

Sept. 8, 1942.

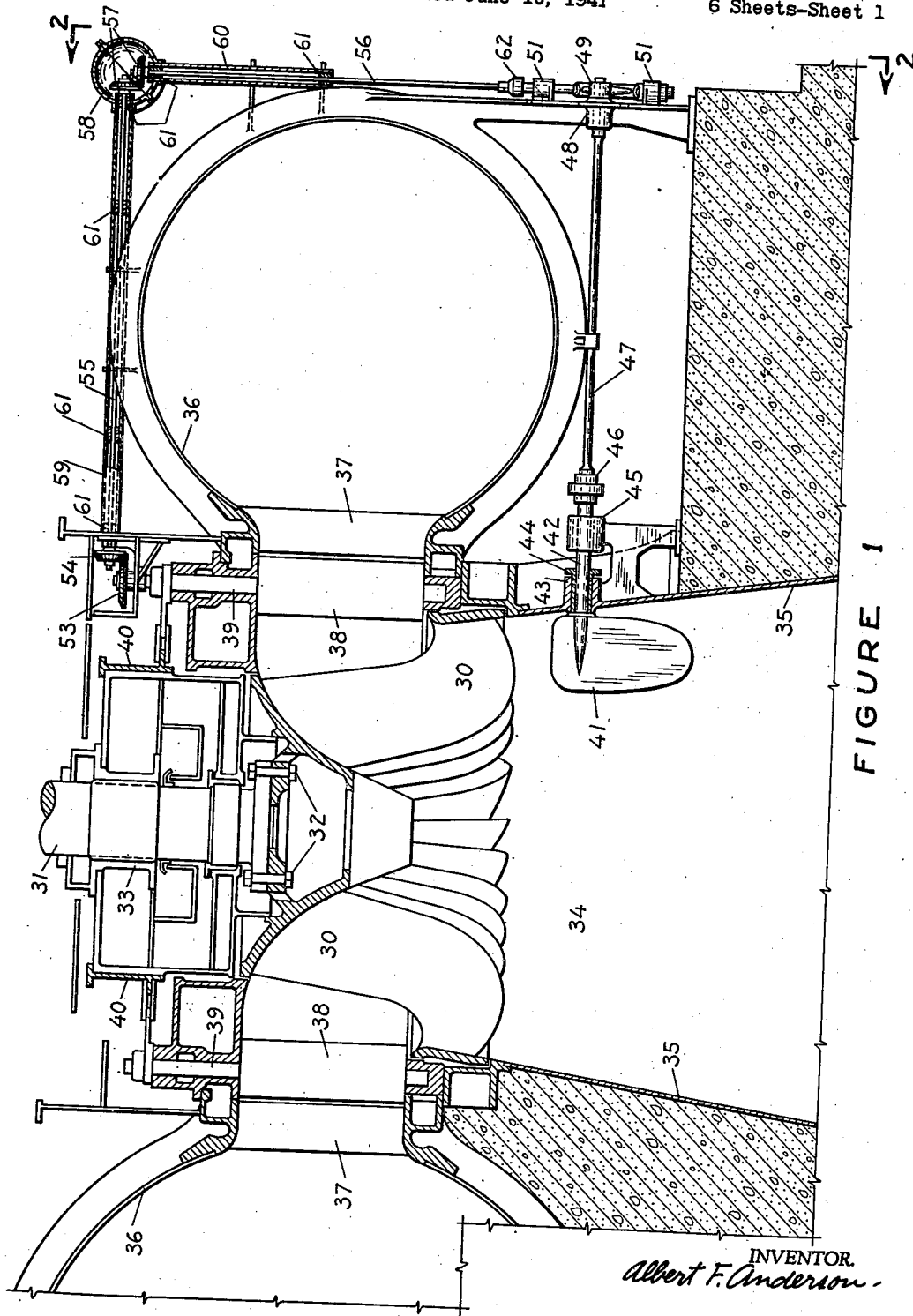
A. F. ANDERSON

2,295,495

WHIRL DEFLECTING VANES FOR HYDRAULIC TURBINES

Filed June 10, 1941

6 Sheets-Sheet 1



Sept. 8, 1942.

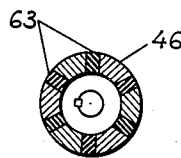
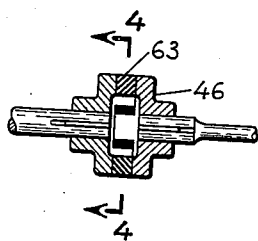
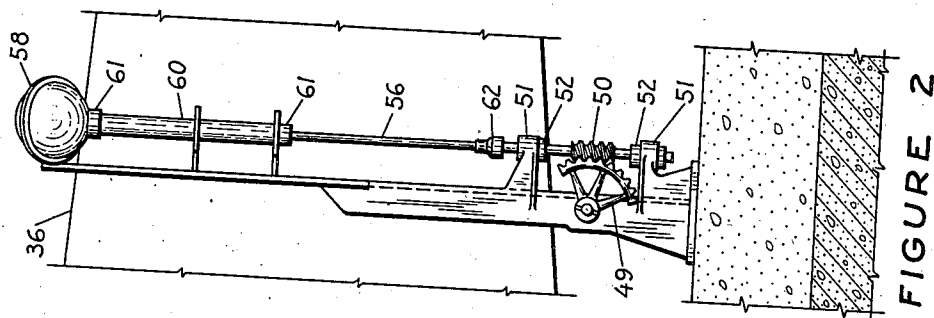
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6 Sheets-Sheet 2



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6 Sheets-Sheet 3

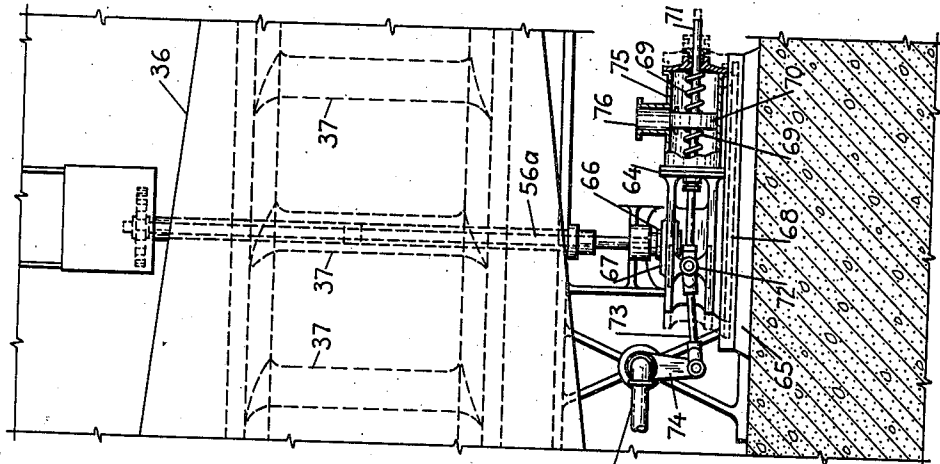


FIGURE 6

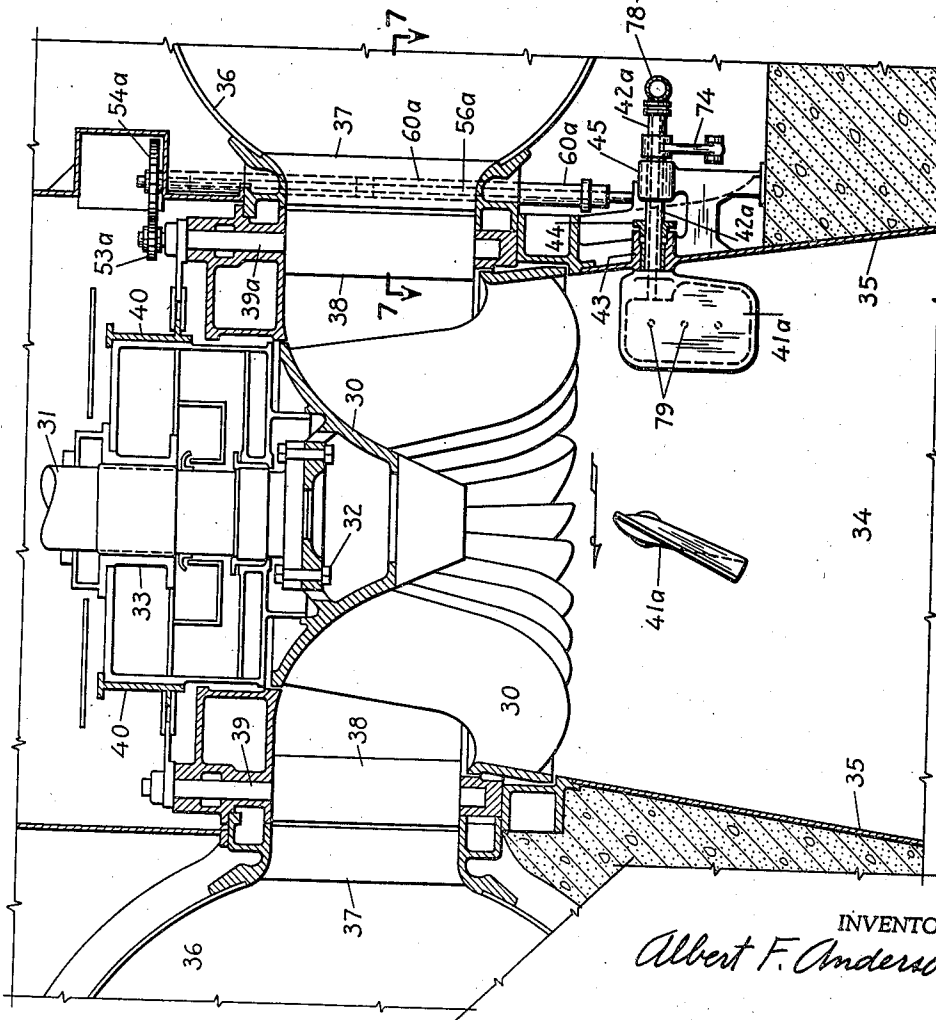


FIGURE 5

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2,295,495

WHIRL DEFLECTING VANES FOR HYDRAULIC TURBINES

Filed June 10, 1941

6 Sheets-Sheet 4

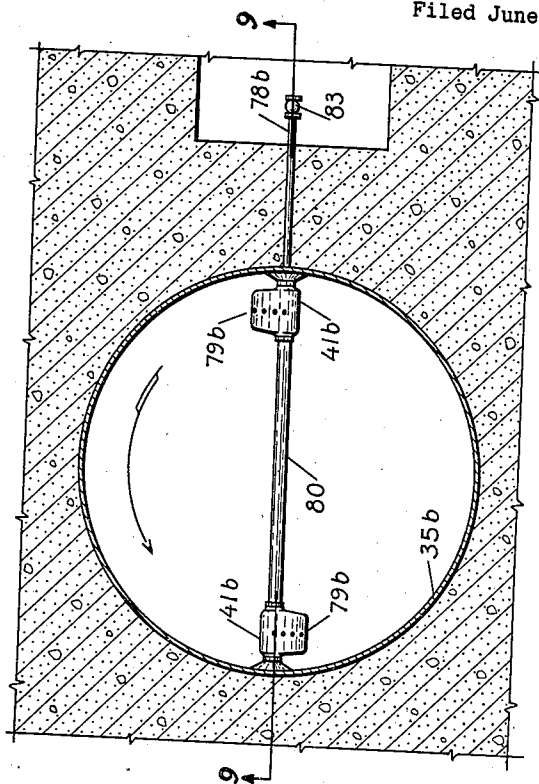


FIGURE 8

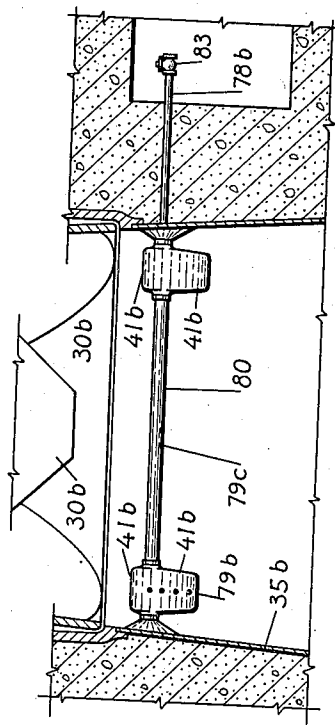


FIGURE 9

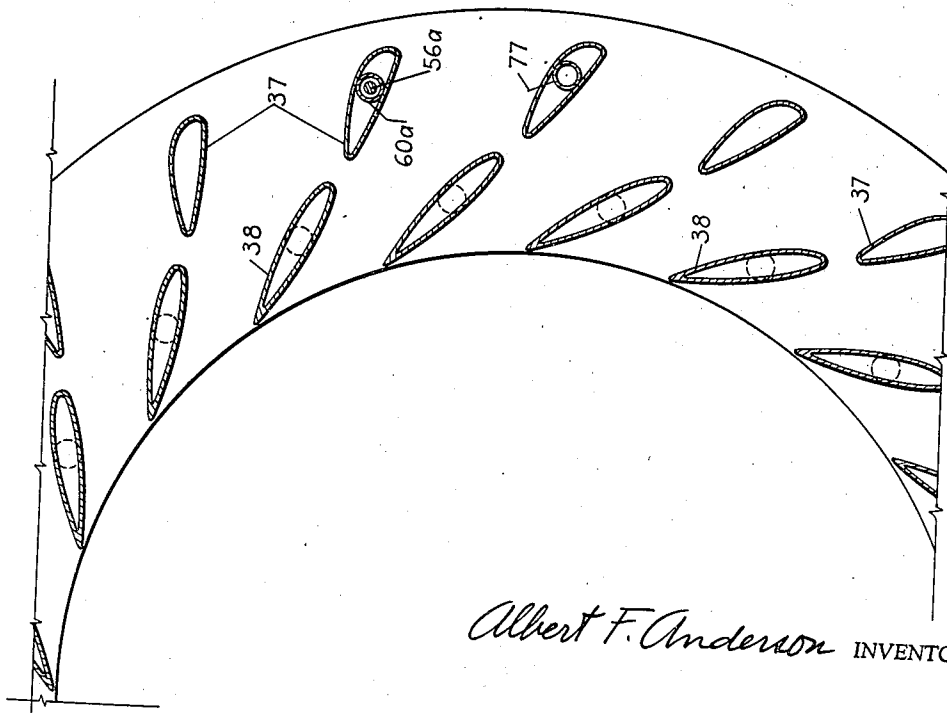


FIGURE 7

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2,295,495

WHIRL DEFLECTING VANES FOR HYDRAULIC TURBINES

Filed June 10, 1941

6 Sheets-Sheet 5

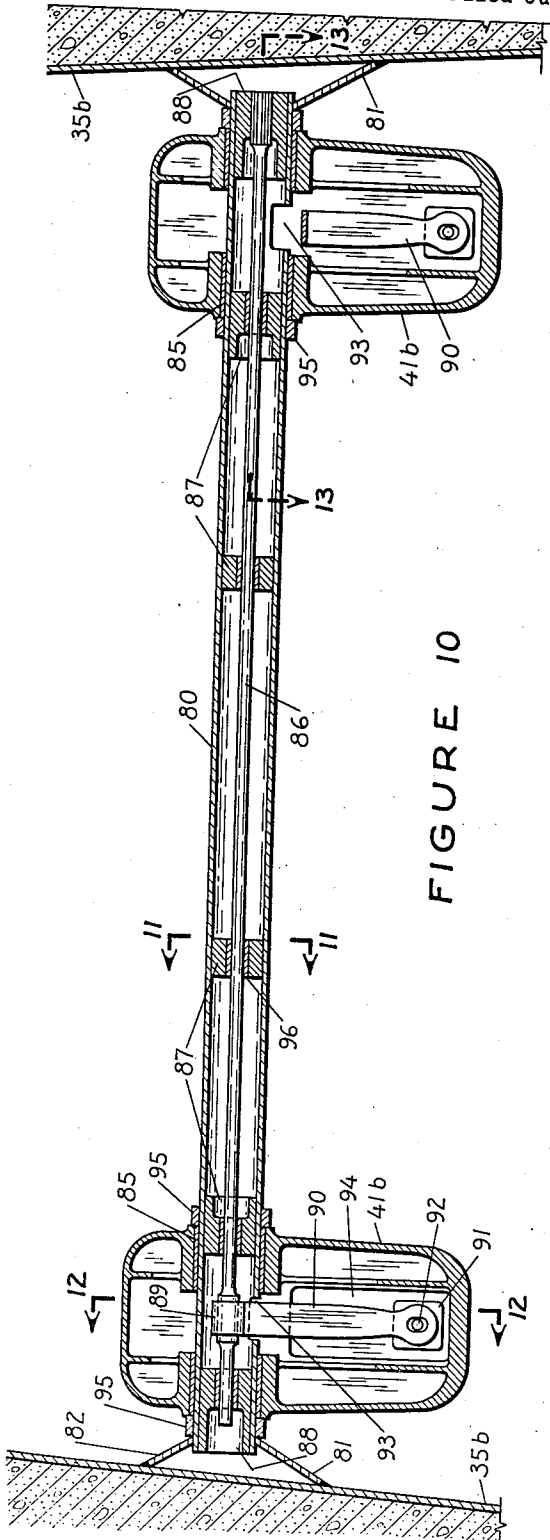


FIGURE 10

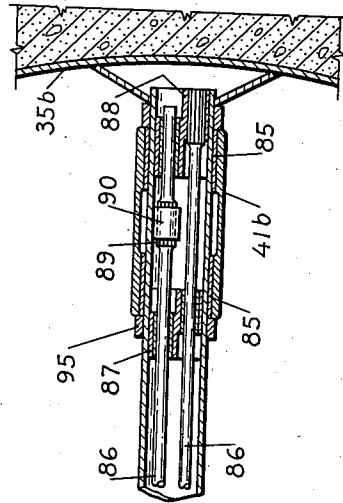


FIGURE 13

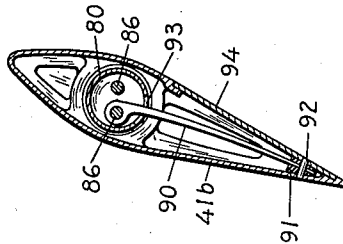


FIGURE 12

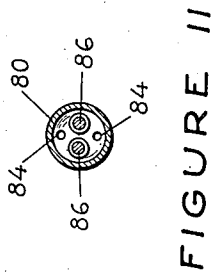


FIGURE 11

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2,295,495

WHIRL DEFLECTING VANES FOR HYDRAULIC TURBINES

Filed June 10, 1941

6 Sheets-Sheet 6

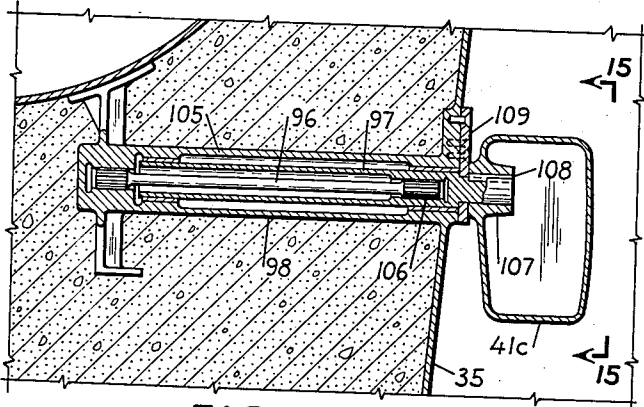


FIGURE 14

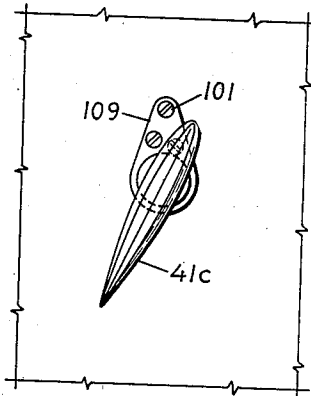


FIG. 15

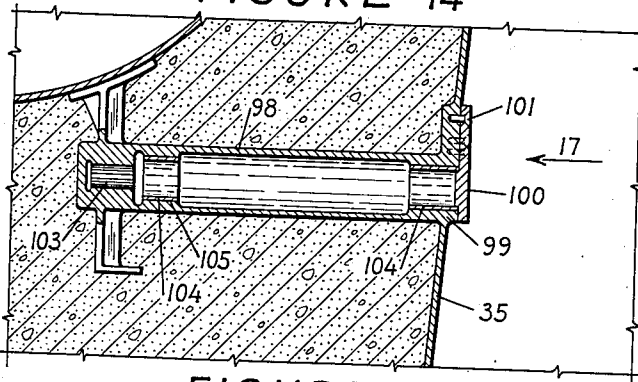


FIGURE 16

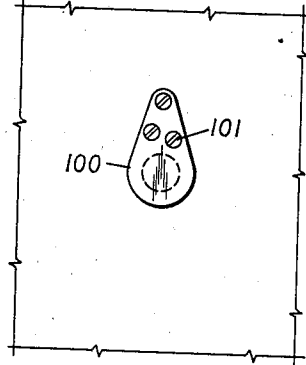


FIG. 17

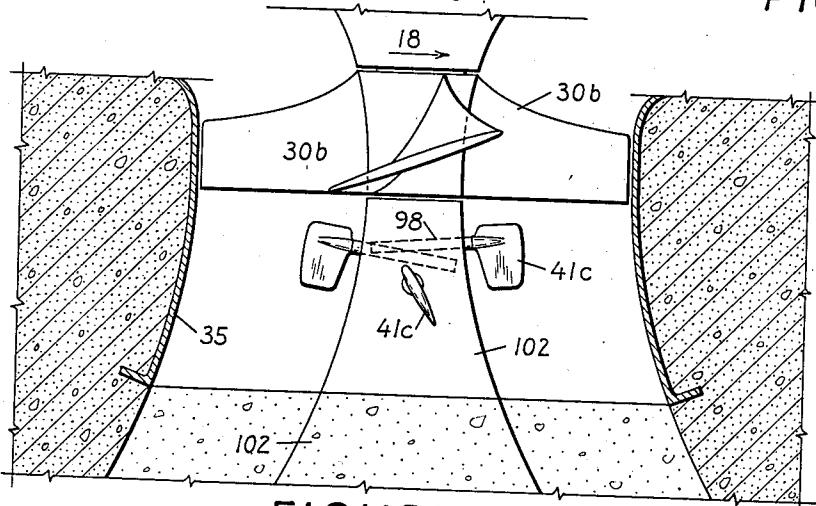


FIGURE 18

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UNITED STATES PATENT OFFICE

2,295,495

WHIRL DEFLECTING VANE FOR HYDRAULIC
TURBINES

Albert F. Anderson, San Francisco, Calif.

Application June 10, 1941, Serial No. 397,353

10 Claims. (Cl. 253—117)

This invention relates to improvements in hydraulic turbines and appertaining penstocks and draft tubes. It may also be applied to other hydraulic apparatus such as centrifugal pumps and to their inlet and outlet pipes. It also may be applied to fans and air ducts.

More specifically, this invention relates to improvements in "anti-swirl vanes" and in the means used in their application to hydraulic apparatus; the invention comprising principally of new and more convenient methods of installing these vanes in new and old turbines.

"Anti-swirl vanes" are employed in hydraulic turbines primarily to suppress "power swings" in the electrical transmission lines of hydroelectric power plants, either by altering the power swing frequency of each turbine generator unit so that the frequency will be inharmonic with all other units and with the natural frequency of the power swings in the transmission system itself, or by reducing the magnitude of the swings in each turbine generator unit interconnected with the system.

These vanes also improve the efficiency of hydraulic turbines and of the governing mechanism.

The more advantageous design of most hydraulic turbines is such that its discharge will have a whirl; but to allow this whirl to continue throughout the length of the draft tube is a decided disadvantage and means for reducing the whirling flow without introducing a baffling effect on the flow is attained by the use of "anti-swirl vanes" which deflects the whirling flow into a more direct course through the tube.

The function, construction and mode of operation of these vanes has been explained in the specification of United States Patent No. 2,244,479 which has been granted to me on June 3, 1941; and in the following description it will be assumed that the general functioning of the vane is understood together with that of the turbine.

Although the vane may be connected so as to be adjusted by the turbine governor it should be understood that the vane is essentially self operating and is not dependent on the governor, but merely takes its most favorable setting therefrom, according to conditions, depending mainly on whether the turbine is lightly loaded or heavily loaded.

Normally the vane is set so as to feather into the moderately whirling flow of the turbine discharge, applying little or no deflecting force on the stream until the whirl becomes excessive and tends to turn the vane about its pivot. The vane

yields to this turning effort in a limited degree only and with progressively increasing resistance; thereby effecting a deflecting force on the stream which guides it into the desired course without imposing a baffling effect thereon.

The vane's resistance to turning is provided by resilient means, usually by means of a torsion rod made of spring bronze or spring steel.

The resilient means employed must be capable of restoring the vane to its normal position instantly; since in some turbines violent vortices are formed at very rapid rates; or more than one or two per second.

An undesirable whirling flow may also develop at the inlets of turbines and pumps. In the case of turbines having vertical or steeply inclined penstocks a slight whirl is very likely to develop and at the bends or elbows of such a penstock the whirling flow may be greatly accentuated; causing considerable increase in the resistance to the flow besides adversely affecting the operation of the turbine.

By employing "anti-swirl vanes" at the bends of penstocks the whirling flow can be counteracted just as it is done in draft tubes.

Having thus, in a general way, described the invention and its objects, it will now be described in detail and for this purpose reference will be had to the accompanying drawings in which the invention has been illustrated and in which:

Figure 1 represents a diametrical section through a hydraulic turbine and the upper part of its draft tube; the turbine being of the vertical shaft type.

Figure 2 is end view looking in the direction of arrows 2—2, Figure 1;

Figure 3 is a diametrical section of the flexible shaft coupling designated by numeral 46 in Figure 1;

Figure 4 is a section taken on line 4—4, Figure 3;

Figure 5 is a view similar to that shown in Figure 1, showing a slightly modified form of construction;

Figure 6 is a side elevation looking to the left in Figure 5;

Figure 7 is a section taken on line 7—7, Figure 5;

Figure 8 is a horizontal section through a draft tube showing a modified form of vane;

Figure 9 is a vertical diametrical section taken on line 9—9, Figure 8;

Figure 10 is a longitudinal diametrical section through the vane assembly shown in Figures 8 and 9;

Figure 11 is a transverse section taken on line 11—11, Figure 10;

Figure 12 is a section taken on line 12—12, Figure 10;

Figure 13 is a section taken on line 13—13, Figure 10;

Figure 14 is a sectional view showing a modified form of the invention;

Figure 15 is an end elevation looking through plane 15—15, Figure 14;

Figure 16 is a view similar to that shown in Figure 14, but with parts removed;

Figure 17 is an elevation looking in the direction of arrow 17, in Figure 16; and

Figure 18 is a diametrical section through a portion of a hydraulic turbine of the high specific speed type.

Figure 1 illustrates one means of attaining adjustment of the vane setting from the turbine governor. The automatic or self operating ability of the vane mechanism remaining undisturbed during the adjustment process.

Figures 2, 3 and 4 show details of the mechanism illustrated in Figure 1; Figure 2 being a view looking in the direction of arrows 2—2, and Figures 3 and 4 illustrating a resilient shaft coupling of no special significance since the required resilience is attained with the usual means; the coupling merely serves to connect this means to the vane and afford additional resilience. However, such a coupling may be an aid to the dampening of vibration in some instances.

Referring first to Figure 1, the various parts of the hydraulic turbine have been designated by numerals; the same numerals applying to Figure 5 which shows a similar view of a turbine.

Numeral 30 designates the turbine runner, and 31 its shaft; to which it is secured by coupling bolts 32. The shaft is positioned by the lower steady bearing 33.

Below the turbine runner is the upper portion of the draft tube 34 with its steel liner 35.

The inlet to the turbine runner is formed by walls of the scroll case 36 which have stay-vanes 37, past which the water must flow to enter the turbine runner 30; the control of the water being regulated by wicket gates 38 which are pivotally mounted so that they may be turned by means of their stems 39, which are interconnected by means of levers, links and pins to shifting ring 40 through which means, the governor adjusts the wicket gates 38 and controls the speed of the turbine.

The angular movement of wicket gates 38 depends on the design of the turbine and usually they are not required to turn much more than fifty degrees in order to move the gates from their closed position to their fully opened position.

Only one "whirl deflecting vane" 41 has been shown on Figure 1, its shaft 42 is positioned by bearing 43 having stuffing box 44 and thrust bearing 45. A shaft coupling 46 serves to connect shaft 42 to rod 47 which is made of resilient material such as spring bronze or spring steel.

The other end of this rod is enlarged as it passes through bearing 48 and to its extreme end is immovably secured an adjustable anchor in the form of a worm quadrant 49; illustrated in Figure 2, where the adjusting worm 50 and its supporting bearings 51 together with thrust collars 52, are also shown.

The necessary angular movement and required restraining force for the operation of the whirl deflecting vane 41, is regulated by the torsion

rod 47 which is proportioned so as to allow some movement to the vane 41 while its end is securely held by anchor quadrant 49.

In the operation of most turbines the conditions are such that the most favorable angular position of the vane 41 is more or less dependent on the "gate opening" of the turbine; corresponding to the angular position of wicket gates 38 and in some installations it will be desirable to interconnect the whirl deflecting vane 41 with the wicket gates 38 through suitable means in order to maintain the most favorable relationship under varying operating conditions.

One such means is that illustrated in Figures 1 and 2, comprising a transmission system composed of gears and shafting with their supporting parts such as brackets, bearings and coverings. Through this transmission system any rotation or angular movement in the wicket gate 38 will produce a corresponding angular movement of lesser degree in the vane anchor quadrant 49 and thereby effect a change in the angular position of vane 41 accordingly.

For most turbines the angular movement or rotation of the anchor quadrant 49 need not be more than five or ten degrees in so far as the operating range of the turbine is concerned, but in shutting down the turbine, the quadrant and consequently the vane 41 will be rotated through greater angles.

Since the turbine governor usually operates the wicket gates 38 it will also control the position of anchor quadrant 49 and alter the neutral position of vane 41 through the mechanical transmission system illustrated.

In this system the bevel gear 53 is keyed to an extension of a gate stem 39 and is rotated thereby; and being meshed with its companion gear 54, which is immovably attached to the shaft 55, causes it to rotate the vertical shaft 56 by means of miter gears 57 housed in a case 58. Both shafts 55 and 56 are shown sheathed with tubes 59 and 60 and provided with suitable bearings 61.

The rotary movement of shaft 56 is communicated to the adjusting worm 50 through the shaft coupling 62 which connects the two in a manner that may provide some back-lash (or free play) if such a back-lash is found to be desirable.

The meshing of the worm threads with the worm teeth of anchor quadrant 49 completes the transmission system.

It is understood of course, that other transmission devices or systems can supplant the use of the mechanical power transmission system shown and described, without detracting from the spirit and scope of this invention as defined in the claims. As an example of a suitable power transmitting system attention is called to the various kinds of rudder control devices employed on large ships, some of which are electrical and some hydraulic.

In Figure 3 a sectional view of shaft coupling 46 is shown. Figure 4 is a cross-section of the coupling viewing it in the direction of arrows 4—4 in order to illustrate that resilient material 63, such as live rubber, is interposed between the jaws of the two halves of the coupling. Such couplings are not new and need no further explanation.

Another mechanical transmission employing shafting and gears is illustrated in Figures 5 and 6 which illustration, also shows an improvement in the whirl deflecting vane 41—A. This vane is applicable to turbines which are so designed

that the whirl in their draft tubes rotates in one direction only.

The vane 41—A and its shaft or stem 42—A are also provided with ports for admitting air into the turbine draft tube.

The practice of admitting air into the draft tubes of turbines is not new and in many turbines having no whirl deflecting vanes, some benefit in the regulation or governing of the turbine has been experienced thereby and it is quite possible that some benefit may also be derived by admitting a small quantity of air into the draft tube of turbines that do have whirl deflecting vanes.

In the illustrations of Figures 5 and 6 the required equalizing and restraining force for the operation of the whirl deflecting vane 41—A, is supplied by means of an air cushion provided by the dash-pot mechanism shown.

For convenience the entire dash-pot mechanism has been designated by the numeral 64.

On account of mechanism being subject to adjustment from the turbine governor it is mounted on a base 65 on which it may slide bodily. The limits of its movements from the mid-position (shown in full lines on the drawing Figure 6) are indicated by dotted lines at both ends of the mechanism.

This movement is made by means of shaft 56—A which rotates in a pinion 66 secured to its lower end and which engages with a cooperating rack 67 attached to the dash-pot frame 64.

The dotted lines 68 represent guides in which the frame slides and by which it is held in alignment.

The endwise movement of the dash-pot frame 64 effects a force in one direction or the other, according to the direction of the movement, through helical springs 69 which function to centralize the position of the dash-pot piston 70 and this force is communicated to the whirl-deflecting vane 41—A through the mechanism shown, comprising the piston 70, its rod 71, cross-head assembly 72, connecting rod 73, crank 74 and the vane shaft or stem 42—A.

The dash-pot shown in the illustration is of the double acting type but this type is not essential in the case of turbines whose whirl rotates in one direction only.

When piston 70 is in the mid position, both ends of the cylinder or dash-pot 75 are opened to the influences of atmospheric pressure through port 76, and when the piston 70 is moved one way or the other by the forces imposed on vane 41—A, air is confined in one end of the dash-pot 75 and is compressed, providing a cushioning effect.

When the forces tending to turn vane 41—A are removed the air cushion with the aid of the helical springs 69, forces the vane to return to its neutral position.

In Figures 5 and 6 the power required to change the adjustment of the apparatus controlling the vane 41—A, is transmitted in a manner similar to that described with reference to Figures 1 and 2 inasmuch as the means used is mechanical; employing gears and shafts.

In this illustration the gate stem 39—A has a pinion 53—A nonrotatably secured to its upper extension which pinion meshes with a spur gear 54—A to which the shaft 56—A, is suitably secured so as to rotate pinion 53 at its lower end when gates 39 are turned by the turbine governor through its servomotor; neither of which are shown.

Shaft 56—A is sheathed by a tube 60—A which

extends from the upper region of the turbine to the under portion; passing through one of the hollow stay vanes 37.

Figure 7 has been drawn to illustrate this feature somewhat further; the figure represents a sectional plan view of that portion of the turbine embraced by the arrows 7—7 on Figure 5 showing both the fixed stay vanes 37 and the pivoted wicket gates 38, in cross-section.

The shaft 56—A and its sheath 60—A is also shown in cross-section.

The figure also shows air pipe 77 in cross-section and it may be presumed that this pipe connects with the air pipe 78 as shown in Figure 6.

Referring again to Figure 5 air pipe 78 is connected to the hollow shaft or vane stem 42—A by means of a suitable swivel pipe connection. Vane 41—A may be hollow or fitted with conduits which provide passageways for air to the small ports or holes 79 provided on one side of the vane for admitting air into the draft tube of the turbine.

The outer surface of the whirl deflecting vane 41—A is faired or streamlined to accommodate the particular part of the vortex or whirling flow of the turbine discharge in which it is situated. Such a vane is suitable only for turbines whose whirl does not reverse.

Figure 5 shows one view of vane 41—A which indicates that the edge of the vane nearer to the draft tube axis, lies in a plane having a greater angle to said axis than the more remote edge of the vane.

The difference between these angles increases with the increase in width of the vane.

The arrow shown above the vane indicates the direction in which the turbine runner revolves and the direction in which the water revolves or whirls in the draft tube.

Figures 8, 9, 10, 11, 12 and 13 illustrate a design of whirl deflecting vanes and appurtenances which makes it possible to install them in turbines whose draft tubes are inaccessible except from within; on account of thick walls of concrete which surround the draft tube liners.

Figures 8 and 9 illustrate the general arrangement of the apparatus in the draft tube of such a turbine and the other figures illustrate the various details of construction; Figure 8 being a sectional plan view showing the upper portion of the draft tube in cross-section and a top plan view of the whirl deflecting vane apparatus.

Figure 9 is a sectional elevation of the same portion of the draft tube showing the apparatus in elevation.

The vanes in these several illustrations will be designated by 41—B, the draft tube liner by 35—B, the turbine runner by 30—B, the air pipe by 78—B and the air ports in the vanes by 79—B; other air ports 79—C are shown near the center of the tubular beam 80 which spans the draft tube and forms the supports for the whirl deflecting vanes 41—B.

Referring to Figures 8 and 9 and to the other figures showing this embodiment of the invention, it will be observed, from study of the construction of the apparatus, that the tubular support 80 carrying vanes 41—B can be completely assembled into a compact unit before it is installed in the draft tube.

Presuming that the draft tube liner is encased in concrete and is inaccessible from the outside, all the work of installing the apparatus must be done from within the draft tube; and presuming that welded construction may be resorted to; saddles or sockets 81 are first installed, by weld-

ing them to the draft tube liner 35b; provision for inserting the tubular support 80 being made in any suitable manner; one convenient method being to make one of the saddles 81 in two parts so that only the lower part need be installed to hold the end of support 80 and the upper part 82 welded on, after the installation is about complete.

A check valve 83 terminates the inlet of air pipe 78—B, allowing air to pass into the draft tube through this pipe and connecting passageways, but checks its flow in the reverse direction.

Air ports 79—B are indicated on one side of each vane 41—B but when conditions permit, it is preferable to admit air into the draft tube through holes closer to the center or axis of the draft tube, or through holes 79—C in the tubular support 80.

Figure 10 shows a longitudinal section through the apparatus as it may be constructed when no provision for admitting air into the draft tube is made; the only difference in construction being that the air ports and passageways are omitted.

Figure 11 is a cross section of the tubular beam or support 80, taken in the direction of arrows 11—11, showing how air ports 84 through the parts 87 inside of the tubular support 80 may be provided whenever they are desired. The other illustrations do not show these ports nor the pipe 78—B for supplying air.

Figure 12 is a vertical cross-section of the whirl deflecting vane 41—B, viewing it in the direction of arrows 12—12, and Figure 13 is a horizontal sectional view of the vane and the portion of the appertaining apparatus embraced by, and viewed in the direction of, arrows 13—13.

In this embodiment of the invention the supporting beam 80, corresponding to the vane stem 42 or 42—A, in the other illustrations, does not rotate with the vane 41—B but is immovably fixed into the draft tube by means of saddles or brackets 81, to which we may assume, it is welded, or otherwise adequately secured.

The required degree of rotation, which may be as little as 10 or 15 degrees in some turbines operating under comparatively stable conditions, is provided by mounting the vanes 41—B on the tubular supporting beam 80 by means of bearings 85 embraced in the construction of vanes and lined with suitable bearing metal or other material, such as rubber or lignum vitae which are sometimes used when water is depended upon for lubrication.

The vanes being pivoted in this manner are restrained from turning beyond the required amount by the mechanism enclosed within themselves and their tubular support 80.

The principal resilient force upon which the proper functioning of the whirl deflecting vanes depend, is provided by spring rods 86: these rods are made of resilient material such as spring bronze or spring steel and in the illustrations, one torsion or spring rod 86 is provided for each vane 41—B. Both rods 86 are supported in tube 80 by common bearings 87 which may be held in their respective places by any suitable attachment to tube 80, for example, by spot welds executed through small holes in tube 80 provided for this purpose. In the same manner the spring rod anchors 88, may be securely attached to tubular support 80.

Each rod anchor 88 provides an additional bearing for one of the spring rods 86, besides serving as an anchor for the end of the other spring rod.

The construction and manner of support of both vanes 41—B are similar; likewise their connections to spring rods 86 are similar.

One end of each spring rod 86 is enlarged and non-rotatably and non-movably attached to its anchor 88 by means of interlocking splines assisted by welds.

Near the other end of rod 86, a splined connection 89 is formed for non-rotatably attaching lever 90, which lever extends to the bottom end of vane 41—B where it terminates in a cushioned attachment to the vane.

Cushion pads 91 are made of rubber and an elongated hole in the end of lever 90 and pads 91, provides clearance around pin 92 which is riveted, or screwed in place to aid in keeping lever 90 in alignment.

Levers 90 are designed in the form of leaf springs to attain additional resilience, although the resilience of spring rods 86 may be adequate in themselves; and conversely, a form of leaf spring replacing spring lever 90 can be devised that would be adequate in itself, in which case, spring rods 86 would be unnecessary and tubular beam 80 or any beam replacing it would not need to extend across the draft tube, but could take the form of a cantilever beam.

Aperture or opening 93, in tube 80, is large enough to clear lever 90 in its two extreme positions as well as being large enough to permit the insertion of the upper end of the lever in the process of assembling the apparatus.

A cover 94 is tack welded over an opening in one face of vane 41—B. The opening is necessary for placing lever 90 inside of vane 41—B, and to expedite the assembly of the parts.

Set collars 95 for preventing lateral movement of vane 41—B may be welded to tubular support 80 or secured by any other suitable means, such as, by means of set screws.

Since spring rod 86 has an enlargement on either end, the bushings 96 in bearings 87 may be soldered or otherwise secured in its exact position on spring rod 86 before the rod is inserted in tubular support 80.

This embodiment of the invention as illustrated by drawings is suitable for turbines whose whirl revolves in one direction only; but only slight changes in construction would accommodate it to turbines whose whirl may rotate in either direction.

The arrow in the draft tube in Figure 8 indicates the direction of whirl rotation for which these vanes are suitable.

Figure 12 indicates the normal inclination of the vane, the forces imposed on the vane by the turbine discharge tends to rotate the vane in a clockwise rotation but the restraining force of the spring rod 86, through lever 90, prevents it from rotating more than 10 or 15 degrees further in this direction.

Positive stops can be incorporated in the design of the set collars 95, as a precautionary measure and also to reduce the size of opening 93 in tubular support 80, to a minimum.

In many instances, the embodiment of the invention as illustrated in Figures 14 and 15 can supplant the embodiment just described which are for turbines of old construction having their draft tube liners completely encased in concrete, but the work of making the installation requires a longer shut down period for the turbines.

This embodiment of the invention also has many advantages in its adaptation to turbines of new design. It is of simple construction and of

rugged design; it is also easy and inexpensive to install and in instances where a plurality of small whirl deflecting vanes are preferable to several large ones, its compact design permits its installation in limited space with a minimum of interference.

Some flexibility in the application of the vanes is also afforded by providing receptacles for additional vanes before they are actually required; which also provides for their removal again when they are not required.

Figure 14 is a longitudinal section through the embodiment of the invention now referred to and Figure 15 is a view of the invention taken in the direction of arrows 15—15 in Figure 14.

Figure 16 is a section similar to that of Figure 14 showing a diametrical section of the tubular receptacle 98 of the same whirl deflecting vane mechanism, when the vane and mechanism are removed and the opening of bearing 99 is fitted with a cover 100 held in place by screws 101.

Figure 17 is a view in the direction of arrow 17, in Figure 16 showing a view of the cover 101.

Figure 18 is a diametrical section through a portion of a hydraulic turbine of the propeller type or of the high specific speed type, showing the runner 30—B which revolves in a clockwise rotation when viewed from beneath, as indicated by arrow 18.

The upper part of the draft tube with its liner 35 is also shown, together with the hydrocone 102 supporting whirl deflecting vanes 41—C.

Some builders of turbines prefer to design this type of turbine so that the whirl in the discharge therefrom is considerable and in such cases the whirl does not reverse its direction of rotation but follows that of the runner.

In this illustration the hydrocone carries the whirl deflecting vanes 41—C. Additional vanes could be placed in the draft tube walls in the usual way; but none are shown in that location in this illustration.

Hydrocones occupy the center region of the vortex of the turbine discharge where the horizontal component representing the velocity of the flow is usually much greater than that of its axial or vertical component; causing the turbine discharge to assume a winding course through the draft tube instead of a direct course; adding greatly to its resistance and detracting from the efficiency of the draft tube.

Hydrocones in draft tubes would serve their purpose to greater advantage if they were equipped with whirl deflecting vanes.

Whirl deflecting vanes are of greater efficacy when situated near the origin of whirls consequently they are located close to the runner of hydraulic turbines, but if the form of the draft tube of turbines is such that whirls originate in other parts of the tube, vanes can be applied to these localities also.

In pipes and penstocks the best location of whirl deflecting vanes is just beyond the bends or turns leading into straight portions of the penstocks or pipes. This will deflect the whirling path assumed by the water in the flow, into a more direct one and reduce the velocity and consequent friction of the water flowing along the surface forming the walls of the penstock or pipe, besides shortening the path of the entire water stream flowing through the same.

Referring again to Figure 16 it will be observed that the receptacle 98 comprises two spaced bearings joined with a tube having one end closed with a socket 103 and the other end

where bearing 99 is located, joined to the draft tube liner 35 by the process of welding. Any other kind of joint such as a flanged joint can replace the welded joint if desired.

5 The receptacle also is fitted with suitable bushings 104, for bearings 99 and 105.

The socket 103 is channelled or grooved to receive the splined end of spring rod 96, illustrated in Figure 14, which shows that the other end of spring rod 96 is also splined and provided with a socket 106, inside the vane stem 97, which is hollow so that the rod 96 may extend therein and be of whatever length required consistent with its diameter and the amount of twist it must sustain in the operation of the apparatus.

10 The figure illustrates that the receptacle 98, vane stem 97 and the spring rod 96 are telescoped together as it were.

The vane stem 97 is rotatably positioned by bearings 99 and 105 and non-rotatably attached to whirl deflecting vane 41—C by hub 107 and key 108.

20 The vane and stem are thus free to rotate or oscillate but keeper plate 109 prevents its endwise, or shifting movement. Screws 101 serve to hold keeper plate securely against the draft tube liner 35.

The endwise movement of spring rod 96 is limited by the clearance provided in the general construction and assembly of the apparatus and each end of rod 96 is nonrotatably inserted in sockets 103 and 106 so that the rotation of vane 41—C and its stem 97 twists the spring rod 96 because socket 103 is not free to turn, but is fixed.

30 In this manner the necessary resilient and yielding force for opposing the forces tending to turn the vane 41—C are balanced so that the vane can meet small forces with gentle resistance and greater forces with increased resistance, and when such forces are removed the spring rod 96 will return vane 41—C to its normal position; in which position no deflecting force is applied to the stream flowing past the vane, by its means. The vane thus, adjusts its deflecting force according to the amount required.

40 Having described the several embodiments of the invention what is claimed as new is:

1. In draft tubes for hydraulic turbines or in conduits through which a stream of fluid may flow, means for applying apparatus to control or actuate whirl deflecting vanes situated therein; comprising in combination, a whirl deflecting vane, a supporting stem therefor, said supporting stem having part of its length of tubular form, a shaft for providing resilience partially enclosed in the tubular part of said stem and to which it is suitably attached at one of its ends; the other end of said shaft projecting beyond the end of the tubular stem, a socket carried by the draft tube, for fixing or anchoring the shaft, a hollow cylindrical receptacle also carried by the draft tube and into which the vane stem extends, and spaced bearings in the cylindrical receptacle for positioning the vane stem therein.

2. In draft tubes for hydraulic turbines, or the like, through which fluid may flow, the wall of said tube having at least one opening, a whirl deflecting vane provided with a hollow stem, said stem projecting into one of said openings, a resilient rod positioned in the hollow stem, means for anchoring one end of the rod to the stem, and means positioned in the opening and secured to the draft tube for anchoring the other end of the rod.

3. In draft tubes of hydraulic turbines, or the like, having whirl deflecting vanes and actuating mechanisms therefore, means incorporated into the walls thereof for positioning the whirl deflecting vanes and their actuating mechanisms, said means comprising a receptacle of substantially hollow cylindrical form having one end open and accessible from the inside of the draft tube, the other end being closed and provided with a socket, a tubular stem connected with each vane, the hollow receptacle having bearings for positioning the stem therein, a spring rod positioned within the tubular stem, one end of the rod being secured in a socket in the stem and the other in the socket in hollow receptacle.

4. In an apparatus as described in claim 3 in which the spring rod has enlarged ends for insertion into the sockets, that portion of the rod between the enlarged ends constituting a torsion spring.

5. In draft tubes for hydraulic turbines or the like, a tubular supporting member carried by the draft tube, a whirl deflecting vane mounted for limited oscillation about the axes of the tubular support, and resilient means for yieldingly resisting rotation of the vane relative to the tubular support, said means comprising a resilient bar having one end secured to the vane and the other nonrotatably connected with the tubular support, said bar serving as a torsion spring.

6. In hydraulic turbines having draft tubes with hollow whirl deflecting vanes situated therein and secured thereto for pivotal movement about an axis substantially perpendicular to the axis of the draft tube, means for admitting air into the draft tubes through the vanes, comprising conduits having one end in communication with the interior of the vanes, the latter having openings through which air may enter the draft tube, the other ends of the conduits communicating with an air supply.

7. In hydraulic turbines having draft tubes, whirl deflecting vanes positioned therein, hollow supporting stems associated with the vanes, the wall of the draft tube having openings through

which the supporting stems extend, means for admitting air into the draft tubes, comprising air conduits formed within the whirl deflecting vanes and their supporting stems, said conduits terminating in suitable ports for dispensing air into the draft tubes; said conduits being in communication with suitable air sources outside of the draft tubes through suitable openings.

8. In hydraulic turbines having draft tubes, whirl deflecting vanes, stay vanes and adjustable wicket gates with their operating mechanisms and connections to the turbine governors, means comprising interconnected shafts and gears for transmitting motion from the wicket gates to the whirl deflecting vanes to effect simultaneous adjustment of said gates and vanes.

9. In hydraulic turbines having draft tubes, hollow stay vanes and adjustable wicket gates, means for adjusting the wicket gates, whirl deflecting vanes positioned in the draft tube, means for effecting simultaneous adjustment of the wicket gates and the whirl deflecting vane, comprising a shaft extending through a stay vane, means for transmitting rotation from the wicket gates to one end of the shaft and means at the other end of the shaft for transmitting a corresponding movement from it to the whirl deflecting vane.

10. In a hydraulic turbine having stay vanes, adjustable wicket gates, a draft tube positioned beneath the turbine runner, and whirl deflecting vanes mounted in the draft tube for pivotal adjustment; means for effecting simultaneous pivotal adjustment of the wicket gates and the whirl deflecting vanes, said means comprising a shaft extending from near the upper end of the wicket gate to a point below the same, means for transmitting rotary movement from the wicket gate to the upper end of the shaft and means for transmitting a corresponding rotary movement from the lower end of the shaft to the whirl deflecting vane.

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