

Dec. 7, 1965

A. E. TRAVER

3,221,545

ANALYZER FOR INTERNAL COMBUSTION ENGINES

Filed Feb. 8, 1962

4 Sheets-Sheet 1

Fig. 1A

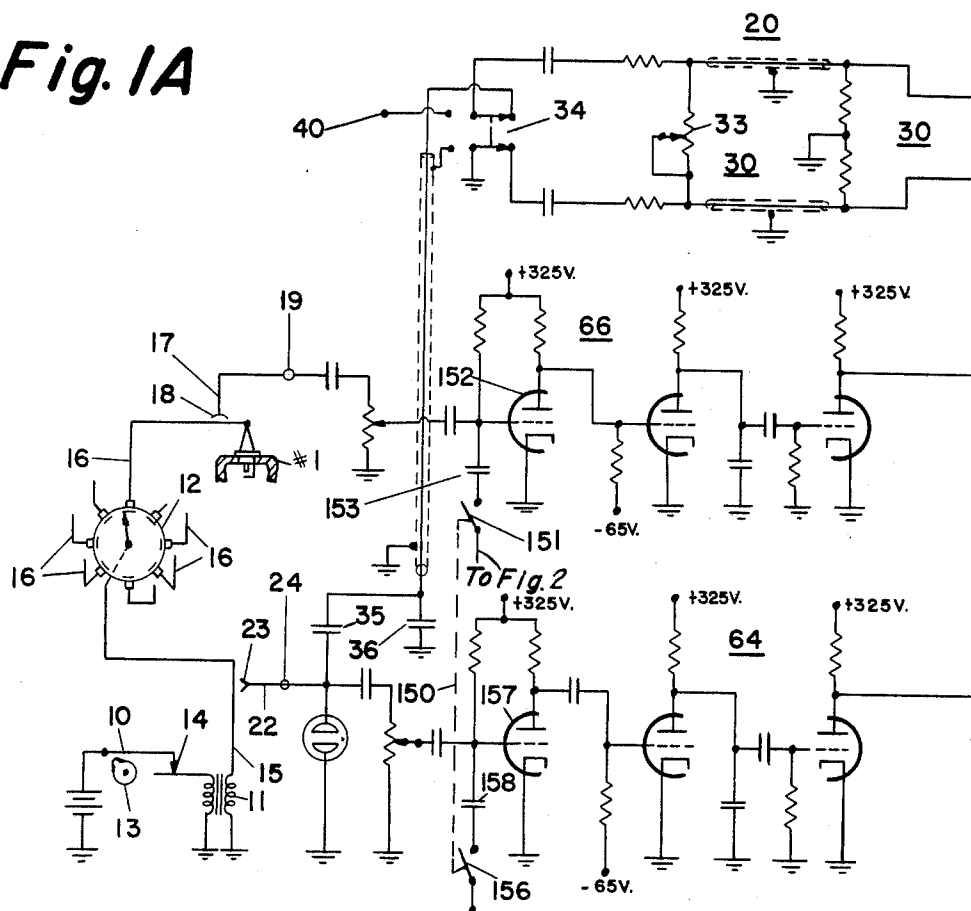


Fig. 4A

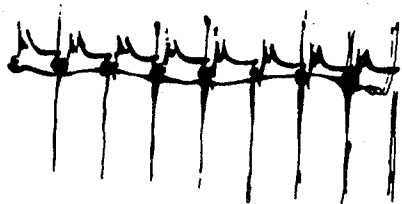
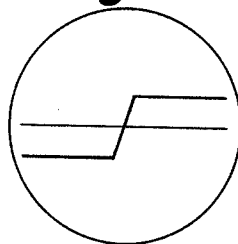


Fig. 4B



Fig. 8



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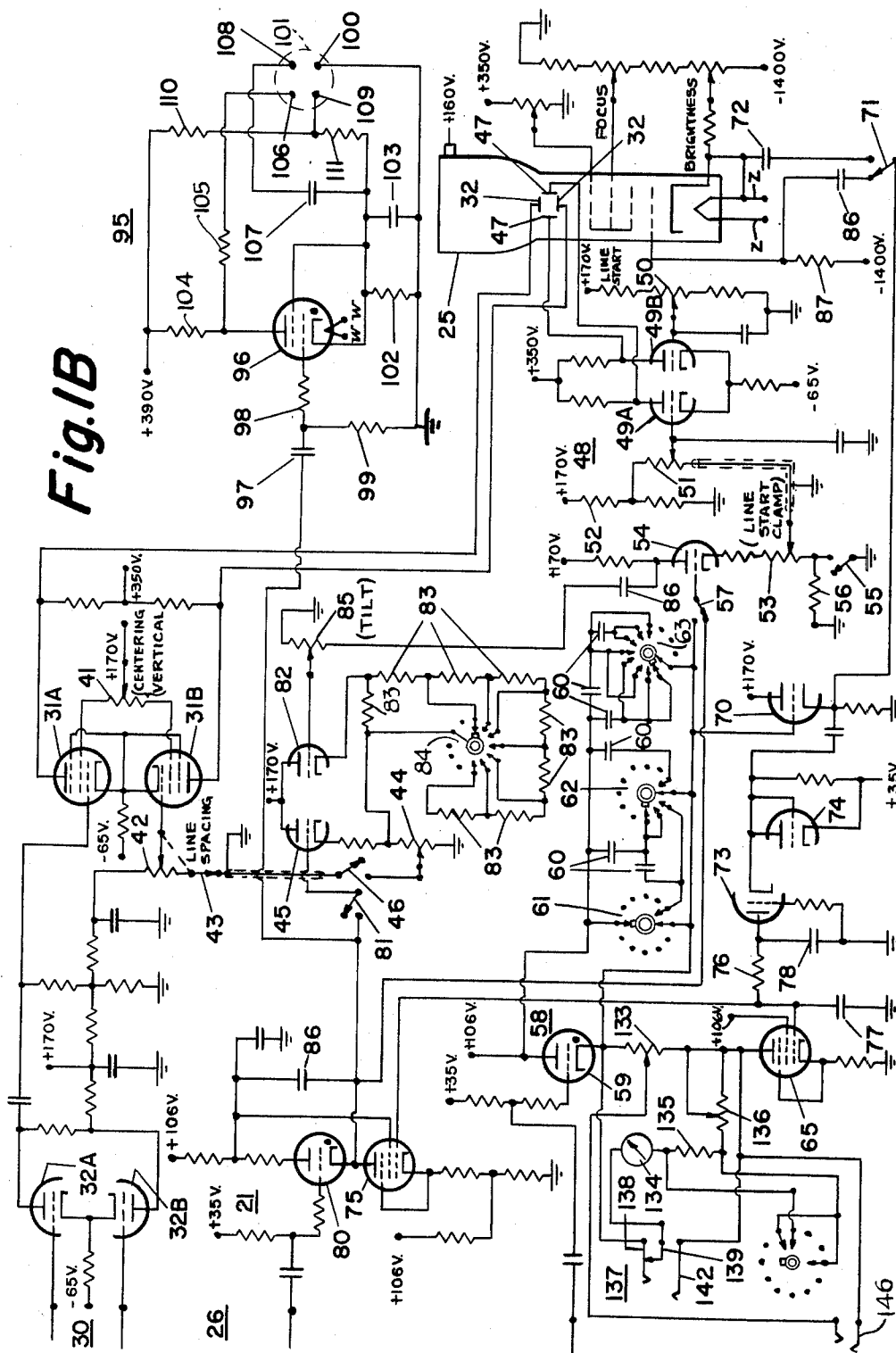
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Fig. 1B



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Fig. 2

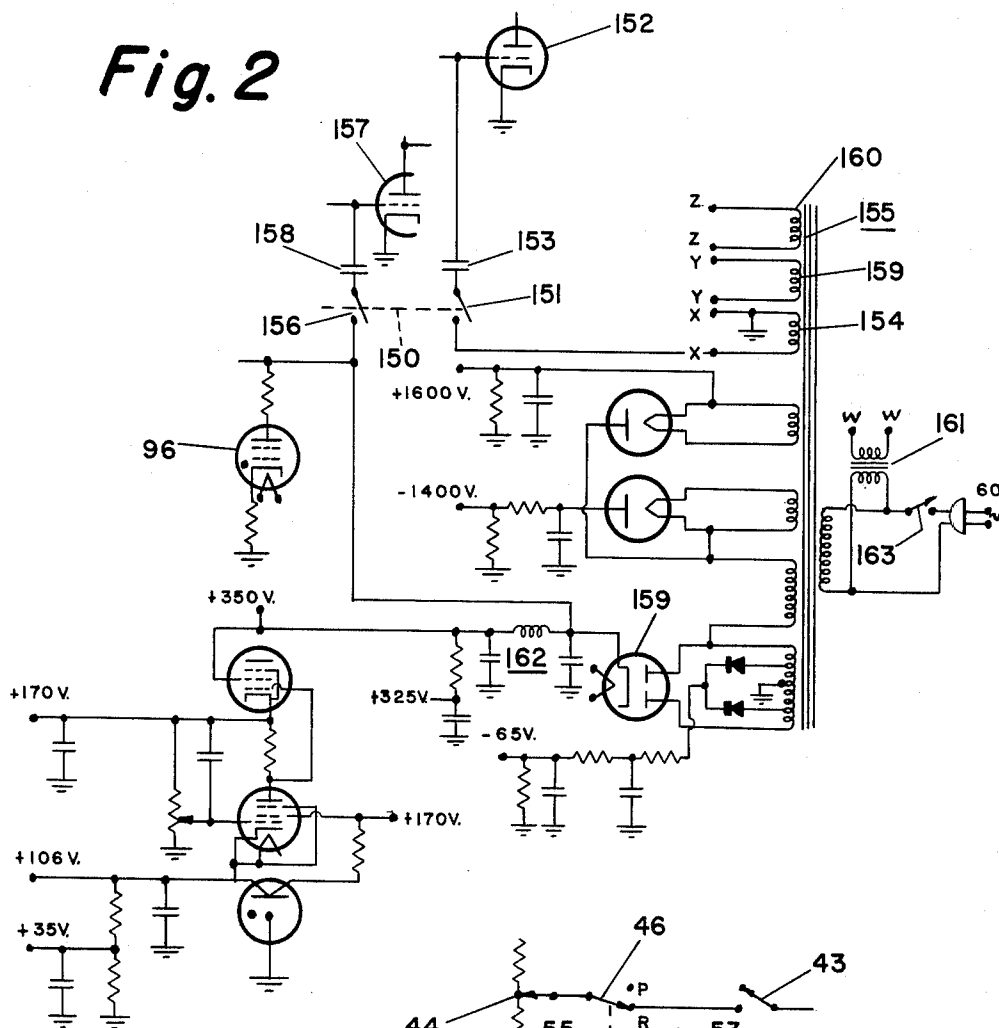
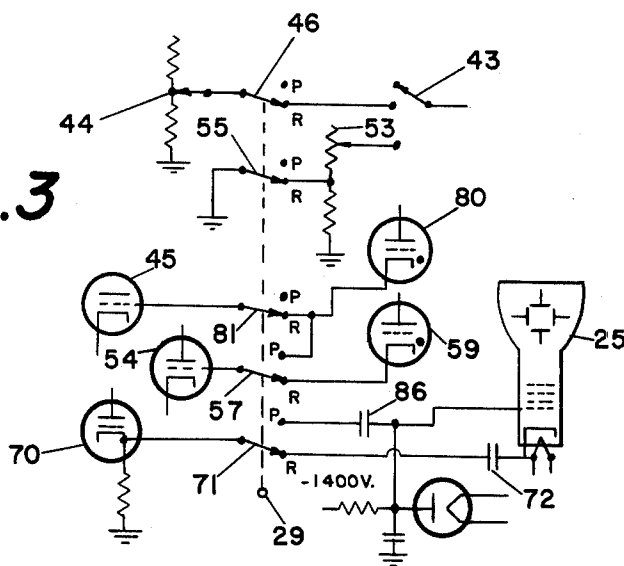


Fig. 3



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Fig. 5

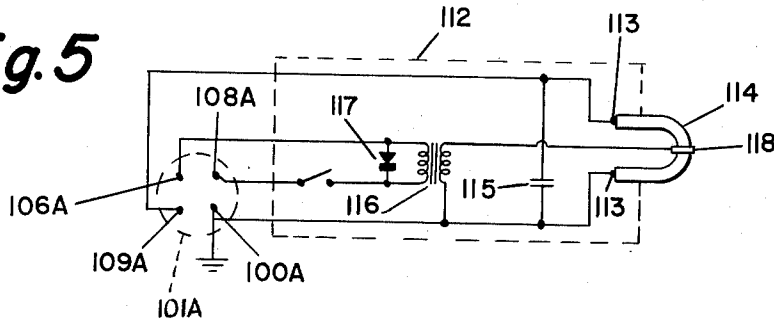


Fig. 6

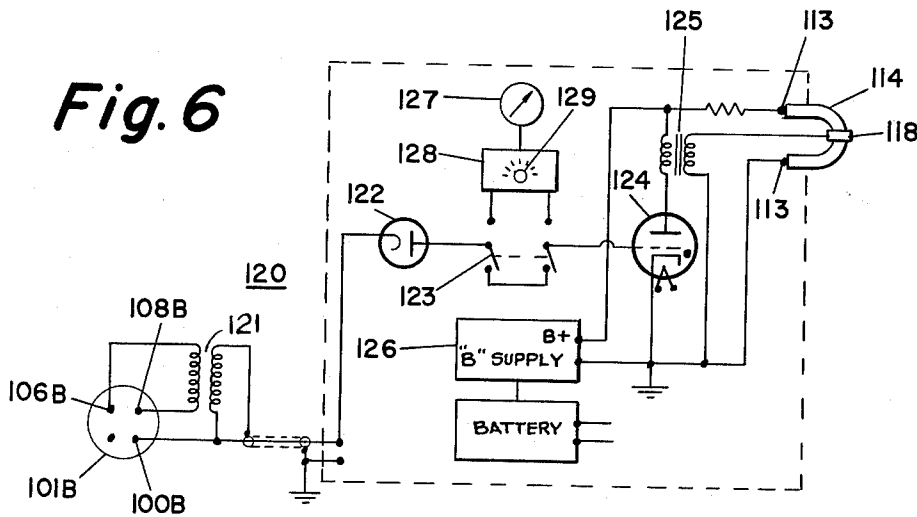
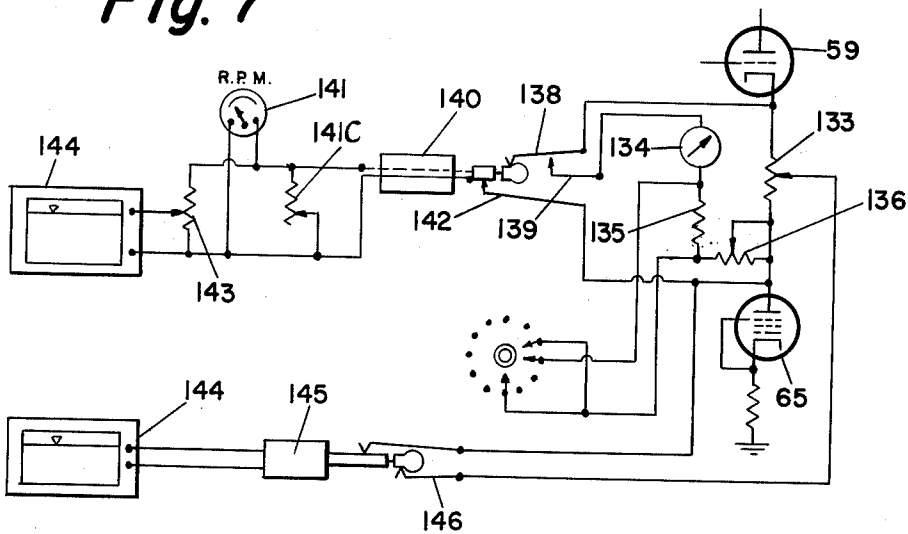


Fig. 7



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ANALYZER FOR INTERNAL COMBUSTION ENGINES

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5 Claims. (Cl. 73-116)

This invention concerns systems for analyzing the performance of multi-cylinder internal combustion engines, and particularly relates to modifications and improvements of engine-testing apparatus such as disclosed in my Patent 2,608,093 and in my copending application Serial No. 44,070, filed July 20, 1960, now Patent No. 3,101,611.

In accordance with the present invention, it is provided that the connections of the vertical and horizontal sweep oscillators respectively associated with the vertical and horizontal deflection circuits of the cathode-ray tube to produce a raster display are modified so that with the vertical sweep oscillator synchronized by the ignition pulses of a selected cylinder and with the ignition pulses of all cylinders applied to the vertical deflection amplifier and to the horizontal sweep oscillator, there is produced a parade display of the ignition circuits of each cylinder in firing sequence and a reading of the engine speed.

It is further provided that for such parade display the connections of the beam-intensity control circuit for the cathode-ray tube are modified to insure that the high amplitude, short-duration spikes corresponding with firing of the cylinders are made clearly visible notwithstanding the fast writing speed of the cathode beam at such times.

It is further provided that all of the circuit changes required to produce either a parade display or a raster display can be effected by a simple switching operation requiring no knowledge by the test operator of the internal circuit complexities of the oscilloscope and requiring no resetting of various oscilloscope controls.

Further in accordance with the invention, the oscilloscope includes a thyatron relay triggered by the vertical sweep oscillator for control of an internal stroboscope light which is utilized to determine the ignition advance of spark-fired engines and for accurate setting of pickup devices used in testing of diesel engines.

Further in accordance with the invention, the oscilloscope has provisions for plug-in connections to one of its sweep circuits of an external tachometer and/or speed recorder. For checking the calibration of the meter or recorder, the sweep-oscillator circuits include switching means for applying to them two known frequencies derived from the power supply of the oscilloscope. With the oscilloscope pattern checking proper functioning of the sweep oscillators for the applied known frequencies, the calibrating resistance of the tachometer or speed-recorder may be reset if necessary to provide a correct speed reading.

The invention further resides in an analyzer apparatus having features hereinafter described and claimed.

For a more detailed understanding of the invention, reference is made in the following description of a preferred embodiment thereof to the accompanying drawings in which:

FIGS. 1A and 1B form a composite figure schematically showing the components and circuitry of the analyzer;

FIG. 2 is a schematic of the power supply for the analyzer of FIGS. 1A and 1B;

FIG. 3 is a detailed view showing a multi-gang switch and its connections to certain components of the analyzer;

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FIGS. 4A and 4B show a typical parade display with and without trace-brightening;

FIGS. 5 and 6 illustrate two types of strobolamp units with plug-in connections for control by an electronic relay of FIG. 1B;

FIG. 7 schematically illustrates external speed-indicating and recording means together with associated circuitry of FIG. 1B; and

FIG. 8 shows a cathode-ray display for calibration and checking purposes.

Referring to FIG. 1A, the timer 10, ignition coil 11 and distributor 12 are exemplary of a typical high-voltage ignition system of an internal combustion engine to be tested. The cam 13 of timer 10 effects separation of contacts 14 suitably before the end of the operation of each cylinder of the engine. The resultant interruption of current flow in the primary winding of the ignition coil 11 induces a high-voltage in the secondary winding which at that time is connected by the distributor 12 to the spark plug of the cylinder to be fired.

Thus, for each cycle of the engine, the high-tension lead 15 from the ignition coil 11 to the distributor 12 is energized by high-voltage firing pulses in number corresponding with the number of cylinders of the engine. Also during each cycle of the engine, each of the high-tension leads 16 from the distributor 12 to a corresponding one of the cylinder spark plugs is in firing sequence energized by a high-voltage firing pulse.

In the analyzer arrangement shown, the firing pulses for a selected cylinder, for example cylinder #1, are picked up by lead 17, capacitively coupled as by insulated clip 18 to the high-tension lead 16 individual to the spark plug of that cylinder. The lead 17 is connected to terminal 19 of the oscilloscope 20, which, as later explained, is in the preamplifier circuit 66 of the vertical sweep oscillator 21 (FIG. 1B) of the oscilloscope. The firing pulses for all cylinders are picked up by the lead 22 (FIG. 1A) which is capacitively coupled as by insulated clip 23 to the high-tension lead 15 common to all cylinders. The lead 22 is connected to terminal 24 of the oscilloscope which, as later explained, is connected both to the vertical deflection amplifier 30 of the oscilloscope and to the preamplifier 64 of the horizontal sweep amplifier 58 of the oscilloscope (FIG. 1B). With its input circuits so coupled to the ignition system and with its internal connections modified as hereinafter explained, the cathode-ray tube 25 (FIG. 1B) of the oscilloscope produces a parade pattern, exemplified by FIGS. 4A and 4B, of the firing pulses of the cylinders each with its accompanying damped oscillatory discharge and subsequent wavetrain due to reclosure of the timer contacts.

In producing this display, the ignition system pulses of all cylinders are impressed upon the vertical deflection amplifier 30 whose push-pull output tubes 31A, 31B (FIG. 1B) are respectively coupled to the vertical deflection plates 32 of the cathode-ray tube 25. The output tubes 31A, 31B are driven by a preamplifier stage including tubes 32A, 32B. The sensitivity of the amplifier 30 can be adjusted by resistor 33 (FIG. 1A) connected between the grids of the preamplifier tubes. With switch 34 thrown to the position shown, the ignition pulses applied to terminal 24 of the oscilloscope are applied to the input circuit of the vertical-deflection preamplifier tubes 32A, 32B. Because of the high level of the ignition pulses, they are attenuated by a capacitive potential-divider network including capacitors 35, 36. By way of example, capacitors 35, 36 may respectively be 10 micromicrofarads (mmfs.) and 0.01 microfarad (mf.). With switch 34 thrown to its opposite position for connection of the vertical deflection amplifier 20 to terminal 40 of the oscilloscope, the attenuator network 35, 36 is excluded for am-

plification of low-level signals applied to terminal 40 and utilized as disclosed in my aforesaid copending application, Serial No. 44,070, now Patent No. 3,101,611 for analysis of the operation of Diesel-type engines.

The variable resistance 41 (FIG. 1B) in the screen-grid circuits of the output tubes 31A, 31B of the vertical deflection amplifier 30 is for vertical centering of a raster or parade display on the face of the cathode-ray tube. The variable resistance 42 in the grid circuit of output tube 31B is for adjusting the line spacing of a raster type of display pattern. For such purpose, it is connected via switch 43 to the adjustable contact of the D.C.-balance resistor 44 in the cathode circuit of the vertical drive tube 45, which for the raster display is coupled to the circuit of the vertical sweep oscillator 21. For the parade type of display, the connection of resistor 44 to the vertical deflection amplifier is broken by switch 46 (FIGS. 1B and 3) which, as will subsequently appear, is preferably ganged with other switches in the oscilloscope circuits to provide a display-selector 29.

The horizontal deflection plates 47, 47 of the cathode-ray tube are coupled to the output of the horizontal deflection amplifier 48 comprising tubes 49A and 49B. The resistance 50 in the grid-biasing circuit of tube 49B is adjustable to select the starting position of the beam spot at the beginning of a horizontal sweep. The resistance 51 in the grid circuit of tube 49A is adjustable to vary the sensitivity of amplifier 48 to the horizontal sweep signals. One terminal of resistance 51 is connected to a point of fixed biasing potential afforded by the tapped potential-divider resistance 52. Its other terminal is connected to the adjustable contact of resistance 53 in the cathode circuit of the preamplifier tube 54. For the raster type display, the lower end of resistor 53 is connected to ground through switch 55 (FIGS. 1B and 3) and the setting of resistance 53 provides the line-start clamp-bias for successive lines of the raster. For the parade type display, the switch 55 is opened to connect the lower end of line-start clamp-resistor 53 to ground through an additional cathode resistor 56 of relatively high magnitude, for example, 6800 ohms. Preferably and as shown in FIG. 3, this switch is one of those included in the display selector 29.

For the raster type of display, the grid of the preamplifier tube 54 of the horizontal-deflection amplifier 48 is connected via switch 57 to the output circuit of the horizontal sweep oscillator 58 including the gaseous discharge tube 59. The anode-cathode circuit of tube 59 includes a selected combination of capacitors 60 as predetermined by the setting of the ganged wafer switches 61, 62, 63. In the interval between successive conduction periods of tube 59, as effected by the firing pulses of all cylinders as picked up by lead 22 and amplified by amplifier 64, the selected capacitors 60 are charged by the anode current of tube 65 in the cathode circuit of the sweep oscillator tube 59. Thus, during such intervals the grid potential of preamplifier tube 54 falls at a rate preset by switches 61-63. Each time the tube 59 is fired, it affords a low resistance path for discharge of the selected capacitors 60 and accordingly the grid potential of tube 54 is abruptly increased for a fast return sweep of the cathode-ray beam.

The sawtooth output of the horizontal sweep oscillator 58 is also applied to the grid of tube 70 whose cathode is connected through switch 71 and capacitor 72 (FIGS. 1B and 3) to the cathode of the cathode-ray tube 25. Capacitor 72 and its coupling resistor have a short time constant so only the fast voltage rise portion at the sawtooth-wave is effective. The return traces of the cathode-ray spot are thus suppressed or blanked out by the positive fast return sweep pulse. The sawtooth-wave as appearing at the cathode of tube 70 is also applied to the rectifiers 73, 74 to provide the grid bias for the charging tube 65 of the horizontal sweep oscillator 58 and of the charging tube 75 of the vertical sweep oscillator 21. The rectifiers 73, 74 are positively biased so only the positive tip of the

sawtooth-wave is rectified. The pulse output of rectifiers 73, 74 is smoothed by the filter comprising resistor 76 and capacitors 77, 78.

Also for the raster type of display, the cathode of the vertical sweep oscillator tube 80 is connected via switch 81 (FIGS. 1B and 3) to the grid of tube 45 of the vertical drive circuit. The resistor 44 is common to the cathode circuits of tubes 45 and 82. The cathode circuit of tube 82 additionally includes a resistance means 83 adjustable step-by-step by wafer switch 84 to correspond with the number of cylinders of the engine under test. This switch is ganged with switches 61-63 which affords step-by-step adjustment of the time constant of the horizontal sweep oscillator circuit. The potentiometer or tilt adjustment resistor 85 in the grid circuit of tube 82 of the vertical drive circuit is coupled by capacitor 86 to the anode circuit of preamplifier tube 54 of the horizontal deflection amplifier 48.

In the interval between successive firing of the #1 cylinder, the capacitor 86 in the anode-cathode circuit of the gaseous oscillator tube 80 is charged by the anode current of tube 85. Each time the #1 cylinder is fired, the ignition pulse picked up by lead 17 triggers tube 80 to conductive state to provide a discharge path for capacitor 86. The abrupt change in the cathode potential of tube 80 as applied to the grid of tube 45 with resultant change of its cathode current and the grid bias of tube 31B causes the cathode-beam spot to return to the starting position for the top raster line (switches 43 and 46 being closed). As each of the other cylinders in turn fires, the vertical drive sawtooth-wave applied to the grid circuit of tube 82 from the preamplifier tube 54 of the horizontal drive circuit is effectively vertically to displace the beam spot for the next lower line of the raster and to keep the raster line horizontal.

For the parade type of display, the switches 57, 81 and 46 are thrown to the positions shown in FIG. 1B to connect the horizontal drive preamplifier 54 to the vertical sweep oscillator 21 instead of to the horizontal sweep oscillator 58, to disconnect the vertical sweep oscillator 21 from the vertical drive circuit including tubes 45, 82, and to disconnect the vertical drive circuit from the vertical deflection amplifier 30. Thus, for each cycle of the engine, the cathode-beam spot now makes one horizontal traverse of the face of tube 25 with the pulse trains related to the firing of the individual cylinders sequentially displaced in firing order (FIGS. 4A, 4B).

With the cathode of tube 70 connected to the cathode of the cathode-ray tube 25, the parade display, as shown in FIG. 4B, has a series of eight blank spots each occurring when one of the cylinders is fired. To eliminate these blank spots and to make clearly visible the high amplitude, short-duration spikes occurring for each firing (FIG. 4A), the beam-blanking circuit is converted to a beam-brightening circuit by shifting the connection of the cathode of tube 70 to the grid of the cathode-ray tube 25 via the switch 71 and capacitor 86 (FIGS. 1B and 3). The coupling capacitor 86 for trace-brightening is substantially larger than the coupling capacitor 72 used for trace blanking, for example, their respective capacitances may be 0.0022 mf. and 470 mmfs. The resistance 78 of the order of 100,000 ohms, for example, is included in the grid biasing circuit of the cathode-ray tube to provide the desired coupling resistance for the positive trace-brightening. It is to be noted that the horizontal sweep oscillator continues to oscillate in normal manner for the parade display position of the multi-point switch including switch 57 so to provide the eight trace-brightening pulses and to provide the D.C. feedback to tube 75 which maintains a constant pattern length.

As shown in FIG. 3, all of the switches 46, 53, 81, 57 and 71 are preferably ganged for simultaneous operation either to their raster display position R or to their parade display position P. Thus, a test operator by turning the

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single actuating knob of the display selector 26 may make all of the necessary circuit changes for either type display.

The oscilloscope unit 20 also includes a thyatron relay circuit 95 (FIG. 1B) controlled by the vertical sweep oscillator 21 to provide trigger pulses for an external strobelight unit. The control grid circuit of the relay tube 96, which may be a type 2D21, is coupled to the output circuit of the vertical sweep oscillator 21 by the capacitor 97 which may be of the order of 0.001 mf. The control grid of tube 96 is connected to the ground terminal 100 of socket 101 through resistors 98, 99 which may respectively be of the order of 10,000 and 500,000 ohms. The cathode of tube 96 is connected to ground through resistor 102 which may be of the order of 5600 ohms, and which is shunted by the bypass condenser 103, which may be of the order of 25 mfs. The anode of tube 96 is connected through resistor 104 to the positive terminal of a source of anode voltage provided by the power supply (FIG. 2) and also to the terminal 106 of socket 101 through the resistor 105. Suitable values of resistors 104, 105 are respectively 166,000 and 100 ohms. The capacitor 107 which may be of the order of 0.2 mf. is connected from the cathode of tube 96 to socket terminal 108. The remaining terminal 109 of socket 101 is connected to the junction of resistors 110, 111 forming a potential-divider circuit between the cathode of tube 96 and its source of anode voltage.

When the cable of the strobeltube unit 112 (FIG. 5) is plugged into socket 101 of oscilloscope 20, the pins 100A, 109A of its plug 101A engage the socket terminals 100, 109 to connect the end terminals 113, 113 of the strobetube 114 between ground and the gas-ionizing potential afforded by resistors 110, 111 of the relay circuit 95 (FIG. 1B). Internally of unit 112, the end terminals 113, 113 of the strobetube 114 are connected to capacitor 115, which may be of the order of 2 mfs. for additional stabilization of the ionizing voltage. The unit 112 also includes an internal transformer 116 whose primary winding, as shunted by diode 117, is connected to pins 106A, 108A of the cable plug 101A. The secondary winding of the step-up transformer 117 is connected between one of the end terminals 113 of the strobetube and its flash electrode 118. With unit 112 plugged into the oscilloscope socket 101, the diode 117 completes a charging circuit for capacitor 107 of the thyatron relay 95. Such charging occurs in the interval between successive trigger pulses from the vertical sweep oscillator 21; and during such charging the diode 117 effectively shunts the primary winding of the transformer 116. For each trigger impulse, the capacitor 107 of relay 95 is discharged by firing of thyatron 96 and part of the discharge current flows through the primary winding of transformer 116 in unit 112. The resulting high voltage pulse induced in the secondary winding of transformer 116 and applied to electrode 118 of the strobetube 114 is effective to produce a brief high-intensity flash which is repeated in accurately timed relation to successive cycles of the vertical sweep oscillator 21.

Because of the automatic spark advance incorporated in automotive type engines, the display of the cathode-ray tube 25 does not correlate the time of firing of the cylinders to crankshaft position, but such correlation can be determined by the strobe-lamp unit. The flywheel or vibration damper of the engine is calibrated in crankshaft degrees and a cooperating stationary pointer or marker indicates when the #1 piston, for example, is at top dead-center. With the strobetube 114 positioned to illuminate the pointer and the adjacent flywheel area, the test operator can ascertain the extent to which the spark is advanced for the different engine speeds.

The portable strobe-unit 112 may also be used accurately to set synchronizing and marker pickup devices, such as shown in my copending application, for use of the oscilloscope unit in Diesel engine testing. The position of such devices can be set only approximately with

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the engine at rest. With the engine running, the mounting brackets for the pickup devices can be adjusted so that as illuminated by the strobe-light flashes, the top center or other selected crank angle calibration of the flywheel is in alignment with the stationary marker to start the raster lines at any desired crank angle.

The thyatron relay 95 of the oscilloscope 20 may also be used to provide trigger pulses for the type of strobelight unit 120 shown in FIG. 6. With the cable plugs 101B of this unit inserted into the oscilloscope socket 101, its pins 106B, 108B connect the primary winding of the step-up transformer 121 in circuit with the capacitor 107 of relay 95 of the oscilloscope. The transformer 121 may be incorporated in the cable at or near the plug 101B. The ungrounded secondary lead of this transformer is connected through diode 122 and switch 123 to the grid of a thyatron tube 124. The anode circuit of tube 124 includes a primary winding of a second step-up transformer 125 whose ungrounded secondary lead is connected to the flash electrode 118 of the strobetube 114. The end terminals 113, 113 of the strobetube 114 are connected across the battery-powered inverter 126 or equivalent D.C. source of anode current for tube 124. Thus, each time the relay 95 of the oscilloscope unit 20 is triggered by the output of its vertical sweep oscillator 21, the secondary winding of transformer 121 of the external unit 120 produces a high-voltage pulse sufficient to trigger the thyatron 124. The thyatron 124 in turn is momentarily conductive to excite transformer 125 and so cause a brief high-intensity flash in the strobetube 114.

The synchronized flash of the strobetube 114 of unit 120 may be used in the same ways as above described in connection with the strobetube of unit 112 for testing both spark-fired engines and those of the Diesel type. The unit 120 additionally incorporates a meter 127 and a one-shot multivibrator 128. With the switch 123 thrown to its upper position, the multivibrator is switched to one state by the trigger impulses from relay 95 of the oscilloscope, and upon self-induced return to its original state produces a trigger pulse for the thyatron 124 of unit 120. The time delay ensuing before the multivibrator is returned to its original state by its internal circuitry is adjustable by the impedance control knob 129. A time scale associated with knob 129 may be calibrated in degrees of crank angle with respect to dead-center and the meter 127 connected in circuit with one of the multivibrator tubes is set to produce a given deflection when, at slow speed, the #1 cylinder fires with its piston at top dead-center. At higher engine speeds, the time delay is increased by adjustment of knob 129 until the strobetube flashes show alignment of the top dead-center mark of the flywheel with the stationary index or pointer. The advance of the spark in crank-angle degrees may then be read from the scale associated with knob 129.

As shown in FIG. 1B, the resistor 133 between the cathode of the horizontal sweep oscillator tube 59 and the anode of tube 65 is shunted by a voltmeter circuit including, in series, the meter 134, multiplier resistance 135 and calibrating rheostat 136. The scale of meter 134 reads in revolution per minute of the engine under test and is mounted on the panel face of the oscilloscope 20. It is to be noted that for either the raster display or the parade display, the sawtooth oscillator 58 is triggered by the ignition pulses of all cylinders so that the tachometer gives the same engine speed reading for both displays. To obtain enhanced readability and accuracy of the readings of engine speed, the oscilloscope 20 is provided with a jack 137 for plugging in an external tachometer 141 (FIG. 7) having a much larger scale and a more accurate meter movement. As shown in FIG. 1B, the normally closed contacts 138, 139 of the jack 137 complete the internal tachometer circuit above described. When the external tachometer plug 140 is inserted (FIG. 7), the jack contacts 137, 138 are separated to disconnect the internal tachometer 134 and at the same time the external

tachometer 141 is connected across resistor 133 by the jack contacts 138, 142. By way of example, the external tachometer 141 may have a scale over seven inches long with full deflection for a meter current of 100 micro-amperes. It may have two scales respectively calibrated to read either 1,000 or 4,000 r.p.m. full scale with a multiplier switch, not shown, to select either scale. The associated rheostat 141C which may be of the order of 1,000 ohms is for calibrating the external tachometer.

For recording the engine speeds during a test run, the tachometer 141 may be shunted by a relatively high resistance potentiometer 143 having, for example, a resistance of the order of 10,000 ohms. A self-balancing recorder 144 of known type is connected across a potentiometer which is adjustable for calibration purposes. At balance, the recorder 144 does not draw current from the tachometer circuit and so does not affect the tachometer reading. For recording speed with the internal tachometer 134 in circuit, the recorder 144 is connected by plug 145 (FIG. 7) and the normally-open circuit jack 146 of the oscilloscope 20 between an end terminal and the adjustable contact of potentiometer resistance 133. The contact of resistance 133 is adjustable for calibration of recorder 144. At balance, the recorder 144 does not draw current from the resistance 133 and so does not affect the reading of internal tachometer 134.

For adjusting or checking the calibration of the tachometers and/or speed recorders, the input circuits of the horizontal and vertical synchronization preamplifiers 64 and 66 are switched to apply to them two different frequencies available from the power supply (FIG. 2) of the oscilloscope 20. Specifically, when the calibrating switch 150 (FIGS. 1A and 2) is closed, its contact 151 completes a circuit from the grid of tube 152 through capacitor 153 to the undergrounded terminal of secondary winding 154 of the supply transformer 155 and its contact 156 completes a circuit from the grid of tube 157 through capacitor 158 to the cathode of the high-voltage rectifier tube 159. Thus, with switch 150 closed, a 60-cycle or power-line frequency signal is applied as a synchronizing pulse for the vertical sweep oscillator 21 and a signal of twice that frequency is applied as a synchronizing pulse for the horizontal sweep oscillator 58.

With the ganged display selector 26 set for a raster display, the proper presentation on the face of the cathode-ray tube for calibration purposes is substantially as shown in FIG. 8. Assuming the power-line frequency of 60 cycles, the speed reading of the tachometer 134, 141 and of the recorder 144 should be 3600 r.p.m. for such display. If not, the associated calibration resistance 136, 141C and 133 should be adjusted until that reading is obtained. After checking or re-calibration, the contacts 151, 156 of the calibrating switch 150 are opened for beginning or resumption of engine testing.

The secondary winding 154 which provides the 60-cycle calibration signal is also used for supplying the heater current of a group of tubes of the oscilloscope. The heater current of the remaining tubes is supplied from the other lower voltage secondary windings 159, 160 of transformer 155. The heater current for the relay tube 96 may be supplied from one of these low-voltage windings of transformer 155, or, as shown in FIG. 2, may be supplied from an additional transformer 161 incorporated in the oscilloscope and controlled by the on-off switch 163 of the oscilloscope.

The full-wave rectifier 159, which supplies the 120-cycle calibration signal, also supplies the relay tube 96 with anode current having a substantial 120-cycle ripple component and which is of higher voltage, because taken off in advance of filter 162, than applied to all tubes of the oscilloscope with the exception of the cathode-ray tube 25. The remainder of the oscilloscope power supply circuits need not be discussed in detail because con-

ventional and because the legends on FIG. 1B indicate the various operating voltages applied to the various tubes of the oscilloscope and the corresponding legends of FIG. 2 indicate where such voltages are derived from the various rectifier and voltage-regulation circuits.

What is claimed is:

1. A multi-cylinder engine analyzer for testing a spark-fired internal combustion engine comprising an oscilloscope having vertical deflection and horizontal deflection amplifiers respectively connected to the vertical and horizontal deflection circuits of a cathode-ray tube, a vertical sweep oscillator, a horizontal sweep oscillator, means capacitively coupled to the high-tension ignition system of said engine for supplying the ignition circuit pulses of all cylinders to said vertical deflection amplifier and to said horizontal sweep oscillator and for supplying the ignition circuit pulses of a selected one of said cylinders to said vertical sweep oscillator, a vertical drive circuit, switching means operable selectively to provide a raster display or a parade display of the ignition circuit events comprising switches which for the raster display provides connections from said vertical drive circuit to said vertical sweep oscillator and to said vertical deflection amplifier and provides connections from said horizontal sweep oscillator to said horizontal deflection amplifier and which for the parade display breaks said connections and provides connections from said vertical sweep oscillator to said horizontal deflection amplifier, said horizontal deflection amplifier including a preamplifier tube selectively connected by one of said switches to the horizontal sweep oscillator and to the vertical sweep oscillator, said preamplifier tube having in its cathode circuit a potentiometer providing an adjustable raster-line start-clamp bias for said horizontal deflection amplifier, and in which said switching means includes a switch which for the raster display connects said potentiometer directly to ground and which for the parade display connects said potentiometer to ground through a high resistance to provide a suitably high bias irrespective of the adjustment of said potentiometer.

2. A multi-cylinder engine analyzer as in claim 1 in which the output circuit of the horizontal sweep oscillator includes a meter for reading the engine speed both for the raster display and for the parade display.

3. A multi-cylinder engine analyzer as in claim 2 in which the oscilloscope is powered from an A.C. power line, and in which for checking and adjusting the meter calibration there is provided a second switching means for applying the power-line frequency to synchronize said vertical sweep oscillator and a harmonic of said power-line frequency to synchronize said horizontal sweep oscillator, said display-switching means being set for a raster display to provide a cathode-ray pattern representative of an engine speed within the range of said meter.

4. A multi-cylinder engine analyzer as in claim 1 which additionally includes a beam-intensity circuit selectively connected by said switching means to said horizontal sweep oscillator for the raster display and to said vertical sweep oscillator for the parade display, and in which said switching means includes a switch applying the output of said beam-intensity circuit selectively to the cathode or to the grid of said cathode-ray tube to provide blanking of the return traces of the cathode-ray beam for the raster type of display and to intensify the beam during the successive firing intervals of all cylinders for the parade type of display.

5. A multi-cylinder engine analyzer as in claim 1 including a thyatron relay fired by the output pulses of said vertical sweep oscillator, and an external unit including a strobetube triggered by the output of said thyatron relay for correlating said displays with positions of the engine crankshaft.

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RICHARD C. QUEISSER, *Primary Examiner*.