

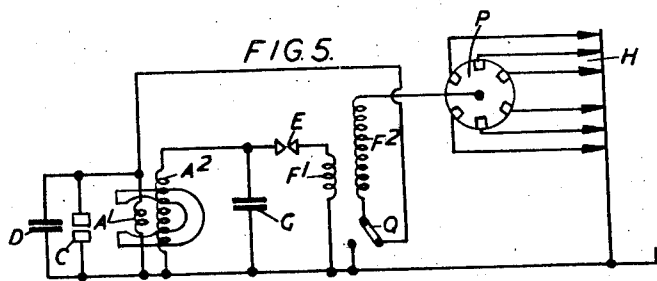
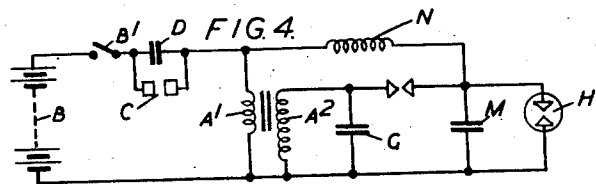
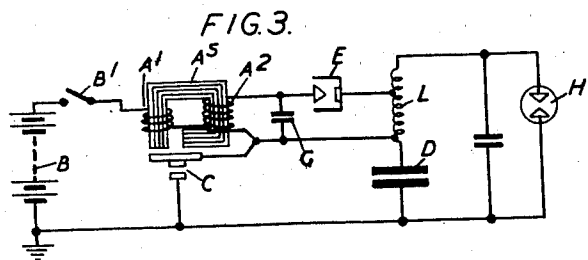
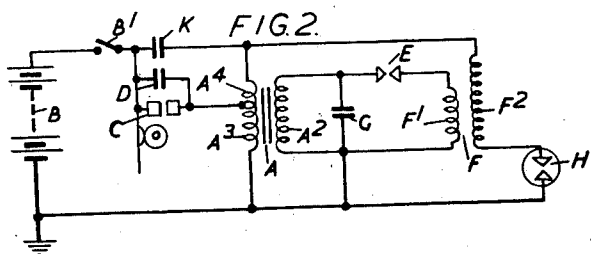
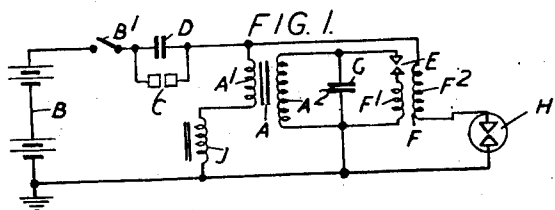
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ELECTRICAL IGNITION SYSTEM

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ELECTRICAL IGNITION SYSTEM

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This invention relates to electrical ignition apparatus or systems of the kind in which electrical impulses provide a spark discharge across a spark gap situated where the ignition is desired, and is particularly applicable to ignition systems for igniting a mixture of fuel and air, as in internal combustion engines, internal combustion turbines, jet propulsion apparatus, liquid fuel furnaces, or the like.

For the sake of convenience the term "spark plug" will be used for the member carrying the spark gap across which the ignition spark discharge takes place, the term ignition coil will be used to mean a coil of the type normally employed for coil ignition in internal combustion engines and having its primary winding associated with the usual contact breakers for producing and timing the current impulses, and the term "magneto" will be used in its usual sense to mean an electrical impulse generator of the usual character employed to produce high tension ignition impulses for ignition in an internal combustion engine. The term "low pass impedance" will be used to designate a coil or winding which offers substantial impedance to high frequency currents while permitting passage of low frequency currents. While the above terms will be used with the meanings referred to, it is to be understood that the relative values of the primary and secondary windings of an ignition coil or a magneto and the usual condenser associated therewith may for the purpose of the present invention differ from those commonly in use at present in accordance with the requirements of the present invention.

In electrical ignition systems of the kind referred to for internal combustion engines, where the usual ignition coil or magneto is provided with its secondary winding connected to the sparking plug or plugs, each spark occurs in two phases. First on opening of the contact breaker a high voltage is built up until it ionises and breaks down the spark gap, whereupon the capacity immediately associated with the gap is discharged as a spark across the gap. This capacity is usually very small, being generally only the capacity of the high tension lead to earth, and moreover the resistance of the now ionised gap is small, so that this initial discharge is very brief. The initial discharge thus produced is followed immediately by the second stage which consists of a considerably longer discharge at lower voltage across the ionised gap, of the energy stored in the secondary winding of the coil or magneto, which, being of high resistance, limits both the

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rate of discharge and the maximum current. Thus the initial high voltage discharge may be regarded as blasting the path for the subsequent longer low voltage discharge. For example, the spark in an existing normal internal combustion engine ignition system may consist of an initial discharge of the order of ten thousand volts with a current of one hundred amperes lasting for a quarter of a micro-second, while the secondary discharge is of the order of one-tenth of an ampere and lasts for about one-thousand micro-seconds.

It is found that sparking with this system will fail if the gap becomes shunted by a leakage path, in the form for example of a conducting layer on the insulator of the plug, of the order of $\frac{1}{4}$ to 1 megohm depending upon the energy available, due to the leakage of the energy by way of the shunt leakage path. To overcome this difficulty a high frequency ignition system has been proposed in which essentially the high tension current impulses from the secondary winding of an ignition coil or magneto are delivered through a spark gap to the primary winding of a high frequency transformer (sometimes known as a Tesla coil), the secondary winding of which is connected to the sparking plug or plugs which thus receive high frequency impulses. It has been found that such high frequency impulses will be discharged across the spark gap in preference to passing through any normally encountered shunting leakage path so that sparking is assured under more adverse conditions than was possible with the old arrangement.

With this so-called high frequency system, however, while satisfactory operation can be obtained when the engine is hot, it is found that starting becomes difficult or impossible in a cold engine or with low grade fuels since a greater degree of local heating than is given by the high frequency spark is required to ignite the fuel, while the system is also useless in other cases where the spark has to effect a substantial degree of local heating of the fuel to be ignited before its actual ignition, as for example, in furnace or other ignitors for comparatively heavy fuels.

An object of the present invention is to provide an improved ignition system or apparatus having advantages over the above previous proposals.

To this end an electrical ignition system according to the present invention includes a high frequency circuit to be coupled or connected to a sparking plug, means including a trigger spark gap for producing a high tension current impulse

in the high frequency circuit to initiate high frequency current and ionise the sparking plug gap, and means for supplying a current at lower voltage to follow up the high frequency current through the sparking plug gap and develop heat therein.

In one form of the invention the system includes an ignition coil or magneto, a high frequency circuit connected to the secondary winding of the coil through a trigger spark gap and coupled or connected to a sparking plug circuit so that the high frequency current resulting from a trigger spark gap will ionise the sparking plug gap, and means, independent of the secondary winding of the coil, for supplying to the sparking plug circuit a relatively low tension discharge following up the high frequency current to develop heat in the sparking plug gap.

The source of high tension impulses will generally be the ignition coil or magneto, the secondary winding of which is coupled or connected to the high frequency circuit, in which case the source of low tension current may be the primary winding of the ignition coil or magneto.

Conveniently, the high frequency circuit includes a high frequency transformer with its primary winding connected to the secondary winding of the ignition coil through a trigger spark gap, and its secondary winding arranged to be connected in series with the sparking plug across the primary circuit of the ignition coil. Alternatively, it may include a high frequency coil or auto-transformer connected to the secondary winding of the ignition coil through a trigger spark gap and arranged to be connected in series with a sparking plug across the contact breaker and condenser in the primary circuit of the ignition coil.

In this way it will be seen that the necessary low tension impulses to maintain the low tension spark discharge across the sparking plug gap, after its ionisation by the high frequency spark, will automatically be available at the time when each high frequency spark occurs.

Alternatively, however, in some cases, where for example it is desired to maintain the spark discharge across the sparking plug gap over a longer period, for the purpose say of igniting the fuel under adverse conditions, the low tension current may be supplied to the sparking plug circuit from a battery.

Where, as described above, the low tension current is supplied in the form of impulses from the primary winding of the magneto or ignition coil which also supplies the high tension impulses to the high frequency circuit, the primary winding of the magneto or ignition coil may be formed as an auto-transformer, the battery and contact breaker being connected across a portion of it whilst the sparking plug circuit is connected across the whole of it. A step-up effect is thereby obtained to increase the voltage of the low tension impulse supplied to the sparking plug circuit. Alternatively, or in addition, an inductance may be connected in series or in parallel with the primary winding of the ignition coil or magneto to increase the low tension energy available for discharge across the spark gap after ionisation by the high frequency spark. In a further alternative a similar effect is obtained by making the coupling between the primary and secondary winding of the ignition coil less than a maximum, for example by winding them on different limbs of a core having an air gap in it, to increase the energy available from the primary circuit.

It will be understood that the invention can readily be applied to existing high frequency spark ignition systems wherein the secondary winding of the magneto or ignition coil is connected through a spark gap to the primary winding of a high frequency transformer by connecting the primary winding of the magneto or ignition coil to the end of the secondary winding of the high frequency transformer which is not connected to the distributor or sparking plug, so as to deliver low tension impulses thereto from the primary winding of the magneto or ignition coil. In such an arrangement, moreover, a selector switch may be provided whereby the end of the secondary winding of the high frequency transformer not connected to the sparking plug or distributor can alternatively be connected to the primary winding of the magneto or ignition coil for starting purposes, or to earth for normal running when the engine is hot.

A peak voltage of the order of 250 volts normally occurs at the contact breaker of an ignition coil or magneto, and if the unearthed side of the contact breaker is connected to the secondary circuit of the high frequency transformer as described above, it will be seen that this voltage will discharge across the spark gap already ionised by the high frequency spark impulse and that in this way much of the excess energy, which is normally lost in heating the secondary winding of the ignition coil or magneto and in flashing across the contact breaker as it breaks, is usefully expended in the spark gap. Further only a small proportion of the voltage need be lost in traversing the secondary winding of the high frequency transformer since the resistance of this secondary winding can be very low.

The invention may take various forms in practice but certain arrangements will be described purely by way of example with reference to the accompanying drawings in which Figures 1 to 5 are respectively circuit diagrams of five different arrangements.

In the form of the invention shown in Figure 1 as applied to a coil ignition system the apparatus comprises the usual coil A, the primary winding A¹ of which is connected to a battery B through a switch B¹ and the usual contact breaker C which is shunted by a condenser D. The secondary winding A² of the coil is connected in series with a pilot spark gap E and the primary winding F¹ of a high frequency transformer F and is shunted by a condenser G. The sparking plug H has one terminal connected to earth and the other terminal connected to one end of the secondary winding F² of the high frequency transformer.

The arrangement so far described resembles known arrangements for high frequency coil ignition. In such known arrangements the other end of the secondary winding of the high frequency transformer would be connected to earth but in accordance with the invention this end of the secondary winding of the high frequency transformer is connected to the primary winding of the ignition coil. Hence, the circuit through the sparking plug and the secondary winding of the high frequency transformer is completed through the primary winding of the ignition coil.

Thus, when the contact breaker opens, the sparking plug receives substantially simultaneously a high frequency impulse from the secondary winding of the high frequency transformer, which breaks down and ionises the spark gap, and a low tension impulse or surge from the primary winding of the ignition coil which dis-

charges a much higher current across the gap for a limited period thereafter.

In an arrangement embodying the invention the energy received from the secondary winding of the ignition coil is not wholly relied upon to heat the spark gap, but is supplemented or replaced by energy from the primary winding. Accordingly, it may be desirable to increase the amount of energy stored in and available from the primary circuit at the expense of that available from the secondary winding. One way of doing this is by connecting a choke in series with the primary winding as indicated at J in Figure 1.

Another way of doing this is indicated in Figure 2 which is similar to Figure 1 except that the primary winding of the ignition coil is formed as an auto-transformer comprising two sections A³ and A⁴. The section A³ is included in the circuit with the contact breaker and battery, while the secondary winding of the high frequency transformer is connected to the end of the section A⁴ so that the whole winding is included in the high frequency circuit. A condenser K is connected between this end of the winding A⁴ and the further side of the contact breaker. In this way the voltage of the low tension current impulse delivered to the secondary circuit of the high frequency transformer is increased.

A further method of increasing the primary energy at the expense of the secondary energy is by adopting looser coupling between the primary and secondary winding. Such an arrangement is indicated diagrammatically in Figure 3 in which the primary winding A¹ and the secondary winding A² are wound on separate limbs of a core A³ having in it an air gap.

The form of contact breaker adopted may vary in accordance with the particular application. In the case of the normal ignition of a piston engine it may be mechanically operated by means of a cam as indicated diagrammatically in Figure 2. On the other hand, where a succession of sparks is required, as in the case of a booster or for jet propulsion and like applications, the contact breaker may be operated by means of a vibrator as indicated diagrammatically in Figure 3 which shows the armature of the vibrator bridging the air gap in the core of the ignition coil.

Figure 3 also indicates the use of a high frequency auto-transformer L in place of the separately wound transformer F. In one example this has a ratio of 1½ to 1 but this may be varied in accordance with requirements. In general the step-up effect is advantageous but if it is not required the auto-transformer may be replaced by a simple high frequency coil. Figure 3 also incorporates slight rearrangements of the circuit, in which it will be seen that the contact breaker is included on the earthed side of the primary winding of the ignition coil and the primary winding of the high frequency transformer, instead of being directly earthed, is connected to the contact breaker. Hence the high frequency circuit is completed through the condenser D of the contact breaker, which may be of several microfarads capacity.

In the arrangement of Figure 1 the sparking plug circuit is transformer coupled to the high frequency circuit and directly connected to the low tension circuit.

In the arrangement of Figure 3 it is directly connected to the high frequency circuit and the

low tension circuit which may be regarded as arranged in series with the contact breaker condenser serving as a high frequency by-pass. Various other forms of coupling between the sparking plug circuit and on the one hand the high frequency circuit and on the other hand the low tension circuit may be adopted.

One such arrangement is indicated in Figure 4, in which the sparking plug is directly connected to the high frequency circuit, which in this case is constituted by a condenser M together with the inductance of the leads, in parallel with the low tension circuit, that is to say, the primary winding A¹ of the ignition coil. A high frequency choke N is interposed in the connection providing a high frequency barrier, while permitting current from the low tension circuit to pass, thus constituting a low pass impedance.

Figure 5 shows an arrangement in which the invention is applied to a magneto ignition system. As in known high frequency magneto ignition systems the primary winding A¹ is shunted by a contact breaker C and condenser D while the secondary winding A² is connected in series with a trigger spark gap E and the primary winding F¹ of a high frequency transformer F. The winding F¹ may also be shunted by a condenser G although the capacity of the leads may be sufficient to render this condenser unnecessary. The secondary winding F² is connected through the distributor P to the sparking plugs H. In known systems of high frequency ignition the opposite end of the secondary winding F² of the high frequency transformer is connected to earth. In accordance with the invention on the other hand this end of the secondary winding is connected to the unearthed end of the primary winding A¹ of the magneto as in the arrangement of Figure 1. In order to allow the arrangement to function either in accordance with the invention or in accordance with known practice this end of the secondary winding F² is shown as connected to a selector switch Q whereby it can be connected either to the primary winding of the magneto or to earth at will. Thus, for cold starting the secondary circuit of the high frequency transformer can be connected to the primary winding of the magneto, so as to give substantial energy and appreciable duration to the spark at each opening of the contact breaker, whereas during normal running it can be connected to earth so that the system operates as a high frequency system of the known type.

It will be appreciated that the invention enables the advantages of high frequency ignition to be combined with a spark which produces a considerable quantity of heat and energy. For example, in a booster circuit such as that in Figure 3 the heating effect of the spark is many times that obtained with a normal high frequency arrangement. The initial high frequency oscillation breaks down the insulation of the sparking plug gap but provides very little energy and will generally be inadequate to heat up any fuel which must be vapourised by the spark before it can be ignited. In the normal arrangement the ensuing surge of current due to the energy stored in the core of the ignition coil must pass through the resistance of the secondary winding of the ignition coil. As this may be of the order of 5,000 ohms the current is very limited. On the other hand in the present arrangement the energy does not have to pass

through this resistance but flows directly to the secondary winding of the high frequency transformer from the primary circuit, where a voltage builds up across the contact breaker. As normally constructed for radio purposes the resistance of this winding might be of the order 5 or 10 ohms. If, however, the maximum effectiveness of spark is required it is preferred to employ a high frequency coil or transformer of specially low resistance. This may be produced by winding a series of flat spirals of copper strip placed coaxially so as to produce a suitable high frequency coil having a resistance of the order of a fifth of an ohm. Such a coil can be made relatively compact so as to require only a small screen.

The trigger gap may be of any preferred form but a cup gap in which one electrode is formed as a cup and the other is situated within it is generally preferred since it deionises more quickly. Such a gap may be mounted coaxially with the high frequency coil.

In one particular embodiment of the invention arranged as shown in Figure 3 the efficiency of energy conversion was found to be of the order of 60 to 80 per cent, that is to say 60 to 80 per cent of the input energy was converted into heat in the sparking plug gap. As a result it was found that the ignition coil remained cold even with an input of some 70 watts.

It will be appreciated that the invention is not limited to the arrangements described by way of example or to the particular applications described. Thus, for example, it may be used for such purposes as starting an arc, whether between carbon or other solid electrodes or from a mercury electrode. It is, however, primarily applicable to the ignition of fuels and especially fuels that are difficult to ignite. For example, ordinary paraffin (kerosene) is accompanied by practically no vapour and in order to ignite it the spark must develop sufficient heat to vapourise it first.

What I claim as my invention and desire to secure by Letters Patent is:

1. An electrical ignition system including an electrical impulse generator for producing high tension ignition current including a primary winding, a secondary winding, and a contact breaker; a source of high frequency energy including the said secondary winding and an auxiliary spark gap in series with it; a source of low tension energy including the said primary winding; and means for coupling a sparking plug circuit to the sources including low-pass impedance means in series with the said low tension source, so that the high frequency current resulting from an auxiliary gap spark will ionise the sparking plug gap, and a relatively low-tension discharge will follow it up to develop heat in the sparking plug gap.

2. An electrical ignition system including an electrical impulse generator for producing high tension ignition current including a primary winding, a secondary winding, and a contact breaker; a source of high frequency energy including the said secondary winding and an auxiliary spark gap in series with it; a source of low tension energy including the said primary winding; and means for coupling a sparking plug circuit to the said sources including low-pass impedance means comprising high-frequency transforming means in series with the said low tension source, so that the high-frequency current resulting from an auxiliary gap spark will ionise

the sparking plug gap, and a relatively low tension discharge will follow it up to develop heat in the sparking plug gap.

3. An electrical ignition system including an electrical impulse generator for producing high tension ignition current including a primary winding, a secondary winding, and a contact breaker; a source of high frequency energy including the said secondary winding and an auxiliary spark gap in series with it; a source of low tension energy including the said primary winding; and means for coupling a sparking plug circuit to the said sources including low pass impedance means comprising a high-frequency transformer winding in series with the said low tension source, so that the high frequency current resulting from an auxiliary gap spark will ionise the sparking plug gap, and a relatively low tension discharge will follow it up to develop heat in the sparking plug gap.

4. An electrical ignition system including an electrical impulse generator for producing high tension ignition current including a primary winding, a secondary winding, and a contact breaker; a source of high frequency energy including the said secondary winding and an auxiliary spark gap in series with it; a source of low tension energy including the said primary winding; and means for coupling a sparking plug circuit to the said sources including low pass impedance means comprising a high frequency auto-transformer winding in series with the said low tension source, so that the high frequency current resulting from an auxiliary gap spark will ionise the sparking plug gap, and a relatively low tension discharge will follow it up to develop heat in the sparking plug gap.

5. An electrical ignition system including an electrical impulse generator for producing high tension ignition current including a primary winding, a secondary winding, and a contact breaker; a source of high frequency energy including the said secondary winding and an auxiliary spark gap in series with it; a source of low tension energy including the said primary winding; and means for coupling a sparking plug circuit to the said sources including low pass impedance means comprising a high frequency choke in series with the said low tension source, so that the high frequency current resulting from an auxiliary gap spark will ionise the sparking plug gap, and a relatively low tension discharge will follow it up to develop heat in the sparking plug gap.

6. An electrical ignition system including an electrical impulse generator for producing high tension ignition current, a high frequency transformer having a primary winding connected to the secondary winding of the said generator through an auxiliary spark gap and a secondary winding connected in series with the sparking plug circuit across the primary circuit of the said generator.

7. An electrical ignition system including an electrical impulse generator for producing high tension ignition current, a high frequency auto-transformer having a primary winding connected to the secondary winding of the said generator through an auxiliary spark gap, and a secondary winding connected in series with the sparking plug circuit across the primary circuit of the said generator.

8. An electrical ignition system including an electrical impulse generator for producing high tension ignition current, an auxiliary spark gap connected in series with the sparking plug cir-

cuit across the secondary winding of the said generator, and a high frequency choke connected in series with the sparking plug circuit across the primary circuit of the said generator.

9. An electrical ignition system including an electrical impulse generator for producing high tension ignition current, including a primary winding, a secondary winding, and a contact breaker; a source of high frequency energy including the said secondary winding and an auxiliary spark gap in series with it; a source of low tension energy including the said primary winding; means for coupling a sparking plug circuit to the said sources including low-pass impedance means in series with the said low tension source; and means for increasing the energy stored in the primary circuit.

10. An electrical ignition system including an ignition coil including a secondary winding, a tapped primary winding constituting an auto-transformer, and a contact breaker connected in circuit with a primary portion of said auto-transformer; a source of high frequency energy including said secondary winding and an auxiliary spark gap in series with it; a source of low tension energy including the whole of said auto-transformer winding; and means for coupling a sparking plug circuit to said sources including low-pass impedance means in series with said low tension source.

11. An electrical ignition system including an ignition coil including a secondary winding, a tapped primary winding constituting an auto-transformer, and a contact breaker connected in circuit with a primary portion of said auto-transformer; high frequency transforming means having a primary winding connected to the secondary winding of the said ignition coil through an auxiliary spark gap, and a secondary winding connected in series with the sparking plug circuit across the whole of the primary winding of the said ignition coil.

12. An electrical ignition system including an electrical impulse generator for producing high tension ignition current, including a primary winding, a secondary winding, and a contact breaker; an inductance in series with said primary winding and contact breaker; a source of

high-frequency energy including said secondary winding and an auxiliary spark gap in series with it; a source of low tension energy including said primary winding and said inductance; and means for coupling a sparking plug circuit to said sources including low-pass impedance means in series with said low tension source.

13. An electrical ignition system including an electrical impulse generator for producing high tension ignition current, including a primary winding, a secondary winding, and a contact-breaker; an inductance connected in series with the said primary winding and contact breaker, high frequency transforming means having a primary winding connected to the secondary winding of the said generator through an auxiliary spark gap, and a secondary winding connected in series with the sparking plug circuit across the said inductance and the primary winding of the said generator.

14. An electrical ignition system including an electrical impulse generator for producing high tension ignition current, including a core with an air-gap in it, a primary winding and a secondary winding wound on separate limbs of the core to make the coupling between said windings less than a maximum, and a contact breaker; a source of high frequency energy including the said secondary winding and an auxiliary spark gap in series with it; a source of low tension energy including the said primary winding; and means for coupling a sparking plug circuit to the said sources including low-pass impedance means in series with the said low frequency source.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,409,202	Francis	Oct. 15, 1946

FOREIGN PATENTS

Number	Country	Date
527,412	Great Britain	Oct. 8, 1940