O. M. KUCHS.

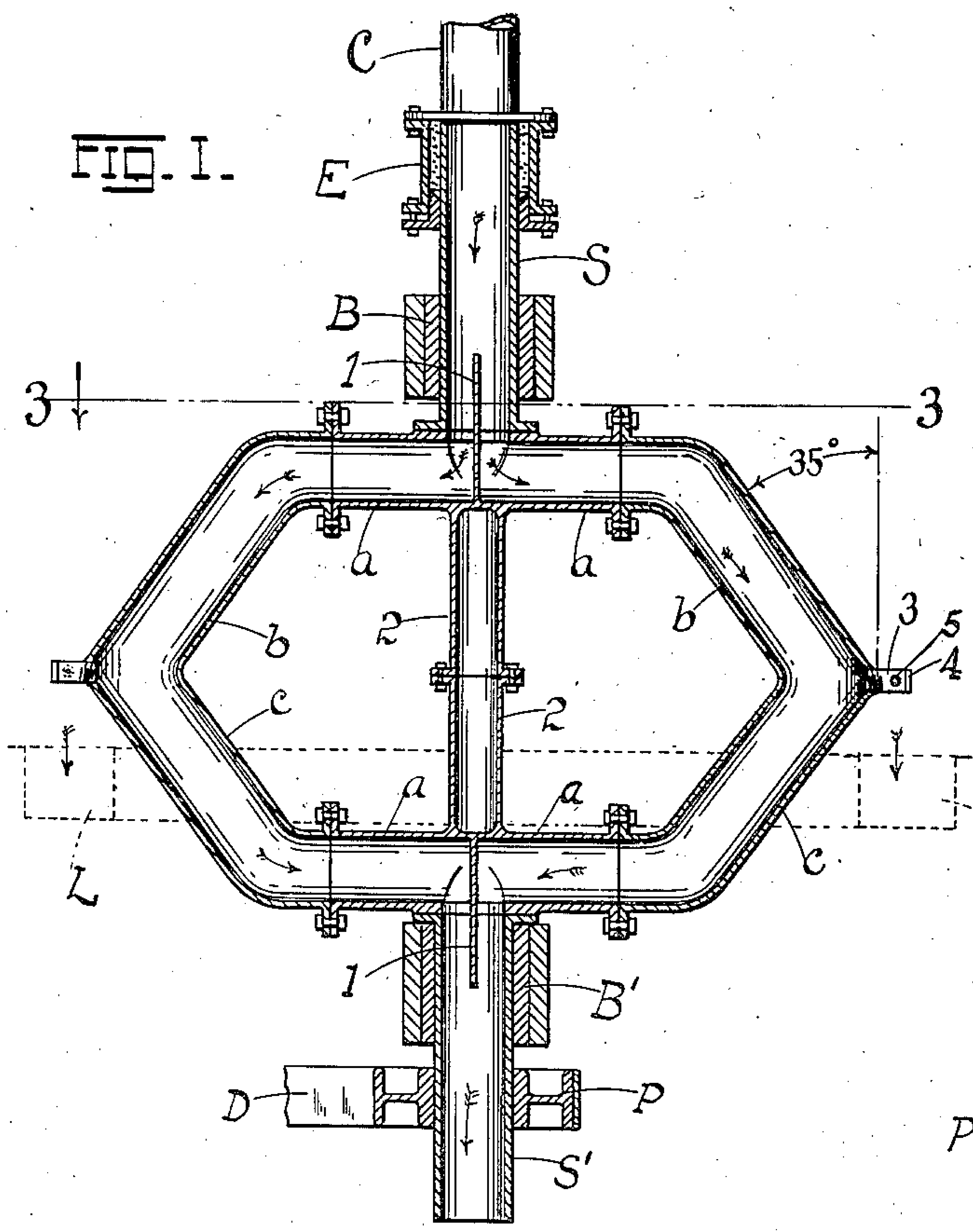
CENTRIFUGAL SLIME SEPARATOR.

APPLICATION FILED JUNE 30, 1909.

943,083. **Patented Dec. 14, 1909.**

4 SHEETS—SHEET 1.

FIG. 1.



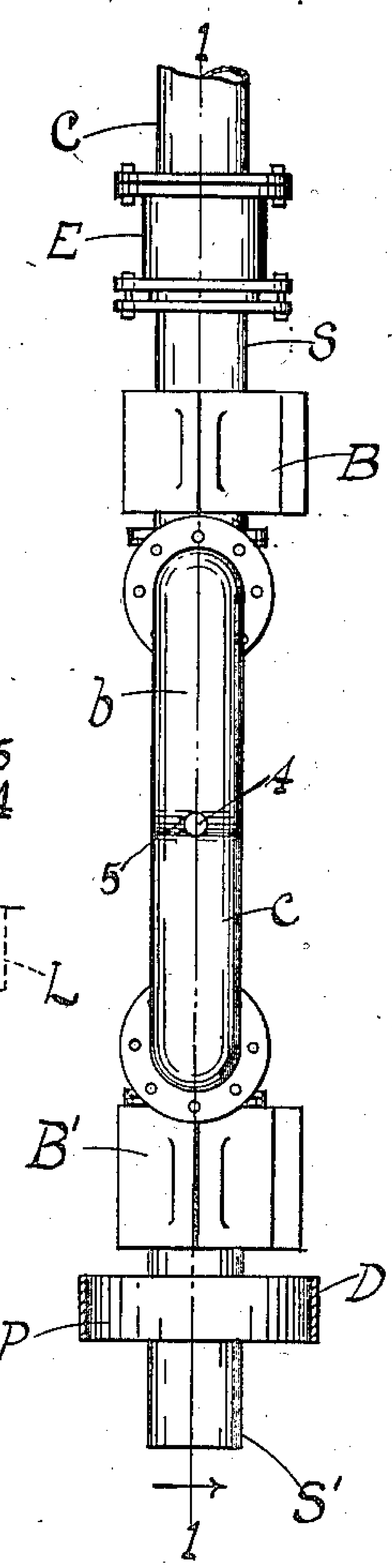


FIG. 2.

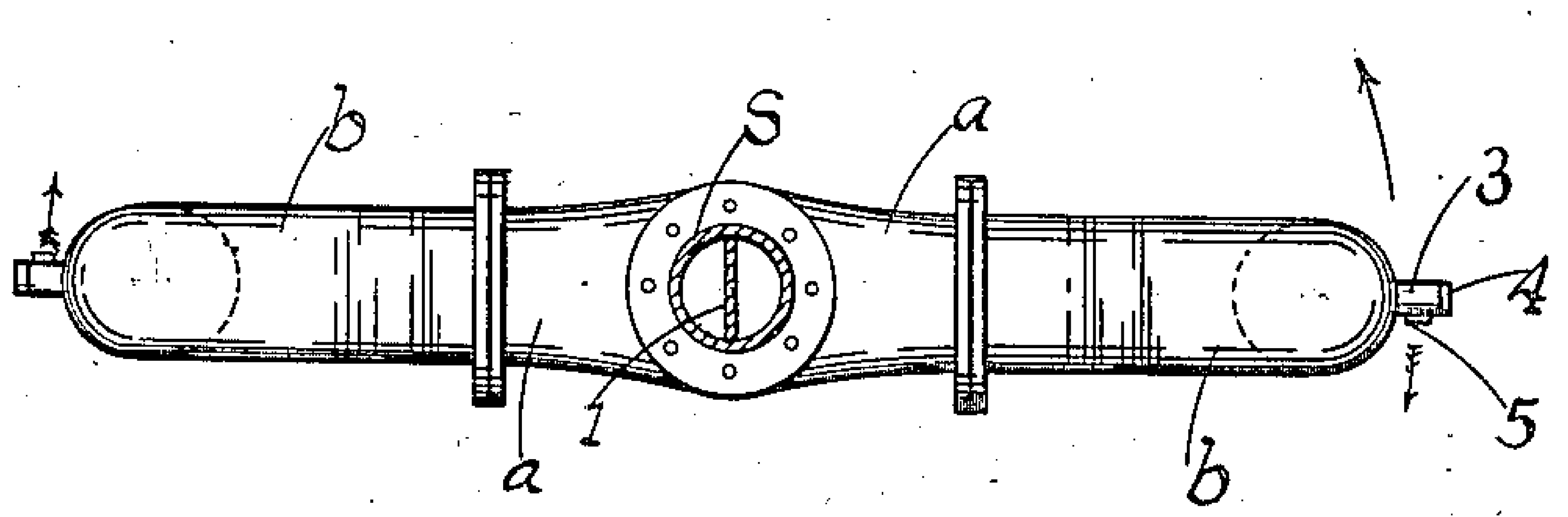


FIG. 3.

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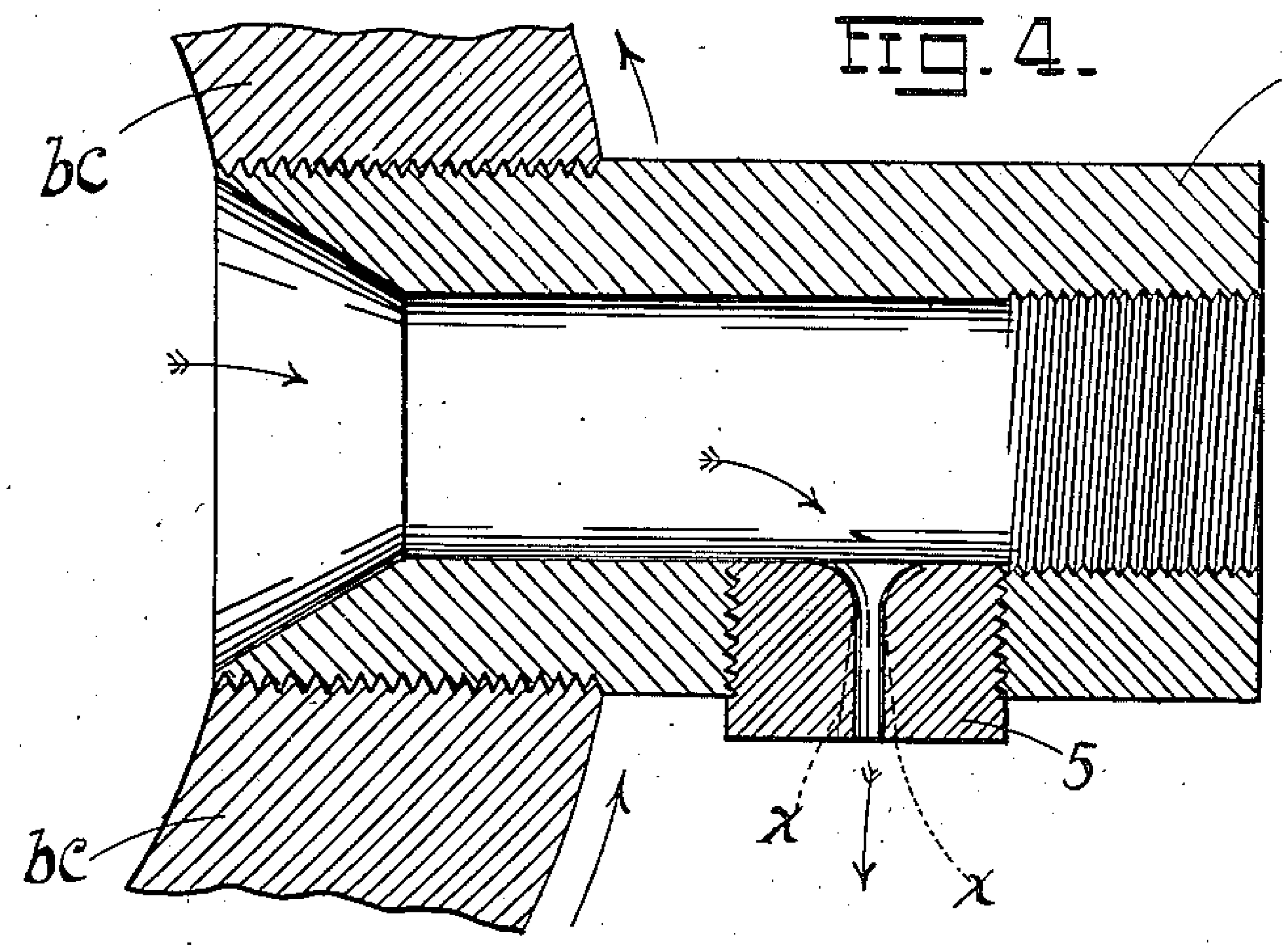
4 SHEETS—SHEET 2.

FIG. 4.



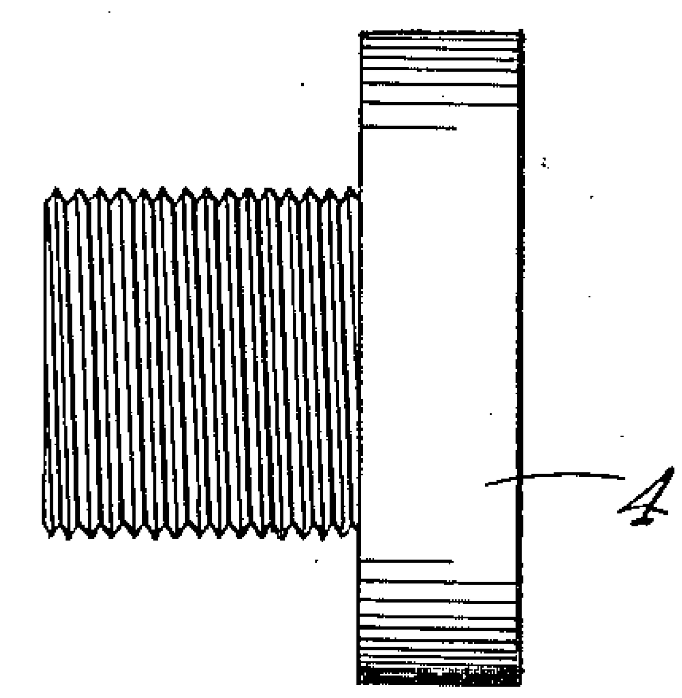


FIG. 5.

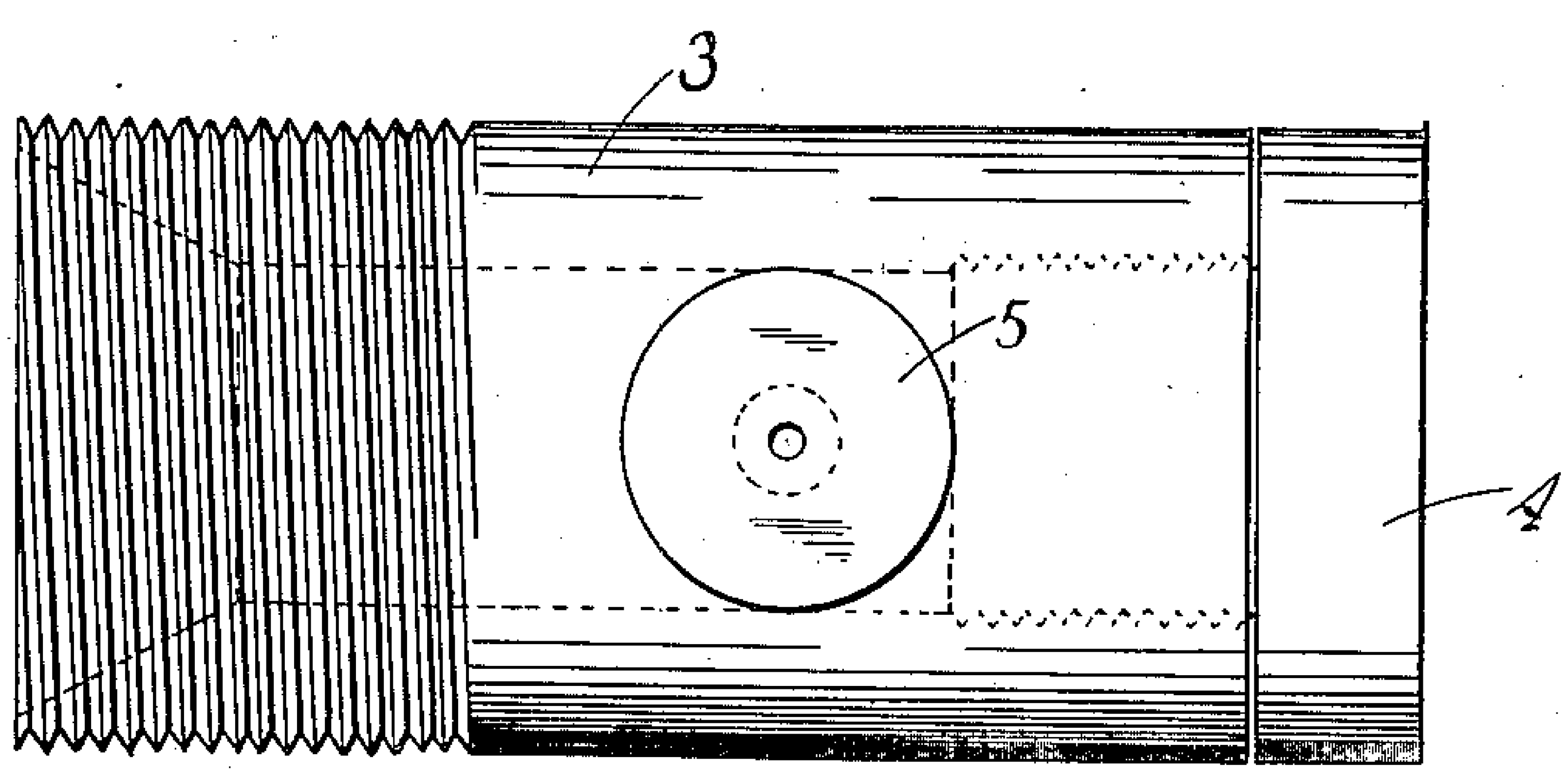
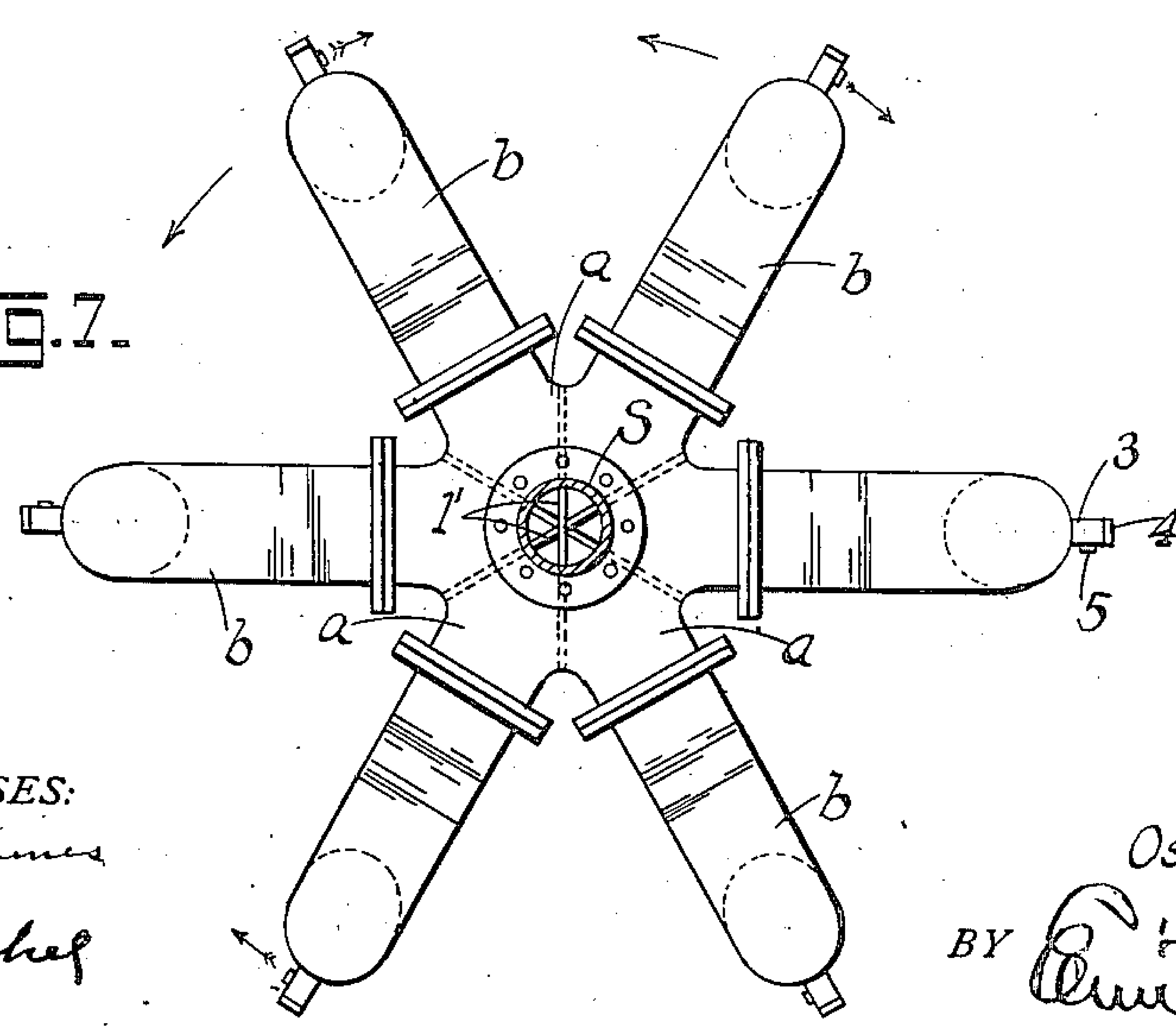


FIG. 6.

FIG. 7.



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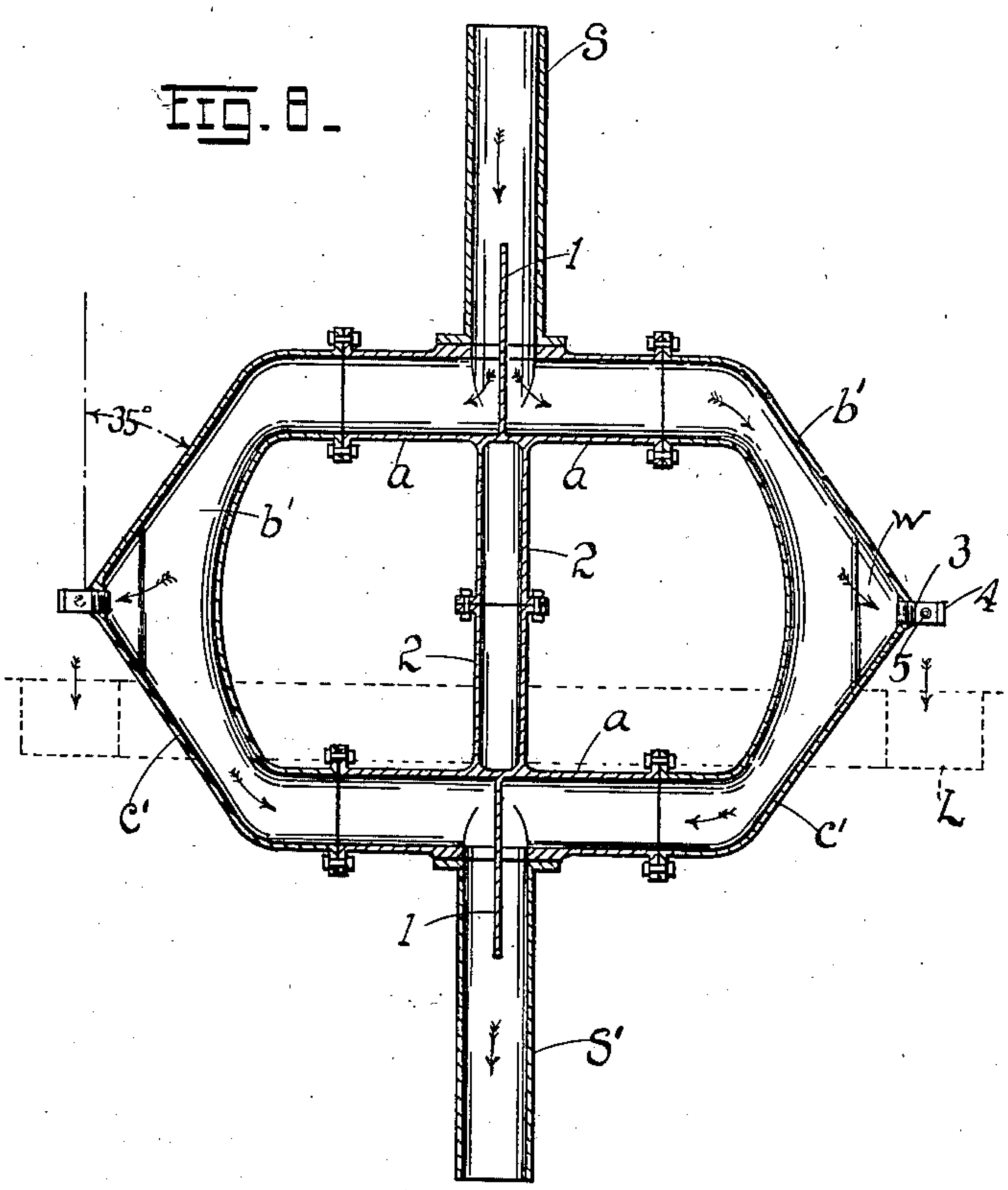
4 SHEETS—SHEET 3.

Fig. 8.



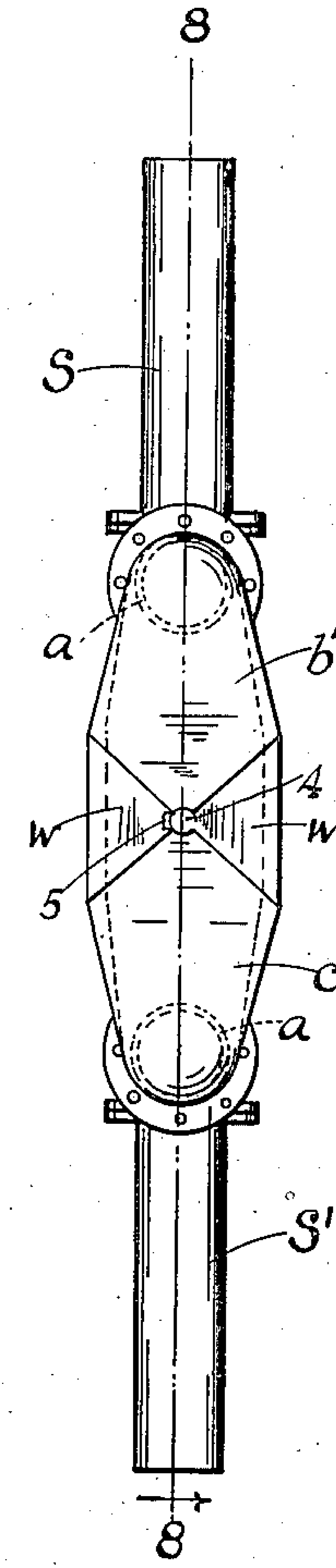


Fig. 9.

Fig. 10.

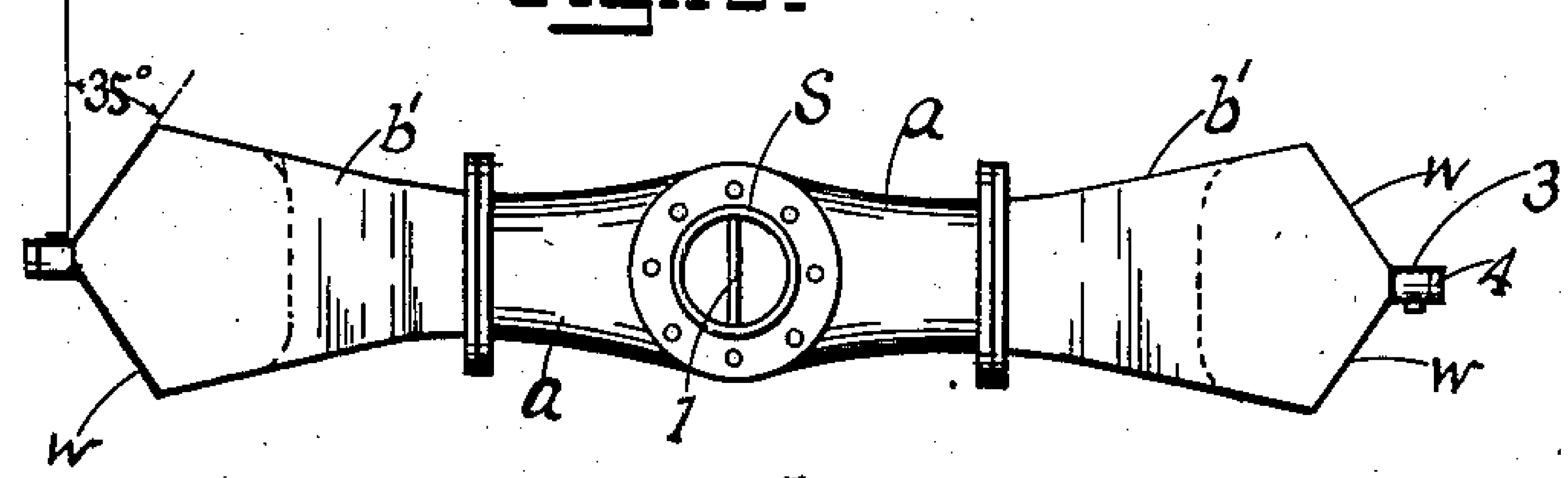
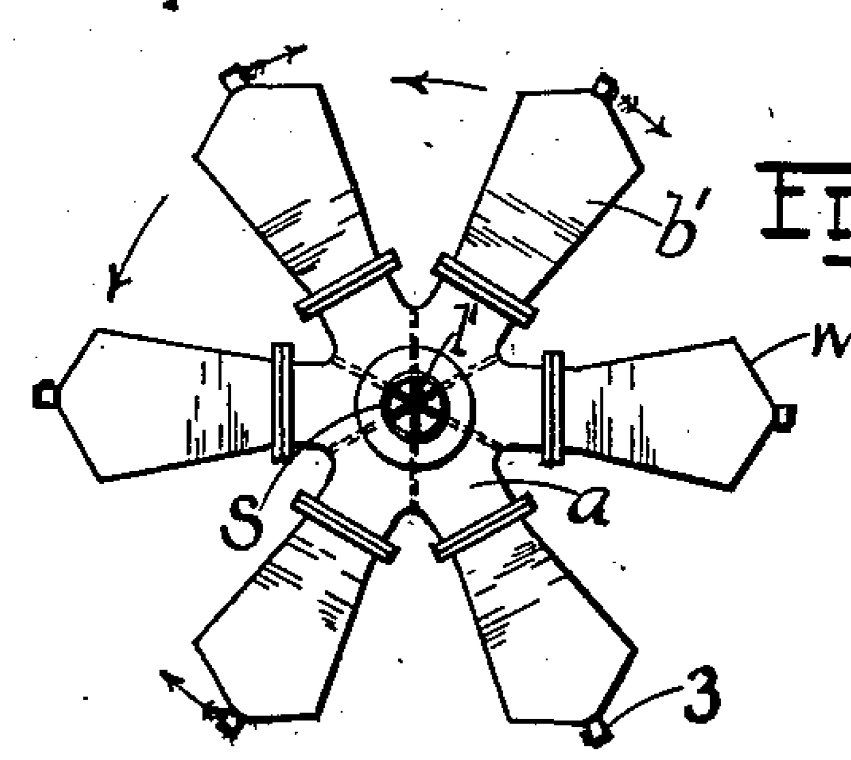


Fig. 11.



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4 SHEETS—SHEET 4.

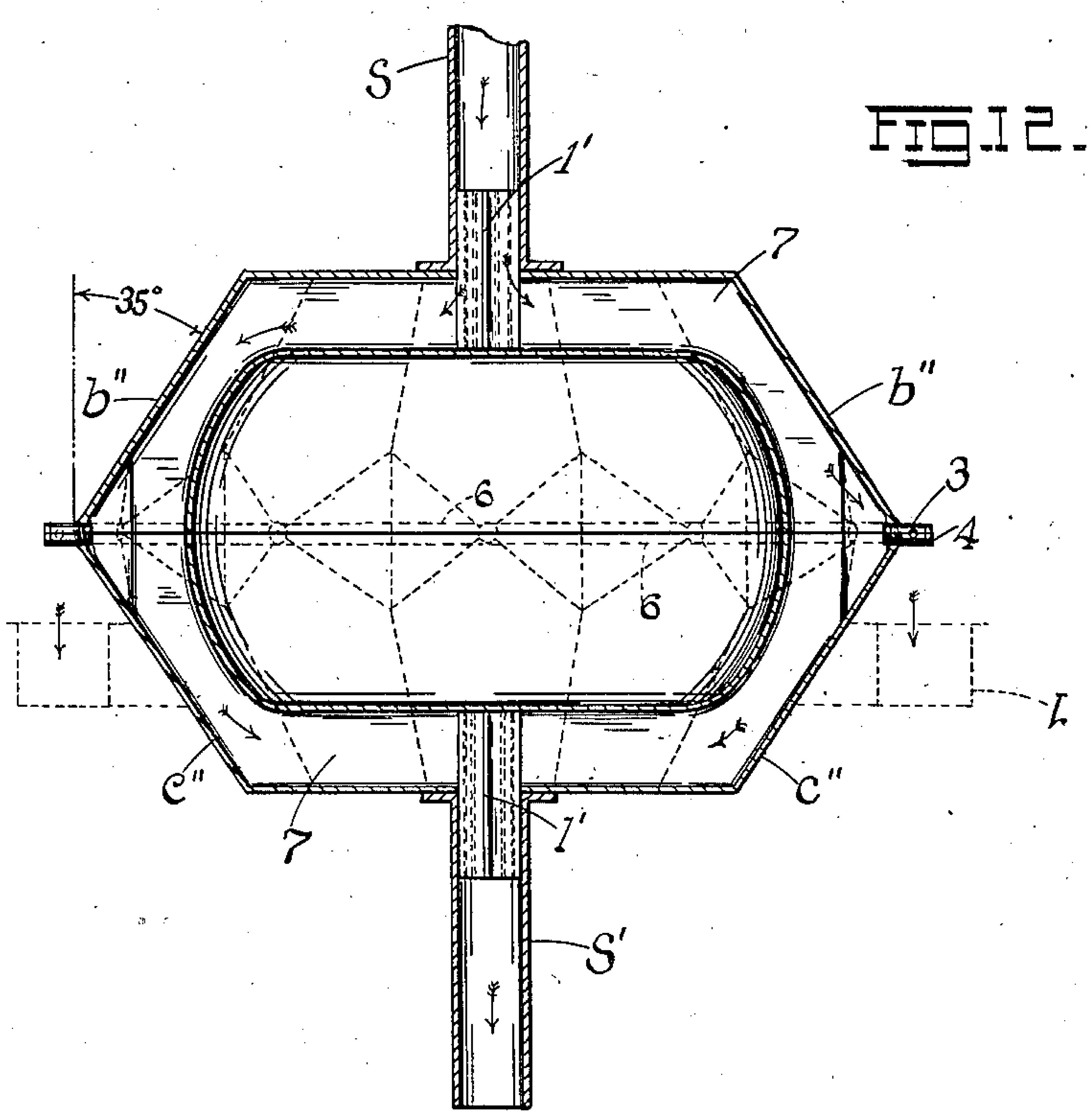

Fig. 12.

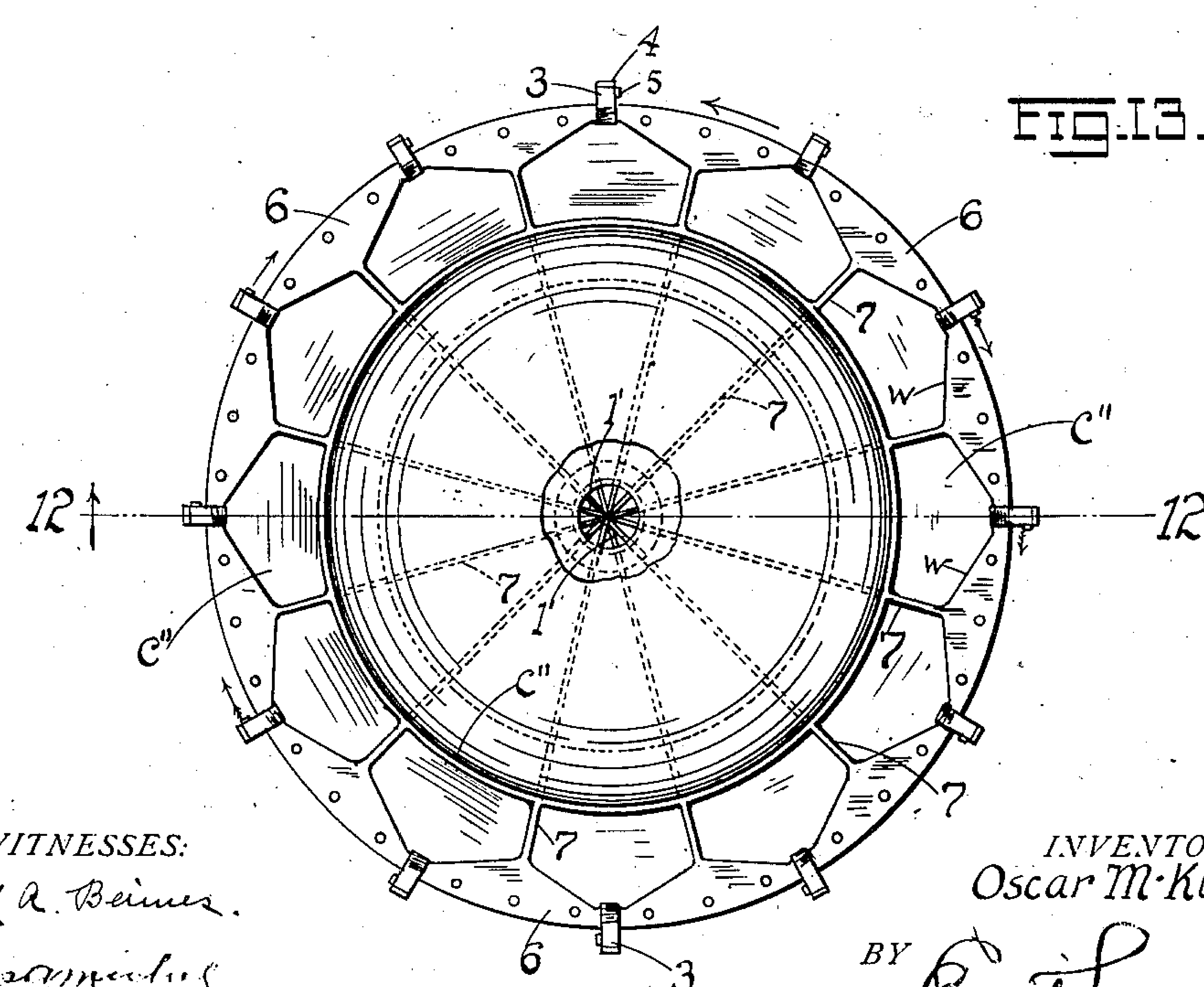

Fig. 13.

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UNITED STATES PATENT OFFICE.

OSCAR MAX KUCHS, OF ANACONDA, MONTANA, ASSIGNOR OF ONE-HALF TO FREDERICK LAIST, OF ANACONDA, MONTANA.

CENTRIFUGAL SLIME-SEPARATOR.

943,083. Specification of Letters Patent. **Patented Dec. 14, 1909.**

Application filed June 30, 1908. Serial No. 505,207.

To all whom it may concern:

Be it known that I, OSCAR M. KUCHS, a citizen of the United States, residing at Anaconda, in the county of Deerlodge and State of Montana, have invented certain new and useful Improvements in Centrifugal Slime-Separators, of which the following is a full, clear, and exact description, reference being had to the accompanying drawings, forming a part hereof.

My invention has relation to improvements in centrifugal slime separators; and it consists in the novel arrangement and combination of parts more fully set forth in the specification and pointed out in the claims.

In the drawings, Figure 1 is a vertical longitudinal section on the line 1—1 of Fig. 2 showing one form of my separator; Fig. 2 is an edge view of the same; Fig. 3 is a horizontal section on the line 3—3 of Fig. 1; Fig. 4 is an enlarged middle longitudinal section of the discharge plug and nipple; Fig. 5 is a side view of the screw-cap detached; Fig. 6 is a front view of the plug, nipple and screw-cap assembled; Fig. 7 is a top plan of a modified form of separator showing a cluster of arms on the order of those shown in Figs. 1, 2, and 3; Fig. 8 is a vertical longitudinal section on the line 8—8 of Fig. 9 showing another modification of my invention; Fig. 9 is an edge view of said modified form; Fig. 10 is a top plan thereof; Fig. 11 is a top diagrammatic view of a separator showing a cluster of arms on the order shown in Figs. 8, 9 and 10; Fig. 12 is a vertical middle section on the line 12—12 of Fig. 13 of a still further modification; and Fig. 13 is an inside plan of one of the sections or truncated cones entering into the construction of this last modification.

The object of my invention is to construct a centrifugal machine for the purpose of treating ore slimes with a view of separating the crystalline or sandy constituent of the slime from the amorphous or colloid component, the sandy component as is well understood carrying practically all the metallic values and being amenable to treatment and concentration by prevailing methods (such as jigs, tables, vanners), the amorphous colloid mass which is mainly composed of clay, hydrated silicates, and oxids, being either discarded or subjected to special treatment for the recovery of whatever values it may possess. The present machine however, is not limited to the treatment of ore slimes, but the same may be availed of for the separation of crystalline from colloidal material in the preparation of clays for pottery works where it becomes necessary to remove fine sands when mixed with the clay.

A further object is to provide a machine which will effect the foregoing separation at low cost, both as to power consumption and repairs, one possessing a maximum efficiency, one which combines the principle of direct settling by centrifugal force, and subsequent classification in the presence of the same force, and in which the classified material is discharged from the periphery of the machine at substantially the velocity of the machine at such periphery but in opposition to the direction of rotation of the machine, whereby the discharging stream will fall "dead", all energy of motion having been expended therefrom as it leaves the machine.

The machine contains features the advantages of which will be better apparent from a detailed description of the invention which is as follows:—

Referring to the drawings, and for the present to Figs. 1 to 6 inclusive, S represents the intake or supply section of a hollow rotatable shaft, or pipe, and S′ the discharge section, the respective shaft sections being guided and supported in the bearings B, B′, and rotated by a pulley P from which leads a belt D to any suitable source of power (not shown.) The intake section S derives its supply from a stationary supply pipe C, which terminates in a stuffing-box E for receiving the upper end of the shaft-section S. The adjacent ends of the respective shaft sections terminate in, or have formed therewith, hollow bosses *a* to the terminal flanges of which are bolted the arms or branches *b*, *c* of an angular or bent pipe, conduit or container, the slope of the surfaces of the walls of the respective branches on which the sands are deposited approximating an angle slightly in excess of, or not less than, the angle of repose of the separated sandy constituent of the slime or pulp treated (substantially 35 degrees as indicated) this angle being obviously the complement of that which the outer sloping walls of the conduit branches make with a plane at right angles to the axis of rotation of the shaft S, S′. Located respectively at the discharge and intake ends of the shaft-sections S, S′, and reaching to the bosses *a*, are deflecting plates or distributers 1, 1, for properly directing and proportioning the flow of the pulp into the branches *b*, *b*, from the section S, and into the section S′ from the branches *c*, *c*. Between the bosses *a*, *a* of the respective shaft sections is a tubular brace 2 preferably made of two terminally flanged sections bolted together to add stiffness and rigidity to the apparatus. At the line of convergence or angle of the outer walls of the conduit-branches *b*, *c* is screwed the countersunk end of the hollow plug 3 the outer end of which is closed by a screw-cap 4 upon removal of which access may be had to the inside of the plug. Formed in the peripheral or side wall of the plug is an opening which receives the discharge nipple 5 projecting a slight distance beyond the plug-wall as shown to best advantage in the detail in Fig. 4. The passage of the nipple 5 flares inwardly and is rounded off to reduce the friction of the escaping water and concentrates and thereby insure a maximum quantity of discharge. The longitudinal axis of the passage of the nipple is perpendicular to the longitudinal axis of the plug, the latter axis being radial to the axis of rotation of the hollow shaft S, S′. The passage or opening of the nipple from the point of beginning of the inner flaring portion to the outer end of the nipple has a ratio of length to the average diameter of the cross section of the passage of about 4 to 1, though it may vary from between $2\frac{1}{2}$ and 4, to 1, this type of nipple discharging about 97 per cent. of the theoretical quantity indicated by the formula

$$Q=\sqrt{2gH\times a},$$

where Q. is the quantity of water discharged, g the acceleration due to gravity, H, the height of the water column, and a the area of the hole through which the water is discharging. This percentage however, increases to approximately 98 per cent. by the time the opening in the nipple has worn slightly conical as shown by the dotted lines *x*, *x*, in Fig 4.

The operation of the machine and the principle of that operation may be readily described in connection with the simple form of the invention illustrated in the figures thus far alluded to, namely, Figs. 1, 2, 3, 4, 5 and 6, and is substantially as follows:— Rotation being imparted to the machine through the medium of the driving pulley P during the passage of the pulp from the shaft section S to the shaft section S′ through the bosses *a*, and arms *b*, *c*, of the angular conduit or pipe (the quantity of the flow being properly apportioned through the arms by the distributers 1, 1), the solid contents of the stream will be projected toward the periphery of the conduit, the heavier or sandy component accumulating against the outer inclined wall of the outflowing branch *b*, sliding along the inner surface of said wall toward the discharge nipple 5, the machine being rotated in a direction contrary to the direction of discharge from said nipple, which discharge is substantially at right angles to a radial line extending from the axis of rotation of the shaft S, S′, or tangential to such rotation. For convenience the arms *b*, *b* are termed the outflowing arms, and the arms *c*, *c* the return or inflowing arms since the respective arms conduct the pulp first away from the shaft and then back toward the shaft. The angle or point of convergence between the arms or branches *c*, *c* may be termed an elbow. In the arm *b* a direct settling takes place as a result of centrifugal action, the sands being, as already stated, projected against the outer wall of said arm as far as the elbow. After the pulp makes a turn at the elbow it flows toward the shaft through the branch *c*, that is it flows in opposition to the centrifugal force, on the order of a "rising" current in a gravity classifier, so that the arm *c* acts as a classifier, the sands "falling" or being projected against an opposed or "rising" current (the current flowing toward the shaft in opposition to the centrifugal force developed by the rotation of the machine). Only those particles which "fall" (or are projected through) more rapidly than the current "rises" (or flows in opposition to the centrifugal force developed) settle out, while those particles which "fall" more slowly than the current "rises" are carried out at the discharge end or shaft section S′. It thus follows that separation of the sands takes place in the outflowing branch *b* (or what would be the equivalent of a descending branch in a gravity machine) by direct settlement, whereas separation in the return or inflowing branch *c* (or what would be the equivalent of a rising branch in a gravity machine) takes place by classification, the separated sands being discharged through the nipple 5 tangentially and in opposition to the direction of rotation imparted to the machine. The rate of feeding the pulp or slime water into the machine with a given rate of rotation, determines the extent to which the sands will be removed from the slimes.

It is of course, desirable to reduce to a minimum the lost power attending the discharge of the sands or material from the periphery of the machine, and this is accomplished not only by discharging the same in opposition and tangentially to the direction of rotation of the machine, and regulating the feeding of the slime according to the speed of rotation, but by improvising a nipple which will discharge the material at a rate substantially equal to the peripheral speed at the point of discharge. The purpose of the specific construction of the nipple and its supporting plug will be referred to after explaining the theory of the tangential discharge availed of in the present machine. In a centrifugal separator such as here described in which the water column extends continuously from the axis of rotation to the discharge opening for the sand pulp, the average centrifugal force exerted by a unit of weight of water uniformly distributed from the shaft to the discharge plug is $\frac{1}{2}$ F, F being the centrifugal force which a unit of weight of water would exert if concentrated at the plug. The average centrifugal force or $\frac{1}{2}$ F, multiplied by R or the radius at the plug gives the height of the water column which would be required to counterbalance the pressure induced in the machine as a result of the centrifugal action. If we assume water discharging through a short tube with a discharge coefficient of 1 under a head of $\frac{1}{2}$ FR, the velocity of discharge will be given by the formula

$$V=\sqrt{2gH}$$

in which V is the velocity in feet per second, g the acceleration due to gravity in feet per second, and H the head of water. (The quantity

$$\sqrt{2gH}$$

is equal to V in the equation

$$Q=\sqrt{2gH}\times a$$

previously referred to). If in the equation

$$V=\sqrt{2gH},$$

we substitute for H the value $\frac{1}{2}$ FR, we get

$$V=\sqrt{\frac{2gFR}{2}} \text{ or } V=\sqrt{gFR}$$

which shows the theoretical velocity of discharge in a centrifugal machine at the end of the radius R. We know however, that the centrifugal force is equal to the mass times the square of the velocity divided by the radius, and since the mass of a body is equal to its weight divided by gravity, the centrifugal force may be expressed by the formula

$$F=\frac{MV^2}{R}=\frac{WV^2}{gR}$$

in which F is the centrifugal force in units of weight W, V, the peripheral speed in feet per second, R the radius in feet, and g the acceleration in feet per second due to gravity. If we assume W as unity we have

$$F=\frac{V^2}{gR},$$

or, by transposition we have

$$V^2=gFR \text{ or } V=\sqrt{gFR}.$$

This last equation

$$V=\sqrt{gFR}$$

corresponds to the first equation

$$V=\sqrt{gFR},$$

showing that the theoretical velocity of discharge from the periphery of a centrifugal separator as described is equal to the peripheral speed at that point. It follows therefore that if the stream which discharges from the periphery of the machine be directed tangentially, and in opposition to, the direction of rotation of the machine, such stream will fall "dead" (the opposite velocities neutralizing each other) and contain theoretically no energy of motion as it leaves the machine. Of course, no form of discharge opening can ever give the theoretical discharge velocity. The nipple 5 here designed approaches 97 per cent. of such theoretical velocity of discharge, and by the time the passage thereof has worn conical as shown by the dotted lines x, x, (Fig. 4) such velocity increases to 98 per cent. As stated above the length of the nipple opening from the narrow portion of the inner rounded flaring intake end or mouth to the outer end of the opening may range from $2\frac{1}{2}$ to 4 cross-sectional diameters of such opening in practice, and yet give the results here specified. The water carrying the concentrates or sands and discharging through the nipples 5 may be caught in launders L, and conducted to any point for subsequent treatment of the concentrates.

Obviously, the present machine is susceptible of many modifications. For example in Fig. 7, I combine a cluster of six pipes or conduits coupled to their corresponding bosses a radiating from a single shaft S (S′), the distributer 1′ in that case having a series of wings or vanes corresponding to the number of conduits, so as to properly distribute the proper portion of the pulp to each conduit. In Figs. 8, 9 and 10 is shown a machine on the simple order of that illustrated in Figs. 1 to 3 inclusive, but with the branches b', c' provided with sides diverging or flaring outwardly for a portion of their length, then converging toward the peripheral discharge end or toward the angle formed by the convergence of the outer walls of the branches b', c', forming the main depositing surfaces for the concentrates, (as already explained) the angle of convergence of the terminal side walls (w, w) being substantially a trifle greater but not less than, the angle of repose of the concentrates or sands (see Fig. 10). In Fig. 11 is illustrated in top diagrammatic view a cluster of six conduits on the order shown in Figs. 8, 9 and 10, the distributer 1′ likewise having a series of vanes to properly apportion the flow to the respective conduits or branches. In Figs. 8 to 11 inclusive, the inner wall of each conduit is rounded so that no defined angle or bend occurs opposite the angle or point of convergence of the outer depositing walls thereof.

In Figs. 12 and 13 is shown a still further modification in which the entire circumference of the machine is utilized as a settling and classifying space. In this type we have virtually two truncated cones set base to base and united by bolts (not shown) passed through registering openings (Fig. 13) of the outer peripheral flanges 6, the conduit branches b'', c'', constituting in effect sections of a multiple separator, the converging walls or partitions 7 between the sections forming continuations of the vanes of the distributer 1′ so that each branch is supplied with its proportionate quantity of pulp. In other respects this modification is the same as that shown in Figs. 8, 9, 10 and 11. The forms here shown obviously do not exhaust all possible modifications of which the invention is susceptible, but a sufficient number are here offered by way of example, to enable those skilled in the art to adopt that form best suited for any special purpose or for a given capacity or output of the plant. Details illustrated in connection with the several later modifications but to which no reference has been made, are already fully described in connection with the form illustrated in Figs. 1 to 6 inclusive, and need not be here repeated.

Having described my invention, what I claim is:—

1. In a centrifugal separator, a conduit provided with branches disposed at an angle to one another and rotatable about a fixed axis opposite said angle, means for feeding the pulp to said conduit and subsequently discharging the tailings therefrom at points along said axis, means for discharging the concentrates from the conduit at the angle formed between the branches in a direction opposed to the direction of rotataion of the conduit, and means for conforming the velocity of such discharge substantially to the peripheral speed at the point of discharge.

2. In a centrifugal separator, a conduit provided with branches disposed at an angle to one another and rotatable about a fixed axis opposite said angle, means for feeding the pulp to said conduit and subsequently discharging the tailings therefrom at points along said axis, means for discharging the concentrates from the conduit at the angle formed between the branches, in a direction opposed and tangential to, the direction of rotation of the conduit, and means for conforming the velocity of such discharge substantially to the peripheral speed at the point of discharge.

3. In a centrifugal separator, a hollow shaft having a feed and a discharge end, a conduit rotatable about the axis of the shaft and having outflowing and return branches disposed at an angle to one another and in free communication with the interior of the shaft, the outer or depositing surface of the outflowing branch being disposed at an angle not less than the angle of repose of the separated material lodging against said surface, means for discharging said separated material from the outer end of said outflowing branch in a direction opposed and tangential to the direction of rotation of the conduit, and means for conforming the velocity of such discharge substantially to the peripheral speed at the point of said discharge.

4. In a centrifugal separator, a rotatable hollow shaft having a feed and discharge end, a conduit provided with outflowing and return branches coupled to the shaft between the feed and discharge ends aforesaid, said branches making an angle with one another and rotatable with the shaft, means for discharging the concentrates at the angle between the branches in a direction opposed to that of the rotation of the shaft and conduit, and means for conforming the velocity of such discharge substantially to the peripheral speed at the point of discharge.

5. A centrifugal concentrator rotatable about a fixed axis, and provided with conduits having their opposite ends opening along said axis for respectively receiving the pulp and discharging the tailings therefrom, the conduit having an intermediate portion spaced a suitable distance from said axis and discharging the concentrates at such intermediate portion in a direction opposed to the direction of rotation of the concentrator and means for conforming the velocity of such discharge substantially to the peripheral speed at the point of discharge.

6. A centrifugal concentrator rotatable about a fixed axis and provided with angular conduits having the ends of their respective branches opening along said axis, and means for discharging the concentrates at the angle of the conduit in a direction opposed to the direction of rotation of the concentrator and means for conforming the velocity of such discharge substantially to the peripheral speed at the point of discharge.

7. In a centrifugal separator, a container for the pulp rotating about a fixed axis, a peripheral discharge nipple discharging in opposition and tangentially to, the direction of rotation of the container, the length of the passage of the nipple being proportioned from 2½ to 4 times the average cross-sectional diameter of the passage, whereby the

velocity of discharge approaches the peripheral speed at the point of discharge.

8. In a centrifugal separator, a series of conduits having branches disposed at an angle to one another, and rotating about a fixed axis opposite said angle, the side walls of the branches flaring outwardly for a portion of their length then converging toward the outer ends of the arms, said side converging terminals and the depositing surfaces of the outer walls of the respective branches being disposed at angles not less than the angle of repose of the concentrates depositing thereon.

9. A centrifugal concentrator rotatable about a fixed axis and provided with angular conduits having the ends of their respective branches opening along said axis, means for discharging the concentrates at the angle or bend of the conduit in a direction opposed and tangential to, the direction of rotation of the concentrator, and means for conforming the velocity of such discharge substantially to the peripheral speed at the point of discharge.

In testimony whereof I affix my signature, in presence of two witnesses.

OSCAR MAX KUCHS.

Witnesses:
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EDGAR M. DUNN.