

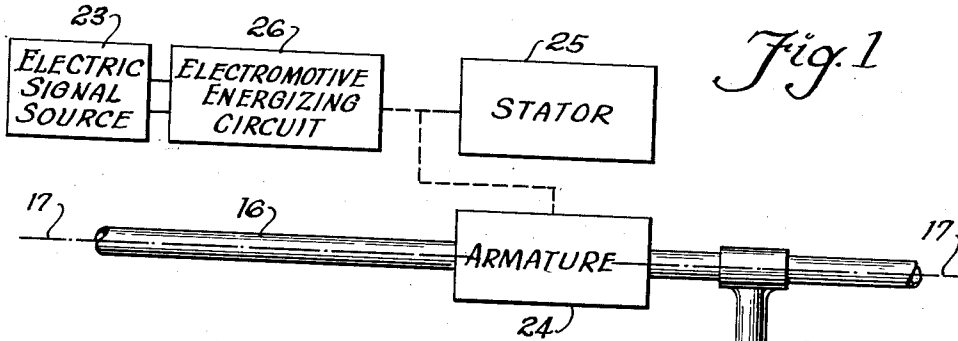
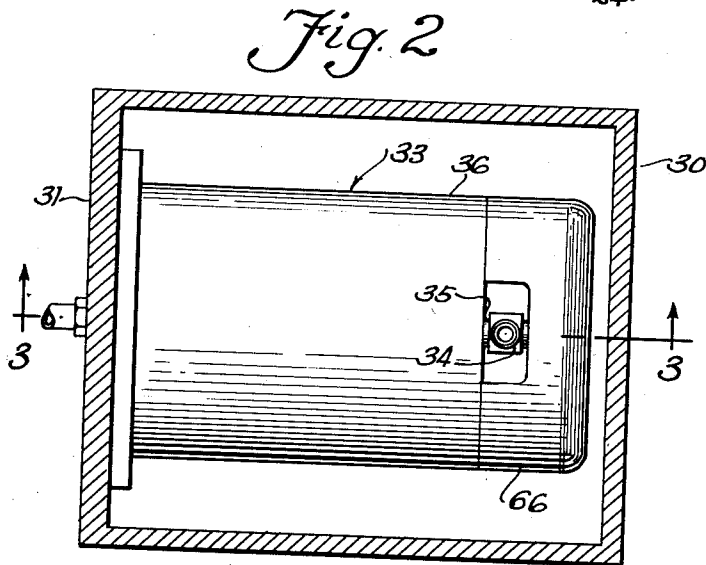
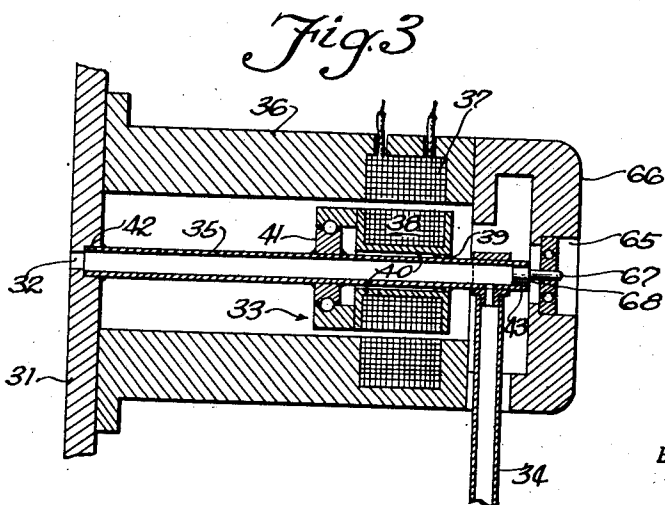
Jan. 11, 1955

H. ZIEBOLZ
JET PIPE SIGNAL DEVICE

2,699,356

Filed Oct. 14, 1950

3 Sheets-Sheet 1



INVENTOR.
Herbert Ziebolz
BY *[Signature]*
Att'ys

Jan. 11, 1955

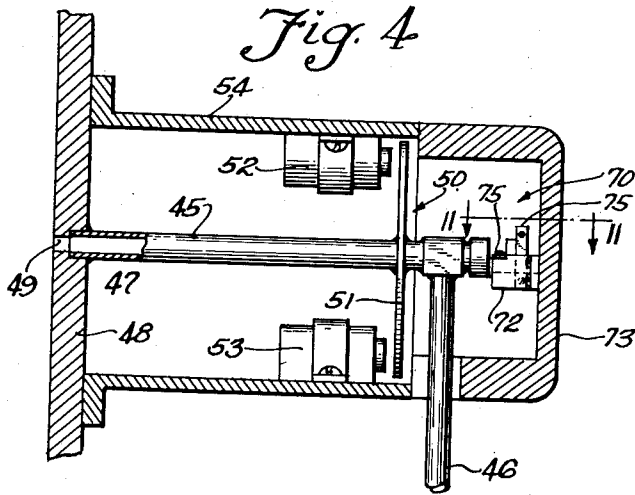
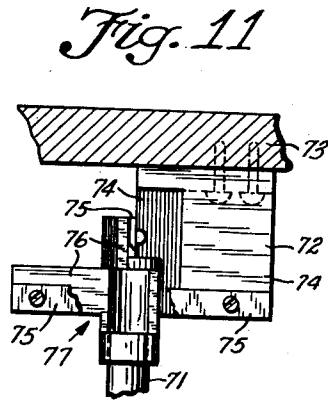
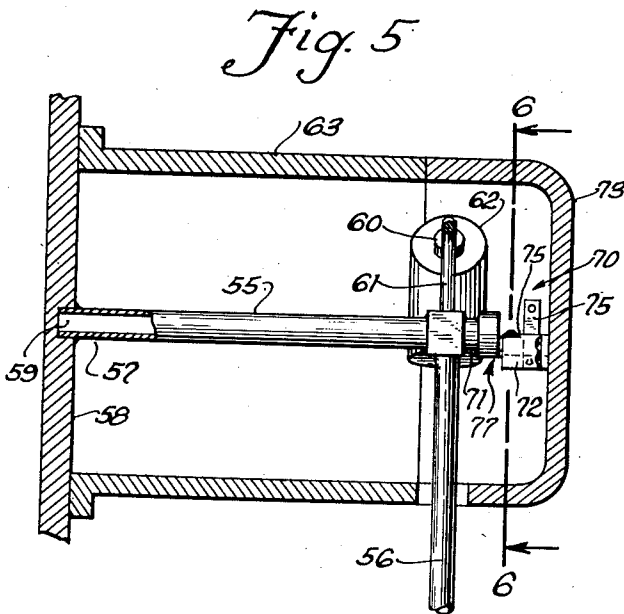
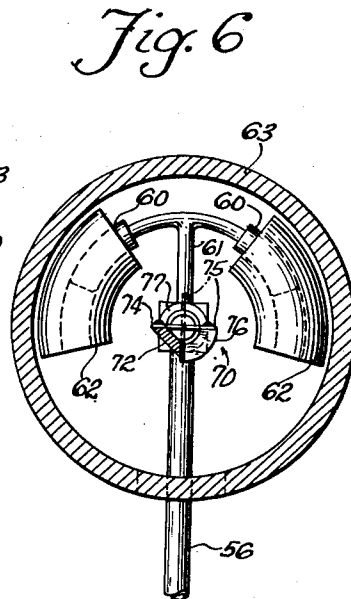
H. ZIEBOLZ

2,699,356

JET PIPE SIGNAL DEVICE

Filed Oct. 14, 1950

3 Sheets-Sheet 2

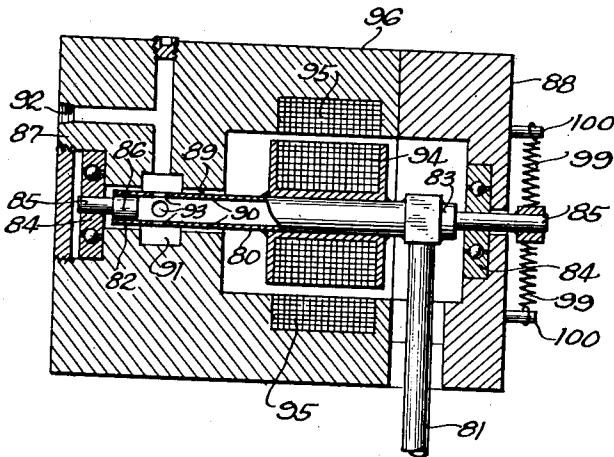
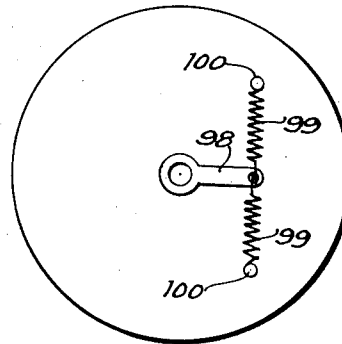
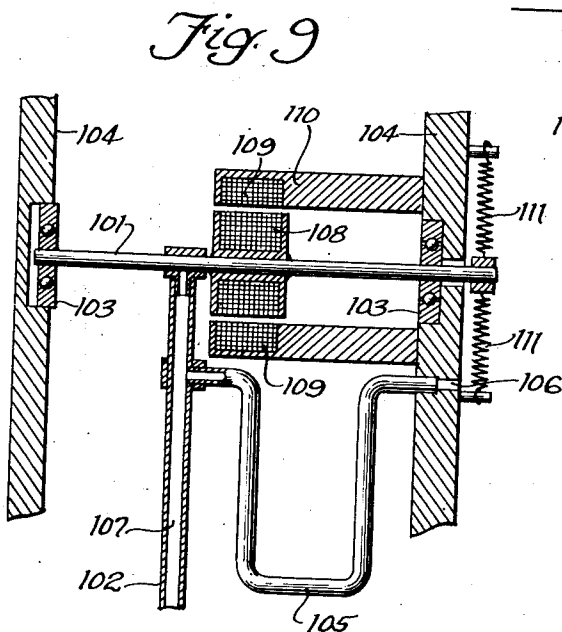
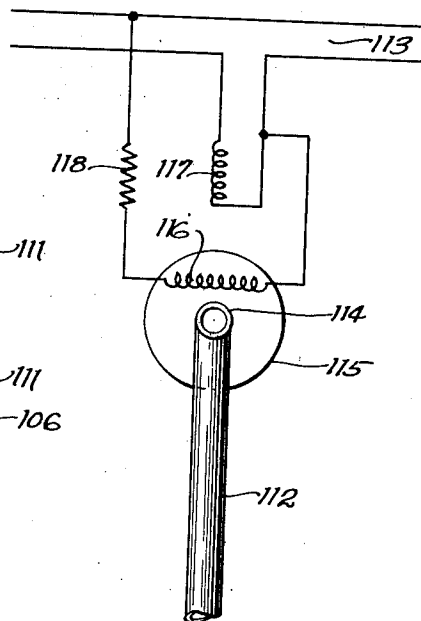


INVENTOR.
Herbert Ziebolz
BY *James B. Coyle*
Att'y

Filed Oct. 14, 1950

2,699,356

3 Sheets-Sheet 3



INVENTOR.
Herbert Ziebolz
BY *James A. [unclear]*
Attys

1

2,699,356

JET PIPE SIGNAL DEVICE

Herbert Ziebolz, Chicago, Ill., assignor to Askania Regulator Company, Chicago, Ill., a corporation of Illinois

Application October 14, 1950, Serial No. 190,129

8 Claims. (Cl. 299—73)

The present invention relates to jet pipe regulators, that is to say, relay regulators of a type including a jet pipe having an orifice for discharging a stream of fluid under pressure toward a receiver port and being mounted for swinging about a fixed pivot axis for selection of degree of registration of its discharge orifice with such receiver port. The position of the jet pipe is determined by magnitude of a signal that is applied to it to deflect it from a preselected neutral position, and the pressure within the receiver port developed by fluid entering the port thereby is rendered proportional to the signal magnitude.

One aspect of the present invention relates to improvements in means for developing force signals and applying them to the movable assembly of a jet pipe regulator for positioning the jet pipe in accordance with magnitude of an electrical condition, as voltage, current or power, that constitutes a primary input signal to the regulator. Heretofore such signals have been applied to a jet pipe as forces or movements applied in directions extended along a chord of the travel path of the discharge orifice about the pivot axis. This mode of signal application has involved development of the force signal by a conventional device for converting the primary electrical condition to a mechanical force or movement, translating the output of such device to exert it in a direction extended along the chord of the arcuate path of swinging of the jet pipe discharge orifice, and transporting the force through an axially movable thrust link for delivery to the jet pipe. According to the present invention, a signal force is developed from the electrical primary signal and applied directly to the movable assembly of the regulator as a torque exerted about the preselected pivot axis of jet pipe swinging.

A second aspect of the invention relates to suspending a swinging jet pipe and rotative element of such a signal device.

A primary object of the invention is the provision of a novel arrangement for applying a signal to the movable assembly of a jet pipe regulator.

Another object is the provision of a novel combination of jet pipe regulator and an electromotive signal device for positioning the jet pipe in accordance with magnitude of an electrical condition energizing such device.

Still another object is the provision in a jet pipe regulator of novel signal and zeroing bias means.

An additional object is the provision of a swinging jet pipe assembly with novel, cooperative signal and suspension means.

A further object is the provision of a novel arrangement for translating an electrical signal to a mechanical signal and exerting it directly upon a movable jet pipe assembly as a torque exerted to swing the jet pipe of such assembly without necessity for translating or transporting such mechanical signal for application to the jet pipe.

In the accompanying drawings:

Fig. 1 is a schematic diagram disclosing a basic principle of the invention.

Fig. 2 is a horizontal section, looking upward, through a regulator assembly and showing the bottom plan of a regulator unit arranged in accordance with the invention.

Fig. 3 is a vertical longitudinal section on line 3—3 of Fig. 2.

Fig. 4 is a vertical longitudinal section similar to Fig. 3, showing a modified signal-applying device embodying the invention.

2

Fig. 5 is a similar longitudinal section showing a second modified form of signal-applying device embodying the invention, and also showing a modified jet pipe suspension device.

Fig. 6 is a transverse section on line 6—6 of Fig. 5.

Fig. 7 is a longitudinal section showing a different form of the invention.

Fig. 8 is an end elevation of the arrangement of Fig. 7.

Fig. 9 is a median longitudinal section disclosing application of the invention to a different type of jet pipe movable assembly.

Fig. 10 is a schematic diagram showing a highly specialized application of the invention.

Fig. 11 is an enlarged fragmentary view on a plane indicated by line 11—11 of Fig. 4, showing the top plan of the flexure support.

First describing and analyzing the basic principles and general mode of operation of the invention, and referring to Fig. 1, a jet pipe 15 is mounted on a support for swinging about a preselected and rigidly fixed pivot axis 17. The jet pipe has an internal passage 18 communicating with an orifice 19 in the jet pipe end for axial discharge of fluid toward a pair of receiver ports 20, 21 opening through a surface of a distributor structure 22 in closely spaced relation in the direction of swing of orifice 19 about axis 17. Heretofore, conventional practice has been to supply fluid through an internal passage in support member 16 by way of a floating swivel joint suspending one end of the latter, the second end of the member 16 being rotatably supported and fixed against lateral movement by a conventional bearing assembly. In accordance with the prior practice, signals have been applied to the jet pipe itself at a point between its orifice and the supporting element 16, to control degree of registration of orifice 19 with the respective receiver ports 20, 21. Usually a zero biasing spring has been connected with the jet pipe at a point directly opposite the point of signal application, to maintain the jet pipe in a preselected zero position in absence of a signal and to proportion degree of deflection of the jet pipe from such zero position to magnitude of a force applied to swing it from that position and constituting the signal. Application of signal and bias forces tend to deflect the movable jet pipe assembly from the preselected pivot axis. The problem of maintaining the actual pivot axis of jet pipe swinging in coincidence with the axis preselected to provide an orifice swing path properly located relative to the receiver ports is complicated by the characteristics of various types of suspension devices used to support the member 16 for rotative movement, and for supplying fluid to it from a fixed supply line. Bearing assemblies of relatively movable parts, and packed fluid-conducting swivel joints introduce unpredictable frictional resistance to jet pipe swinging, that usually appears as a tendency to interfere with accurate return of the jet pipe to its neutral position under the influence of the biasing system. Flexure type suspensions avoid friction effects but are subject to lateral distortion that permits the rotative jet pipe assembly to deflect laterally from the preselected pivot axis.

Problems of this nature are increasingly serious with increasing magnitudes of signal forces and the accompanying increased bias force magnitude ranges, since lateral deflection effects of such forces increase with force magnitudes, and heavier suspension devices capable of resisting them introduce greater friction effects. Satisfactory performance has been accomplished by making use of delicate suspension devices and fluid-supplying swivel connections capable of maintaining the jet pipe supporting element, as 16, centered upon the preselected pivot axis against signal and bias forces of relatively small magnitudes, and in restricting such forces to magnitudes within the resistance capacities of such devices.

Returning to Fig. 1, an electrical signal device 23 may be of conventional form to produce a voltage or current output. The arrangement of the invention for applying such output to deflect jet pipe 15 from a preselected zero position to a degree proportional to magnitude of such output, comprises an electromotive assembly including an armature 24 mounted on and secured to the

3
jet pipe support 16, a stator 25 and an energizing circuit 26 that translates the electrical signal output of source 23 into a torque of proportional magnitude exerted between stator 25 and armature 24 to swing jet pipe 15 a proportional degree from its zero position. The electromotive assembly 24, 25, 26 also may discriminate between opposite senses of electrical signal and swing the jet pipe in corresponding ones of two opposite directions.

Figs. 2 to 9 disclose practical physical arrangements of the system of Fig. 1. As shown by Figs. 2 and 3, the jet pipe regulator may be enclosed in a main housing structure 30 including a wall 31 through which extends a passage 32 for supplying fluid under pressure to the regulator. The signal-applying electromotive assembly 33 of a stator disposed concentrically about the pivot axis about which a jet pipe 34 is to swing and about which is concentrically disposed a tubular jet pipe-supporting element 35, which also is to supply fluid to the jet pipe. The stator includes a casing 36 mounted on housing wall 31 and projecting therefrom surrounding tubular element 35, and enclosing and supporting a field winding system 37. The rotor 38, which constitutes the armature of the electromotive assembly, is mounted on and secured to the tubular element 35. Preferably the rotor 38 is secured to tubular element 35 only at its end 39 that is more remote from supporting wall 31, and the rotor throughout its length is spaced from the outer surface of tubular element 35 to provide a clearance 40. A bearing assembly 41 advantageously is interposed between rotor 38 tubular element 35 at the end of the former that is more adjacent wall 31.

While various arrangements for suspending tubular element 35 may be employed to permit swinging of the jet pipe and for biasing the latter to a zero position, arrangements such as those disclosed in my copending application for United States patent, Serial No. 190,130, filed October 14, 1950, are preferred, and herein disclosed. In Fig. 3 such an arrangement, which is peculiarly advantageous when used with the signal devices herein disclosed, comprises one wherein the tubular jet pipe-supporting element itself acts as a biasing device as well as one for supporting and supplying fluid to the jet pipe. The tubular element, between its point of attachment to wall 31 and the point of attachment to it of the armature or rotor 38, acts as a torque tube, the wall of the element at the latter point being circumferentially rotatable by torque exerted upon it and developed between the rotor and stator, and the tubular element wall between that point and the wall-attached element end being circumferentially distortable by such rotative movement, and resilience of the tubular element wall enables it to act as a biasing device. This type of arrangement is accomplished by rigidly securing the inlet end 42 of tubular element 35 to housing wall 31 in surrounding relation to the outlet of supply passage 32, and spacing the point of attachment 39 of rotor 38 to element 35 from wall 31 to provide a reach of element 35 long enough to act in the torque tube fashion described. Jet pipe 34 is secured to tubular element 35 to the opposite side of the rotor from wall 31, and preferably the second end 43 of element 35 is free to rotate with the rotor so that the angular position of the jet pipe exactly corresponds with that of the rotor.

Various types of electromotive assemblies may be associated with a jet pipe regulator in the general type of arrangement of which Fig. 3 discloses an example. Thus in Fig. 4, wherein the tubular element 45 that supports jet pipe 46 again has its first end 47 rigidly secured to a supporting wall 48 surrounding the outlet of a supply passage 49, the electromotive assembly comprises a two phase induction motor 50. This motor comprises an eddy current disk 51 secured to tubular element 45, and field windings 52, 53 adapted to cooperate with disk 51 to exert torque thereon when energized by currents having a quadrature phase relation. Windings 52, 53 are supported by a housing 54 that in turn is secured to supporting wall 48.

In Figs. 5 and 6 the tubular element 55 that supports jet pipe 56 again has its first end 57 secured to a supporting wall 58 surrounding the outlet of a supply passage 59 that wall 58 encloses. The electromotive assembly disclosed by these figures comprises a pair of magnetically permeable armatures 60 that are supported on

and in radially spaced relation to tubular element 55 by a radial arm 61. These armatures are respectively associated with a pair of solenoid coils 62 secured to a housing 63 that in turn is supported on wall 58.

In assemblies of the general type disclosed by Figs. 3 to 6, with the tubular element that supports and supplies fluid to the jet pipe rigidly attached at one of its ends to serve as a torque tube biasing device, it is desirable that suspension means be provided at the second end of the tubular element to insure maintenance of the axis of the tubular element in coincidence with the preselected axis of pivotal movement of the jet pipe. Since the rigid attachment of the first end of the tubular element to the supporting wall tends to maintain this coincidence, selection of the particular suspension means at the second end may be made with the object of a desirable characteristic of resistance to rotative movement of the jet pipe-supporting element end, rather than with the object of a rigid support of the element end against lateral deflection. Consequently, a highly torque-sensitive bearing assembly of relatively movable parts may be used, or a flexure type of suspension may be used. The latter type of suspension device comprises an arrangement including a member that is distortable by relative movement of the elements that it connects, rather than an assembly of relatively movable parts of conventional rotary bearing type.

In Fig. 3 the suspension device for the second end 43 of tubular element 35 is shown as a conventional ball bearing assembly 65 mounted in an end structure 66 that caps housing 36. A stub spindle 67 projecting from a plug body 68 that stops the bore of tubular element 35 adjacent the second end 43 of the latter is engaged in bearing assembly 65.

A typical flexure suspension device 70 is disclosed in Figs. 4 to 6 and 11 as supporting the second ends 71 of the tubular jet pipe-supporting elements 45, 55 of the respective assemblies.

This device comprises a supporting member 72 projecting inward from the end wall structure 73 to one side of the preselected axis of jet pipe swinging and having surfaces 74 that are disposed along planes that cross at the pivot axis. To these surfaces are secured ends of resilient strips 75 that cross at the pivot axis and have their free ends attached to surfaces 76 of a cradle structure 77 that are angularly related as are the support element surfaces 74. The end 71 of the tubular element, 45 in Fig. 4 and 55 in Figs. 5 and 6, is supported in the cradle structure 77. When the reach of the tubular jet pipe-supporting element to which the electromotive armature is attached is rotated to swing the jet pipe, the second tubular element end 71 is permitted to rotate by flexing of resilient strips 75.

Obviously, use of an electromotive system with a torque-developing armature secured to the swingable jet pipe assembly in concentric relation to the axis of pivotal movement of the latter is not limited to assemblies of the torque tube type of suspension of Figs. 3 to 6. In Fig. 7 the movable jet pipe assembly is suspended and supplied in accordance with an arrangement described and claimed in my co-pending application for United States patent, Serial No. 134,483, filed December 22, 1949, now Patent No. 2,633,385, dated March 31, 1953. In this arrangement the tubular spindle element 80 that supports jet pipe 81 is suspended at each of its ends 82, 83 by a ball bearing assembly 84 that cooperates with a stub spindle 85 projecting from a plug 86 in the internal bore of element 80, the bearing assemblies being suitably mounted in housing structural wall parts 87, 88. The end reach of tubular element 80 adjacent its first end 82 is arranged within a bore 89 in housing part 87, which bore is sufficiently larger than element 80 to provide a very small clearance between the opposed surfaces of the housing structure and element, shown in greatly exaggerated form at 90. A chamber 91 surrounds a part of tubular element 80 within housing structure 87 and opens into bore 89, and a supply passage 92 also enclosed by housing structure 87 communicates with chamber 91.

In registration with chamber 91 for entry of fluid to its interior therefrom, the wall of element 80 is provided with ports 93. The narrow clearance 90 affords freedom of frictional resistance to rotative movement of element 80, but its narrowness affords sufficient resistance to fluid flow to prevent substantial loss of fluid or pressure drop.

In the arrangement of Fig. 7, the armature of the

5

electromotive system is shown as a rotor 94 secured to tubular element 80. Since the latter is suspended by bearing assemblies for free rotation of both of its ends 82, 83, rotor 94 may be secured to it along the entire length of the rotor. A system of field windings 95 is mounted in a casing 96 for torque-developing cooperation with the rotor when electrically energized.

Since the jet pipe assembly of Fig. 7 is freely rotatable as so far described, it is advantageous to provide a zeroing bias system, and furthermore, it is preferable to arrange such bias system to exert a minimum tendency to disturb the axial position of tubular element 89. Such a bias system is shown in Figs. 7 and 8 as comprising a lever arm 98 secured to one stub spindle 85, preferably at the outer side of the bearing assembly 84 that supports that spindle, and shown as being on the outer side of housing structural part 88. A system of zeroing springs 99, having opposite ends fixed respectively to a housing end structure 100 and lever 98, is arranged to bias lever 98, tubular element 80 and jet pipe 81 rotatively toward a preselected zero position of the latter. Still another system is shown by Fig. 9. This system also is fully disclosed and claimed by the above-identified application, Serial No. 190,130. In this arrangement the element 101 that supports jet pipe 102 is a solid spindle rotatably supported at each of its ends by a conventional bearing assembly 103 secured in a supporting wall 104. A resiliently flexible U-shaped supply tube 105 has one of its ends secured to one wall 104 in surrounding relation to the outlet of a supply passage 106 enclosed by that wall, the other end of tube 105 being rigidly secured to jet pipe 102 between the ends of the latter, and with its internal passage 107 connected with supply passage 106 through the interior of the tube 105.

A rotor 108 is secured to spindle 101, and a system of field windings 109 is suitably supported, as by structure 110, for cooperation with rotor 108 to exert torque on the latter when the electromotive system is energized electrically.

In this arrangement, when the electromotive system 108, 109 is energized to develop torque exerted on spindle 101, and jet pipe 102 is thereby swung about the pivot axis of the spindle as fixed by bearing assemblies 103, flexible supply tube 105 is distorted to accommodate the jet pipe movement. A zeroing bias system of springs 111, similar to that of Figs. 7 and 8, may be employed.

Fig. 10 discloses a specialized system for positioning a jet pipe 112 in accordance with the true power of an alternating current load circuit 113. The swingable jet pipe-supporting element 114 may be arranged in accordance with any of the foregoing disclosures, the electromotive system being specially arranged to proportion the torque that it develops to the true power, that is to say, current, voltage and power factor, of circuit 113. This electromotive system comprises a wattmeter torque motor arrangement of a rotor 115, secured to support element 114, and carrying a system of windings 116 that is energizable by conduction of current from an external source, and a stator having a field winding system 117 that also is energizable by current from an external source. The windings of systems 116, 117 are so arranged, and rotor 115 is biased to such a position relative to field windings 117, that torque exerted upon rotor 115 is a function of amplitudes of currents respectively energizing them and of departure of such currents from a predetermined, maximum torque-producing phase relationship, typically phase agreement. One winding system, shown as the stator system 117, is connected in series in load circuit 113 to act as a current winding. The other winding system, here rotor system 116, is connected across circuit 113 in series with a resistance 118, to act as a voltage winding. The functions of resistance 118 are to limit amplitude of current energizing winding system 116 and proportion it to amplitude of the load circuit voltage, and also to properly phase such current relative to the load circuit voltage by making the rotor winding system 116 primarily resistive. By this arrangement, the torque exerted upon jet pipe-supporting spindle 114 by rotor 115 is proportioned to true power of circuit 113. Degree of deflection of element 114 and jet pipe 112 from a preselected zero position is proportioned to magnitude of such circuit power and torque by any of the bias systems disclosed above, or by any equivalent system.

6

It will be seen from the foregoing that the invention is extremely flexible as to particular arrangements that may be adopted for practicing it. Consequently it is to be understood that the scope of the invention is to be determined by the claims rather than by the foregoing specific exemplary disclosures.

I claim:

1. A jet pipe regulator comprising a supporting structure including a first portion enclosing a fluid supply passage having an outlet that opens through a surface of said structure, a supply tube having one of its ends supported by said structure and having at said end an inlet arranged for receiving fluid supplied by said passage, said tube having axially spaced from said end a reach that is circumferentially rotatable about its axis, a jet pipe supported by said reach and radially projecting therefrom for axial discharge of fluid supplied through said tube from said passage, said supporting structure including a second portion extended alongside the supply tube and a third portion positioned adjacent the second end of said tube, means secured to said third portion and supporting said second supply tube end, and an electric motor assembly including an armature secured to said tube reach in concentric surrounding relation thereto, a stator mounted on said second supporting structure portion, and electrically energizable means associated with said stator and rotor for exerting on the latter a rotative torque when electrically energized.

2. A jet pipe regulator in accordance with claim 1, wherein said suspension means suspends said second supply tube end for rotation with said supply tube reach.

3. A jet pipe assembly in accordance with claim 1, wherein said suspension means comprises a bearing assembly disposed to maintain said tube reach and rotor centered on a preselected pivot axis about which the jet pipe is to swing.

4. A jet pipe regulator in accordance with claim 1, wherein said supporting structure comprises a housing of which said second portion comprises a sidewall structure extended axially of and surrounding said supply tube, and of which said first and third portions comprise end walls closing the respective ends of said housing.

5. A jet pipe regulator in accordance with claim 1, wherein said first supply tube end is rigidly secured to said first supporting structure portion, and said supply tube is circumferentially distortable between its said first end and said reach by torque exerted on the latter by said motor means.

6. A jet pipe regulator in accordance with claim 1, wherein said first supply tube end is rigidly secured to said first supporting structure portion, said supply tube is circumferentially distortable between its first said end and said reach by torque exerted on the latter by said motor, and said suspension means supports said second tube end for rotative movement with said reach and rotor.

7. A jet pipe regulator in accordance with claim 1, wherein said first supply tube end is rigidly fixed to said first supporting structure portion, and said supply tube is resilient and circumferentially distortable between its said first end and said reach, said supply tube is rotatively positioned to bias said reach and jet pipe to a preselected zero position, and resilience of said supply tube constitutes the sole bias means of the regulator.

8. A jet pipe regulator in accordance with claim 1, wherein said rotor is disposed between said first tube end and said jet pipe.

References Cited in the file of this patent

UNITED STATES PATENTS

1,431,627	Bristol	Oct. 10, 1922
2,047,922	Seligmann	July 14, 1936
2,104,627	Von Manteuffel	Jan. 4, 1938
2,125,983	Bettison	Aug. 9, 1938
2,205,228	Smith	June 18, 1940
2,341,652	Rey	Feb. 15, 1944
2,384,515	Wise	Sept. 11, 1945
2,451,263	Webb	Oct. 12, 1948
2,518,574	Skopeczek	Aug. 15, 1950
2,606,093	Reason	Aug. 5, 1952