

Sept. 9, 1941.

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ROTATIONAL SPEED RESPONSIVE DEVICE

Filed Sept. 7, 1938

2 Sheets-Sheet 1

Fig. 1

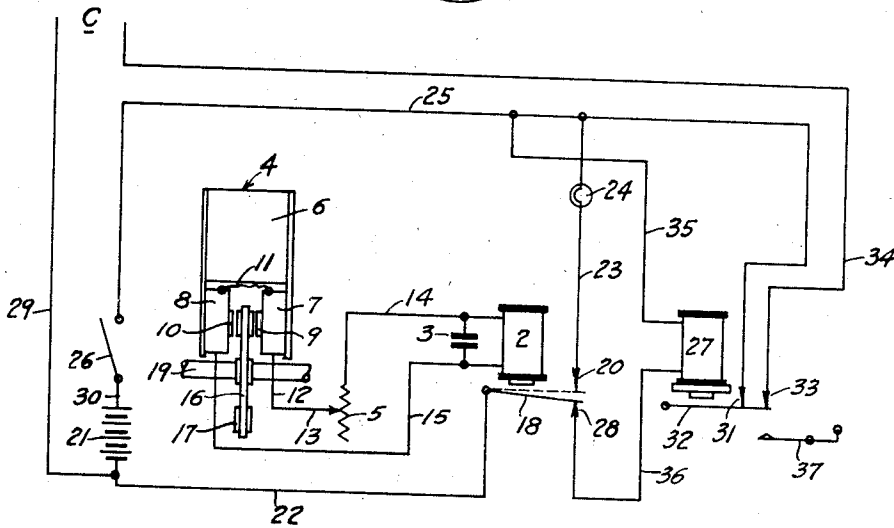
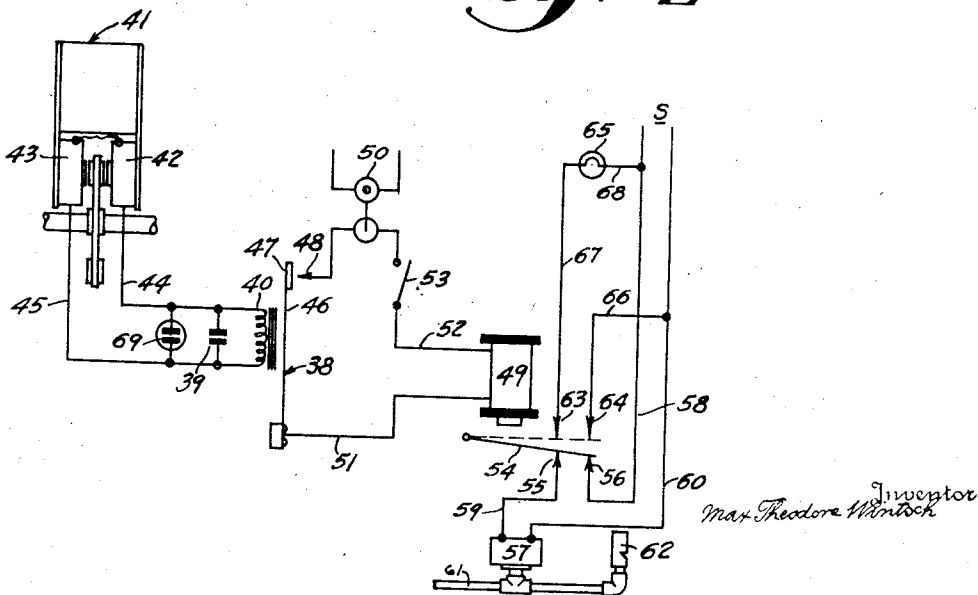


Fig. 2



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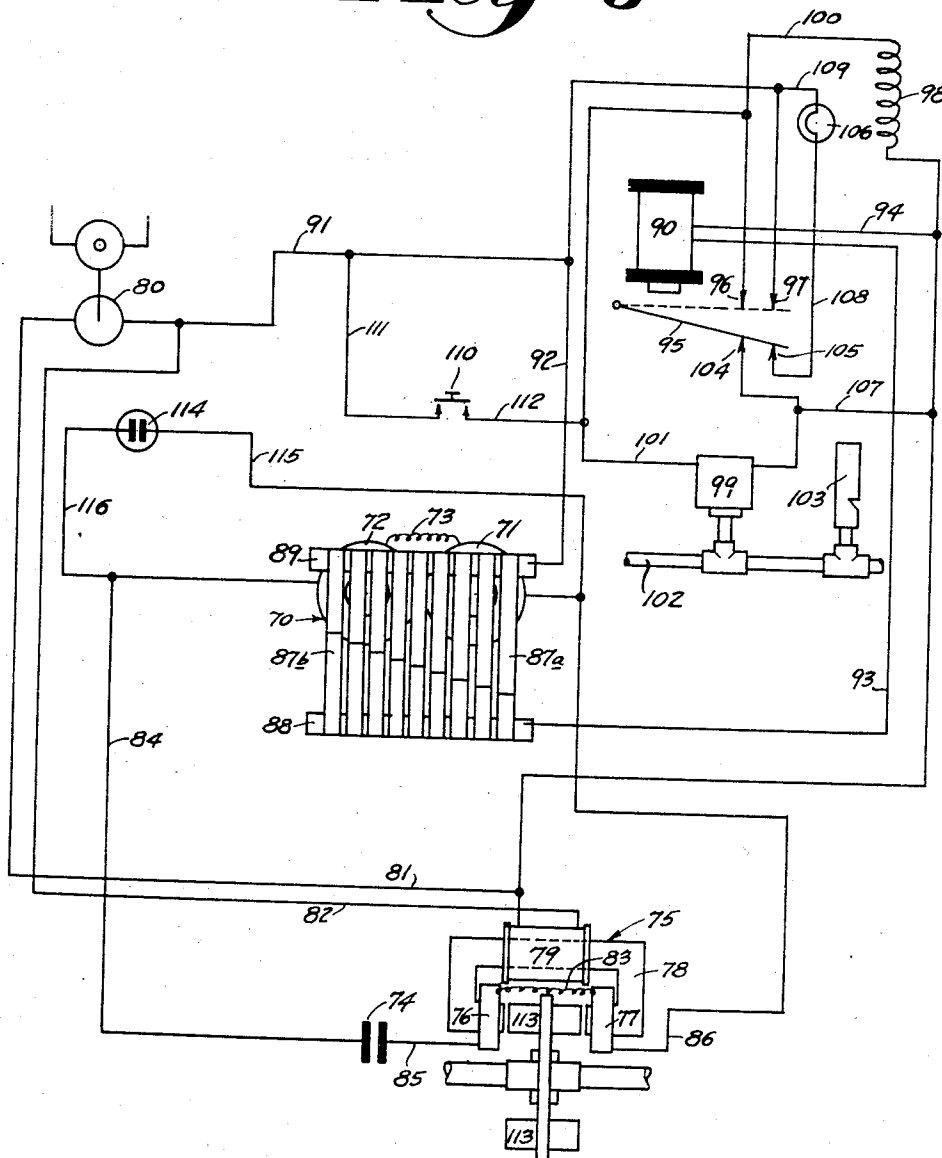
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2 Sheets-Sheet 2

Fig 3



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ROTATIONAL SPEED RESPONSIVE DEVICE

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This invention relates to a rotational speed responsive device and more particularly to a device for indicating the speed of rotational bodies and for controlling the speed of operation thereof.

My invention contemplates an electrical system for rotational speed indication and/or control in which an electrical relay, responsive only to current of a predetermined frequency or frequencies, is effective for controlling the initiation of a signal and/or a control device, said relay being tuned so as to resonate at such predetermined frequency and being electrically connected to a variable reactance which is periodically varied by altering its field of magnetic flux, preferably by periodically introducing into its magnetic field ferrous metal, such as wrought iron armature pieces, whereby the current flow in a winding of said reactance is periodically increased and decreased, the lines of force or magnetic flux being greatly increased as the ferrous metal armature pieces approach the magnetic field between the pole pieces of the reactance, reaching a maximum point when an armature piece is in axial alignment with the reactance core pole pieces, and decreasing as the armature pieces move out of the magnetic field. The means for introducing such armature pieces into the field of the reactance core, and thus varying the reactance of said core and its winding, is connected to the apparatus, the rotational speed of which is to be indicated and/or controlled.

A variable reactance suitable for the purpose may comprise a permanent magnet, preferably formed of cast "Alnico," having a pair of operating coils connected in series and mounted on to the two pole pieces of the magnet, and a non-magnetic disk carrying uniformly spaced armature pieces, preferably also formed of "Alnico" or iron. If desired, a magnetizable metal core may be provided having an energizing field coil positioned thereabout, instead of a permanent magnet.

My invention also contemplates, but in a somewhat more limited sense, a system in which there is provided a slow release relay controlled by a tuned master relay, which slow release relay is effective for initiating a control upon the operation of said master relay for a predetermined interval. This unit preferably comprises a slow release relay, as previously mentioned, and a mechanical latching arrangement effective for normally holding the low voltage ignition system in closed circuit, if used on an internal combustion engine, but effective, upon deenergiza-

tion for a predetermined interval, for permanently interrupting such circuit, until said latch is manually reset.

Another modification of my invention provides a control system effective for insuring the maintenance of a rotational speed within predetermined limits. This preferably takes the form of a tuned reed relay having a plurality of reeds operable at predetermined frequencies within a prescribed range, said reeds engaging a common contact bar and being effective when in vibration for maintaining a control relay in energized position, thus rendering the signal and/or control inoperative, so that in the event of failure of the apparatus to properly function, either by reason of the rotational speed of the machine decreasing below or increasing above the prescribed range, or by reason of failure of the electrical system, the signal and/or control will be initiated. This type of speed control device is well suited for use in place of the usual mechanical centrifugal speed governors in any industrial application.

It will become apparent that my invention contemplates other features and combinations, as the detailed description thereof is considered in conjunction with the attached drawings, in which:

Figure 1 is a schematic diagram illustrating the apparatus of my invention in a preferred form for use on an automobile or other internal combustion engine, for example;

Figure 2 is a similar view showing a modification of my invention designed primarily for steam or air propelled rotational bodies and incorporating an appropriate control for the braking or propelling fluid; and

Figure 3 is a similar view illustrating an embodiment of my invention in which a multi-reed relay is employed for rotational speed control, as employed on an electrically propelled engine for example.

Referring first to Figure 1, there is provided a master relay 2 which is tuned by a condenser 3 connected across the operating winding thereof. The relay 2 and condenser 3 form part of a tuned circuit including reactor 4 and an adjustable resistance 5. The reactor 4 comprises an "Alnico" permanent magnet 6 having armature coils 7 and 8 surrounding poles 9 and 10, respectively, cast integral with the magnet 6. The coils 7 and 8 are connected in series by wire 11. The other side of coil 7 is connected by wire 12 to the sliding contact 13 of adjustable resistor 5, which resistor is connected by wire 14 to one

side of the coil of master relay 2. Likewise, wire 15 connects the coil 8 with the other side of the coil of master relay 2, condenser 3 bridging the wires 14 and 15. This provides a tuned circuit including the relay 2, condenser 3, and resistor 5 which circuit is periodically energized when the reactance is varied. The windings on the relay 2 and coils 7 and 8, the capacity of the condenser 3, and the value of resistance 5 are predetermined and set so that the entire circuit will resonate only when current of a predetermined frequency flows therethrough.

The air gap between pole pieces 9 and 10 is adapted to be decreased periodically by means of disk 16 which carries a plurality of armature pieces 17. The disk 16 is formed of brass, "Bakelite," or other non-magnetic material. The armature pieces 17 are uniformly spaced about the disk 16 and are so positioned as to come periodically into axial alignment with the pole pieces 9 and 10, but not into actual contact therewith, thus periodically reducing the air gap between said pole pieces 9 and 10 and inducing increased lines of magnetic flux to pass more readily therebetween, with concomitant increase of the amplitude of the current passing through the tuned relay circuit. As the armature pieces 17 progressively move away from the opposed pieces 9 and 10, thus increasing the air gap therebetween, there is a gradual diminution of current flow. It will be apparent, therefore, that as the armature pieces 17 progressively approach and recede from the gap between the pole pieces 9 and 10, there is built up a frequency of current, which, when it reaches the point of resonance for which the circuit is tuned, will energize relay 2, causing it to lift its armature 18.

For purposes of illustration, let it be assumed that with the standard automobile speedometer cable driving the disk 16 through its driving shaft 19 a speed of movement of the vehicle of 50 miles per hour will effect revolution of the cable and shaft 19 at the rate of 750 revolutions per minute and let it be further assumed that disk 16 carries four equally spaced armature pieces 17. With such hypothetical basis, the circuit including the relay 2, condenser 3, reactor 4, and resistor 5 would be so tuned and adjusted to resonate at 50 cycles per second. (The rotation of the disk 16 at 750 revolutions per minute would effect a frequency of 3000 cycles per minute or 50 cycles per second.)

When the speed of disk 16 reaches 750 revolutions per minute, and the circuit is in resonance, relay 2 will be energized and its armature 18 lifted into engagement with front point of contact 20, (the relay 2 is shown in deenergized position in Figure 1) and current will flow from a battery 21, through wire 22 connected to armature 18, front point of contact 20, and through wire 23 connected to a signal light 24, the other side of the light 24 being permanently connected to the other side of the battery 21, through wire 25, when switch 26 is closed.

From the foregoing, it will be clear that when the apparatus, the rotational speed of which is to be indicated and/or controlled is not in rotation or has not attained a predetermined speed, relay 2 will not be energized and consequently signal light 24 will not be illuminated, but that, immediately the speed of rotation reaches a predetermined point, resonance will be established in the circuit causing the master relay 2 to lift its armature 18 and thus connecting signal light

24 to its current source and effecting illumination thereof.

In Figure 1, there is shown, in addition to the signal 24, a control relay 27 which is energized when armature 18 of master relay 2 is in open position and in contact with back point of contact 28 as shown. Relay 27 has slow release characteristics such that it must remain deenergized for a predetermined period of time, say three seconds, before its armature will fall.

In the embodiment shown in Figure 1, lead 29 connects directly from battery 21 to the primary ignition circuit C and lead 30 connects from the other side of the battery 21, through switch 26 and wire 25 to front point of contact 31 of control relay 27. The circuit for the primary ignition circuit C is completed through armature 32 of control relay 27, the other front point of contact 33 and wire 34. Thus, when control relay 27 is energized, current is fed to the primary ignition circuit C from the current source therefor.

Control relay 27 has one side of its operating winding connected directly to the battery 21 through wires 35 and 25, switch 26 and wire 30 leading to the battery 21. The other side of the operating winding is connected to the battery 21 through a lead 36, back point of contact 28, armature 18, and wire 22. Thus, control relay 27 is energized so long as master relay 2 remains deenergized and, so long as control relay 27 is energized, current is fed to the primary ignition circuit C.

In the event the maximum speed of rotation be reached, lifting armature 18, thus deenergizing control relay 27, and such speed be maintained for a predetermined time, concomitantly causing control relay 27 to be deenergized for a time period longer than its time lag, armature 32 will fall, being latched against return by latch 37 positioned in the path of travel thereof. Upon release of armature 32 from its closed position, the supply of current for the primary ignition circuit C will fail and the engine will be stopped.

The latch 37 is preferably so positioned that the vehicle operator cannot conveniently hold it against operation. If the apparatus be directly interconnected with the speedometer drive cable under the dash board this will insure that the operator will bring the car to a complete stop to reset the latch 37 and thus permit closing of the primary ignition circuit. This will effectively aid in the apprehension of code violators and thieves since, if pursued by an officer, it will be impossible to exceed a predetermined speed, say 50 miles per hour, without the control relay becoming deenergized and locking the primary ignition system out of operation until switch 37 is manually reset.

In Figure 2, I have shown a similar circuit but here there is employed a tuned reed relay and a somewhat different control. This particular apparatus is suited for use on mobile or stationary engines employing fluid propulsion, such as steam, water, or air, or fluid braking. In the basic principles, the system of Figure 2 is the same as the device of Figure 1. It includes a tuned reed master relay 38 which has a tuning condenser 39 connected across its operating winding 40. Like the circuit shown in Figure 1, master relay 38 constitutes part of a resonant circuit including a variable reactance 41, the series coils 42 and 43 of which are connected in closed circuit with the operating coil 40 of

the master relay 38 by wires 44 and 45. The tuned reed 46 of master relay 38 will vibrate only when resonance is established in the tuned circuit including its operating winding 40. The variable reactance 41 is identical with that described in conjunction with Figure 1 and, accordingly, a detailed description is deemed unnecessary.

When reed 46 is caused to vibrate by reason of the attainment of resonance in the tuned circuit effected by rotation of the rotatable disk of reactor 41 at a predetermined speed, contact 47 of reed 46 will be vibrated into and out of engagement with contact point 48 in accordance with the frequency of vibration natural to the reed 46. When contact 47 is in engagement with contact point 48, current for the operating winding of a control relay 49 is fed from a motor generator set 50, through contact point 48, contact 47, reed 46 and a wire 51 which connects with the mounting for the reed 46. The other side of the operating winding of relay 49 is normally connected through wire 52 and switch 53 to the other side of the motor generator 50. Thus, it will be apparent that relay 49 is normally deenergized, but is energized when the circuit including the operating winding 40 of master relay 38 is in resonance.

When relay 49 is deenergized, its armature 54 lies in open position in engagement with back points of contact 55 and 56 which are effective for connecting one side of high voltage supply S with a solenoid type fluid control valve 57, through lead 58, contact 56, armature 54, contact 55 and lead 59. The other side of the operating winding, for the control valve 57 is normally connected to the source S through lead 60.

The valve 57 normally holds the supply pipe 61 for fluid, either for propulsion or braking, closed so that the fluid is effective for causing rotation of the apparatus or for holding the brakes against operation. When master relay 38 is energized, however, the relay 49 is also energized, lifting armature 54 and interrupting the flow of current to control valve 57, the fluid pressure will cause valve 57 to open and the fluid will be exhausted to atmosphere through a whistle 62, and at the same time, either slowing down or stopping the apparatus or applying the braking mechanism.

When master relay 38 is energized by reason of the speed of rotation of the disk of reactance 41 effecting resonance in its circuit, the armature 54 of relay 49 will rise (by reason of current flow thereto from motor generator 50) into engagement with front points of contact 63 and 64, thus connecting signal light 65 with wire 60 from source S through wire 66, front point of contact 64, armature 54, front point of contact 63 and wire 67. The signal light 65 is connected permanently to the other side of the source S by wire 68.

If desired, a "neon" pilot light 69 may be provided which is connected across the leads 44 and 45. This light will be illuminated when the reactance disk is in rotation at a speed sufficient to effect a flow of current in the circuit including the "neon" light and thus illuminate the same. If a six volt light be used, rotation of the disk at low speed will result in its illumination.

In the system shown in Figure 3, there is provided a minimum and maximum rotational speed control device in combination with an indicating signal. Also, in this embodiment, there is provided a modified type of variable reactor, one in which there is provided a field coil for magnetiz-

ing a laminated magnetizable core. As in the embodiment shown in Figure 2, there is provided a vibrating reed relay generally indicated by the numeral 70. This relay is provided with a pair of energizing coils 71 and 72 connected in series by wire 73. The relay 70 has a tuning condenser 74 connected across the windings of coils 71-72. The variable reactance designated generally by the numeral 75 includes a pair of operating coils 76 and 77 which are positioned around the legs of an electromagnet 78 which is energized by a field coil 79 connected to a direct current motor generator set 80 by wires 81 and 82. The operating coils 76 and 77 are connected in series by wire 83 and they constitute a part of a tuned circuit including coils 71 and 72, the latter of which is connected by lead 84 to condenser 74, also forming part of the tuned circuit. Coil 76 is connected to condenser 74 by lead 85 and coil 77 is connected by lead 86 to the coil 71 completing the circuit.

The relay 70 is provided with a plurality of individual reeds 87—in the embodiment illustrated there being 9—each of which is connected to a common bar 88 and each being adjusted for natural vibration at a predetermined frequency, the group as a whole being adjusted to vibrate within a prescribed range of frequencies predetermined in accordance with the range of rotational speed desired. The reeds 87 make contact, when in vibration, with a common contact bar 89.

When any of the reeds 87 is in vibration, and consequently making contact with bar 89, current will flow to control relay 90 from the motor generator 80, through lead 91 connected to one side of the generator 80 and lead 92 connecting lead 91 with bar 89. Current will flow through the reed or reeds 87 which happen to be in vibration and thence through common connecting bar 88 to a wire 93 which leads to control relay 90. The other side of the motor generator 80 is normally connected to the relay 90 by a connecting wire 94, joining with the common lead 91.

It will be observed, therefore, that whenever master relay 70 is in operation, control relay 90 will likewise be energized, regardless of the particular reed or reeds 87 of master relay 70 which are in vibration. The relay 90 is shown in deenergized position in Figure 3. When relay 90 is energized, its armature 95 will be brought into engagement with back points of contact 96 and 97, thus closing the circuit for the holding coil 98 for the circuit breaker if one be employed, and for also closing the circuit for the solenoid coil of an electro-pneumatic valve 99. The circuit for the holding coil 98 is from motor generator 80 through lead 91 to back point of contact 97, through armature 95 to back point of contact 96 which connects through wire 100 to the holding coil 98. The other side of the coil is normally connected to the motor generator 80 through common lead 91. The circuit for the solenoid coil of the valve 99 is the same, a lead 101 connected to the coil being also connected with lead 100 from back point of contact 96 of relay 90.

The electro-pneumatic valve 99 is normally held closed when its coil is energized but is opened by the fluid, which may be steam or air, passing through conduit 102 and if desired a whistle 103 may be provided in this line which will be sounded when valve 99 is deenergized, such sounding being effected by means of the exhausting steam or air passing therethrough from conduit 102.

When relay 90 is deenergized—that is when none of the reeds 87 is in vibration—its armature

95 will fall into engagement with front points of contact 104 and 105 thus completing the circuit for a warning signal light 106 which is then connected to the motor generator through common lead 81, lead 107, front point of contact 104, armature 95, front point of contact 105 and lead 108. The other side of the light is connected by a wire 109 to the common lead 91 which connects with the motor generator 80.

Since the control relay 90 is effective for shutting down the machine when speeds below, as well as above, a predetermined range are encountered, a starting switch 110 is provided which is effective for connecting the supply of current for the valve 99 until the minimum speed is reached thus placing the reed relay 70 into operation. The starting switch 110 connects the non-common lead 101 for the solenoid valve 99 and non-common lead 100 for the holding coil 98 with common lead 91 from motor generator 80, through wires 111 and 112. As previously pointed out common lead 81 is normally connected to the other side of the solenoid 99 and holding coil 98.

For purposes of illustration, it will be assumed that the rotational speed is to be controlled between limits of 375 and 600 revolutions per minute and that the rotating disk of the variable reactor 75 is connected through its shaft to rotate at the same speed as the apparatus to which it is connected and the speed of which is to be indicated and/or controlled, and further, it will be assumed that the rotating disk of reactor 75 is provided with four armature pieces 113. Under such conditions, when a speed of 375 R. P. M. is attained by the apparatus, the current flowing in the tuned circuit including the coils 71-72, condenser 74 and coils 76 and 77 will have a frequency of 25 cycles and the first reed of the series, 87a, will be adjusted to vibrate at about that frequency. When a speed of 600 R. P. M. is attained by the apparatus the frequency in the circuit will be 40 cycles and accordingly reed 87b should be adjusted to vibrate at about that frequency, and the seven intermediate reeds should be adjusted to vibrate within the range between 25 to 40 cycles so that at least one of the reeds will be in vibration at all times when the speed of rotation of the apparatus is such that a frequency between the range of 25 and 40 cycles exists in the tuned circuit.

If desired, a pilot light 114 may be provided connected by leads 115 and 116 across the coils 76 and 77 of the variable reactance 75 and this pilot light 114 will be illuminated whenever current is flowing in the tuned circuit and will indicate proper functioning of the variable reactor circuit.

The operation of the device shown in Figure 3 will be briefly described in order to insure clarity of understanding of the invention. The machine operator presses button 110 which effects energization of valve 99 and holding coil 98, thus releasing the brake on the machine or supplying the machine with propelling fluid, depending upon the control employed, and holding the circuit breaker in position if electric propulsion be employed. As the speed of rotation of the apparatus increases, the frequency of the current in the tuned circuit will increase until the minimum speed of 375 R. P. M. is reached at which time reed 87a will vibrate and control relay 90 will become energized extinguishing the light 106 which will give the operator an indication that minimum speed has been attained and that the starting button 110 may be released. So long as

the speed of rotation of the apparatus continues within the prescribed range (between 375 and 600 R. P. M.) the functioning of the device will remain unchanged, excepting that various of the reeds 87 may from time to time be in vibration. In the event, however, a speed below or above the prescribed range obtains, then the tuned circuit will be out of resonance with any of the reeds and none will vibrate thus opening the circuit for control relay 90, whereupon valve 99 will be deenergized and the control fluid will be exhausted through warning whistle 103 and the brakes will be applied or the supply of propelling current will be disrupted. Light 106 will be energized and holding coil 98 will be deenergized, if the vehicle be electrically propelled, permitting the circuit breaker which it controls to fall and thus interrupt the supply of propelling current for the vehicle.

The group of reeds disposed in the vicinity of reed 87a may be used to control an electro-valve similar to the valve 99 effective to increase the supply of operating power and thus increasing the speed of rotation of the machine and the group of reeds disposed adjacent reed 87b may be used to control a second valve disposed so as to operate in a manner similar to valve 99 initiating a warning signal and cutting off the supply of operating power so as to reduce the speed of rotation to within the prescribed limits.

While I have described and illustrated certain preferred embodiments of my invention it will be understood that the same is not so limited but may be otherwise embodied and practiced within the scope of the following claims.

I claim:

1. A rotational speed responsive device comprising in combination a tuned relay, a variable reactance connected in series with said relay, means for producing a current which varies in accordance with the variations of the reactance, said relay being responsive only to current of a predetermined frequency established by said reactance, a source of current, and a slow release relay effective for interrupting the supply of current from said source upon energization of said first mentioned relay for a predetermined interval greater than the time lag of said slow release relay.

2. A rotational speed responsive device comprising in combination a tuned vibrating reed relay, a variable reactance connected to apparatus, the rotational speed of which is to govern the operation of said device, said reactance being effective for bringing the circuit including its operating winding and the operating winding of said relay into resonance, an electro-pneumatic valve for controlling said apparatus and a control relay effective for deenergizing said electro-pneumatic valve upon energization of said reed relay.

3. A rotational speed responsive device comprising in combination a reed relay including a plurality of reeds having natural periods of vibration in a prescribed range, a reactance connected in series with said relay, means for tuning said relay, a control relay effective upon energization for completing an electrical circuit, said reactance being connected to the apparatus the rotational speed of which is to govern the operation of said device, the plurality of said reeds engaging a common contact bar and effective for energization of said control relay within said prescribed range of frequency induced by said reactance device.

4. A rotational speed responsive device comprising in combination a reed relay including a plurality of reeds having natural periods of vibration within a prescribed frequency range and effective when in vibration for contact with a common contact bar, a variable reactance connected to the apparatus, the rotational speed of which is to govern the operation of said device, and electrically connected in series with said relay, means for tuning said relay, said reactance being effective for bringing the circuit including its operating winding and the operating winding of said reed relay into resonance within said prescribed frequency range, and electrical means connected in circuit through said bar when at least one of said reeds is in vibration.

5. A rotational speed responsive device comprising in combination a tuned relay, a variable reactance connected in series with said relay, means for producing a current which varies in accordance with the variations of the reactance, said relay being responsive only to current of a predetermined frequency established by said reactance, a source of current, a slow release relay effective for interrupting the supply of current from said source upon energization of said first mentioned relay for a predetermined interval greater than the time lag of said slow release relay and means for latching said slow release relay in open position.

6. A rotational speed responsive device comprising in combination a tuned relay, a variable reactance connected in series with said relay, means for producing a current which varies in accordance with the variations of the reactance, said relay being responsive only to current of a predetermined frequency established by said reactance, a source of current, and a time lag relay effective for interrupting the supply of current from said source upon energization of said first mentioned relay for a predetermined interval greater than the time lag of said time lag relay.

7. A rotational speed responsive device comprising in combination a reed relay including a plurality of reeds having natural periods of vibration within a prescribed frequency range and effective when in vibration for contact with a common contact bar, a variable reactance connected to apparatus, the rotational speed of which is to govern the operation of said device and electrically connected in series with said relay, means for tuning said relay, said reactance being effective for bringing the circuit including its operating winding and the operating winding of said reed relay into resonance within said prescribed frequency range, and a control relay connected in circuit through said bar when at least one of said reeds is in vibration.

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