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Skalski

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[54] **CONTACTLESS IGNITION SYSTEM**

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[51] **Int. Cl.**..... **H05b 37/02;** H01v 5/00

[58] **Field of Search**.... 315/209 T, 209 M; 123/154, 123/148 E, 146.5 A; 324/41; 84/1.15; 307/309; 200/19

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[57] **ABSTRACT**

Novel electromagnetic transducer and electronic circuit concepts allow the realization of low cost contactless ignition systems for internal combustion engines. The invention permits the elimination of mechanical ignition points by means of simple bolt-in components.

15 Claims, 7 Drawing Figures

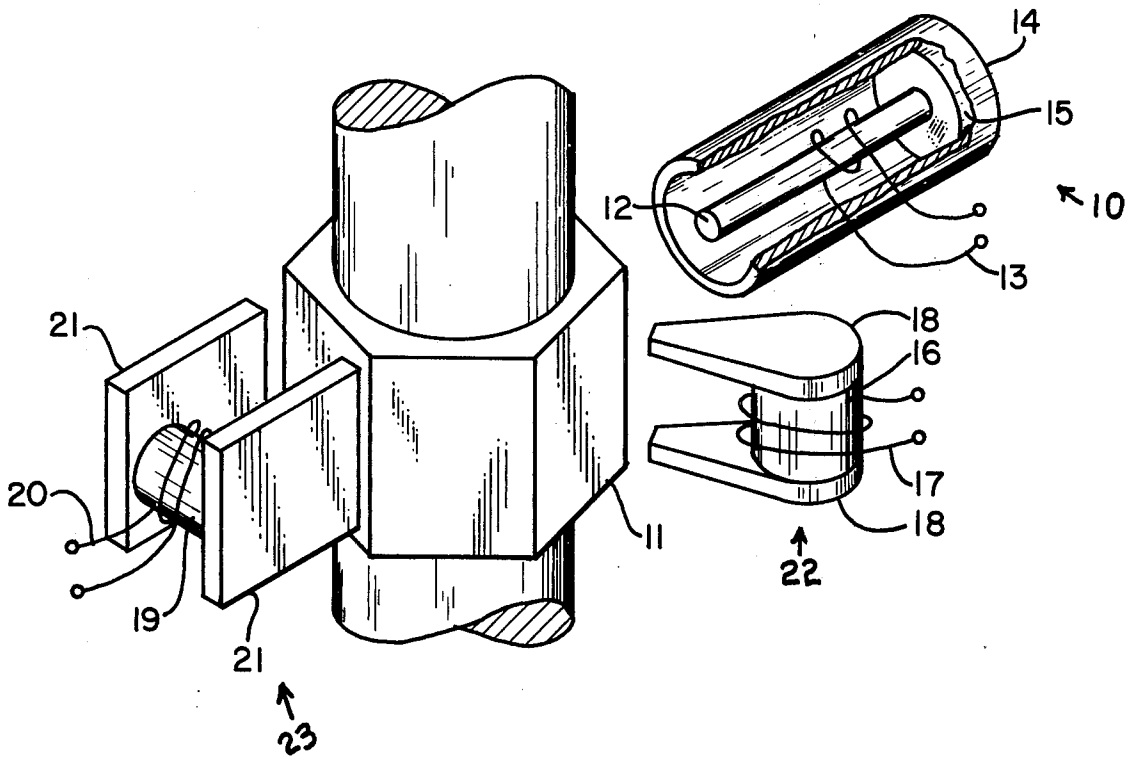
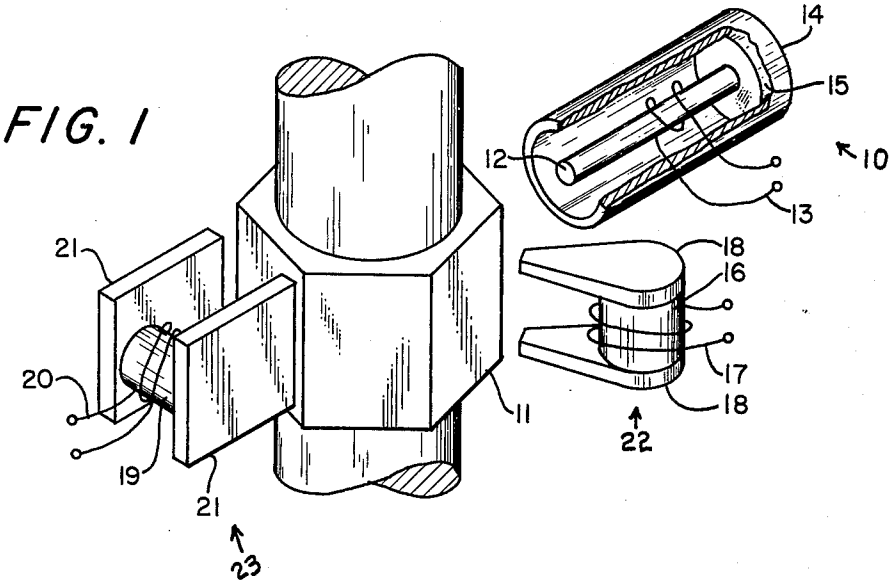


FIG. 1



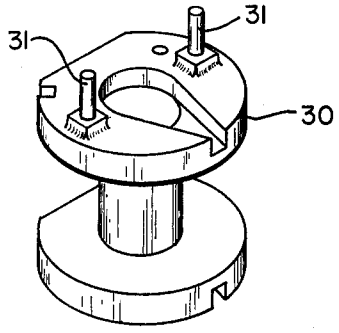


FIG. 2

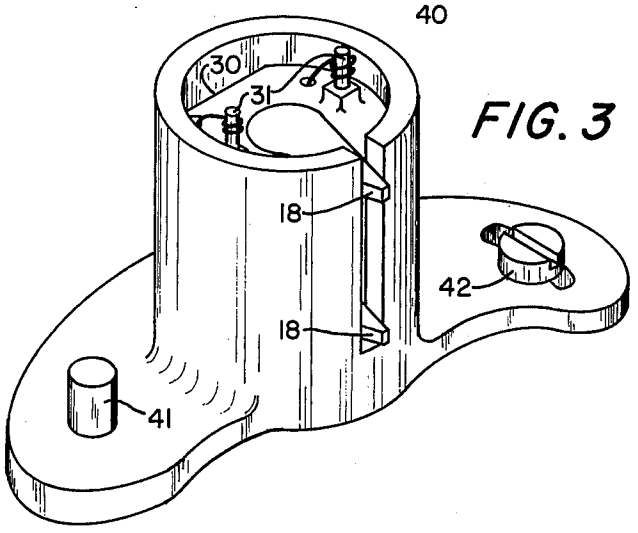


FIG. 3

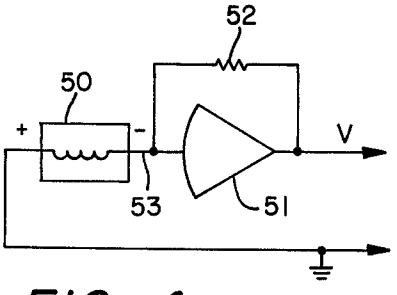


FIG. 4

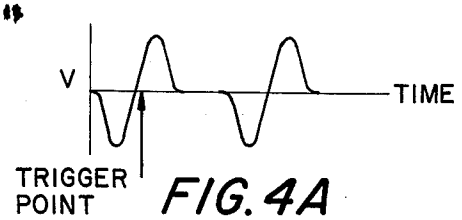


FIG. 4A

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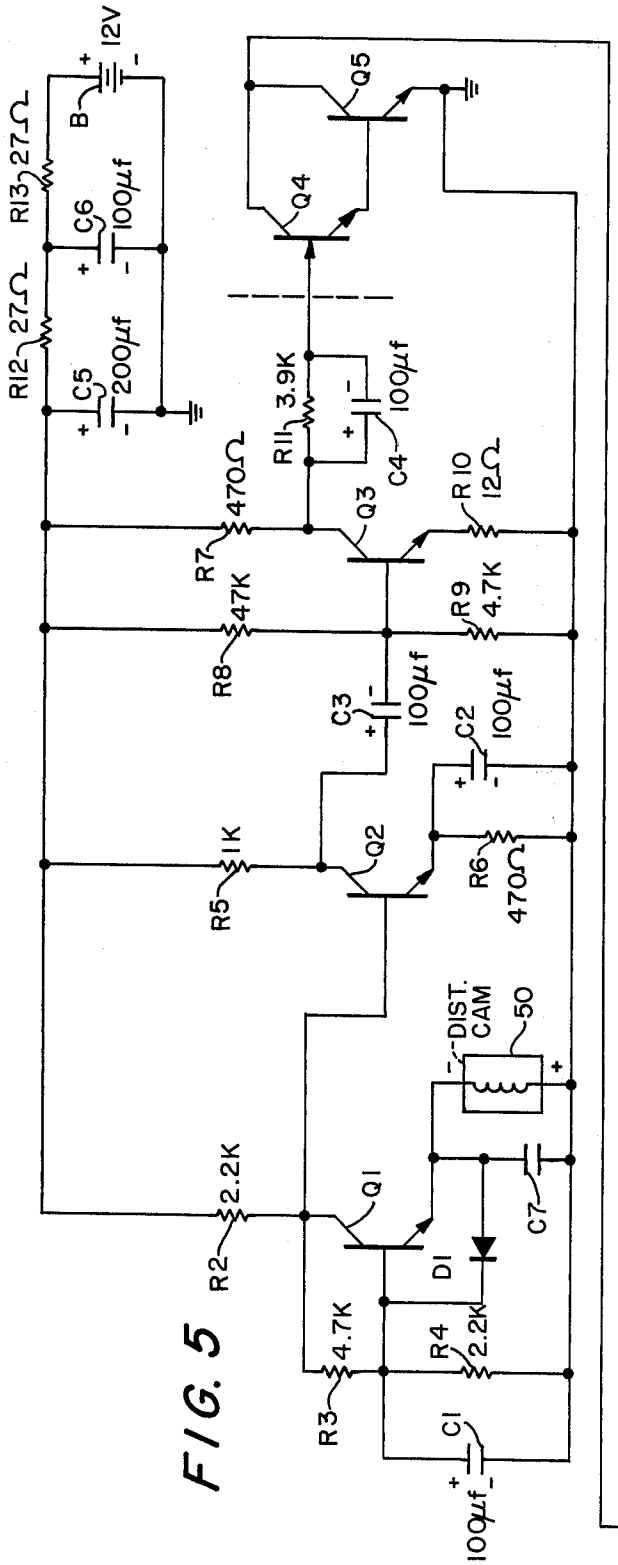


FIG. 5

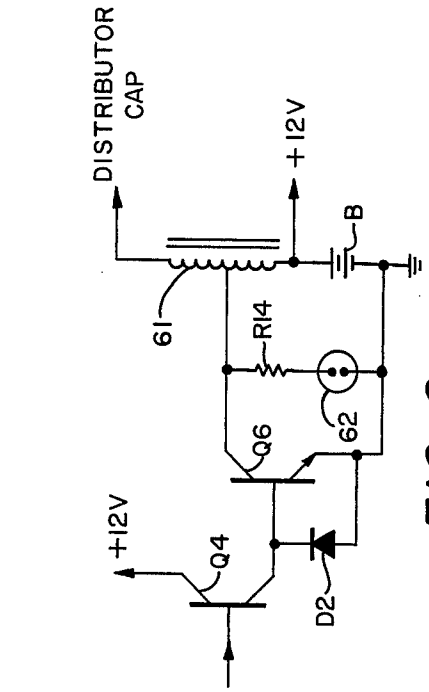
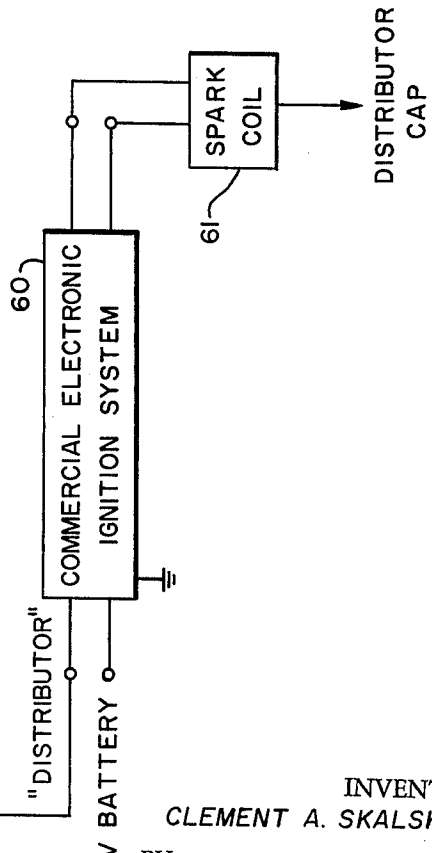


FIG. 6



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CONTACTLESS IGNITION SYSTEM

BACKGROUND OF THE INVENTION

This invention relates in general to improved ignition systems for internal combustion engines, and more particularly concerns a direct replacement for mechanical ignition points, especially in automotive engines, by bolting in a simple and low-cost electromagnetic transducer and associated electronic circuitry.

The points employed in present day automobiles are usually one of the most unreliable parts of these vehicles. This is the result of burning of the contact points and wear of the piece that rubs against the distributor cam. In order to keep an automotive engine properly tuned, the point setting usually needs to be checked every 5,000 miles. When using a conventional ignition system, it is advisable to change the points every 10,000 miles. The cost of point malfunction is high in terms of inefficient fuel utilization and attendant air pollution. This malfunction may be the result of wear and/or improper adjustment. It invariably occurs at high engine speeds, no matter how the points are adjusted. Besides the problems related to performance, the cost of having points serviced and replaced for the life of an engine is high. Often, removal of the distributor from an engine is necessary for proper servicing.

While the idea of using a magnetic, more precisely electromagnetic, pickoff to replace the points in a distributor is known, commercially available electronic ignition systems are typically triggered using a signal derived from mechanical points. They, therefore, require periodic service, frequently referred to as an ignition tune-up. By using electromagnetic pickoffs, such periodic tune-ups are unnecessary.

Conventional megnetic pickoffs are expensive, not well suited for use with presently available distributor cams, and require machine work for installation. Interfacing commercially available pickoffs and the spark coil presents problems.

The present invention has as an important object the providing of a well shaped and precise trigger signal obtained by noncontacting means for triggering such apparatus as electronic ignition systems.

Still another object of the invention is to provide a low-cost, bolt-in, direct replacement for mechanical ignition points when an engine is already equipped with an electronic ignition system.

Still another object of the invention is to provide electromagnetic pickoff transducers suitable for low-cost, high-volume production.

Still another object of the invention is to provide electronic circuitry free from complexity that makes it unneccessary to carefully control the number of turns of wire used in an electromagnetic pickoff transducer.

Still another object of the invention is to provide a transistor biasing technique that enhances the performance of the electronic circuitry that follows an electromagnetic pickoff transducer so that reliable performance can be obtained over a very wide temperature range.

SUMMARY OF THE INVENTION

According to the invention, an electromagnetic transducer that produces a doublet pulse having both positive and negative polarity is used to drive a pulse amplifier that limits. A doublet pulse is generated each time an edge of the distributor cam passes by the face of the transducer. The transducer is so connected to the pulse amplifier that the leading edge of the second half of the doublet pulse determines the leading edge of the square pulse produced as a result of limiting in the pulse amplifier. The output of the pulse amplifier may be used to directly control an electronic ignition system, or it may be used to control an electronic switch that in turn controls a commercial electronic ignition system. The invention thus provides a way of eliminating the mechanical points usually employed with an internal combustion engine.

More specifically, the transducer in its preferred embodiment comprises a cylindrical magnet to whose ends are affixed a pair of pole pieces that are tapered to small cross sections at the ends that are in close proximity to the distributor cam. A coil is wound around the magnet to detect changes in magnetic flux that result when the edges of the distributor cam approach and recede from the tips of the pole pieces. The electronic circuitry used with the transducer amplifies and shpaes its ouput. Furthermore, when the transducer and electronic circuitry are used together, the variation in electrical resistance of the transducer with temperature helps to stabilize some of the bias voltages in the circuitry. The circuitry in turn makes it unnecessary to carefully control the number of turns of wire wound on the transducer. Also, the circuitry acts on the transducer so as to reinforce the field produced by the magnet.

Numerous other features, objects and advantages of the invention will become apparent from the following specification when read in connection with the accompanying drawing in which:

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 illustrates exemplary types of electromagnetic transducers that can be used with a distributor cam;

FIG. 2 shows a bobbin design for the preferred form of the invention;

FIG. 3 depicts an electromagnetic transducer that is a bolt-in replacement for mechanical ignition points;

FIG. 4 indicates a desirable way of amplifying the output of an electromagnetic transducer;

FIG. 4A is the output wave form as a function of time.

FIG. 5 shows an electomagnetic ignition point system in combination with a commercial electronic ignition system; and

FIG. 6 illustrates a useful modification of the system shown in FIG. 5.

With reference now to the drawing and more particularly FIG. 1 thereof, there are shown three electromagnetic pickoff transducers positioned about a distributor cam 11. This cam is usually made of hardened steel, has one to eight circumferentially disposed edges, and has a typical diametrical dimension of 1 inch. The edges of the cam are preferably as sharp as practical when electromagnetic transducers are to be employed. The edges on a typical automotive distributor cam are, however, rounded to provide smooth lifting of mechanical points. The rounding of the cam edges presents another problem in providing a good electromagnetic pickoff replacement for mechanical points.

The transducer 10 is typical of presently available electromagnetic transducers. Wound on a permanent magnet 12 is a coil 13 having many turns of wire. Pieces

14 and 15 are made of iron or ferrite and serve as a return path for magnetic flux.

The voltage induced in coil 13 is proportional to the number of turns and the time rate of change of magnetic flux through the coil, provided that the flux threads each turn of the coil uniformtly. To maximize the voltage coming from coil 13 when the diameter of magnet 12 is fixed, it is desirable to make the number of turns large. This may be accomplished by using fine wire, a long magnet, and a large diameter for the return sleeve 14. A long magnet is helpful not only because it may carry a greater number of turns of wire but also because for a given airgap between magnet 12 and cam 11, the average magnetic flux density through the coil is generally greater than with a shorter magnet. In practice, the length of the magnet 12 is limited by considerations of flux leakage and allowable outside dimensions. The diameter and thickness of return sleeve 14 are generally determined by a maximum outside dimension and allowable circumferential eddy-current losses.

Electromagnetic transducers generally are used to provide velocity and timing, i.e., synchronizing, information. For use as a replacement for mechanical ignition points, it is important that an electromagnetic transducer provide a synchronizing signal whose phase accuracy is better than 0.1°referenced to the distributor rotor. Making the width of the tip of magnet 12 small, preferably less than 0.030 inch, helps achieve this resolution. A practical way of obtaining this dimension is with a tapered pole piece on the end of the magnet 12. This pole piece is preferably cylindrical on one end, commensurate with the diameter of the magnet, and tapers from a circular cross section to a small rectangular cross section at the end that faces the distributor cam.

The cylindrical electromagnetic transducer, such as 10, is widely used because it can provide velocity and timing information at moderate cost. Also, most commercial cylindrical electromagnetic transducers are enclosed in a threaded cylindrical housing to facilitate mounting, typically in a single tapped hole.

While the cylindrical electromagnetic transducer has many virutes, it has some disadvantages for use in present automotive distributors. It is relatively expensive whrn designed to function in presently available distributors. The basic magnetic circuit configuration is not very efficient when the moving element is a conventional distributor cam. The outer sleeve 14 of a cylindrical electromagnetic transducer provides an inefficient magnetic coupling with a distributor cam. Furthermore, this type of flux return does not take good advantage of the permanent magnetism that the transducer will induce in the distributor cam. Moreover, the design of cylindrical electromagnetic transducers is not optimum with respect to minimization of eddy-current losses in the flux return parts 14 and 15. Eddy-current effects in an electromagnetic transducer may introduce undesired phase shift and loss in high frequency response. Such phase shifts could, for example, cause the timing of an engine to be undesirably sensitive to speed and temperature variations.

Transducer 22 embodies the magnetic circuit for the preferred form of the invention. This configuration comprises magnet 16 carrying a winding 17. Tapered pole pieces 18 are affixed to the magnet.

The magnet 16 is preferably grain oriented Alnico V. This magnet material has a high energy product, good stability with time, is readily magnetized, and is inexpensive for small magnets. To reduce magnet costs below those of Alnico V, a ceramic magnet material can be used with good results. Because the magnet 16 will generally have a length of less than 0.25 inch and substantial airgaps, ceramic magnets can be expected to ordinarily provide flux densities that are comparable to those of Alnico V. Ceramic magnets are more difficult to magnetize and are less stable than those made of Alnico V.

The use of ceramic magnet material for the magnet 16 is not difficult, since a diameter in the order of 0.25 inch is advisable. The magnet 12, used in a cylindrical electromagnetic transducer, will usually need to have a diameter of less than 0.125 inch. This may make the use of the brittle ceramic magnet material uneconomical, since excessive breakage may occur during manufacture.

The winding 17 that surrounds magnet 16 is of ordinary magnet wire. It may appear that as many turns as possible should be used in order to maximize the output of the transducer. This would imply the use of many turns of very fine wire. Fine wire, however, has the disadvantage that it is difficult to handle. It thus shows production. For this reason, it is advisable to use number 30–36 wire. In practice, 1,000 turns of number 36 wire has been found to be very satisfactory. Because of the way the transducer is to be employed, it is not necessary nor desirable to use too many turns. Generally, it will be desirable for winding 17 to have a resistance in the range 10–100 ohms. The reasons for limiting the number of turns will become clear during the discussion of preferred electronic circuitry.

The pole pieces 18 may be sheet metal stampings, typically having a thickness in the order of 0.06 inch and a finished pole tip width in the order of 0.03 inch. A desirable material for these pole pieces is Carpenter Core Iron, since it is quite permeable and allows flux densities in excess of 17,000 gauss. Because of small pole-piece dimensions, eddy currents in these parts do not present a serious problem. By going to a magnetic grade iron having a lower electrical conductivity than Core Iron, eddy current effects can be further reduced. Carpenter Silicon Core Iron A, for example, has approximately the same magnetic properties as Core Iron but less than half the conductivity.

That that pole pieces 18 can be fabricated by stamping sheet metal is an important advantage because iron having good magnetic properties is not easily machined by turning on a lathe, using a milling machine, and the like.

Before discussing how the preferred transducer is made in a form suitable for use in an ignition system distributor, consider an alternative transducer 23. It comprises a magnet 19 carrying winding 20. Affixed to the ends of the magnet are pole pieces 21. Many of the design considerations that apply to the two other transducers shown in FIG. 1 pertain to the design of this transducer. Insofar as performance as a transducer is concerned, this is probably the best of the three shown when it is precisely fabricated. It utilizes a fairly long magnet having substantial cross-sectional area; the ends of the pole pieces can easily be made to have a width of less than 0.03 inch; and airgap reluctances are as low as practical. Transducer 23 may present me-

chanical problems. Pole pieces **21** should be precisely spaced; an excessive rotational adjustment of a distributor that has been retrofitted with this transducer may be necessary; and setting both airgaps with a single adjustment may be impossible.

The bobbin shown in FIG. **2** serves to position and hold the parts **16–18** of the preferred transducer **22** shown in FIG. **1.** The body of the bobbin **30** is made by injection molding or similar processes. Desirable materials are nylon, polystyrene, and many others. Attached to the top of bobbin **30** are two wire terminals **31** made of plated or tinned brass or copper. These terminals are secured to the bobbin with an interference fit, cementing, or other suitable means.

Referring to FIG. **3** there is shown a perspective view of the bobbin assembly **30–31** together with magnet **16,** coil **17,** and pole pieces **18** housed in transducer case **40.** FIG. **3** also shows the post **41** found on many distributor breaker plates and the screw **42** for securing he transducer to the breaker plate. The indicated mounting arrangement is identical to the one used for mechanical points, and the gap between the pole tips and the distributor cam is adjusted by a method identical to that used to set the gap on mechanical points. Screw **42** is loosened, and the case **40** is rotated about the pivot **41** until the correct gap is obtained. The screw is then tightened to preserve the adjustment.

The case **40** can be made by a variety of mass production techniques. It can be made of nonferrous sheet metal; it can be a die casting of an aluminum or zinc alloy; or it can be injection molded of a plastic such as nylon.

Assembly of the complete transducer is accomplished as follows:

1. Attach terminals **31** to bobbin **30.** Then wind the coil on this assembly and solder the two leads coming from the coil to the terminals.
2. Place magnet **16** inside the assembly **16, 300, 31.** Then place several drops of epoxy cement on one side of the flat surfaces of two pole pieces. Press the pole pieces in place with the epoxy cement facing the magnet. The magnet will hold the pole pieces securely in place.
3. Place a little epoxy cement in the bottom of the cylindrical portion of the case **40.** Then insert the assembly completed as a result of step (**2**). Using adhesive tape, cover the slot on the side of the case. Pour hot epoxy cement into the top of the case. It will flow down into the assembly, principally through the opening provided by flattening the back of the top of the bobbin **30.**
4. Cure the epoxy cement in an oven. If the epoxy cement is fairly viscous, a vacuum oven should be used to assure thorough impregnation by the cement.
5. After the epoxy cement has cured, the front of the transducer is machined by grinding, or other suitable techniques. Material is removed along the taped slot to expose the pole tips and to assure that the pole tips will be equidistant from the vertical edges of the distributor cam **11.** Using even simple equipment, it should be possible to grind the pole tips in a few seconds.

The transducer assembly technique just described indicates an important advantage of the invention. The electromagnetic transducer which replaces machanical points can be simply and economically manufactured.

While the transducer is an important aspect of the invention, the associated electronic circuitry has certain features. This circuitry may be manufactured at low cost, is extremely reliable, and functions well over a wide temperature range.

FIG. **4** shows how the transducer **50** may be used in conjunction with an operational amplifier **51** and a feedback resistor **52.** The amplifier **51** has a very high voltage gain, a very high input impedance, and provides an output which is inverted with respect to the input. Under these conditions, the voltage at the summing junction **53** is practically zero, and the magnitudes of currents flowing through the transducer **50** and resistor **52** are essentially equal. This means that the magnitude of the output voltage V is equal to the magnitude of the open-circuit voltage of the transducer multiplied by the ratio of the resistance **52** to the internal resistance of the transducer. To a first approximation, the output voltage V is independent of the number of turns of wire used in the electromagnetic transducer because both the output of the transducer and its internal resistance are to a first approximation proportional to the number of turns of wire used. This reasoning may be extended to support a conclusion that neither too many nor too few turns of wire should be employed. Too many turns, for example, leads to a situation where resistance increases substantially faster than the increase in voltage. Usually, a broad range exists for the number of turns of wire that will give good performance.

Referring to FIG. **4A** there is shown the output waveform (V as a function of time) expected when the transducer **50** is excited by a moving distributor cam. With reference again to FIG. **1,** each time an edge of the cam **11** passes by the tips of the pole pieces **18,** it causes the flux linking the coil **17** to increase momentarily to some peak value to generate the doublet pulses shown in FIG. **4A.** The time required for the voltage to go from its extreme negative value to its extreme positive value is related approximately to the angular pole tip width. For example, this time increment corresponds to 0.06 radian, approximately 3.6°, when the pole tips have a width of 0.03 inch and the cam has a maximum diametrical dimension of 0.5 inch.

Previously, it was pointed out that it may be desirable to time an engine to better than 0.1 degree referenced to the distributor. To accomplish this, the zero crossing indicated by the designated "trigger point" in FIG. **4A** must be determined. This can be done by using the waveform V to drive a saturating amplifier that responds only to positive signals. The result of using this technique is the generation of a train of rectangular pulses at the output of the saturating amplifier. The leading edges of these pulses carry accurate timing information.

Returning to the example where the spacing between positive and negative peaks of a voltage doublet shown in FIG. **4A** is 3.6°, an amplifier that saturates at a voltage that is one-eighteenth the peak voltage of the doublet pulse will produce timing pulses whose leading edges are accurate to approximately 0.1°.

A practical embodiment of the invention is given in FIG. **5.** It comprises an electromagnetic transducer **50** which drives a saturating pulse amplifier which in turn controls the Darlington connected switch comprising transistors Q4 and Q5. This electronic switch controls a commercial electronic ignition system **60** which drives a spark coil **61.** A suitable electronic ignition system is the commercially available Mark Ten that is manufactured by Delta Products, Inc. of Grand Junction, Colo.

The circuitry utilizes only inexpensive components and allows wide variations in component values. Low cost silicon transistors are used. Transistors Q1–Q4 are small signal transistors, such as type 2N697. Transistor Q5 is a power type, such as 2N3055. Silicon diode D1 is used to protect the base-emitter junction of transistor Q1 from excessive reverse voltages.

The components R12–R13 and C5–C6 comprise a decoupling network. This network prevents signal regeneration because of coupling in the lead going to the battery B. This lead often has the spark coil ballast resistor in series with it.

Transistor Q1 comprises a common-base amplifier that has some unique features. First, as with the system shown in FIG. 4, the voltage output from this stage is to a first approximation independent of the number of turns of wire used in the electromagnetic transducer 50. The resistance of the transducer winding is preferably in the range 10–100 ohms. Secondly, the technique used to bias transistors Q1 and Q2 assures stable operation over an extremely wide temperature range. The resistors R3 and R4 form the bias network. By connecting resistor R3 to the collector of transistor Q1 instead of to the power supply, there is a degenerative feedback process that strongly stabilizes the bias. Further bias stabilization against temperature variations results because the internal resistance of the transducer 50 increases with temperature. A third feature is the use of the bias current through transistor Q1 to reinforce the magnetic field inside transducer 50. This technique provides further benefit in eliminating one coupling capacitor.

The transducer 50 is connected to the circuitry by means of a coaxial cable or a twisted wire pair such that its output voltage has the polarity indicated for the second half of each doublet pulse that is generated by rotation of the distributor cam. Sometimes, especially when long leads are used for connecting various parts of an ignition system together, harmless but annoying oscillation can occur when the ignition system is turned on but the engine is not running. This problem is caused by very high frequency regeneration. It may be eliminated by connecting capacitor C7 across the transducer. A value of up to 0.1 microfarad is satisfactory for capacitor C7, although 0.01 mirofarad will suffice in most cases. Addition of the capacitor C7 does not noticeably affect engine timing provided the stated limitation is observed. Engine timing is for all practical purposes determined by the position of the transducer in the distributor, not by the electronic circuitry.

The stages comprising transistors Q2 and Q3 are ordinary common-emitter amplifiers. Transistor Q3 is biased nearly as cut off. This helps assure response only to positive signals coming from the transducer. Transistor Q3 is coupled to transistor Q4 by means of resistor R11 and capacitor C4. The coupling technique used assures that transistors Q4 and Q5 are conducting heavily during quiescent conditions. This means that transistor Q5 functions as a normally closed electronic switch. Capacitor C4 functions as a speed-up capacitor that quickens the opening of the electronic switch when commanded by the transducer.

Preferred gap settings for transducers 22 and 23 are considered now. Under normal circumstances, a gap of 0.010 inch is desirable between transducer pole tips and distributor cam edges. This allows for normal limits of looseness and for normal operation of the vacuum spark advance used on most engines. In a precision distributor, the gap can probably be reduced to 0.005 inch in order to achieve slightly higher timing accuracy. In a badly worn distributor, one that should normally be replaced, a gap as large as 0.020 inch can be used with results much superior to those achieved using mechanical points.

The invention as shown in FIG. 5 together with a transducer of the type shown in FIG. 3 has these important performance features. For typical six and eight cylinder automotive engines, the ignition system functions properly for cranking speeds below 20 rpm, measured at the crankshaft. Normal cranking speeds are many times this. The system provides high timing accuracy for the life of the engine without need for adjustment, except initially. At higher engine speeds, sometimes as low as several thousand rpm, the bounce of mechanical points results in deleterious performance. With the invention the timing accuracy increases with engine speed, and an effect analogous to mechanical point bounce does not occur. The invention as described is useful in racing engines as well as those used in less demanding service. For racing engines it can, for example, eliminate the need for a dual-point distributor.

The system shown in FIG. 5 may be further refined to reduce its cost. This may be accomplished by replacing the circuitry shown to the right of the dash line in this figure by the circuitry shown in FIG. 6. Now, instead of using transistor Q4 to control a transistor that controls a commercial electronic ignition system, this transistor is used to control a highvoltage transistor Q6. Transistor Q6 in turn controls the flow of current in spark coil 61. By means of inductive kickback, high voltage can be developed from the collector to the emitter of transistor Q6. Transistor Q6 should typically have a collector voltage rating in the order of 400 volts. Silicon diode D2 limits the base-emitter reverse voltage and coacts with resistor R14 and a breakdown device 62 to provide overvoltage protection. The device 62 can be a Zener diode, a gas discharge tube, or other suitable device. It should breakdown, i.e., conduct strongly, when its terminal voltage exceeds 400 volts.

There has been described a novel contactless electromagnetic ignition system characterized by long life, efficient operation under diverse conditions and capable of replacing existing ignition systems having mechanical breaker points. It is evident that those skilled in the art may now make numerous uses and modifications of and departures from the specific embodiments described herein without departing from the inventive concepts. Consequently, the invention is to be construed as embracing each and every novel feature and novel combination of features present in or possessed by the apparatus and techniques herein disclosed and limited solely by the spirit and scope of the appended claims.

What is claimed is:

1. Electromagnetic transducing apparatus comprising,

a cylindrical magnet surrounded about its axis by a coil of wire,

and substantially planar pole pieces affixed to the ends of said cylindrical magnet,

said pole pieces being tapered and aligned with their tips along a line for facing one edge at a time of a cam made of magnetic material for rotation about an axis thereof,

whereby rotation of said cam produces a sequence of sharp pulses across said coil of wire as each edge of the said cam passes closely adjacent to said tips.

2. Electromagnetic transducing apparatus in accordance with claim **1** and further comprising a bobbin for carrying said coil and maintaining said pole pieces and said magnet in alignment

3. Electromagnetic transducing apparatus in accordance with claim **1** and further comprising a housing for supporting said transducing apparatus with the ends of said pole pieces closely adjacent to the path traveled by a distributor cam.

4. Electromagnetic transducing apparatus in accordance with claim **1** wherein said pole pieces are beveled at their tips.

5. Electromagnetic transducing apparatus in accordance with claim **2** and further comprising a housing carrying said bobbin, magnet and pole pieces with the tips of said pole pieces closely adjacent to the path traveled by the circumferential edge of a rotating distributor cam when said housing is seated in the place ordinarily occupied by mechanical ignition points.

6. Electromagnetic transducing apparatus comprising,

a cylindrical magnet surrounded about its axis by a coil of wire,

substantially planar pole pieces affixed to the ends of said cylindrical magnet,

first and second leads from said coil,

an operational amplifier having a common terminal, a summing junction and an output terminal and a predominantly resistive feedback impedance intercoupling said summing junction and said output terminal,

said first and second leads being connected to said summing junction and said common terminal respectively.

7. Apparatus in accordance with claim **6** and further comprising,

saturable amplifier means having its input coupled to said operational amplifier output for providing a signal for controlling the current in the spark coil of an ignition system.

8. Apparatus in accordance with claim **7** and further comprising a high voltage transistor responsive to the signal provided by said saturable amplifier means for controlling the current in the spark coil of an ignition system.

9. Apparatus in accordance with claim **8** and further comprising overvoltage protection means including diode means for preventing excessive base to emitter voltage of said high voltage transistor and a resistor in series with a breakdown device for preventing excessive collector to emitter voltage of said high voltage transistor.

10. Electromagnetic transducing apparatus comprising,

a cylindrical magnetic surrounded about its axis by a coil of wire,

substantially planar pole pieces affixed to the ends of said cylindrical magnet,

first and second leads from said coil of wire,

a common terminal,

a transistor having at least base, emitter and collector electrodes,

said first and second leads being connected to said common terminal and said emitter respectively.

11. Apparatus in accordance with claim **10** and further comprising means for interconnecting said coil of wire and said transistor so that the direct current flowing through said coil produces a magnetic field that reinforces the magnetic field established by said magnet.

12. Apparatus in accordance with claim **11** and further comprising a resistor from the transistor collector to the transistor base for biasing said transistor.

13. Apparatus in accordance with claim **12** and further comprising,

a saturating amplifier means driven by said transistor for controlling a normally closed electronic switch for triggering a standard electronic ignition system.

14. Electromagnetic transducing apparatus in accordance with claim **1** and further comprising,

said cam rotatably mounted for presenting edges one at a time adjacent to said line as said cam rotates.

15. Electromagnetic transducing apparatus comprising,

a cylindrical magnetic surrounded about its axis by a coil of wire,

substantially planar pole pieces affixed to the ends of said cylindrical magnet and separated by a predetermined spacing corresponding to the separation between adjacent edges of a distributor cam,

said distributor cam made of magnetic material for rotation about an axis thereof,

said cylindrical magnet being positioned with said pole pieces arranged to simultaneously face consecutive edges of said cam.

* * * * *