and 14.1 project radially from the outer periphery of the bronze ring 12 for connection to the pole yoke 11, and suitable exciting or field coils 16 and 16.1 are disposed to encircle the radially-projecting portion of the pole pieces 14 and 14.1 respectively, the field coils 16 and 16.1 being housed within the space between the bronze ring 12 and the pole yoke 11. Each of the exciting field coils 16 and 16.1 is wound with suitable insulated magnet wire and is fitted around its respective pole piece before the bronze ring 12, with the pole pieces attached thereto, is fitted into the steel ring or pole yoke 11; the bolts 15, which are arranged for threaded engagement with the pole pieces being applied after the bronze ring 12 has been properly positioned within the pole yoke.

The field coils are electrically connected in series or series-parallel, depending upon the available source of exciting current, and current is supplied by way of insulated lead wires 16.2 which pass through suitable openings in the flange 13 of the bronze ring 12. The exciting current may be obtained from any suitable direct-current source, not shown, and regulated in the usual manner by control devices also not shown.

Thus the magnetic field system consists of as many magnetic paths, through the poles 14 and 14.1, pole yoke 11, air gap 41 and the armature core, as there are magnetic poles, each and all of which magnetic paths lie in a plane at right angles to the dynamometer axis. Whereas in other electro-dynamic absorption dynamometers heretofore used there is only one exciting field coil, the axis of which coincides with the dynamometer shaft axis, resulting in one annular magnetic path which lies in a plane parallel with the dynamometer axis. This causes the rotor shaft to be magnetized resulting in a strong, stray magnetic field at the ends of the rotor shaft which is an unsafe condition, especially in high speed rotating machinery.

The stator is finally completed by a pair of end members 17 and 18, each of which consists of a steel casting, suitably formed to precisely fit within the ends of the steel ring or pole yoke 11 and against the flanged ends of the bronze ring 12, and to be attached by means of bolts 19 to the radial flanges 13 of the bronze ring 12. Also, as shown, the peripheral edges of the end members 17 and 18 are secured directly to the steel ring or pole yoke 11 by means of angularly-spaced, radially-disposed set screws 20.

The end members 17 and 18 are formed to tightly fit against the ends of the bronze ring 12 so as to provide a water-tight joint therebetween, and also the central portion of each of the end

members 17 and 18 is arranged to house an annular ring and groove grease-filled seal, adapted to prevent passage of fluid along the shaft 2, where it passes through the end members, without creating frictional resistance to shaft rotation.

As shown, each of the grease-filled seals comprises an annular inner member 21, suitably fitted onto the shaft 2 and provided with a series of axially-spaced annular grooves 22 and an annular outer member 23 which consists of a diametrically-split ring having a plurality of axially-spaced annular ribs 24 on its inner surface, the ribs 24 being located so as to fit into the annular grooves 22 on the inner member 21. The annular outer member 23 is also provided with an inwardly-projecting radial flange 25 on its inner end and an annular ring 26 is disposed between the flange 25 and the inner end of the member 21 to reduce the shaft opening through the respective end member to a minimum.

The seal assembly is accomplished by first mounting the clearance ring 26 and the member 21 on the shaft 2 and then applying the two halves of the outer member 23 after which the respective end members are fitted over the seal and against the ends of the bronze ring 12. As shown in Fig. 1, the seal is secured to an inwardly-projecting flange 27 at the outer end of each end member by means of a series of bolts 28, which pass through the flange 27 and into the end of the split outer member 23.

The tortuous passageway in the seal provided by the interfitting rings and grooves of the seal members is filled with water-proof grease by means of a suitable fitting 23.1 connected through the end member by an appropriate passage, thus permitting rotation of the inner seal member 21, which is fastened to the shaft 2, relative to the outer seal member 23 without leakage of fluid along the shaft 2 and through the end members 17 and 18.

As shown in Fig. 1, each of the end members 17 and 18 is provided with angularly-spaced spider arms 29 which project axially from the outer face of the respective end member, and carry at their ends an annular flange 30 and, as shown, a ball bearing housing 31 is suitably fitted and attached by bolts 31.1 to the flange 30. Each ball bearing housing 31 is designed to house a ball bearing 32, arranged with its inner race fitted onto the shaft 2, and with its outer race fitted into the bearing housing 31, and a lock nut 33 threaded onto the shaft on the outer side of each ball bearing 32 is provided to clamp the ball bearing 32 against a suitable shoulder 34 formed on the shaft 2.

Also, the outer end of each bearing housing 31 is arranged to receive an externally-mounted self-aligning ball bearing 35, the outer race of which is fitted into a bearing stand or support 36 which is an integral part of the stationary base, not shown, for the dynamometer assembly.

Thus, my improved dynamometer comprises a rotor fixedly mounted on the shaft 2 and surrounded by a water-tight housing or stator which, itself, is journaled in the bearing stands 36 for independent rotation on the axis of the shaft 2, the shaft 2 being journaled in the housing or stator on the bearings 32 so that the shaft 2 is free to rotate relative to the stator housing.

As shown in Figs. 2 and 3, the steel ring or pole yoke 11 which comprises the outer shell of the stator or housing, is provided with oppositely-disposed torque arms 37 which extend radially

from the pole yoke in a direction normal to the axis of the shaft 2, and in operation one of the arms 37 is connected in the usual manner to a suitable torque-measuring apparatus, such as a scale or weight-measuring device, not shown.

It will now be seen that the inner faces of the pole pieces 14 and 14.1, the bronze ring 12 and the inner surfaces of the end members 17 and 18, together with the grease seals at the shaft openings in the end members, form an enclosed fluid-tight casing within which the rotor or armature alone is housed and as shown in Fig. 1, an inlet 38 at the lower side of the end member 18 and an outlet 39 at the upper side of the end member 17 are provided for the passage of a suitable cooling fluid through the interior of this armature housing.

The field coils have their own separate cooling system, as distinguished from the armature cooling system, to dissipate the energy used in their excitation and to keep them within safe operating temperatures. This is accomplished by means of the natural convection of heated air currents between suitably positioned openings in the pole yoke 11 leading to the exterior thereof, which openings, while not shown, are well known and commonly used for this purpose.

The cooling fluid for the armature may be water or any other suitable means supplied from a source, not shown, having a pressure head of two pounds or more and in operation of the dynamometer the flow of such cooling fluid is accelerated by the action thereupon of the armature which functions as a centrifugal pump impeller.

In accordance with the usual practice with hydraulic dynamometers, regulating valves, not shown, may be inserted in the outlet connection, or in both inlet and outlet connections, to regulate the rate of fluid flow through the device. Also, in the present device, a temperature indicating means, not shown, is connected in the outlet since one function of the fluid is to cool the operating parts. Thus, the flow of fluid can be regulated to keep the discharge temperature within a safe operating range of between 160° and 180° F.

In order to positively direct the cooling fluid supplied at the inlet 38 through the interior of the stator or housing and around and through the armature core, the inside surfaces of the end members 17 and 18 are provided with an annular, axially-curved channel or passage 40 located between the inner periphery of the bronze ring 12 and the axis of the aligned openings 6 in the rotor rings 1; thus providing a smooth radial path to direct the flow of the cooling fluid from the inlet passage 38 along the sides of the rotor to the aligned openings 6, where the cooling fluid enters the rotor and then passes outwardly therefrom through the passageways 7 between the core discs 1.

The clearance space 41 between the periphery of the rotor and the inner periphery of the pole pieces 14 and the bronze ring 12, which forms a gap in the path of the magnetic flux set up in the magnetic circuit by the respective pole pieces, also serves as a passage for the cooling fluid, flowing through the spaces 7 to the periphery of the rotor or armature, so that the cooling fluid may recirculate from the periphery of the rotor around the ends thereof and into the aligned openings 6, the cooling fluid eventually, in the course of rotation of the rotor, finding its way to the outlet passageway 39 in the end member 17.

During operation of the herein-described absorption dynamometer, cooling fluid is circulated through the stator or housing from the inlet passage 38 to the outlet passage 39 at a rate proportionate to the power absorbed by the combined hydraulic and electro-dynamic functions of the device, the rotor thus being completely enclosed or surrounded by cooling fluid which is also circulated and recirculated through the rotor structure at a rate proportionate to the peripheral speed of the rotor to keep the dynamometer cooled to within proper operating temperatures. Also, the rotor, being driven by means of the shaft 2 which in turn is driven by a prime mover or motor, not shown, serves both as a pump impeller and a friction creating element, the axially-extending, peripherally-disposed winding bars 9 on the rotor serving as impeller blades which speed up or accelerate circulation and recirculation of the cooling fluid through the dynamometer and which set up resistance to rotor rotation. Thus as the rotor or armature is driven by the prime mover the power load developed by the latter is absorbed in the dynamometer both by fluid friction and electro-dynamically and the total torque developed in the dynamometer during such power absorption is measured by means of the torque arms 37 in the well-known manner.

For example, knowing the torque (lbs.) as measured from the torque arms 37, and the revolutions per minute (R. P. M.), the horsepower developed by the prime mover and absorbed by the dynamometer can be readily calculated by the formula:

$$H. P. = \frac{\text{lbs.} \times R. P. M.}{K}$$

where K is the constant of the dynamometer. The value for K is determined as follows:

$$K = \frac{2S\pi \times \text{radius of torque arm in feet}}{33,000}$$

the radius of the torque arm usually being made so that K is an even thousand number.

There are two features to the herein-described dynamometer which develop the torque; namely, the hydraulic feature and the dynamic feature. The hydraulic feature is present in the dynamometer at all operating speeds and is an inherent feature of the present construction, because any body or mass, in this case the rotor, revolving in a body of fluid is opposed to motion by fluid friction. This hydraulic feature or function is further accentuated by the centrifugal action of the rotor bars 9 acting as impeller blades in a centrifugal pump causing the fluid to attain increased velocity and to circulate and recirculate through the rotor body.

Thus, the hydraulic feature will absorb power in proportion to the speed of rotation and to the quantity of fluid enclosed in the rotor housing or stator, which power absorption however, is only a portion of the power for which the present dynamometer is designed, further power absorption up to full load capacity of the dynamometer being obtained by the dynamic feature.

The dynamic feature is obtained by exciting the field coils 16 and 16.1 on the radial pole pieces 14 and 14.1 from a separate source, not shown, of direct current at a suitable voltage connected to the field coil lead wires 16.2.

The pole pieces 14 and 14.1 being of alternate North and South polarity, a magnetic flux is set up in a path consisting of the pole pieces 14 and 14.1, the pole yoke 11, the gap 41, and

the rotor core. The rotor revolving in this magnetic field causes the rotor bars 9 to cut magnetic lines of force and thus set up an electromotive force causing current to flow in the rotor bars 9, which being connected together by the end rings 10, causes the current to flow through a closed circuit, entirely contained on the rotor body, the energy created by such current flow being dissipated as heat. The cooling fluid circulated and recirculated through the rotor passages 6 and 7, which is a function of the hydraulic feature of this device, absorbs the heat created by the current flow in the rotor bars 9 and the rings 10 and ultimately removes such heat energy from the machine upon being discharged through the outlet 39.

The dynamic feature of my improved dynamometer absorbs power in proportion to the product of the voltage and the current in the rotor bars 9. The said voltage and current are, in turn, proportional to and may be varied by variation of the speed of rotation and, or, the current in the exciting field coils 15.

In the electro-dynamic dynamometers of the wound-rotor type, absorption of the energy created within the dynamometer was obtained by some externally-connected device such as a rheostat and the present construction is intended to obviate such cumbersome, expensive and inconvenient means. This has been accomplished by both generating and dissipating power currents on the rotor or armature itself in a closed circuit high resistance winding confined entirely to the rotor body and capable of carrying a sufficiently large current. Thus slip rings or commutator and all external connections to the armature are eliminated. A high resistance winding for this purpose is essential in devices of the kind hereindescribed in that it keeps the armature currents limited and permits a high voltage to be obtained, thus producing the highest degree of armature performance.

Also, in other electro-dynamic machines, it is common practice to absorb the generated power by means of eddy currents created in the rotor body and in the stator, however, such eddy currents tend to de-magnetize the pole pieces or the magnetic field and therefore defeat the function of the apparatus. In my improved dynamometer the construction is particularly designed to minimize such objectionable eddy currents and for this reason the laminated rotor discs are preferable, thus providing a device from which maximum operating efficiency and capacity can be obtained.

The principal advantages of my improved dynamometer lie in the novel arrangement, whereby a hydraulic function and a dynamic function are combined in a single highly-efficient power absorption device, whereby greater capacity for the device may be obtained without increasing the bulk or weight of the construction. Other advantages are to be found in the small size in which the dynamometer can be built for any predetermined maximum power condition, thus providing a more convenient device, since it may be readily moved from place to place. Other advantages are found in the simplicity with which the device is operated, particularly in that the necessity for external rheostats, or other externally-connected means, to dissipate heat produced by the dynamic function or feature is obviated.

Although but one specific embodiment of this invention is herein shown and described, it will

be understood that details of the construction shown may be altered or omitted without departing from the spirit of this invention as defined by the following claims.

I claim:

1. An electro-dynamic dynamometer comprising a stator, an armature rotatably housed within said stator and arranged to generate power currents the circuit for which is wholly confined to the armature itself, and means to circulate a cooling liquid through said stator to dissipate heat produced in the rotor body by said power currents, said stator comprising an annular field magnet frame, a plurality of radial angularly-spaced pole pieces carried by said frame, and fluid-tight means within said frame arranged to enclose said pole pieces whereby the ends only thereof may be contacted by said cooling liquid.

2. An electro-dynamic dynamometer comprising a stator, an armature rotatably housed within said stator and arranged to generate power currents the circuit for which is wholly confined to the armature itself, and means to circulate a cooling liquid through the interior of said stator to dissipate heat produced in the rotor body by said power currents, said stator comprising an annular field magnet frame, a plurality of radial angularly-spaced pole pieces carried by said frame, and non-magnetic fluid-tight means within said frame arranged to enclose said pole pieces whereby the ends only thereof may be contacted by said cooling liquid.

3. An electro-dynamic dynamometer comprising a stator, an armature rotatably housed within said stator and arranged to generate power currents the circuit for which is wholly confined to the armature itself, and means to circulate a cooling liquid through the interior of said stator to dissipate heat produced in the rotor body by said power currents, said stator comprising a hollow annular field magnet frame, a pair of end members closing the ends of said frame, a plurality of radially-disposed angularly-spaced pole pieces carried by and projecting inwardly from said frame, and an inner shell disposed within said frame and having liquid-tight connection with said end members, said shell having peripheral openings to receive the ends of said pole pieces and the edges of said openings being in liquid-tight contact therewith.

4. An electro-dynamic dynamometer comprising a stator, an armature rotatably housed within said stator and arranged to generate power currents the circuit for which is wholly confined to the armature itself, and means to circulate a cooling liquid through the interior of said stator to dissipate heat produced in the rotor body by said power currents, said stator comprising a hollow annular field magnet frame, a pair of end members closing the ends of said frame, a plurality of radially-disposed angularly-spaced pole pieces carried by and projecting inwardly from said frame, and an annular non-magnetic ring concentrically disposed within said frame and having liquid-tight connection with said end members, said ring having peripheral openings to receive the ends of said pole pieces and the edges of said openings being in liquid-tight contact therewith.

5. An absorption dynamometer comprising a hollow fluid-tight housing having end closures and respective inlet and outlet openings therein for passage of a cooling liquid through said housing, a rotatable shaft extending through said housing, and a rotor mounted on said shaft and

enclosed within said housing, said rotor having axially-extending passages therethrough and radial passages leading from said axially-extending passages to the rotor periphery, said end members each having an axially concentric annular channel in its inner face communicating with a respective one of said inlet and outlet openings, and said channels having one side directed toward said axially-extending rotor passages to direct passage of cooling liquid thereinto.

6. An absorption dynamometer comprising a hollow fluid-tight housing having end closures and respective inlet and outlet openings therein for passage of a cooling liquid through said housing, a rotatable shaft extending through said housing, a rotor fixed on said shaft and enclosed within said housing, said rotor having axially-extending passages therethrough and radial passages leading from said axially-extending passages to the rotor periphery, means forming a closed circuit winding on said rotor, means on said housing providing a magnetic field normal to the axis of and within the path of said rotor, said end closures each having an axially concentric annular channel in its inner face and communicating with a respective one of said inlet and outlet openings, and said channels having one side directed toward said axially-extending rotor passages to direct passage of cooling liquid thereinto and to permit circulation of said liquid around the ends of said rotor.

7. In an electro-dynamic dynamometer, a stator comprising a cylindrical non-magnetic open-ended ring having annular radial outwardly projecting end flanges, a pole yoke annularly surrounding said ring and periphery engaging the end flanges thereof, a plurality of angularly-

spaced pole pieces attached to said pole yoke and projecting radially inward through respective openings in said ring, said pole pieces having their inner end faces substantially flush with the inner surface of said ring and having fluid-tight contact with the edges of said openings, respective exciting coils surrounding said pole pieces and housed between said ring and said pole yoke, and end members respectively closing off the ends of said ring and arranged to provide an enclosed fluid-tight space within the same, said end members having an inlet and outlet passage respectively for the passage of fluid through said enclosed fluid-tight space.

8. In an electro-dynamic dynamometer, a stator comprising a cylindrical non-magnetic open-ended ring, a pole yoke annularly surrounding and spaced from the cylindrical body of said ring, a plurality of angularly-spaced pole pieces attached to said pole yoke and projecting radially inward through respective openings in said ring, said pole pieces having their inner end faces substantially flush with the inner surface of said ring, and said pole pieces having the entire periphery of their inner end faces integrally connected with said ring to provide a fluid-tight joint therebetween, respective exciting coils surrounding said pole pieces and housed between said ring and said pole yoke, and end members respectively closing off the ends of said ring and arranged to provide an enclosed fluid-tight space within the same, said end members having an inlet and outlet passage respectively for the passage of fluid through said enclosed fluid-tight space.

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