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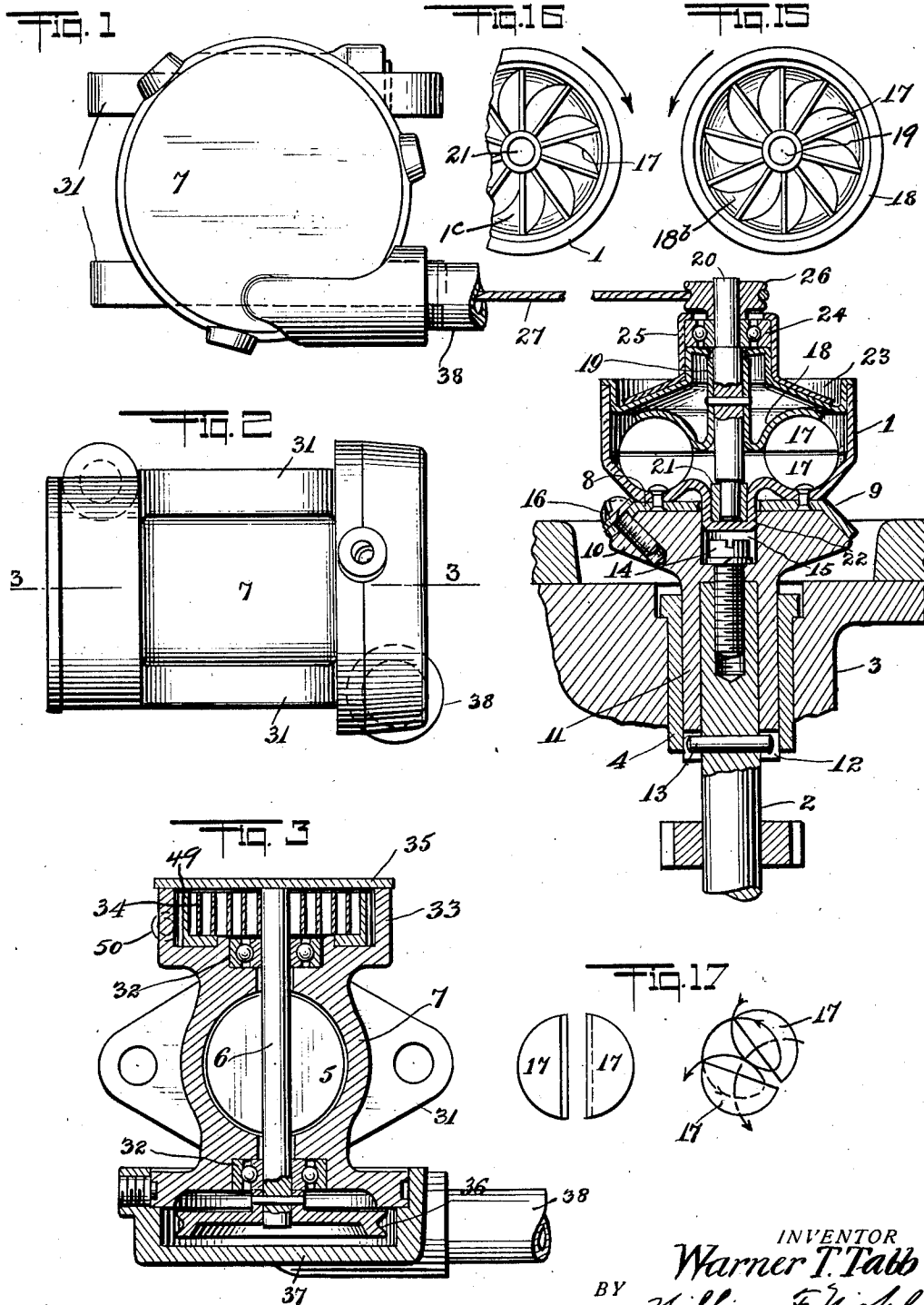
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W. T. TABB

SPEED REGULATOR

Filed March 7, 1921

3 Sheets-Sheet 1



WITNESS
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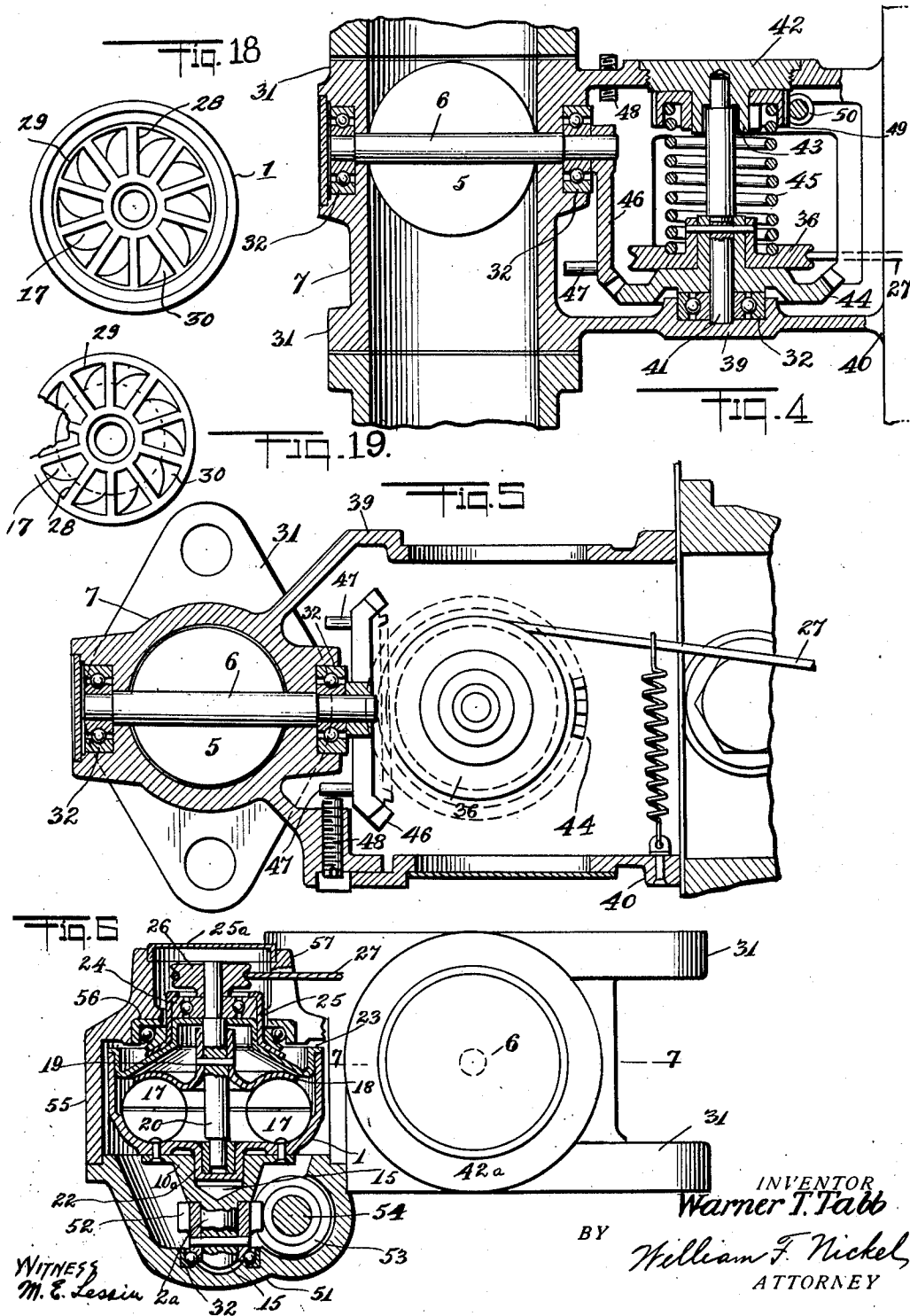
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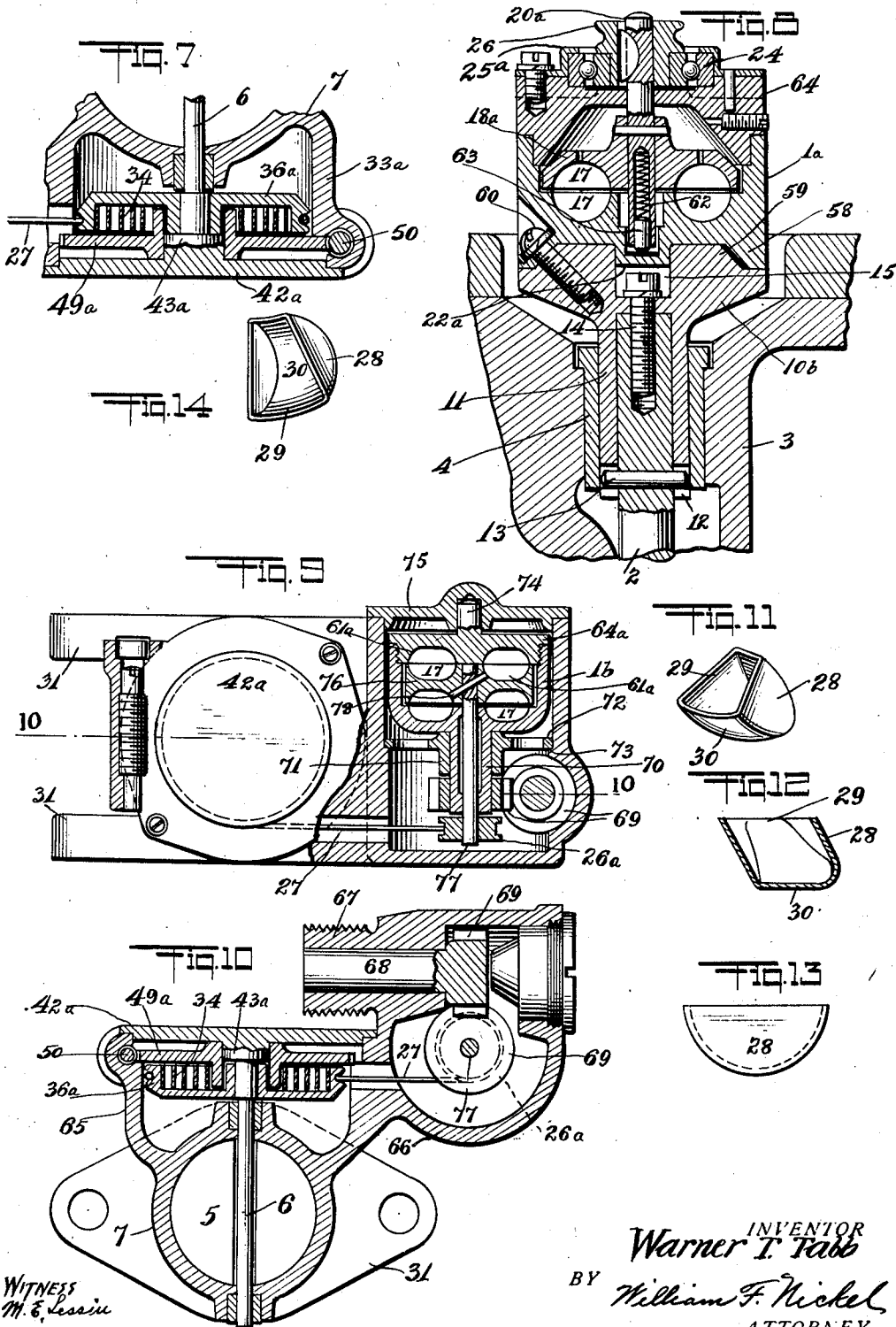
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UNITED STATES PATENT OFFICE.

WARNER T. TABB, OF BROOKLYN, NEW YORK, ASSIGNOR TO DUPLEX ENGINE GOVERNOR COMPANY, INC., OF BROOKLYN, NEW YORK, A CORPORATION OF NEW YORK.

SPEED REGULATOR.

Application filed March 7, 1921. Serial No. 450,261.

To all whom it may concern:

Be it known that I, WARNER T. TABB, a citizen of the United States, residing in Brooklyn, in the county of Kings and State of New York, have invented certain new and useful Improvements in Speed Regulators, of which the following is a specification.

This invention relates to an improved regulator; especially a regulator to limit the speed of power units requiring a motive agent to operate them.

An object of this invention is to provide a regulator comprising a governing device having a driven member that is capable of a relatively great range of movement to afford a governing or regulating effect; and that is subjected to the influence of a fluid in motion, the fluid creating an unbalanced force acting to turn said member to a greater or less extent, according as the available energy of the fluid increases or decreases; and an element, such as a throttle valve, connected to the governing device, and actuated by it, to control the supply of the motive agent to the power unit, for the purpose of reducing the supply of said agent, or interrupting it entirely, to prevent the power unit from exceeding a predetermined speed.

Another object of this invention is to provide a regulator embracing a governing device adapted to afford the maximum torque and efficiency; whereby the governing device can be made very compact and of relatively small size, and therefore easy to mount in almost any position on the engine with which the speed regulator is to be used.

A further object of this invention is to provide a regulator including a governing device consisting of an impeller member and a member to be driven or impelled thereby; the impelling and impelled members together enclosing an annular working space in which the path of the operating fluid is confined; both members carrying vanes to be moved in said space, with the vanes disposed at intervals apart, and having their

faces conforming effectively to the direction taken by said fluid; the portions of said space between the vanes of each member constituting in effect pockets or recesses which are open only at their fronts or mouths, so that no pocket on either member can communicate directly with another pocket on said member, but with the mouths of the pockets on the impeller presented to the mouths of the pockets of the impelled member, the mouths of the pockets of one member being thus enabled to communicate with the mouths of the pockets on the other.

Still another object is to provide a device consisting of an impeller member and a member to cooperate therewith; both members having the vanes and recesses above set forth, and capable of being used for the general purpose of producing effects in accordance with or in response to the speed of operation, or some mathematical function thereof.

Additional objects and advantages of this invention will appear from the following description taken with the accompanying drawings; and the novel features of this invention will be defined in the appended claims. This disclosure however is explanatory only; and I may resort to changes in the shape, size and arrangement of the various parts, without departing from the nature and scope of the invention; as indicated by the general meanings of the terms in which the claims are expressed.

In the drawings:—

Figure 1 shows in longitudinal section a governing device and the outside of the casing of a throttle valve connected thereto, according to my invention;

Figure 2 is an end view of the valve casing;

Figure 3 is a horizontal section on the line 3—3, of Figure 2;

Figure 4 is a sectional view of a different throttle valve and casing therefor, showing another manner of connecting the governing device to the valve;

Figure 5 is a top view partly in section of what is shown in Figure 4;

Figure 6 is a side view, partly in section, of a speed regulator according to this invention, with the throttle valve and governing device made in the form of a single unit;

5 Figure 7 is a sectional view on the line 7-7 of part of Figure 6;

Figure 8 is a view similar to Figure 1 showing in longitudinal section a modified form of governing device;

10 Figure 9 is a side view partly in section, showing a speed regulator according to this invention comprising a governing device mounted in a casing that is integral with the throttle valve casing;

15 Figure 10 is a section on the line 10-10 of Figure 9.

Figure 11 is a perspective view of a cup-shaped element to be disposed in the structure of the governing device to provide vanes 20 therefor;

Figure 12 is a cross sectional view of said element;

Figure 13 is a side view;

Figure 14 is a front view of same;

25 Figure 15 is a diagrammatic view illustrating the disposition of the vanes of the driving part or impeller of the governing device;

30 Figure 16 is a similar view of the vanes of the member driven by the impeller;

Figure 17 shows the relative positions of the vanes of the impeller and driven member and the conformation of the positions of the vanes to the path taken by the fluid that 35 turns said member;

Figure 18 is a view similar to Figure 15, and Figure 19 is a view similar to Figure 16; showing cup-shaped elements providing 40 vanes carried by the impeller and the driven member respectively.

Referring first to Figure 1, I show a governing device comprising a cup-shaped casing 1, to be rotated by a shaft 2 which revolves in suitable bearings in the frame-work 3, of a power unit, such as 45 an internal combustion or other engine. Wherever this engine shaft engages a bearing in the frame work 3, the bearing may be provided with a lining or bushing 4, and the governing device may be connected to actuate a controlling element or throttle valve 50 5 fixed upon a stem or spindle 6 rotating in bearings in a casing 7. The casing 1 in this form has its bottom made fast to a disk 8, having a central opening and provided with a flaring rim 9; which engages the coned edge of a support or head 10 having a hub 11, which is bored out to enable it to be 55 fitted over the end of the shaft 2. In the end of this hub remote from the body of the head 10 are notches or recesses 12 at opposite points, and the shaft 2 carries a pin 13 to engage the notches 12, so that when the shaft 2 revolves, the head 10 and casing 1 revolve 60 with it. By this construction the pin 13 can

simply be driven through the shaft 2 and the head 10 can be slipped upon the end of the shaft 2, until the ends of the pin 13 enter the recess 12. A screw 14, the head of which is located in a central recess 15 in the face of 70 the head 10 contacting with the disk 8, passes through the head and engages a threaded bore in the end of the shaft 2 and holds the shaft and head together. The disk 8 may be riveted to the bottom of the casing 1 and 75 is secured to the head 10 by a screw passing through the rim 9 and into a threaded hole in the head, this screw being indicated by the numeral 16.

To the bottom of the casing 1 are fixed 80 vanes 17 which may be held in place by the same rivets that secure the disk 8 to the casing. These vanes cooperate with similar vanes 17, carried by and secured to a rotatably driven member 18, having a hub 19 85 which engages a shaft 20 in the casing 1 in line with the shaft 2. In the position of the parts shown in Figure 1, the shaft 20 has a reduced portion extending from a shoulder adjacent its lower end and this reduced portion fits into a bushing 21 which provides a 90 foot or thrust bearing for the shaft 20; this bushing 21 being in turn received by and located in a boss 22 which extends from the bottom of the casing 1 into the recess 15 of 95 the head 10. The top of the casing 1 is closed by a cover 23, which is shaped to enter the casing for a slight distance and has its edge turned up and outward to provide an encircling rim or flange to abut against 100 the edge of the casing and providing a snug fit. The center of the cover 23 is of course perforated to allow the upper end of the shaft 20 to pass through the same; and resting on the top or outside of this cover are 105 the parts of a ball bearing 24 for the shaft 20. To keep the ball bearing 24 in place on top of the cover 23, I employ a cap 25, in the form of an inverted cup. This cap has 110 its rim or lower edge bent outward to rest upon the top of the cover 23 and its top is apertured, presenting an edge turned inward to provide a flange which overlaps parts of the bearing 24 and thus prevents displacement thereof. The shaft 20 projects beyond 115 the bearing 24 and carries a grooved wheel 26 to which is attached a cord 27, so that when the shaft 20 turns a pull can be exerted on the cord 27 to turn the valve 5 towards closed position. 120

The vanes are preferably afforded by cup-shaped elements shown in Figures 11, 12, 13 and 14. These elements are shown as having semi-circular sides 28, open mouths or 125 fronts 29 and curved backs 30 or bottoms. The sides 28 are not parallel, neither are they normal to the backs 30, but are arranged at an angle thereto. Hence when they are secured to the casing 1 or the member 18 by riveting through the backs 30, 130

or by welding or otherwise, the sides 28 of one cup will lie against the sides 28 of another and each pair of contacting sides will provide a vane that makes an angle with a plane containing the axis of rotation of the shafts 2 and 20 and a line or radius passing from this axis along the straight edges of any pair of these vanes. In other words the vanes will have a slight pitch to enable them to act more effectively upon the liquid to give a turning movement to the member 18. I can make the parts 1, 8, 12, 23 and 25 and the cup shaped elements providing the vanes by stamping or otherwise; thus obtaining a governor that may be cheaply manufactured and very easily assembled. Of course if desired the cup-shaped vane elements can be replaced with semi-circular plates that are secured to the parts 1 and 18 by welding or in any other convenient manner. The use of semicircular disks to provide vanes, is in fact illustrated in Figures 8, 9, 15 and 16. I may give to the casing 1 and the member 18 such shape that the inner face of the bottom of the casing and the opposing face of the member 18 may present concave curved surfaces, making in effect endless or circular grooves in each, and to the bottoms of these grooves the backs 30 of the vane elements are secured. The sides 28 of each element converge, the narrow ends of the elements being closer to the axis of rotation of the shafts 2 and 20 than the wide ends, as the cups lie side by side in their proper positions on the member 18 and in the casing 1.

The casing for the throttle valve 5 may be in the form of a single casting having flanges 31, which may be inserted in the line of the intake pipe of the engine and bolted to similar flanges on said pipe. A bore passes therethrough from one flange 31 to the other, of the same shape as the inside of the intake pipe, and the valve 5 can be turned to open or close this bore, according to the position of the valve. The stem 6 to which this valve is secured passes through the sides of the casing 7 midway between the flanges 31 and is parallel therewith. Adjacent its opposite ends it is engaged by ball bearings 32, mounted in recesses in the casing 7; and surrounding one of these ball bearings is an extension 33 which contains a spiral spring 34. This spring is arranged to hold the valve 5 open and resist the closing thereof, and a cover 35 fitting over the end of the extension 33 and secured thereto, completely houses this spring. Of course, the adjacent end of the shaft projects through the side of the casing 7 far enough to enable one end of the spring to be attached thereto, the other end of the spring being suitably anchored to a fixed point. The opposite end of the shaft extends through the other side of the casing 7 and

carries thereon a grooved wheel 36 similar to the wheel 26; a cap 37 secured to the side of the casing enclosing the wheel 36. This cap has an extension 38 through which the cord 27 may pass so that one end of the cord will be attached to the grooved wheel or pulley 26 and the other to the grooved wheel or pulley 36.

In operation when the shaft 2 rotates, it turns the head 10 and casing 1. This casing will be filled with some suitable fluid such as mercury or oil and as the casing 1 revolves the vanes in the casing will throw the contents of the impeller 1 against the vanes of the impelled member 18. The force of the whirling liquid when the speed reaches a certain point will turn the shaft 20 against the force of the spring 34 and thus move the valve 5 towards closed position. The mercury provides a fluid metallic transmission medium between the impeller 1 and member 18.

In Figures 15, 16 and 17 the action of the vanes 17 of the impeller or casing 1 upon the vanes 17 of the driven member 18 is illustrated. Figures 15 and 16 are somewhat diagrammatic in character and they illustrate the impeller 1 and the impelled member 18 in the form of two rotatable bodies having endless circular grooves 1^a and 18^b, in their faces, the vanes being fastened in radial position and extending across these grooves. The vanes are illustrated as if they were semicircular disks cast or welded into position. With a construction like that shown in Figure 1, cup-shaped vane elements as indicated in Figures 11 to 14 inclusive, should preferably be employed; such elements being riveted to the bottom of the impeller 1 and to the lower face of the driven member 18, both the impeller 1 and the member 18 being shaped to fit the backs 30. As shown in Figure 1 and the member 18 is of relatively less width than the impeller and the groove in the lower face thereof is comparatively shallow. As long as cup-shaped vane elements are employed, this element 18 need be no larger and the groove therein no deeper. If, however, instead of cup-shaped elements, semicircular disks are to be employed to provide vanes for the governing device illustrated in Figure 1, the impelled member 18 would be made wider and the grooves therein deeper; in the manner indicated in Figure 8, wherein the part 18^a has a diameter approximately equal to the inside width of the impeller 1^a. However, the action of the vanes will be the same, whether cup-shaped elements as indicated in Figure 1 or semicircular disks as indicated in Figures 8, 15 and 16 are employed. The vanes of the casing or impeller have a certain pitch; that is, they are inclined with respect to the plane of revolution of the

impeller, which is to be rotated in such a direction that the straight edge of each vane, which is the edge nearer to the impelled member, is the leading edge; and the curved edge of each side 29 which joins the back 30 is the trailing edge. As for the impelled member 18, the vanes thereof are given somewhat the same pitch with respect to the plane of revolution, but the direction of rotation is to be such that the straight edge of the vane or the edge nearest the impeller is the trailing edge and the opposite part of the vane is the leading edge.

Figures 18 and 19 show respectively how the impeller and the impelled member will appear in face view when carrying the cup-shaped elements shown in Figures 11 to 14 inclusive, to provide vanes for these parts.

The pitch of the vanes of the impeller and of the impelled member will vary with the particular design, depending on the speed range of the impeller and on the size of the units. The pitch of the vanes for any particular design need not be uniform but may be made to vary with the distance from the axis of rotation or otherwise as determined by the conditions of operation and convenience of manufacture. With this arrangement, the face of each vane of the impeller, that is the front or forward face, with reference to the direction of revolution is then in effect slightly undercut; while in regard to the driven member, the rear face of each vane, with reference to the direction of rotation is slightly undercut; and the backs of the cup-shaped vane elements, or if disks are used instead of vane elements, the cross section of the grooves in which the vanes are set, will present a curve that is approximately semi-circular or semi-elliptical. Hence the liquid between any two of the vanes on the impeller may flow without diminishing in velocity or energy over to the driven member and in between any two vanes on the driven member. In effect the intervals between vanes on either the impeller or the impelled member, whether these vanes are provided by the sides 29 of the cup-shaped elements already mentioned, or simply by the use of semicircular disks secured in proper position, constitute recesses closed on all sides and at the back. The concave curved backs of the pockets or recesses between the vanes of the member 18 will gradually change the direction of the liquid, so that it will flow back into position to receive further energy from the vanes of the impeller and the rotation of the driven member maintained. As stated above it is advantageous to make the curvature of the bottoms 30 of the cup-shaped elements approximately cylindrical, from the narrow end of the mouth 29 to the wider end and to shape the opposite faces of the impeller 1 and impelled

member 18 so as to fit these bottoms; and where semicircular disks are employed instead of cup-shaped vane elements, to make the grooves in which these vanes are transversely secured, as indicated in Figures 8, 15 and 16, substantially semi-circular or semi-elliptical in cross section; or even polygonal, provided no well defined or deep corners are presented. As the impeller revolves, the liquid in the governing device is whirled around by the forward or undercut faces of the vanes 17 of the impeller; and the centrifugal force acting upon the particles of liquid tends to make them move as far away from the axis of rotation as possible. Under the circumstances, the curved backs or inner ends of the cup shaped elements or recesses between the vanes will direct the particles of liquid not only away from the axis of rotation but also towards the impelled member 18 and in between the vanes thereon. The backs or inner ends of these recesses or pockets of the member 18, whether semicircular vanes or cup shaped vane elements are employed, will change the direction of the flow of the particles of liquid so that the particles will come back towards the axis of rotation and into the impeller; and in so doing they strike against the undercut trailing faces of the vanes on the impelled member 18; and the impelled member therefore revolves in the same direction as the casing 1. As shown in Figure 17, the particles of liquid follow the path of an endless spiral, the coils of which extend from between the vanes of the impeller over between the vanes of the impelled member, all round the circle through which the vanes are revolved.

The impeller and the impelled member, by reason of the fact that they are shaped to receive and fit the curved inner edges of the vanes, and the presence in each of the groove containing the vanes 17, and the fact that these grooves oppose each other, thus enclose an endless space which confines the endless spiral path of the fluid within it. The term "space" is used simply to indicate the fact that the opposing faces of the impeller 1 and impelled member 18 are separated from each other, and the vanes extend radially across this space and revolve in it. The impeller 1 and member 18 thus enclose and contain that part of the working fluid which actually takes effect on the vanes of the member 18 to turn the latter; such part being always located in this space; and any part that might temporarily flow out beyond the outer ends of the vanes of the impeller or member 18 does no work for the time being, but as the governing device is mounted in such position that the axis of rotation is generally vertical, any part of the fluid in the casing 1 that flies out of the endless or annular space mentioned and

beyond the reach of the vanes 17 tends to flow back to the bottom of the casing in between the impeller and impelled member and thus be united with the working portion of the fluid in said space. A portion of this space between any two vanes on either the impelling or the impelled member, whether cup-shaped vane elements or semi-circular disks for vanes are employed, makes a recess or pocket, closed on all its sides and at the back, but open in front. Hence the pockets of the impelling member may communicate through their open mouths with the mouths of the pockets of the impelled member, but the pockets on either member are not in direct communication with one another; and because of the concave curved backs or bottoms or inner ends of these pockets or recesses the pockets of either member are open on the side adjacent the other member, and completely closed on the side remote from said other member.

The body of the liquid which does the work of impelling the member 18 is therefore always in the pockets or recesses, between the vanes 17 and any liquid outside of this space is inactive. In practice sufficient liquid will be introduced into the governing device to keep the grooves in both members substantially filled under all conditions of operation. If desired small ports may be drilled through the member 18 in the backs of the pockets between the vanes, to allow the escape of any air entrapped therein, and insure a full and free circulation of liquid through all parts of the space enclosed by the impeller and the impelling member and containing the vanes 17. Such ports are indicated in Figure 8 and they will be of such small diameter that practically none of the working fluid ever passes through the same; therefore the pockets between the vanes, even in such a case, remain substantially closed except at the front or mouths.

It will thus be seen that the path of the working portion of the fluid is in effect wholly confined within the opposed mutually supplementary grooves of the impelling and impelled members and the pockets or recesses thereof and no external space is therefore required for circulation of the fluid. Also, on account of this arrangement and on account of the pitch of the vanes and the shape of the guiding surfaces of the inner ends of the recesses or pockets between them which, with the faces of the vanes, effectively conforms to the direction of motion of the fluid throughout its path, great efficiency is obtained and a strong torque from the impelled member.

By providing a governing device that is compact and small in size, and of high efficiency much material can be saved and

at the same time the governing device will be strong enough to meet the requirements imposed. Further by reason of the limited space it occupies, the governing device can be mounted in practically any position on the power unit, a thing which is often not possible with governing devices of relatively great size and weight.

While the impeller 1 with its vanes 17 and the stator member 18, with its vanes, are shown and described as particularly intended for a speed regulator, the device including these parts may obviously be employed to serve any other purpose requiring a stator member against the vanes of which a working fluid is to be driven by the vanes of an impeller, to produce effects in accordance with the speed at which the impeller is revolved.

In Figures 4 and 5, the same type of governing device may be used but a different method of connecting the valve to the governing device can be employed. In this construction, the casing 7 has an extension 39 extending from one side between the flanges 31 and the outer end of the extension may have a flange 40 to enable it to be joined to any convenient part of the engine frame work 3. In one side, such as the lower side or bottom of this extension, there may be a recess or pocket to receive a ball-bearing 32 which engages the lower end of the shaft 41. The opposite side of the extension 39 has an opening which may be closed by a screw cap 42; this screw cap being provided with a hub 43 bored out to provide a bearing for the other end of the shaft 41. To the shaft adjacent the bearing 32, I secure a gear wheel 44 and adjacent the gear wheel 44 is the grooved wheel 36. This grooved wheel may have a hub which receives the hub of the gear 44 so that a single pin passing through both hubs and the shaft 41 is all that is needed to make the wheel 36, and gear 44 and the shaft 41 rigid with one another. Encircling the shaft 41 is a coiled spring 45 affixed to the wheel 36 at one end and secured at its opposite end so as to hold the wheel 36 in a given position. Meshing with the gear wheel 44 is a segmental gear 46, this segment being mounted upon one end of the spindle 6 which projects out of the casing 7 into the extension 39. Normally the spring 45 acts through the wheel 36, gear 44 and gear 46 to hold the valve 5 open; and in this position a projection 47 on the gear 46 engages a screw or bolt 48 carried by the extension 39 to limit the movement of the valve and the segment. A similar projection may be mounted upon the segmental gear 46 at the opposite side to engage another adjustable screw 48 when the valve is in closed position. By means of the two bolts 48, the limit of the move-

ment of the valve in either direction can be fixed and adjusted; and I also adjust the tension of the spring 45 by affixing the end opposite to that secured to the wheel 36 to a disk 49, having a hub at the center which fits over the hub 43. This disk may have a rim provided with teeth or threads to be engaged by an adjusting screw 50 carried by the extension 39. A similar disk 49 may be disposed in the extension 33 of the regulator shown in Figures 1 and 3, and be engaged by a similar screw 50. This disk 49 in Figure 3 engages the inner end of the recess provided by the extension 33 and encircles the shaft 6 without engaging it. One end of the spring 34 is fastened to the shaft and the other end to the disk.

The forms thus far described are intended to be used in cases where the casing 1 is to be located at some distance from the valve 5. In Figures 6 and 7, I show the valve and governing device made up as a compact speed regulator in the form of a single unit. Here the casing 7 is provided with an extension 51 containing a driving gear 52 which is made rigid with a shaft 2^a extending from a head or support 10^a. This gear 52 is driven by similar gear 53 on a shaft 54 in the extension 51. The shaft 34 may be connected to some moving part of the engine to be driven thereby. The shaft 2^a is engaged by a ball bearing 32 in the bottom of the extension 51; and head 10^a, with which it is made integral, is provided with a central recess 15 to receive the hub of the casing 1 of the governing device. This governing device is similar in all respects to that shown in Figure 1 except that the disk 8 and screws 14 and 16 are omitted. Of course the head 10^a is riveted or otherwise secured to the casing 1. The extension 51 may be open on top and provided with a cover 55 in the form of an inverted cup having an opening in its bottom to receive the cap 25; and this opening may be shaped to provide a shoulder 56 around its inner end to receive a ball bearing to engage the lower portion of the cap 25. A cover 25^a may close the outer end of the opening so as to screen the grooved wheel 26 therein. From the wheel 26 the cord 27 passes through a hollow projection 57 to a grooved wheel 36^a on the valve stem 6. This valve stem or shaft is mounted as before in ball bearings in the sides of the casing 7 and one end projects from the casing far enough to carry the grooved wheel 36^a. This wheel is of course rigid with the stem 6 and made drumlike to house the spring 34. The casing 7 is provided with an extension 33^a similar to the extension 33 in Figure 1; containing the wheel 36^a; and this extension is closed by a cover 42^a having a central projection 43^a which serves as a journal for a suitable

disk 49^a which has teeth or threads on its rim, to be engaged by an adjusting screw 50. One end of the spring 34 is attached to the wheel 36^a and the other to the disk 49^a and when the vanes 17 cause the member 18 to turn the wheel 36^a will be turned against the force of the spring 34 to move the valve towards closed position.

Figure 8 discloses another form of governing device. In this construction the casing 1^a is secured to a head 10^b which is of practically the same construction as the head 10 in Figure 1. The construction 1^a may be machined or cast and it is provided with a central projection or boss 22^a on its bottom which fits into the recess 15 of the head 10^b; and the bottom of this casing also has a flange 58 which engages a coned projection 59 on the adjacent face of the head 10^b. A screw 60 engages both the casing and the head to hold the two together. Into the end of the impeller 1^a remote from the head 10^b are formed cup-shaped pockets or recesses, the walls of which act to guide the fluid in its movements and to impel the same into similar cup-shaped spaces in the impelled member 18^a, rotatably mounted inside the casing, to impel said member rotarily as has been described in previous types. The member 18^a may be mounted upon a shaft 20^a, the lower end of which has a bore 62 to receive a spring pressed plug 63 which extends into the boss 22^a and engages the closed end of the same. Secured to the rim of the casing 1^a remote from the head 10^b is a closure 64 which carries a ball bearing 24 on its outer face, engaged by a cap 25^a to hold the ball bearing on the cover 64 in proper position in the same manner as does the cap 25 above mentioned. On the outer end of the shaft 20^a beyond the cap 25^a is a grooved wheel 26. This type of governing device may be used in place of that shown in Figure 1 or it may even be made up in a construction similar to that shown in Figures 6 and 7.

Figures 9 and 10 show unitary constructions in which the governing device and the valve are combined after the fashion of the speed regulator shown in Figures 6 and 7. The casing 7 has an extension 65 enclosing a space to receive the wheel 36^a, the adjusting disk 49^a, and the spring 34, the arrangement of the parts being the same as described above in connection with Figures 6 and 7. Integral with the extension 65 is another extension 66 in which the governing device is housed. This extension comprises a hollow projection 67 into which extends a shaft 68 carrying a gear 69. This gear 69 may be connected to any movable part of the engine and the gear 69 meshes with a similar gear rigid with a hollow projection 70 forming a hub or shaft to rotate a casing 1^b. This hub

or shaft 70 and casing 1^b are supported in a bearing 71 made integral with a disk or plate 72 which rests on a shoulder 73 on the inside of the extension 66, and the casing is provided with a cap or screw cover 64^a having a journal 74 which fits into a bore on the inside of a closure 75 for the open end of the extension 66. Inside the impeller 1^b is an impelled member 76 which is provided with endless grooves on both faces; the bottom of the casing 1^b and the cap 64^a being provided with opposing grooves, all of which are indicated by the numeral 61^a. These grooves may receive the cups providing the vanes shown in Figures 11, 12, 13 and 14, or the vanes may be cast in the grooves, and the vanes will be inclined and be separated by recesses or pockets of the same shape as above mentioned. The member 76 is made fast to a shaft 77 which extends downward through a bore in the hub 70 and projects from the lower end of this hub and it has made fast thereon a pulley or grooved wheel 26^a which it carries. This device is made to operate by means of a liquid in casing 1^b and the vanes carried by the casing 1^b and the cover 64^a drive the liquid against the vanes carried by the member 76 to turn the valve 5 towards closed position. A duct 78 in the member 76 may unite the grooves in the opposite faces of same. Of course it is not essential that the cup-shaped vane elements shown by Figures 11 to 14 inclusive shall each have two sides 28. If each had only one side and a bottom 30, the shape of this element being otherwise unchanged, it would serve the same purpose when secured to the impeller 1 and impelled member 18; because the open side of each element then would be closed by the side of the element next to it.

In the foregoing description it is clear that, in all forms of the invention shown and described, the vanes extend radially outward from the axis of rotation, although these vanes do not always necessarily have to be absolutely straight. The sides of the vanes make the sides of the pockets or recesses between them; and, the general shape of the inner ends of these pockets being concave, the ends of each two adjacent vanes near to the axis of rotation and the opposite ends of each two adjacent vanes remote from the axis of rotation are bridged by opposite edges of these pockets. All the edges of the mouth of each pocket, are therefore in the same plane as the leading or advance edges of the vanes of the impeller or the trailing edges of the vanes of the impelled member, as the case may be. Hence these pockets or recesses are closed on all sides and are open only at their mouths, as has already been stated; and the working fluid, in passing from the impeller to the impelled member, takes the spiral path indi-

cated in Figure 17, develops the maximum torque to turn the impelled member, and enables a very powerful governor of small size to be constructed and operated.

In all forms herein described the surfaces of the impeller and impelled member across which the vanes extend are provided either directly by the endless grooves in the opposing faces of the impeller and impelled member, or by the backs 30 of the cup-shaped elements which in the aggregate give the same effect and whether disks or cup-shaped elements are to be used will depend on choice or circumstances. Of course the impelled member does not rotate continuously but merely turns through a sufficient angle to move the valve towards and to closed position. Further, the straight edges of the vanes need not always be in exact radial position provided they run in a general direction outward from the axis of rotation and the phrase "radially extending" is to be understood accordingly.

Having described my invention, what I believe to be new and desire to secure and protect by Letters Patent of the United States, is:—

1. A speed-responsive device having an impeller and a member to co-operate therewith and cup shaped elements carried by said impeller and said member, said elements each having one or more sides and a closed back, with an open mouth, the elements providing vanes for the impeller and said member.

2. A speed-responsive device including an impeller and a member to be operated by the impeller through the medium of a working fluid, and vanes carried by said impeller, the impeller having a surface across which said vanes extend at intervals apart to afford pockets between said vanes, said pockets being concave at their inner ends, and being closed at all sides and at their inner ends and presenting open mouths to said member, the interior faces of said pockets effectively conforming to a substantially spiral direction of motion of said fluid.

3. A speed-responsive device including an impeller and a member to be operated by the impeller through the medium of a working fluid, and vanes carried by said member, the member having a surface across which said vanes extend at intervals apart to afford pockets between said vanes, said pockets being concave at their inner ends and being effectively closed at all sides and at their inner ends and presenting open mouths to said impeller, the interior surfaces of said pockets effectively conforming to a substantially spiral direction of motion of said fluid.

4. A governing device comprising a casing, a head secured to said casing, said head having a hollow boss projecting therefrom,

notches in the end of said boss, and a shaft secured to the head and having a transverse pin to be inserted into the said boss so that the ends of said pin engage said notches.

5 5. A governing device comprising a casing, a disk having an opening secured to the lower end of said casing, said disk having a conical rim, a head having a coned edge to be engaged by said rim, said head having a central recess and said casing a boss projecting externally therefrom to pass through the opening in the disk into the said recess, vanes carried by the casing, a member therein carrying vanes opposed to the first vanes, and a shaft in said casing carrying said member, and projecting to the outside of said casing.

6. The combination of a valve, a spring normally tending to open said valve and a governing device comprising a casing having a boss projecting therefrom, a head attached to said casing, and having a recess to receive said boss, said head having a shaft integral therewith, a gear on said shaft, vanes connected to the inside of said casing, a rotary member in said casing having vanes thereon, a shaft for said member projecting from said casing, and a connection between said shaft and said valve, whereby the rotation of the gear will revolve the casing and cause said member at a predetermined speed of said unit to move said valve towards closed position.

7. A speed regulator comprising a valve, a spring tending to hold said valve in open position, a governing device comprising a casing, a head having a projection with a central recess therein to be fitted to the bottom of said casing, the bottom of said casing having a rim to engage said projection and a central boss to enter said recess, vanes secured to the inside of the bottom of said casing, a member carrying vanes opposed to the first mentioned vanes, a shaft carrying said member and projecting to the outside of said casing and a connection between said second shaft and said valve.

8. A speed-responsive device including an impeller and a member to be rotatably driven by the impeller through the medium of a working fluid, said impeller having vanes inclined to the plane of rotation, said vanes and said impeller being so shaped and the vanes being so disposed upon said impeller as to provide pockets between said vanes, said pockets having open mouths presented to said member and being effectively closed at all other points.

9. A speed-responsive device including an impeller and a member to be rotatably driven thereby through the medium of a working fluid, said member having vanes inclined to the plane of rotation, said member and said vanes being so shaped and vanes being so disposed on said member as

to provide recesses between said vanes, said recesses having open mouths presented to said impeller and being effectively closed at all other points.

10. A speed-responsive device including a rotary impeller and a rotatable member opposed to the impeller to be operated by the impeller through the medium of a working fluid, and vanes carried by said impeller, the impeller having a surface across which said vanes extend at intervals apart so as to afford pockets between said vanes, said pockets having their inner ends concave, the ends of each to adjacent vanes close to the axis of rotation and the ends of the said vanes remote from said axis being bridged by opposite edges of said pockets, whereby said pockets are closed at all sides and at their inner ends, but present open mouths to said member, the interior faces of said pockets effectively conforming to a substantially spiral direction of rotation of said fluid.

11. A speed-responsive device including a rotary impeller and a rotary member opposed to the impeller to be operated thereby through the medium of a working fluid, and vanes carried by said member, the member having a surface across which said vanes extend at intervals apart so as to afford pockets between said vanes, said pockets having concave inner ends, the ends of each two adjacent vanes close to the axis of rotation and the opposite ends of each two adjacent vanes remote from the axis of rotation being bridged by opposite edges of said pockets, whereby said pockets are effectively closed on all sides and at their inner ends, but present open mouths to said impeller, the interior surface of said pockets effectively conforming to a substantially spiral direction of rotation of said fluid.

12. A speed-responsive device including a rotary impeller and a rotatable member opposed to the impeller to be driven thereby through the medium of a working fluid, said impeller having vanes inclined to the plane of rotation, said impeller having a surface across which the vanes extend at intervals apart so as to provide pockets between said vanes, said pockets having concave inner ends, and the ends of each two adjacent vanes close to the axis of rotation and the opposite ends of each two adjacent vanes remote from said axis being bridged by opposite edges of said pockets, said pockets thus having open mouths presented to said member and being effectively closed at all other points.

13. A speed-responsive device, including a rotary impeller and a rotatable member opposed to the impeller to be driven thereby through the medium of a working fluid, said member having vanes inclined to the plane of rotation, said member having a surface across which said vanes extend at intervals

apart so as to provide recesses between said
vanes, the inner ends of said recesses being
concave, and the ends of each two adjacent
vanes near the axis of rotation and the op-
posite ends of each two adjacent vanes re-
mote from the axis of rotation being bridged
by opposite edges of said recesses, said re-

cesses thus having open mouths presented to
said impeller and effectively closed at all
other points.

In witness whereof, I have signed my
name to this specification this 28th day of
February, 1921.

WARNER T. TABB