May 28, 1929. B. C. CARTER 1,714,658

CENTRIFUGAL SEPARATOR

Filed Dec. 10, 1928 8 Sheets-Sheet 1

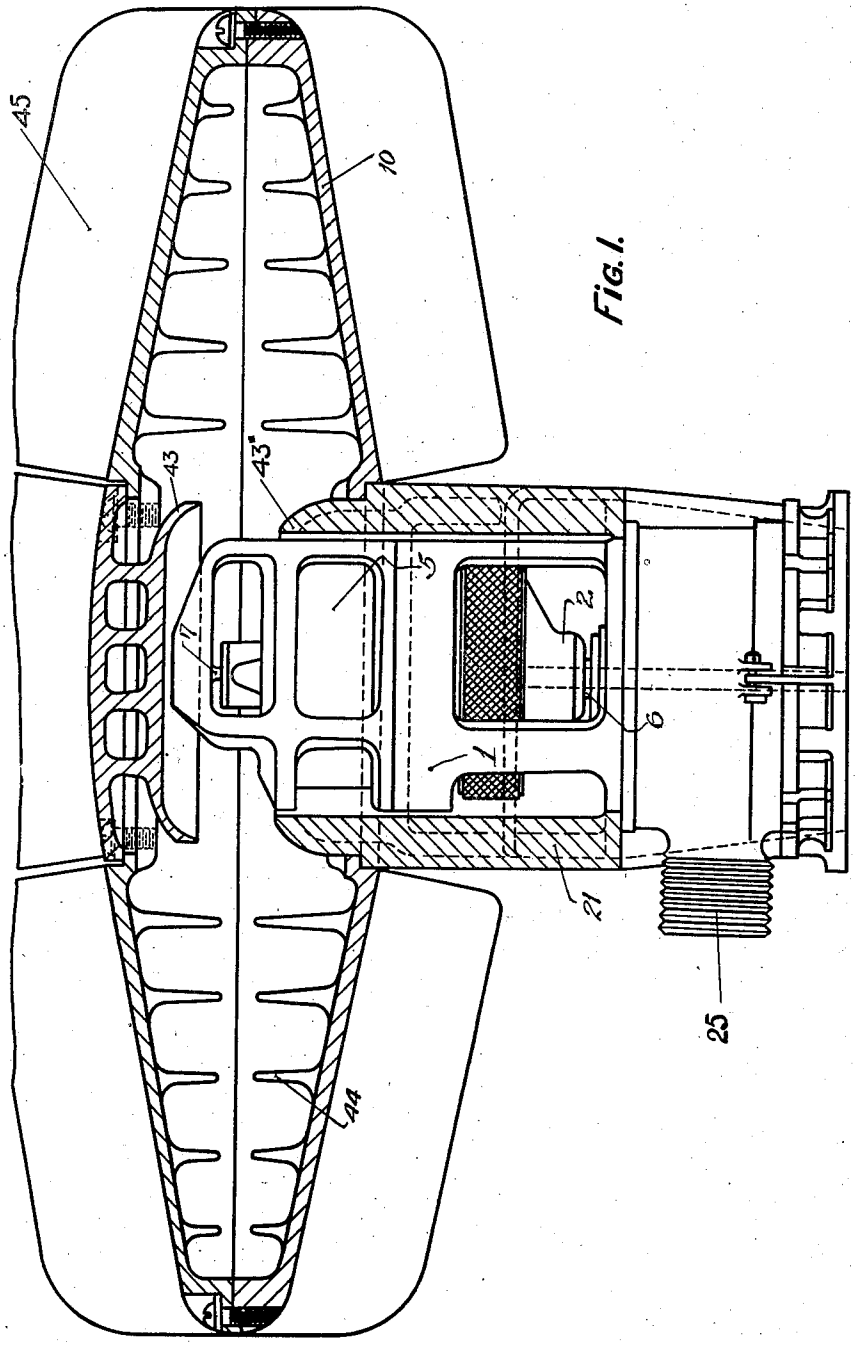


Fig. 1.

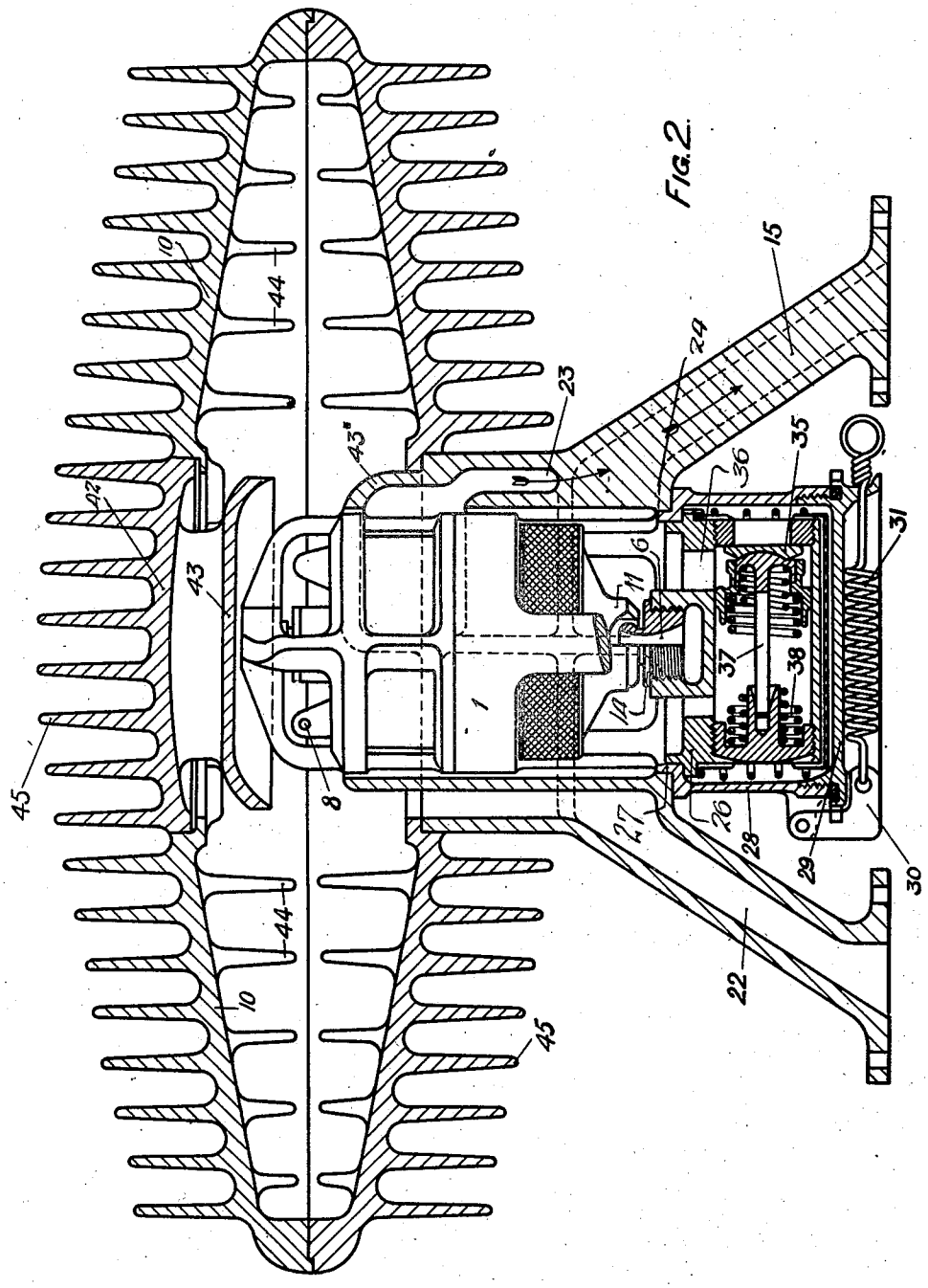
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May 28, 1929. B. C. CARTER 1,714,658

CENTRIFUGAL SEPARATOR

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FIG. 2.



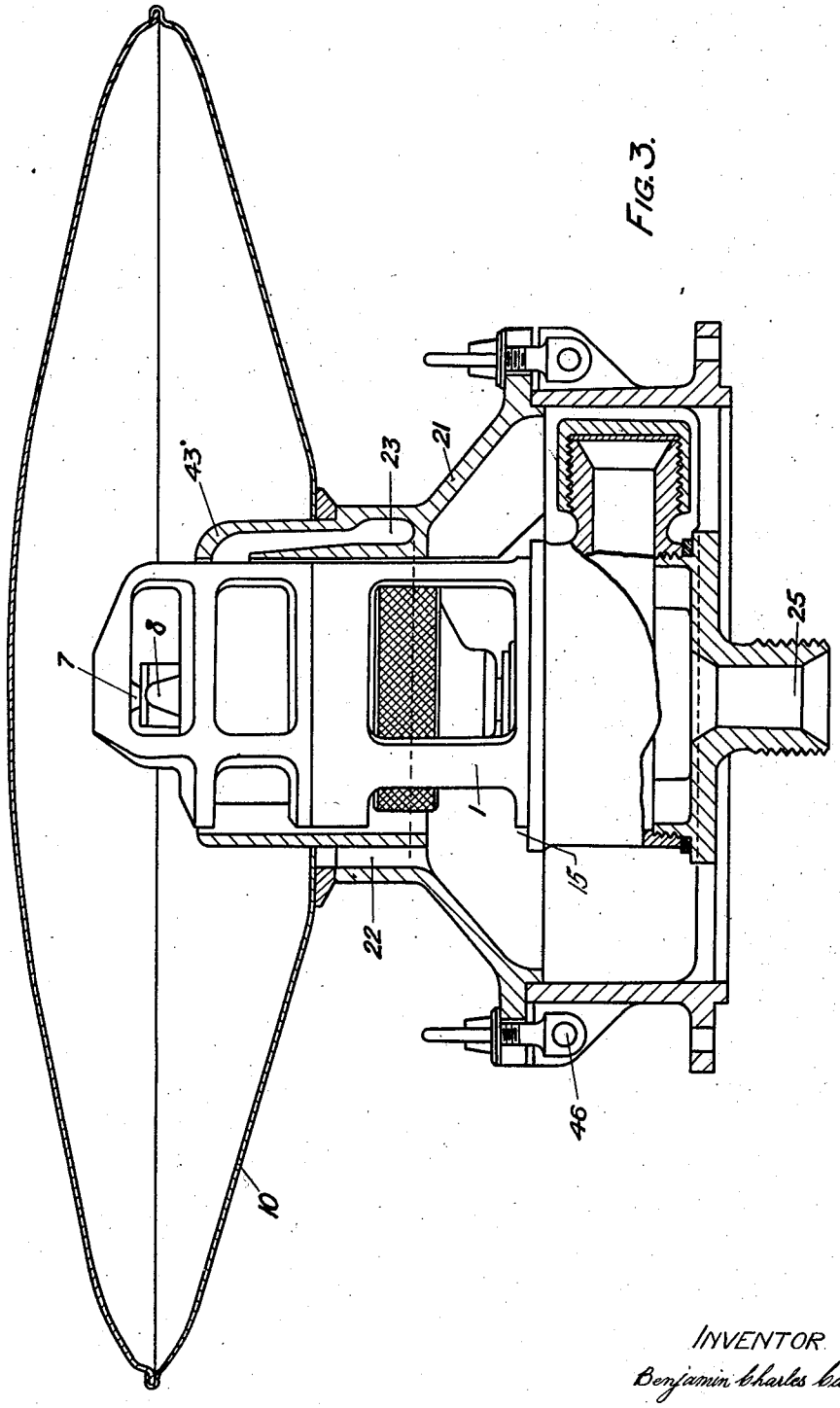
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CENTRIFUGAL SEPARATOR

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FIG. 3.



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CENTRIFUGAL SEPARATOR

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FIG. 4.

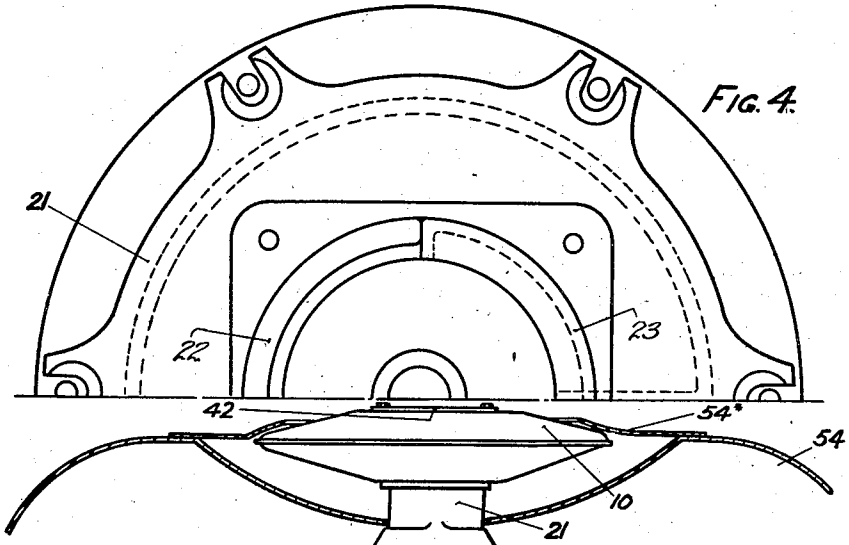


FIG. 8.

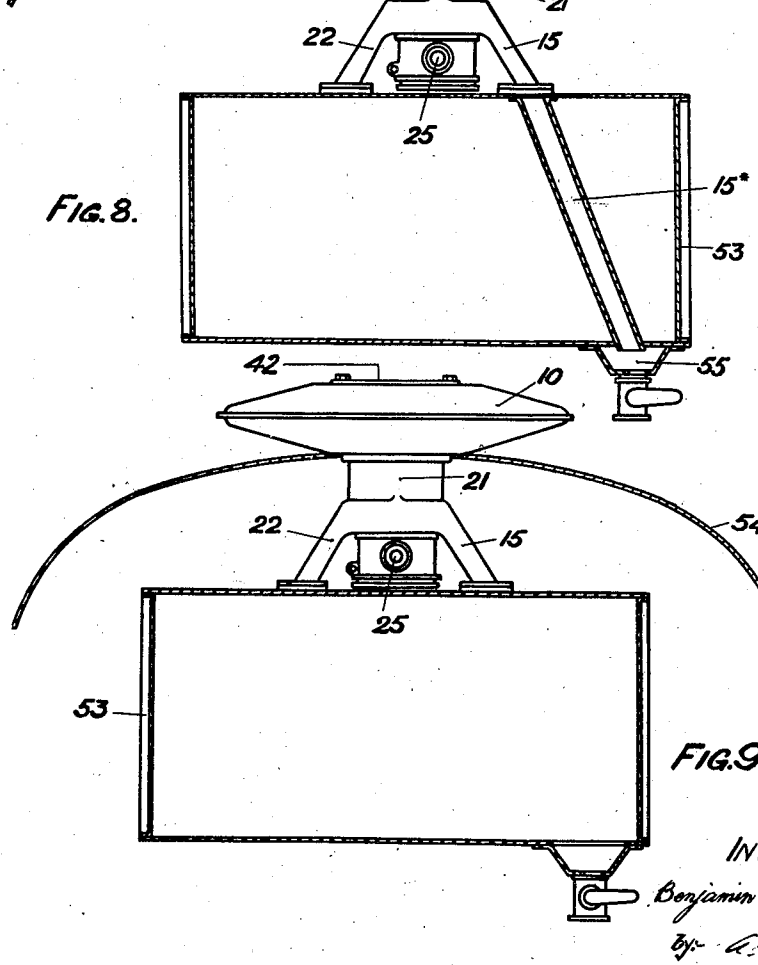


FIG. 9.

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CENTRIFUGAL SEPARATOR

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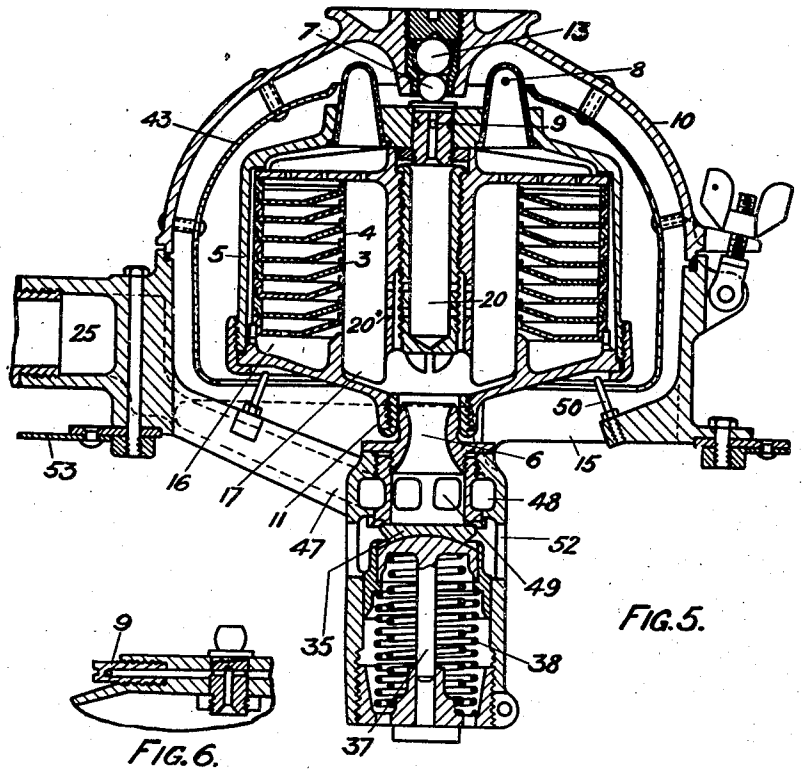


FIG. 5.

FIG. 6.

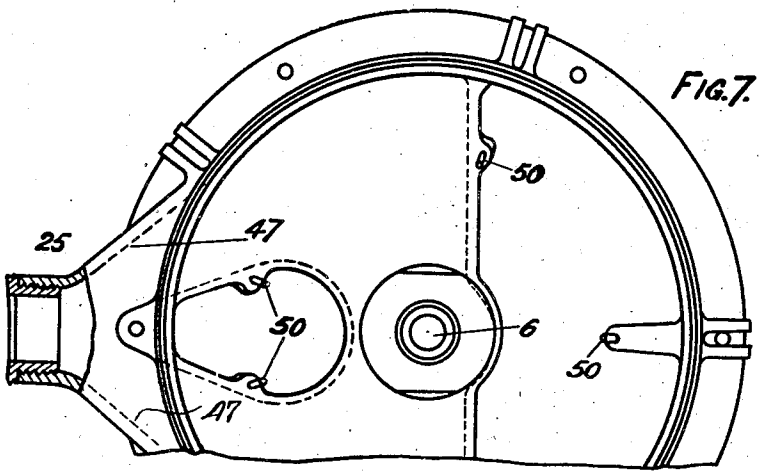


FIG. 7.

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CENTRIFUGAL SEPARATOR

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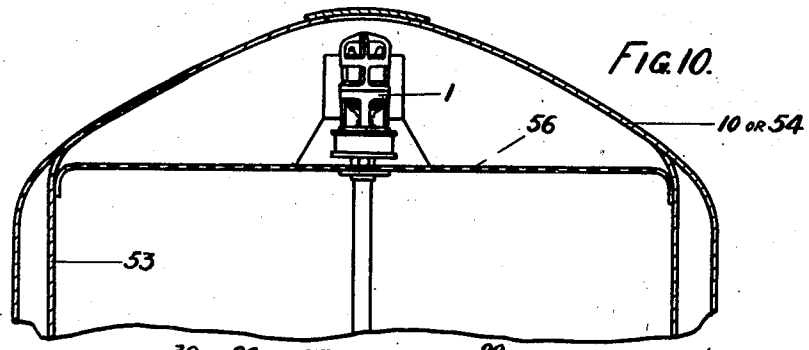


FIG. 10.

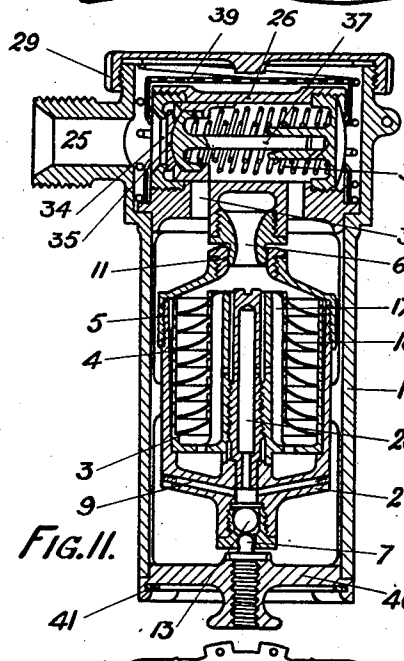


FIG. 11.

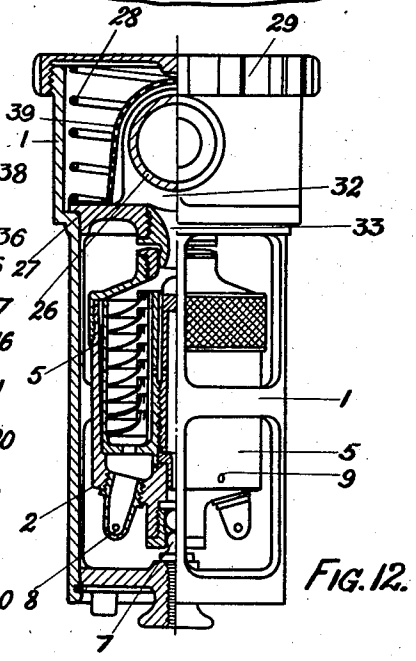


FIG. 12.

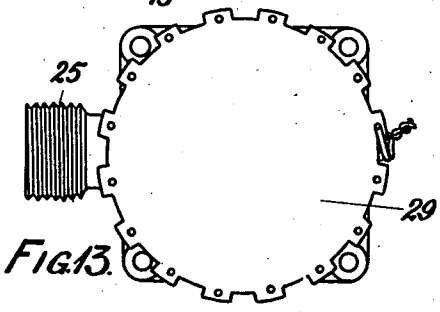


FIG. 13.

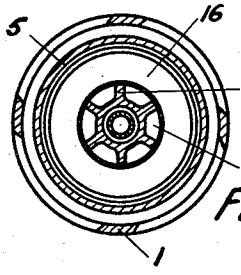


FIG. 14.

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CENTRIFUGAL SEPARATOR

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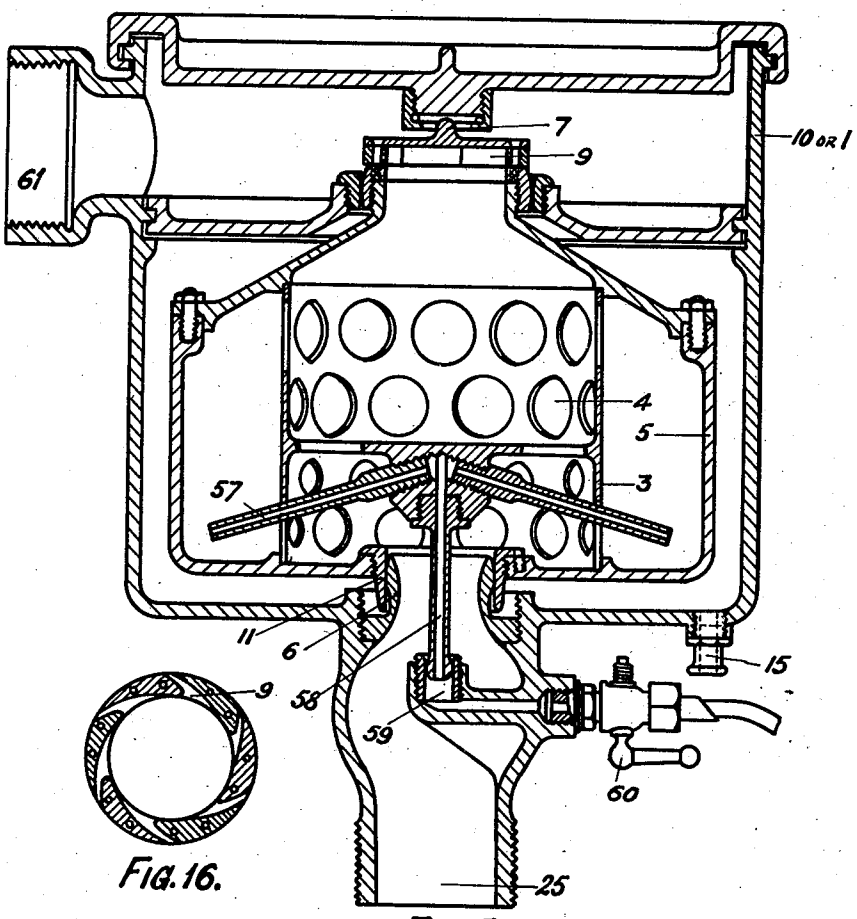


FIG. 15.

FIG. 16.

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CENTRIFUGAL SEPARATOR

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FIG. 17.

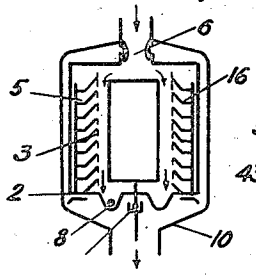


FIG. 20.

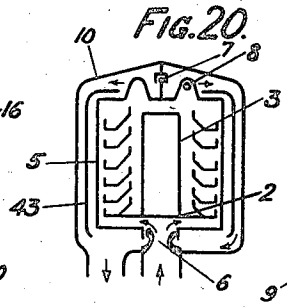


FIG. 25.

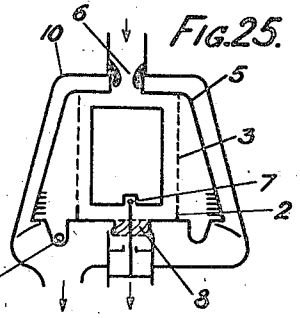


FIG. 18.

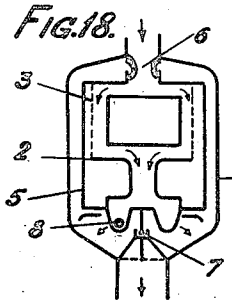


FIG. 21.

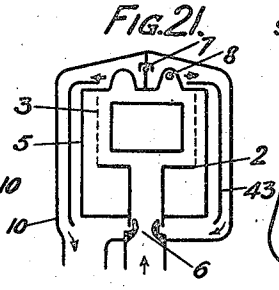


FIG. 26.

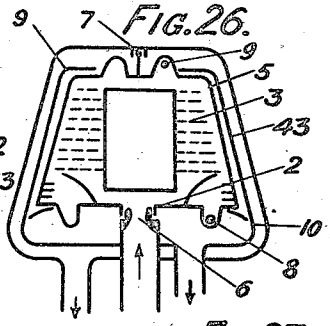


FIG. 19.

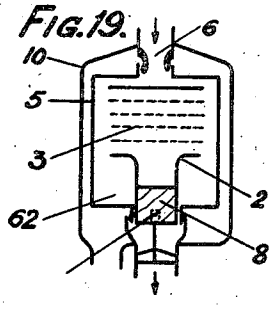


FIG. 22.

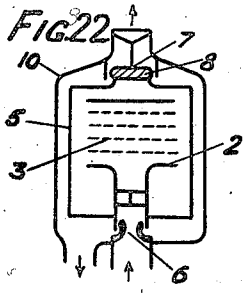


FIG. 27.

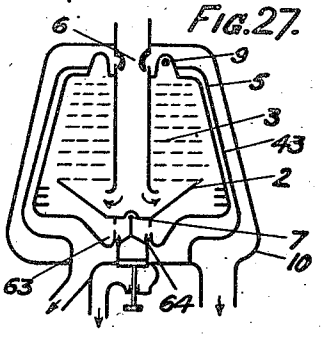


FIG. 23.

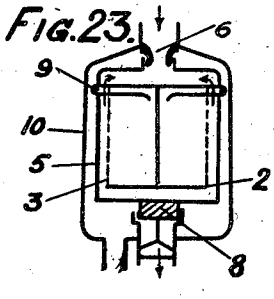
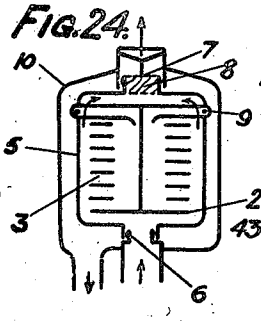


FIG. 24.



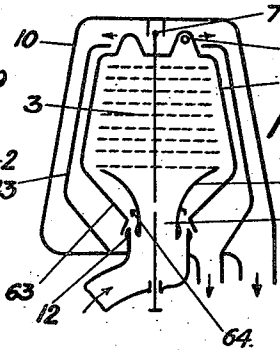


FIG. 28.

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Patented May 28, 1929. 1,714,658

UNITED STATES PATENT OFFICE.

BENJAMIN CHARLES CARTER, OF SOUTH FARNBOROUGH, ENGLAND.

CENTRIFUGAL SEPARATOR.

Application filed December 10, 1928, Serial No. 325,132, and in Great Britain October 28, 1927.

This invention relates to rotary or centrifugal coolers and rotary or centrifugal separators for treating liquids or gases.

According to one feature of the invention a rotary or centrifugal separator is combined with a rotary or centrifugal cooler.

According to another feature of the invention a combined separator and cooler comprises a rotor provided with nozzles or the like for distributing or spraying separated fluid against the interior surface of a cooling chamber, the jets of fluid serving to drive or aid in driving the rotor.

According to another feature of the invention, the fluid cooler comprises a rotary or centrifugal distributing or spraying device for delivering the fluid against the interior surface of a cooling chamber.

According to another feature of the invention, the axial flow centrifugal separator comprises a stationary casing containing a rotor having an inner rotary cylindrical wall or structure formed with radial passages or perforations through which solid or other impurities to be separated pass radially inwards or outwards, and an outer rotary cylindrical wall of imperforate construction on which solid impurities chiefly collect, the rotor being supported within the casing by means of pivot bearings, one pivot being hollow to form an entrance passage for the liquid or fluid to be treated, and the other being solid, and the outlet for liquid or air or gas from the rotor being in the form of nozzles or the like and arranged tangentially in such a manner that the rotor is driven by the issuing fluid or separated fluids.

Some of the nozzles may be inclined to give the fluid jets a slight upward direction, and some of the nozzles may be inclined to give the fluid jets a slight downward direction. In this arrangement, the liquid jets sweep out the upper and lower portions or different portions respectively, of the interior surface of the cooling chamber. Projections or fins may be arranged inside and outside the cooling chamber. The nozzles may be made in the form of round holes or in the form of slits. The nozzles may be of thimble form provided with holes countersunk on the outside, so that for oil or the like the jet issues from a sharp-edged orifice.

The rotor being driven by the fluid jets issuing therefrom in the manner of a turbine, the fluid may be delivered against the interior surface of the cooling chamber in the form of spray. The fluid to be cooled travels at high speed in lines tangential to the circle described by the outlet reaction nozzles of the rotor.

The rotor may conveniently be turned at speeds in the region of 8000 to 10,000 R. P. M., and the velocity of the liquid relative to the surface upon which it impinges may be in the region of 30 ft. per sec. or more. Under these conditions, the transfer of heat from fluid to metal is efficient.

A relief valve may be provided in the cleaner or otherwise for bypassing the liquid in the event of the pressure in a pipe line leading to the cleaner rising to a predetermined value.

The cooling action may be regulated by adjustable guards or deflectors to determine the quantity of the fluid jet entering the cooling regions of the cooling chamber or the amount of exposure of the cooling chamber to the air-flow. Deflectors or guards may also be provided extending from the interior surface of the cooling chamber to between the liquid jets and the air or gas jets to aid in keeping these fluids separate from one another.

Annular or other screens may be provided for shielding the outside of the separator rotor from issuing liquid and for aiding in keeping apart any separated fluids, and separate passages may be provided for leading off separated cooled liquid, air or other gas, and any bypassed liquid to a tank or reservoir for the liquid.

The provision of means in the separator whereby air or gas in a liquid is separated and led from the air or gas nozzles in the rotor principally through a passage which is separate from that down which the cooled liquid, such as oil, is drained, obviates or minimizes frothing. The air or gas nozzles may be made of such a size that all the air or gas and a little liquid flow through them with automatic intermittent action owing to plugs of liquid intermittently accumulating in the conduits leading to these nozzles.

In an internal combustion engine lubricating system, the oil may be contaminated with fuel of lower specific gravity, and in this case if the oil is treated in the separator the fuel may be caused to issue with the separated air or gas and be prevented from returning into the oil circulating system.

When the liquid in the pipe line leading to the cleaner is so cold that more than a specified pressure (say 35 lbs. per sq. in.) is neces-

sary to force it through the cleaner, the relief valve associated with the separator bypasses the bulk of the liquid past the rotor so that it drains back to the tank or reservoir without entering the rotor. The distinct passage for the cooled liquid is arranged so that it cannot obtain access to the separator casing and thus produce a braking effect on the rotor. The cooling chamber drains itself naturally to the passage for the cooled liquid, and thus cannot become charged with congealed oil. As the cooling chamber is never subjected to pressure, it can be made of light construction.

The combined separator and cooler are particularly applicable for use on air craft, motor cars or other vehicles, for cleaning or cooling engine oil. The cooling chamber may be exposed to the relative air flow past the vehicle outside a cowl or other surface on the vehicle. The separator casing may project from the cowl on the aircraft, or may be entirely enclosed by the cowl or by the cowl and the cooling chamber. The cooling chamber may be of lenticular, dome or other suitable form.

The cleaner may be connected to the oil and air discharge from the scavenge pump of an internal combustion engine so that the separator is operated by hot aerated oil. The cooling is effected after the cleaning, for which latter high temperature is advantageous.

The invention is illustrated in the accompanying drawings, in which:—

Figs. 1 and 2 are longitudinal sections at right angles to one another of one form of combined rotary separator and rotary cooler;

Figs. 3 and 4 are respectively a longitudinal section and a fragmental plan view with parts removed, of another form of combined rotary separator and rotary cooler;

Figs. 5, 7 and 6 are respectively a longitudinal section, a sectional detail, and a fragmental plan view with parts removed, of another form of combined rotary separator and rotary cooler;

Figs. 8, 9 and 10 are general arrangement views showing the application of a combined rotary separator and rotary cooler to an oil tank on an aeroplane or the like;

Figs. 11 and 12 are longitudinal sections at right angles to one another of one form of rotary separator;

Figs. 13 and 14 are respectively a plan and a transverse section of Fig. 11;

Figs. 15 and 16 are respectively a longitudinal section and a transverse section of a detail of another form of rotary separator; and

Figs. 17 to 28 are diagrammatic longitudinal sections of different forms of rotary separators in cooler casings.

Like reference numerals indicate similar parts wherever repeated in the drawings, in which:—The rotary separator is shown as consisting of a stationary casing 1, a rotor 2 having an inner rotary wall 3 formed with radial passages 4 through which impurities to be separated pass radially inwards or outwards, and an outer rotary imperforate wall 5 on which solid impurities chiefly collect mounted within said casing, a hollow pivot 6 serving as an inlet passage. A solid pivot 7 supports the rotor, and outlets 8 or 9 or both are arranged tangentially in the rotor in such a manner that the rotor is driven by the issuing fluid or separated fluids. The rotary cooler is shown as consisting of the rotary distributing or spraying devices 8, and a cooling chamber 10 against the interior surface of which the fluid issuing from the outlets 8 is cooled.

The pivot bearings at the inlet end may consist of a running gland 11 outside a stationary gland bush 6 (Fig. 2), or a running gland bush 6 inside a stationary gland 12 (Fig. 28). The pivots may be of spherical form, as shown, in the region of contact with cylindrical bearing surfaces in which they work. Thrust may be taken by a ball 13 (Fig. 5) engaging the end of the solid pivot 7. If, however, the cleaner is installed with the hollow pivot 6 at the bottom (Fig. 2), the weight of the rotor may be utilized to reduce the thrust due to liquid pressure. When this pressure is low the rotor may be located axially by engagement between a shoulder on the hollow pivot 6 and one end of the gland 11 or 12. The casing 1 may be of open form (Fig. 1) or of enclosed form (Fig. 15) and is provided with a drain 15 for liquid which has escaped thereinto or for liquid which is bypassed as hereinafter referred to, and the drain is located at such a position that the liquid is discharged from the rotor at the lower end of the separator.

The rotor may be provided with transverse vanes 16 dividing it into laminated separating zones and with axial-radial vanes 17. In Figs. 5 to 14, the vanes 16 consist of a tier of separated channel-section annular trays fitting into the rotor 2 and provided at their inner peripheries with lips or flanges which conjointly form the inner rotor wall 3. The spaces between these lips or flanges constitute the passages 4 in such wall and they communicate with an annular space 19 (Fig. 11) for liquid to be treated to flow through axially, the annular space surrounding an air or gas escape tube 20 provided with branches leading to the periphery of the rotor. The trays rest upon or interlock with one another at their outer flanges and here form the imperforate wall 5, whereas the inner flanges form a perforate wall as above stated. Any centrifugal foreign solid matter is collected chiefly on the outer flanges or wall. On shutting down, relatively heavy liquid such as water, or fine congealed matter, in the trays is retained therein. The

trays may be carried on a frame formed by the axial-radial vanes 17 surrounding the air or gas tube 20, the frame being so shaped that its component radial vanes provide means for removing the tier of trays from the rotor for cleaning.

Referring to Figs. 1 and 2, the separator casing 1 is made fast to the cooling chamber 10 by means of a cylindrical coupling 21 which at one side is supported by a hollow standard 22 forming an outlet for cooled-cleaned liquid from the cooling chamber, and at the other side is supported by a hollow standard divided into two separate branches 23, 15, respectively for separated air or gas and liquid which has leaked or been bypassed into the separator casing 1. The separator is similar to that shown in Figs. 11 to 14 but inverted and will be described with reference to these figures also. The liquid to be treated enters the separator casing at 25 and passes therefrom past an inner casing 26, which bears on an annular seating 27 in the separator casing 1 under the pressure of a spring 28 and normally divides the casing 1 into two parts. The spring bears against a detachable cover 29. The cover may be screwed on the casing and secured by a detent 30, which is pivoted on the casing and engages one or a series of notches in the edge of the cover, and by a spring 31 anchored in another of the notches. The liquid can pass from the inlet 25 into one end of the casing 1 and thence through a passage 32 to an axial passage 33 in the casing 26 and leading to the interior of the rotor 2. The inner casing also has an inlet 34 normally closed by a valve 35 and leading through an inlet 36 to the other end of the casing 1 beyond the inner casing 26. The valve 35 is arranged with its axis diametrically of the casing 1 and consists of a self-centering disc-valve, which is pressed on to its seating by a piston 37 working in a cylindrical portion of the inner casing 26 and acted on by two springs 38.

A coarse mesh gauze or other filter 39 is arranged over the inner casing 26 or at other convenient position for excluding pieces of material large enough to choke the nozzles 8, which may be in the region of $\frac{1}{16}$ inch diameter or more. The end 40 of the casing, where the solid pivot 7 is situated, may be made detachable as shown in Figs. 11 and 12, and be secured by a circular clip 41 sprung into engagement with grooves in lugs on the part 40 and the casing 1.

The cooling chamber 10 is shown of lenticular form and composed of two nearly identical castings bolted together at the outer peripheries.

The cooling chamber 10 and the separator casing 1 are located in axial alignment, and may be arranged vertically or at any suitable inclination. The rotor 2 may be removed for periodically emptying separated foreign matter, by opening either end of the separator in the arrangement shown in Figs. 11 and 12, or by opening the lower end of the separator in the arrangement shown in Figs. 1 and 2. The part 20 is made as an extractor screw, so that by turning the same with a screw driver the centre portion of the rotor carrying the trays 16 and frame 17 may be removed from the wall 5. The rotor wall 5 may be slightly tapered to facilitate this extraction. The cooling chamber in Figs. 1 and 2 has its top half closed by a cover 42, which permits the rotor to be removed through the cooling chamber in some cases. The cleaner casing 1 is of cage or skeleton form, to allow the jets of liquid and/or gas issuing from the nozzles 8 and 9 to pass into the cooling chamber 10.

43 is a screen for shielding the outside of the rotor 2 from issuing liquid, and 43* is a deflector for aiding in keeping apart separated liquid and air or gas.

44 are projections inside the cooling chamber, and 45 are cooling fins outside the cooling chamber.

Figs. 3 and 4 show a simplified form of the combined separator and cooler just described. The cooling chamber 10 has plain surfaces and is connected to the separator casing by means of a coupling 21. The coupling is made in two parts connected by swivel bolts 46. The top part can be removed bodily with the cooling chamber from the bottom part, when inspection of the separator is required. The inlet 25 to the separator casing 1 is axial, and the cooled liquid from the passage 22 and the bypassed liquid from the drain 15 meet one another. The separated air or gas passes to the passage 23, whence it may be led off separately from the liquid.

Figs. 5 to 7 show another form of combined separator and cooler. In this arrangement the separator casing is formed as a cooling chamber 1, or 10, and is made in two separable parts connected together by swivel bolts as in Fig. 3. The top part is dome shaped, and the bottom part is cylindrical. The inlet 25 to the separator is arranged as a forked passage 47 leading to an annular passage 48, which in turn leads by radial ports 49 to the axial inlet 6 of the rotor. The dome can be removed to give access to the separator, which is centred during this operation by supporting studs 50.

43 is a screen for the rotor, which also aids in keeping apart separated liquid issuing from the nozzles 8, and separated air or gas issuing from the nozzles 9. The separated air or gas passes to the nozzles 9 through a central air tube 20, which latter is fed through radial holes 20* near the inner wall 3 of the rotor.

In this arrangement a relief valve 35 is disposed axially, and bypassed liquid escapes through passages 52.

Referring to Figs. 8, 9 and 10, the numeral 53 represents an oil or the like tank covered by a cowl 54 on an aeroplane or the like vehicles. The cooling chamber 10 projects more or less beyond the cowl in Figs. 8 and 9, and in Fig. 10 is constituted by the cowl itself. 54* is a detachable shield for controlling the cooling effect.

In Figs. 8 and 9, the coupling 21 connecting the cooling chamber and the separator is mounted directly on the tank.

In Fig. 9, the passages 22 and 15 lead directly to the tank. In Fig. 8, the passage 22 leads directly to the tank, but the passage 15 leads by an extension 15* directly to a sump 55 in the tank, which is connected to the suction side of the oil feed or pressure pump of the aero engine or the like. The inlet 25 to the separator is connected to the oil and air discharge from the scavenging pump of the engine.

When the oil is cold it is bypassed from the relief valve to the sump 55 and the suction side of the pressure pump, and as the oil becomes warmer the pressure pump takes an increasing proportion of oil from the oil tank owing to the relief valve closing. This arrangement facilitates quick warming up of the engine.

In an alternative arrangement, oil, which in existing arrangements is bypassed through a relief valve to the suction side of the pressure pump or to the engine sump, may, by suitable arrangements of conduits and cocks, be circulated through the separator, so that only a proportion of the oil in circulation is centrifuged all the time, but not merely an isolated portion.

When a relief valve is associated with the separator, the relief valve in the pressure pump may be dispensed with and its function fulfilled by the separator which is so installed as to constitute a permanent leak, the valve in the cleaner preventing the oil pressure from becoming excessive.

In Fig. 10, the combined separator and cooler is supported on a perforated diaphragm 56 across the top of the tank 53.

The general form of the centrifugal separator may be according to that described in my British patent specification No. 258,204.

Various arrangements for separating and cooling two fluids may be employed, according to the conditions and requirements of the case. For example apart from dirt extraction there may be two liquids, two gases, or a liquid and a gas to separate. With two liquids, the heavier or the lighter may preponderate. The case of two liquids with a preponderance of the lighter one arises in the separation of water from petrol; the reverse case may arise in the refining of oil or in the separation of oil from water on ships. Either or both of the fluids may be delivered into a pipe line, or it may suffice for one or both to be ejected unsubmerged into a vessel. It may be sufficient to accumulate one separated fluid for periodic removal, or it may be required to remove it continuously.

In Figs. 15 and 16 liquid to be treated flows axially through the perforate central tube or inner wall 3, entering at 25. The light liquid discharges through the nozzles 9 into the cooling chamber 10, and the heavy liquid discharges from near the outer wall 5 of the rotor through radial conduits 57 to a central conduit 58, whence it passes through a running gland 59 to outside the separator, under the control of a cock 60. 61 is the outlet for the lighter liquid.

In another arrangement (Fig. 17), the rotor has the inlet 6 at the top, and tangential or helical outlets 8 at the bottom. Separation takes place through a perforated tube or the like 3 and the separated liquid is retained in removable trays 16 in the rotor 2. Alternatively (Fig. 18), separation may take place through a perforated tube 3 without trays, or (Fig. 19) between perforated transverse discs 3, in which cases the lower part of the rotor 2 may be formed as a reservoir 62 for separated liquid.

In a modification (Figs. 20 to 22), the rotor 2 has the inlet 6 at the bottom and tangential outlets 8 at the top. An annular screen 43 may be used to shield the rotor 2 from issuing liquid (Figs. 20 and 21).

In another arrangement (Fig. 23), the rotor 2 has the inlet 6 at the top and tangential outlets 8, 9, for two fluids at the bottom and top. Alternatively (Fig. 24), the rotor 2 has the inlet 6 at the bottom and tangential outlets 8, 9, for two fluids at the top.

In another arrangement (Fig. 25), the rotor 2 has the inlet 6 at the top and tangential outlets 8, 9, for two fluids at the bottom. Alternatively (Fig. 26), the rotor 2 may have the inlet 6 at the bottom and tangential outlets 8, 9 for two fluids at the bottom and top. In this case a screen 43 for shielding the rotor 2 from issuing liquid may be employed.

In another arrangement (Fig. 27), the rotor 2 has the inlet 6 at the top, tangential outlets 9 for one fluid at the top, and an annular outlet 63 controlled by a valve 64 for another fluid at the bottom. Alternatively (Fig. 28), the rotor 2 has the inlet 6 at the bottom, tangential outlets 8 for one fluid at the top and an annular outlet 63 controlled by a valve 64 for another fluid at the bottom. In each case, a cylindrical screen 43 for shielding the rotor from issuing liquid may be employed.

When a solid is separated from a fluid, the solid accumulates on the imperforate wall of the rotor.

In each of the arrangements shown in Figs. 17 to 28, the tangential or helical outlets deliver the fluid against the wall of a chamber 10 which serves as a cooling chamber.

Although the separators according to the

invention have been described in association with cooling means, they may in some cases be employed without the combination with cooling means.

What I claim is:

1. In a rotary separator, a stationary outer casing; a rotor therein; means for supplying fluid to be separated to the rotor; means for separating solid constitutents from the fluid; and a multiplicity of nozzles on said rotor through which the separated fluid is discharged in jets against the inner wall of the stationary casing and to drive the rotor solely by the reaction produced by the jets.

2. In a rotary separator, a stationary chamber; a rotor therein; means for supplying fluid to be separated to the rotor; means for separating solid constitutents from the fluid; and a multiplicity of nozzles on said rotor through which the separated fluid is discharged in jets against the inner wall of the stationary chamber and to drive the rotor solely by the reaction produced by the jets.

3. A separator according to claim 1, in which the rotor is supported by pivot bearings, one pivot being hollow to form an inlet to the rotor, and the other pivot being solid; and in which the nozzles are arranged tangentially to produce the jet reaction.

4. A separator according to claim 2, in which the rotor is supported by pivot bearings, one being hollow to form an inlet to the rotor, and the other pivot being solid; and in which the nozzles are arranged tangentially to produce the jet reaction.

5. A separator according to claim 2, in which the rotor is supported by pivot bearings, one pivot being hollow to form an inlet to the rotor, and the other pivot being solid; and in which the inner wall of the rotor is formed with radial passages, while the outer wall is imperforate.

6. In a rotary separator, a stationary chamber; a rotor therein; and a tier of separated, channel-section annular trays communicating at their inner peripheries with a space for fluid to flow through axially and resting upon one another at their outer peripheries to form an imperforate wall, said trays dividing the rotor into a vertical series of separating zones.

7. In a rotary separator, a stationary chamber; a rotor; a tier of separated, channel-section annular trays communicating at their inner peripheries with a space for fluid to flow through axially and resting upon one another at their outer peripheries to form an imperforate wall, said trays dividing the rotor into a vertical series of separating zones; and a removable frame wherein the trays are carried and which consists of axial radial vanes.

8. In a rotary separator, a stationary outer casing; a rotor therein; means for supplying fluid to be separated to the rotor; means for separating solid constituents from the fluid; a multiplicity of nozzles on said rotor through which the separated fluid is discharged in jets against the inner wall of the stationary casing and to drive the rotor solely by the reaction produced by the jets; and a screen inside said casing between the wall thereof and the rotor to shield the outside of said rotor from fluid issuing from the nozzles.

9. In a rotary separator, a stationary chamber; a rotor therein; means for supplying liquid to be separated to the rotor; means for separating solid constituents from the liquid; a multiplicity of nozzles on the rotor through which the separated liquid is discharged in jets against the inner wall of said chamber and to drive the rotor solely by the reaction produced by the jets; and separate passages for leading off cleaned liquid, gaseous substance, and bypassed liquid.

10. In a rotary separator, a stationary chamber; a rotor therein; means for supplying fluid to be separated to the rotor; means for separating solid constituents from the fluid; a multiplicity of nozzles on the rotor through which the fluid is discharged in jets against the inner wall of said chamber and to drive the rotor solely by the reaction produced by the jets; and a pair of pivot bearings for supporting the rotor at opposite ends, one pivot being solid and the other being hollow and providing an inlet for material to be separated.

11. A separator according to claim 10, in which the driving jets are situated at the same end of the rotor as the solid pivot.

12. In a rotary separator, a stationary casing; a rotor therein; means for supplying liquid to be separated to the rotor; a multiplicity of nozzles on said rotor acting to discharge jets of liquid against the inner wall of the casing and to drive the rotor solely by the reaction produced by the jets; and a relief valve associated with the liquid-supplying means for bypassing the liquid when its pressure reaches a predetermined degree.

13. A separator according to claim 12, in which the rotor is supported at one end on a hollow pivot providing an inlet for the liquid; and in which the liquid-supplying means includes an annular passage immediately below said hollow pivot and communicating with its interior, and a passage leading to said annular passage, the relief valve being disposed immediately below the hollow pivot.

In testimony whereof I have signed my name to this specification.

BENJAMIN CHARLES CARTER.