March 23, 1954 E. L. CLINE 2,672,953

DYNAMOMETER WITH BUILT-IN HEAT EXCHANGER

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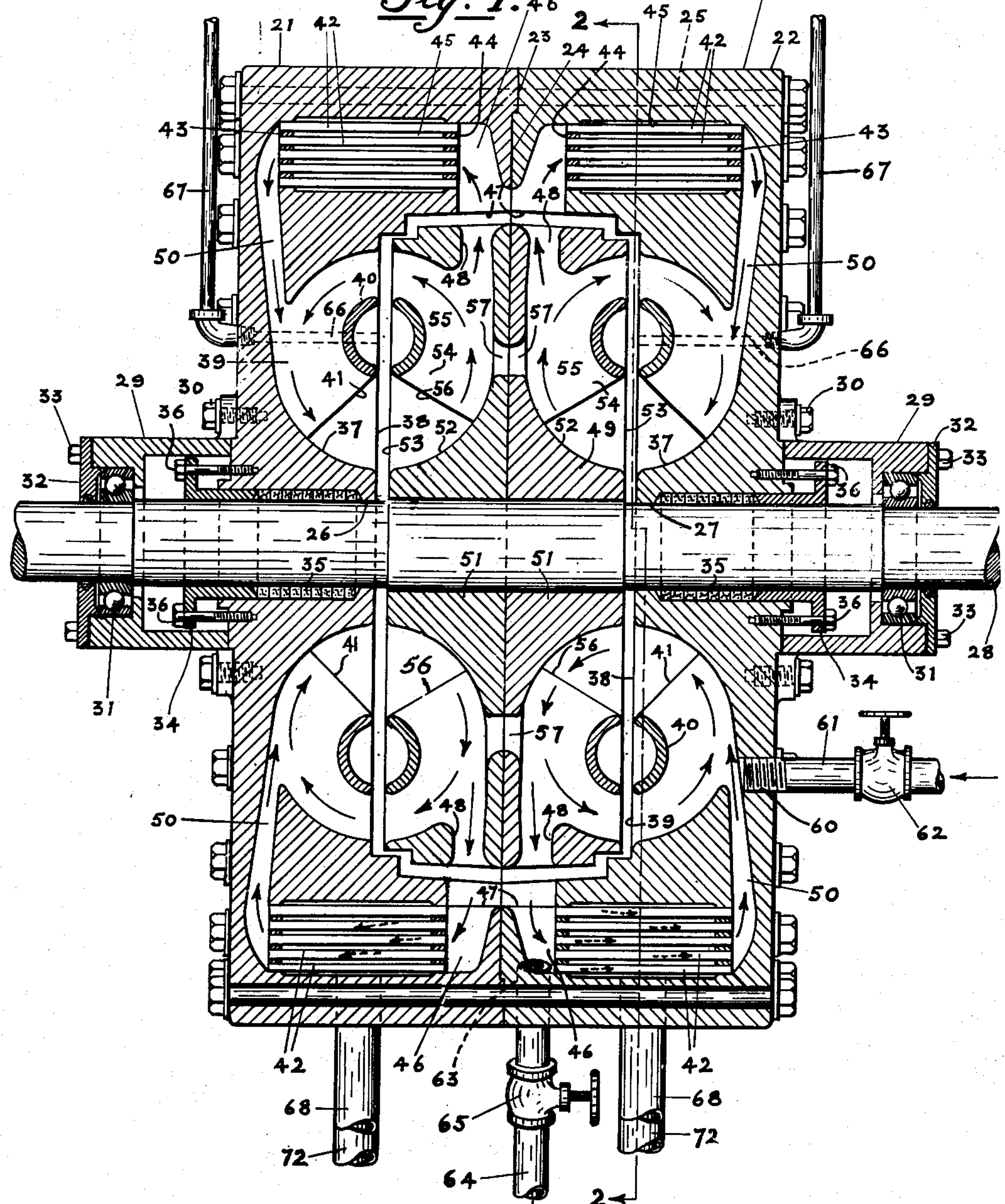
Fig. 1.



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DYNAMOMETER WITH BUILT-IN HEAT EXCHANGER

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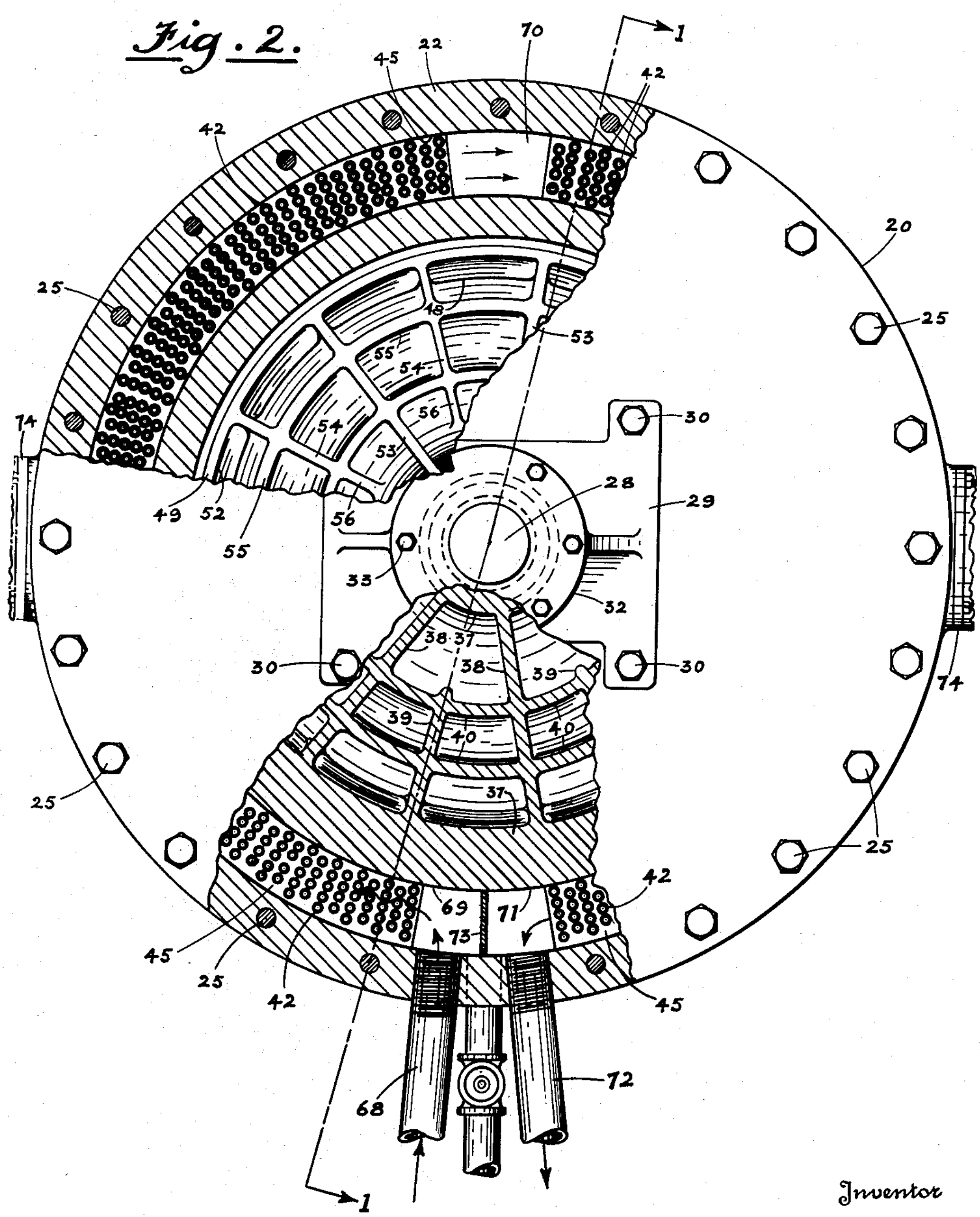
Fig. 2.



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DYNAMOMETER WITH BUILT-IN HEAT EXCHANGER

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Fig. 3.

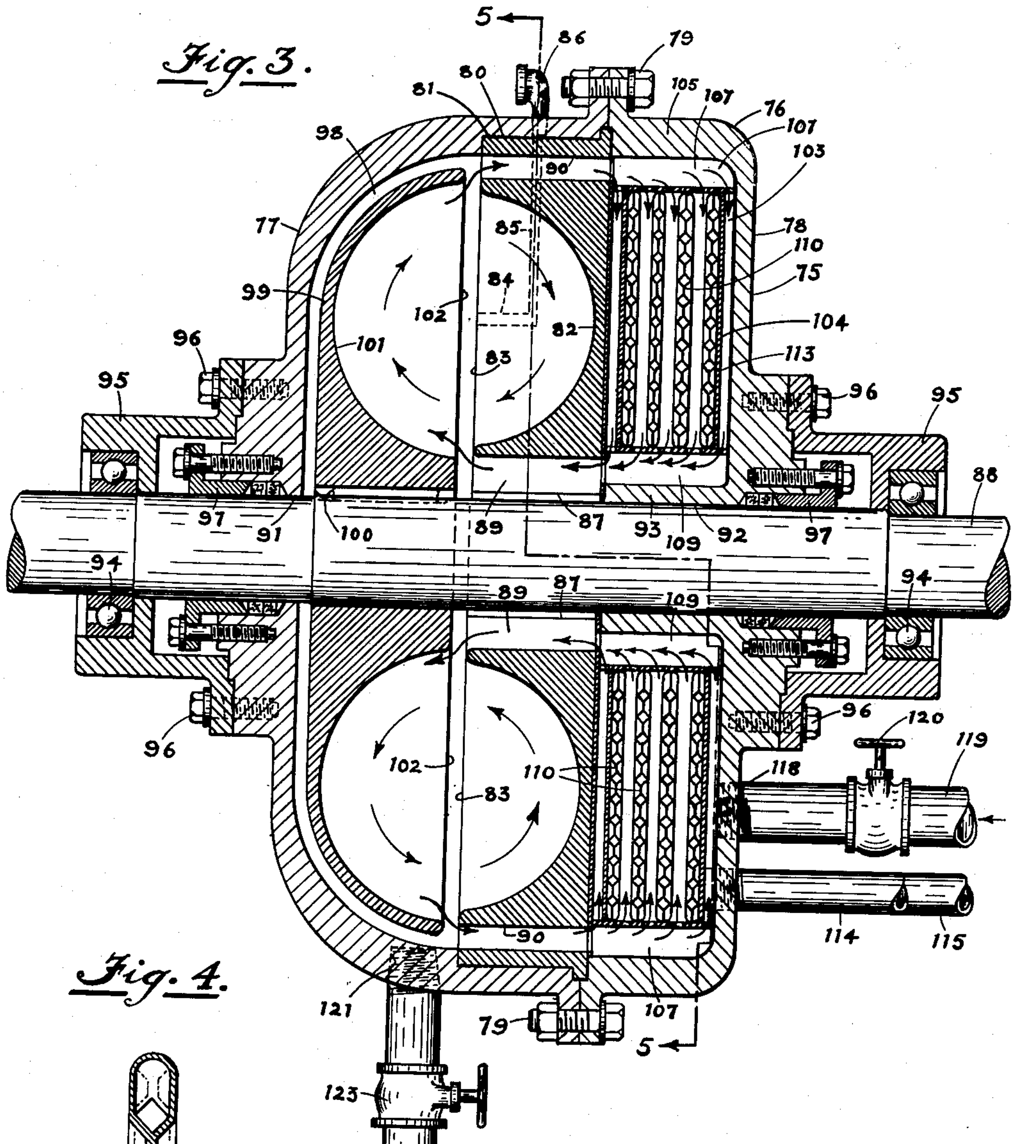
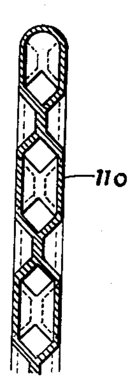


Fig. 4.



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DYNAMOMETER WITH BUILT-IN HEAT EXCHANGER

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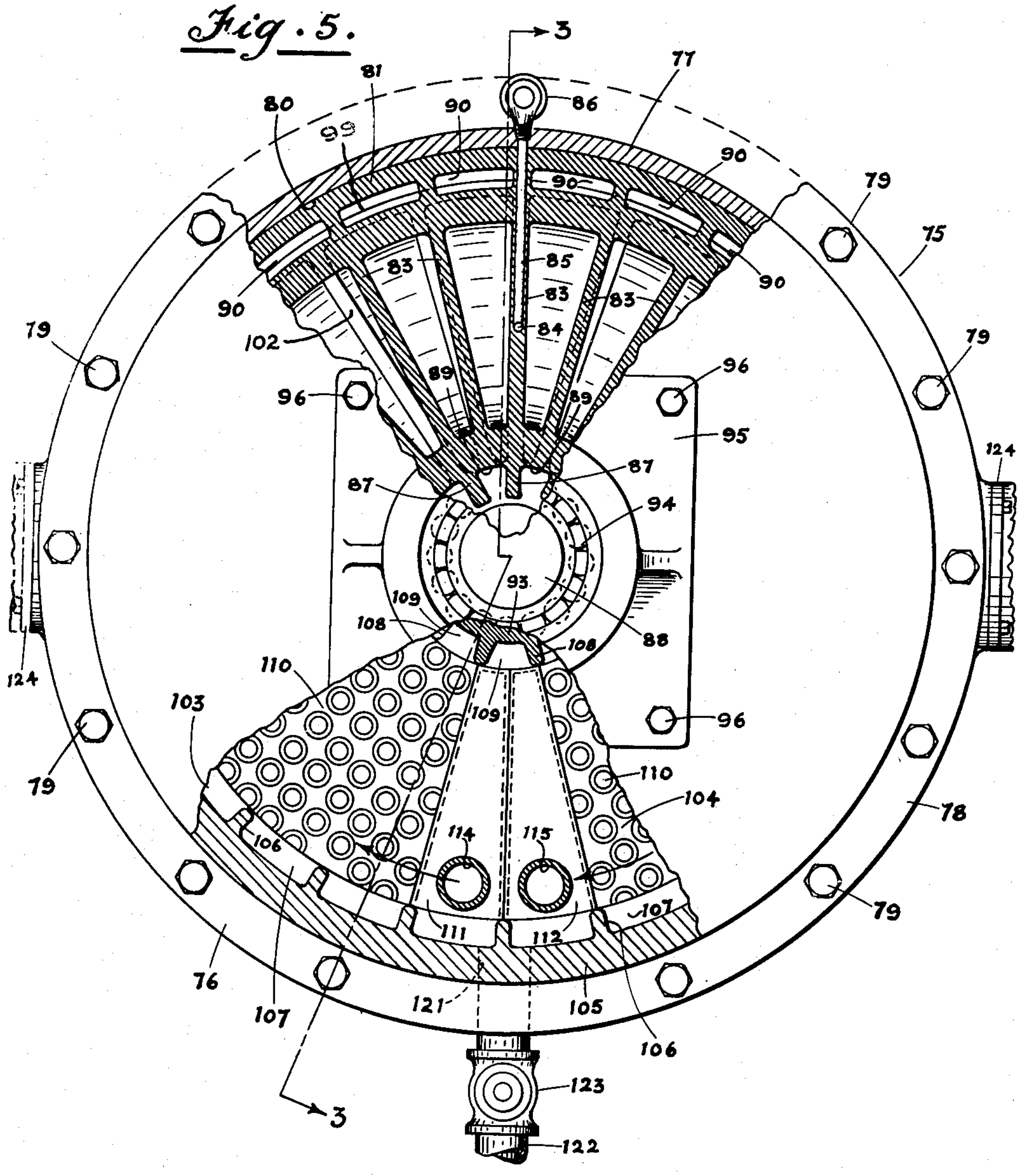
Fig. 5.



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DYNAMOMETER WITH BUILT-IN HEAT EXCHANGER

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Fig. 6.

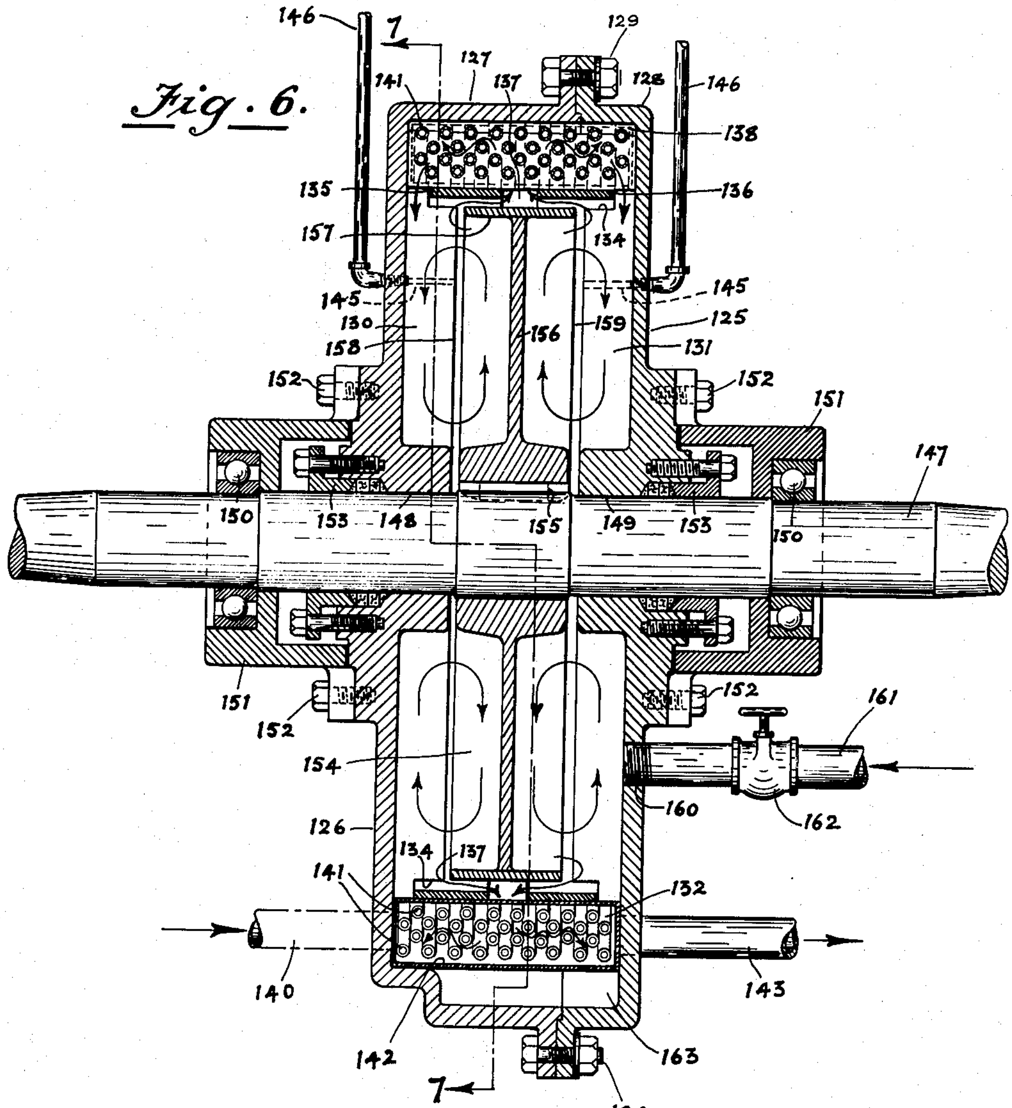

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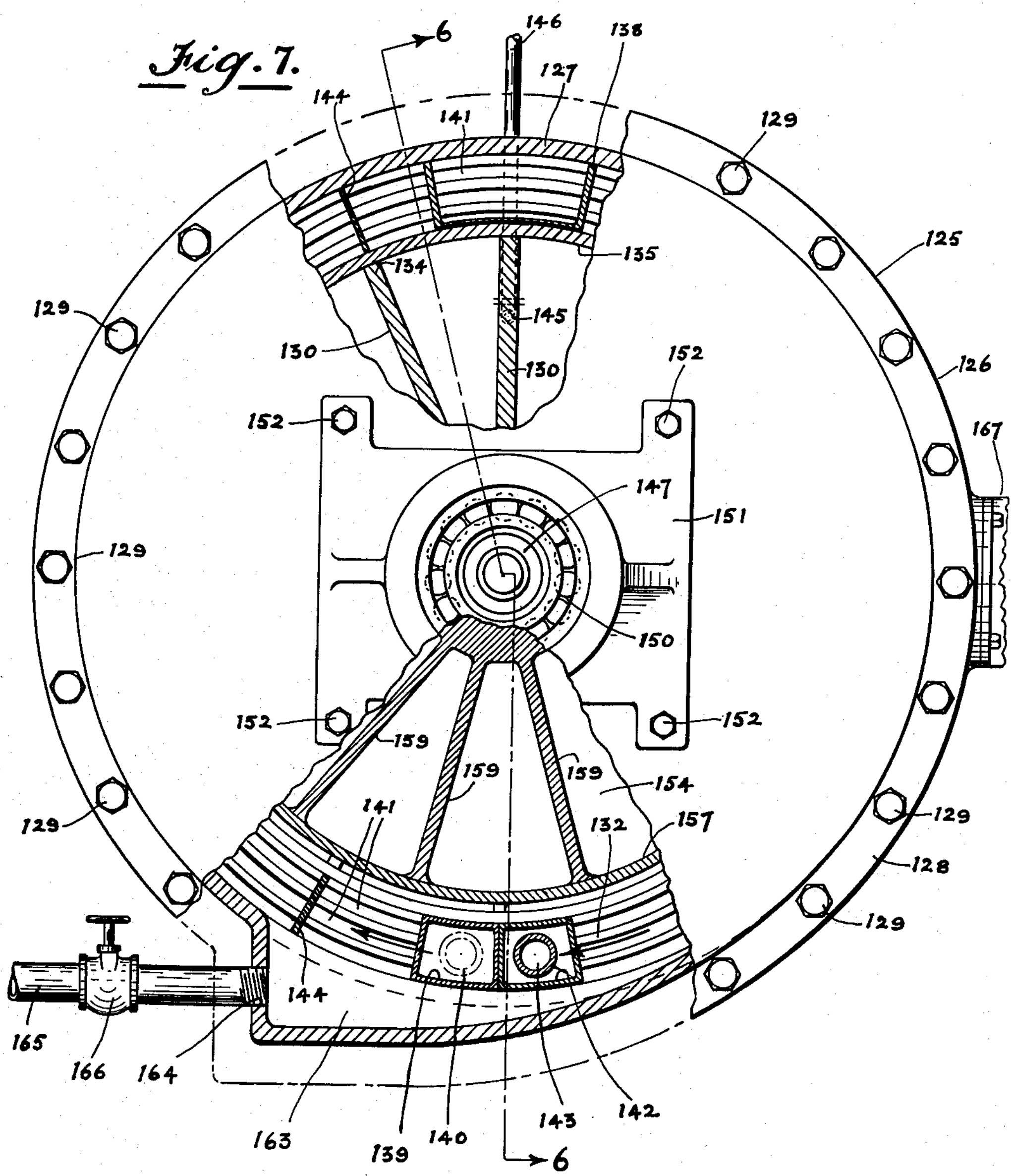
Fig. 7.



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DYNAMOMETER WITH BUILT-IN HEAT EXCHANGER

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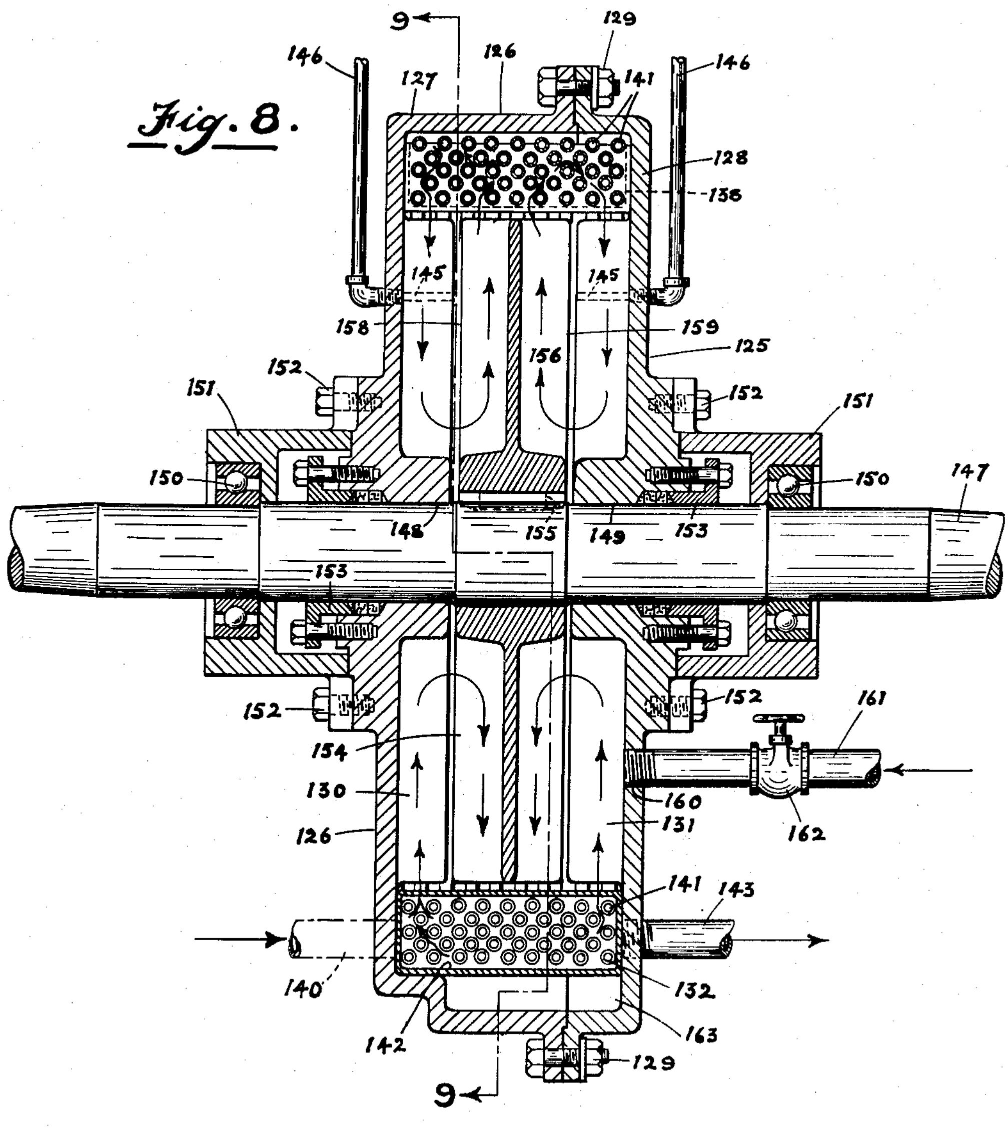
Fig. 8.



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DYNAMOMETER WITH BUILT-IN HEAT EXCHANGER

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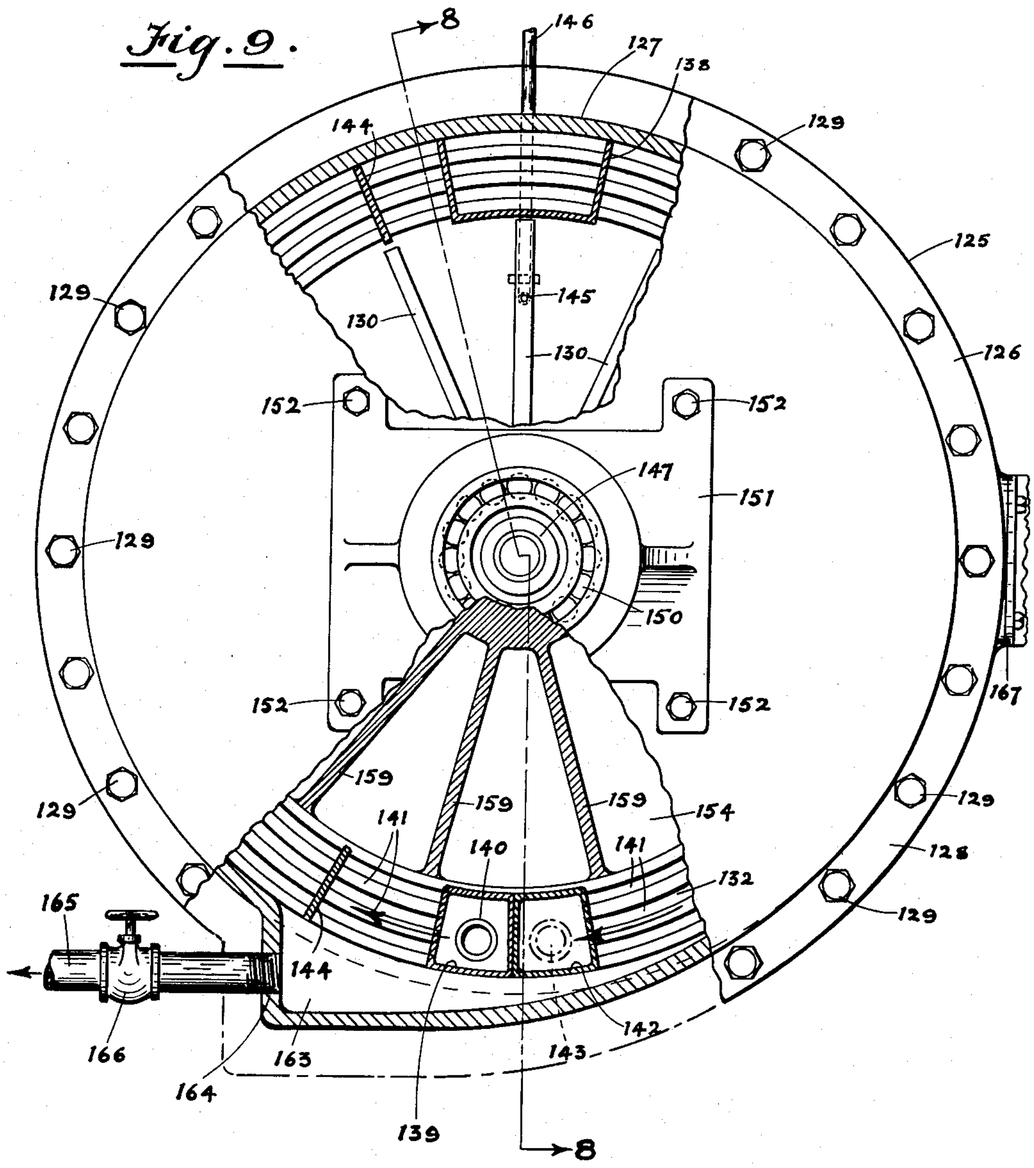
Fig. 9.



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DYNAMOMETER WITH BUILT-IN HEAT EXCHANGER

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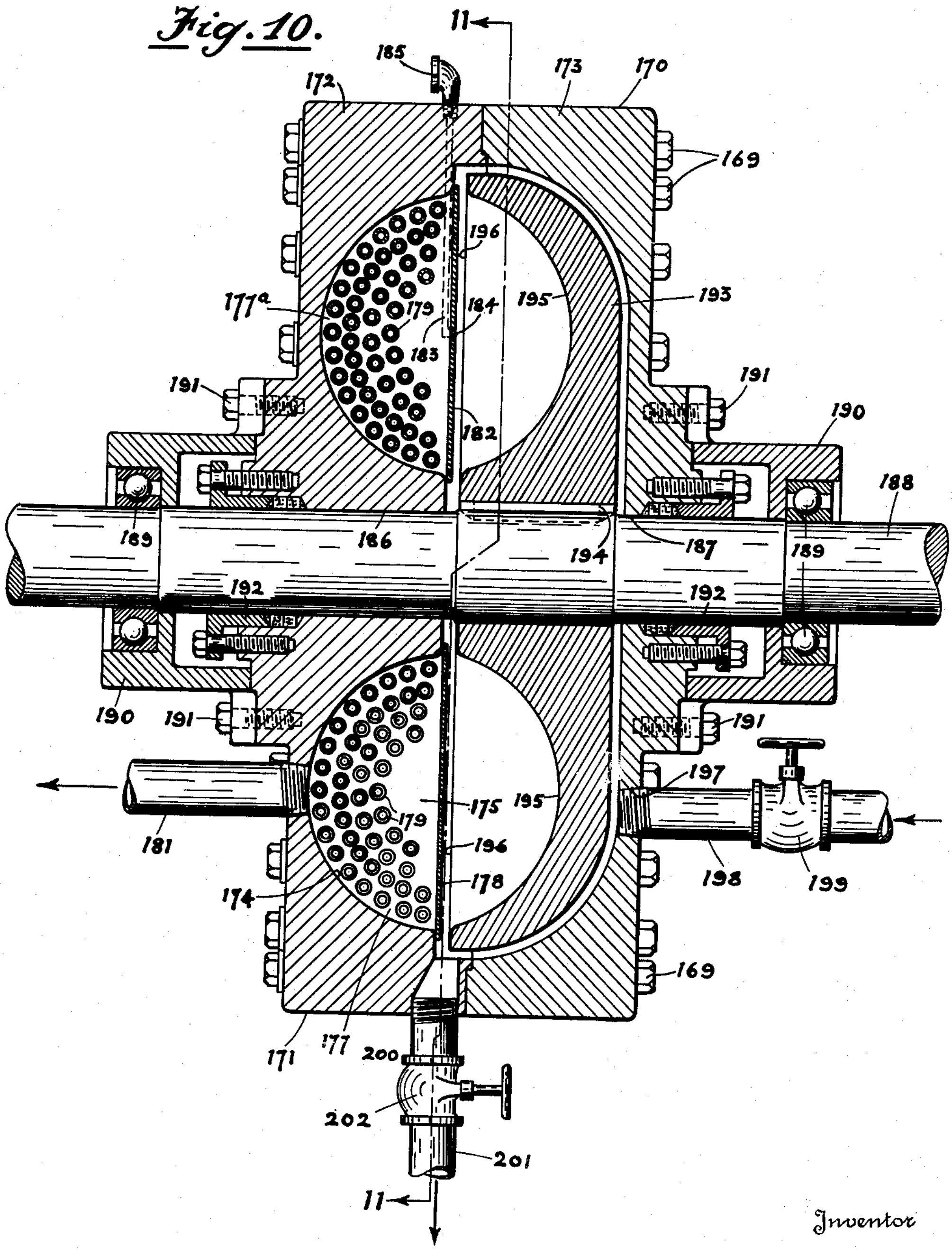
Fig. 10.



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DYNAMOMETER WITH BUILT-IN HEAT EXCHANGER

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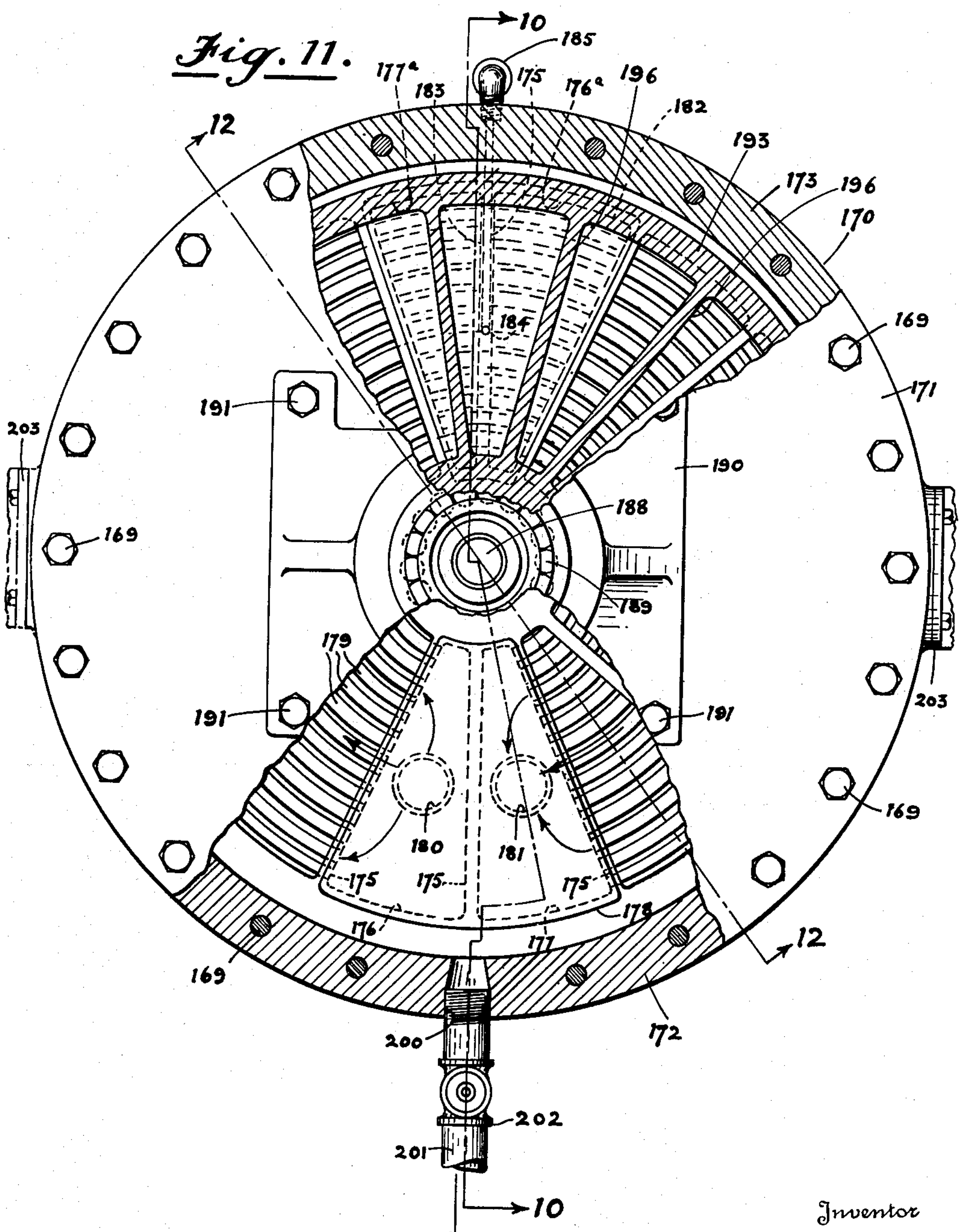
Fig. 11.



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DYNAMOMETER WITH BUILT-IN HEAT EXCHANGER

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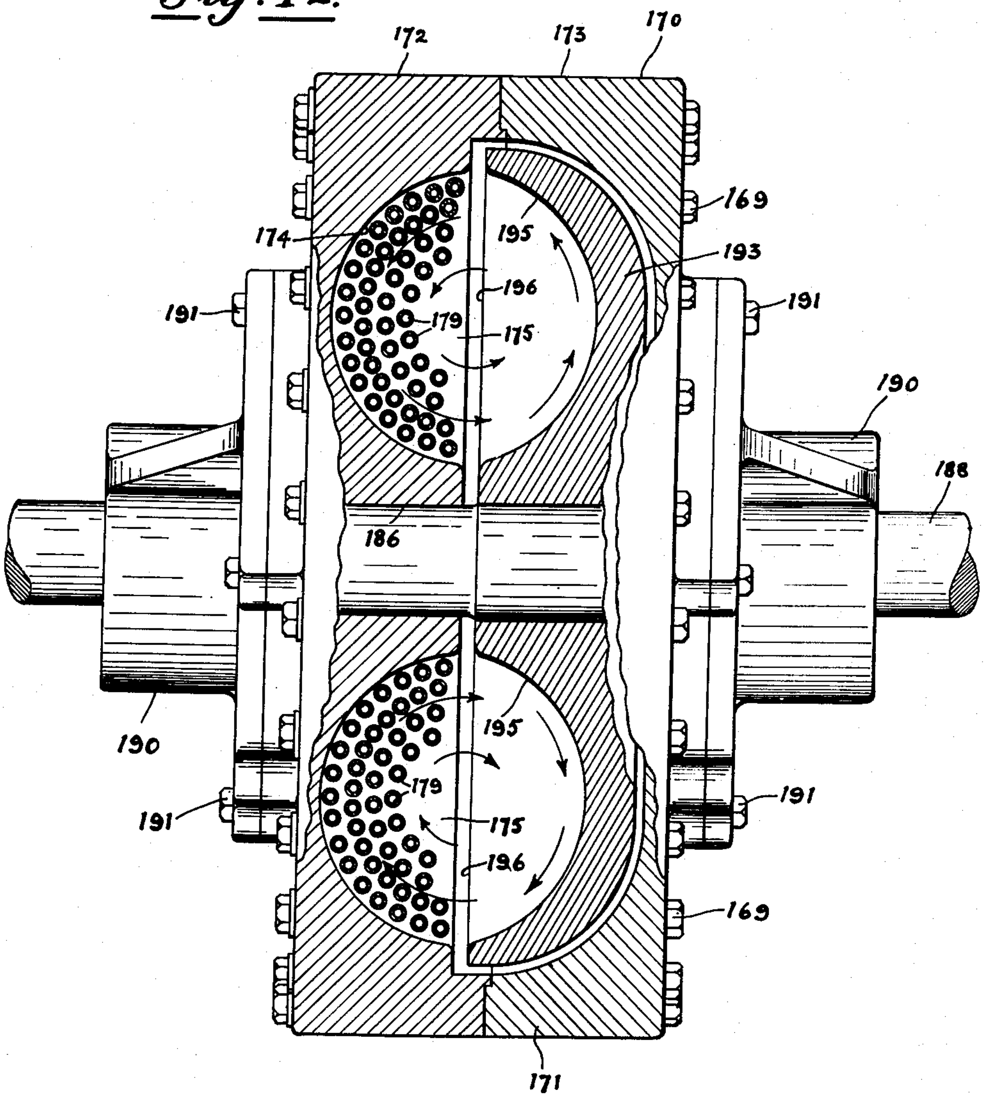
Fig. 12.



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DYNAMOMETER WITH BUILT-IN HEAT EXCHANGER

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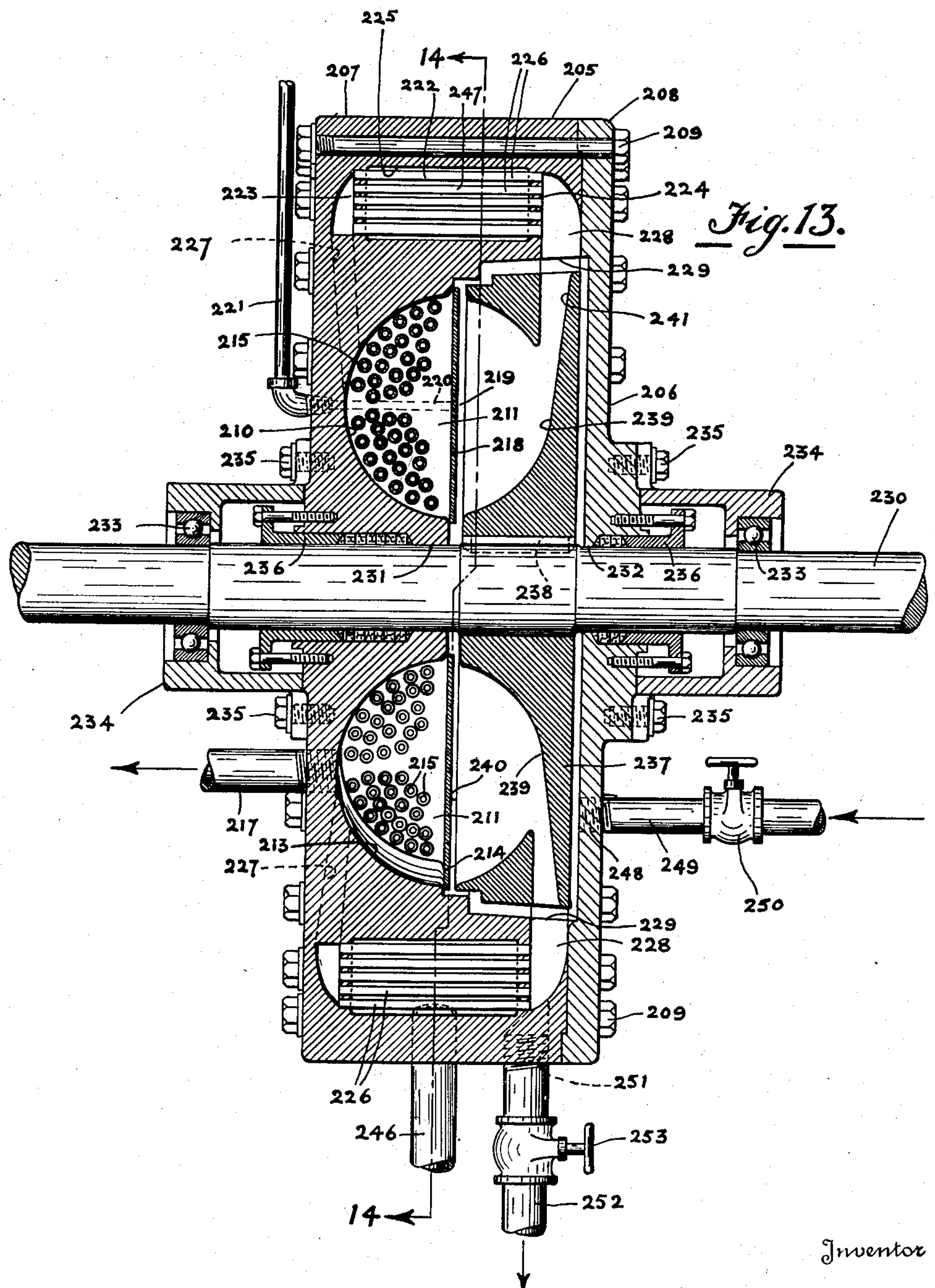

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DYNAMOMETER WITH BUILT-IN HEAT EXCHANGER

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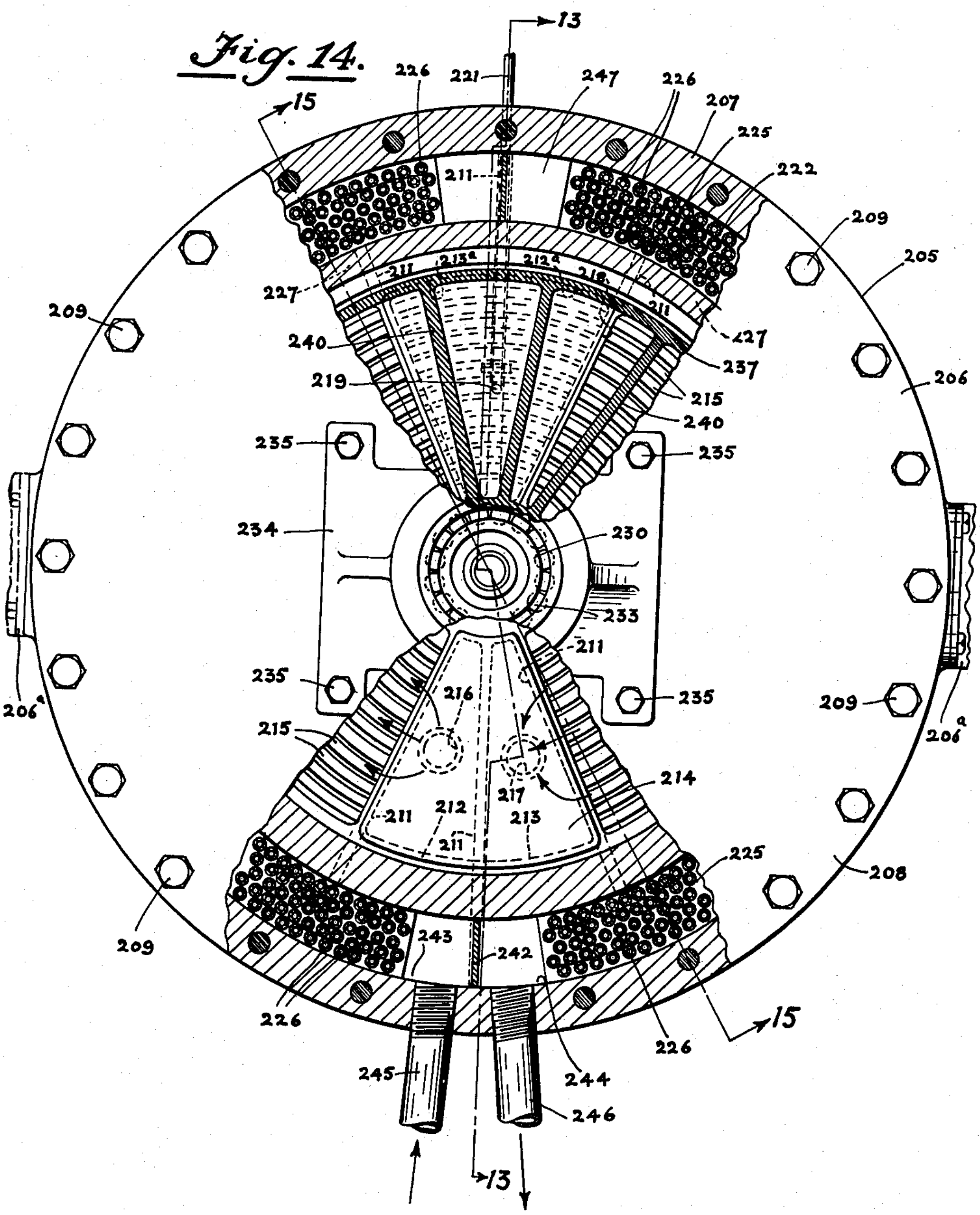
Fig. 14.



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DYNAMOMETER WITH BUILT-IN HEAT EXCHANGER

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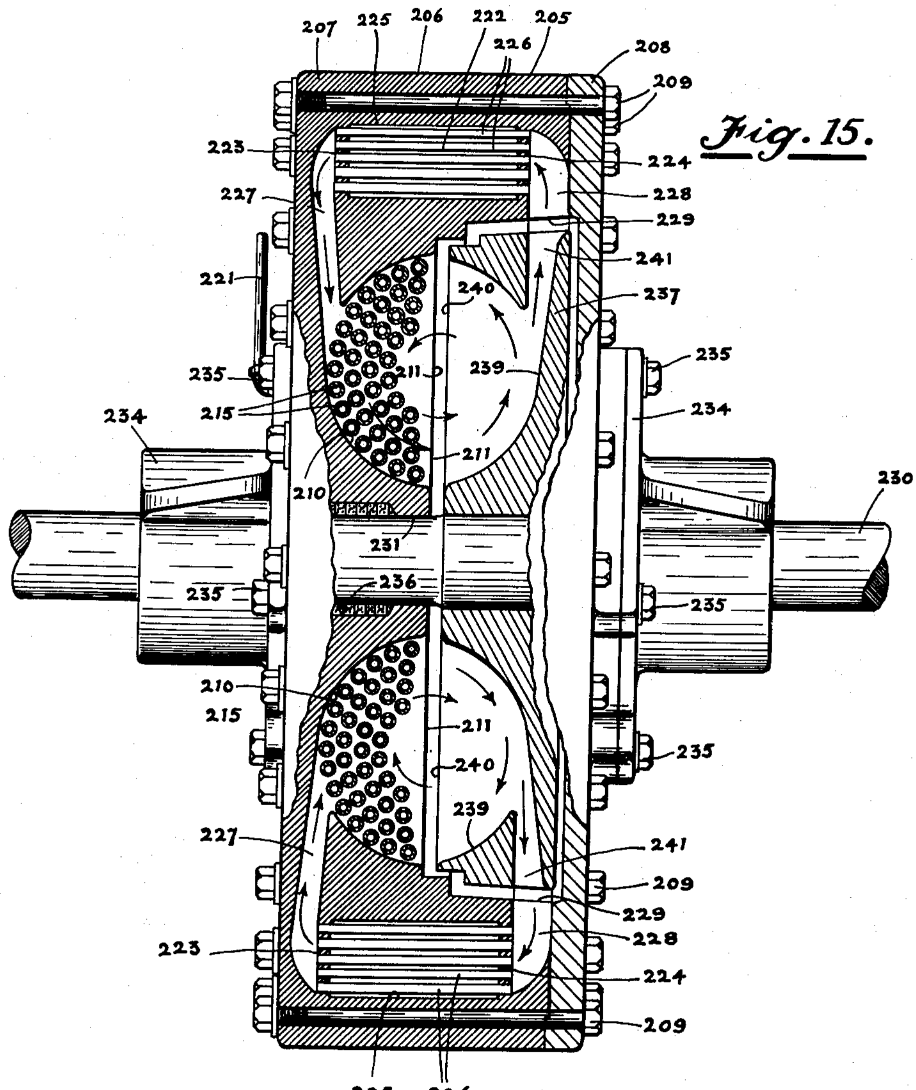

Fig. 15.

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DYNAMOMETER WITH BUILT-IN HEAT EXCHANGER

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Fig. 16.

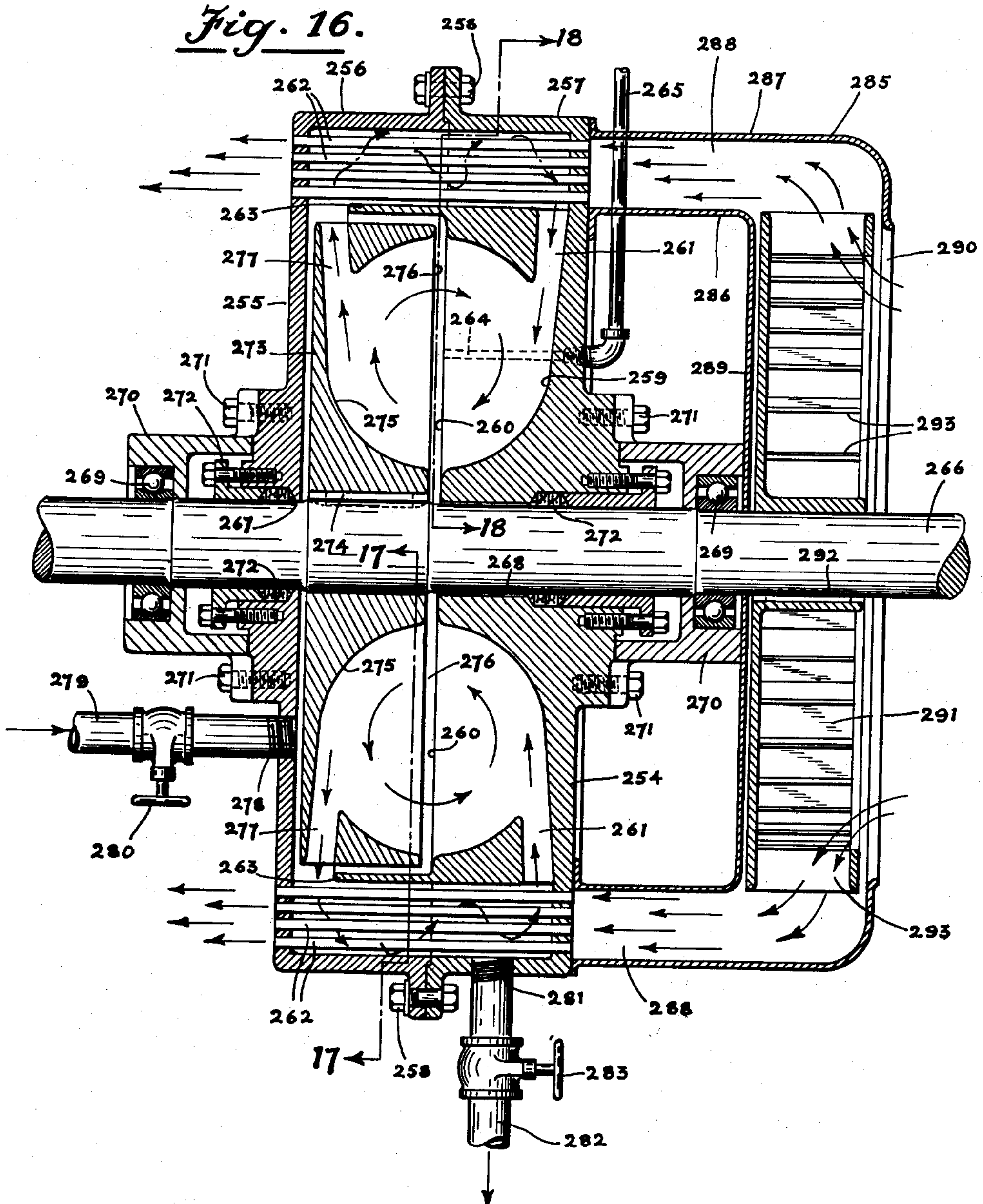

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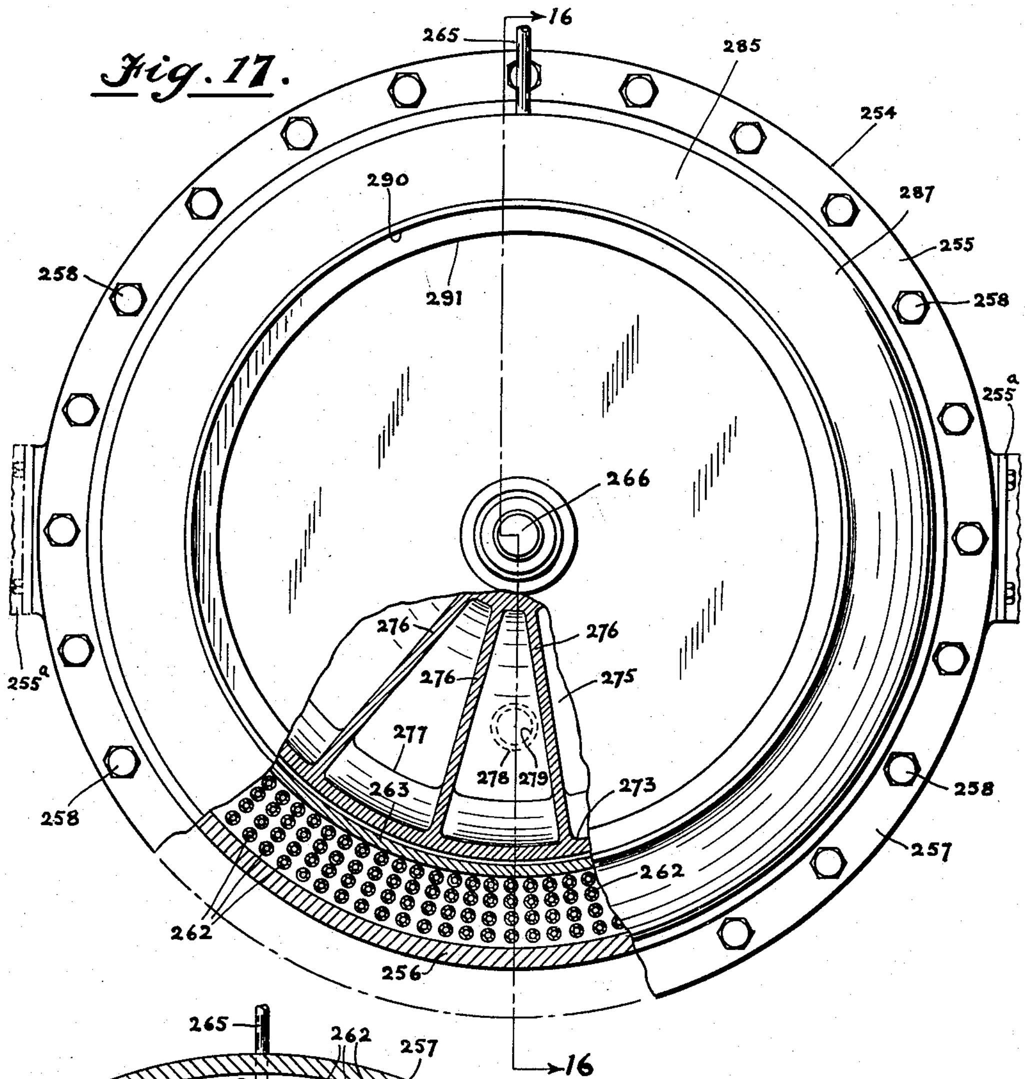
Fig. 17.



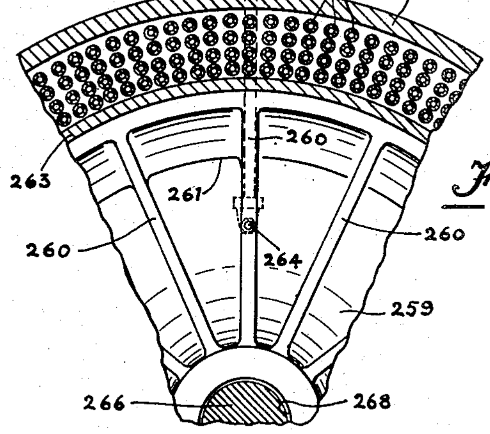


Fig. 18.

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DYNAMOMETER WITH BUILT-IN HEAT EXCHANGER

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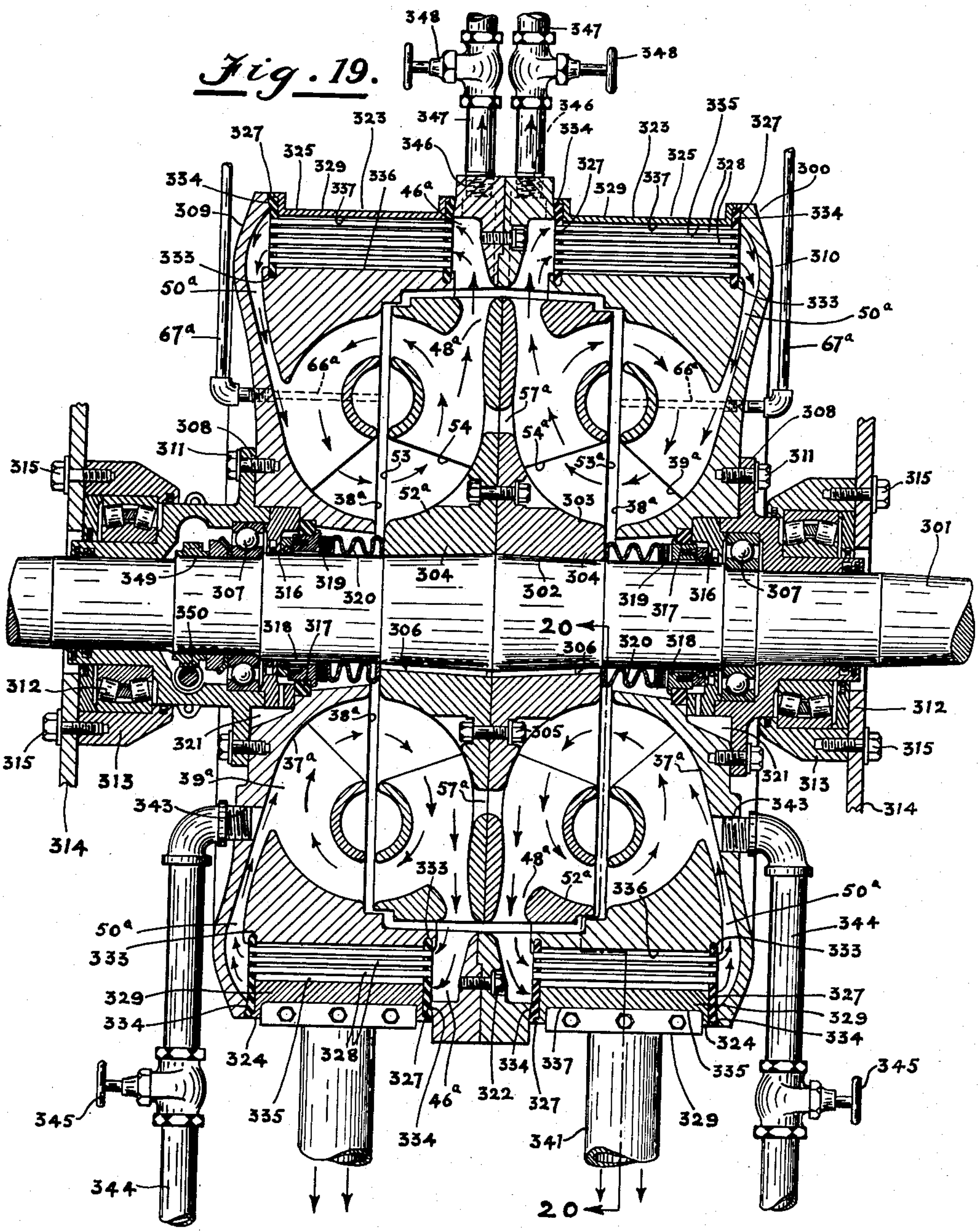
Fig. 19.



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DYNAMOMETER WITH BUILT-IN HEAT EXCHANGER

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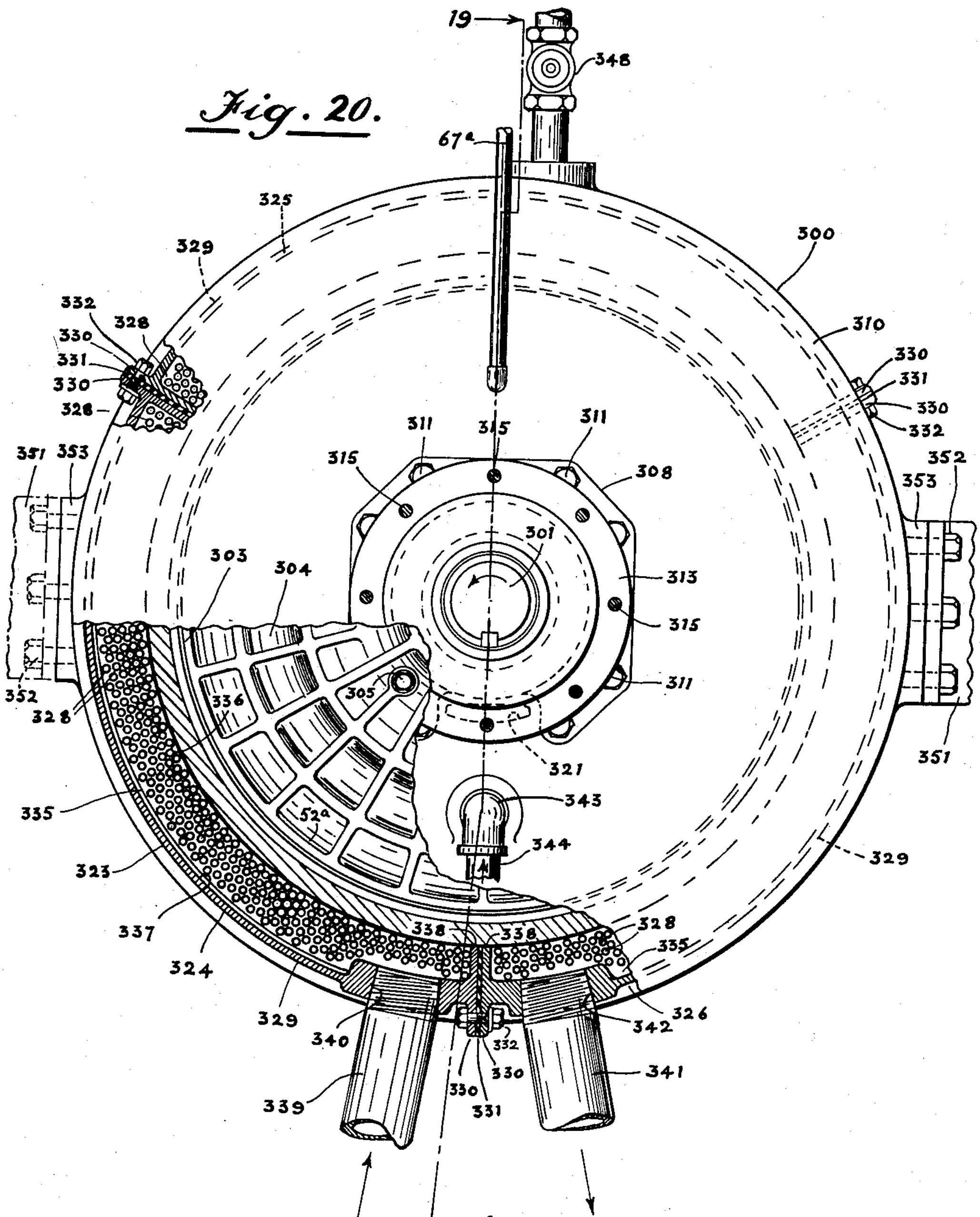
Fig. 20.



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Patented Mar. 23, 1954

2,672,953

UNITED STATES PATENT OFFICE

2,672,953

DYNAMOMETER WITH BUILT-IN HEAT EXCHANGER

Edwin L. Cline, Pasadena, Calif., assignor to Clayton Manufacturing Company, Alhambra, Calif., a corporation of California

Application August 2, 1946, Serial No. 688,004

57 Claims. (Cl. 188—90)

1

The present invention relates to hydraulic dynamometers or brakes, and more particularly to dynamometers or brakes employed as power absorption devices and having heat exchange means associated therewith for effecting cooling of the power absorption fluid.

More specifically, the invention relates to a novel power absorption device including heat exchange means arranged in the housing of the device, whereby the device can be made as an extremely compact, self-contained unit. The present invention contemplates disposing the heat exchange means in either the normal working circuit of a brake or dynamometer (which provides an extremely compact unit), or externally of the normal working circuit; or where unusually great amounts of heat are to be absorbed, disposition of the heat exchange means in both the normal working circuit and externally of said working circuit. The invention further contemplates the use of any suitable liquid or gas as the power absorption fluid, the heat exchange means disclosed being adapted to cool both. When a gas, such as air, is employed as the power absorption fluid, the same can be introduced into the brake or dynamometer housing under super-atmospheric pressure and used alone to absorb loads slightly in excess of the normal "windage" load, or used with a liquid to effect stability under certain load conditions, or alone under sub-atmospheric pressure where loads less than the normal windage load are to be absorbed, all as fully set forth in greater detail in my copending application Serial No. 686,346, filed July 26, 1946, Patent No. 2,634,830, April 14, 1953. The invention still further contemplates the use of liquid or air as a cooling medium for the power absorption fluid.

The principal object of the invention is to provide a compact power absorption device having a built-in heat exchanger of sufficient capacity to maintain the power absorption fluid at a desired operating temperature regardless of the load.

Another object of the invention is to provide a power absorption device with a built-in heat exchanger so associated with the normal working circuit of said device as to provide a closed circulating system for the brake or power absorption fluid, thereby making it possible to maintain any desired constant load without excessive operating temperatures.

Another object of the invention is to provide a hydraulic power absorption device including heat exchange means constructed to permit high

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velocity flow therethrough during all conditions of operation of the device so as to maintain the air and the liquid in the device in a state of thorough mechanical intermixture, whereby to maintain a constant load by preventing air from collecting in large bodies and at the same time effecting efficient cooling of said mixture.

Another object of the invention is to provide a power absorption device having heat exchange means disposed within the housing thereof in either the normal working circuit of the device, or externally of the normal working circuit of the device, or in both the normal working circuit and externally of the normal working circuit of the device.

A further object of the invention is to provide a power absorption device with a heat exchanger that can be readily removed for servicing or repairs, if necessary.

A still further object of the invention is to provide a power absorption device having a built-in heat exchanger and in which all of the parts including those of the heat exchanger are hydrodynamically balanced to reduce harmonics and undue vibration.

A still further object of the invention is to provide a self-contained power absorption unit including heat exchange means rendering the unit extremely compact, and particularly adapted for use in installations where space is at a premium, for example, in chassis dynamometers.

Other objects and advantages of the invention will be apparent from the following description taken in conjunction with the accompanying drawings, which more or less diagrammatically illustrate several operative embodiments of the invention, and in which:

Fig. 1 is a vertical sectional view through one form of power absorption device or dynamometer, taken on the section line 1—1 of Fig. 2, and having a built-in heat exchanger including transverse tubes disposed in a cooling circuit separate from the normal working circuit of the dynamometer and in a zone outwardly beyond the periphery of the rotor;

Fig. 2 is a side elevational view of the dynamometer shown in Fig. 1, with portions thereof shown in cross-section as viewed on the staggered section line 2—2 of Fig. 1;

Fig. 3 is a vertical sectional view through another form of dynamometer taken on the section line 3—3 of Fig. 5, and having a removable heat exchanger in a circuit separate from the normal working circuit of the dynamometer but in a zone coaxial with the rotor;

Fig. 4 is an enlarged fragmentary sectional view through one of the cores of the heat exchanger shown in Fig. 3;

Fig. 5 is a side elevational view of the dynamometer shown in Fig. 3, with portions thereof shown in cross-section as viewed on the staggered section line **5—5** of Fig. 3;

Fig. 6 is a vertical sectional view through another form of dynamometer taken on the section line **6—6** of Fig. 7, and having a heat exchanger disposed in a circuit separate from the normal working circuit of the dynamometer and including circumferentially extending tubes disposed in a zone outwardly beyond the periphery of the rotor;

Fig. 7 is a side elevational view of the dynamometer shown in Fig. 6, with portions thereof shown in cross-section as viewed on the staggered section line **7—7** of Fig. 6;

Fig. 8 is a vertical sectional view of a dynamometer somewhat similar to that shown in Fig. 6, but including a modified form of rotor and being taken on the section line **8—8** of Fig. 9;

Fig. 9 is a side elevational view of the dynamometer shown in Fig. 8, with portions thereof shown in cross-section as viewed on the staggered section line **9—9** of Fig. 8;

Fig. 10 is a vertical sectional view through another form of dynamometer, taken on the section line **10—10** of Fig. 11, and including circumferentially extending heat exchange tubes disposed in the normal working circuit of the dynamometer;

Fig. 11 is a side elevational view of the dynamometer shown in Fig. 10, with portions thereof shown in cross-section as viewed on the staggered section line **11—11** of Fig. 10;

Fig. 12 is a view partly in section taken on the section line **12—12** of Fig. 11 and particularly illustrating the path of the power absorption fluid with respect to the heat exchange tubes;

Fig. 13 is a vertical sectional view through another form of dynamometer, taken on the section line **13—13** of Fig. 14, including two heat exchangers, one of which is disposed in the normal working circuit of the dynamometer and the other of which is disposed externally of said normal working circuit, but both functioning to cool the same power absorption fluid;

Fig. 14 is a side elevational view of the dynamometer shown in Fig. 13, with portions thereof shown in cross-section as viewed on the staggered section line **14—14** of Fig. 13;

Fig. 15 is a view partly in section taken on the section line **15—15** of Fig. 14;

Fig. 16 is a vertical sectional view through still another form of dynamometer, taken on the section line **16—16** of Fig. 17, including a heat exchanger arranged externally of the normal working circuit of the dynamometer with the tubes of the heat exchanger adapted to be air cooled;

Fig. 17 is a side elevational view of the dynamometer shown in Fig. 16, with a portion thereof shown in cross-section as viewed on the section line **17—17** of Fig. 16;

Fig. 18 is a fragmentary sectional view taken on the section line **18—18** of Fig. 16;

Fig. 19 is a vertical sectional view through another form of dynamometer, taken on the line **19—19** of Fig. 20, including two removable heat exchangers arranged in a cooling circuit externally of the normal working circuit of the dynamometer; and

Fig. 20 is a side elevational view of the dynamometer shown in Fig. 19 with a portion thereof shown in cross-section as viewed on the section line **20—20** of Fig. 19.

Referring now to Figs. 1 and 2 of the drawings, the dynamometer shown therein comprises a housing **20** including two housing sections **21** and **22**. The housing sections **21** and **22** include stepped, mating surfaces **23** and **24** for axially aligning said sections, and bolts **25** pass through said sections to secure the same together. The housing sections **21** and **22** are provided with openings **26** and **27**, respectively, for the reception of a rotor shaft **28**. The shaft **28** is adapted to be connected with a prime mover (not shown) for absorbing the power developed by said prime mover.

A bracket **29** is secured to each of the housing sections **21** and **22** by bolts **30**. Each of the brackets **29** contains a ball bearing **31** serving as an anti-friction mounting for the shaft **28**. The bearings **31** are held in the brackets **29** by a dust-excluding, retainer plate **32** fastened to the brackets **29** by bolts **33**. Enclosed within each of the brackets **29** is a gland **34** which engages packing material **35** surrounding the shaft **28** to prevent the leakage of fluid from within the housing **20** outwardly along the shaft **28**. Screws **36** are provided for adjusting the gland **34** to compress the packing **35** into sealing relation around the shaft **28**.

Each of the housing sections **21** and **22** is provided with an annular pocket **37**, which is substantially semi-circular or semi-toroidal in radial cross-section. Each of the pockets **37** is provided with a set of radial vanes **38** which extend completely thereacross and a second set of radially extending vanes **39** is disposed between each two adjacent radial vanes **38**. A circumferentially extending, substantially semi-circular vortex-forming web **40** is disposed between each of the vanes **38—39**. The vanes **39**, as distinguished from the vanes **38**, do not terminate at their innermost portion in a plane common with that of the inner face of the pocket **37**, but on the contrary, terminate in an edge **41** extending angularly from the innermost portion of the web **40**, as best shown in Fig. 1.

A multiplicity of heat exchange tubes **42** is arranged transversely in each housing section **21—22** in a zone disposed outwardly beyond the substantially semi-toroidal pockets **37**. The tubes **42** are supported at their opposite ends in spaced header walls **43** and **44** that cooperate to provide a chamber **45** for cooling liquid, which is brought into contact with the exterior surface of the tubes **42** in a manner explained hereinafter. The innermost ends of the tubes **42** communicate with inlet passages **46** disposed between vanes **47** formed in the housing sections **21** and **22** in a vertical plane disposed inwardly of the pockets **37** and in alignment with pumping pockets **48** formed in a rotor **49**. Continuations of the spaces between the stator webs **38** and **39** form return passages **50** extending from the outer ends of the tubes **42** to the semi-toroidal pockets **37**.

The rotor **49** may be keyed or otherwise suitably secured to the shaft **28** for rotation therewith. The rotor **49** may be made in one piece, or in two sections **51**, as best shown in Fig. 1. The sections **51** may be secured together in any suitable manner. Each of the sections **51** is provided with a substantially semi-toroidal pocket **52** arranged in confronting relation with one of the pockets **37**. A set of radial vanes **53** extends completely across the pockets **52** and a second set of radial vanes **54** is provided with one of said vanes disposed between each two adjacent vanes **53**. The vanes **53** and **54** are interconnected by arcuate, vortex-forming webs **55**, which are disposed in confronting relation with the complemental webs **40**. The vanes **54**, like the vanes **39**, terminate at the lower portion thereof in an angularly extending edge **56**. The object of having a portion of the webs **39** and **54** terminate short of the plane of the webs **38** and **53** is to insure adequate passage area for the brake fluid adjacent the hub portions of the housing sections **21** and **22** and the rotor sections **51**. The vanes **53** and **54** of each of the rotor sections **51** extend outwardly to the periphery of said sections so that portions thereof and the spaces therebetween form the pumping pockets **48**, previously referred to. The rotor sections **51** are also provided with registering openings **57**, which serve to balance the pressure on the opposite sides of the rotor **49**.

The stator pockets **37** and the vanes **38**, **39** and the arcuate vortex-forming webs **40** cooperate with the rotor pockets **52**, the vanes **53** and **54**, and the arcuate-vortex forming webs **55** to form the normal working circuit for the power absorption fluid. Such working circuit assumes a generally or substantially toroidal shape, like an endless ring, as is well understood by those skilled in the art. However, it is to be understood that the term "substantially toroidal" is not to be construed as limited to a toroidal working circuit which is truly circular in radial cross-section, inasmuch as the principles of the invention are applicable to working circuits of various cross-sectional shapes, as is evident from the numerous embodiments of the invention disclosed herein. The pumping pockets **48**, passages **46**, tubes **42** and passages **50** provide a cooling circuit for the power absorption fluid, the cooling circuit being separate from the normal working circuit and being adapted to receive power absorption fluid from the working circuit and by-pass the same around a portion of said working circuit.

In practice, the total number of vanes in each housing section **21** and **22** is preferably greater than the number of vanes on each of the rotor sections **51**. Thus, each housing section **21—22** may be provided with a total of eighteen vanes made up of nine of the vanes **38** and nine of the vanes **39**, and the rotor preferably has sixteen vanes consisting of eight vanes **53** and eight vanes **54**. The purpose of providing a different number of vanes on the stator or housing **20** from the number of vanes on the rotor **49** is to balance the diametric hydraulic forces and to prevent excessive vibration and harmonics. Also, the fewer number of vanes on the rotor **49** provides for an increase in the volume of the fluid therein equal to the space that would be occupied by the width and radial length of two vanes, thereby slightly increasing the volume of fluid that can be handled by the rotor **49** as compared with the stator **20**. This increased volume tends to make up for the volume of fluid which by-passes the portion of the normal working circuit in the stator for passage through the cooling or heat exchange circuit. The difference in the number of the rotor and stator vanes also reduces the magnitude, and increases the frequency, of the torque impulses. By using the proper number of vanes on the rotor and stator, frequencies high enough to be out of a range detrimental to the prime mover being tested by the dynamometer can be reached. Also, a dynamometer taking this factor into consideration will provide superior and more satisfactory results than one designed without consideration of these factors.

The vanes **47**, which direct the brake liquid from the pumping pockets **48** into the spaces **46**, may extend radially inwardly from the housing sections **21** and **22** and may be equal to, but are preferably greater in number than, the number of vanes employed in the housing sections **21** and **22**. The object of such arrangement is to reduce the individual vane impingement forces resulting from the rotation of the rotor **49**, thereby prolonging the life of the vanes **47**. If desired, the vanes **47** may be coated with rubber (not shown) to further increase their life, depending upon the use for which the dynamometer apparatus is intended.

The housing section **22** is provided with an opening **60** having a pipe **61** threaded therein containing a valve **62**. The pipe **61** is connected with a source of brake liquid, preferably water, under pressure, and the valve **62** serves as a loading valve to admit the water into the dynamometer housing **20** to impose the desired load upon the engine being tested. The housing section **22** is also provided with an opening **63** having a pipe **64** connected therewith containing a valve **65** which is adapted to be opened to drain brake liquid from the housing **20** to reduce the volume of brake liquid in the housing and thus effect unloading of the dynamometer.

One or more of the vanes **38** may be provided with a vent passage **66** for venting air from the housing **20**, as the brake liquid is introduced thereinto. Each of the passages **66** communicates with a vent pipe **67**, which is open to the atmosphere. Thus, as brake liquid is introduced into the housing **20**, the air within the housing is readily displaced through the vent pipe **67**, and, as the brake liquid is exhausted or drained from the housing, air is admitted through the vent pipe **67** to prevent the formation of a vacuum condition within the housing **20**.

Water for effecting cooling of the tubes **42** is admitted into each of the chambers **45** through pipes **68**, which communicate with an inlet header space **69** in each of the housing sections **21—22**. The cooling water thus introduced passes over the exterior surface of half of the tubes **42**, through a dummy header space **70** and over the outer surface of the remaining half of the tubes **42** into an outlet header space **71** having a drain pipe **72** communicating therewith. The dummy header **70** is located diametrically opposite the headers **69** and **71** for the purpose of balancing the hydraulic forces to reduce forced or resonant vibration. The header spaces **70** and **71** are separated by a partition **73**. A torque arm **74** can be bolted to either side of the housing **20** to yieldably oppose rotation thereof, as is well understood.

In operation, the rotor **49** is revolved through the connection of the shaft **28** with the shaft whose power is to be absorbed, usually a brake shaft or an engine shaft. In order to load the dynamometer, the unloading valve **65** is closed and the loading valve **62** is opened to introduce power absorption fluid, usually water, into the working circuit of the dynamometer until the desired torque load has been reached. Assuming that only a small volume of brake liquid has been introduced into the housing **20** but not enough to fill all of the heat exchange tubes **42**, the rotation of the rotor **49** will cause the brake liquid to be thrown by centrifugal force from the rotor pockets

52 through the pumping pockets 48 into the spaces 46 between the vanes 47 for passage through the heat exchange tubes 42 and for return to the stator pockets 37 through the passages 50. The liquid absorbs some power and in doing so becomes heated and is cooled by the water in the chambers 45 as said liquid passes through the heat exchange tubes 42 for return to the stator and cycling through the cooling circuit. The closed circulating and cooling system thus provided enables a great quantity of brake liquid to be circulated at high velocity through a small circuit assuring a homogeneous mixture of the air and liquid through its entire path of flow and also maintains a higher temperature differential between the average brake liquid temperature and the temperature of the cooling water passing over the outer surfaces of the tubes 42. The high velocity of flow maintained through the heat exchange tubes 42 by the pumping action of the rotor 49 enables the use of a heat exchanger having a relatively small heat transfer area for a given capacity dynamometer.

Assuming that it is desired to further increase the load, and that the volume of liquid now required is more than sufficient to fill all of the heat exchange tubes, the loading valve 62 is again opened until the load has reached the desired point and is then closed. The circulation of the liquid through the cooling circuits has now reached proportions great enough to completely fill these circuits, and the excess liquid will then circulate through the normal working circuits of the dynamometer, being forced outwardly by centrifugal force through the spaces between the vanes 53 and 54 of the rotor sections 51, across the gap between said rotor sections and the stator sections 21—22 at the outer peripheral portions of said rotor sections and then flowing inwardly in the spaces between the vanes 37 and 39 of said stator sections toward the hubs of said rotor sections, to then pass across the gap at said hubs and into the spaces between said rotor vanes to repeat the circulation cycle. Hence, under such load condition, a portion of the brake liquid is required to circulate through the working circuits provided by the semi-toroidal pockets 37 and 52, and a portion of the liquid is continuously diverted from the working circuits into the cooling circuits through the pumping pockets 48.

The working circuits provided by the vaned chambers 37 and 52 serve primarily for power absorption purposes, inasmuch as little power is required to circulate the brake liquid through the heat exchangers. Nevertheless, a sufficient volume of the liquid is continuously diverted for circulation through the heat exchangers to achieve exceptionally good cooling of the liquid. The torque load can, of course, be further increased by increasing the volume of liquid in the dynamometer housing 20 until the working circuit, or the entire housing is full. On the other hand, the torque loads can be reduced by opening the unloading valve 65 to permit the liquid to be pumped from the housing 20 by the centrifugal pumping action of the rotor 49. The unloading valve 65 can be closed whenever it is desired to maintain any given reduced load. The selected points within the vortex-forming webs 40 and 55 which are bled to the atmosphere by the passages 66 and vent pipes 67 permit air to enter said housing during unloading of the dynamometer to prevent the creation of a vacuum condition therein. The location of the passages 66 in either the vanes 37 or 39 with the inner end of the passages 66 terminating at the inner edge of said vanes, permits rotation of the rotor 49 in either direction, because then the passages 66 always open at a low pressure zone in the dynamometer.

It is to be noted at this point that, in the actual design of dynamometers with built-in heat exchangers, certain basic mathematics common to the hydraulics of brakes and centrifugal water pumps are applicable as well as those relating to heat transfer surfaces, etc. In actual practice, it has been found that it is desirable to provide from 2 to 85% less total area in the return passages 50 than in the total internal cross-sectional area of either the tubes 42 or the pumping pockets 48, to insure filling of the heat exchange tubes 42 as early in the loading operation of the dynamometer as possible. The passages 50, therefore, restrict the rate of flow through the heat exchanger to a volume less than the capacity of the rotor pumping pockets 48. The relative ratio of the areas of the pumping pockets 48 and the return passages 50 is dictated by the operational capacity, speed and power range of a particular dynamometer.

While the vanes 47 forming the passages 46 and the extended portions of the vanes 37 and 39 forming the passages 50 are not absolutely essential, they are highly desirable inasmuch as they contribute to the stability of the dynamometer during periods of low horsepower absorption, and especially if the dynamometer is disposed so that the shaft 23 is in a horizontal position. Again, the provision of the dummy header space 70 opposite the header spaces 69 and 71 is not absolutely essential, but its presence is preferred inasmuch as it serves to maintain equal and also opposite hydraulic forces which reduce forced or resonant vibration, as previously pointed out.

While Fig. 2 illustrates two working circuits, and two heat exchange circuits externally of said working circuits, it will be apparent that the dynamometer illustrated can be constructed with only one of each. Here again, the preference is dictated by the particular use to which the dynamometer is to be put and to other requirements.

Figs. 3 and 5 illustrate a dynamometer construction with but one working circuit for the power absorption fluid or brake liquid and one cooling or heat exchange circuit arranged externally of the working circuit, but with the heat exchanger itself disposed in general axial alignment with the rotor. The advantage of such an arrangement is that the overall diameter of the dynamometer housing can be maintained at a minimum.

Fig. 3 illustrates a dynamometer generally identified by the numeral 75 comprising a housing 76 including sections 77 and 78 secured together by bolts 79. The housing section 77 has a recess 80 formed in the inner surface thereof for the reception of an annular, removable stator section 81. The relative transverse dimensions of the recess 80 and the stator section 81 are such that the stator section 81 is clamped tightly in place when the housing sections 77 and 78 are drawn together by the bolts 79.

The housing section 81 is provided with a substantially semi-toroidal pocket 82 and a plurality of vanes 83 extending radially across said pocket at spaced intervals. At least one of the vanes 83 is provided with a transverse passageway 84 communicating with a radially extending passageway 85 which extends to the outer periphery of the housing section 81. A pipe fitting 86 is mounted in the housing section 77 so that it communicates with the outer end of the passageway **85**. The passages **84**, **85** and the pipe fitting **86** serve as a means for venting air from the interior of the housing **76** to the atmosphere.

The annular stator section **81** is provided at its inner periphery with a plurality of axially extending vanes **87** disposed radially inwardly of the pocket **82** and adjacent a rotor shaft **88**, said vanes terminating short of the outer periphery of said shaft and providing spaces **89** between said vanes. The stator section **81** is further provided with passages **90** radially aligned with but disposed outwardly of the spaces between the vanes **83**. The passages **90** and the spaces **89** between the vanes **87** constitute a part of the cooling circuit for the power absorption fluid, as will be pointed out in further detail hereinafter.

The shaft **88** is adapted to be connected with another shaft (not shown) whose power is to be absorbed. The shaft **88** extends through an opening **91** in the housing section **77** and an opening **92** formed in an elongated hub portion **93** of the housing section **78**. The shaft **88** is mounted in ball bearings **94** carried by brackets **95**, respectively, secured to the housing sections **77** and **78** by bolts **96**. Leakage of the brake liquid from within the housing **76** along the shaft **88** is prevented by conventional packing means **97** assoociated with each of the housing sections **77** and **78**.

The stator section **81** cooperates with the housing section **77** to provide a chamber **98** at one side of said stator section in which a rotor **99** is disposed. The rotor **99** is secured to the shaft **88** by a key **100**. The rotor **99** is provided with a substantially semi-toroidal pocket **101** and a plurality of radially extending vanes **102** extending completely across said pocket in confronting relation with the vanes **83** on the stator section **81**. Here again, the stator section **81** will preferably have more vanes than the rotor **99**. Thus, the stator section **81** may have eighteen of the vanes **83**, and the rotor **99** may have sixteen of the vanes **102**, the number of vanes varying in accordance with the operating requirements of a given dynamometer. Incidentally, the number of vanes **87** is half that of the number of vanes **83**, as will be apparent from the sectioned portion in the upper half of Fig. 5.

The housing section **78** (Fig. 3) is shaped to provide a substantially circular coaxial chamber **103** on the side of the housing section **81** remote from the rotor **99**. The chamber **103** contains a heat exchanger generally identified by the numeral **104**. The housing section **78** includes a peripheral wall portion **105** having a plurality of vanes **106** extending inwardly therefrom and forming passageways **107** constituting extensions of the passages **90** in the stator section **81**. The hub portion **93** of the housing section **78** carries a plurality of outwardly extending vanes **108** providing passageways **109** that constitute extensions of the passageways **89** formed between the vanes **87** of the stator section **81**.

The heat exchanger **104** is disposed in the chamber **103** of the housing section **78** between the vanes **106** and **108** thereof and includes a plurality of removable, conventional high-heat exchange core elements **110**, one of which is shown in cross-section on an enlarged scale in Fig. 4. The cores **110** may be considered to be segmental and to have the interior space thereof communicating with an inlet header **111** (Fig. 5) and an outlet header **112**. A dummy header **113** is disposed diametrically opposite the headers **111** and **112**. The header **111** has a cold water supply pipe **114** connected therewith and the header **112** has a discharge pipe **115** connected therewith, so that cooling water introduced through the pipe **114** flows through the interior of the cores **110** and is discharged through the pipe **115**. The brake liquid in the brake housing **76** flows over the exterior surfaces of the cores **110** as indicated by the arrows in the lower portion of Fig. 3.

The housing section **78** has a threaded opening **118** connected with a supply pipe **119** having a loading valve **120** connected therein. The other housing section **77** has a threaded opening **121** having a discharge pipe **122** connected therewith and containing an unloading valve **123**. As will be readily apparent, the loading valve **120** and the unloading valve **123** may be manipulated to impose any desired torque load to resist rotation of the shaft **88**. A torque arm **124** which can be mounted on either side of the housing yieldably opposes rotation of said housing.

It will be understood that upon introduction of brake liquid into the housing **76** by opening of the loading valve **120**, the liquid will find its way from the chamber **103** into the pockets **82** and **101** through the passageways **109** and the spaces **89** between the vanes **87**, due to the pumping action of the rotor **99**. The liquid thus introduced will, if the volume thereof is sufficient, quickly fill the spaces between the cores **110** and a portion thereof will be caused to circulate in the working circuit formed by the pockets **82**—**101** and the vanes **83**—**102**, as indicated by the arrows, as the rotor **99** rotates. The rotation of the rotor **99** necessarily causes a diversion and a forced circulation of a portion of the brake liquid through the heat exchanger **104**. Thus, and as indicated by the arrows, a portion of the liquid is diverted from the spaces between the vanes **102** and passes into the passages **90** in the stator section **81** from whence it flows into the spaces **107** between the vanes **106** of the housing section **78**. The liquid diverted into the passages **107** passes inwardly across the exterior surfaces of the cores **110** to be cooled by the water circulating through the interior of said cores. The thus cooled brake liquid passes through the passageways **109** between the vanes **108**, and then flows through the passages **89** between the vanes **87** and returns to the working circuit at the inner portion of the pocket **82**, all as indicated by the arrows in Fig. 3. Here again, the area of the passages **90** is so proportioned with respect to that of the passageways **89** that the heat exchanger **104** is quickly filled and the proper ratio of liquid diverted to said heat exchanger with respect to that maintained in the working circuit is such that effective cooling of the liquid is accomplished.

Usually, the heat exchanger is maintained filled with brake liquid and a volume equal to that diverted or displaced from the working circuit of the dynamometer for cooling by the heat exchanger **104** is replaced by an equal volume forced out of the heat exchanger and returned to said working circuit, so that any desired constant load can be maintained.

The arrangement of the heat exchanger shown in Fig. 3 has the advantage over that shown in Figs. 1 and 2 in that the heat exchange cores **110** are made of conventional material and the heat exchanger **104** can be readily replaced as a unit if desired. A further advantage resides in the fact that the heat exchanger **104**, being disposed to one side of the rotor 99 and stator section 81, instead of in surrounding relation to the rotor 99, makes it possible to provide a dynamometer of substantially reduced maximum diameter. While Fig. 3 shows a core-type heat exchanger, it is to be understood that the invention is not limited to the use of any particular arrangement or type of heat exchanger.

Figs. 6 and 7 illustrate another dynamometer identified by the numeral 125 and provided with a heat exchanger circuit arranged outwardly of the periphery of the working circuit, as in Figs. 1 and 2 but differing therefrom in that the rotor is devoid of special pumping pockets, but never the less not only forces the liquid through the working circuit but also pumps the liquid into the heat exchanger from the working circuit, thereby incorporating the advantages of the construction shown in Figs. 3 and 5. However, the working circuit of the dynamometer 125 is less efficient than those previously described, but it will be understood that the geometric shape and proportions of the working circuit are matters of design to meet given operating requirements and do not in any way affect the principles of separate working and cooling circuits within the concepts of the present invention.

The dynamometer 125 comprises a housing 126 including housing sections 127 and 128 secured together by bolts 129. The housing section 127 is provided with a series of radially extending vanes 130 and the housing section 128 is provided with a series of radially extending vanes 131, all of which vanes terminate short of the peripheral walls of said housing sections. A heat exchanger 132 is disposed within the housing sections 127 and 128 outwardly of the ends of the vanes 130 and 131. Each of the vanes 130 and 131 is cut away to provide a recess 134 and baffle ring members 135 and 136 are disposed in the housing 126 so that they partially extend into the recesses 134, the adjacent sides of the rings 135 and 136 being separated to permit the liquid in the housing to flow into a space 137 therebetween.

The heat exchanger 132 includes an inlet header 139 (Fig. 7) connected with a water supply pipe 140. A plurality of circumferentially extending tubes 141 communicate at one end thereof with the header 139 and extend circumferentially within the housing 126 and terminate at their opposite ends in a header 142 having a drain pipe 143 connected therewith. A dummy header 138 is disposed diametrically opposite the headers 139 and 142. The tubes 141 are maintained in spaced relation throughout the periphery of the housing 126 by partition members 144 radially aligned with the vanes 130 and 131 and extending between the outer periphery of the baffle rings 135 and 136 and the inner side and peripheral walls of the housing sections 127 and 128, the exterior surface of the tubes 141 being exposed to the brake liquid between adjacent partitions 144. At least one of each of the vanes 130 and 131 is provided with a passage 145 which communicates with an air vent pipe 146.

A shaft 147 extends through a hub opening 148 (Fig. 6) in the housing section 127 and a hub opening 149 in the housing section 128. The shaft 147 is journalled in ball bearings 150 carried by brackets 151 secured to the housing sections 127 and 128 by bolts 152. Conventional packing glands 153 prevent the brake liquid from leaking out of the housing 126 along the shaft 147. A rotor 154 is secured to the shaft 147 by a key 155. The rotor 154 includes a circular, radially extending web 156 arranged centrally thereof and a band 157 is welded or otherwise secured to the periphery of the web 156. Vanes 158 and 159 arranged upon opposite sides of the web 156 extend radially outwardly from the hub of the rotor to the peripheral rim or band 157. It will be noted from Fig. 6 that the baffle rings 135 and 136 are arranged so that they straddle the gaps between the stator vanes 130—131 and the rotor vanes 158—159, thus requiring tortuous circulation of the liquid in passing through the heat exchanger 132.

The housing section 128 has a threaded opening 160 connected with a supply pipe 161 containing a loading valve 162. The housing sections 127 and 128 include an enlargement arranged to provide a pumping pocket 163 which extends below the headers 139 and 142. The housing section 127 has a threaded opening 164 (Fig. 7) communicating with the pocket 163 and connected with a drain pipe 165 containing an unloading valve 166. A torque arm 167 yieldably opposes rotation of the housing 126.

In the operation of the dynamometer 125 shown in Figs. 6 and 7, brake liquid is admitted into the housing 126 upon opening of the loading valve 162. The centrifugal action of the rotor 154 causes the liquid thus introduced to be forced outwardly between the vanes 158 and 159 and a portion thereof is deflected inwardly by the baffle rings 135 and 136 so that it flows into the space 137 between the adjacent sides of said rings and thence into the spaces between adjacent partitions 144, which prevent circumferential circulation of the brake liquid in the zone of the tubes 141. The liquid then flows outwardly over the tubes 141 and around the outer edges of the baffle rings 135 and 136 to be returned to the working circuit of the dynamometer. The liquid not diverted for circulation over the tubes 141 of the heat exchanger 132 circulates between the vanes 130—158 and 131—159 in the working circuit of the dynamometer, following the path generally indicated by the arrows in Fig. 6, any given drop of liquid in the working circuit travelling in a spiral path generally corresponding to that of a point on a rotating vortex ring. Cooling liquid, of course, circulates through the interior of the tubes 141 to cool the brake liquid in the housing 126 which has been diverted from the working circuit to the cooling circuit. The hydraulic forces of the liquid within the housing 125 are balanced by the dummy header 138 which is disposed diametrically opposite the headers 139 and 142 in the circulation path of the brake liquid outwardly of the working circuit. Unloading of the dynamometer 125 to reduce the load absorption capacity thereof can be effected by opening the unloading valve 166, whereupon the pumping action of the rotor 154 will force liquid out of the pocket 163 for discharge through the pipe 165. It will be apparent that the pumping action of the rotor 154 also effects forced circulation of a portion of the brake liquid over the outer surface of the heat exchange tube 141 to effect efficient cooling of all of the brake liquid.

Figs. 8 and 9 illustrate a dynamometer similar to that shown in Figs. 6 and 7, but omitting certain elements which result in placing the heat exchange tubes in the working circuit of the dynamometer. Thus, the plate 157 at the periphery of the rotor 154 in Fig. 6 has been omitted in Fig. 9, and the baffle rings 135 and 136, together with the recesses 134 in the vanes 130 and 131, have also been omitted.

Accordingly, the dynamometer shown in Fig. 8 includes two working circuits, one on either side of the central web 156, with the heat exchange tubes 141 disposed in the outermost portions of said working circuits. The circulation of the liquid within the housing 126 is outwardly by centrifugal force between the rotor vanes 158 and 159 on opposite sides of the web 156, then over the heat exchange tubes 141 in the spaces between the partitions 144, and then inwardly between the stator vanes 130 and 131 toward the hub portions of the stator sections 127 and 128, and then across the gap between the stator and rotor vanes at said hub portions, for recirculation in a manner to repeat the cycle described.

The dynamometers illustrated in Figs. 6 and 8 are relatively inexpensive to manufacture, although the working circuits are not as efficient as those of the dynamometers shown in Figs. 1 to 5 and the noise level and impingement forces on the heat exchanger parts are also greater. However, these dynamometers can be satisfactorily used for certain kinds of load tests.

Figs. 10 to 12 illustrate another dynamometer construction in which the heat exchanger is disposed in the working circuit of the dynamometer inwardly of the periphery of the rotor, the working circuit being much more efficient than the working circuit shown in Figs. 6 and 8. Thus, the dynamometer 170 shown in Figs. 10 to 12 comprises a stator or housing 171 including sections 172 and 173 secured together by bolts 169. The housing section 172 is provided with a substantially semi-toroidal pocket 174 having a series of spaced vanes 175 extending radially thereacross and providing spaces therebetween. Spaces identified as 176 and 177 in Fig. 11 are covered by a plate 178 which may be welded or otherwise secured to the housing section 172 to prevent communication between the spaces 176 and 177. Heat exchange tubes 179 communicate at one end with the space 176 and extend circumferentially of the pocket 174 and communicate at the opposite end thereof with the space 177. A supply pipe 180 communicates with the space 176 so that it functions as an inlet header and a pipe 181 communicates with the space 177 causing it to function as an outlet header. The spaces in the stator section 172 opposite the spaces 176 and 177 are identified by the numerals 176ᵃ and 177ᵃ. These spaces are closed by a dummy header 182, which serves to balance the hydraulic forces within the dynamometer and reduce resonance. The vane 175 between the spaces 176ᵃ and 177ᵃ is provided with a passage 183 that communicates at one end with a passage 184 in the dummy header 182 and is open to the atmosphere at its opposite end through a pipe fitting 185. The interior of the dynamometer housing 171 is thus vented to the atmosphere.

The housing section 172 has an opening 186 and the housing section 173 has an opening 187 through which a dynamometer shaft 188 extends. The shaft 188 is journalled in ball bearings 189 carried in brackets 190 secured to the housing sections 172 and 173 by bolts 191. Conventional packing means 192 associated with the housing sections 172 and 173 prevents the leakage of brake liquid from the interior of said housing along the shaft 188.

A rotor 193 is secured to the shaft 188 by a key 194. The rotor 193 has a substantially semi-toroidal pocket 195 confronting the pocket 174. A series of spaced vanes 196 extend radially across the rotor pocket 195. It will be noted from Fig. 10 that the cross-sectional area of the stator pocket 174 is greater than that of the rotor pocket 195. The object of this difference in areas is to compensate for the area occupied by the heat exchange tubes 179 in the stator pocket 174, so that the actual area available for the flow of brake liquid in the working circuit is substantially equal in both the rotor pocket 195 and said stator pocket.

The housing section 173 has a threaded opening 197 communicating with a supply of pipe 198 having a loading valve 199 connected therein. The housing section 172 has a threaded opening 200 communicating with a drain pipe 201 having an unloading valve 202 connected therein. The valves 199 and 202 may be manipulated to impose any desired torque load upon the shaft 188, as will be readily understood. Rotation of the housing 171 is yieldably opposed by a torque arm 203, which can be mounted on either side of said housing. Any brake liquid introduced into the housing by opening the loading valve 199 will quickly find its way into the working circuit of the dynamometer 170. The brake liquid will be forced by the rotation of the rotor 193 to follow the path generally indicated by the arrows in Fig. 12. In other words, the brake liquid will travel outwardly under centrifugal force in the spaces between the rotor vanes 196 and then inwardly in the spaces between the stator vanes 175, thus necessarily passing over the heat exchange tubes 179 to be cooled by the water circulating therethrough. Thus, Figs. 10–12 illustrate a dynamometer construction in which the heat exchanger is disposed in one of the main pockets of the working circuit of the dynamometer and provides a more compact and more efficient unit than those previously described herein.

Figs. 13 to 15 illustrate a dynamometer construction including two heat exchangers, with one of the heat exchangers disposed in the normal working circuit of the dynamometer as in Fig. 10, and the other heat exchanger disposed exteriorly of the normal working circuit as in Fig. 1. In other words, the dynamometer shown in Fig. 13 combines, in a single unit, the feature of a heat exchanger disposed externally of the normal working circuit and the feature of a heat exchanger within the normal working circuit. Thus, the dynamometer 205 shown in Fig. 13 comprises a housing 206 including housing sections 207 and 208 secured together by bolts 209. The housing section 207 is provided with a substantially semi-toroidal pocket 210 having a series of vanes 211 extending radially thereacross. A space 212 between adjacent vanes 211 serves as an inlet header and a space 212 adjacent thereto serves as an outlet header. A plate 214 covers the spaces 212 and 213 and adapts the same to serve as inlet and outlet headers, respectively. A plurality of circumferentially extending heat exchange tubes 215 communicate at one end thereof with the inlet header 212 and communicate at the opposite end thereof with the outlet header 213, said tubes passing through all intermediate vanes 211. A supply pipe 216 introduces cooling water into the inlet header 212 and a drain pipe 217 serves as a drain for the header 213. A dummy header 218 covers diametrically opposite spaces 212ᵃ and 213ᵃ. The dynamometer 205 is vented to the atmosphere through a hole 219 in the dummy header 218, a passageway 220 in the vane 211 between the spaces 212^a and 213^a, and a vent pipe 221.

A heat exchanger 222 is disposed outwardly of the stator pocket 210 and comprising header walls 223 and 224 providing a chamber 225 for cooling liquid. Transverse heat exchange tubes 226 extending through the walls 223 and 224, and across the chamber 225. The vanes 211, removed from the zone of the pockets 212, 213, 212^a and 213^a, are extended to the wall 223 to provide passages 227 communicating with the outlet end of the tubes 226 for returning cooled brake liquid to the working circuit of the dynamometer. Additional passageways 228 formed in the housing section 207 between vanes 229 adjacent the wall 224 and defined in part by the housing section 208 provide access passages for the brake liquid to enter the heat exchange tubes 226.

A rotor shaft 230 extends through an opening 231 in the housing section 207 and through an opening 232 in the housing section 208. The rotor shaft 230 is supported by ball bearings 233 carried in brackets 234 secured to the housing sections 207 and 208 by bolts 235. Conventional packing means 236 forms a liquid-tight seal between the rotor shaft 230 and the housing sections 207 and 208 to prevent leakage of brake fluid from the housing along said shaft. A rotor 237 is secured to the shaft 230 by a key 238. The rotor 237 is provided with a substantially semi-toroidal pocket 239 which confronts the stator pocket 210. A series of vanes 240 extends radially across the pocket 239, the spaces between the vanes 240 being extended to provide pumping pockets 241 disposed in alignment with the passages 228 in the housing 206. Here again, the cross-sectional area of the stator pocket 210 is greater than that of the rotor pocket 239 to compensate for the volume of the former occupied by the heat exchange tubes 215, so that the actual volume available in the stator 207 for circulation of the working fluid is substantially equal to that provided by the pocket 239 in the rotor 237.

The chamber 225 of the heat exchanger 222 is divided by a partition wall 242 (Fig. 14) to provide an inlet header 243 and an outlet header 244. Cooling liquid is introduced into the header 243 through an inlet pipe 245 and cooling liquid is drained from the outlet header 244 through a pipe 246. A dummy header space 247 is provided diametrically opposite the header spaces 243 and 244 to balance the hydraulic forces in the dynamometer.

The housing section 208 is provided with a threaded opening 248 having a supply pipe 249 connected therewith containing a loading valve 250. The housing section 207 is provided with a threaded opening 251 having a drain pipe 252 connected therewith containing an unloading valve 253. The dynamometer 205 can be loaded or unloaded to impose any desired load on the shaft 230 by manipulation of the loading valve 250 and/or the unloading valve 253. Rotation of the housing 206 is yieldably opposed by a torque arm 206^a, which can be mounted upon either side of said housing.

It will be apparent from the foregoing that, any brake liquid introduced into the housing 206 as a result of opening of the loading valve 250 will have a portion thereof diverted from the normal working circuit of the dynamometer by the pumping pockets 241, which, by centrifugal force, will force the diverted liquid into the spaces 228 for passage through the heat exchange tubes 226 at high velocity and return through the passages 227 to the working circuit of the dynamometer. Simultaneously, such portion of the liquid as remains in the working circuit will be cooled by the tubes 215 as it travels at high velocity in a generally circular path, indicated by the arrows, and which circular path moves helically and circumferentially of the dynamometer, as is well understood. Thus, extremely efficient cooling of the brake liquid is effected by the joint action of the heat exchanger 222 arranged externally of the normal working circuit of the dynamometer 205 and by the heat exchanger 215 disposed in the path of the working circuit of said dynamometer.

Figs. 16 to 18, illustrate a dynamometer construction having a heat exchanger arranged externally of the normal working circuit of the dynamometer with the heat exchange tubes disposed so that cooling is effected by air circulated therethrough. The dynamometer 254 shown in Fig. 16 comprises a housing 255 including housing sections 256 and 257, secured together by a plurality of bolts 258. The housing section 257 includes a substantially semi-toroidal pocket 259 having a plurality of vanes 260 extending radially thereacross. The spaces between the vanes 260 are extended to provide return passages 261. A plurality of heat exchange tubes 262 extends transversely through the housing sections 256 and 257 in a zone disposed outwardly of the return passages 261. An annular flange 263 projects laterally from the housing section 257 in a zone beyond the pocket 259 and forms a baffle disposed inwardly of the heat exchange tubes 262. One of the vanes 260 is provided with a passageway 264 communicating with a pipe 265 for venting the dynamometer to the atmosphere.

A rotor shaft 266 extends through an opening 267 in the housing section 256 and through an opening 268 in the housing section 257. The shaft 266 is journalled in ball bearings 269 carried in brackets 270 secured to the housing sections 256 and 257 by bolts 271. Leakage along the shaft 266 is prevented by conventional packing means 272 associated with each of the housing sections 256 and 257.

A rotor 273 is secured to the shaft 266 by a key 274 and has the major portion thereof disposed within the baffle ring 263. The rotor 273 is provided with a substantially semi-toroidal pocket 275 and a series of vanes 276 extends radially across said pocket. The spaces between the vanes 276 are continued to the periphery of the rotor 273 to provide pumping pockets 277 in said rotor. These pockets, as will be noted from Fig. 16, are disposed in a zone which is clear of the baffle ring 263.

The housing section 256 has a threaded opening 278 communicating with a supply pipe 279 having a loading valve 280 connected therewith. The housing section 257 has a threaded opening 281 communicating with a discharge pipe 282 having an unloading valve 283 connected therein.

A blower 285 is provided to force air through the heat exchange tubes 262 to effect cooling of the brake liquid surrounding the same. The blower 285 includes concentric casing sections 286 and 287 arranged to provide an annular passageway 288 communicating with one end of the heat exchange tubes 262, the opposite end of said tubes being open to the atmosphere. The casing sections 286 and 287 may be mounted in any suitable or convenient manner upon the housing section 257. The casing section 286 includes a transverse wall **289** disposed adjacent one of the brackets **270**. The other casing section **287** is provided with a large air inlet opening **290**. A squirrel-cage type impeller **291** is mounted upon the rotor shaft **266** by a key **292** and is adapted to be driven upon rotation of said rotor shaft. The impeller **291** includes vanes **293** disposed adjacent the periphery of the inlet opening **290**. The vanes **293** are arranged so that when the impeller **291** is driven, air is drawn in through the opening **290** and forced into the annular space **288** and then through the interior of the heat exchange tubes **262** for final discharge to the atmosphere. Rotation of the housing **255** is opposed by a torque arm **255**^{a}, which can be mounted upon either side of said housing.

The brake liquid admitted into the dynamometer housing **255** upon opening of the loading valve **280** is forced in an outward direction by the vanes **276** and the pumping pockets **277** of the rotor **273** so that it passes over the heat exchange tubes **262** adjacent one end thereof in a zone outwardly of the baffle **263**. The liquid thus diverted from the normal working circuit of the dynamometer flows along the heat exchange tubes **262** and is returned to said working circuit through the passages **261** adjacent the opposite end of said heat exchange tubes. The general path of travel of the liquid while being cooled by the tubes **262** is indicated by the arrows in Fig. 16. The normal working circuit of the brake liquid in the pockets **259** and **275** is also generally indicated by arrows. Thus, the brake liquid is circulated in contact with the outer surface of the heat exchange tubes **262** by the pumping action of the rotor **273**, and cooling of the brake liquid is effected by air caused to circulate through said heat exchange tubes by the impeller **291** driven by the rotor shaft **266**.

Figs. 19 and 20 illustrate a dynamometer construction patterned somewhat after that shown in Figs. 1 and 2, but including heat exchange units that are adapted to be removed for service and cleaning, if necessary, without completely dismantling the dynamometer.

Referring to Fig. 19, the dynamometer is generally identified by the numeral **300** and includes a rotor shaft **301** adapted to be connected with a shaft (not shown) whose power is to be absorbed. The shaft **301** includes a tapered enlargement **302** intermediate its ends upon which is mounted a rotor **303** comprising two like rotor sections **304**. The rotor sections **304** are tapered internally to snugly fit the tapered enlargement **302**, and are secured together and held against longitudinal movement relative to the shaft **301** by bolts **305**. A key **306** prevents relative rotation between the rotor sections **304** and the shaft **301**.

The shaft **301** is mounted in ball bearings **307** received in brackets **308**, which are secured to housing or stator sections **309** and **310** by bolts **311**. The brackets **308** are mounted in self-aligning roller bearings **312** mounted in cradle brackets **313** secured to main frame supports **314** by bolts **315**. A retainer ring **316** is disposed adjacent each of the ball bearings **307** in the housing sections **309** and **310** inwardly of the brackets **308**. The retainer rings **316** are each associated with a rubber ring **317**, and a metal ring **318** forms a seal between the housing sections **309** and **310** and each of the retainer rings **316**. A carbon sealing ring **319** engages the inner face of the rings **317** and an expansible bellows **320** is disposed between the carbon ring **319** and the

adjacent hub portion of the rotor sections **304**. The bellows **320** urges the carbon ring **319** into sealing engagement with the ring **318** to prevent leakage of fluid from within the housing along the rotor shaft **301**. Any fluid which should find its way beyond the ring **319** will be drained to the atmosphere through a recess **321** in the housing sections **309** and **310**.

The housing sections **309** and **310** are secured together at their adjacent ends by bolts **322**. Each of the housing sections **309** and **310** is provided with a substantially semi-toroidal pocket and vanes similar to those shown in Fig. 2. Thus, the housing sections **309** and **310** each includes a pocket **37**^{a}, vanes **38**^{a} and **39**^{a}, heat exchange tube inlet passages **46**^{a} and return passages **50**^{a}. A passage **66**^{a} extends through one of the vanes **38**^{a} and communicates with an air vent pipe **67**^{a}.

The rotor **303** is also generally similar to the rotor **49**, in that each of the rotor sections **304** is provided with a substantially semi-toroidal pocket **52**^{a}, vanes **53**^{a} and **54**^{a}, pumping pockets **48**^{a} and pressure equalizing openings **57**^{a} to balance the pressure on the opposite sides of said rotor.

A removable heat exchange unit generally identified by the numeral **323** is mounted in each of the housing sections **309** and **310** in a zone outwardly of the normal working circuit of the dynamometer provided by the pockets **37**^{a} and **52**^{a}. Each of the heat exchange units **323** consists of three arcuate sections **324**, **325**, and **326** (see Fig. 20). Each of the sections **324**, **325** and **326** comprises a pair of circumferentially extending rubber headers **327** vulcanized to the outer surfaces of a plurality of copper heat exchange tubes **328** at a point adjacent the ends of said tubes. Three arcuate, metal clamping members **329**, each of which carrier transverse flanges **330** at the opposite ends thereof, preferably have a pair of the headers **327** vulcanized to the sides thereof. A gasket **331** is disposed between adjacent faces of the flanges **330**, and bolts **332** project through said flanges to clamp the arcuate members **329** together to form a continuous ring.

The inner periphery of the rubber headers **327** is received in grooves **333** (Fig. 19) formed in the housing sections **309** and **310** and forms a tight seal therewith. A seal is formed between the outer marginal side portion of the rubber headers **327** and the adjacent surfaces **334** of the housing sections **309** and **310** as the result of a flowing action produced in the rubber headers by the clamping together of the heat exchange segments or sections **324**, **325** and **326**. Thus, a chamber **335** for cooling liquid is formed between an outer peripheral wall **336** of each of the housing sections **309** and **310** and an inner peripheral wall **337** of the clamping sections **329** and the inner surfaces of the rubber headers **327**, thereby isolating the cooling liquid of the heat exchanger from the brake liquid in the housing sections **309** and **310**.

The clamping members **329** of the heat exchange sections **324** and **326** include inwardly extending flanges **338** (Fig. 20) which form a baffle across the interior of the heat exchanger **323**. A cold water supply pipe **339** is threaded into an opening **340** in the clamping member **329** of the heat exchange segment **324**, and a drain pipe **341** is threaded into an opening **342** in the clamping member **329** of the heat exchange segment **326**. Thus, cooling liquid introduced through the pipe 329 flows circumferentially and progressively passes over the exterior surfaces of the heat exchange tubes 328 in the heat exchange segments 324, 325 and 326 and finally discharges through the drain pipe 341. A thermostat valve (not shown) may be connected in the pipe 341, if desired, to maintain a desired temperature in the cooling liquid.

Each of the housing sections 309 and 310 has a threaded opening 343 connected with a supply pipe 344 having a loading valve 345 connected therein. Each of the housing sections 309 and 310 is also provided with a threaded opening 346 having a discharge pipe 347 connected therewith containing an unloading valve 348.

A gear 349 (Fig. 19) is keyed to the rotor shaft 301 and is adapted to drive a tachometer shaft 350. An arm 351 (Fig. 20) is secured by bolts 352 to either of two bosses 353 formed on the housing sections 309—310. The torque arm 351 is associated with torque measuring means (not shown) and yieldably restrains rotary movement of the dynamometer housing, as is well understood in the art.

The operation of the dynamometer shown in Figs. 19 and 20 is substantially the same as that of the dynamometer shown in Figs. 1 and 2. That is to say, brake liquid is introduced into the housing sections 309 and 310 through the pipes 344 upon opening of one or both of the loading valves 345. Rotation of the rotor 303 will cause the liqud first introduced to move outwardly through the pumping pockets 48^a under centrifugal force into the passages 46^a for flow through the heat exchange tubes 328. The liquid is then returned through the passages 50^a to the pockets 37^a in the stator sections 309 and 310 from whence it flows into the pockets 52^a in the rotor 303 to complete its cycle. The passages 46^a and 50^a are so proportioned that the heat exchange tubes 328 are substantially filled even during low water volume operations. The smaller total cross-sectional area of the passages 50^a causes the heat exchange tubes 328 to become filled and the liquid then backs up filling the passages 46^a and the pumping pockets 48^a so that all liqud in excess of the capacity of the passages 50^a is caused to pass from the rotor pocket 52^a to the stator pocket 37^a and follow the normal working circuits established by the vanes in these two pockets. Of course, a certain amount of liqud is continuously diverted from the working circuits to fill the heat exchange tubes 328 to be cooled and returned to the working circuit. The flow of the liquid through the heat exchange tubes 328 occurs at a very high velocity so that with an ample supply of cooling liquid, a maximum of heat transfer can be extracted from the brake liqud through the copper tubes 328 to the cooling liquid.

Actual efficiencies as high as 849 B. t. u. per hour per square foot per degree temperature difference between the liquid to be cooled and the cooling liquid has been actually attained in practice with certain units. This may be compared with from 100 to 300 B. t. u. per square foot, etc., with the best of commercial heat exchangers.

The use of heat exchangers with dynamometers such as disclosed herein has also made it possible to absorb a surprisingly great amount of power with an extremely small brake unit. Thus, a dynamometer having a single working circuit approximately 3″ wide and employing a rotor of approximately 8 and ¼″ in diameter has

been successfully used for continuously adsorbing 200 horsepower at relatively low speeds.

A dynamometer has also been built following the general principles of operation of the devices shown in Figs. 6 and 7, which weighs only 90 pounds complete and which is capable of absorbing 200 horsepower at speeds between 1800 and 4000 R. P. M.

While a considerable number of different forms and types of dynamometers have been illustrated herein, to show the general application of the principles of a built-in heat exchanger to various dynamometer constructions, it will be understood that the details of construction and the arrangement of the dynamometers and heat exchangers may be varied considerably from that disclosed herein, without departing from the spirit of the invention or the scope of the annexed claims.

I claim:

1. A torque absorption device, comprising: a housing member and a rotor member in said housing member, each having spaces and vanes cooperating to provide a substantially toroidal working circuit for power absorption fluid; and heat exchange means in one of said members in the path of said working circuit for effecting cooling of said power absorption fluid.

2. A torque absorption device, comprising: a stator member and a rotor member, each having spaces and vanes cooperating to provide a substantially toroidal working circuit for power absorption fluid; and heat exchange means in one of said members out of the path of said working circuit and including hollow heat transfer means providing a circuit for the flow of power absorption fluid therethrough for effecting cooling of said power absorption fluid.

3. A torque absorption device, comprising: a stator member and a rotor member, each provided with a series of substantially radially extending vanes and spaces between said vanes, with the vanes and spaces of said stator and rotor arranged in confronting relation and forming a substantially toroidal working circuit for power absorption fluid; and hollow heat exchange means in one of said members adapted to receive the flow of power absorption fluid therethrough for effecting cooling of said power absorption fluid.

4. A torque absorption device, comprising: a stator and a rotor, each provided with a series of substantially radially extending vanes and spaces between said vanes, with the vanes and spaces of said stator and rotor arranged in confronting relation and forming a substantially toroidal working circuit for power absorption fluid; means for introducing power absorption fluid into and for withdrawing power absorption fluid from said stator section to vary the torque absorption capacity of said device; and hollow heat exchange means in said stator for effecting cooling of said power absorption fluid, said heat exchange means including heat transfer surfaces arranged so that the centrifugal action of said rotor causes said power absorption fluid to flow through the interior of said heat exchange means in contact with said heat transfer surfaces at high velocity.

5. A torque absorption device, comprising: a stator and a rotor, each provided with a series of substantially radially extending vanes and spaces between said vanes, with the vanes and spaces of said stator and rotor arranged in confronting relation and forming a substantially toroidal working circuit for power absorption fluid; means for introducing power absorption fluid into and for

withdrawing power absorption fluid from said stator; hollow heat exchange means disposed in said stator for effecting cooling of said power absorption fluid; and passage means in said stator establishing communication between said working circuit and the interior of said heat exchange means.

6. A torque absorption device, comprising: a stator and a rotor, each having means cooperating to provide a substantially toroidal working circuit for power absorption fluid; means for introducing power absorption fluid into and for exhausing power absorption fluid from said stator to vary the torque absorption capacity of said device; heat exchange means in said stator arranged to contact and cool said power absorption fluid and including a plurality of heat transfer elements; means in said stator forming an inlet space within said stator arranged to receive a cooling medium for cooling said elements; and means in said stator forming an outlet space within said stator in juxtaposed relation to said inlet space for the discharge of said cooling medium after it has cooled said elements.

7. A torque absorption device, comprising: a stator and a rotor, each having means cooperating to provide a substantially toroidal working circuit for power absorption fluid; means for introducing power absorption fluid into and for exhausing power absorption fluid from said stator to vary the torque absorption capacity of said device; heat exchange means in said stator arranged to contact and cool said power absorption fluid and comprising a series of heat transfer elements; means forming an inlet space in said stator for receiving a cooling medium to cool said elements; means forming an outlet space in said stator for discharging said cooling medium after it has cooled said elements; and partition means in said stator separating said spaces.

8. A torque absorption device, comprising: a stator and a rotor, each having means cooperating to provide a circulation path for power absorption fluid; means for introducing power absorption fluid into and for exhausting power absorption fluid from said stator to vary the torque absorption capacity of said device; heat exchange means in said stator arranged to contact and cool said power absorption fluid and comprising a series of heat transfer elements; means forming an inlet space in said stator in said circulation path for receiving a cooling medium to cool said elements; means forming an outlet space in said stator in said circulation path adjacent said inlet space for discharging said cooling medium after it has cooled said elements; and means forming a dummy header space in said stator in said circulation path disposed substantially diametrically opposite said inlet and outlet spaces, whereby the fluid forces produced in the device as a result of flow interruption in said circulation path at said spaces are substantially balanced and resonance is reduced to a minimum.

9. A torque absorption device, comprising: a stator and a rotor, each having means cooperating to provide a circulation path for power absorption fluid; means for introducing power absorption fluid into and for exhausting power absorption fluid from said stator to vary the torque absorption capacity of said device; heat exchange means in said stator comprising a series of circumferentially extending tubes arranged to contact and cool said power absorption fluid; an inlet header in said stator in said circulation path communicating with one end of said tubes; an outlet header in said stator in said circulation path adjacent said inlet header communicating with the opposite end of said tubes; and a dummy header in said stator in said circulation path disposed substantially diametrically opposite said inlet and outlet headers, whereby the fluid forces produced in the device as a result of flow interruption in said circulation path at said headers are substantially balanced and resonance is reduced to a minimum.

10. A torque absorption device, comprising: a stator and a rotor, each having spaces and vanes cooperating to to provide a substantially toroidal working circuit for power absorption fluid; means for introducing power absorption fluid into and for exhausting power absorption fluid from said stator to vary the torque absorption capacity of said device; heat exchange means in said stator out of the path of said working circuit providing a circuit for effecting cooling of said power absorption fluid; and means for diverting a portion of said power absorption fluid tangentially from the peripheral portion of said substantially toroidal working circuit for flow through said cooling circuit.

11. A torque absorption device, comprising: a stator and a rotor, each having pockets and vanes cooperating to provide a working circuit for power absorption fluid; means for introducing power absorption fluid into and for exhausing power absorption fluid from said stator to vary the torque absorption capacity of said device; heat exchange means in said stator disposed in a zone radially beyond said pockets and providing a circuit communicating with said working circuit for effecting cooling of said power absorption fluid; and means for diverting a portion of said power absorption fluid from said working circuit for flow through said cooling circuit.

12. A torque absorption device, comprising: a stator and a rotor, each having pockets and vanes cooperating to provide a substantially toroidal working circuit for power absorption fluid; means for introducing power absorption fluid into and for exhausting power absorption fluid from said stator to vary the torque absorption capacity of said device; and heat exchange means in said stator providing a circuit externally of said working circuit for effecting cooling of said power absorption fluid, said rotor having vane portions providing pumping pockets arranged therein for diverting a portion of said power absorption fluid from said working circuit and forcing it through said cooling circuit.

13. A torque absorption device, comprising: a rotor and a stator, each having pockets and vanes cooperating to provide a substantially toroidal working circuit for power absorption fluid; means for introducing power absorption fluid into and for exhausting power absorption fluid from said stator to vary the torque absorption capacity of said device; means including a series of tubes in said stator disposed in a zone radially outwardly of said pockets and said working circuit and providing a cooling circuit communicating with said working circuit for effecting cooling of said power absorption fluid by flow through said tubes.

14. A torque absorption device, comprising: a rotor and a stator, each having means cooperating with the other to provide a working circuit for a power absorption fluid; means including a series of tubes in said stator disposed in a zone radially outwardly of said rotor and providing a circuit communicating with said working circuit for effecting cooling of said power absorption fluid;

and means for diverting a portion of said power absorption fluid from said working circuit for cooling by said tubes.

15. A torque absorption device, comprising: housing and rotor sections, each provided with a series of substantially radially extending vanes and spaces between said vanes, with the vanes and spaces of said housing and rotor sections arranged in confronting relation and forming a substantially toroidal working circuit for a power absorption fluid; and a heat exchanger in said housing section arranged in substantially concentric relation with said rotor section and including means providing heat transfer surfaces, said housing section having separate inlet and return passage means formed therein for follow of power absorption fluid therethrough and serving to establish communication between said working circuit and said heat exchanger.

16. A torque absorption device, comprising: a housing and a rotor in said housing, each provided with a series of substantially radially extending vanes and spaces between said vanes, with the vanes and spaces of said housing and rotor arranged in confronting relation and forming a working circuit for a power absorption fluid; with means cooperating with the other to provide a working circuit for a power absorption fluid; a heat exchanger and heat exchange means in said housing including heat transfer surfaces, said housing having passage means establishing communication between said working circuit and said heat exchange means, said passage means being proportioned to constrict flow beyond said heat exchange means and thereby effect rapid filling of said heat exchange means.

17. A torque absorption device, comprising: housing and rotor sections, each provided in said housing section arranged in substantially concentric relation with said rotor section and including means providing heat transfer surfaces, said housing section having passage means establishing communication between said working circuit and said heat exchanger; and means for diverting power absorption fluid from said working circuit for flow in contact with said heat transfer surfaces of said heat exchanger.

18. A torque absorption device, comprising: housing and rotor sections, each provided with a series of substantially radially extending vanes and spaces between said vanes, with the vanes and spaces of the housing and rotor sections arranged in confronting relation and forming a substantially toroidal working circuit for power absorption fluid; means for introducing power absorption fluid into and for exhausting power absorption fluid from said housing section to vary the torque absorption capacity of said device; and a heat exchanger arranged in substantially concentric relation with said rotor section and including axially spaced circumferentially extending header walls and transversely extending tubes having their ends disposed in said walls, said housing section having passage means for the flow of said power absorption fluid from said working circuit into contact with and through said tubes.

19. A torque absorption device, comprising: housing and rotor sections, each provided with a series of substantially radially extending vanes and spaces between said vanes, with the vanes and spaces of the housing and rotor sections arranged in confronting relation and forming a working circuit for power absorption fluid; means for introducing power absorption fluid into and for exhausting power absorption fluid from said housing section to vary the torque absorption capacity of said device; and a heat exchanger arranged in substantially concentric relation with said rotor section and including circumferentially extending header walls and transversely extending tubes having their ends disposed in said walls, said housing section having passage means establishing communication between said working circuit and the ends of said tubes.

20. A torque absorption device, comprising: housing and rotor sections, each provided with a series of substantially radially extending vanes and spaces between said vanes, with the vanes and spaces of the housing and rotor sections arranged in confronting relation and forming a working circuit for power absorption fluid; means for introducing power absorption fluid into and for exhausting power absorption fluid from said housing section to vary the torque absorption capacity of said device; and a heat exchanger arranged in substantially concentric relation with said rotor section and including circumferentially extending header walls and transversely extending tubes having their ends disposed in said walls, said housing section having passage means formed by extensions of the spaces between the vanes thereof establishing communication between said working circuit and at least one of the ends of said tubes.

21. A torque absorption device, comprising: a stator and a rotor, each having means cooperating to provide a working circuit for power absorption fluid; means for introducing power absorption fluid into and for exhausting power absorption fluid from said stator to vary the torque absorption capacity of said device; heat exchange means in said stator comprising heat transfer elements arranged in generally concentric fashion relative to said rotor and providing a cooling circuit externally of said working circuit; and means interconnecting said cooling circuit and working circuit at spaced zones located substantially throughout the circumferential extent of said working circuit.

22. A torque absorption device, comprising: stator and rotor sections, each having pockets and vanes cooperating to provide a substantially toroidal working circuit for power absorption fluid; means for introducing power absorption fluid into and for exhausting power absorption fluid from said stator section to vary the torque absorption capacity of said device; heat exchange means in said stator section disposed in a zone radially beyond the periphery of said rotor section and comprising a series of tubes; and means within said stator section separating said working circuit from said heat exchange means and providing passage means for conducting power absorption fluid from said working circuit into contact with said tubes.

23. A torque absorption device, comprising: stator and rotor sections, each having pockets and vanes cooperating to provide a working circuit for power absorption fluid; means for introducing power absorption fluid into and for exhausting power absorption fluid from said stator section to vary the torque absorption capacity of said device; heat exchange means in said stator section disposed in a zone radially beyond the periphery of said rotor section and comprising a series of tubes; and baffle means disposed between

the innermost of said tubes and the outer periphery of said rotor section for directing circulation of the power absorption fluid into contact with said tubes.

24. A torque absorption device, comprising: stator and rotor sections, each having pockets and vanes cooperating to provide a working circuit for a power absorption fluid; heat exchange means in said stator section disposed in a zone radially beyond the periphery of said rotor section and comprising a series of circumferentially extending tubes; an inlet header communicating with one end of said tubes; an outlet header communicating with the opposite end of said tubes; and baffle means disposed between the innermost of said tubes and the outer periphery of said rotor section for directing circulation of the power absorption fluid over the exterior surface of said tubes.

25. A torque absorption device, comprising: a rotor and a stator, each provided with a substantially semi-toroidal pocket and vanes forming a working circuit for power absorption fluid; means for introducing power absorption fluid into and for exhausting power absorption fluid from said stator to vary the torque absorption capacity of said device; and heat exchange means disposed in one of said pockets for effecting cooling of said power absorption fluid while it is moving through said working circuit.

26. A torque absorption device, comprising: rotor and stator sections, each provided with a pocket and vanes disposed in said pockets confronting each other and forming a working circuit for power absorption fluid; means for introducing power absorption fluid into and for exhausting power absorption fluid from said stator section to vary the torque absorption capacity of said device; and heat exchange means disposed in the pocket of said stator section for effecting cooling of said power absorption fluid while it is moving through said working circuit.

27. A torque absorption device, comprising: a rotor and a stator, each provided with a substantially semi-toroidal pocket and vanes forming a working circuit for power absorption fluid; means for introducing power absorption fluid into and for exhausting power absorption fluid from said stator to vary the torque absorption capacity of said device; heat exchange means including a plurality of tubes disposed in the pocket of said stator for effecting cooling of said power absorption fluid while it is moving through said working circuit; an inlet header in the pocket of said stator communicating with one end of said tubes; and an outlet header in the pocket of said stator communicating with the opposite end of said tubes.

28. A torque absorption device, comprising: a rotor and a stator, each provided with a substantially semi-toroidal pocket and vanes forming a working circuit for power absorption fluid; means for introducing power absorption fluid into and for exhausting power absorption fluid from said stator to vary the torque absorption capacity of said device; heat exchange means including a plurality of tubes disposed in the pocket of said stator for effecting cooling of said power absorption fluid while it is moving through said working circuit; an inlet header in the pocket of said stator communicating with one end of said tubes; an outlet header in the pocket of said stator adjacent said inlet header communicating with the opposite end of said tubes; and a dummy header in said stator disposed substantially diametrically opposite said inlet and outlet headers.

29. A torque absorption device, comprising: a stator and a rotor, each provided with a substantially semi-toroidal pocket and vanes cooperating to form a working circuit for power absorption fluid; means for introducing power absorption fluid into and for exhausting said power absorption fluid from said stator to vary the volume of fluid and, hence, the torque absorption capacity of said device; and heat exchange means disposed in the pocket of said stator for effecting cooling of said power absorption fluid while it is moving through said working circuit, the effective radial cross-sectional area of the pocket in said stator section for the passage of said power absorption fluid being substantially equal to the radial cross-sectional area of the pocket in said rotor section.

30. A torque absorption device, comprising: stator and rotor sections, each provided with a substantially semi-toroidal pocket and vanes cooperating to form a working circuit for power absorption fluid; means for introducing power absorption fluid into and for exhausting said power absorption fluid from said stator section to vary the volume of fluid and, hence, the torque absorption capacity of said device; and a plurality of heat exchange tubes disposed in the pocket of said stator section for effecting cooling of said power absorption fluid while it is moving through said working circuit, the total radial cross-sectional area of the pocket in said stator section minus the radial cross-sectional area of said pocket occupied by said heat exchange tubes being substantially equal to the radial cross-sectional area of the pocket in said rotor section, whereby the volume of the portion of the working path in said stator section is substantially equal to the volume of the portion of the working path in said rotor section.

31. A torque absorption device, comprising: rotor and housing sections, each provided with a substantially semi-toroidal pocket and vanes forming a working circuit for power absorption fluid; means for introducing power absorption fluid into and for withdrawing power absorption fluid from said stator section to vary the torque absorption capacity of said device; heat exchange means disposed in said pocket of said housing section for effecting cooling of said power absorption fluid while it is moving through said working circuit, the effective radial cross-sectional area of the pocket in said housing section for the passage of said power absorption fluid being substantially equal to the radial cross-sectional area of the pocket in said rotor section; heat exchange means providing a cooling circuit for said power absorption fluid externally of said working circuit; and means establishing communication between said pocket of said housing section and said last-mentioned heat exchange means.

32. A torque absorption device, comprising: a stator and a rotor in said stator, each provided with a series of substantially radially extending vanes and spaces between said vanes, the vanes and spaces of said stator and rotor being arranged in confronting relation and forming a working circuit for power absorption fluid; a rotor shaft rotatably mounted in said stator, said rotor being secured to said rotor shaft; means for introducing power absorption fluid into and for exhausting power absorption fluid from said stator to vary the torque absorption capacity of said

device; heat exchange means including a series of tubes arranged transversely of said stator in a zone radially outwardly of said rotor for effecting cooling of said power absorption fluid; means for diverting a portion of said power absorption fluid from said working circuit for flow in contact with one surface of said tubes; and means for bringing a cooling medium into contact with another surface of said tubes.

33. A torque absorption device, comprising: a stator and a rotor in said stator, each provided with a series of substantially radially extending vanes and spaces between said vanes, the vanes and spaces of said stator and rotor being arranged in confronting relation and forming a substantially toroidal working circuit for power absorption fluid; a rotor shaft rotatably mounted in said stator, said rotor being secured to said rotor shaft; means for introducing power absorption fluid into and for exhausting power absorption fluid from said stator to vary the torque absorption capacity of said device; heat exchange means including a series of transverse tubes extending through said stator in a zone radially outwardly of said rotor and providing a circuit communicating with said working circuit for effecting cooling of said power absorption fluid; means for diverting a portion of said power absorption fluid from said working circuit for flow over the exterior surface of said tubes; a rotatable blower element mounted upon said rotor shaft; and a casing arranged to receive air from said blower element and to direct the same to one end of said tubes for passage through said tubes.

34. A torque absorption device, comprising: rotor and stator sections, each having spaces and vanes cooperating to provide a substantially toroidal working circuit for power absorption fluid; means for introducing power absorption fluid into and for exhausting power absorption fluid from said stator section to vary the torque absorption capacity of said device; a detachable heat exchanger surrounding said rotor and including a plurality of arcuate sections, each comprising circumferentially extending arcuate headers and a plurality of laterally extending tubes secured at their ends in said headers; means securing said arcuate sections of said heat exchanger in assembled relation; and means establishing communication between said working circuit and the ends of said tubes.

35. A torque absorption device, comprising: rotor and stator sections, each having spaces and vanes cooperating to provide a substantially toroidal working circuit for power absorption fluid; means for introducing power absorption fluid into and for exhausting power absorption fluid from said stator section to vary the torque absorption capacity of said device, said stator section being provided with a recess disposed in a zone radially outwardly of said pockets; a removable heat exchanger disposed in said recess and including a plurality of arcuate sections, each comprising circumferentially extending headers and a plurality of laterally extending tubes secured at their ends in said headers; and means securing said arcuate sections of said heat exchanger in assembled relation around said stator section, said stator section having passage means establishing communication between said working circuit and the ends of said tubes.

36. A torque absorption device, comprising: rotor and stator sections, each having spaces and vanes cooperating to provide a substantially toroidal working circuit for power absorption fluid; means for introducing power absorption fluid into and for exhausting power absorption fluid from said stator section to vary the torque absorption capacity of said device, said stator section being provided with a recess including side walls and a bottom wall disposed in a zone radially outwardly of said pockets; a detachable heat exchanger disposed in said recess and including a plurality of arcuate sections, each comprising circumferentially extending rubber headers and a plurality of laterally extending tubes vulcanized at their ends in said headers; and clamping means securing said arcuate sections of said heat exchanger in assembled relation, with the inner periphery of said headers sealingly engaging said bottom wall of said recess, said rubber headers being adapted to be compressed at the outer marginal portion thereof into sealing engagement with the side walls of said recess to form a seal therewith, said stator section having passage means establishing communication between said working circuit and the ends of said tubes.

37. A torque absorption device, comprising: stator and rotor sections, each having pockets and vanes cooperating to provide a working circuit for power absorption fluid, said stator having means providing a circulation path for cooling said power absorption fluid; means for introducing power absorption fluid into and for exhausting power absorption fluid from said stator section to vary the torque absorption capacity of said device; heat exchange means in said stator section disposed in a zone radially beyond the periphery of said rotor section and comprising a series of circumferentially extending tubes arranged to contact and cool said power absorption fluid; an inlet header in said circulation path communicating with one end of said tubes; an outlet header in said circulation path adjacent said inlet header communicating with the opposite end of said tubes; and a dummy header in said circulation path in said stator section diametrically opposite said inlet and outlet headers, whereby the fluid forces produced in the device as a result of flow interruption in said circulation path at said headers are substantially balanced and resonance is reduced to a minimum.

38. A torque absorption device, comprising: stator and rotor sections, each having spaces and vanes cooperating to provide a working circuit for power absorption fluid; means for introducing power absorption fluid into and for exhausting power absorption fluid from said stator section to vary the torque absorption capacity of said device; heat exchange means in said stator section disposed in a zone radially beyond the periphery of said rotor section and comprising a series of circumferentially extending tubes arranged to contact and cool said power absorption fluid; an inlet header communicating with one end of said tubes; an outlet header communicating with the opposite end of said tubes; and a series of partitions in said stator section arranged transversely with respect to said tubes for retarding circumferential circulation of said power absorption fluid relative to the exterior surface of said tubes.

39. A torque absorption device, comprising: stator and rotor sections, each having spaces and vanes cooperating to provide a working circuit for power absorption fluid; means for introducing power absorption fluid into and for exhausting power absorption fluid from said stator sec-

tion to vary the torque absorption capacity of said device; heat exchange means in said stator section disposed in a zone radially beyond the periphery of said rotor section and comprising a series of circumferentially extending tubes arranged to contact and cool said power absorption fluid; an inlet header communicating with one end of said tubes; an outlet header adjacent said inlet header communicating with the opposite end of said tubes; a dummy header in said stator section diametrically opposite said inlet and outlet headers; and a series of partitions in said stator section arranged transversely with respect to said tubes for preventing circumferential circulation of said power absorption fluid relative to the exterior surface of said tubes.

40. A torque absorption device, comprising: a housing, a rotor section and a removable stator section in said housing, said stator and rotor sections each having pockets and vanes cooperating to provide a working circuit for power absorption fluid; means for introducing power absorption fluid into and for exhausting power absorption fluid from said housing to vary the torque absorption capacity of said device; heat exchange means disposed in said housing on the side of said stator section remote from said rotor section, said stator section having laterally extending passage means formed therein cooperating with said heat exchange means for providing a cooling circuit externally of said working circuit for effecting cooling of said power absorption fluid.

41. A torque absorption device, comprising: a hollow housing, a rotor section, a stator section and a heat exchanger section arranged side by side in said housing in the order named, the adjacent faces of said rotor and stator sections each being provided with a substantially semi-toroidal pocket and vanes cooperating to provide a working circuit for power absorption fluid; and means for introducing power absorption fluid into and for exhausting power absorption fluid from said housing to vary the torque absorption capacity of said device, said stator section having two sets of transverse passages formed therein, with one set arranged inwardly of and the other radially beyond the semi-toroidal pocket thereof, said housing also including channels forming continuations of said passages and communicating with passageways in said heat exchanger, said passages, channels and passageways forming a circuit for effecting cooling of said power absorption fluid.

42. A torque absorption device, comprising: a hollow housing; a rotor section, a stator section and a heat exchange section arranged side by side in said housing in the order named, the adjacent faces of said rotor and stator sections each being provided with a substantially semi-toroidal pocket and vanes cooperating to provide a working circuit for power absorption fluid; means for introducing power absorption fluid into and for exhausting power absorption fluid from said housing to vary the torque absorption capacity of said device, said stator section having two sets of passage means formed therein with one set arranged inwardly of and the other radially beyond the semi-toroidal pocket thereof, said housing also including channels forming continuations of said passage means and communicating with passageways in said heat exchanger, said passage means, channels and passageways forming a circuit for effecting cooling of said power absorption fluid, said substantially semi-toroidal pocket in said rotor section being wider radially than said substantially semi-toroidal pocket in said stator section, whereby to facilitate the diversion of power absorption fluid from said working circuit to said cooling circuit and the return thereof to said working circuit.

43. A torque absorption device, comprising: rotor and housing sections, each provided with spaces and vanes forming a working circuit for power absorption fluid; means for introducing power absorption fluid into and for withdrawing power absorption fluid from said housing section to vary the torque absorption capacity of said device; heat exchange means disposed in the spaces of said housing section for effecting cooling of said power absorption fluid while it is passing through said working circuit; heat exchange means providing a cooling circuit for said power absorption fluid externally of said working circuit; and means establishing communication between said spaces and said last-mentioned heat exchange means.

44. A torque absorption device, comprising: stator and rotor sections, each having pockets and vanes cooperating to provide a working circuit for power absorption fluid; means for introducing power absorption fluid into and for exhausting power absorption fluid from said stator section to vary the torque absorption capacity of said device; heat exchange means in said stator section disposed in a zone radially beyond the periphery of said rotor section and comprising a series of circumferentially extending tubes; an inlet header within said stator communicating with one end of said tubes; means for introducing a coolant into said inlet header; an outlet header within said stator communicating with the opposite end of said tubes; means for draining coolant from said outlet header; partition means maintaining said tubes in spaced relation to each other; and means forming a peripheral rim on said rotor section disposed between the innermost of said tubes and the outer ends of said rotor vanes for deflecting a portion of the power absorption fluid for circulation over the exterior surface of said tubes.

45. A torque absorption device, comprising: a stator section having opposed side walls; a rotor section in said stator section, said rotor and stator sections each having pockets and vanes cooperating to provide a working circuit for power absorption fluid; means for introducing power absorption fluid into and for exhausting power absorption fluid from said stator section to vary the torque absorption capacity of said device; heat exchange means in said stator section disposed in a zone radially beyond the periphery of said rotor section and comprising a series of circumferentially extending tubes; an inlet header extending transversely within said stator section communicating with one end of said tubes; a supply pipe connected to one end of said inlet header for introducing a cooling medium into said inlet header; an outlet header extending transversely within said stator communicating with the opposite end of said tubes; and a drain pipe connected to one end of said outlet header for draining said cooling medium from said outlet header.

46. A torque absorption device as defined in claim 45, including partition means maintaining the tubes in spaced relation to each other, and wherein the supply pipe extends through one side

wall of the stator and the drain pipe extends through the other side wall of the stator.

47. A torque absorption device, comprising: housing means; a rotor in said housing means; said rotor and housing means having pockets and vanes confronting each other and cooperating to provide a working circuit for power absorption fluid; means for introducing power absorption fluid into and for exhausting power absorption fluid from said housing means to vary the torque absorption capacity of said device; and an annular heat exchanger in said housing means spaced from said rotor, said housing means having passageways separate from and exteriorly of said working circuit for establishing communication between said working circuit and said heat exchanger.

48. A torque absorption device, comprising: a stator and a rotor, each having pockets and vanes cooperating to provide a working circuit for power absorption fluid; means for introducing power absorption fluid into and for exhausting power absorption fluid from said stator to vary the torque absorption capacity of said device; and heat exchange means in said stator disposed radially beyond the periphery of said rotor for effecting cooling of said power absorption fluid, said rotor having peripheral openings for the flow of power absorption fluid from said working circuit to said heat exchange means.

49. A torque absorption device as defined in claim 48, in which the heat exchange means includes tubes and the peripheral openings in the rotor divert power absorption fluid from the working circuit for flow in contact with said tubes.

50. In a Froude type dynamometer, a resistance-liquid-containing stator casing and a rotor therein, the stator and rotor being complementally radially vaned to produce toroidal circulation of the resistance liquid, and a coolant liquid filled conduit within the casing located in the toroidal circulation path of at least part of the resistance liquid.

51. In a Froude type dynamometer, a stator casing defining a chamber for the reception of resistance liquid, and a rotor in said chamber; each of the stator and rotor having means cooperating with like means of the other to provide a substantially toroidal resistance liquid circuit, to absorb power; a heat exchanger within the stator chamber disposed circumferentially about the periphery of the rotor to be immersed in resistance liquid which is centrifugally flung from such rotor; and an inlet to and an outlet from said heat exchanger, for circulation through the latter of a coolant fluid, out of communication with the resistance liquid, to cool the latter.

52. A torque absorption device, comprising: stator and rotor sections, each having means cooperating with the other to provide a working circuit for a power absorption fluid; heat exchange means in said stator section disposed in a zone radially beyond the periphery of said rotor section and comprising a series of circumferentially extending tubes; an inlet header communicating with one end of said tubes; an outlet header communicating with the opposite end of said tubes; and baffle means in said stator section arranged to direct circulation of power absorption fluid from said rotor over the exterior surface of said tubes.

53. In a Froude type dynamometer, a vaned stator casing adapted to contain resistance liquid; a vaned rotor in said stator; and heat exchange conduit means disposed within the stator casing circumferentially about the rotor, said conduit means being adapted to have a coolant liquid flow in contact with one surface thereof, said rotor having means for directing at least part of the resistance liquid for contact with another surface of said conduit means prior to its rejoining the remainder thereof, for transfer of heat from the resistance liquid to the coolant liquid.

54. In a Froude type dynamometer, a vaned stator casing adapted to contain a resistance liquid; a vaned rotor in said stator cooperating with said stator to provide a toroidal circulation path for resistance liquid; a heat exchanger including conduit means disposed within the stator casing outwardly of the rotor's periphery; and means to direct at least a portion of the resistance liquid into contact with said conduit means for heat exchange therebetween; and means in said stator to induce flow of resistance liquid, after being thus cooled, away from said conduit means, and into the toroidal circulation path.

55. In a Froude type dynamometer, a vaned stator casing adapted to contain resistance liquid; heat exchange conduit means disposed about the rotor's periphery, but within the casing, the rotor having a plurality of spaced, peripheral liquid discharge apertures directed towards said conduit means for discharge of a portion only of the circulating resistance liquid for contact with said conduit means for extraction of heat from such resistance liquid.

56. In a Froude type dynamometer, a vaned stator casing adapted to contain resistance liquid; a vaned rotor in said stator; heat exchange conduit means disposed about the rotor's periphery in radially spaced relation thereto, but within the casing, the rotor having a plurality of liquid discharge apertures spaced about its periphery, and directed towards said conduit means, for discharge of a portion only of the circulating resistance liquid for contact with the conduit means, and for extraction of heat from such resistance liquid; and means activated by the normal circulation of the resistance liquid for inducing flow of resistance liquid away from said conduit means.

57. In a Froude type dynamometer, a rotor having radial vanes defining cups; a stator casing including a portion surrounding and spaced from the periphery of said rotor; and heat exchange means in said space, the stator being vaned to define cups terminating at their outer ends beyond the rotor's periphery and in communication with the heat exchange means, the rotor having bleed parts in its periphery for discharge of a part of the resistance liquid from the rotor's cups into contact with said heat exchange means.

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