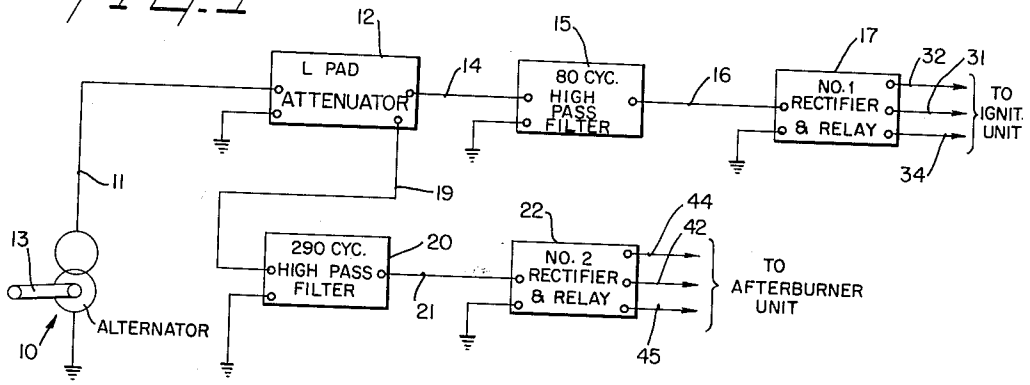
Aug. 21, 1962 D. E. CLARK 3,049,879

ELECTRONIC SPEED RESPONSIVE DEVICE

Filed Aug. 19, 1958 2 Sheets-Sheet 1

Fig. 1



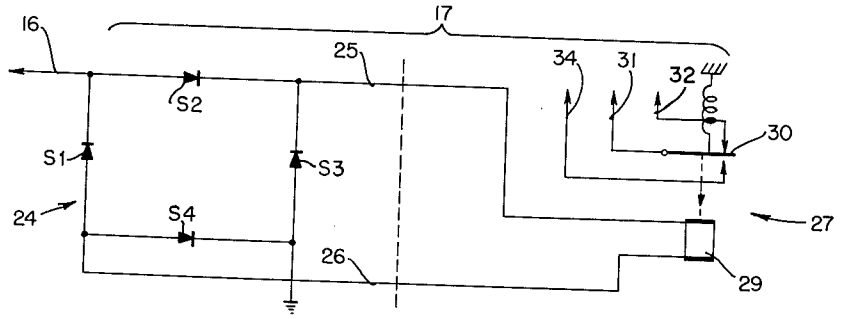


Fig. 2

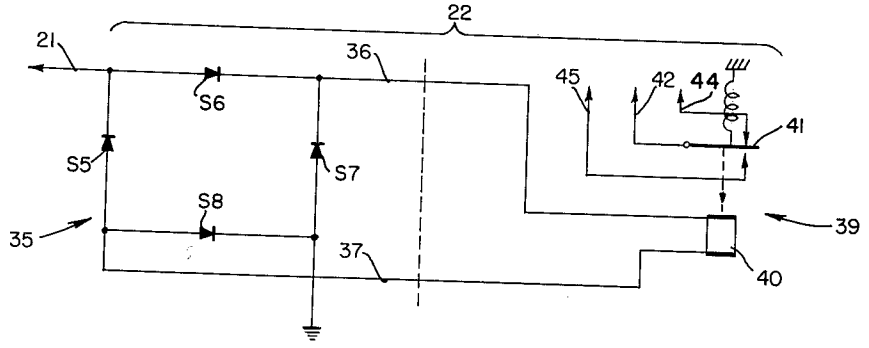


Fig. 3

INVENTOR.
DONALD E. CLARK

BY
Bauer and Seymour
ATTORNEYS

Aug. 21, 1962 D. E. CLARK 3,049,879

ELECTRONIC SPEED RESPONSIVE DEVICE

Filed Aug. 19, 1958 2 Sheets-Sheet 2

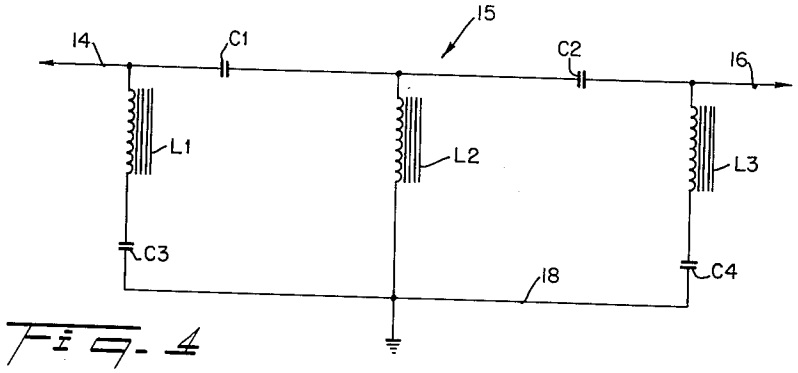


Fig. 4

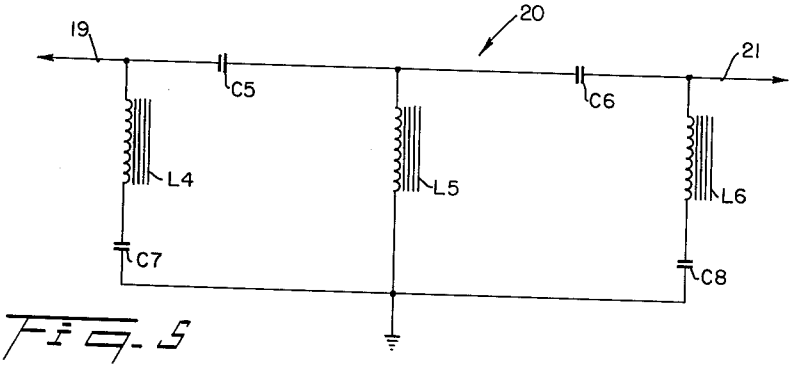


Fig. 5

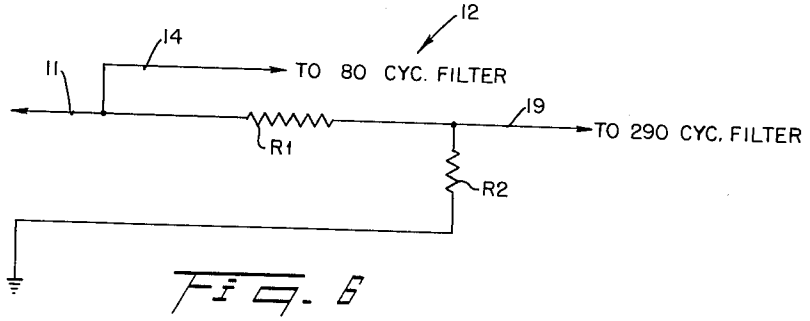


Fig. 6

INVENTOR.
DONALD E. CLARK
BY
Bauer and Seymour
ATTORNEYS

United States Patent Office 3,049,879 Patented Aug. 21, 1962

3,049,879

ELECTRONIC SPEED RESPONSIVE DEVICE

Donald E. Clark, Ninevah, N.Y., assignor to The Bendix Corporation, a corporation of Delaware

Filed Aug. 19, 1958, Ser. No. 756,023
3 Claims. (Cl. 60—39.14)

This invention relates to an electronic speed responsive device.

In the embodiment of the speed responsive device shown herein the device is responsive to a plurality of different rotational speeds, and is particularly adapted for the control of appurtenant mechanisms associated with the rotating shaft which controls the speed responsive device. An illustrative rotational speed responsive device is a switch used with a jet engine for controlling the ignition and afterburner systems thereof. A typical jet engine equipped with an afterburner requires the ignition system to be energized at speeds of roughly 0 to 825 r.p.m., of a subordinate shaft rotating in synchronism with the engine, and for the ignition system to be deenergized at all speeds of such subordinate shaft from roughly 825 to 3600 r.p.m. and above, the flame in the engine being then self-sustaining. Such engine also requires the afterburner system to be deenergized in a subordinate shaft speed range from 0 to generally 2905 r.p.m., and to be energized for all speeds higher than 2905 r.p.m.

Such functions of controlling the ignition and afterburner systems have in the past been performed by switches of the centrifugal type. Such switches, however, are far from accurate, since the speeds at which they operate are significantly affected by varying friction between the parts, such as caused by wear or dimensional variations due to temperature changes. The speed responsive device of the present invention is substantially wholly electronic in nature and is thus free from variations in its manner of operation caused by differences in friction, temperature, etc.

The invention has among its objects the provision of a novel electronic speed responsive device.

A further object of the invention resides in the provision of an electronic speed responsive device which consists largely of simple filter circuits whereby the device is initially accurate and remains so throughout the long operating life.

Yet another object of the invention resides in the provision of an electronic speed responsive device which is economical to make and maintain, and the operation of which remains substantially constant in character despite wide variations of operating temperature to which it is subjected.

The above and further objects and novel features of the invention will more fully appear from the following description when the same is read in connection with the accompanying drawings. It is to be expressly understood, however, that the drawings are for the purpose of illustration only and are not intended as a definition of the limits of the invention.

In the drawings, wherein like reference characters refer to like parts throughout the several views,

FIG. 1 is a somewhat schematic block diagram of the circuit of an illustrative embodiment of electronic speed responsive device made in accordance with the invention;

FIG. 2 is a schematic wiring diagram of a first rectifier and relay employed in the device of FIG. 1;

FIG. 3 is a schematic wiring diagram of a second rectifier and relay employed in the device of FIG. 1;

FIG. 4 is a wiring diagram of a low frequency filter component of the device of FIG. 1;

FIG. 5 is a wiring diagram of a high frequency filter component of the device of FIG. 1; and

FIG. 6 is a wiring diagram of an L pad attenuator employed in the device of FIG. 1 in advance of the filters thereof.

Turning now to the drawings, in FIG. 1 there is shown the wiring diagram of an electronic speed responsive device which is used in the above discussed application of controlling the ignition and afterburner systems of a jet engine. Such device includes an alternator schematically shown at **10**, such alternator being driven by a shaft **13** which in this instance is a subordinate shaft connected to rotate in synchronism with the main shaft of the engine. It will be understood that in some instances the alternator may be directly connected to the main shaft of an engine or other device being controlled. Alternator **10** is of such design as to feed an alternating current through output wire **11**, the frequency of such generated current bearing a fixed relationship to the speed of rotation of shaft **13**.

In the described illustrative embodiment, alternator **10** has a twelve pole stator with a rotor in the form of a four pole permanent magnet rotating therewithin. With such construction the ratio between the revolutions per minute of shaft **13** and the cycles per second of the alternating current delivered to wire **11** is 10:1. The alternator output is delivered to an L pad attenuator **12** to be specifically described in connection with FIG. 6, and thence through one branch wire **14** to an 80 cycle (per second) high pass filter **15** from which the output is led through a wire **16** to a first rectifier and relay unit **17** which controls the ignition system of the engine. Another branch wire **19** from attenuator **12** leads to a 290 cycle pass filter **20**. The output from filter **20** is led through wire **21** to a second rectifier and relay unit **22** which controls the afterburner system of the engine. Each of the units **12**, **15**, **17**, **20**, and **22** is grounded, as is one output lead from generator **10**.

Unit **17** is made up of a rectifier unit **24** and a relay unit **27**, as shown in FIG. 2. Rectifier unit **24** consists of a closed loop of four serially connected half-wave rectifiers S_1–S_4, one corner of the thus formed bridge being connected to wire **16**; the opposite corner of the loop or bridge is connected to ground. A further, different corner of the bridge is connected to one end of coil **29** of relay **27** by wire **25**, the fourth corner of the bridge being connected by a wire **26** to the other end of coil **29** of the relay. The relay **27** has a movable contactor **30** connected to a central terminal **31**. Contactor **30** is movable between an upper fixed contact connected to a terminal **32** and a lower fixed contact connected to a terminal **34**. The relay **27** is of such construction that contactor **30** is constantly urged toward the upper position shown in FIG. 2 in which circuit **31**, **30**, **32**, is closed and thereby to energize the ignition system of the engine. When, however, a sufficient voltage difference exists between wires **25** and **26**, coil **29** of the relay **27** is energized sufficiently to move contactor **30** downwardly, thereby opening the circuit **31**, **30**, **32**, and deenergizing the ignition system.

The second rectifier and relay unit **22** shown in detail in FIG. 3 is substantially similar to unit **17**. Rectifier unit **35** of unit **22** has a closed loop consisting of four serially connected half-wave rectifiers S_5–S_8 which are connected to their supply wire (**21**) and to ground in the same manner as in unit **24**. Delivery wires **36** and **37**, connected to opposite corners of the loop or bridge, are connected to opposite ends of coil **40** of relay **39**. Relay **39**, which is generally similar to relay **27**, has a movable contactor **41** which is biased toward its upper position in which circuit **42**, **41**, **45** is open. When relay **39** is energized by the existence of a sufficient difference in potential between the wires **36** and **37**, contactor **41** is moved downwardly to complete circuit **42**, **41**, **45**, thereby to initiate operation of the afterburner.

The first, **80** cycle high pass filter **15** is shown in detail

in FIG. 4. Input wire **14** has two serially connected condensers C_1 and C_2 interposed between it and delivery wire **16**; an opposed conductor **18** is connected to ground. Between wire **14** and conductor **18** at a position in advance of condenser C_1 there are interposed series connected inductance L_1 and condenser C_3; at a position between condensers C_1 and C_2 an inductance L_2 is connected between wire **14** and conductor **18**. At a position beyond condenser C_2 serially connected inductance L_3 and condenser C_4 are interposed between wire **14** and conductor **18**.

Typical values for the inductances and condensers of unit **15** are given below. For the moment it will suffice to say that such components are so chosen that at frequencies below 80 cycles filter **15** prevents the flow of sufficient power to relay **27** to move its contactor **30** downwardly. Above 80 cycles per second the impedance of filter **15** drops sharply, such impedance then being low enough in the range 80 cycles per second (800 r.p.m. of shaft **13**) to 290 cycles per second (2900 r.p.m.) to cause relay **27** then to cause contactor **30** to be moved into and be held in the lower inoperative position.

The second, 290 cycle high pass filter **20** is shown in detail in FIG. 5. Such filter includes the same number of components positioned in a manner identical with those in filter **15**, the components differing, however, in value so that filter **20** presents a sufficiently high impedance to prevent operation of relay **40** in the range 0 to 290 cycles per second (2900 r.p.m.). At 290 cycles per second the impedance of filter **20** drops sharply and remains low through 360 cycles per second (3600 r.p.m.), thereby permitting coil **40** of relay **39** to be energized. When the relay is thus energized, the circuit **42, 41, 45** is closed and the afterburner is operated.

The L pad attenuator **12** is shown in detail in FIG. 6. A first resistor R_1 is interposed between input wire **11** and output wire **19** leading to filter **20**. Interposed between wire **11** beyond resistor R_1 and filter **20** and ground is a second resistor R_2. The lead wire **14** of filter **15** connects to wire 11 in advance of resistor R_1. Attenuator **12** functions to match the alternator output impedance to the filter input impedance and also absorbs excess alternator power, especially at higher alternator speeds.

Typical illustrative but non-limiting values of the various circuit components above described are as follows:

C_1, C_2	.22 mfd.
C_3, C_4, C_7, C_8	1.0 mfd.
C_5, C_6	.25 mfd.
L_1, L_3	6.65 H 4,250 turns, #38 wire.
L_2	4.0 H 3,300 turns, #37 wire.
L_4, L_6	.45 H 950 turns, #31 wire.
L_5	.27 H 735 turns, #30 wire.
R_1	800 ohms.
R_2	200 ohms.
S_1–S_8	Hughes Aircraft, silicon diodes HD 6002.
Relay No. 1	Sigma V, 5F64000 CDW–SCR.
Relay No. 2	Sigma V, 5F64000 CDW–SCR.

The switches operate as follows: In the low speed range, from 0–800 r.p.m, (alternator), both the 80 cycle and the 290 cycle filters offer high impedance to both rectifier and relay circuits, preventing the flow of power necessary to operate the relays **27** and **39**. Thus under such conditions the ignition system is energized, and the afterburner is deenergized. At 800 r.p.m. the alternator **10** is operating at a frequency of 80 cycles, which is the cut-off frequency, or the frequency that allows current to pass through the 80 cycle filter **15**. The impedance of the 80 cycle filter **15** drops at this point, allowing current to pass through the rectifier **24** and into the relay **27**, causing the relay **27** to open. The ignition system is thus deenergized. The impedance of the 80 cycle filter **15** remains low through 3600 r.p.m. (360 cycles) allowing current to flow through the whole speed range, keeping the relay **27** open. The reverse is true as the speed is reduced to 800 r.p.m. The impedance of the 80 cycle filter then increases sharply and reduces the current to the relay **27** and allowing such relay to close, thereby again activating the ignition system.

The 290 cycle filter **20** operates in the same manner. Such filter acts as a high impedance to the second relay **39** at alternator speeds of from 0 to 2900 r.p.m. At 2900 r.p.m. theimpedance of filter **20** drops sharply, allowing current to pass through the filter **20** into the rectifier **35** and closing the second relay **39**. The afterburner is thus started. The impedance of filter remains low through 3600 r.p.m., keeping the relay **39** closed and the afterburner in operation. Upon reduction of the alternator speed to 2900 r.p.m., the 290 cycle filter impedance rises sharply, causing the relay **39** to open and afterburner operation to be stopped. From 2900 to 3600 r.p.m. both filters **15, 20** and relays **27, 39** are drawing power from the alternator **10**.

Although only a limited number of embodiments of the invention have been illustrated in the accompanying drawings and described in the foregoing specification, it is to be expressly understood that various changes, such as in the relative dimensions of the parts, materials used, and the like, as well as the suggested manner of use of the apparatus of the invention, may be made therein without departing from the spirit and scope of the invention as will now be apparent to those skilled in the art.

What is claimed is:

1. In a variable speed engine of the jet type having a rotatable shaft driven in synchronism with the engine, said engine having a main burner, an afterburner, an ignition system for the main burner, and an ignition system for the afterburner, said ignition system for the main burner being operated in a low range of speed of the engine and the ignition system for the afterburner being operated in a high range of speed of the engine, and a speed responsive device for controlling said ignition systems, the improved speed responsive device which comprises an alternator driven by said shaft in synchronism therewith, two circuits connected in parallel to the output of the alternator, a high pass filter in each of said circuits, the filters in the respective circuits having different cut-off frequencies, and a relay in each circuit connected to the output of the respective filter for controlling further separate circuits of the respective ignition systems.

2. An apparatus as claimed in claim 1, wherein the relay controlling the circuit of the main burner ignition system is resiliently biased toward circuit-closed position, and the relay controlling the circuit of the afterburner ignition system is resiliently biased toward circuit-open position.

3. An apparatus as claimed in claim 2, comprising an attenuator interposed between the alternator and the filters to match the alternator to the filter input impedances and to absorb excess input power at higher speeds of the engine.

References Cited in the file of this patent

UNITED STATES PATENTS

2,167,007	Schott et al.	July 25, 1939
2,178,290	Sorensen	Oct. 31, 1939
2,231,174	Trogner	Feb. 11, 1941
2,366,167	Adorjan	Jan. 2, 1945
2,544,523	Bogdanoff	Mar. 6, 1951