United States Patent [19]

Schneider et al.

[11] **3,750,441**

[45] **Aug. 7, 1973**

[54] **DEVICE FOR FORMING WORKPIECES BY MEANS OF UNDERWATER SPARK DISCHARGES**

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[22] Filed: **Feb. 26, 1971**

[21] Appl. No.: **119,158**

[30] **Foreign Application Priority Data**

Mar. 18, 1970 Germany ..... P 20 12 783.7

[52] **U.S. Cl.** **72/56**

[51] **Int. Cl.** **B21d 26/10**

[58] **Field of Search** 72/56; 313/341, 345, 313/352, 355; 29/421

[56] **References Cited**

UNITED STATES PATENTS

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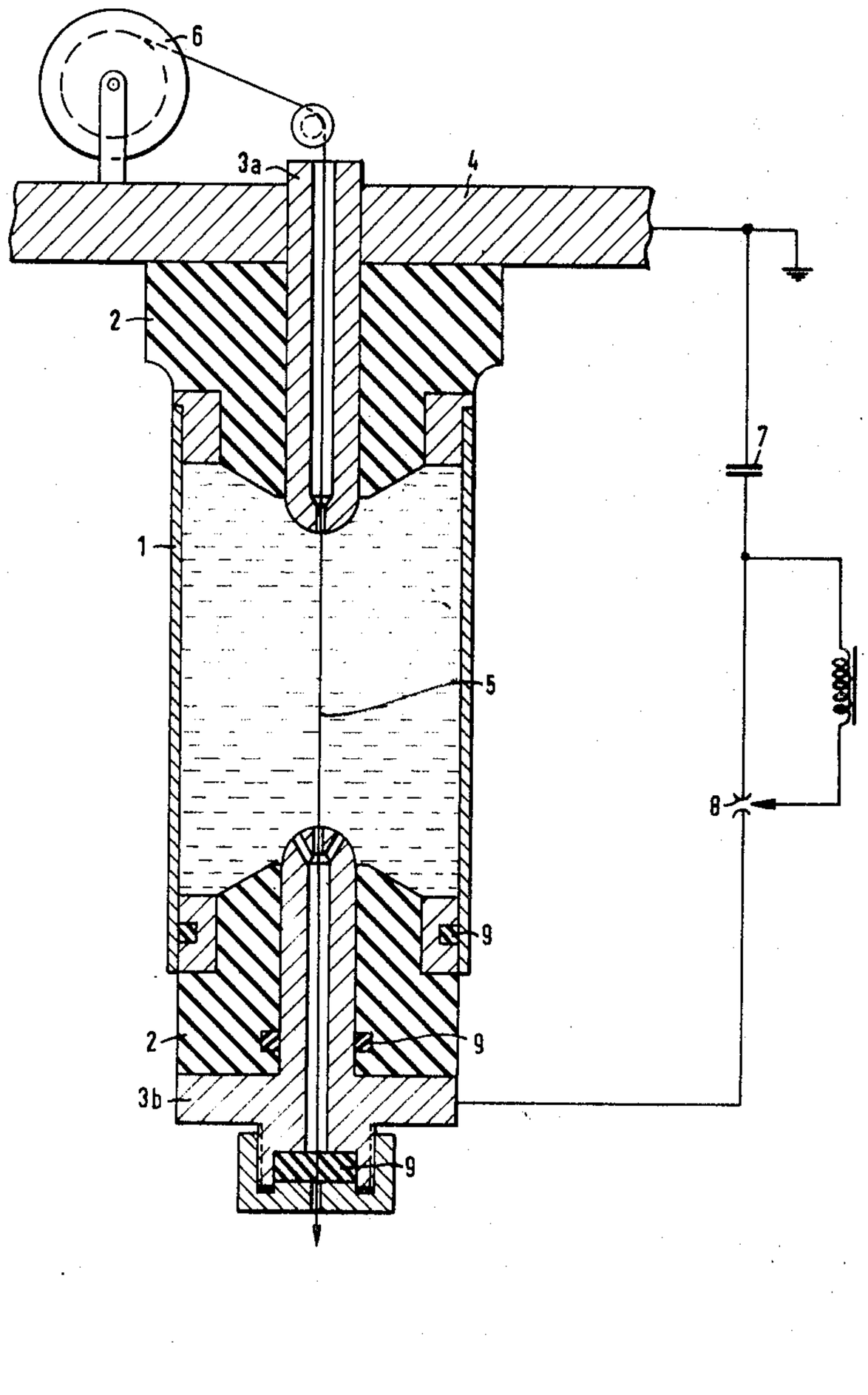
[57] **ABSTRACT**

A device for forming workpieces by pressure waves generated in a liquid by an undersurface spark discharge has two electrodes in the liquid and mutually separated so as to define a spark gap. A capacitor battery is connected across the electrodes and an ignitor is suspended between the electrodes in the spark gaps. The ignitor has a synthetic carrier thread made of thermoplastic and a thin metal ignition wire is embedded in the surface region of the latter. The ignitor wire has a diameter smaller than the diameter of the thread.

3 Claims, 3 Drawing Figures



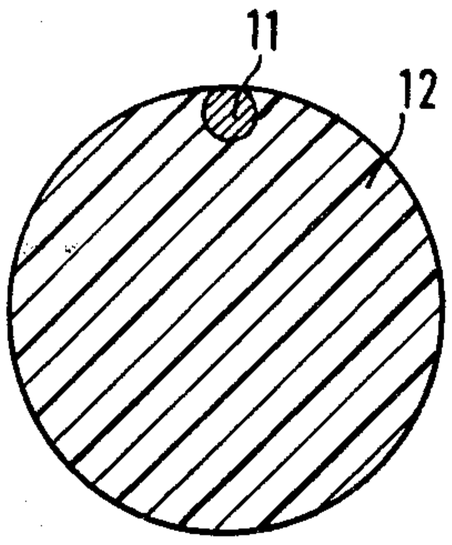


Fig.1

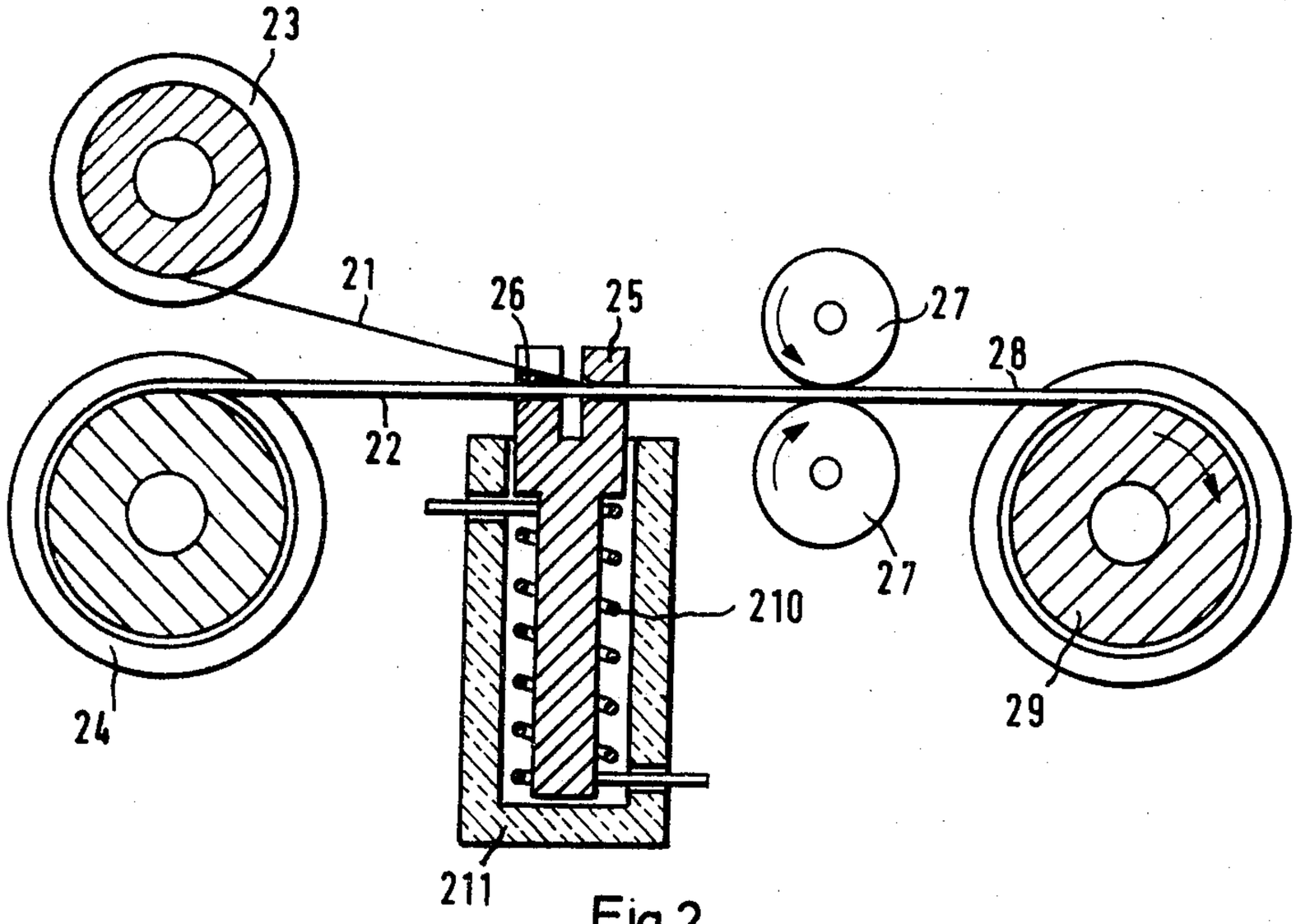


Fig.2

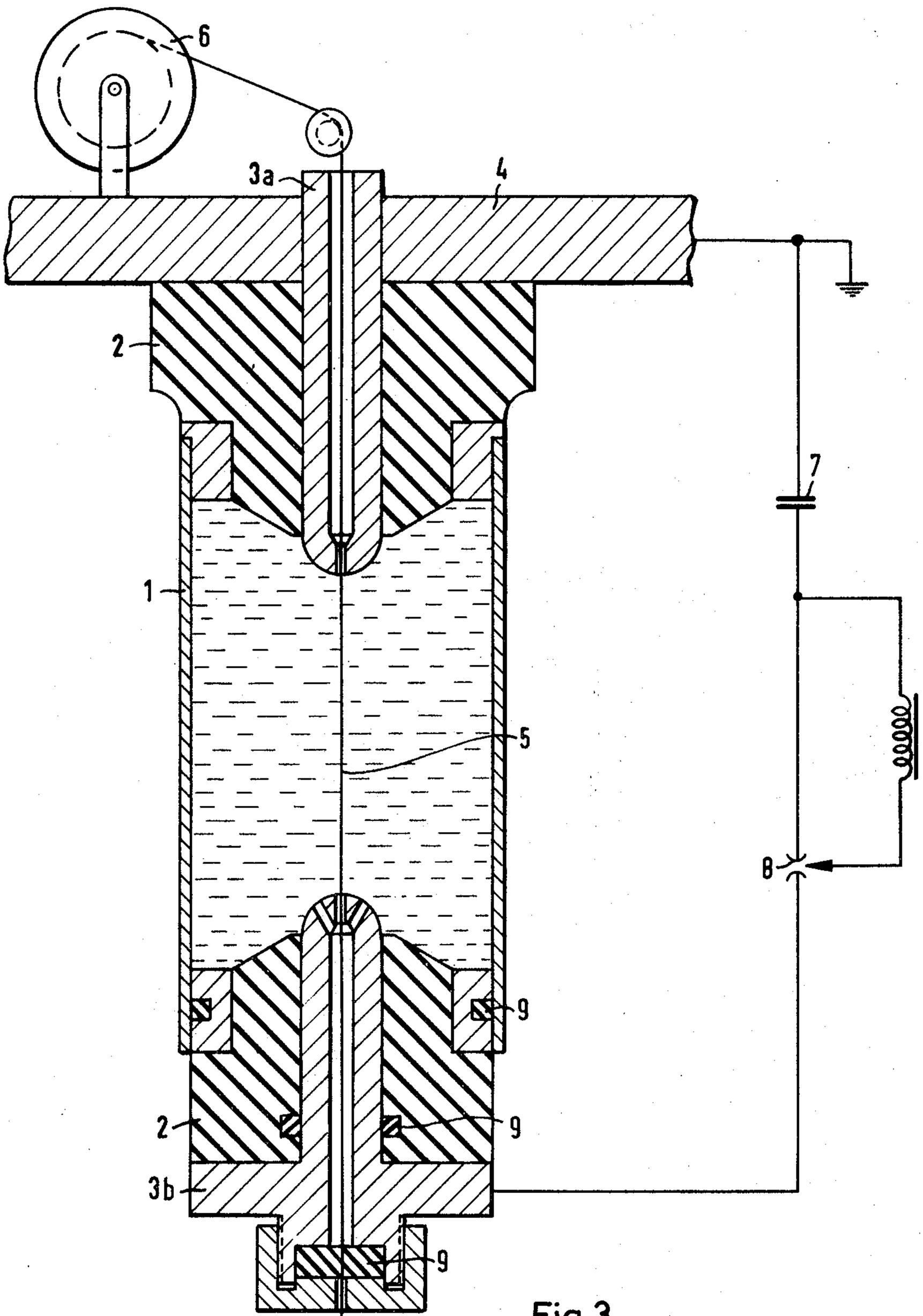


Fig.3

DEVICE FOR FORMING WORKPIECES BY MEANS OF UNDERWATER SPARK DISCHARGES

Our invention relates to a device for forming workpieces by the action of pressure waves produced by underwater spark discharges occasioned by the discharge of a bank of capacitors over a spark gap. A thin metal wire is suspended across the spark gap.

The flash over of the underwater spark discharge occurs between the electrodes located in the water after the high voltage charged capacitor batteries are connected into the electrode circuit provided the electric field strength determined by the electrode spacing and condensor voltage is sufficient for collision ionizing the water or corresponding transmission medium. Since in the known apparatus, the stored voltage of 25 to 30 kv is not exceeded, the electrode spacing for a free flash-over is limited to several centimeters.

Should the forming problem require an electrode spacing which cannot be bridged by a free flash-over or if a small spacing between electrodes and the workpiece is unavoidable the ignition must be introduced in a manner other than by a free flash-over. The best known measure is to use an ignitor in the form of a thin wire as an electrical conductor which is tensioned between the electrodes and becomes vaporized in an explosion-like manner when the capacitor discharge is initiated. In order to achieve the highest possible efficiency, ignition wires must be used having a diameter less than **0.1** mm. This type of thin wire is difficult to handle because of its small mechanical strength. In addition, the wires are completely destroyed in the ignition action, so that each time the ignition wire must be threaded anew into the forming device.

A device for forming workpieces hydroelectrically is disclosed in patent application, Ser. No. 834,690 of H. Seiffert and G. Hausler, filed June 19, 1969 assigned to the assignee of the instant application and having the title: Device for Forming Workpieces Hydroelectrically. The application discloses how the above-mentioned difficulties are prevented. In the referenced application, an ignitor is used which has a non-conductive carrier with a conducting jacket. The non-conductive carrier is not destroyed by an underwater discharge. The ignitor can, therefore, be pulled through the electrodes for a renewed discharge so that the spark gap is again bridged by the metallic jacket of the ignitor. The metallic jacket can for example be produced through chemical or electro-chemical deposition or through vapor deposition. In order to achieve a reproducible forming of material, it is necessary that the metal content and electrical characteristics of the metallic jacket of such a type of ignitor be as constant as possible.

It is an object of our invention to provide an ignitor having improved electrical characteristics. Subsidiary to this object is an object of our invention to provide improvements in ignitors which simplifies their manufacture and construction.

According to a feature of the invention a metallic wire is embedded in the surface region of a carrier comprising a thermoplastic synthetic thread so as to precisely define a metal surface zone. Preferably, the ignitor is dimensioned so that the diameter of the metal wire is from 0.02 to 0.06 mm and the diameter of the synthetic thread is from 0.5 to 1 mm.

The ignitor according to the invention has all the desired characteristics required for the forming of material by means of underwater spark discharge. The mechanical strength is determined by the insulating synthetic carrier. The synthetic thread is not destroyed either by the underwater spark or by the exploding of metal wire. Threading and pulling a new length of the ignitor into the spark gap in a forming device is therefore very simple. The consistency with which material is formed by a device equipped with the ignitor of the invention is guaranteed by the constancy of the wire diameter and its ever constant electrical characteristics. In addition, the cross-section and material characteristics of the metal embedded in the thread can be optimally selected for the best forming efficiency.

The invention will now be described with reference to the drawings wherein:

FIG. **1** illustrates in section an ignitor according to the invention;

FIG. **2** is a schematic representation of an apparatus for producing the ignitor of FIG. **1**; and,

FIG. **3** illustrates a device for forming workpieces hydroelectrically which is equipped with an ignitor according to the invention.

FIG. **1** illustrates in section an ignitor according to the invention wherein reference numeral **11** designates a thin copper wire having a diameter of 0.05 mm and is embedded in the surface region of the synthetic thread **12.** In the illustrated embodiment, the wire **11** is shown embedded in thread **12** so that the surface of the wire coincides with the surface of the thread to provide the latter with metal surface zone. The thread **12** can be made of polyamide and has a diameter of 0.9 mm. The mechanical strength of the ignitor is determined by the synthetic thread **12.** Thread **12** is not destroyed by the electrical discharge so that for a new discharge another length of the thread can be pulled into the spark gap of the forming device. The copper wire **11** can be optimally selected with respect to its cross-section for obtaining a large forming action.

FIG. **2** schematically illustrates, for example, a simple apparatus for economically producing an ignitor according to the invention in practically any desired length. The metal wire **21** and the synthetic thread material **22** is directed from delivery spools **23** and **24** through a heated pull nozzle **25.** The temperature of the pull nozzle **25** is selected so that the metal wire **21** is melted into the surface region of thread **22.** For polyamide this temperature is approximately 250° C. Preferably, the synthetic thread **22** is preheated in a preheating nozzle **26** before the metal wire **21** is embedded into the thread. The metal wire **21** and the synthetic thread **22** are pulled through the nozzle **25** by transport rollers **27** with a constant velocity, for example with a velocity of 0.1 m per second. The finished ignitor **28** is taken up by the take-up spool **29.** The nozzle **25** is heated by means of a heating winding **210** disposed in a thermal insulation **211.**

FIG. **3** illustrates a device used for forming workpieces having a cylindrical configuration. This device is equipped with an ignitor according to the invention and makes it possible to form an elongated cylindrical workpiece according to the hydro-spark method with multiple discharges and a one-time installation of the workpiece in the workpiece forming device.

Referring to FIG. **3**, reference numeral **1** denotes the workpiece to be formed, namely, a water-filled tube which is sealed on top and bottom by insulating parts **2.** By means of a central bore through the insulating

parts 2, two electrodes 3*a*, 3*b* extend into the water chamber and are screwed into the terminal brackets 4 of the hydro-spark installation. The ignitor 5 starts from a reel 6 and is guided through the bore of earth grounded electrode 3*a*. Provided the insulation is adequate, electrode 3*b* is connected to a bank of capacitors 7 via three-electrode spark gap 8. When the capacitor bank is energized, a high voltage is applied to electrode 3*b*. The energizing circuit for the capacitor bank and an ignition electrode for energizing the three-electrode spark gap 8 are disclosed in copending application, Ser. No. 803,179 of J. Hausler and G. Marz, filed on Feb. 28, 1969, assigned to the assignee of the instant application and having the title: Hydroelectric Forming of Cylindrical Workpiece by Capacitor Discharge.

After a discharge is completed, the non-conductive carrier of the ignitor 5 is transported along the electrode 3*b* such that the segment of the ignitor 5 between the electrodes will again conductively bridge the electrodes. The second discharge can follow provided the assembly remains tight after the first discharge. The assembly will remain tight because the second and subsequent discharges are of significant consequence only if the preceding discharge results in a slight forming of the workpiece. The means required to ensure a good seal are only symbolically represented by the sealing rings 9.

While the invention has been described by means of specific examples and specific embodiments we do not

wish to be limited thereto, for obvious modifications will occur to those skilled in the art without departing from the spirit and scope of the invention.

We claim:

1. In an apparatus for forming workpieces by pressure waves generated in a liquid by an undersurface spark discharge, comprising two electrodes immersed in the liquid and mutually separated so as to define a spark gap, a capacitor battery connected across the electrodes, and an ignition assembly suspended between the electrodes in said spark gap, said assembly being provided with a carrier of thermoplastic synthetic thread, a thin metal wire of a diameter smaller than the diameter of said thread disposed in and partially surrounded by said thread, to thereby expose a defined surface area of said wire coincidental with the outside of such thread.

2. In an apparatus according to claim 1, wherein said diameter of said thread varies from 0.5 to 1 mm and said diameter of said ignitor wire varies from 0.02 mm to 0.06 mm.

3. An ignition assembly for use in an apparatus for forming workpieces with pressure waves generated in a liquid by an undersurface spark discharge, wherein: said ignition assembly comprises; a thermoplastic synthetic carrier thread having an exposed surface, and a metal wire partially encapsulated by said carrier thread to thereby define an exposed surface zone of said wire at said thread outer surface.

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