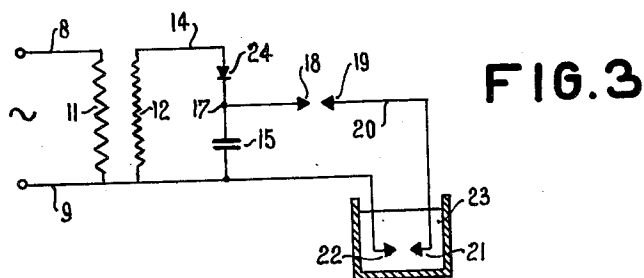
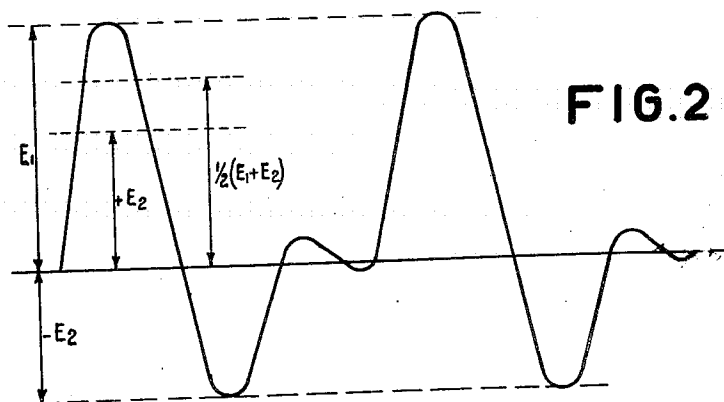
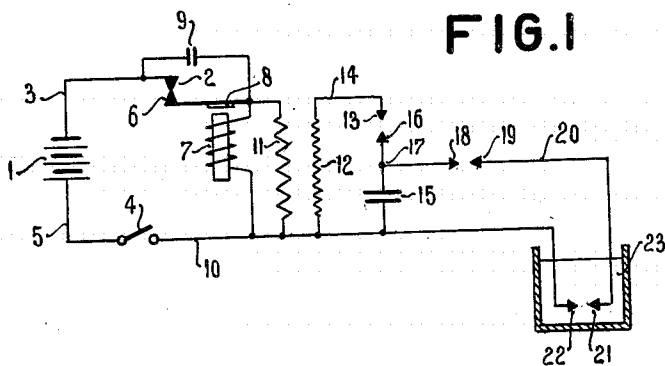


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 APPARATUS FOR THE IGNITION OF
 EXPLOSIVE MATERIAL IN LIQUIDS
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APPARATUS FOR THE IGNITION OF EXPLOSIVE MATERIAL IN LIQUIDS

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1 Claim. (Cl. 175-115)

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This invention is a continuation-in-part of that described in the main patent application Serial No. 704,023, Patent No. 2,507,277, dated May 9, 1950, which relates to an apparatus for the ignition of a welding torch or the like under water, comprising a spark plug adapted for immersion in water, a storage capacitor electrodes defining therebetween an auxiliary spark gap, conductors connecting said spark plug and said auxiliary spark gap in a series connection which is shunted to said capacitor, a device for the generation of an alternating voltage, means adapted to have a rectifying effect on said voltage, at least one switch and conductors connecting said capacitor, said device, said means and said switch in a series circuit, said means adapted to have a rectifying effect on said voltage being a set of electrodes defining therebetween a spark gap. In this apparatus the alternating voltage is generated by the cooperation of a direct current battery, an interrupter and a transformer. It is a well known fact that an alternating voltage generated in that way is very asymmetric due to the damping caused by the resistance of the circuit. If such a voltage is laid across the series connection of a capacitor and a spark gap having in itself no rectifying effect and if the spark gap is so adjusted that its ignition voltage is higher than the peak voltage of the asymmetrically alternating voltage in one direction but lower than the peak voltage thereof in the other direction, the spark gap has a rectifying effect on said asymmetrically alternating voltage, since it lets current through in one direction only whereby the capacitor is loaded.

Although sufficient in many cases the efficiency of a spark gap as a rectifying means is not very great. It has now been found, that a better result is obtained, when instead of the spark gap a rectifier is used. A rectifier has not only the advantage that it completely checks the current in one direction, so that per period of the feeding alternating voltage more energy is stored in the capacitor, but it is also appropriate to operate on a symmetrically alternating voltage. That is why according to the present continuation-in-part the spark gap has been replaced by a rectifier.

Any type of rectifier will do, e. g. a rectifying discharge tube, an electrolytic rectifier or a dry rectifier, but the latter type of rectifier is preferred.

The invention will be better understood from the next description of the embodiments illustrated in the accompanying drawing, in which:

Fig. 1 shows a diagram of the electrical connec-

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tions of the ignition system according to the main patent application Serial No. 704,023.

Fig. 2 shows a graph of the voltage generated in the system according to Fig. 1, and

Fig. 3 is a diagram of the electrical connections of the essential part of an ignition system according to the present invention.

In Fig. 1 of the drawing 1 designates a battery. This battery is connected to a fixed contact 2 by a conductor 3 and to one terminal of a manually operable switch 4 by a conductor 5. Contact 2 cooperates with the movable contact 6 of an electromagnetic interrupter, of which the coil is designated by 7 and one terminal of said coil is connected to the movable contact 6 by a conductor partly formed by the movable armature 8 of the interrupter. The contacts 2 and 6 of the interrupter are bridged by a small capacitor 9. The other terminal of coil 7 is connected to a conductor 10 leading from the other terminal of switch 4. Connected between the conductors 8 and 10, that means shunted to coil 7 is the primary winding 11 of a transformer. The secondary winding 12 of said transformer is connected with one end to one electrode 13 of a spark gap by a conductor 14 and with the other end to conductor 10, to which also one plate of a storage capacitor 15 is connected. The other plate of said capacitor is connected to the other electrode 16 of said spark gap by a conductor 17 which is branched to one electrode 18 of a second spark gap. The other electrode 19 of said second spark gap is connected by a conductor 20 to one electrode 21 of a spark plug of which the other electrode 22 is connected to conductor 10. The spark plug 21, 22 is immersed in water 23. The operation of the above described ignition apparatus is as follows:

When the contacts 2 and 6 of the interrupter are closed a current will flow both through coil 7 of the interrupter and through primary winding 11 as soon as switch 4 is closed. Thereby the interrupter is excited, attracts its armature 8 and separates contacts 2 and 6, whereby the circuit of coil 7 and primary winding 11 is broken. The result thereof is that the armature 8 is released and the contacts 2 and 6 are closed again and the opening operation of said contacts by the electromagnetic coil 8 is repeated. The effect of the alternate opening and closing of contacts 2 and 6 is shown in Fig. 2. The closing of contacts 2 and 6 causes the voltage generated in the secondary winding 12 of the transformer to increase to a value E_1 , e. g. 10,000 volts. When, thereupon, the contacts 2 and 6 are opened the voltage rapidly decreases, becomes negative,

then again positive, again negative etc., till it is completely damped. Since the circuit is damped by its natural resistance the amplitudes or peaks of the successive phases of the voltage curve will rapidly decrease so that the main negative peak voltage E_2 will be much lower than the main positive peak voltage E_1 , say 4000 volts. Thus, the curve of the alternating voltage generated on the terminals of the secondary winding 12 of the transformer is very asymmetric. If in the chosen example the ignition voltage of the spark gap 13, 16 is 7000 volts only the main positive peaks E_1 will be able to ignite said spark gap and to have a current flown to the storage capacitor 15. This capacitor having a certain capacity will be charged by the first impulse up to a voltage V , which in general will be much lower than the peak voltage E_1 , say 500 volts.

The voltage of the storage condenser counteracts the positive voltage impulses and amplifies the negative voltage impulses, so that the next positive impulse has to rise up to 7500 volts before the potential difference across the spark gap 13, 16 is 7000 volts and the gap is ignited. Therefore, during the second positive impulse the voltage of the storage capacitor is increased less, say with 450 volts, so that its voltage will then be 950 volts, and so on. The more the potential difference across the capacitor increases the smaller is the raise of voltage by each impulse.

Assuming now that there is no discharge circuit constituted by the second spark gap 18, 19 and the spark plug 21, 22, the voltage across capacitor 15 will be gradually raised up to 3000 volts without any difficulty. However, as soon as the storage capacitor has reached a voltage of 3000 volts the potential difference between the electrodes 13 and 16 of the spark gap will become 4000 volts+3000 volts=7000 volts during the negative impulse E_2 , having a peak of 4000 volts, and the spark gap 13, 16 will be reignited, so that the capacitor is discharged through said spark gap and the secondary winding 12. Consequently, the spark gap 13, 16 has a limited rectifying effect on the asymmetrically alternating voltage generated in the secondary winding 12 of the transformer.

In the system according to Fig. 1 the capacitor 15 is shunted by the series connection of the auxiliary spark gap 18, 19 and the spark plug 21, 22. The spark plug is immersed in water, which must be considered as semi-conductive material. This means, that the spark plug is bridged by a resistance and that the entire voltage of the storage capacitor 15 is effective between the electrodes 18, 19 of said auxiliary spark gap. Assuming that the ignition voltage of this spark gap is 2500 volts, said spark gap will be ignited as soon as the storage capacitor has been charged up to a voltage of 2500 volts. After the ignition of said spark gap 18, 19 the resistance thereof immediately drops to a negligible value and the condenser is discharged through said spark gap and the spark plug 21, 22. The discharge current blows the water shunt between the electrodes 21, 22 of the spark plug to pieces and causes thereby the desired spark. It will be noted that, the ignition voltage of spark gap 18, 19 being 2500

volts the capacitor will never reach its maximum voltage of 3000 volts referred to. Several impulses of the voltage generating device are needed for loading the capacitor to the ignition value of the spark gap 18, 19. Thus the frequency of the closing and opening operation of the contacts 2, 6 of the interrupter is higher than the frequency of the sparks.

As stated above the spark gap 13, 16, if adjusted well, has only a restricted rectifying effect on an asymmetrically alternating voltage, e. g. a damped alternating voltage. Consequently, a normal undamped alternating voltage cannot be used for feeding the transformer 11, 12 when spark gap 13, 16 is used.

According to the present invention spark gap 13, 16 is replaced by a rectifier 24 (Fig. 3). Should the transformer 11, 12 be fed by means of the battery 1 and the interrupter 2, 6, 7, the entire main positive impulse E_1 would be used for charging the storage capacitor and the negative impulse would not have any effect. In that case the capacitor 15 could be charged up to the peak voltage E_1 , say 10,000 volts, assuming of course that the spark gap 18, 19 of the discharge circuit would be adjusted up to an ignition voltage of about the value E_1 . Generally it will be adjusted to an ignition voltage less than the peak value E_1 , say 8000 volts. It will be obvious that the use of a rectifier is much more efficient. In order to obtain spark of the same power as in the system according to Fig. 1, the capacity of capacitor 15 need be less than one third of that of the storage capacitor in Fig. 1. More energy of the positive impulse is used for loading the capacitor so that the latter will be charged sooner and the frequency of the sparks produced on the spark plug will be higher. Another advantage of the use of rectifier 24 is that for feeding transformer 11, 12 a normal undamped alternating current source may be used.

What I claim is:

An apparatus for the ignition of a welding torch or the like under water, comprising a spark plug adapted for immersion in water, a storage capacitor, electrodes defining therebetween an auxiliary spark gap, conductors connecting said spark plug and said electrodes in series across said capacitor, a step-up transformer, a rectifier, conductors connecting said capacitor, said rectifier and the secondary winding of said transformer in a series circuit, and conductors for connecting the primary winding of said transformer to a source of alternating current.

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