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[54] **SIGNAL GENERATING MECHANISM**

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[73] Assignee: **The Ford Motor Company,** Dearborn, Mich.

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[52] **U.S. Cl.** **310/70,** 123/148

[51] **Int. Cl.** **H02k 11/00**

[58] **Field of Search** .... 310/68 R, 68 C, 69, 310/70, 154; 123/148; 315/218

[56] **References Cited**

UNITED STATES PATENTS

3,145,324	8/1964	Race	310/70 R
3,233,128	2/1966	Tyzack	310/70 R
3,447,004	5/1969	Falge	310/70 R

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Assistant Examiner—Robert J. Hickey
Attorney—Keith L. Zerschling et al.

[57] **ABSTRACT**

A signal generating mechanism is disclosed for producing an electrical signal having a frequency proportional to the angular velocity of a rotating shaft. The signal generating mechanism may be used in the distributor for a breakerless ignition system for a multicylinder internal combustion engine, in which case the frequency of the alternating signal is equal to the rate at which ignition sparks are to be generated. The signal generating mechanism includes a lower plate and bushing through which the rotating shaft passes. A non-adjustable stator assembly is formed by a hub positioned around the bushing, the hub having an upper plate attached to it on which is affixed a permanent magnet. A stator is positioned on the permanent magnet and has an extending pole-piece that passes through an electrical pickup coil. An armature, or rotor, is formed by a toothed-wheel that is affixed to the rotating shaft. The teeth of the toothed-wheel come into and go out of alignment with the portion of the stator pole-piece that extends through the electrical coil.

5 Claims, 7 Drawing Figures

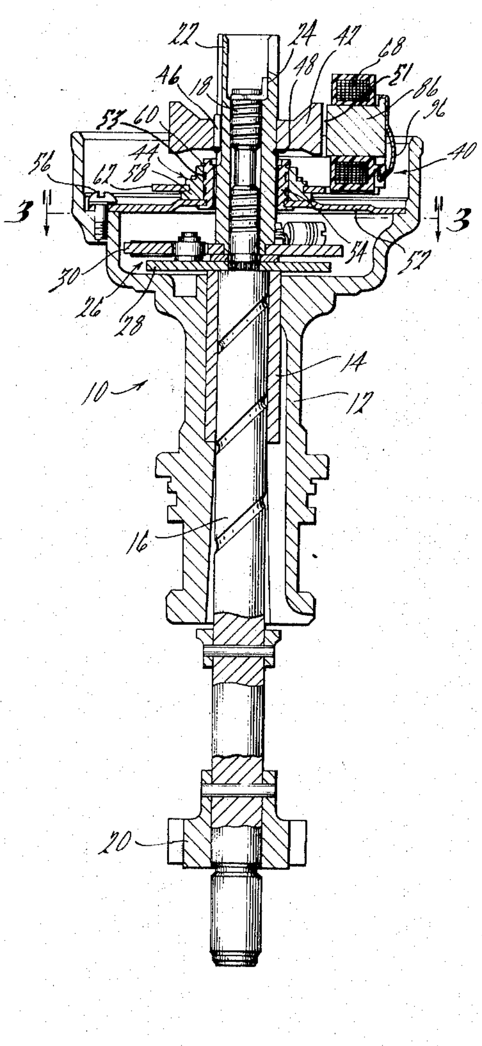
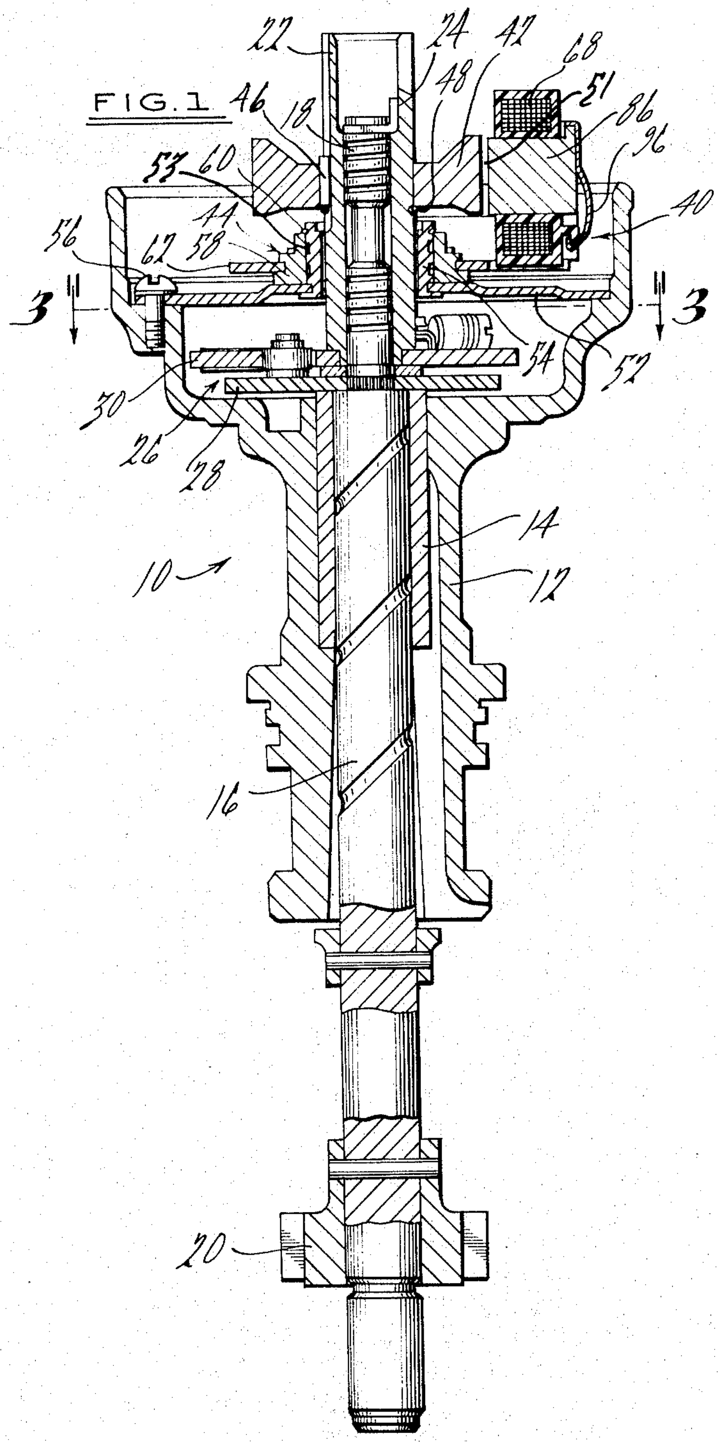


FIG. 1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24
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68
51
46
18
48
86
96
53
60
44
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62
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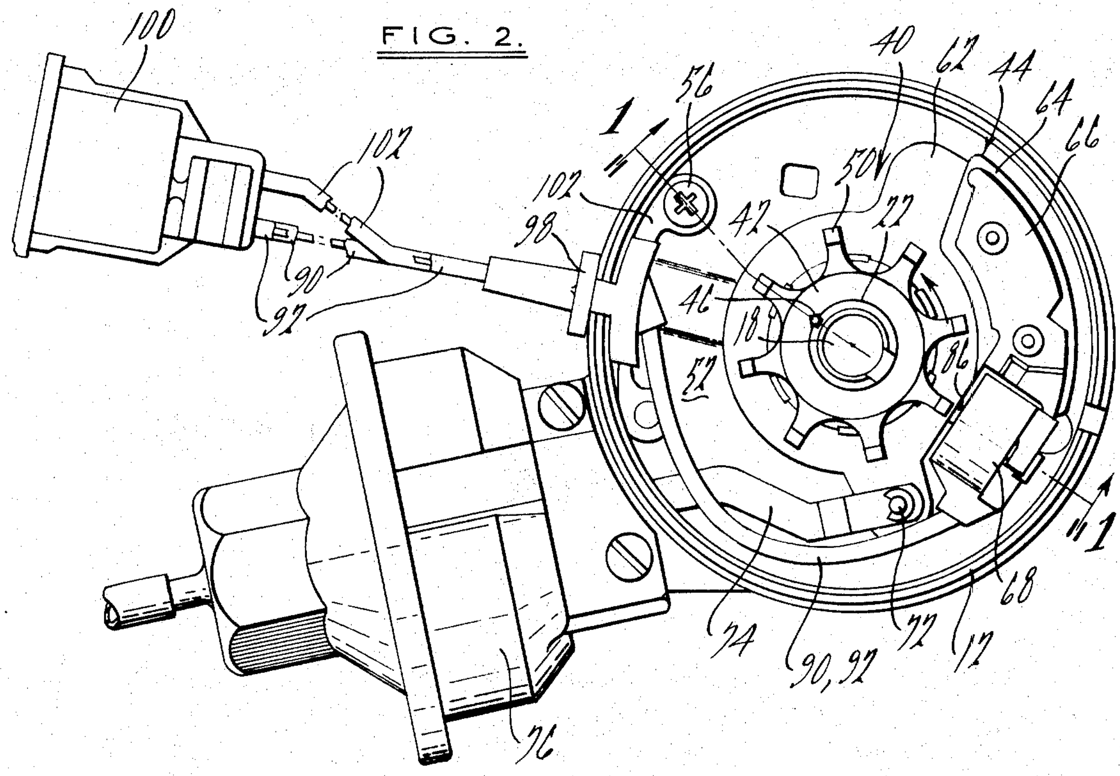
52
30
26
28
14
10
12
16
20

FIG. 2.


100
102
102
98
90
92
56
1
40
62
44
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66
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42
22
46
18
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86
1
68
12
72
90,92
74
76

FIG. 3.

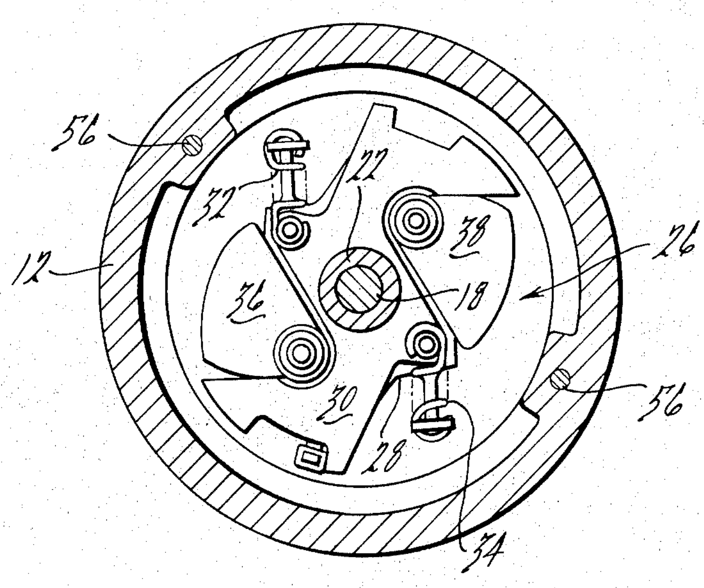

56
32
22
38
26
12
36
18
30
28
56
34

FIG. 4.

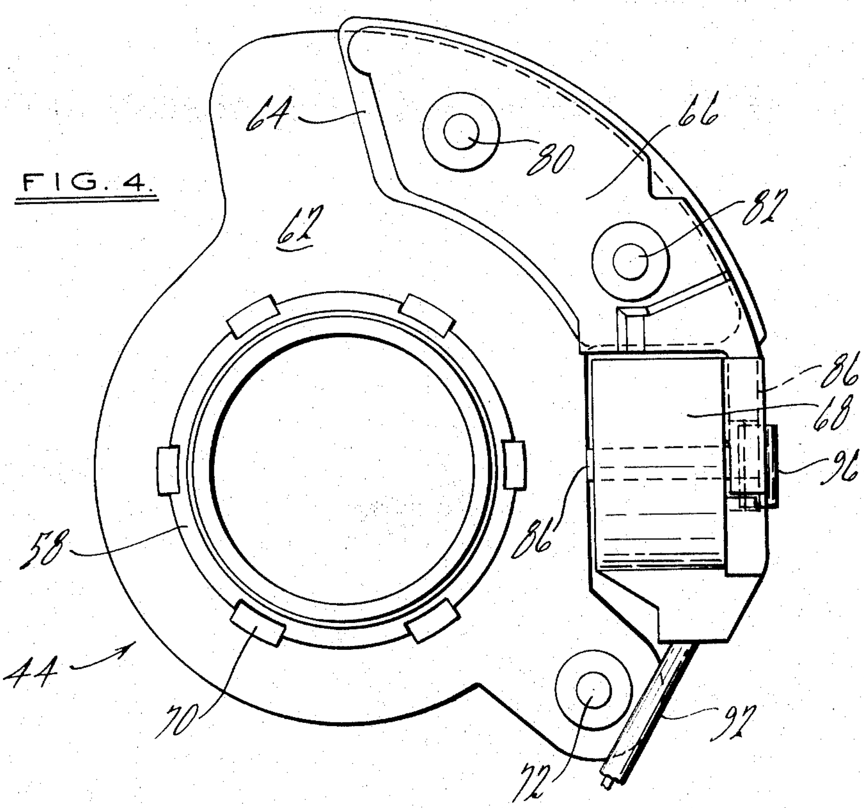
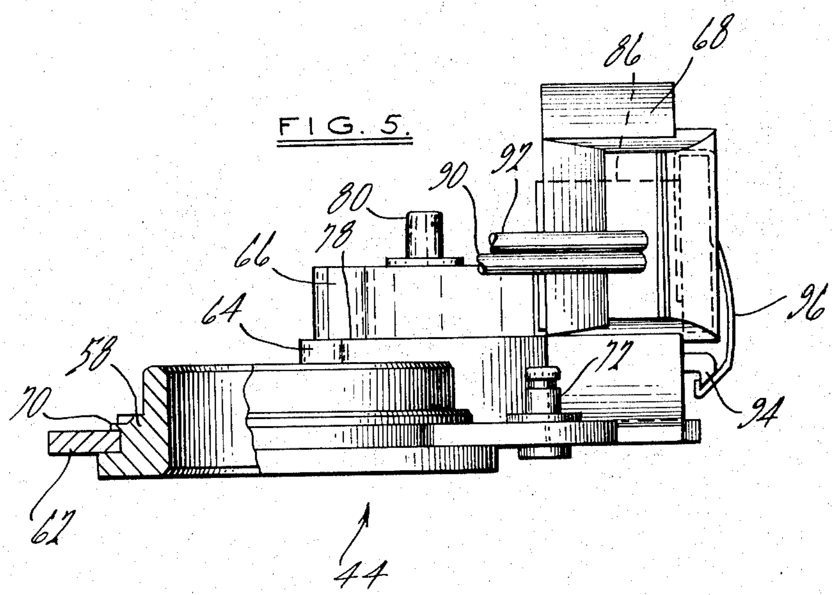

64
66
80
82
62
86
68
96
58
86
44
70
92
72

FIG. 5.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80
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66
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58
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94
62
44

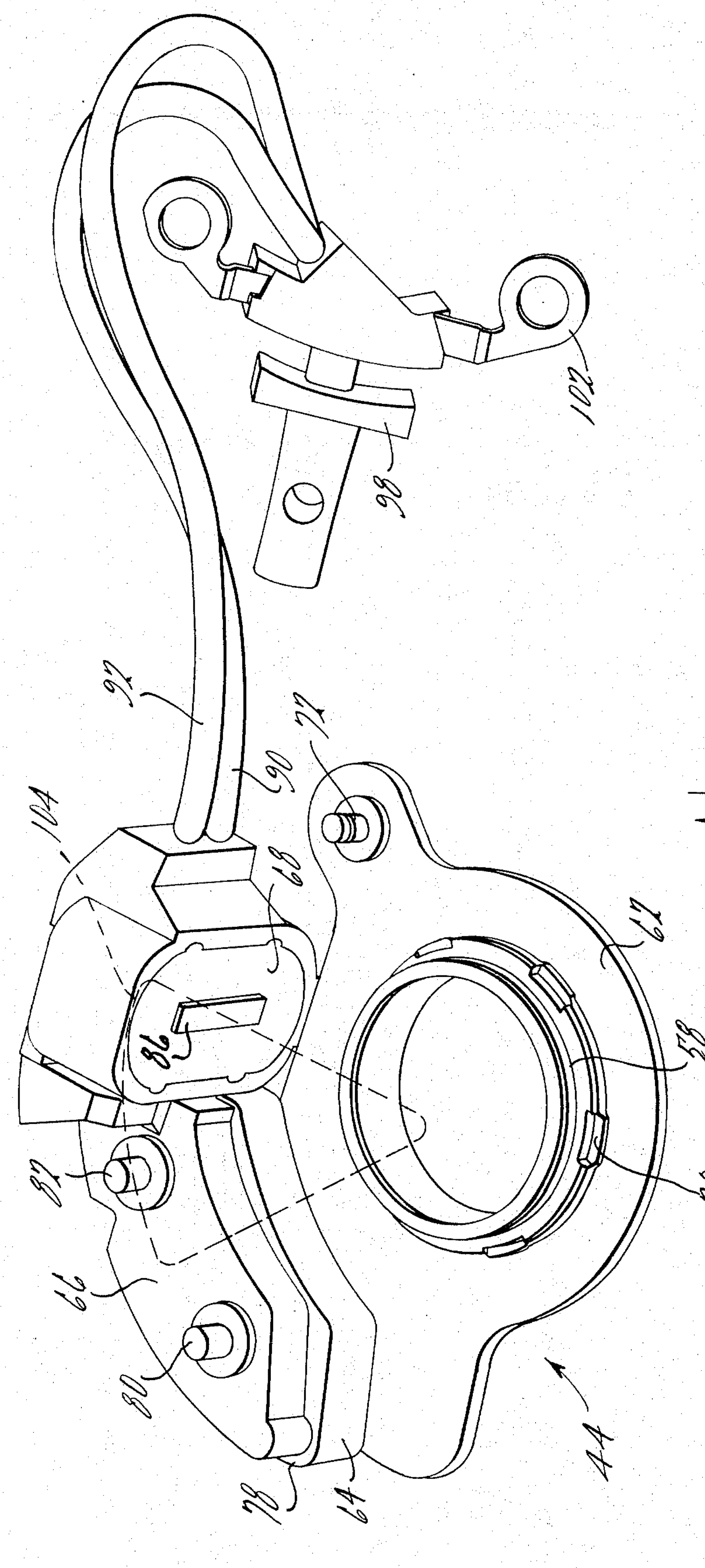
102
98
92
90
72
104
68
62
86
58
70
82
66
80
78
64
44

FIG. 6

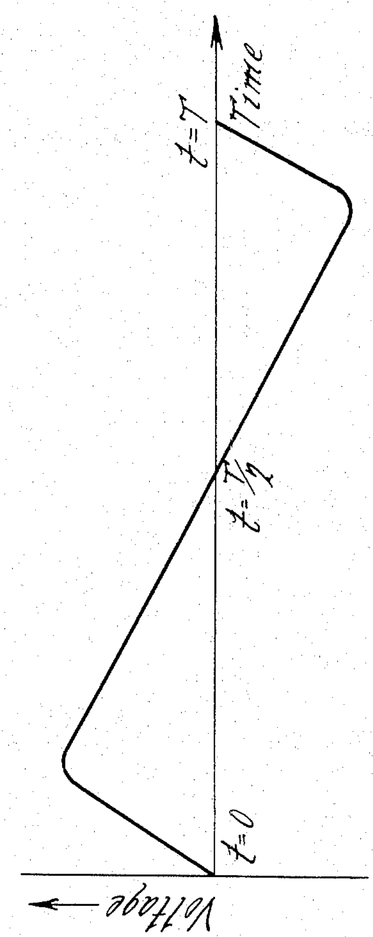
Time
t=T
t=T/2
t=0
Voltage

FIG. 7

SIGNAL GENERATING MECHANISM

BACKGROUND OF THE INVENTION

This invention relates to a signal generating mechanism for producing an alternating electrical signal having a frequency proportional to the angular velocity of a rotating shaft. More particularly, the invention relates to a signal generating mechanism particularly suitable for use in a distributor for a breakerless ignition system for a multi-cylinder internal combustion engine.

Common past and present practice in ignition systems for multi-cylinder internal combustion engines has been to employ a set of breaker points in a distributor to generate sparks as required by the engine. Electronic ignition systems eliminating these breaker points recently have been developed. These electronic breakerless ignition systems require a signal generating mechanism capable of indicating the times or instants at which it is desired to generate sparks in the various engine combustion chambers. A common feature of such signal generating devices is that they produce an electrical signal having a frequency proportional to the angular velocity of a rotating shaft, the shaft usually being the shaft in a distributor which rotates at an angular velocity equal to that of the engine's cam shaft.

Although various signal generating mechanisms have been proposed for use with multi-cylinder internal combustion engines, the present invention is directed to the type which employs a toothed-wheel affixed to the rotating shaft. The toothed-wheel forms the armature, or rotor, of an alternating signal generator. The stator assembly of the alternating signal generator includes an electrical pickup coil through which a stator pole-piece passes. The teeth of the toothed-wheel come into and go out of alignment with the stator pole-piece to vary the flux produced by a permanent magnet having a magnetic circuit including the stator and its pole-piece and the rotating toothed-wheel. This produces an alternating electrical signal across the terminals of the electrical coil. This alternating signal, in turn, may be coupled to a breakerless ignition system capable of producing sparks in relation to the alternating signal, for example, at one or more selected points in the signal waveform.

SUMMARY OF THE INVENTION

In accordance with the invention, a signal generating mechanism for producing an alternating electrical signal having a frequency proportional to the angular velocity of a rotating shaft comprises a lower plate that is fixed relative to the rotating shaft. The lower plate has an annular opening therein and a bushing is affixed in the annular opening. The shaft passes through the bushing. A stator assembly is positioned above the lower plate. The stator assembly includes a hub which is positioned around a portion of the bushing affixed to the lower plate. Attached to the hub is an upper plate, parallel with the lower plate, on which is positioned a permanent magnet having a magnetic field that is perpendicular to the upper plate. The stator assembly further includes the stator itself, which is positioned in contact with the permanent magnet, the permanent magnet being located intermediate the stator and the upper plate. The stator has a pole-piece which passes through and supports an electrical coil the axis of which is perpendicular to the shaft axis. An armature, or rotor, is formed by a toothed-wheel that is affixed to the shaft for rotation therewith. The toothed-wheel is concentric with the shaft axis and the teeth of the toothed-wheel are positioned to come into and to go out of alignment with the pole-piece of the stator.

Rotation of the shaft and the toothed-wheel attached to it produces a voltage across the terminals of the electrical coil. This voltage is determined in accordance with the well known equation $E = -N\, d\phi/dt$ where E is the electromotive force produced across the terminals of the electrical coil, N is the number of turns in the electrical coil and $d\phi/dt$ is the time rate of change of magnetic flux.

The entire stator assembly is non-adjustably secured together, thus, eliminating screw adjustments or the like. Prior art devices have required adjustments of this type to obtain voltage signals of a desired level. The elimination of such adjustments simplifies the manufacture of the signal generating mechanism and eliminates the possibility of maladjustment during use of the device

The invention will be better understood by reference to the detailed description which follows and to the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a sectional view, the section being taken along the line **1—1** of FIG. **2**, of an ignition distributor for a multi-cylinder internal combustion engine, the distributor including a signal generating mechanism for producing an alternating electrical signal having a frequency proportional to the angular velocity of the rotatable distributor shaft;

FIG. **2** is a plan view of the distributor of FIG. **1**;

FIG. **3** is a sectional view of the distributor, the section being taken along the line **3—3** in FIG. **1**, and illustrates a centrifugal weight mechanism for timing advance;

FIG. **4** is an enlarged plan view of the stator assembly used in the signal generating mechanism of the distributor of FIG. **1**;

FIG. **5** is an enlarged elevational view, partially in section, of the stator assembly of FIG. **4**;

FIG. **6** is an enlarged pictorial view of the stator assembly of FIGS. **4** and **5**; and

FIG. **7** is an illustration of the alternating signal waveform that may be produced by the signal generating mechanism in the ignition system distributor.

DETAILED DESCRIPTION

With particular reference now to FIGS. **1** through **3**, there is shown an ignition system distributor **10** for supplying sparks to a multi-cylinder internal combustion engine. The distributor **10** includes a housing **12** having a cylindrical bearing **14** positioned therein. A shaft **16** is rotatably journalled within the bearing **14.** The shaft **16** is driven by a gear **20** that, in use, meshes with another gear (not shown), driven by the internal combustion engine. The shaft **16** has a reduced-diameter portion **18,** and both the larger-diameter and reduced-diameter portions of the shaft contain grooves for lubrication purposes.

A ferromagnetic sleeve **22** fits over the reduced-diameter portion **18** of the shaft **16.** The sleeve **22** is retained on the shaft **16** with a wire retainer **24.** The sleeve **22** is rotatably mounted on the reduced-diameter portion **18** of the shaft **16,** and this rotation relative to the shaft is controlled by a centrifugal advance mechanism of the usual design.

The centrifugal advance mechanism, generally designated by the numeral **26**, comprises a plate **28** affixed to the shaft **16** and a plate **30** affixed to the sleeve **22.** In the usual manner, the plates **28** and **30** are coupled together by means of springs **32** and **34.** In order for the plate **30** and sleeve **22** to rotate about the plate **26** and shaft **16,** the force of the springs must be overcome. When the shaft **16** rotates, a pair of weights **36** and **38,** pivotally connected to the plate **28,** exert a force that acts against that of the springs **32** and **34** and tends to rotate the plate **30** and sleeve **22** with respect to the shaft **16.** The magnitude of this force is proportional to the shaft angular velocity. This provides a centrifugal advance in the ignition timing. For the purpose of the present invention, the sleeve **22** may be regarded as a part of the shaft **16** with which it rotates.

The ignition system distributor **10** is shown without the usual cap and high-voltage distribution rotor. It should be understood that these elements would be present in a complete distributor installation. The distributor cap would be of the usual configuration in which a plurality of electrical contacts would be connected by high-voltage leads to spark plugs for the multi-cylinder internal combustion engine. The high-voltage distribution rotor would be secured to the sleeve **22** and would rotate with it to distribute voltage from the high-voltage side of an ignition coil to the electrical leads to the various spark plugs.

The ignition system distributor **10** includes a signal generating mechanism of the invention, generally designated by the numeral **40,** for producing an alternating electrical signal having a frequency proportional to the angular velocity of the rotating shaft **16** and sleeve **22.** Preferably, the alternating signal generating mechanism has a frequency equal to the rate at which sparks are to be generated by the ignition system. Typically, this frequency is equal to the speed of the shaft in revolutions per second times the number of cylinders in the internal combustion engine.

The signal generating mechanism **40** illustrated in the drawings is intended for an 8-cylinder engine. It comprises a toothed-wheel **42,** hereinafter referred to as a rotor, and a stator assembly **44.** The rotor **42** is attached to the sleeve **22** for rotation therewith by means of a roll pin **46.** Also, the position of the rotor **42** on the axis of the sleeve **22** is determined by a rotor ring retainer **48.** The rotor **42** may be made from a sintered high-permeability material and has eight radially extending teeth **50,** these corresponding in number to the number of cylinders in the engine. Preferably, to achieve a desirable signal, the teeth extend radially outward a distance of from about five to 15 times the dimension of the air-gap **51** between the rotor and stator. Also, it is preferred that the air-gap **51** have a dimension ranging from a maximum of 0.062 in. to a minimum of 0.023 in., the midpoint of this range being most satisfactory. In this connection, it should be noted that similar signal generating mechanisms of the prior art were limited to air-gap dimensions ranging from about 0.006 in. to 0.001 in. and required adjustment means to maintain this dimension.

The stator assembly **44** is located and positioned by means of a lower plate **52** that has an annular opening therein in which an annular bushing **54,** made from a ferromagnetic material, is fixed. The shaft **16** and associated sleeve **22** pass through the bushing **54** and rotate freely within it. The lower plate **52** is positioned perpendicularly to the axis of the shaft and is secured to the distributor housing **12** by a plurality of screws **56.** The bushing **54** has a portion which extends above the lower plate **52.** This upwardly extending portion of bushing **54** has lubrication grooves **53** on its radially outward exterior that are filled with grease during the assembly of the mechanism.

The stator assembly **44** may best be seen in the enlarged views of FIGS. **4** through **6.** It includes an annular hub **58,** also made from a ferromagnetic material, that is positioned around the bushing **54** so that the stator assembly may rotate about the bushing. A wire ring retainer **60** (FIG. **1**) is used to hold the stator assembly **44** in position on the bushing **54.** The stator assembly **44** comprises the hub **58,** an irregularly shaped, ferromagnetic upper plate **62** positioned parallel to the lower plate **52,** a permanent magnet **64,** a stator **66** and an electrical pickup coil **68.**

The upper plate **62** of the stator assembly is securely staked in locations **70** to the hub **58.** A pin **72** extends upwardly from the upper plate **62.** In FIG. **2,** it may be seen that a rod **74** of a vacuum motor **76,** used in addition to the centrifugal timing mechanism **26** for ignition-timing advance and retard, is pivotally connected to the pin **72** on the upper plate **62.** The rod **74** controls rotation of the hub **58,** and the remainder of the stator assembly **44,** about the bushing **54.**

The permanent magnet **64** has an arcuate shape. Preferably, it is made from a ferrite material, such as sintered ceramic strontium ferrite. It is preferred that the permanent magnet **64** be magnetized at assembly of the signal generating mechanism. Its magnetic field should be oriented such that its direction through the magnet is perpendicular to the upper plate **62.** Accordingly, the upper surface **78** of the permanent magnet **64** may be made a south pole and the lower surface, that is, the surface in contact with the upper plate **62,** may be made a north pole. In such case, an imaginary line interconnecting these poles is perpendicular to the upper plate **62.** The permanent magnet **64** preferably is magnetized to an induction of about 3600 gauss.

The stator **66** and the permanent magnet **64** are non-adjustably secured to the upper plate **62** of the stator assembly with rivets **80** and **82.** To avoid impact damage to the permanent magnet, a spin-type riveting process may be used. The stator **66** is made from a ferrogmagnetic material and preferably is made from a sintered-iron, high-permeability, low-carbon material having a minimum density of about 6.8 grams per cubic centimeter. The stator **66** has a generally arcuate shape but also has a pole-piece **86** of rectangular cross-section extending through the central region of the electrical coil **68** and radially toward the axis of the shaft **16.** The teeth **50** of the rotor **42** come into and go out of alignment with the pole-piece **86** of stator **66** as the shaft **16** and its sleeve **22** rotate. It should be noted that the axis of rotation of the stator assembly **44** about the bushing **54** is the same as the axis of shaft **16,** and, thus, the air gap between the rotor teeth and pole-piece does not change during ignition timing changes.

The electrical pickup coil **68** is supported by and surrounds the stator pole-piece **86** and preferably is formed from a helical winding of from about 4,000 to 4,075 turns of gauge number 39 (American Wire Gauge) copper wire and may have a resistance of from

600 to 700 ohms. Preferably, the electrical pickup coil **68** is encapsulated by molding in a suitable insulating material. The pickup coil **68** has leads **90** and **92** connected to the electrical winding terminals that extend out of the coil encapsulation material. Also, the pickup coil has a hook **94** attached to it. A spring clip **96** is connected to the hook **94** and to the stator pole-piece **86** to hold the electrical pickup coil on the pole-piece **86** in a secure manner. The axis of the coil **68** is perpendicular to the axis of the shaft **16**.

In FIG. **2**, it may be seen that the wires **90** and **92** enter and pass through a grommet **98**, preferably made from a molded polyvinyl chloride material, to a connector **100**. The grommet **98** contains a third wire **102** that is connected by one of the screws **56** to the lower plate **52** to establish an electrical ground. The wire **102** extends out of the grommet **98** and into the connector **100**. The wire **102** is a ground lead.

In operation, the rotor **42** preferably turns in the counterclockwise direction indicated in FIG. **2** by the arrow on one of its teeth. As the rotor **42** rotates, the magnetic flux changes to produce a time varying voltage across the electrical leads **90** and **92** of the electrical coil **68**. This voltage or EMF is produced in accordance with the aforementioned equation $E = -N\, d\phi/dt$.

The magnetic circuit is illustrated by the dotted line **104** in FIG. **6**. This magnetic circuit includes the stator **66** and its pole-piece **86**, the toothed rotor **42** and shaft **16** (not shown in FIG. **6**), and the upper plate **62** that is in contact with the bottom surface of the permanent magnet **64**.

With reference in particular to FIGS. **2** and **7**, wherein one of the teeth **50** of the rotor **42** is in alignment with the pole-piece **86** of the stator **66**, let it be assumed that the rotor is turning in a counterclockwise direction. At this instant with the tooth in alignment with the pole-piece **86**, there is no change in flux with respect to time and the generated voltage is zero. This corresponds to the time $t = 0$ of FIG. **7**. As the tooth moves out of alignment with the pole-piece **86** of the electrical coil, a voltage is generated across the coil leads **90** and **92** due to the change in magnetic flux. This flux change, and consequently the generated voltage, reaches a maximum and then decreases to zero at a time $t = T/2$ corresponding to the time when the pole-piece **86** is midway between two of the teeth **50** of the rotor **42**. Continued rotation of the rotor **42** produces a change in magnetic flux that generates a voltage of opposite polarity. This voltage increases until it once again becomes zero at time $t = T$ when the next tooth **50** is in alignment with the pole-piece **86**. Thus, an alternating signal is generated having a frequency proportional to the angular velocity of the rotating shaft of the distributor.

Based upon the foregoing description of the invention, what is claimed is:

1. A signal generating mechanism for producing an alternating electrical signal having a frequency proportional to the angular velocity of a rotating shaft, said signal generating mechanism comprising, in combination: a lower plate fixed relative to said rotating shaft, said lower plate having an opening therein; an annular bushing affixed in said lower plate opening, said bushing extending above said lower plate, said shaft passing through said bushing; a stator assembly, said stator assembly including an annular hub positioned around the portion of said bushing extending above said lower plate, said hub being rotatable about said bushing, an upper plate parallel to said lower plate and affixed to said hub, a permanent magnet attached to said upper plate, said magnet being polarized to produce a magnetic field having a direction through said magnet that is perpendicular to said upper plate, a stator positioned on said permanent magnet, said stator having a pole-piece, and an electrical coil positioned on said stator pole-piece; and a rotor attached to said shaft for rotation therewith, said rotor having at least one tooth positioned to come into and go out of alignment with said stator pole-piece; whereby rotation of said rotor produces an alternating electrical signal across the terminals of said electrical coil having a frequency proportional to the angular velocity of said rotating shaft.

2. A signal generating mechanism for producing an alternating electrical signal having a frequency proportional to the angular velocity of a rotating shaft, said signal generating mechanism comprising, in combination: a lower plate fixed relative to said rotating shaft, said lower plate having an opening therein; an annular ferromagnetic bushing affixed in said lower plate opening, said bushing extending above said lower plate, said shaft passing through said bushing; a stator assembly, said stator assembly including an annular ferromagnetic hub positioned around the portion of said bushing extending above said lower plate, said hub being rotatable about said bushing, a ferromagnetic upper plate parallel to said lower plate and affixed to said hub, a permanent magnet polarized to produce a magnetic field having a direction through said magnet that is perpendicular to said upper plate, a ferromagnetic stator positioned on said permanent magnet, said stator and said permanent magnet being non-adjustably secured to said upper plate, said stator having a pole-piece extending radially towards said shaft axis, and an electrical coil positioned on said pole-piece, said pole-piece extending through said electrical coil; and a ferromagnetic rotor affixed to said shaft for rotation therewith, said rotor having a plurality of teeth positioned to come into and to go out of alignment with said pole-piece of said stator during rotation of said shaft; whereby rotation of said shaft produces an alternating signal across the terminals of said electrical coil.

3. The signal generating mechanism of claim **2** wherein a gap exists between a tooth of said rotor that is in alignment with said pole-piece, said gap being within the dimensional range from 0.062 of an inch to 0.023 of an inch.

4. A signal generating mechanism for producing an alternating electrical signal, which comprises, in combination: a housing; a shaft rotatably journalled in said housing; a lower plate secured to said housing, said lower plate having an opening therein and being positioned perpendicular to said shaft; a ferromagnetic bushing affixed in said lower plate opening, said bushing extending above said lower plate and having lubrication grooves on the radially exterior portion thereof, said shaft passing through said bushing; a ferromagnetic sleeve on the portion of said shaft passing through said bushing, said sleeve being rotatable about said shaft; a centrifugal mechanism interconnecting said sleeve and said shaft for controlling rotation of said sleeve about said shaft; a toothed ferromagnetic rotor secured to said sleeve for rotation therewith, the teeth of said rotor extending radially outward from the axis of said shaft; a stator assembly, said stator assembly including an annular ferromagnetic hub positioned around the portion of said bushing extending above said lower plate, said hub being rotatable about said bushing, a ferromagnetic upper plate parallel to said lower plate and affixed to said hub for rotation therewith, an arcuately-shaped permanent magnet positioned on said upper plate, said permanent magnet having a north pole and a south pole, an imaginary line interconnecting said north and south poles being perpendicular to said upper plate, said permanent magnet being made from a ceramic ferrite material, a ferromagnetic stator positioned on said permanent magnet, said stator and permanent magnet being non-adjustably secured to said upper plate, said stator having a pole-

piece positioned to permit said rotor teeth to come into and to go out of alignment with it, and an electrical coil surrounding said pole-piece of said stator, said electrical coil being helically wound and having an axis perpendicular to the axis of said shaft; and means connected to said upper plate of said stator assembly for controlling the rotation of said stator assembly about said bushing.

5. The signal generating mechanism of claim **4** wherein a gap exists between a tooth of said rotor that is in alignment with said pole-piece, said gap being within the dimensional range from 0.062 of an inch to 0.023 of an inch.

* * * * *