

AN ELECTRIC IGNITER ASSEMBLY

This invention relates to an electric igniter assembly comprising a transformer-coupled electric ignition element, for example, an electric detonator fusehead as used
5 in blasting operations. The invention also includes a method of arming and a method of firing an electric ignition element. The invention enhances the safety of transformer-coupled electric ignition elements by providing greater protection against spurious electric currents.

10 Electric detonator assemblies adapted for inductive coupling to an electrical firing energy source are marketed widely by Nobel's Explosive Company Limited under the Registered Trade Mark 'Magnadet', the blasting system using
15 such detonators being generally described as the 'Magnadet' system. In this blasting system an encased resistive ignition element of an electric detonator for detonating the blasting charge has its two terminals connected respectively
20 to the ends of a continuous conductor wire which extends outside the detonator casing. The external portion of the conductor wire is fully insulated and is wound as a secondary winding of 3-5 turns on a ferrite ring core, which is
usually termed a toroid (although it is generally a flat cylindrical section of a tube and it may have shapes other
25 than circular, such as rectangular or multi-angular). For firing the detonator an insulated conductor wire is threaded as a single loop primary winding through one or more toroid
ring cores and connected to a suitable source of A.C. firing current. These inductively coupled detonators are described
30 in United Kingdom Patent Specifications Nos. 2022222A and 2109512A.

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Inductively coupled 'Magnadet' detonators are advantageous in many blasting operations because of their convenience in connecting for use and their high degree of safety from premature ignition by stray electric currents and static electricity. The inductive coupling can be designed to be frequency selective so that signals outside a designed band within a range of about 10 to 100 kHz will be effectively attenuated to prevent them firing the ignition element. Thus in general such detonators are designed to pass efficiently a signal of 10-20 kHz and in use are used with a blasting machine (exploder) generating a current within this frequency band. The safety characteristics therefore ensure safety from all the common sources of dangerous electric currents. However the detonators are necessarily not protected against a spurious signal having a frequency within the designed frequency band and are therefore at some risk from such a signal when the primary conductor wire is in position in the toroidal core and especially when the primary wire is connected to the firing source. Since it is often necessary to position explosive charges and 'Magnadet' detonators in shotholes for a considerable period of time before blasting and, moreover, the primary wire is connected to the firing source for some time before blasting, it would be advantageous if the detonators were completely safe from all currents until the time for firing.

In accordance with the invention an electric igniter assembly comprises: a transformer having a magnetically permeable core, a primary circuit adapted to be connected to a source of A.C. energy and a secondary circuit, an ignition element connected to said secondary circuit, and means for applying a steady magnetic field within at least a portion of said core, the intensity of said steady magnetic field within said core being sufficiently strong to prevent effective transmission of electrical energy from said primary circuit to said secondary circuit for firing the ignition element.

(17)

The means to apply the magnetic field may comprise one or more magnets, preferably permanent magnets. The magnet(s) may advantageously be movable with respect to the said core to vary the field intensity. With such an arrangement the magnetic field can be maintained within the magnetically permeable core until the transmission of current is required and then reduced or removed by relative movement of the magnet and core.

The said permanent magnet advantageously has its poles disposed so that they may both simultaneously be in close proximity to the magnetically permeable core.

The means to apply the magnetic field should preferably be capable of magnetically saturating the magnetically permeable core, thereby rendering the device incapable of passing any significant current when the magnetic field is applied within the core.

The magnetically permeable core is advantageously a ferrite core and is preferably a ring core, hereinafter termed a toroidal core or toroid. The primary circuit may be a single-strand closed loop threaded through the toroidal cores of one or several igniter assemblies.

In using the assembly of the invention at least one of said primary and secondary circuits is coupled as a winding of at least one turn to a magnetically permeable core and the primary circuit is connected to an A.C. source. When the core is a toroidal core at least one of said circuits may be coupled as a single strand of wire threaded through the said toroid. When the magnetic field intensity within the core is at a high value the transmission of electrical energy from the primary to the secondary circuit is inhibited but as the field intensity is reduced the energy transmission increases.

For firing the ignition element an A.C. signal is applied to the primary circuit when the magnetic field intensity is sufficiently low to permit firing energy to be transmitted.

- The invention also includes a method of firing an electric
- 5 ignition element comprising the steps of
- applying a steady magnetic field within at least a portion of a magnetically permeable core of a transformer the intensity of said magnetic field being sufficiently strong to prevent effective transmission of energy through
- 10 the transformer;
- connecting a secondary circuit of said transformer to an electric ignition element;
- connecting an A.C. energy source to a primary circuit of said transformer;
- 15 decreasing the intensity of said steady magnetic field to allow energy to be transferred between said primary circuit and said secondary circuit.
- and applying an A.C. signal from said energy source to said primary circuit.
- 20 The magnetic field is advantageously applied by a magnet which is movable with respect to the core and when energy transmission is desired the magnet is moved from a position in which the core lies within the magnetic field of said magnet to a position in which the core is effectively outside
- 25 said magnetic field.

From a further aspect the invention includes

A method of arming an electric ignition element comprising the steps of:

- applying a steady magnetic field within at least a
- 30 portion of a magnetically permeable core of a transformer having a secondary circuit connected to an electric ignition element and a primary circuit connected to a source of A.C. energy, the intensity of said steady magnetic field being sufficiently strong to prevent effective transmission of

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electrical energy from said primary circuit to said secondary circuit to maintain said ignition element in a safe condition; and

decreasing the intensity of said magnetic field to permit the transmission of firing energy between said primary circuit and said secondary circuit to said ignition element to arm said ignition element.

The invention is further illustrated by the preferred embodiment which is hereinafter described, by way of example, with reference to the accompanying drawings wherein,

- Figure 1 shows diagrammatically the firing circuit of an inductively (transformer) coupled electric detonator assembly of the prior art.
- 15 Figure 2 shows the firing circuit of an assembly in accordance with the invention having a magnetic field established within the transformer core,
- Figure 3 shows the circuit of Fig. 2 with the magnetic field effectively withdrawn from
- 20 the transformer core;
- Figure 4 shows a test circuit diagram for testing the efficiency of a transformer coupling; and
- Figure 5 shows graphs of the secondary circuit current with various magnetic field intensities
- 25 within the core of the assembly of Fig. 2.

The assembly of Fig. 1 is a 'Magnadet' electric detonator firing circuit comprising a ferrite toroid 1 to which an electric detonator 2 is coupled by a secondary circuit 3 and an A.C. generator 4 is coupled by a primary circuit

30 5. The secondary circuit 3 comprises three turns of insulated wire around the core 1 and the primary circuit 5 comprises a single loop of insulated wire through the toroid 1. In normal use the detonator is fired by generating firing current in the generator 4 at a

35 frequency within the range which the toroid is designed to transmit effectively.

In the assembly as shown in Fig. 2 two permanent magnets 6 are positioned respectively on opposite sides of the toroid 1 and in close proximity thereto, with both poles (12,13) of each magnet close to the toroid 1. With the magnets 6 in this position the coupling efficiency of the toroid 1 is temporarily reduced so that current supplied by the generator 4 is not transmitted to the detonator 2. The efficiency is most effectively reduced by having the poles of one magnet positioned facing like poles of the other magnet through the toroid. When the detonator 2 is to be fired the magnets 6 are removed from the vicinity of the toroid 1 as shown in Fig. 3, whereupon the coupling efficiency of the toroid 1 is restored to its original value and firing energy may be transmitted from the generator 4 to the detonator 2.

The effectiveness of the magnets 6 in reducing the coupling efficiency of a toroid 1 was tested in the circuit arrangement of Fig. 4. In the test circuit a variable frequency A.C. generator 9 was connected to provide input to a power amplifier 8. The A.C. output from the amplifier 8 was fed through a primary circuit 10 coupled to a toroid 1 by a single loop (as in Fig. 1). A secondary circuit 11 coupled to the toroid 1 by three turns of wire (as in Fig. 1) was connected to a resistive load 7 of 1 ohm, which corresponds approximately with the resistance of the ignition element in the electric detonator 2.

The following Table gives the secondary circuit currents measured at different frequencies for a primary circuit of 6 amps using (a) no magnet (as in fig. 1), (b) one magnet, and (c) two magnets (as in Fig. 2) positioned close to the toroid 1. The magnets were 'Eclipse' ^(A.T.M.) E852 'Maxi Magnets' having a closed circuit flux density of approximately 630 gauss.

The observations given in the Table are shown graphically in Fig. 5. These results show that over the frequency range 5 to 50 kHz the secondary current can be substantially

reduced by the magnets. Thus the transmission of sufficient energy to fire an inductively coupled detonator, which usually requires a minimum firing current of about 1 amp., can be readily prevented by the application of a steady magnetic field within the core of the assembly of the invention.

TABLE

Frequency kHz	SECONDARY CURRENT (AMPS)		
	No Magnets	One Magnet	Two Magnets
5	1.23	0.14	0.0009
10	1.77	0.33	0.0002
15	1.85	0.48	0.0033
20	1.90	0.66	0.0042
25	1.90	0.77	0.0055
30	1.90	0.87	0.0066
40	1.90	1.02	0.0088
50	1.91	1.23	0.0108

CLAIMS

1. An electric igniter assembly comprising:
a transformer having a magnetically permeable core, a primary circuit adapted to be connected to a source of A.C. energy and a secondary circuit;
an ignition element connected to said secondary circuit;
and
means for applying a steady magnetic field within at least a portion of said core, the intensity of said steady magnetic field within said core being sufficiently strong to prevent effective transmission of electrical energy from said primary circuit to said secondary circuit for firing the ignition element.
2. An assembly as claimed in claim 1 wherein the means to apply the magnetic field comprises at least one magnet, the said transformer core being disposed within the magnetic field of said magnet.
3. An assembly as claimed in claim 2 wherein the said magnet and said core are relatively movable thereby allowing the core to be moved towards and away from the said magnetic field.
4. An assembly as claimed in claim 2 or claim 3 wherein the said magnet is a permanent magnet.
5. An assembly as claimed in claim 4 wherein the said permanent magnet is formed with poles disposed so that both poles may simultaneously be in close proximity to the magnetically permeable core.



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6. An assembly as claimed in any one of claims 1 to 6 inclusive wherein the means to apply the magnetic field comprises a magnet providing a magnetic field capable of magnetically saturating the magnetically permeable core.

7. An assembly as claimed in any one of claims 1 to 6 inclusive wherein the magnetically permeable core is a ferrite core.

8. An assembly as claimed in any one of claims 1 to 7 inclusive wherein the core is a ring core.

9. An assembly as claimed in claim 8 wherein at least one of said circuits is coupled as a winding of at least one turn through said ring core.

10. A coupling device as claimed in claim 8 or claim 9 wherein at least one of said circuits is coupled as a single strand of wire threaded through the said ring core.

11. A method of firing an electric ignition element comprising the steps of:

applying a steady magnetic field within at least a portion of a magnetically permeable core of a transformer the intensity of said magnetic field being sufficiently strong to prevent effective transmission of energy through the transformer;

connecting a secondary circuit of said transformers to an electric ignition element;

connecting an A.C. energy source to a primary circuit of said transformer,

decreasing the intensity of said steady magnetic field to allow energy to be transferred between said primary circuit and said secondary circuit.

and applying an A.C. signal from said energy source to said primary circuit.



12. A method is claimed in claim 12 wherein the steady magnetic field is applied by a magnet which is movable with respect to the core from a position in which the core lies within the magnetic field of said magnet to a position in which the core is effectively outside said magnetic field.

13 A method of arming an electric ignition element comprising the steps of:

applying a steady magnetic field within at least a portion of a magnetically permeable core of a transformer having a secondary circuit connected to an electric ignition element and a primary circuit connected to a source of A.C. energy, the intensity of said steady magnetic field being sufficiently strong to prevent effective transmission of electrical energy from said primary circuit to said secondary circuit to maintain said ignition element in a safe condition; and

decreasing the intensity of said magnetic field to permit the transmission of firing energy between said primary circuit and said secondary circuit to said ignition element to arm said ignition element.

14. An electric igniter assembly substantially as described herein with reference to the accompanying drawings.

15. A method of firing an electric ignition element, substantially as described herein with reference to the accompanying drawings.

16. A method of arming an electric ignition element substantially as described herein with reference to the accompanying drawings.



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