Aug. 11, 1931. W. T. TABB 1,818,826

SPEED RESPONSIVE CONTROL

Filed July 27, 1929 4 Sheets-Sheet 1

Fig. 1.

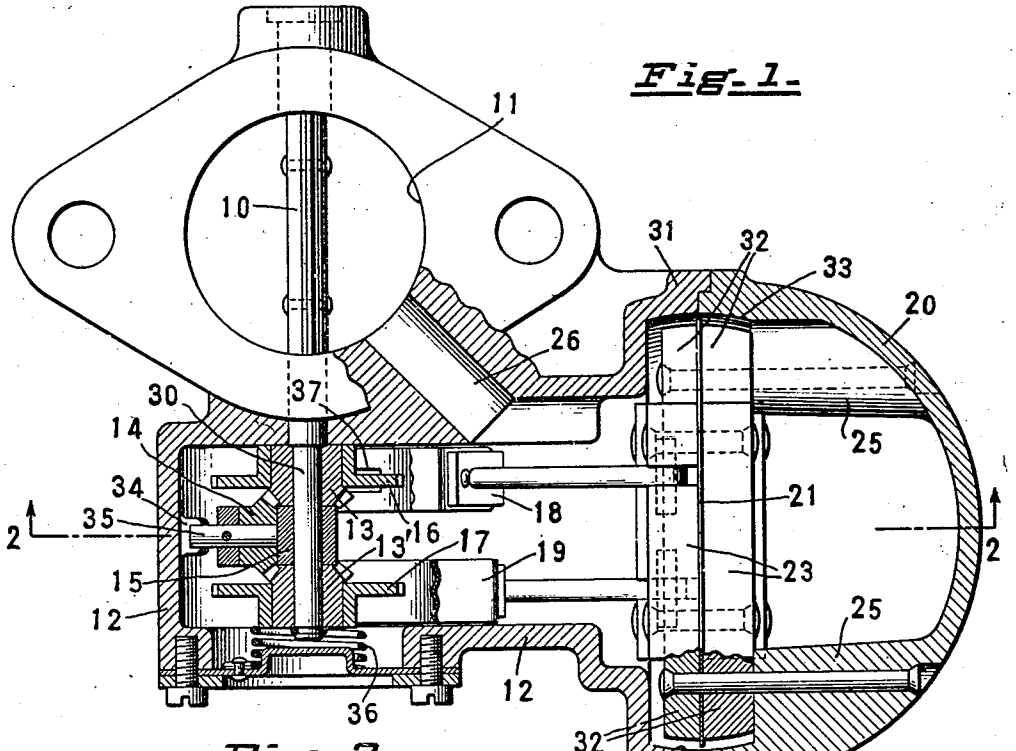
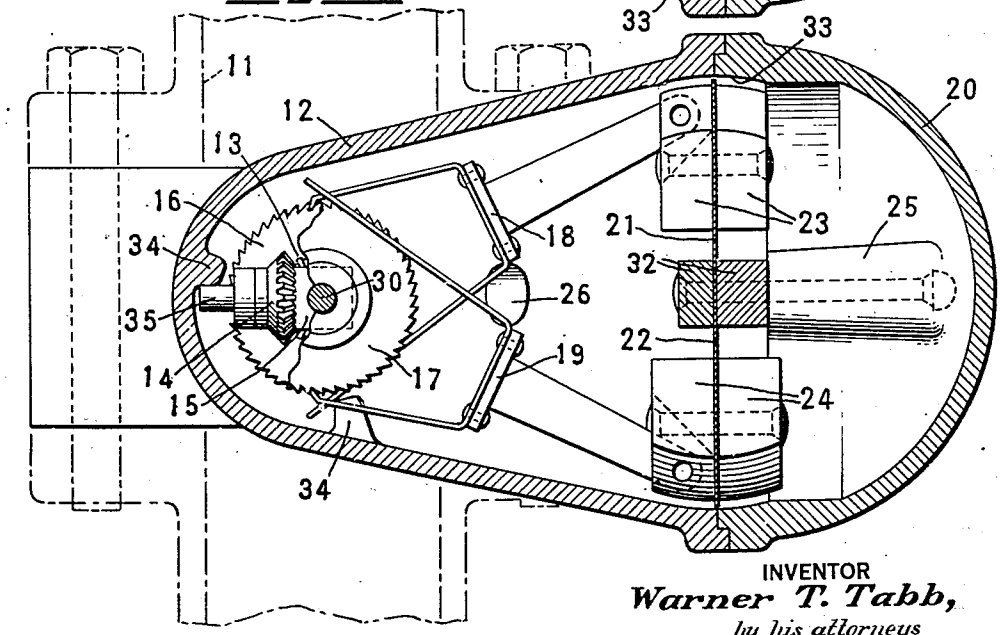


Fig. 2.



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SPEED RESPONSIVE CONTROL

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Fig. 3.

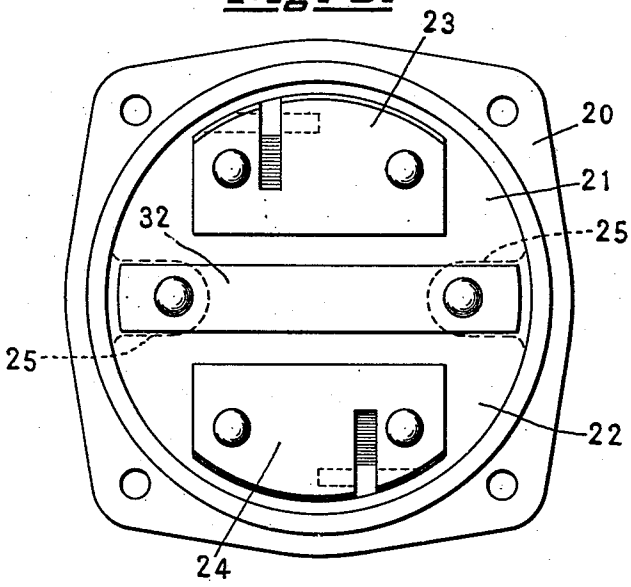
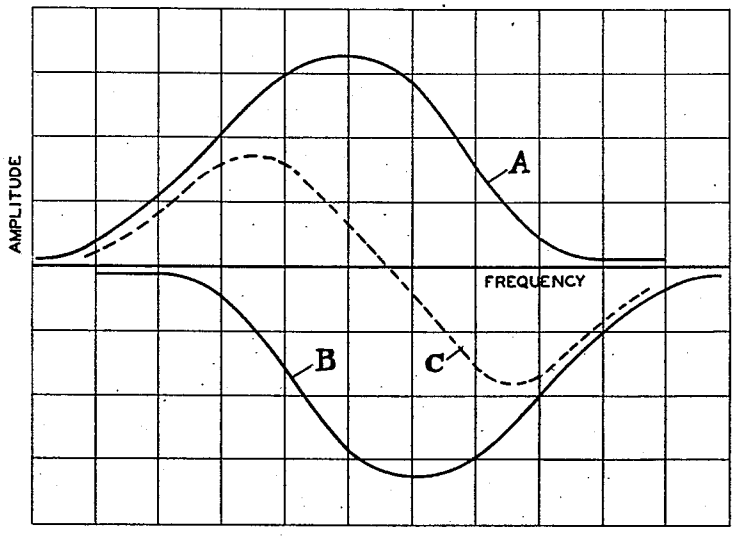


Fig. 4.



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SPEED RESPONSIVE CONTROL

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Fig. 5.

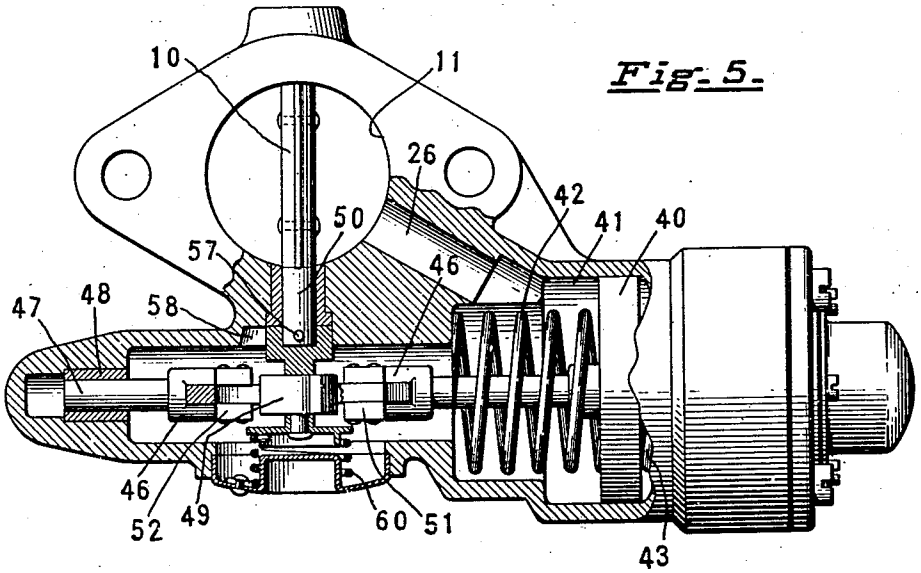
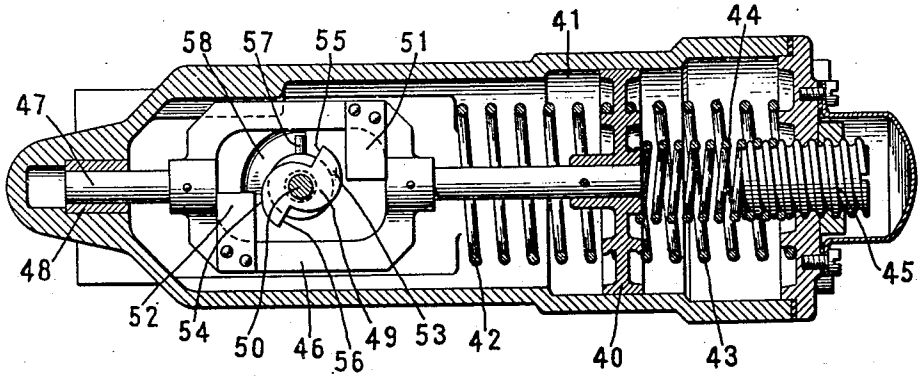


Fig. 6.



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Aug. 11, 1931. W. T. TABB 1,818,826

SPEED RESPONSIVE CONTROL

Filed July 27, 1929 4 Sheets-Sheet 4

Fig. 7.

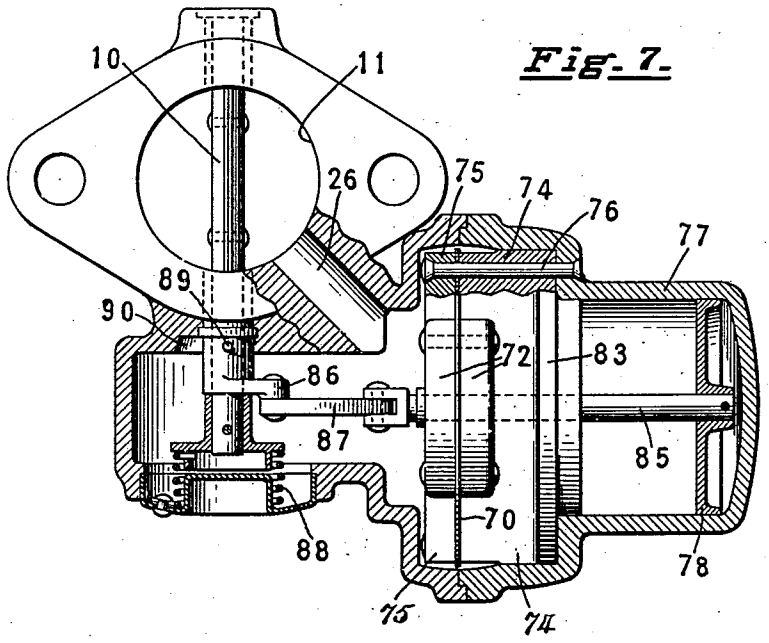
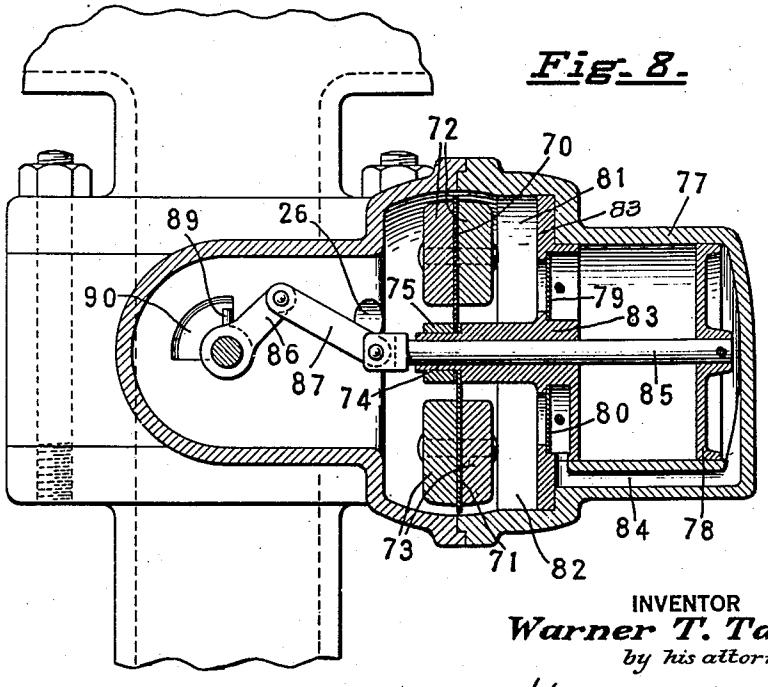


Fig. 8.



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Patented Aug. 11, 1931

1,818,826

UNITED STATES PATENT OFFICE

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SPEED-RESPONSIVE CONTROL

Application filed July 27, 1929. Serial No. 381,631.

This invention has to do with speed responsive devices. Its underlying thought is to utilize, as the source of energy for causing the performance of the function that is to respond to a certain speed, the vibration of an element which has a predetermined natural frequency and which is set in motion by the vibratory motion of another element whose frequency varies with the speed to which the device is to respond. The vibrator thus set in motion is caused to do work, by means of a suitable connection, either in controlling the supply of energy to the machine whose speed it responds to, as in the case of a governor, or in operating some separate instrumentality having a function which it is desired to relate to a certain speed or range of speeds of the said machine.

It will be apparent that the device may be put to various uses. As an illustration, chosen because it is the best known and because the invention was developed with reference particularly to this use, the invention is described herein as used to govern the speed of the machine to whose speed it responds and, in particular, as it is used to govern the speed of an internal combustion engine by utilizing the pulsations of the gas flow through the intake line of the engine to set in motion a vibratory element connected to operate a throttle valve in the said intake line. It is to be borne in mind however that the invention in its broader aspects has many other fields of application which are not to be deemed excluded by this description of the invention as applied to the problem of governing.

It is important to distinguish, at the outset, the form of the invention to be described here from the known "suction governor" which depends upon the mean effective value of the suction for operating the controlling valve and upon the variation of this value with the speed of the engine. Such variation is not a very close function of the speed variation since it depends upon the load and upon other factors to a very material degree. The governing thereby effected is not as accurate or as satisfactory generally as is demanded by many of the situations which give rise to the need for governing.

The primary object of the present invention therefore is to provide a speed responsive device, useful as a governor or otherwise, which shall be simple in construction and shall be reliable in its response to speed variation, being more nearly accurate in this response than known devices of comparable simplicity.

Several forms of governor adapted particularly for use with an internal combustion engine and embodying this invention are illustrated in the accompanying drawings and are described hereinafter with reference thereto.

In the drawings—

Figure 1 is a view, partly in section, through a unit consisting of a rotary valve, a vibrating element and a ratchet driven differential gear for translating the motion of the vibrating element into a motion of the valve.

Figure 2 is a view in section on the line 2—2 of Figure 1 but with the vibrating element shown in elevation and with the outer ratchet partly broken away to show the planetary gear and the inner ratchet.

Figure 3 is a view looking into the end cover at the right of Figures 1 and 2 and showing the vibrating element in elevation.

Figure 4 is a plot of amplitude of the vibrating element against engine speed showing a characteristic action of a governor of the type shown in Figures 1, 2 and 3.

Figure 5 is a view, partly in section, of a similar governor unit having a modified form of device for operating the valve from the vibrating element.

Figure 6 is a sectional view of the same modified unit, the view being taken in a plane at right angles to that of Figure 5.

Figure 7 is a view, partly in section, of a like unit with still another device for actuating the valve from the vibrating element.

Figure 8 is a sectional view of the same unit in a plane at right angles to that of Figure 7.

In the form of governor shown in Figures

1 and 2, the governor valve 10 is mounted between the carburetor and the manifold in the intake line 11 of an internal combustion engine which may be assumed to be of the four cycle type in which each cylinder exerts a suction effort in the intake once for every two revolutions. The valve has a permissive movement of 90° between open and closed positions, being turned by a spindle 30 extending outside of the intake line and into the governor casing 12 where it carries a ratchet actuated differential gear drive mechanism for turning it in either direction. This mechanism consists of two bevel gears 13, 13', free to turn on the valve spindle and in mesh with a planetary bevel gear 14 carried by a stud 35 on a frame 15 that is mounted to turn bodily with the valve spindle. These gears have oppositely acting ratchet wheels 16, 17 secured to them, by means of which they are turned as the ratchets are actuated by their respective pawls 18, 19. The two lugs 34 spaced 90° lie in the path of the stud 35 and thus limit the turning of the valve.

The vibrating element is mounted in a hemispherical casing 20 which rests against the bell end 31 of the casing for the valve actuating mechanism just described. This element is in two parts, each part being a semi-circular piece of thin resilient metal 21, 22 having a weight 23, 24 fastened to it on each side near the periphery. These semi-circular pieces may be integral or separate but in either case they are clamped in the mid area of the element by diametral members 32, but otherwise are free. The curved edge of each semi-circular disc just clears the wall of the casing which is formed as a true hemisphere in the region 33 of the vibrating element in order to provide a substantially constant clearance for all positions of the vibrating element. The diametral clamping members 32 are supported from the casing by webs 25 and are held together by bolts.

The pawl 18 for the ratchet 16 is connected to the weight 23 by a free pivotal joint, the end of the pawl engaging a pin extending across a slot in one of the weights 23, and the pawl 19 acting on the ratchet 17 is similarly connected to the weight 24,, the pawls being also supported by their engagement with the ratchet wheels. The pawls are two pronged, one prong of each being bent inwardly to engage between adjacent teeth of the ratchet wheel and to push forward while the other prong is slotted and the slot 37 rests over the opposite side of the wheel so as to pull on the teeth of the backward stroke. In order to cause opposite rotation of the ratchets, the pushing prong of one pawl 18 engages its ratchet on the upper side and the slotted pulling pawl engages on the under side, while in the case of the other pawl 19, the pushing prong acts on the under side and the pulling pawl on the upper, the teeth of the two ratchets being oppositely directed. (See Figure 2.) Thus both pawls push on the ratchets when they swing toward them and pull on them when moving back, causing rotation of the two in opposite directions. The direction in which the valve stem turns depends upon the net effect of the two ratchets according to the known principle of such differential gears, since both ratchets act on the planetary gear 14 through their respective bevel gears and when one ratchet turns faster than the other it causes the planetary gear 14 to roll on the bevel gear of the slower ratchet and hence to carry the frame 15 and spindle around with it.

The chamber in which the vibrating element is mounted is in communication with the intake 11 on the engine side of the valve 10 by way of a passage 26 through the casing wall. By reason of this fact, the two vibrators making up the vibrating element are subjected to the influence of the pulsating gas, the frequency of whose vibrations or pulsations varies directly with the speed of the engine. There may be a coil spring 36 connected to the spindle and to the casing to stabilize the valve and to give it a normal bias toward open position but such a spring is not necessary. Such a spring may be used also to provide a means of adjusting the governing speed.

The two vibrators are so made that they have different natural periods of vibration. The period being a function both of the resiliency of the thin disc and of the weight, this difference is easily brought about and still is made capable of ready change by using identical pieces of resilient metal but with different movable weights on them. Further, the natural periods of these weight-spring combinations is of an order of magnitude corresponding to a frequency about equal to the frequency of the gas pulsations caused by the engine speed that is the desired maximum.

As the frequency of gas pulsations increases and approaches the natural frequency of the vibrators, it induces a vibratory motion thereof. The vibrating part of lower natural frequency is connected to the ratchet which tends to open the valve while the other is connected to the valve closing ratchet. When the speed is such that the vibrator of lower natural frequency attains its natural frequence and hence its maximum amplitude the other vibrator is vibrating with a shorter amplitude as it is not at its natural frequency, and thus the net effect of the two is to urge the valve toward and to maintain it in its open position. A higher speed, beyond that giving a pulsation frequency equal to that of the natural

frequency of the part of lower natural frequency, the amplitude of the said part decreases while that of the other vibrator continues to increase as it approaches its natural frequency. It finally dominates and then the net effect of the whole vibrating element is to close the valve.

This action is illustrated in Figure 4 which is a plot of the variation of amplitude with variation of the frequency of gas pulsation or, in other words, with the engine speed. The amplitudes are of the two vibrators as induced by the gas pulsations, the upper curve A being that of the vibrator of lower natural frequency while the inverted curve B represents the vibrator of higher natural frequency. The inversion is to represent the different directions in which the two elements act, one opening, the other closing the valve. The broken line curve C represents the net effect of the two or the effect of the two vibrating elements as a whole. By changing the weights and the spring discs, the curves may be made flat or sharp as desired, a heavier weight with a correspondingly stiff spring giving a sharper turning for any given natural frequency.

It will be understood from known physical laws that in addition to the curves shown, a plot of the amplitudes over a greater range of frequencies of the inducing vibrations would show other curves representing harmonics. These, however, are much weaker than the vibrations at the fundamental. The half tone of the opening part and the overtone of the closing part, of course, would give a desirable effect. In any event, with a properly designed element in which the strength of the springs is such as to prevent vibration of material amplitude at the harmonic without preventing substantial vibration at the fundamental, the net effect of the two parts at the harmonic is negligible. It is even possible to make the difference between the natural frequencies of the two vibrators such that the "half-tone" of the one of higher frequency comes while the other one is having a substantial amplitude at or near its fundamental and sufficient to overcome the "half-tone".

In place of the pawl and rachet drive connection with a planetary gear, for operating the valve from the vibrating element by converting the vibratory motion into cumulative motion in either direction, many other mechanisms may be used, either electrical or mechanical. A suitable mechanical modification is shown in Figures 5 and 6. The vibrating element is in the form of a piston-spring combination. A piston 40 is mounted in a cylinder 41 and is of slightly smaller diameter than the cylinder. The piston is held between two similar springs 42, 43 put under initial compression and bearing against opposite sides of the piston and opposite ends of the cylinder. Another spring 44 is attached to one side of the piston and rests at its other end on a threaded plug 45 which passes through the cylinder wall and whose threads have the same pitch as the turns of the spring so that it may be moved into and out of the coil to limit the effective length of the latter.

There is also in this modification a different mechanism for translating the vibration of the piston into uni-directional rotary motion of the valve spindle. This mechanism consists of a yoke 46 directly connected to the piston and provided with a stem 47 at its other end sliding in a bearing 48 in the casing. This yoke (mounted over the cam 49) which is fixed on the valve spindle 50 has bumpers 51, 52 preferably of hard fibre or some similar substance mounted at diagonally opposite corners in position to engage the cam faces 53, 54 alternately. These faces are portions of a curve which may be the involute of the circle of the valve stem. They extend for 180° each, ending in radial faces 55, 56. A pin 57 on the valve stem turns in a recess 58 which is a quarter segment of a circle and thus limits the movement of the spindle to 90°.

Since there is but a one-part vibrating element and a uni-directional motion translating device, the valve in this modification must be urged toward open position by a coil spring 60 attached to the outer end of the valve stem and to the casing wall. The valve therefore normally is in open position. It is possible, of course, to apply the thought of the previously described modifications by providing two cams and two oppositely acting piston-bumper sets of different natural periods, one acting to open the valve and the other to close it.

As the piston is given a vibration of substantial amplitude when the frequency of gas pulsation in the inlet, communicated through the passage 26, approaches the natural frequency of the piston-spring device, the bumpers act on the cam faces 53, 54 and by their cumulative effect cause the valve stem to turn until the valve is closed. The adjustable spring 44 permits the tuning or governing speed to be varied as its effect is to change the natural period of the vibrating element, of which this spring is a part, corresponding to the weighted resilient discs in the other form described above.

As still another variation illustrating the many possibilities that there are of varying the particular construction of the elements of this invention, there is shown in Figures 7 and 8 a governor in which the vibrating element is in two parts having semi-circular resilient discs 70, 71 of different stiffness and weights 72, 73 of equal

values, the result being two vibrators of different natural period of vibration. The discs are clamped on a diametral web 74 by a bar 75 held thereto by bolts 76. The vibratory motion is translated into rotary motion by a pneumatic motor made up of a cylinder 77 with a piston 78 slidable therein and check valves 79, 80 opening respectively from the diaphragm chambers 81, 82 to opposite sides of the piston. A partition 83 integral with the web 74 forms the valve head and separates the diaphragm chambers from the interior of the cylinder 77. A passage 84 leads from the discharge side of the valve 80 to the outer end of the cylinder while the valve 79 opens directly to the cylinder, thus giving separate outlets from the two diaphragm chambers to opposite sides of the piston 78. The piston is connected to the valve stem by a rod 85, extending through the web 74, and by a crank 86 and connecting rod 87. There is a stabilizing spring 88 on the end of the valve stem tending to hold the valve open and to hold the piston at the right hand end of the cylinder, but it is not necessary with the two-part double acting vibrating element. A pin 89 and quarter circle recess 90 limit the permissive turning of the valve.

As the two parts of the diaphragm are set in motion by the pulsations of the gas in the suction inlet as communicated to the diaphragm chambers 81, 82 by the passage 26, the vibrators discharge the gas through the valves 79, 80 and thus build up pressure on opposite sides of the piston. The vibrator 70, 72 of lower natural frequency causes the gas to be delivered past the valve 79 from the chamber 81 to the left hand side of the cylinder while the other vibrator delivers gas past the valve 80 to the channel 84 which leads to the other side of the piston.

As in the case of the form shown in Figures 1, 2 and 3, the vibrator of lower natural frequency exerts an effort tending to hold the valve open and dominates until the frequency of pulsation exceeds its natural frequency, whereupon its amplitude decreases and that of the other vibrator increases since the latter is being brought to its natural frequency. A point is reached at which the latter vibrator dominates by reason of greater amplitude and greater pumping effort and the result is a movement of the piston 78 to the left, turning the valve toward closed position. As the speed decreases upon throttling, the effect of this higher frequency vibrator decreases and the valve is again opened either part way or wholly. The governing continues in this way.

It will be evident that the type of vibrating element may be varied and that different expedients may be adopted to convert its vibratory motion into a cumulative motion suitable for a valve. There may be a two-part vibrating element acting to open the valve over one range of pulsation frequencies and to close it at another, or there may be a single vibrator with an opposing force such as that of a spring. For the element that induces the motion of the vibrators of predetermined natural frequency, other mediums than the intake manifold gas may be used, since any element whose frequency of vibration or pulsation varies with the engine speed may be availed of. Considering an internal combustion engine alone, there are the gas pulsations caused by the suction, exhaust, compression and fan, the hydraulic systems including both oil and water, and the electrical systems, all of which involve some vibration or pulsation that varies in frequency with the speed of the engine and therefore may supply the energy and periodic effect which induces and maintains the motion of the vibrators.

The motion of the vibrating element may be utilized in various ways to act on the valve or other device directly or to act on a pilot or relay mechanism as is a common thing in other controllers of valves, switches and the like.

The mechanisms described here are illustrative of the underlying principle and of simple, effective ways of putting it to use. It will be appreciated that there are many other forms, some of which involve complications such as phase differences between the maximum or minimum effort of the inducing medium and the position of the induced vibrator in its path. In some cases these phase differences may be utilized and in others they may be compensated for. Such forms present fields for the application of ordinary skill or of further inventive effort within the scope of the broad invention here disclosed. I wish to include therefor within the scope of protection given by a patent all such methods and mechanisms as come within the fair range of the following claims.

I claim—

1. A speed responsive device comprising a vibrating element having a predetermined natural period of vibration, means for subjecting said element to the influence of gas pulsating with a frequency varying with the speed under concern to induce sympathetic vibration of said element, and means for utilizing the motion and energy of said element when vibrating at and near its natural period to cause the performance of the speed responsive function.

2. A speed responsive device comprising a vibrating element having a predetermined natural period of vibration, means for subjecting said element to a vibration inducing influence having a frequency of vibration

varying with the speed under concern, and means for converting the motion of said vibratory element into cumulative motion.

3. A speed responsive device comprising a vibrating element having a predetermined natural period of vibration, means for subjecting said element to a vibration inducing influence having a frequency of vibration varying with the speed under concern, and means for utilizing the motion and energy of said element when vibrating at and near its natural period to cause the speed responsive function to be performed.

4. In combination with a prime mover, means for controlling the supply of energy thereto, a vibratory element having a predetermined natural period of vibration, means for subjecting said element to the influence of pulsations whose frequency varies with the speed of the prime mover to induce sympathetic vibration of said element, and means actuated by said element when vibrating for operating said controlling means.

5. The method of performing a function, in response to a part of the speed range of a mechanism, which comprises setting a primary medium in vibration with a frequency varying with the speed of the said mechanism, causing said medium to induce vibratory motion of an element having a natural period of vibration within that range of frequencies of said primary element which corresponds to said part of the speed range, and utilizing the motion and energy of said element when vibrating to cause the performance of the speed responsive function.

6. In a speed responsive governor, a valve and valve closing mechanism, a chamber with a vibrating element therein having a predetermined natural period of vibration, provision for utilizing the energy of said element when vibrating to operate said valve closing mechanism and means for subjecting said element to a vibration inducing influence having a period of vibration varying with the speed controlled by said valve.

7. In a speed responsive governor, a valve, a vibrating element having a predetermined period of vibration, means for subjecting said element to a vibration inducing influence of varying frequency, and provision for converting the vibratory motion of said element into cumulative motion effective to operate said valve.

8. In a speed responsive governor, a valve casing, a valve therein and valve operating means, a chamber and a vibrating element therein having a predetermined natural period of vibration, together with an inlet from the valve casing to said chamber and provision for utilizing the energy of said element when vibrating to operate the valve operating means.

9. In a speed responsive device, a vibrating element comprising a weighted spring, means for subjecting said element to a vibration inducing influence having a frequency varying with the speed under concern, and means for utilizing the energy of said element when vibrating to perform the speed responsive function.

10. In a speed responsive device, a vibrating element comprising a piece of resilient sheet metal and a weight carried thereby, means for subjecting said element to a vibration inducing influence having a frequency of vibration varying with the speed under concern, and means utilizing the energy of said vibrating element to perform the speed responsive function.

11. In a speed responsive device, a chamber having a wall portion conforming to a part of a sphere, a semi-circular piece of resilient metal mounted to vibrate with its curved edge free and close to said wall portion, a weight carried by said piece, means for subjecting said piece to a vibration inducing influence of varying period of vibration, and provision for utilizing the energy of said weighted metal piece when vibrating to cause the performance of the speed responsive function.

12. In a speed responsive device, two vibrating elements of different natural periods of vibration, mechanism for performing the function responding to the speed under concern, means for utilizing the energy of one element when vibrating to actuate said mechanism and for utilizing the energy of the other element when vibrating to restrain the performance of said function, the two elements being subjected to a vibration inducing influence having a frequency of vibration varying with the speed under concern.

13. In combination with a prime mover, a control for the supply of energy thereto, two vibrating elements of different natural periods of vibration subjected to a vibration inducing influence having a frequency of vibration varying with the speed of the prime mover, means utilizing the vibration of the element of higher natural period to cause said control to stop the supply of energy and means utilizing the vibration of element of lower natural period to cause the control to permit the supply of energy.

14. In a speed responsive governor, a valve, a chamber with two vibrating elements therein of different predetermined natural periods of vibration, means utilizing the energy of the element of higher natural period to close the valve and means utilizing the energy of the other element to open the valve, together with provision for subjecting said elements to a vibration inducing influence having a period of vibration varying with the speed controlled by the said valve.

15. A speed control device comprising an element tuned to vibrate at a predetermined frequency, means for directly subjecting said element to the influence of a gas pulsating with a frequency varying with the speed to cause said element to vibrate when its pulsations correspond to the frequency of said element, speed controlling means and means for utilizing the motion and energy of said element when vibrating to cause the operation of speed controlling means.

16. A speed control device comprising an element tuned to vibrate at a predetermined frequency, means to subject said element to a vibration inducing influence having a frequency of vibrations varying with the speed to be controlled, said influence being effective to cause said element to vibrate when its frequency of vibration corresponds to the vibration frequency of said element and ineffective at other frequencies of vibration, speed controlling means and means for using the motion and energy of said element when vibrating to control the operation of said speed controlling means.

17. A speed control device comprising an element tuned to vibrate at a predetermined frequency, means to subject said element to a vibration inducing influence having a frequency of vibration varying with the speed to be controlled to cause said element to vibrate when its frequency of vibration corresponds to the frequency of vibration of the element, speed controlling means and means for utilizing the motion and energy of said element when vibrating to cause the operation of said speed control means.

18. In a speed responsive governor a valve, a vibrating element tuned to a predetermined frequency, means for subjecting said element to a vibration inducing influence of varying frequency, said vibration inducing influence being effective to vibrate said element when its frequency of vibration corresponds to the vibration frequency of said element and ineffective at other frequencies of vibration, and provision for converting the vibratory motion of said element into cumulative motion effective to operate said valve.

In testimony whereof I have signed my name to this specification.

WARNER T. TABB.