Jan. 3, 1956 S. E. WESTMAN 2,729,751

REGULATING APPARATUS FOR PRIME MOVER DYNAMO PLANTS

Filed June 16, 1951

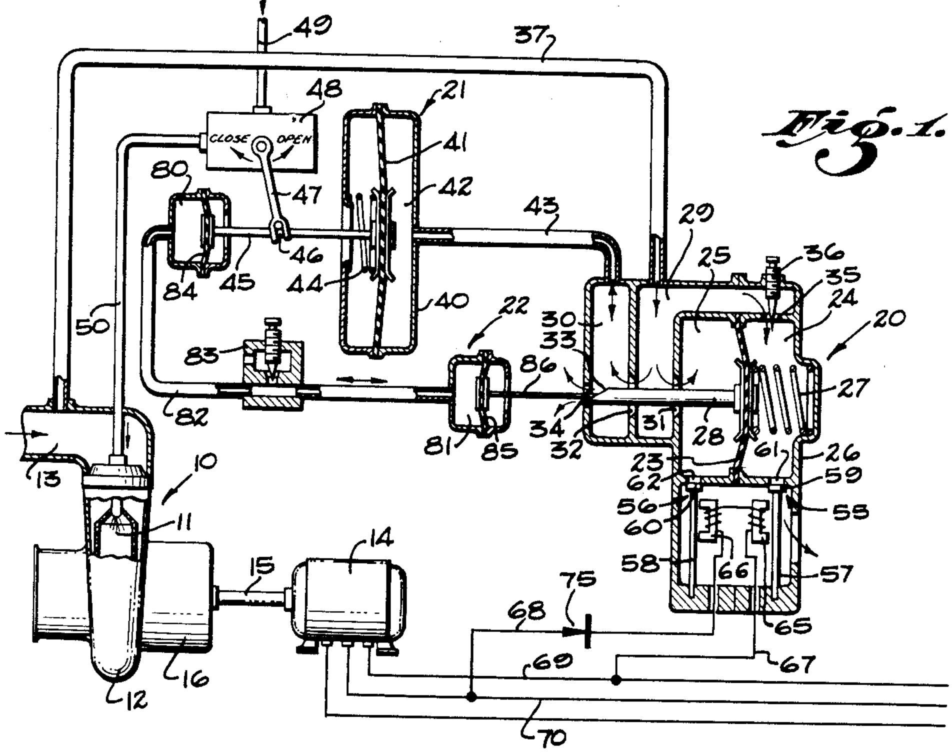

Fig. 1.

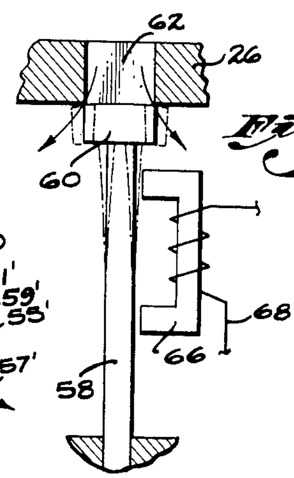

Fig. 2.

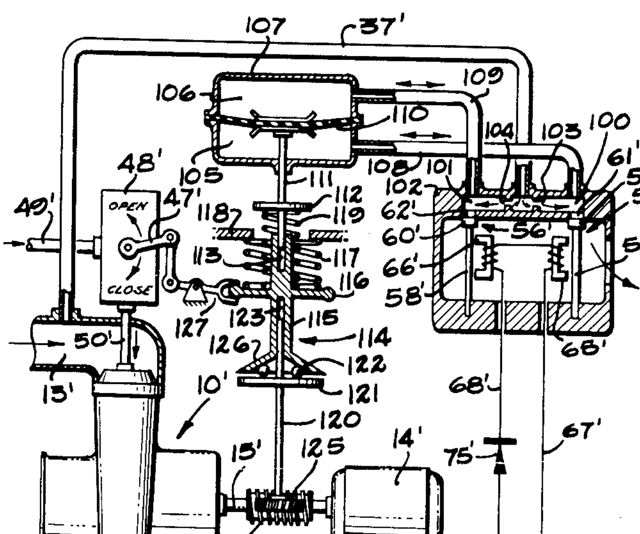

Fig. 3.

SYDNEY E. WESTMAN,
INVENTOR.

BY John H. T. Wallace

United States Patent Office

2,729,751

Patented Jan. 3, 1956

1

2,729,751

REGULATING APPARATUS FOR PRIME MOVER DYNAMO PLANTS

Sydney E. Westman, Inglewood, Calif., assignor to The Garrett Corporation, Los Angeles, Calif., a corporation of California

Application June 16, 1951, Serial No. 232,015

7 Claims. (Cl. 290—40)

This invention relates to a regulating apparatus and more particularly to an apparatus for regulating the speed of a prime mover in response to changes in the output frequency of an alternator driven by the prime mover.

Heretofore, devices proposed for engine regulations have involved complex electrical frequency discriminators followed by some form of electro-mechanical transducer. With these devices, it was difficult to obtain a large power output, unless components of considerable size and weight were used, often involving servo-mechanisms or other power amplifying devices of considerable complexity. These weight, size and complexity factors are of primary importance when the regulator is to be installed in a limited space or where, as in aircraft, large size or weight would prohibit the use of such devices.

Accordingly, it is one object of the present invention to provide a novel regulating mechanism embodying mechanical means responsive to a driven alternator output frequency, for regulating the speed of a prime mover utilized to drive the alternator.

Another object of the invention is to provide a novel electro-mechanical regulating apparatus of light weight, compact and efficient design.

Another object of the invention is to provide a novel fluid operated positioning mechanism.

A further object of the present invention is to provide a novel flow control valve mechanism.

A further object of the invention is to provide a novel fluid operated control system for a prime mover, sensitive in operation and rapid in response to prime mover speed changes.

A still further object of the invention is to provide a novel regulating device for a prime mover, having a follow-up and reset mechanism to correct for droop in the speed of the prime mover.

Another object of the invention is to provide a novel trimmer for a mechanical governor on a prime mover, the trimmer utilizing the apparatus of this invention and being responsive to the output frequency of an alternator driven by the prime mover.

Other important objects of the invention will become apparent from the disclosure in the following specification and appended claims, taken in connection with the accompanying drawing, which is for illustrative purposes only, and wherein like reference numerals indicate like parts:

Fig. 1 is a schematic representation of one embodiment of the regulating apparatus of the present invention;

Fig. 2 is an enlarged fragmentary schematic view of one of the flow control valves; and

Fig. 3 is a schematic view of a modified system embodying the features of the invention.

Referring primarily to Fig. 1, the regulating apparatus of this invention is shown in connection with a prime mover **10**. The prime mover is shown as being a gas turbine having a combustion chamber **11** within a suitable scroll **12**, and a compressed air intake duct **13** through which compressed air is adapted to be delivered from

2

any suitable source. The turbine is adapted to drive an alternator **14** by means of a shaft **15** through suitable gearing (not shown) within a gear box **16**. It is to be understood that the device of this invention is adapted for use with various types of prime movers, the turbine **10** merely being illustrative of one form of prime mover.

The regulating apparatus comprises generally a primary control mechanism **20**, a servo-motor unit **21** and a follow-up and reset device **22**.

The primary control mechanism **20** is provided with a diaphragm **23** positioned to define a movable wall between a pair of chambers **24** and **25** within a housing **26**. The diaphragm is normally urged leftwardly, as seen in Fig. 1, by a compression spring **27** and has a pilot shaft **28** secured thereto and axially movable therewith. The shaft **28** passes through a pair of chambers **29** and **30** and orifices **31** and **32**, the orifice **31** interconnecting the chambers **25** and **29** and the orifice **32** interconnecting the chambers **29** and **30**. The end of the shaft **28** is provided with a pilot valve closure **33** adapted to slidably operate in an opening **34**, which opening establishes communication between the chamber **30** and atmosphere. An adjustable orifice **35** provides a connection between the right hand diaphragm chamber **24** and the chamber **29**, the area of which is variable in accordance with movement of a needle valve **36** threadedly engaging the housing **26**.

Control pressure is provided for the primary control through a conduit **37** which interconnects the turbine intake duct **13** and the chamber **29**. This control pressure may also be supplied from a source independent from the system illustrated. The control pressure is delivered from the chamber **29** through orifices **35** and **31** to each of the diaphragm chambers **24** and **25**, thus creating a balanced condition on each side of the diaphragm **23**. Pressure is also delivered through the orifice **32** and into chamber **30**.

The servo-motor unit **21** comprises a housing **40** which supports a power diaphragm **41**. The housing **40** provides a chamber **42** on the rightward side of the diaphragm **41**, into which control pressure is adapted to be delivered through a conduit **43** opening into the chamber **30**. A compression spring **44** normally urges the power diaphragm **41** rightwardly as seen in Fig. 1. A control rod **45** is secured to and axially movable with the diaphragm **41**. The rod **45** is provided with a pin **46** which is adapted to be engaged by a forked lever **47** operably connected to a power controlling mechanism **48**. This mechanism **48** may be in the form of a fuel flow valve to receive fuel through a conduit **49** and to deliver a controlled portion of the fuel to the turbine **10** through a conduit **50**, and the construction is such that leftward movement of the power diaphragm **41** will rock the lever **47** to decrease the fuel flow delivered through line **50**.

In order to effect operation of the system in response to turbine speed, the diaphragm chambers **24** and **25** are provided with bleed valves indicated generally at **55** and **56** to enable control pressure contained therein to be bled from these chambers. The valves **55** and **56** are substantially identical in operation, details of valve **56** being illustrated in Fig. 2, and they are provided with valve closure members which are in the form of tuned cantilever bars **57** and **58** adapted to resonate at predetermined frequencies. The bars **57** and **58** each have one of their ends secured against movement and are provided at their free ends with obturator heads **59** and **60**, which are positioned for lateral movement over bleed orifices **61** and **62** leading from the chambers **24** and **25**.

A pair of electromagnets **65** and **66** are positioned adjacent the bars **57** and **58** and connected in series by leads **67** and **68** to output leads **69** and **70** from the alternator **13**, whereby the output frequency of the alternator **13** will be transmitted to the electromagnets **65** and **66** to thereby cause resonance of one of the bars 57 or 58 as shown by the dotted lines in Fig. 2. This resonance will permit the control pressure in the chambers 24 and 25 to bleed to atmosphere past the heads 59 or 60 of the bars. The control mechanism described in the two immediately preceding paragraphs forms the subject matter of my divisional application, Serial No. 475,406, filed December 15, 1954, entitled "Regulating Apparatus."

To eliminate the alternate half-waves through electromagnets 65 and 66, and to thereby excite the bars 57 and 58, at the fundamental alternator frequency, a rectifier 75 is located in the lead 68. This rectifier is necessary only when, for mechanical reasons, bars resonating in the vicinity of fundamental frequency are preferable to bars resonating in the vicinity of twice alternator frequency. The amplitude of resonance permissible from the standpoint of stress is reduced when the bars are proportioned to resonate at higher frequencies. Hence, it has been found advantageous to resonate the bars in the region of 600 C. P. S., for example, rather than 1200 C. P. S. when the line frequency is 600 C. P. S.

The follow-up and reset mechanism 22 is composed of a pair of pressure diaphragm chambers 80 and 81 interconnected by means of a pressure transfer conduit 82, said conduit being provided with an adjustable leak orifice 83. Diaphragms 84 and 85 form movable walls within the chambers 80 and 81 respectively, diaphragm 84 being operably connected to the rod 45 and diaphragm 85 being operably connected to a reduced diameter extension 86 of the pilot shaft 28.

Assuming that it is desired to control the speed of the turbine and to maintain the output frequency of the alternator at 600 C. P. S., the bars 57 and 58 would be preset to resonate at frequencies slightly below and slightly above the frequency delivered thereto. In this instance, if a tolerance of plus or minus 30 C. P. S. were permissible in the output frequency of the alternator, the bar 57 would be tuned to resonate with maximum amplitude at 570 C. P. S. and bar 58 similarly tuned to resonate at 630 C. P. S. Bars tuned in this manner, for example, will hold the output frequency of the alternator within ½% and have reserve control power if the ½% is exceeded, such as when suddenly adding or dumping a large load. As the frequency delivered to the electromagnets 65 and 66 drops toward 570 C. P. S., the bar 57 will be caused to resonate with increasing amplitude as the 570 C. P. S. point is approached, opening the valve 55 and "bleeding down" the pressure in the rightward diaphragm chamber 24 to cause the diaphragm 23 to move rightwardly as shown in Fig. 1. This movement of the diaphragm 23 will move the pilot valve closure 33 rightwardly to permit fluid bleed from the chamber 30 through the opening 34 thus reducing the pressure in the servo diaphragm chamber 42 to cause the diaphragm 41 to move rightwardly and, through the rod 45 and lever 47, to open the valve 48 to permit additional fuel to be delivered to the turbine 10. The same motion of the diaphragm 41 is carried directly to the diaphragm 84 of the follow-up and reset mechanism 22 and is transmitted through conduit 82 to the diaphragm 85. This force is also applied through the extension 86 to the pilot valve closure 33 in a sense to oppose its original movement and tend to terminate or taper-off the power correction and thus avoid a sudden surge in the turbine and alternator speed. As the turbine and alternator return to the preselected speed, the regulator will be returned to its original position.

Should the turbine and alternator increase in speed until the frequency delivered to the electromagnets 65 and 66 approaches 630 C. P. S., the bar 58 will be caused to resonate with increasing amplitude and thus reduce the pressure in diaphragm chamber 25, close the valve closure 33, increase the pressure in chamber 30, move the diaphragm 41 leftwardly, and actuate the valve 48 toward closed position to decrease fuel flow to the turbine.

In Fig. 3 the regulating apparatus of the invention is shown as applied to a trimmer for a mechanical governor wherein like parts are indicated by primed reference numerals. Control pressure is delivered through a conduit 37′ to a pair of chambers 100 and 101 within a body 102 through suitable restricting orifices 103 and 104. The chambers 100 and 101 are pneumatically connected to diaphragm chambers 105 and 106 within a housing 107 by conduits 108 and 109. A flexible diaphragm 110 separates the chambers 105 and 106 and is connected to a shaft 111 having a flange 112. The shaft 111 is rotatably supported for axial movement in a bore 113 in a centrifugal governor 114.

The governor has a spindle 115 and a central flange 116 which supports one end of a main compression spring 117, the other end of which bears against a fixed surface 118, and a trimming compression spring 119, the other end of which engages the flange 112 on the shaft 111. The governor 114 further includes a downwardly extending driving shaft 120 provided with a ball retainer plate 121, integral with the shaft 120, and a plurality of fly-balls 122. The lower end of the spindle 115 has an axial bore 123 which receives the upper end of the driving shaft 120 which is driven by means of a governor driving gear 124 secured on the shaft 15′ and a governor gear 125 secured to the lower end of the shaft 120. The spindle 115 is also flared to form a conoidal cup 126 within which the fly-balls 122 are held by means of the retainer plate 121. Axial movement of the spindle 115 is adapted to actuate the lever 47′ for operation of the valve 48′, there being a connection 127 between the lever 47′ and the flange 116.

In operation, as the spindle 115 moves axially upwardly in response to an increase in speed of the turbine 10′ and the alternator 14′, the spindle 115 will find the point at which the forces acting thereon are in balance. That is, the centrifugal force of the fly-balls 122, transmitted through the cup 126, is opposed by the force of the main spring 117 plus the force of the trimming spring 119. The spindle 115 moves until this equilibrium is achieved.

With a fixed position of the trimming spring 119, the spindle 115 assumes a position unique with the rotary speed of the fly-balls 122. Since direct-connected governors, that is, governors in which the spindles directly actuate an engine throttle or equivalent, are satisfied by different speeds for different throttle positions, they operate with droop. This droop is objectionable in some circumstances, therefore the alternator output frequency responsive apparatus of the invention may be employed to reset the governor to the same speed after a load change. Accordingly, changes in the output frequency of the alternator 14′, transmitted through leads 69′, 70′, 67′, and 68′, to electromagnets 65′ and 66′, will cause one of the bars 57′ or 58′ to resonate. For example, should the turbine 10′ decrease in speed, the bar 57′ will resonate, permitting fluid flow from the chamber 100 and through conduit 108, reduce the control pressure in diaphragm chamber 105, thus allowing the diaphragm 110 to move as indicated in Fig. 3. This movement of the diaphragm 110 will result in additional compression being applied to the trimming spring 119 assisting in the movement of the spindle 115 and the actuation of the throttle 48′.

Conversely, it may be seen that as the speed of the turbine and alternator increases, the bar 58′ will be caused to resonate permitting fluid bleed from the chamber 101 to move the diaphragm 110 upwardly. This movement will reduce the compression on the trimming spring 119 to reset the governor 114 to the original speed.

The device shown in Fig. 3 is particularly useful in connection with asychronous alternators, since in this case, the output frequency of the alternator is reset rather than the shaft speed. The slip frequency is therefore compensated along with speed changes due to normal governor droop.

Having thus described the invention and the present embodiments thereof, it is to be understood that many modifications may be resorted to in a manner limited only by a just interpretation of the following claims.

I claim:

1. A regulating apparatus for a prime mover including: an alternator driven by said prime mover, a control operable to vary the output of said prime mover, regulating means operably connected to said control, and tuned vibrating means responsive to the output frequency of said alternator for controlling the operation of said regulating means.

2. A regulating apparatus for a prime mover including: an alternator driven by said prime mover, a control operable to vary the output of said prime mover, fluid operated regulating means operably connected to said control, and tuned vibrating means responsive to the output frequency of said alternator for controlling the operation of said regulating means.

3. In regulating apparatus for a prime mover: a power controlling device operably connected to said prime mover; an alternator driven by said prime mover; a fluid operated servo mechanism adapted when actuated to operate said power controlling device; a source of fluid pressure; a valve body having a movable wall member defining a pair of chambers therein, each of said chambers being supplied with fluid pressure from said pressure source; means to supply fluid pressure to said servo mechanism; means operable by movement of said movable wall member to vary pressure delivered to said servo mechanism; valve ports in said valve body communicating with said chambers; resonant devices normally closing said ports and adapted to open said ports upon resonance; and means responsive to output frequencies of said alternator to cause vibration of said resonant devices.

4. A regulating apparatus for a prime mover including: a power controlling device operably connected to said prime mover; an alternator driven by said prime mover; a fluid operated servo mechanism adapted when actuated to operate said power controlling device; a source of fluid pressure; a valve body having a movable wall member defining a pair of chambers therein, each of said chambers being supplied with fluid pressure from said pressure source; means to supply fluid pressure to said servo mechanism; means operable by movement of said movable wall member to vary pressure delivered to said servo mechanism; valve ports in said valve body communicating with said chambers; resonant devices normally closing said ports and adapted to open said ports upon resonance of said devices; and means responsive to

output frequencies of said alternator above and below a control frequency to cause vibration of said resonant devices.

5. In a trimming mechanism for a prime mover governor, said prime mover driving an alternator: a resilient member for biasing the movement of said governor; and tuned vibrating means responsive to output frequencies of said alternator to move said resilient member.

6. In a trimming mechanism for a mechanical prime mover governor, said prime mover driving an alternator: a movable wall member defining a chamber on each side thereof; means operable by movement of said wall member for biasing the movement of said governor; a valve body having other chambers in fluid connection with said first mentioned chambers; means to supply fluid pressure to each of said first mentioned chambers and each of said last mentioned chambers; valve ports in said valve body communicating with said last mentioned chambers; resonant devices normally closing said ports and adapted to open said ports upon resonance of said devices; and means responsive to output frequencies of said alternator to cause vibration of said resonant devices to thereby reduce pressure in one pair of said first and last mentioned chambers to thereby actuate said trimming mechanism.

7. A regulating apparatus for a prime mover including: an alternator driven by said prime mover; a control operable to maintain operation of said prime mover at substantially constant speed; regulating means operably connected to said control; and tuned vibrating means responsive to the output frequency of said alternator for controlling the operation of said regulating means to thereby maintain the operation of said prime mover at substantially constant speed.

References Cited in the file of this patent

UNITED STATES PATENTS

1,448,409	Kindl	Mar. 13, 1923
1,505,853	Brainard	Aug. 19, 1924
1,783,157	Taylor	Nov. 25, 1930
1,869,134	Dietze	July 26, 1932
2,114,961	Gille	Apr. 19, 1938
2,269,072	Wilde et al.	Jan. 6, 1942
2,284,509	Boes et al.	May 26, 1942
2,408,472	Moynihan	Oct. 1, 1946
2,521,308	Porter	Sept. 5, 1950
2,522,389	Mason	Sept. 12, 1950
2,528,898	McIlvane	Nov. 7, 1950
2,558,729	Buechler	July 3, 1951