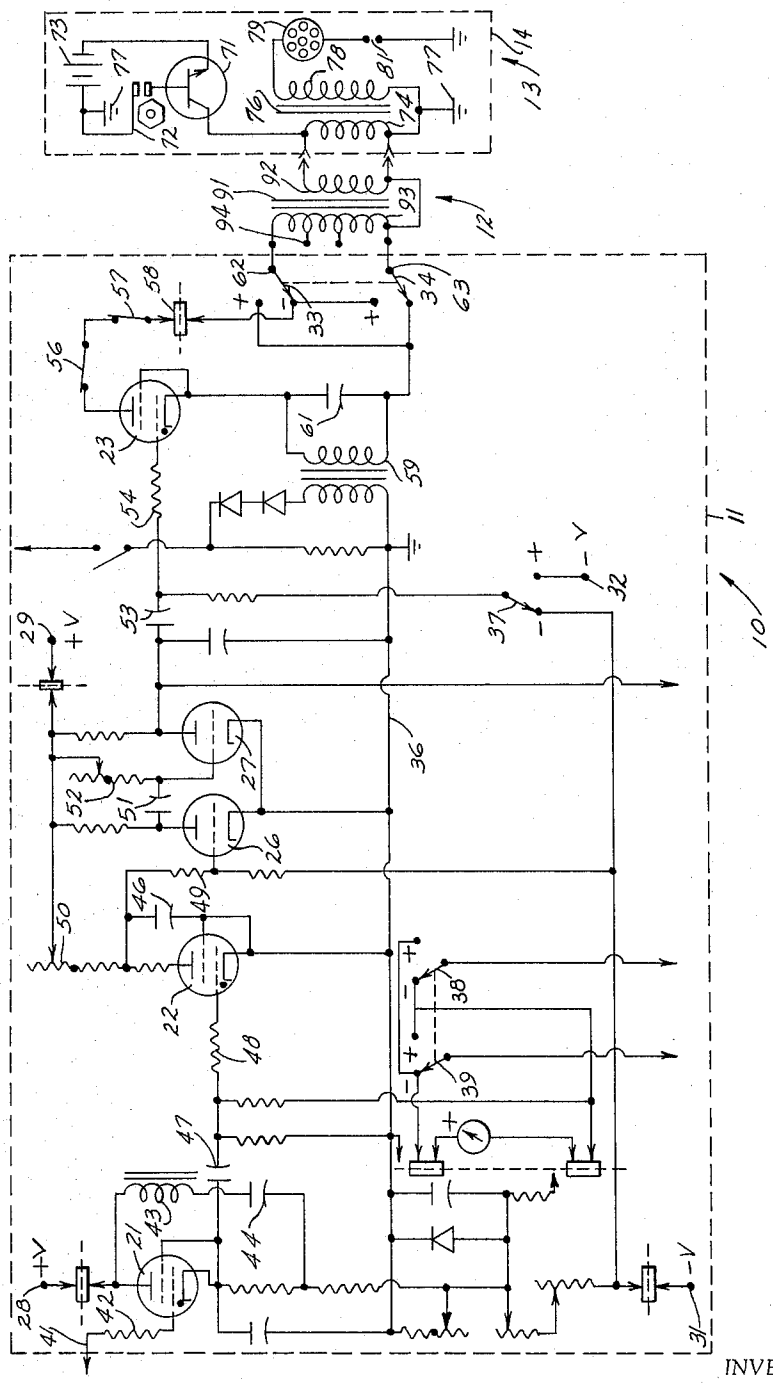
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DYNAMIC COMPRESSION CIRCUIT

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INVENTOR.

ANATOLIJS MAZURKEVICS

BY

Woodhams, Blanchard and Flynn

ATTORNEYS

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DYNAMIC COMPRESSION CIRCUIT

Anatolijs Mazurkevics, Kalamazoo, Mich., assignor to Allen Electric and Equipment Company, Kalamazoo, Mich., a corporation of Michigan

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This invention relates to a dynamic compression testing circuit for electrically ignited internal combustion engines and more specifically relates to a dynamic compression circuit including means adapting it for use with low voltage ignition primary circuits such as those employing transistors as switching elements.

The circuit embodying the invention was developed in response to a need in automotive engine testing and will be described hereinafter in terms of such use for purposes of illustration only. However, the circuit embodying the invention may be used with spark ignited engines other than automotive engines and the specific reference to automotive engines will be recognized as illustrative only.

Existing dynamic compression circuits are known for testing engines having conventional or nontransistorized ignition systems wherein the breaker points are connected directly to the primary winding of the ignition coil for energizing same. One of these existing circuits, namely, that shown in U.S. Patent No. 2,986,032, was connected to a single reference spark plug, usually the No. 1 spark plug of the engine, and across the primary of the ignition coil for preventing firing of another spark plug, namely, the test spark plug associated with the cylinder the compression of which is to be checked. With the engine running at a predetermined speed, a firing pulse applied to the No. 1 spark plug by the ignition system was also applied to the dynamic compression circuit. The pulse applied to the dynamic compression testing circuit was modified and time delayed by a predetermined increment to occur simultaneously with passage of a firing impulse to the test spark plug. The time delayed signal acuated shorting means for shorting the ignition points for preventing energization of the spark plug by said firing impulse, thus, the test plug was not fired. Thus, the engine could be run with a preselected test cylinder electrically shorted, the consequent drop in engine performance being then a measure of the contribution of said test cylinder to the total engine output. In the above-discussed circuit, a trigger device, such as a thyratron tube comprised the shorting means. In the following discussion, a trigger device will be considered to be one which is turned on by two conditions but which is turned off by a change in only a particular one of these two conditions, variations in the other condition being unable to effect turnoff. The thyratron used in previous circuits depended upon the voltage drop across the primary of the ignition coil for anode potential and the relatively high impedance primary winding of a conventional ignition coil satisfactorily supplied this anode potential. Testing machines using this circuit have been built and are in successful use in a large number.

There has for some time been available on the market vehicles and engines having ignition systems of a different type characterized by relatively low coil primary impedances and/or relatively low coil primary voltage drops and include transistorized ignition systems. Further, kits and the like are widely marketed for converting existing engines to this type of ignition system. It has been found that the aforementioned dynamic compression circuit cannot be used with many of these nonconventional systems because the coil primary windings of said systems cannot supply adequate anode potential to the thyratron of the aforementioned dynamic compression circuit as to allow

conduction thereof. In short, the existing dynamic compression circuit has been found unuseable with at least a large number of the transistorized ignition systems currently marketed and in use. The problem is made more acute by the fact that many testing machines incorporating said existing dynamic compression testing circuits are in the hands of relatively small garage owners and the like needing testing machines capable of handling the new transistorized ignition systems but unable to afford expensive modifications on or replacement of their existing testing machines.

Hence, the objects of this invention include:

1. To provide a dynamic compression test circuit capable of use with an electrical ignition system in a spark ignited combustion engine utilizing transistors or the like and with an ignition system having a relatively low ignition coil primary impedance or primary voltage drop.

2. To provide a circuit, as aforesaid, having transformation means capable of sufficiently amplifying the voltage drop across an ignition coil primary of low impedance that trigger means in said circuit are provided adequate anode potential.

3. To provide a circuit, as aforesaid, wherein said transformation means allows transfer of a zero impedance condition therethrough whereby conduction of said trigger shorts the ignition coil primary winding.

4. To provide a circuit, as aforesaid, for use in adapting existing dynamic compression test circuits to transistorized ignition systems and has as few as a single additional part, which part is readily available or manufacturable, which part is adaptable to a wide variety of voltage requirements, which part is easily incorporated in existing circuits, which part is easily fitted within the physical confines of existing testing machines and which part does not materially alter the training required to alter the use of existing machines.

5. To provide a circuit, as aforesaid, which may easily and inexpensively be incorporated into new testing machines during the manufacture on either a mass production or individually produced basis, which increases the probability of easy adaptation of such testing machines to future ignition systems, which requires little or no retraining of personnel in its use, which will have a long, substantially maintenance free, service life and which is easily maintained.

Other objects and purposes of this invention will be apparent to persons acquainted with apparatus of this general type upon reading the following specification and inspecting the accompanying drawing:

In the drawing:

The drawing is a schematic diagram of a dynamic compression testing circuit embodying the invention.

Description

Briefly, the drawing discloses transformation means **12** connecting an existing dynamic compression circuit **10** enclosed by the broken line **11**, with a transistorized ignition system **13**, substantially enclosed by the broken line **14**.

The existing dynamic compression circuit **10** which is generally similar to that of the aforementioned Patent No. 2,986,032 includes thyratrons **21**, **22** and **23** and high vacuum triodes **26** and **27**. Positive anode voltage is supplied to the thyratron **21** from a high voltage point **28** and is supplied to the tubes **22**, **26** and **27** from a high voltage point **29**. Negative potential is supplied to the circuit from the points **31** and **32**. Engine ground potential is applied to the ground line **36** of the dynamic compression circuit through the polarity switches **33** and **34**. The polarity switches **33** and **34** are preferably operably locked to further polarity switches **37**, **38** and **39** so that the dynamic compression testing circuit **10** may be used on ignition systems having either the positive or negative bat-

tery terminals grounded. An input line 41 is connected to the ungrounded electrode of a reference spark plug such as the No. 1 plug of the engine. The input line 41 is connected through a resistance 42 of the control grid of the thyratron 21 whereby a firing voltage across the No. 1 spark plug will cause the thyratron 21 to conduct. A series inductance 43 and capacitance 44 are connected across the primary electrodes of the thyratron 21 and firing of the thyraton 21 is terminated by the quenching action thereof. The thyratron 22 has a capacitance 46 connected thereacross. A relatively sharp pulse caused by the conduction of the thyratron 21 passes through a capacitance 47 and resistance 48 to the control grid of the thyratron 22 to fire same which firing rapidly discharges the capacitor 46 through said thyratron 22. Discharge of the capacitor 46 drops the anode potential on the thyratron 22 and quenches same. The capacitor 46 now begins charging through an adjustable resistance which controls the state of charge thereof. After the capacitor 46 has charged to a preselected voltage thereacross, said voltage is applied through a resistance 49 to the grid of the normally nonconductive tube 26 to render same conductive. Thus, conduction of the tube 26 is time delayed for a preselected interval determined by the setting of the adjustable resistance 50 and will preferably occur when a preselected test spark plug on the engine is about to be fired. In this way the setting of the resistance 50 selects the cylinder to be tested.

The anode of the tube 26 connects to the control grid of the normally conductive tube 27 through a capacitor 51, said control grid also being connected through an adjustable resistance 52 to the high voltage point 29.

When the tube 26 becomes conductive, its anode potential drops and the capacitor 51 transfers this lower potential to the grid of the tube 27 to turn same off. Thereafter, the capacitor 51 charges through the resistance 52 and tube 26 at a rate determined by the resistance 52. After the capacitor 51 has charged to a predetermined voltage, said voltage will rest on conduction of the tube 27. Thus, the tube 27 remains nonconductive and hence has a high anode potential for a period determined by the setting of the resistance 52 whereby to compress a positive pulse of preselected length through a capacitance 53 and resistance 54 onto the control grid of the thyratron 23.

The thyratron 23 has its anode connected through normally closed switches 56, 57 and 58 to the positive contacts of the polarity switches 33 and 34. The negative contacts of the polarity switches 33 and 34 are connected, here through a transformer winding 59 and capacitor 61, to the cathode of the thyratron 23. In this manner the thyratron 23 is connected across the output terminals 62 and 63 of the dynamic compression test circuit. In an ignition system wherein current is supplied to the coil primary directly through a set of breaker points, said output terminals 62 and 63 would be connected directly across the primary winding of the ignition coil.

The transistorized ignition system 13 herein disclosed is merely employed as an example of the low voltage primary ignition systems with which the circuit embodying the invention can be used. It will be recognized that the circuit embodying the invention can be used with other types of transistorized ignition systems and with nontransistorized ignition systems having a low coil primary impedance or voltage drop. The ignition system 13 includes a transistor 71 the base of which is connected through a set of breaker points 72 and a battery 73 to the emitter of the transistor 71. The collector of the transistor 71 connects through the primary winding 74 of the ignition coil 76, engine ground indicated at 77 and the battery 73 to the emitter of the transistor 71. The ignition coil 76 has a secondary winding 78 connected between ground and suitable distributor means 79, said distributor 79 being connectible to spark plugs one of which is indicated at 81. The spark plug 81 will in the following discussion be assumed to be the test spark plug, i.e., the plug associated with the cylinder to be checked for compression.

Thus, closure of the points 72 causes the transistor 71 to conduct through the coil primary 74 to energize same. Upon opening of the points 72 the transistor 71 shuts off and the field in the coil collapses to cause a very high voltage to be applied by the coil secondary 78 through the distributor 79 to one of the spark plugs, for example, the plug 81. The collapse in the coil field simultaneously causes a voltage drop across the coil primary 74. This voltage drop is generally considerably lower in a transistorized ignition system than in a conventional system.

Both the above-described dynamic compression circuit 10 and the transistorized ignition system 13 are known in the art.

The present invention contemplates insertion of the transformation means 12 between the output terminals 62 and 63 of the dynamic compression circuit 10 and the ends of the primary winding 74 of the transistorized ignition system 13. The transformation means 12 comprises a transformer 91 having a primary winding 92 which is to be connected across the primary winding 74 of the ignition coil 76. The transformer 91 has a secondary winding 93 connected at the one end thereof the grounded end of the primary winding 92. The secondary winding 93 preferably has a number of taps thereon, one of which is indicated at 94.

The secondary winding 93 is of higher impedance than the primary 92 and a given transient voltage drop across the primary 92 will result in a larger voltage drop across the secondary winding 93. Conduction of the thyratron 23 will result in a shorting out of the terminals 62 and 63 and hence of the secondary winding 93. Since the impedance of the secondary 93 is a multiple of that of the primary winding 92 it will be obvious that a zero impedance or short across the secondary winding 93 will appear as a fraction of a zero impedance, that is, a zero impedance, across the primary winding 92.

Operation

Although the operation of the circuit embodying the invention has been at least partially disclosed hereinabove, same will be given in detail hereinbelow for assuring a clearer understanding of the invention.

The operation of the dynamic compression test circuit 10, as described hereinabove, places a signal on the control grid of the thyratron 23 which biases said thyratron 23 for conduction. This signal appears in timed relation with, usually simultaneously with, the beginning of the collapse in the field of the ignition coil 76 which would, except for the circuit 10, cause the secondary 78 to fire the test spark plug 81. It will be realized that the thyratron 23 will not conduct without suitable anode-to-cathode potential thereupon. In a conventional ignition system, the test circuit output terminals 62 and 63 would be connected across the coil primary whereby the voltage drop placed thereacross by the collapse of the coil field would supply suitable anode potential for the thyratron 23. In the case of transistorized and other low primary voltage ignition systems, on the other hand, the output of the coil primary 74 if fed directly to the output terminals 62 and 63 would not provide sufficient anode potential to allow conduction of the thyratron 23. However, the transformer 91 steps up the voltage drop across the coil primary 74 and so applies an increased voltage to the terminals 62 and 63 which is sufficient to allow conduction of the thyratron 23. The thyratron thereupon conducts and thereby shorts the terminals 62 and 63 to produce a zero impedance across the secondary winding 93. The transformer 91 simultaneously produces a zero impedance across the primary 92 thereof which in turn is applied to the coil primary 74 to short same. Therefore, no voltage drop is produced across the secondary 78 and the test plug 81 is not fired. Since

the ignition coil 76 is now deenergized, it can no longer furnish anode potential to the thyratron 23 through the transformer 91 and the thyratron 23 is shut off.

The taps 94 on the transformer secondary 93 are placed as desired to afford means for adjusting the voltage applied to the anode of the thyratron 23 so as to readily adapt the test circuit 10 to the ignition systems having a wide range of coil primary characteristics, including conventional ignition systems. It is contemplated that the terminal 62 may be switched from tap to tap by switching means of any desired type. It is further contemplated that the device of the invention may be used in dynamic compression test circuits which employ trigger means other than the thyratron 23, such as, for example, a semi-conductor controlled rectifier or the like.

Although a particular preferred embodiment of the invention has been disclosed hereinabove for purposes of illustration, modifications or variations of such disclosure which lie within the scope of the appended claims, are fully contemplated.

What is claimed is:

1. In a dynamic compression tester for an electrically ignited multiple cylinder internal combustion engine having an ignition system including an ignition coil which has a relatively low primary winding voltage drop, the combination comprising:

a trigger device having anode means, cathode means and control electrode means;

means synchronized with the ignition rate of the engine for providing a firing pulse on said control electrode said trigger device requiring said firing pulse and an anode-cathode voltage in excess of that across said primary for conduction;

transformer means connected between said cathode means and anode means on one side thereof and across said coil primary winding on the other side thereof so that the voltage drop across said coil primary winding is sufficiently increased by said transformer means as to allow conduction of said trigger device and whereby said transformer means transfers the zero impedance resulting from such conduction to short out said ignition coil primary winding.

2. A dynamic compression testing circuit for testing the compression of a spark plug fired test cylinder in an automotive gasoline engine, said engine having an ignition system including a transistor-energized primary winding in its ignition coil, comprising in combination:

a trigger device having a cathode, anode and control electrode;

signal means providing a signal on said control electrode for biasing said trigger device to conduct, said signal being provided when said spark plug in said test cylinder is to be fired;

a voltage multiplying transformer having a first winding connected across said coil primary winding and having a second winding connected across said cathode and anode of said trigger device, a voltage drop across said first winding causing a greater voltage drop across said second winding which is sufficient to allow conduction of said trigger device.

3. The circuit defined in claim 2 wherein said first and second windings are connected at one end thereof for allowing transfer of ground potential of said ignition system to said dynamic compression test circuit.

4. The circuit defined in claim 2 wherein one winding of said transformer is tapped to allow connection of one

of said trigger devices and said ignition coil primary winding to different taps for accommodating trigger devices of differing anode potential requirements and for accommodating different ignition coil primary impedances and voltage drops.

5. The circuit defined in claim 2 wherein said trigger device is a thyratron.

6. In a dynamic compression tester for a spark plug ignited internal combustion engine including an ignition coil having a relatively low impedance primary winding and a secondary winding, a battery in series with the ignition coil primary, means connecting the secondary winding to a test spark plug for energizing same in response to a cessation of current flow from the battery through the ignition and a transistor having high current electrodes in series with the battery and coil primary and means for rendering the transistor conductive through the primary, the combination comprising:

a voltage stepup transformer having a low voltage winding connected across said coil primary and a high voltage winding inductively coupled to said low voltage winding;

a thyratron and means synchronized with the firing point of the test spark plug for supplying control grid potential to said thyratron in a manner to render same conductive in response to an anode-cathode potential above a preselected value;

means connecting said high voltage winding in series with the anode and cathode of said thyratron for furnishing an anode-cathode voltage thereto in excess of said preselected value upon cessation of conduction of said transistor, said connecting means including switch means actuable for connecting one end of said high voltage winding to said anode and the other end of said high voltage winding to said cathode and, alternatively, for reversing the connections of said ends to said anode and cathode to allow energization of said thyratron by ignition systems of opposite battery polarity.

7. The device defined in claim 6 in which said switch means comprises a pair of armatures connected respectively to the ends of said high voltage winding and being connected for simultaneous actuation, said switch further including a first pair of contacts alternatively selectable by the first of said armatures and a second pair of contacts alternatively selectable by the second armature, the contacts of the first pair being connected directly to oppositely selected ones of the second pair of contacts, the contacts of the first pair being connected to the anode and cathode respectively of said thyratron.

8. The device defined in claim 6 in which one end of said high voltage winding is directly connected to the adjacent end of the low voltage winding and is grounded to the ignition system ground regardless of ignition system polarity, said anode and said cathode of said thyratron being connected alternatively through said switch to said grounded ends of said windings.

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RICHARD C. QUEISSER, *Primary Examiner.*

J. W. MYRACLE, *Assistant Examiner.*