(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 885 703 A1

(12) EUROPEAN PATENT APPLICATION
published in accordance with Art. 158(3) EPC

(43) Date of publication:
23.12.1998 Bulletin 1998/52

(21) Application number: **96925129.7**

(22) Date of filing: **29.07.1996**

(51) Int. Cl.[6]: **B28D 1/00**, E21C 37/18

(86) International application number:
PCT/JP96/02140

(87) International publication number:
WO 97/04934 (13.02.1997 Gazette 1997/08)

(84) Designated Contracting States:
CH DE FR GB LI

(30) Priority: **31.07.1995 JP 194411/95**
31.07.1995 JP 194412/95
31.07.1995 JP 194413/95

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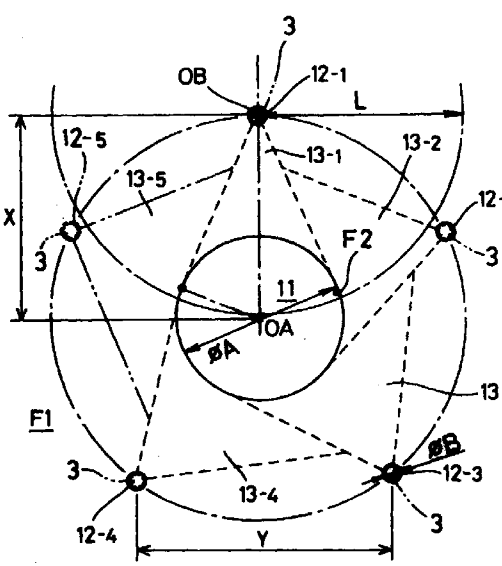
(54) DISCHARGE HYDRAULIC PRESSURE DESTROYING METHOD

(57) A method of destroying an object to be destroyed (1) having only one free surface (F1) by using an electric discharge hydraulic pressure destroying tool comprises the steps of forming a pilot hole (11) in a first free surface (F1) to use the inner surface thereof as a second free surface (F2), forming a destroy hole (12_{-1}) at one place in the first free surface (F1) in the periphery of the pilot hole (11), installing an electric discharge hydraulic pressure destroying tool (3) in the destroy hole (12_{-1}) to destroy the object (1) by electric discharge destruction to widen the destroy hole so as to enlarge the second free surface continuous with the pilot hole (hole) in the periphery of the pilot hole (11), forming a second destroy hole (12_{-2}) parallel with the pilot hole (11) in the periphery of the pilot hole (11), and destroying the object (1) by electric discharge destruction effected by an electric discharge hydraulic pressure destroying tool (13) installed in the destroy hole (12_{-2}), said steps being repeated to gradually widen the pilot hole (11).

FIG.2



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Description

FIELD OF THE INVENTION

The present invention relates to an electric discharge hydraulic pressure destroying method for destroying an object having one free surface, such as a rock bed in a tunnel or a housing land under development, a concrete structure, or an underwater rock bed or a concrete structure.

BACKGROUND OF THE INVENTION

There has heretofore been known an electric discharge hydraulic pressure destroying method which comprises discharging, in a very short time, electric energy stored in a capacitor and feeding it to a thin metal wire, and destroying a near-by object by an impulsive force produced by resulting sudden gasification of the thin metal wire itself and a surrounding destroying liquid. This electric discharge hydraulic pressure destroying method is not influenced by the ambient temperature or by the time elapsed after the installing and does not cause explosion unless a voltage is imposed; thus, the method is extremely safe and is capable of easily adjusting the destroying force and, therefore, is utilized for destroying concrete structures, such as decaying buildings.

Conventionally, an object to which the electric discharge hydraulic pressure destroying method is applied is a concrete mass whose all sides are usually free surfaces, but the method has been rarely applied to an object having only one free surface, such as a rock bed.

DISCLOSURE OF THE INVENTION

An object of the invention is to provide an electric discharge hydraulic pressure destroying method which is capable of more efficiently destroying an object having only one free surface.

To this end, an electric discharge hydraulic pressure destroying method for destroying an object to be destroyed having only one free surface by using an electric discharge hydraulic pressure destroying tool which feeds electric energy stored in a capacitor to a thin metal wire in a very short time to utilize a shock force resulting from sudden gasification and volumetric expansion of the metal wire and a surrounding liquid, comprising the steps of forming a pilot hole in said first free surface vertically of the latter to use the inner surface thereof as a second free surface, forming a destroy hole at one place in the first free surface in the periphery of this pilot hole, installing the electric discharge hydraulic pressure destroying tool in said destroy hole to destroy the object by electric discharge destruction to widen the destroy hole so as to enlarge the second free surface continuous with the pilot hole, forming a second destroy hole in the periphery of the pilot hole, destroying the object by electric discharge destruction effected by the electric discharge hydraulic pressure destroying tool, such procedure being repeated to widen the pilot hole.

According to the above arrangement, it is possible to effectively destroy an object by utilizing the free surface and the second free surface formed by the pilot hole, and to further effectively destroy the object, from the second time on, by using the electric discharge hydraulic pressure destroying tool installed in the next destroy hole, each time by utilizing the second free surface destroyed and enlarged.

Further, in the above arrangement, the invention is characterized in that $\phi A > \phi B$ and $DA \geqq DB$, where ϕA is the diameter of the pilot hole, DA is the depth of the pilot hole, ϕB is the diameter of the destroy hole and DB is the depth of the destroy hole.

According to the above arrangement, setting the diameter ϕA of the pilot hole greater than the diameter ϕB of the destroy hole makes it possible to widen the direct destroy region to make effective use of the destroying force of the electric discharge hydraulic pressure destroying tool. Further, setting the depth DA of the pilot hole greater than or equal to the depth DB of the destroy hole enables the direct destroy region to reliably continue between the destroy hole and the pilot hole, so that the Portion of the object in the direct destroy region can be reliably hollowed, with lumps of material removed therefrom.

Further, another electric discharge hydraulic pressure destroying method for destroying an object to be destroyed having only one free surface by using an electric discharge hydraulic pressure destroying tool which feeds electric energy stored in a capacitor to a thin metal wire in a very short time to utilize a shock force resulting from sudden gasification and volumetric expansion of the metal wire and a surrounding liquid, comprises the steps of forming a pilot hole in said free surface to use the inner surface thereof as a second free surface, forming a plurality of destroy holes around this pilot hole, installing an electric discharge hydraulic pressure destroying tool in each destroy hole, and feeding electric energy stored in the capacitor successively in circumferential order to the individual electric discharge hydraulic pressure destroying tools in the destroy holes, thereby destroying the object by electric discharge destruction.

According to the above arrangement, it is possible to effectively destroy an object by utilizing the free surface and the second free surface formed by the pilot hole, and to further effectively destroy the object, from the second time on, by using the electric discharge hydraulic pressure destroying tool installed in the next destroy hole by utilizing the second free surface destroyed and enlarged. Furthermore, since the destroying is effected continuously, the operating efficiency is high, and since successive destroying is effected, an operator can proceed to the next destroying operation while grasping the operating circumstances.

Further, in the above arrangement, the invention is characterized in that the distance Y between adjacent destroy holes is defined by $Y > L$, where L is the width of direct destroy regions destroyed by the discharge hydraulic pressure destroying tools.

In the above arrangement, the invention is characterized in that $\phi A > \phi B$ and $DA \geqq DB$, where ϕA is the diameter of the pilot hole, DA is the depth of the pilot hole, ϕB is the diameter of the destroy holes and DB is the depth of the destroy holes.

According to the above arrangement, setting the diameter ϕA of the pilot hole greater than the diameter ϕB of the destroy hole makes it possible to widen the direct destroy region to make effective use of the destroying force of the electric discharge hydraulic pressure destroying tool. Further, setting the depth DA of the pilot hole greater than or equal to the depth DB of the destroy hole enables the direct destroy region to reliably continue between the destroy hole and the pilot hole, so that the portion of the object in the, direct destroy region can be reliably hollowed, with lumps of material of the portion removed therefrom.

An electric discharge hydraulic pressure destroying method for destroying an object to be destroyed having only one free surface by using a discharge hydraulic pressure destroying tool which feeds electric energy stored in a capacitor to a thin metal wire in a very short time to utilize a shock force resulting from sudden gasification and volumetric expansion of the metal wire and a surrounding liquid, comprises the steps of drilling a pilot hole in the free surface to use the inner surface thereof as a second free surface, forming a plurality of destroy holes around this pilot hole, installing an electric discharge hydraulic pressure destroying tool in each of the destroy holes, and effecting electric discharge destruction by feeding electric energy stored in the capacitor simultaneously to the individual electric discharge hydraulic pressure destroying tools (4).

According to the above arrangement, it is possible to destroy an object effectively by utilizing the free surface and the second free surface formed by the pilot hole, and to destroy the object effectively as the second surfaces simultaneously destroyed and enlarged interfere with each other. Furthermore, since the destroying is effected simultaneously, the operating efficiency can be increased.

Further, in the above arrangement, the invention is characterized in that the distance Y between adjacent destroy holes is defined by $Y \leqq 2 \times L$, where L is the width of a direct destroy region destroyed by the electric discharge hydraulic pressure destroying tool.

According to the above arrangement, the direct destroy regions in adjacent destroy holes can be interconnected to make it possible to reliably hollow the object, with lumps of material of the destroyed portion removed therefrom, and to increase the volume to be hollowed.

Further, in the above arrangement, the invention is characterized in that $\phi A > \phi B$ and $DA \geqq DB$, where ϕA is the diameter of the pilot hole, DA is the depth of the pilot hole, ϕB is the diameter of the destroy hole and DB is the depth of the destroy hole.

According to the above arrangement, setting the diameter ϕA of the pilot hole greater than the diameter ϕB of the destroy hole makes it possible to widen the direct destroy region to make effective use of the destroying force of the electric discharge hydraulic pressure destroying tool. Further, setting the depth DA of the pilot hole greater than or equal to the depth DB of the destroy hole enables the direct destroy region to reliably continue between the destroy hole and the pilot hole, so that the portion of the object in the direct destroy region can be reliably hollowed, with lumps of material of the portion removed therefrom.

Further, in each of the above arrangements, the invention is characterized in that the intercentral distance X between the pilot hole and the destroy hole is in the range defined by $X \leqq \sqrt{[(\phi A / 2)^2 + L^2]}$, where L is the width of the direct destroy region destroyed by the electric discharge hydraulic pressure destroying tool, and ϕA is the diameter of the pilot hole, and in that the distance L (cm) between direct destroy regions is in the range defined by $|Vc| / 120 \geqq L \geqq |Vc| / 1200$, where Vc (volt) is the charging voltage for the capacitor to be fed to the electric discharge hydraulic pressure destroying tool.

According to the above arrangement, the charging voltage required for a predetermined direct destroy region can be reliably supplied and the required direct destroy region can be reliably obtained.

Another electric discharge hydraulic pressure destroying method for destroying an object to be destroyed having only one free surface by using an electric discharge hydraulic pressure destroying tool which feeds electric energy stored in a capacitor to a thin metal wire in a very short time to utilize a shock force resulting from sudden gasification and volumetric expansion of the metal wire and a surrounding liquid, comprises the steps of forming inclined destroy holes at a plurality of places around a drilled region which defines the center of destruction for the free surface, the front ends of said inclined destroy holes being directed to said center in the drilled region, installing an electric discharge hydraulic pressure destroying tool in each inclined destroy hole, and effecting electric discharge destruction of the object by feeding electric energy from the capacitor simultaneously to the individual electric discharge hydraulic pressure destroying tools in a short time, thereby hollowing the drilled region to form a second free surface, forming a plurality of destroy holes in the first free surface around the second free surface, destroying the object by the electric discharge hydraulic pressure destroying tools installed in the respective destroy holes to further enlarge the second free surface, this operation being repeated to complete the electric discharge destruction of the object to be destroyed.

According to this arrangement, by circumferentially forming a plurality of inclined destroy holes with their front ends disposed close to each other in a drilled region to be crushed in the first free surface, installing an electric discharge hydraulic pressure destroying tool in each inclined destroy hole, and effecting electric discharge destruction of the object, the drilled region which the direct destroy regions terminate short of can be effectively hollowed to form a second free surface. And another group of destroy holes are formed around said second free surface and are then destroyed with electric discharge hydraulic pressure destroying tools, this operation being repeated to enlarge the second free surface, so that the object to be destroyed can be effectively destroyed.

Further, in the above arrangement, the invention is characterized in that the intercentral distance E between the openings of adjacent inclined destroy holes is in the range defined by $E \leqq 2 \times L$, where L is the width of the direct destroy region destroyed by the electric discharge hydraulic pressure destroying tool, and in that, of the adjoining inclined destroy holes, the distance between the front ends of the most greatly separated inclined destroy holes is set such that the direct destroy regions destroyed by two discharge hydraulic pressure destroying tools either contact or overlap each other, the direct destroy regions being interconnected at their bottoms to hollow the drilled region.

According to the above arrangement, the direct destroy regions can be interconnected between the front ends of the inclined destroy holes in the bottom, and even if the range is so wide that the direct destroy regions are not interconnected between the openings of the opposed inclined destroy holes, the drilled region can be circumferentially hollowed between the drilled regions to remove lumps of material of the hollowed portion from the object by interconnecting the direct destroy regions at their bottoms; thus, the second free surface can be formed in a wide range.

Further, in the above arrangement, the invention is characterized in that the width L (cm) of the direct destroy region is in the range defined by $|Vc| / 120 \geqq L \geqq |Vc| / 1200$, where Vc (volt) is the charging voltage for the capacitor to be fed to the electric discharge hydraulic pressure destroying tool.

According to the above arrangement, the charging voltage required to form a direct destroy region can be reliably supplied and the required direct destroy region can be reliably obtained.

Another electric discharge hydraulic pressure destroying method for destroying an object to be destroyed having only one free surface by using a electric discharge hydraulic pressure destroying tool which feeds electric energy stored in a capacitor to a thin metal wire in a very short time to cause sudden gasification and volumetric expansion of the metal wire and a surrounding liquid, comprises the steps of forming inclined destroy holes at a plurality of places, along inclined destroy surfaces extending outward from the innermost central portion of a pilot groove which is formed in the free surface and which defines the center of destruction, installing a electric discharge hydraulic pressure destroying tool in each of the destroy holes, and effecting electric discharge destruction of the object by feeding electric energy from the capacitor simultaneously to the individual electric discharge hydraulic pressure destroying tools in a short time, thereby hollowing out the pilot groove to form a second free surface, forming a next plurality of destroy holes around said pilot groove, and effecting electric discharge destruction of the object to enlarge the pilot groove by the electric discharge hydraulic pressure destroying tools installed in the respective destroy holes.

According to the above method, inclined destroy holes are formed such that their front ends either intersect or close to each other along two inclined destroy surfaces extending outward from the center, and electric electric discharge hydraulic pressure destroying tools are installed in these inclined destroy holes to effect electric discharge destruction, thereby effectively hollowing out the pilot hole to form a second free surface, said second free surface being then utilized to effectively destroy the object.

Further, in the above arrangement, the invention is characterized in that said plurality of inclined s are formed at mutually opposed positions between two inclined destroy surfaces, the front ends of said inclined destroy holes reaching the intersecting line between said two inclined destroy surfaces, in that the intercentral distance XA_1 between the openings of adjacent inclined destroy holes on a same inclined destroy surface and the intercentral distance XA_2 between the front ends of inclined destroy holes are in the range defined by $XA_1 \leqq 2 \times L$ and $XA_2 \leqq 2 \times L$, where L is the width of the direct destroy region destroyed by the electric discharge hydraulic pressure destroying tool, and in that the intercentral distance YA_2 between the front ends of adjacent inclined destroy holes between the two destroy surfaces is in the range defined by $YA_2 \leqq 2 \times L$.

According to the above arrangement, by forming inclined destroy holes in a zigzag pattern along inclined destroy surfaces as seen in a plan view, the pilot groove can be subjected to electric discharge destruction for a width range which is greater than that of the direct destroy region, whereby the object to be destroyed can be reliably hollowed, with lumps of material of the hollowed portion removed from the bottom.

Further, in the previous arrangement, the invention is characterized in that the inclined destroy holes are formed at mutually opposed positions along inclined destroy surfaces, in that the intercentral distance XB_1 between the openings of inclined destroy holes on a same destroy surface and the intercentral distance XB_2 between the front ends of the inclined destroy holes are in the range defined by $XB_1 \leqq 2 \times L$ and $XB_2 \leqq 2 \times L$, where L is the width of the direct destroy region destroyed by the electric discharge hydraulic pressure destroying tool, and in that the intercentral distance YB_2 between the front ends of opposed inclined destroy holes is in the range defined by $YB_2 \leqq 2 \times L \cos (90° - \theta)$, where θ is the angle of inclination of the inclined destroy hole with respect to the first free surface.

According to the above arrangement, by forming destroy holes in opposed relation to each other along destroy surfaces, the opening of the pilot groove can be subjected to electric discharge destruction for a width range which is greater than that of the direct destroy region, whereby the object to be destroyed can be reliably hollowed, with lumps of material of the hollowed portion removed from the bottom.

Further, in the two arrangements above, the invention is characterized in that the width L (cm) of the direct destroy region is in the range defined by $|Vc| / 120 \geqq L \geqq |Vc| / 1200$, where Vc (volt) is the charging voltage for the capacitor to be fed to the electric discharge hydraulic pressure destroying tool.

According to the above arrangement, the charging voltage required to form a direct destroy region can be reliably supplied and the required direct destroy region can be reliably obtained.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows first and second embodiments of the electric discharge hydraulic pressure destroying method according to the invention, (a) being a plan view showing the initial destroying state, (b) being a sectional view;

Fig. 2 is an explanatory view showing the destroying state in said electric discharge hydraulic pressure destroying method;

Fig. 3 is a make-up view of a static electricity hydraulic pressure destroying device using said electric discharge hydraulic pressure destroying method;

Fig. 4 is a sectional view showing the destroyed state of an object destroyed by said static electricity hydraulic pressure destroying device;

Fig. 5 is a graph showing the relation between a discharge impulsive force and a charge voltage in said electric discharge hydraulic pressure destroying method;

Fig. 6 is a graph showing the relation between a direct destroy region and the charge voltage in said electric discharge hydraulic pressure destroying method;

Fig. 7 (a) and (b) are front views showing a pilot hole and a destroy hole in said electric discharge hydraulic pressure destroying method, (a) showing the direct destroy region when the pilot hole diameter is large and the destroy hole diameter is small, (b) showing the direct destroy region when the pilot hole diameter is small and the destroy hole diameter is large;

Fig. 8 (a) and (b) are sectional views each showing the depths of the pilot hole and the destroy hole in the electric discharge hydraulic pressure destroying method, (a) showing the direct destroy region when the destroy hole is shallower than the pilot hole and the destroy hole diameter is small, (b) showing the direct destroy region when the pilot hole is shallow and the destroy hole is deep;

Fig. 9 shows a third embodiment of the electric discharge hydraulic pressure destroying method according to the present invention, (a) being a plan view showing the destroyed state, (b) being a sectional view;

Fig. 10 is a side view, in section, of an object to be destroyed, showing a fourth embodiment of the electric discharge hydraulic pressure destroying method according to the present invention;

Fig. 11 is an explanatory view of a cross section of said object to be destroyed;

Fig. 12 is a plan view of said object to be destroyed;

Fig. 13 is a sectional view, taken when the bottoms of drill hole regions of said object to be destroyed are not connected;

Fig. 14 is a fragmentary perspective view showing a fifth embodiment of the electric discharge hydraulic pressure destroying method according to the invention;

Fig. 15 is a cross sectional view of said object to be destroyed;

Fig. 16 is a perspective view of a pilot groove destroyed by said electric discharge hydraulic pressure destroying method;

Fig. 17 is a fragmentary perspective view showing a fifth embodiment of the electric discharge hydraulic pressure destroying method according to the invention.

Fig. 18 is a cross sectional view of said object to be destroyed;

Fig. 19 is an explanatory view of the cross section of said object to be destroyed; and

Fig. 20 is a perspective view of a pilot groove destroyed by said electric discharge hydraulic pressure destroying method.

DESCRIPTION OF THE EMBODIMENTS

First, the outlines of the electric discharge hydraulic pressure destroying method will be described. As shown in Fig. 3, an electric discharge probe 3 which is a electric discharge hydraulic pressure destroying tool installed in a destroy hole 2 formed in an object to be destroyed 1, comprises a destroy container 5 made of synthetic rubber or waterproofed paper filled with a destroying liquid 4 such as water, a pair of electrode rods 7 extending through the top plate 5a of the destroy container 5 into the destroying liquid 4 and held mutually parallel by spacers 6, and a thin metal wire 8 connected between the front ends of the electrode bars 7. And an energy supply circuit 10 having a capacitor 10a of large capacity disposed away from the object 1 is connected to said electrode bars 7 by a lead wire 9 having an electric discharge switch 9a. The energy supply circuit 10 is provided with a dc high voltage power source 10b for charging the capacitor 10a with electric energy. The capacitor 10a and the dc high voltage power source 10b are interconnected by a connecting wire 10d, with a charging switch 10c interposed in said connecting wire 10d.

The relation between charging voltage Vc for the capacitor 10a of the energy supply circuit 10 and electric discharge shock force F of the electric discharge probe 3 is proportional as shown in the graph of Fig. 5 indicating the F-Vc characteristic. The width (average width) L of a direct destroy region 13 destroyed by the electric discharge probe 3 is such that, as shown in Fig. 4, the width Li of an inner direct destroy region 13b and the width La of a surface direct destroy region 13a differ from each other. And the relation between the electric discharge shock force F and the width Li, La of the direct destroy region 13, as shown in Fig. 6 and by an expression ①, is derived as a proportional relation between the charging voltage Vc (volt) and the width L (cm) of the direct destroy region 13.

$$|Vc| \ / \ 120 \geqq L \geqq |Vc| \ / \ 1200 \ \cdots \ ①$$

In Fig.6, the surface direct destroy region La corresponds to |Vc| / 120 in the expression ①, while the inner direct destroy region Li corresponds to |Vc| / 1200 in the expression ① .

Therefore, it is seen from Fig. 6 and expression ① that the necessary width (Li, La) of the direct destroy region 13 can be reliably obtained by supplying the charging voltage Vc to the capacitor 10a corresponding to the with Li, La of the direct destroy region 13 necessary for destroying the object 1.

A first embodiment of the electric discharge hydraulic pressure destroying method will now be described with reference to Figs. 1 and 2.

The object 1 to be destroyed by this method is one having only one free surface F1, such as a rock bed, concrete foundation, or concrete floor.

a. First, a drilling device or the like is used to form a vertical pilot hole 11 of a large diameter in the first free surface F1 of the object 1, the inner surface of the pilot hole 11 being a second free surface.

b. A destroy hole 12_{-1}, in which an electric discharge probe 3 is to be loaded for destroying, is formed in the first free surface F1 vertically (in parallel with the pilot hole 11) at one place in the circumference of the pilot hole 11.

This destroy hole 12_{-1} is formed such that its diameter ϕB is smaller than the diameter ϕA of the pilot hole 11 and, its depth DB is equal to or shorter than the depth DA of the pilot hole 11 ($\phi A > \phi B$, $DA \geqq DB$).

As can be seen from Fig. 7 (a), (b), a shock force due to electric discharge destruction is exerted around the thin metal wire 8, whereby the width L of the direct destroy region 13 reaches to the inner surface of the pilot hole 11 which is the second free surface F2, destroying the direct destroy region 13 located between the destroy hole 12 and the pilot hole 11. Therefore, the relation $\phi A > \phi B$ is more advantageous, making the direct destroy region 13 greater in volume; if $\phi A \leqq \phi B$, the volume of the direct destroy region 13 destroyed by the electric discharge destruction would be smaller, because the destroying effect cannot be fully developed.

Investigation of the pilot hole 11 and destroy hole 12_{-1} as to their depths shows that as shown in Fig. 8 (a) and (b), when their depths are such that DA < DB, the width L of the direct destroy region 13 extends to the innermost part of the pilot hole 11 which is the second free surface F2, but at deeper places where the pilot hole is absent, the direct destroy regions 13 occasionally connect to each other, so that cracks may occur but none of the object can be removed in lumps. In contrast, when $DA \geqq DB$, the direct destroy region 13 satisfactorily continues.

Further, the position of the destroy hole 12_{-1} is such that, as shown in Fig. 1, since the intercentral distance X between the center OA of the pilot hole 11 and the center OB of the destroy hole 12_{-1} forms a right triangle by cooperating with the radius $\phi A / 2$ of the pilot hole 11 and the distance M between the center OB and the point of contact of a tangent to the pilot hole 11 passing through the center OB of the destroy hole 12_{-1}, the following relation holds.

$$X = \sqrt{[(\phi A / 2)^2 + M^2]}$$

It is necessary that the width L_{-1} of the direct destroy region 13_{-1} to be directly destroyed be equal to the distance M of the tangent or that the distance M be less than that; ($M \leqq L_{-1}$).

Then,

$$X \leqq \sqrt{[(\phi A / 2)^2 + L_{-1}^2]} \cdots ②$$

Of course, the relation ② is applicable to the width L_{-1} of the direct destroy region 13_{-1}.

c. The electric discharge probe 3 is loaded in this destroy hole 12_{-1} and the switch 9a is turned on to supply a high voltage in a very short time from the capacitor 10a to the thin metal wire 8 on the electrode bars 7. Thereby, the thin metal wire 8 and the destroying liquid 4 therearound are instantaneously gasified and the resulting impulsive force is transmitted to the object 1, whereby the direct destroy region 13_{-1} is destroyed. Thereby, the second free surface F2 is enlarged to provide for effective destroying next time.

d. The next destroy hole 12_{-2} is drilled and an electric discharge probe 3 is loaded therein, whereby the next destroy region 13_{-2} is destroyed.

The second electric discharge destruction is effected against the second free surface F2 enlarged by the previous destruction.

Since the second and the following electric discharge destructions are effected with respect to the second free surface F2 which is previously destroyed and enlarged, the direct destroy region 13_{-2} - 13_{-5} is enlarged as shown in Fig. 2. In addition, the intercentral distance Y between destroy holes 12 is not limited by the width L of the direct destroy region 13 as will be later described because the destroy hole 12 has not been formed to receive an electric discharge probe 3 therein.

e. This operation is repeated a predetermined number of times (5 times in the illustrated case) to destroy the entire region around the pilot hole 11.

Next, the second embodiment of the electric discharge hydraulic pressure destroying method will now be described with reference to Fig. 2.

Destroy holes 12_{-1} - 12_{-5} are formed in advance around the pilot hole 11 and electric discharge probes 3 are loaded therein. And a high voltage is successively circumferentially applied starting with the capacitor 10a to the electric discharge probes 3 of the destroy holes 12_{-1} - 12_{-5} to effect electric discharge destruction.

According to this second embodiment, an object to be destroyed can be effectively progressively destroyed by utilizing the first free surface F1 and the second free surface F2 which is formed by the pilot hole 11; the object 1 can be further effectively destroyed by utilizing the second free surface F2 which is progressively enlarged by the second and the following destructions and by means of the electric discharge probes 3 loaded in the subsequent destroy holes 12_{-2} -12_{-5}. Furthermore, the continuous destruction provides a high operating efficiency and the destroy operation can proceed with an operator comprehending the circumstances under which the operation is going on.

In addition, by setting the intercentral distance Y between adjacent destroy holes 12 less than the width L of the direct destroy region 13, i.e., $Y > L \cdots ③$, the electric discharge destruction is prevented from adversely affecting the adjacent destroy holes and electric discharge probes 3 loaded therein, so that electric discharge can be successively smoothly effected.

A third embodiment of the electric discharge hydraulic pressure destroying method will now be described with reference to Fig. 9.

Destroy holes 22_{-1} - 22_{-4} are formed in advance around a pilot hole 21 and electric discharge probes 3 are loaded therein and a high voltage is applied from the capacitor 10a simultaneously to each of the electric discharge probes 3 in the destroy holes 22_{-1} - 22_{-4}.

In this case, the distance Y between the adjacent destroy holes 22_{-1} - 22_{-4} is less than twice the width L of the direct destroy regions 23_{-1} - 23_{-4};

$$Y < 2 \times L \cdots ④$$

Thereby, the direct destroy regions 13_{-1} - 13_{-4} between the adjacent destroy holes 22_{-1} - 22_{-4} are interconnected and large volumes can be simultaneously hollowed by destruction.

According to the third embodiment described above, it is possible to effectively and simultaneously destroy a group of portions of an object by utilizing the first free surface F1 and the second free surface F2 defined by the pilot hole 21 and a subsequent group of portions of said object are likewise effectively destroyed by utilizing the second free surface F2 which has thus been destroyed and enlarged by electric discharge. Such simultaneous destruction greatly increases the efficiency of the destroying operation.

Experiments were made in which concrete samples were destroyed by way of the second and third embodiments of said electric discharge hydraulic pressure destroying method: the results of the experiments will now be described.

Two concrete samples measuring 1 m × 1 m × 0.3 m were each formed with a pilot hole 31 having a diameter ϕA of 4 cm and a depth DA of 20 cm, and destroy holes 32 having a diameter ϕB of 1.3 cm and a depth DB of 15 cm, formed at 6 places at equal intervals Y of 15 cm, separated for a distance X of 15 cm from the center of the pilot hole 31. And an electric discharge probe 3 was loaded in each destroy hole 32, and successive and simultaneous destruction by electric discharge were effected at a charge voltage Vc of 4,000 V. Thereby, a volume of about 3,000 cm^3 could be destroyed.

For a charge voltage Vc of 6,000 V, it was found that the suitable distance X from the center of the pilot hole 31 to the destroy holes was 30 cm and the suitable interval Y was 30 cm.

A fourth embodiment of the electric discharge hydraulic pressure destroying method will now be described with reference to Figs. 10 through 14.

An object to be destroyed 1, such as a rock bed, concrete foundation, or concrete floor, has a single free surface F1, as in the first through third embodiments. In the fourth embodiment, however, the inner surface of the pilot hole is not used as the second free surface and instead the substantially conical destroy surface destroyed by electric discharge probes 3 loaded in a plurality of s is used as the second free surface F2.

a. First, as shown in Figs. 10 and 11, a drilling device or the like is used to drill an area around a drill hole region which will become the center of destruction on the first free surface F1, so as to form inclined destroy holes 42, e.g., 8 in number, inclined toward the center of the drill hole region 41.

The distance E between the openings 42a of the adjacent inclined destroy holes 42 is

$E \leqq 2 \times L\ (La)$, where L is the width of the surface portion 13a of a direct destroy region 13 destroyed by an electric discharge probe 3 (actually, L being La). Thus, it is set at less than twice the L. This direct destroy region 13, of course, satisfies the relation ①.

The distance G between the front ends 42i of the inclined destroy holes 42 which are spaced farthest from each other (i.e., opposed to each other) is set such that the width L (actually, Li) of the innermost portions 13i of the direct destroy regions 13 formed by the electric discharge probes 3 loaded in the inclined destroy holes 42 either contact or overlap each other, and it is arranged that the direct destroy regions 13 connect to each other at the bottom of the drill hole region 41.

That is, let θ be the angle of inclination of the inclined destroy holes 42 with respect to the first free surface F1, then, in the shaded right triangle in Fig. 11,

$$G / 2 \leqq L \cos (90° - \theta)$$

$$\therefore G \leqq 2 \times L \cos (90° - \theta).$$

Thereby, the innermost portions 13i of the direct destroy regions 13 connect to each other at the bottom of the drill hole region 41 and the drill hole region 41 can be hollowed. If $G > 2 L \cos (90° - \theta)$, then the drill hole region 41 cannot be hollowed since the innermost portions 13i of the direct destroy region fail to connect to each other at the bottom, as shown in Fig. 13.

b. With the electric discharge probes 3 loaded in the inclined destroy holes 42, an electric discharge switch 9a is turned on so that a high voltage from the capacitor 10a is fed to all electric discharge probes 3 and imposed on thin metal wires 8 in a very short time. Thereby, the thin metal wires 8 and a destroying liquid 4 therearound are instantaneously gasified and the resulting impulsive forces are transmitted to the object to be destroyed 1, whereby the direct destroy region 13 is destroyed. Thereby, the drill hole region 41 is hollowed and hence a second free surface F2 is formed.

c. The first free surface F1 around the second free surface F2 of the drill hole region 41 is formed with the next group of destroy holes 42' at desired positions and in desired directions in accordance with the direct destroy region 13 for the electric discharge probes 3, and then the electric discharge probes 3 are loaded therein. And successively or simultaneously, the electric discharge probes 3 are destroyed by electric discharge to destroy the object 1, so that the drill hole region 41 is further enlarged. This operation is repeated until the object 1 is completely destroyed.

A fifth embodiment of the electric discharge hydraulic pressure destroying method will now be described with reference to Figs: 14 - 16.

An object to be destroyed 1, such as a rock bed, concrete foundation, or concrete floor, has a single free surface F1. In the third embodiment, the second free surface F2 is formed by substantially conically hollowing the object 1. In contrast thereto, the second free surface F2 is formed by hollowing out a fifth triangular pilot groove 51.

a. First, as shown in Fig. 14, in order to form the first free surface F1 of an object to be destroyed 1 with a pilot groove 51 having two inclined destroy surfaces 51a and 51b extending from the central innermost region along the opposed outer surfaces, a drilling device or the like is used to form a plurality of inclined destroy holes 52A and 52B extending across the inclined destroy surfaces 51a and 51b such that the openings thereof are zigzag in a plan view. Further, these inclined destroy holes 52A and 52B are formed such that their front ends 52i reach the line of intersection between the inclined destroy surfaces 51a and 51b.

The intercentral distance XA_1 between the openings 52a of the adjacent inclined destroy holes 52A and 52B formed in the same inclined destroy surfaces 51a and 51b, and the intercentral distance XA_2 between their front ends 52i are set such that

$$XA_1 \leqq 2 \times L \text{ (la)}$$

$$XA_2 \leqq 2 \times L \text{ (Li)},$$

where L is the width of the direct destroy region 13 destroyed by the electric discharge probes 3 (actually, La and Lb). That is, they are each set at less than twice the width L of the direct destroy region 13.

Further, the width L of the direct destroy region 13 satisfies the above-mentioned relation ①.

b. With the electric discharge probes 3 loaded in the inclined destroy holes 52A and 52B, the electric discharge switch 9a is turned on so that a high voltage from the capacitor 10a is fed to all electric discharge probes 3 and imposed on the thin metal wires 8 in a very short time. Thereby, the pilot groove 51 is hollowed out and hence a second free surface F2 is formed.

In addition, by setting the intercentral distance YA_2 between the front ends 52i of the inclined destroy holes 52A and 52B which are nearest to each other between the opposed inclined destroy surfaces 51a and 51b such that

$$YA_2 \leqq 2 \times L \text{ (La)},$$

it is possible to attain electric discharge destruction, as shown in Fig. 16, by completely destroying the open surfaces of the pilot groove 51 to hollow out a pilot groove 51 in an object to be destroyed 1 having a single free surface

c. As shown in Fig. 16, the next group of destroy holes 51' are formed in the periphery of the pilot groove 51 at desired positions and in desired directions in accordance with the direct destroy region 13 for the electric discharge probes 3, and then electric discharge probes 3 are loaded in the destroy holes 51'. And successively or simultaneously, portions of the object to be destroyed 1 are destroyed to enlarge the pilot groove 51.

This operation is repeated until the object 1 is completely destroyed.

A sixth embodiment of the electric discharge hydraulic pressure destroying method will now be described with reference to Figs. 17 - 19.

In the fifth embodiment described above, the pilot groove is formed by the electric discharge probes 3 in the destroy holes formed in a zigzag pattern. In the sixth embodiment, however, destroy holes are formed in opposed posttions to form a pilot groove 61.

a. First, as shown in Fig. 17, in order to form a first free surface F1 of an object to be destroyed 1 with a pilot groove 61 having two inclined destroy surfaces 61a and 61b extending from the central innermost region along the opposed outer surfaces, a drilling device or the like is used to form a plurality of inclined destroy holes 62A and 62B, each pair being located at opposed positions on a cross section across the inclined destroy surfaces 61a and 61b.

The distance XB_1 between the proximal openings 62a of the inclined destroy holes 62A and 62B adjacent each other on the same inclined destroy surface 61a or 61b, and the distance XA_2 between their front ends 62i are set such that

$$XB_1 \leqq 2 \times L \text{ (la)}$$

$$XB_2 \leqq 2 \times L \text{ (Li)},$$

where L is the width of the direct destroy region 13 destroyed by the electric discharge probes 3 (actually, La and Lb). That is, they are each set at less than twice the L.

Further, the width L of the direct destroy region 13 satisfies the above-mentioned relation ①.

Further, the intercentral distance YB_2 between the front ends 62i of the inclined destroy holes 62A and 62B on the same cross section is set such that the width L (actually, Li) of the direct destroy regions 13 destroyed by the electric discharge probes 3 loaded in the inclined destroy holes 62A and 62B either contact or overlap each other, and it is arranged that the direct destroy regions 13 connect to each other at the bottom of the pilot groove 61.

That is, let θ be the angle of inclination of the inclined destroy holes 62A and 62B with respect to the first free surface F1, then, in the shaded right triangle in Fig. 11,

$$YB_2 / 2 \leqq L \cos (90° - \theta)$$

$$\therefore YB_2 \leqq 2 \times L \cos (90° - \theta).$$

Thereby, the direct destroy regions 13 connect to each other at the bottom of the pilot groove 61 and the pilot groove can be hollowed out. If $YB_2 > 2 L \cos (90° - \theta)$, then the pilot groove 61 cannot be hollowed out since the direct destroy regions fail to connect to each other at the bottom.

b. With the electric discharge probes 3 loaded in the inclined destroy holes 62A and 62B, an electric discharge switch 9a is turned on so that a high voltage from a capacitor 10a is fed to all electric discharge probes 3 and imposed on thin metal wires 8 in a very short time. Thereby, the thin metal wires 8 and a destroying liquid 4 therearound are instantaneously gasified and the resulting shock forces are transmitted to the object to be destroyed 1, whereby the direct destroy regions 13 are destroyed in their interconnected state. Thereby, the pilot groove 61 of an inverted trapezoidal shape is hollowed out and hence a second free surface F2 is formed.

In addition, by setting the distance YB_2 between the front ends 62i of the opposed inclined destroy holes 62A and 62B such that

$$YB_2 \leqq 2 \times L,$$

it is possible, as shown in Fig. 20, to completely destroy the entire open surface of the pilot groove 61, thereby hollowing out, by electric discharge destruction, the pilot groove 61 in the object to be destroyed 1 having a single free surface.

c. As shown in Fig. 20, the next group of destroy holes 62' are formed in the periphery of the pilot groove 61 in accordance with the direct destroy region 13 for the electric discharge probes 3, and then the electric discharge probes 3 are loaded in the destroy holes 62'. And successively or simultaneously, portions of the object to be destroyed are destroyed to enlarge the pilot groove 61. This operation is repeated until the object 1 is completely destroyed.

In said fifth and sixth embodiments, the pilot grooves 51 and 61 have been shown straight; however, they may be curved.

Claims

1. An electric discharge hydraulic pressure destroying method for destroying an object to be destroyed (1) having only one free surface (F1) by using an electric discharge hydraulic pressure destroying tool (3) which feeds electric energy stored in a capacitor (10a) to a thin metal wire (8) in a very short time to utilize a shock force resulting from sudden gasification and volumetric expansion of the metal wire (8) and a surrounding liquid (4), comprising the steps of:

   forming a pilot hole (11) in said first free surface (F1) vertically of the latter to use the inner surface thereof as a second free surface (F2);
   forming a destroy hole (12_{-1}) at one place in the first free surface (F1) in the periphery of the pilot hole (11);
   installing the electric discharge hydraulic pressure destroying tool (3) in said destroy hole (12_{-1}) to destroy the object (1) by electric discharge destruction to widen the destroy hole (12_{-1}) so as to enlarge the second free surface continuous with the pilot hole (11);
   forming a second destroy hole (12_{-2}) in the periphery of the pilot hole (11); and
   destroying the object (1) by electric discharge destruction effected by the electric discharge hydraulic pressure destroying tool installed in said destroy hole (12_{-2});
   said steps being repeated to gradually widen the pilot hole (11).

2. An electric discharge hydraulic pressure destroying method as set forth in Claim 2, characterized in that $\phi A > \phi B$ and $DA \geqq DB$, where ϕA is the diameter of the pilot hole (11), DA is the depth of the pilot hole (11), ϕB is the diam-

eter of the destroy hole (12) and DB is the depth of the destroy hole (12).

3. An electric discharge hydraulic pressure destroying method for destroying an object to be destroyed (1) having only one free surface (F1) by using an electric discharge hydraulic pressure destroying tool (3) which feeds electric energy stored in a capacitor (10a) to a thin metal wire (8) in a very short time to utilize a shock force resulting from sudden gasification and volumetric expansion of the metal wire (8) and a surrounding liquid (4), comprising the steps of:

forming a pilot hole (11) in said free surface (F1) to use the inner surface thereof as a second free surface;
forming a plurality of destroy holes (12_{-1} - 12_{-5}) in the periphery of the pilot hole (11);
installing the electric discharge hydraulic pressure destroying tool in each destroy hole (12); and
feeding electric energy stored in the capacitor (10a) successively in circumferential order to the individual electric discharge hydraulic pressure destroying tools (3) in the destroy holes (12_{-1} - 12_{-5}), thereby destroying the object (1) by electric discharge destruction.

4. An electric discharge hydraulic pressure destroying method as set forth in Claim 3, characterized in that the distance Y between adjacent destroy holes (12_{-1} - 12_{-5}) is defined by $Y > L$, where L is the width of direct destroy regions (13_{-1} - 13_{-5}) destroyed by the electric discharge hydraulic pressure destroying tool (3).

5. An electric discharge hydraulic pressure destroying method as set forth in Claim 4, characterized in that $\phi A > \phi B$ and $DA \geqq DB$, where ϕA is the diameter of the pilot hole (11), DA is the depth of the pilot hole (11), ϕB is the diameter of the destroy holes (12_{-1} - 12_{-5}) and DB is the depth of the destroy holes (12_{-1} - 12_{-5}).

6. An electric discharge hydraulic pressure destroying method for destroying an object to be destroyed (1) having only one free surface (F1) by using an electric discharge hydraulic pressure destroying tool (3) which feeds electric energy stored in a capacitor (10a) to a thin metal wire (8) in a very short time to utilize a shock force resulting from sudden gasification and volumetric expansion of the metal wire (8) and a surrounding liquid (4), comprising the steps of:

drilling a pilot hole (21) in the free surface (F1) to use the inner surface thereof as a second free surface (F2);
forming a plurality of destroy holes (22_{-1} - 22_{-4}) in the periphery of the pilot hole (21);
installing an electric discharge hydraulic pressure destroying tool (3) in each of the destroy holes (22_{-1} - 22_{-4}); and
effecting electric discharge destruction by feeding electric energy stored in the capacitor (10a) simultaneously to the individual electric discharge hydraulic pressure destroying tools (3).

7. An electric discharge hydraulic pressure destroying method as set forth in Claim 6, characterized in that the distance Y between the adjacent destroy holes (22_{-1} - 22_{-4}) is defined by $Y \leqq 2 \times L$, where L is the width of a direct destroy region (13) destroyed by the electric discharge hydraulic pressure destroying tool (3).

8. An electric discharge hydraulic pressure destroying method as set forth in Claim 7, characterized in that $\phi A > \phi B$ and $DA \geqq DB$, where ϕA is the diameter of the pilot hole (11), DA is the depth of the pilot hole (11), ϕB is the diameter of the destroy holes (12_{-1} - 12_{-5}) and DB is the depth of the destroy holes (12_{-1} - 12_{-5}).

9. An electric discharge hydraulic pressure destroying method as set forth in any one of Claims 2, 5 and 8, characterized in that the intercentral distance X between the pilot hole (21) and the destroy holes (22_{-1} - 22_{-4}) is in the range defined by $X \leqq \sqrt{[(\phi A / 2)^2 + L^2]}$, where L is the width of the direct destroy region (13) destroyed by the electric discharge hydraulic pressure destroying tool (3) and ϕA is the diameter of the pilot hole(21), and in that the distance L (cm) between direct destroy regions (13) is in the range defined by $|Vc| / 120 \geqq L \geqq |Vc| / 1200$, where Vc (volt) is the charging voltage for the capacitor to be fed to the electric discharge hydraulic pressure destroying tool (3).

10. An electric discharge hydraulic pressure destroying method for destroying an object to be destroyed (1) having only one free surface (F1) by using an electric discharge hydraulic pressure destroying tool (3) which feeds electric energy stored in a capacitor (10a) to a thin metal wire (8) in a very short time to utilize a shock force resulting from sudden gasification and volumetric expansion of the metal wire (8) and a surrounding liquid (4), comprising the steps of:

forming inclined destroy holes (42) at a plurality of places in the periphery of a drilled region (41) which defines the center of destruction on the free surface, the front ends of said inclined destroy holes being directed to the center of the drilled region (41);

installing an electric discharge hydraulic pressure destroying tool (3) in each inclined destroy hole (42); and

effecting electric discharge destruction of the object (1) by feeding electric energy from the capacitor (10a) simultaneously to the individual electric discharge hydraulic pressure destroying tools (3) in a short time, thereby hollowing the drilled region (41) to form a second free surface (F2), forming a plurality of destroy holes (42') in the first free surface (F1) in the periphery of the second free surface (F2), destroying the object (1) by electric discharge destruction caused by the electric discharge hydraulic pressure destroying tools (3) installed in the respective destroy holes (42') to further enlarge the second free surface (F2);

said steps being repeated to complete the electric discharge destruction of the object to be destroyed (1).

11. An electric discharge hydraulic pressure destroying method as set forth in Claim 10, characterized in that the intercentral distance E between the openings (42a) of the adjacent inclined destroy holes (42) is in the range defined by $E \leqq 2 \times L$, where L is the width of the direct destroy region (13) destroyed by the electric discharge hydraulic pressure destroying tool (3), and in that the distance (G) between the front ends (42i) of the most separated adjoining inclined destroy holes (42) among the inclined destroy holes (42) is set such that the direct destroy regions (13i) destroyed by two electric discharge hydraulic pressure destroying tools (3) either contact or overlap each other, said direct destroy regions (13) being interconnected at their bottoms to hollow the drilled region (41).

12. An electric discharge hydraulic pressure destroying method as set forth in Claim 10 or 11, characterized in that the distance L (cm) between the direct destroy regions (13) is in the range defined by $|Vc| / 120 \geqq L \geqq |Vc| / 1200$, where Vc (volt) is the charging voltage for the capacitor (10a) to be fed to the electric discharge hydraulic pressure destroying tool (3).

13. An electric discharge hydraulic pressure destroying method for destroying an object to be destroyed (1) having only one free surface (F1) by using an electric discharge hydraulic pressure destroying tool (3) which feeds electric energy stored in a capacitor (10a) to a thin metal wire (8) in a very short time to utilize a shock force resulting from sudden gasification and volumetric expansion of the metal wire (8) and a surrounding liquid (4), comprising the steps of:

forming inclined destroy holes (52A, 52B, 62A, 62B) at a plurality of places along inclined destroy surfaces (51a, 51b, 61a, 61b) extending outward from the innermost central portion of a pilot groove (51, 61) which is formed in the free surface (F1) and which defines the center of destruction;

installing the electric discharge hydraulic pressure destroying tool (3) in each of the destroy holes (52A, 52B, 62A, 62B); and

effecting electric discharge destruction of the object (1) by feeding electric energy from the capacitor (10a) simultaneously to the individual electric discharge hydraulic pressure destroying tools (3) in a short time, thereby hollowing out the pilot groove (51, 61) to form a second free surface (F2), forming a next plurality of destroy holes (52', 62') in the periphery of said pilot groove (51, 61), and effecting electric discharge destruction of the object (1) to enlarge the pilot groove (51, 61) by the electric discharge hydraulic pressure destroying tools (3) installed in the respective destroy holes (52', 62').

14. An electric discharge hydraulic pressure destroying method as set forth in Claim 13, characterized in:

that the plurality of inclined destroy holes (52A, 52B) have their openings disposed in a zigzag pattern as seen in a plan view along the inclined destroy surfaces (51a, 51b), front ends (52i) of said inclined destroy holes (52A, 52B) reaching the intersecting line (P) between said inclined destroy surfaces (51a, 51b);

that the intercentral distance XA_1 between the openings (52a) of the adjacent inclined destroy holes (52A, 52B) on the same inclined destroy surface (51a, 51b) and the intercentral distance XA_2 between the front ends (52i) of the inclined destroy holes (52A, 52B) are in the range defined by $XA_1 \leqq 2 \times L$ and $XA_2 \leqq 2 \times L$, where L is the width of the direct destroy region (13) destroyed by the electric discharge hydraulic pressure destroying tool (3); and

that the intercentral distance YA_2 between the front ends of the adjacent inclined destroy holes between the two destroy surfaces is in the range defined by $YA_2 \leqq 2 \times L$.

15. An electric discharge hydraulic pressure destroying method as set forth in Claim 13, characterized in:

that the plurality of inclined destroy holes (62A, 62B) are formed at mutually opposed positions along the two inclined destroy surfaces (61a, 61b);

that the intercentral distance XB_1 between the openings (62a) of the adjacent inclined destroy holes (62A, 62B) on the same destroy surfaces (61a, 61b) and the intercentral distance XB_2 between the front ends (62i) of the inclined destroy holes (62A, 62B) are in the range defined by $XB_1 \leqq 2 \times L$ and $XB_2 \leqq 2 \times L$, where L is the width of the direct destroy region (13) destroyed by the electric discharge hydraulic pressure destroying tool (3); and

that the intercentral distance YB_2 between the front ends (62i) of the opposed inclined destroy holes (62A, 62B) is in the range defined by $YB_2 \leqq 2 \times L \cos (90° - \theta)$, where θ is the angle of inclination of the inclined destroy holes (62A, 62B) with respect to the first free surface.

16. An electric discharge hydraulic pressure destroying method as set forth in Claim 14 or 15, characterized in that the width L (cm) of the direct destroy region (13) is in the range defined by $|Vc| / 120 \geqq L \geqq |Vc| / 1200$, where Vc (volt) is the charging voltage for the capacitor (10a) to be fed to the electric discharge hydraulic pressure destroying tool (3).

FIG.1

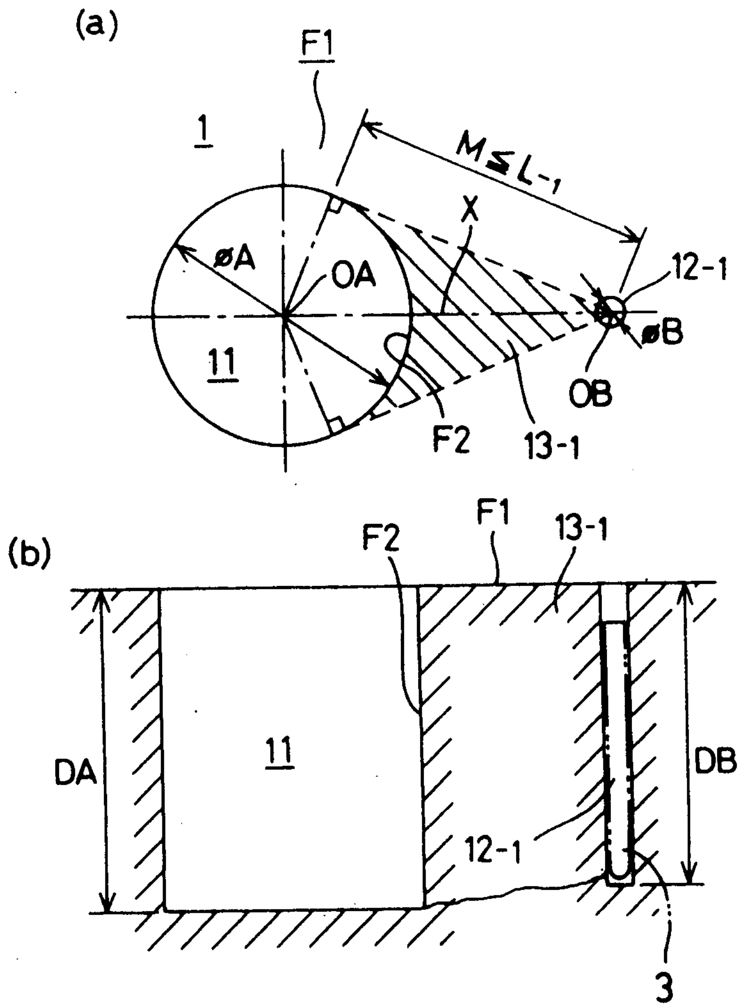


FIG.2

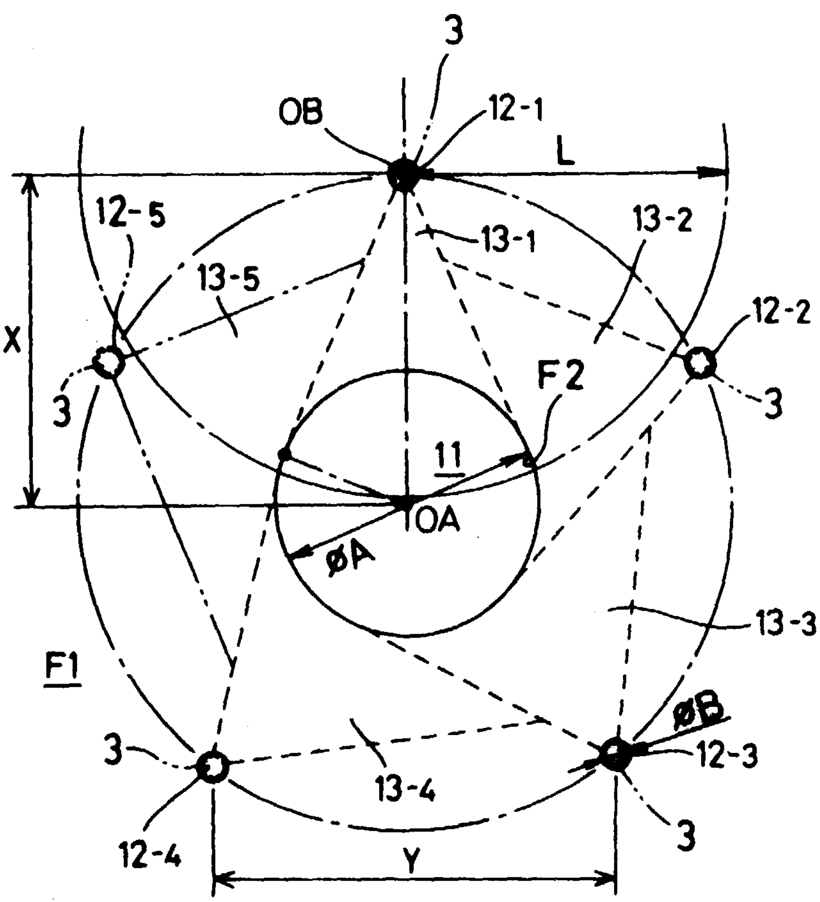

3
OB
12-1
L
12-5
13-1
13-2
13-5
12-2
X
3
F2
3
11
OA
ØA
13-3
F1
ØB
3
12-3
13-4
3
12-4
Y

FIG.3

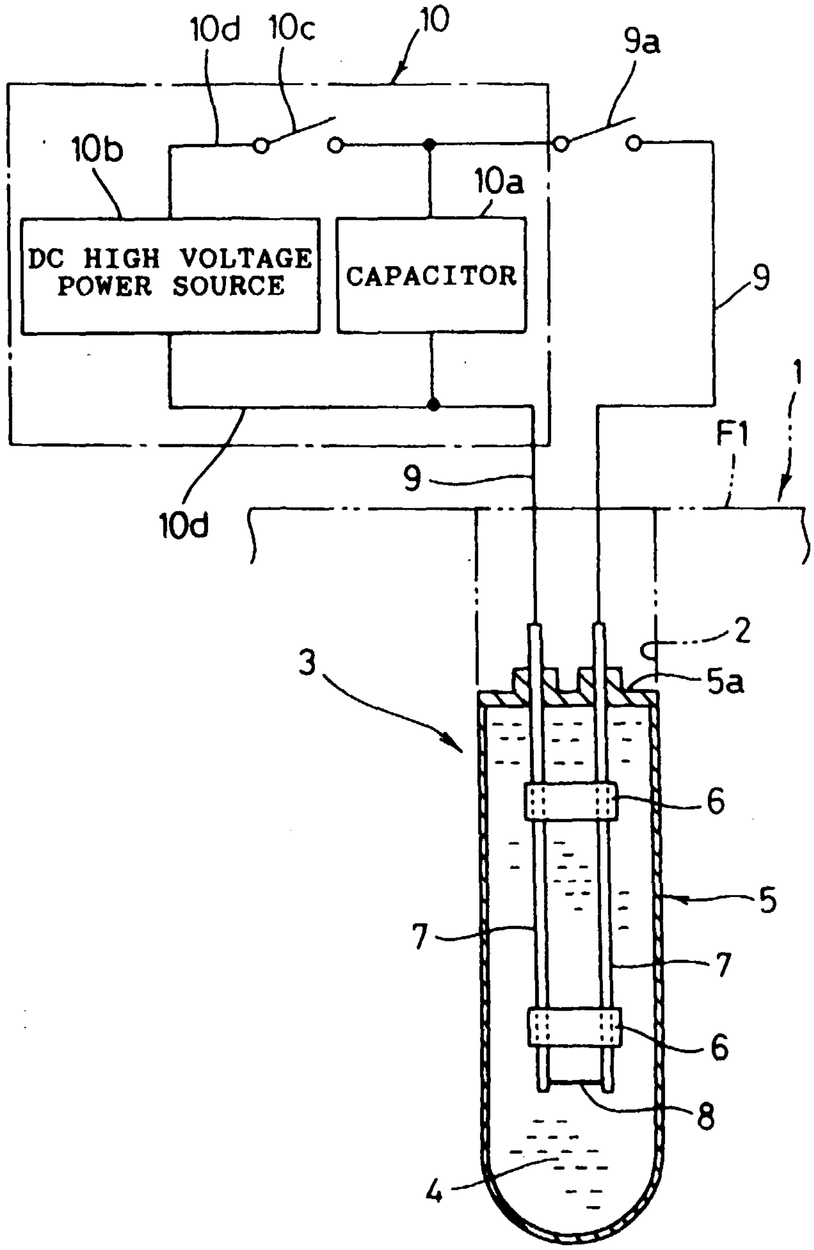

10d
10c
10
9a
10b
10a
DC HIGH VOLTAGE POWER SOURCE
CAPACITOR
9
1
F1
9
10d
2
3
5a
6
5
7
7
6
8
4

FIG.4

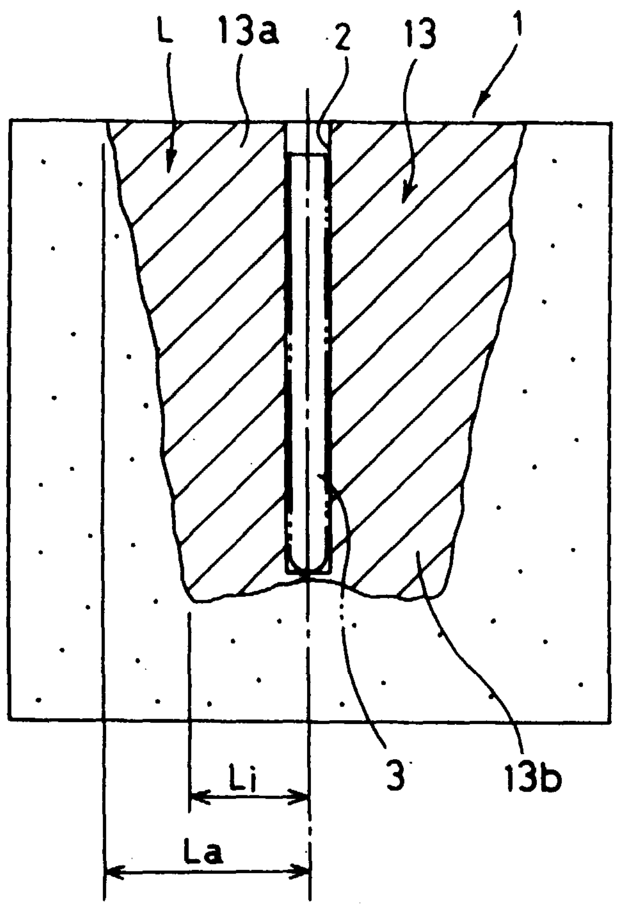


FIG.5

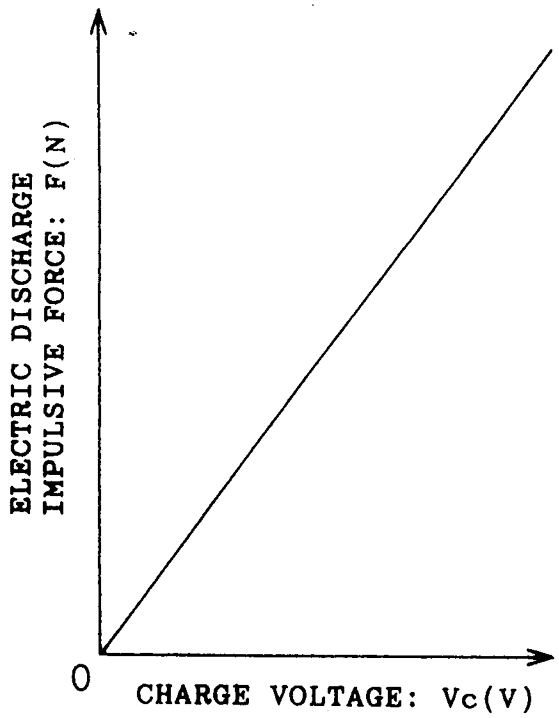

ELECTRIC DISCHARGE
IMPULSIVE FORCE: F(N)
0
CHARGE VOLTAGE: Vc(V)

FIG.6

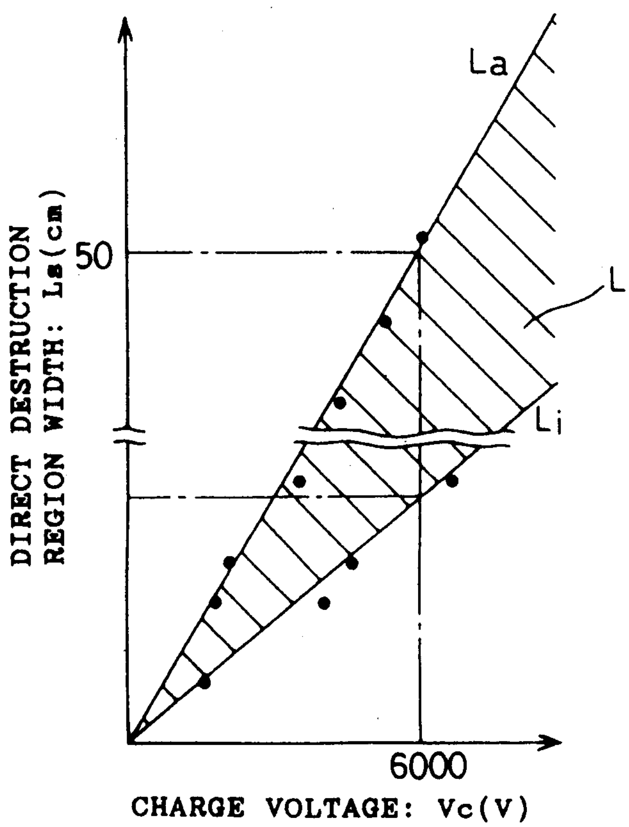

DIRECT DESTRUCTION
REGION WIDTH: Ls(cm)
50
La
L
Li
6000
CHARGE VOLTAGE: Vc(V)

FIG.7

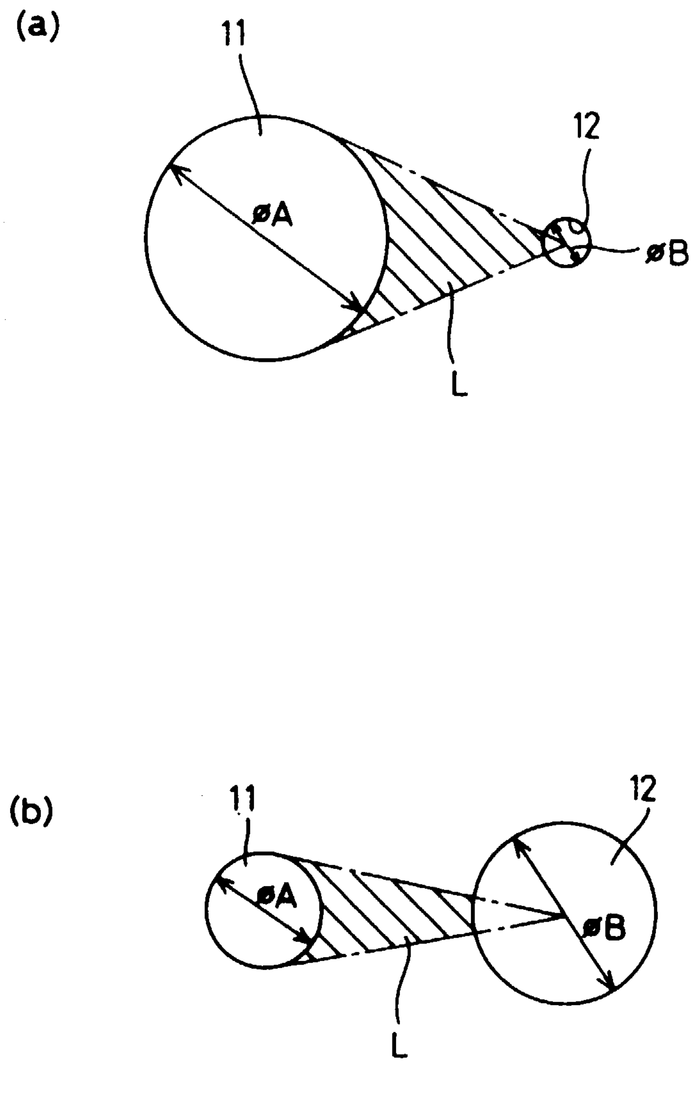
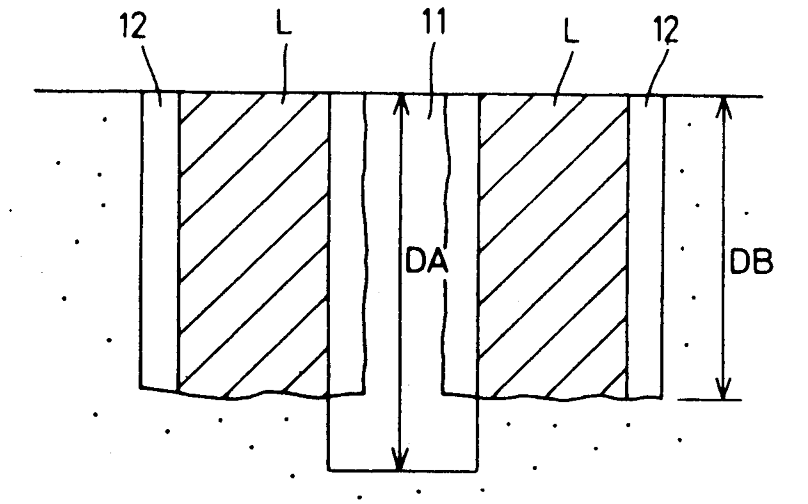


FIG.8

(a)



(b)

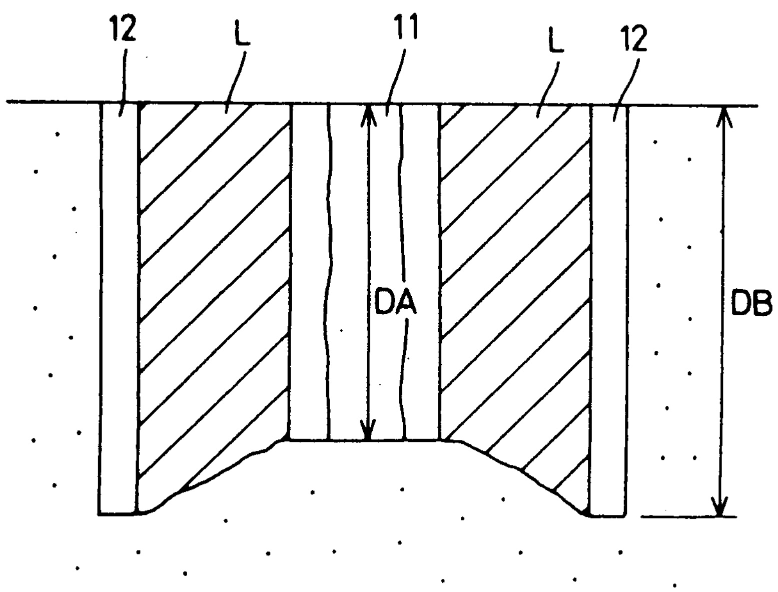
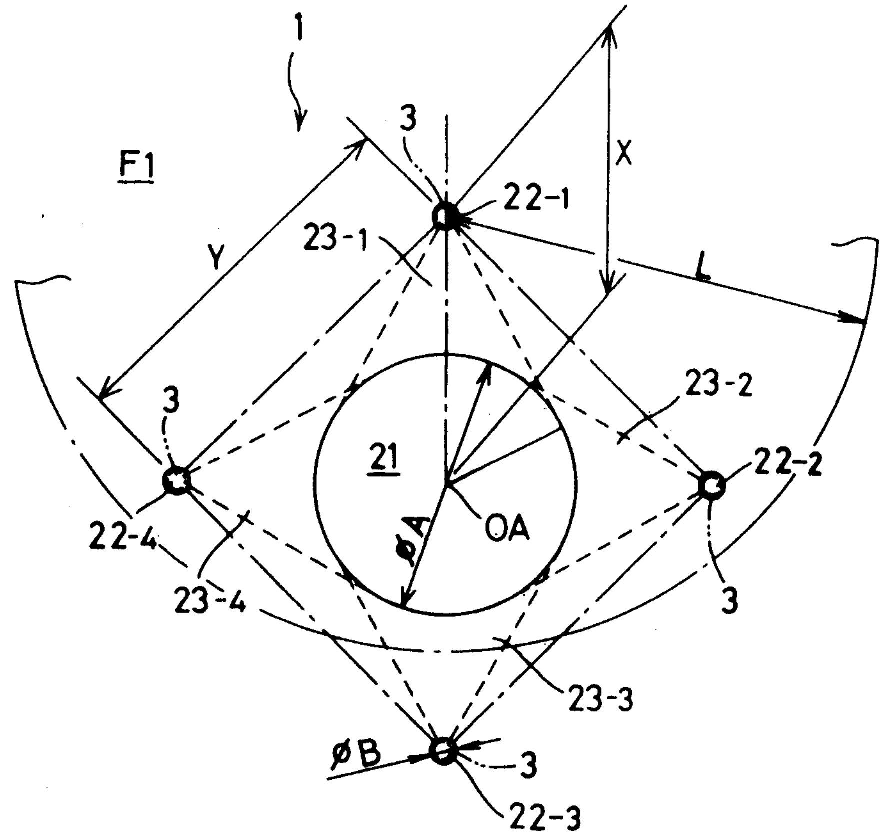


FIG.9

(a)


1
3
F1
22-1
23-1
Y
X
L
23-2
3
21
22-2
22-4
OA
ØA
23-4
3
23-3
ØB
3
22-3

(b)

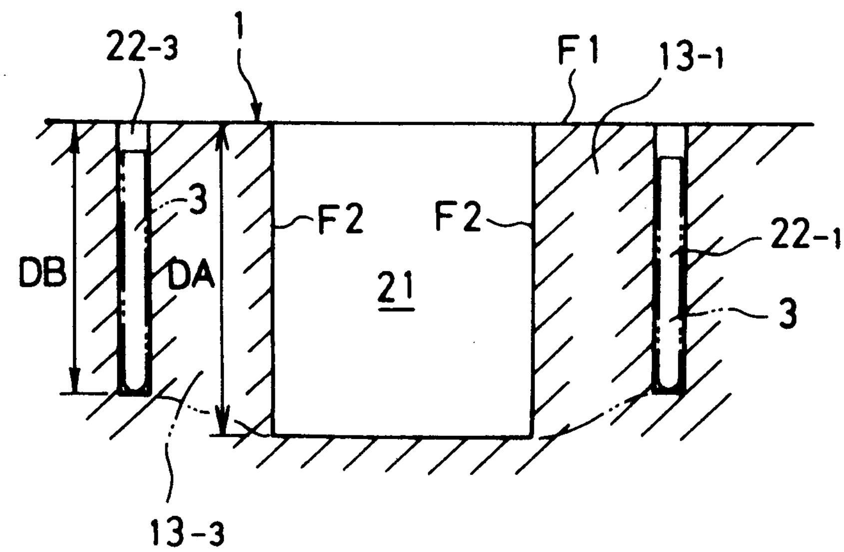

22-3
1
F1
13-1
3
F2
F2
22-1
DB
DA
21
3
13-3

FIG.10

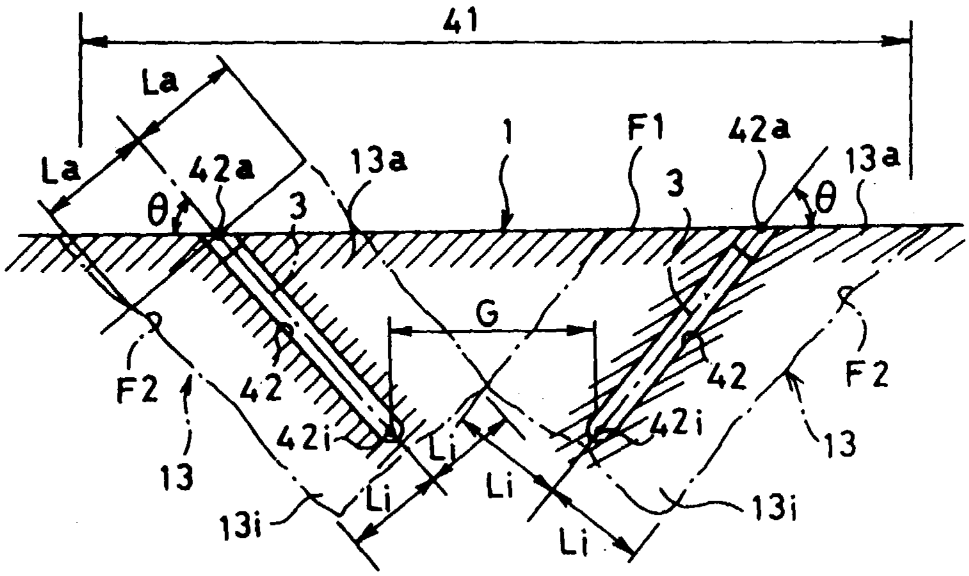

41
La
La
42a
θ
3
13a
1
F1
42a
3
θ
13a
G
F2
42
42i
Li
Li
Li
Li
42
F2
42i
13
13
13i
13i

FIG.11

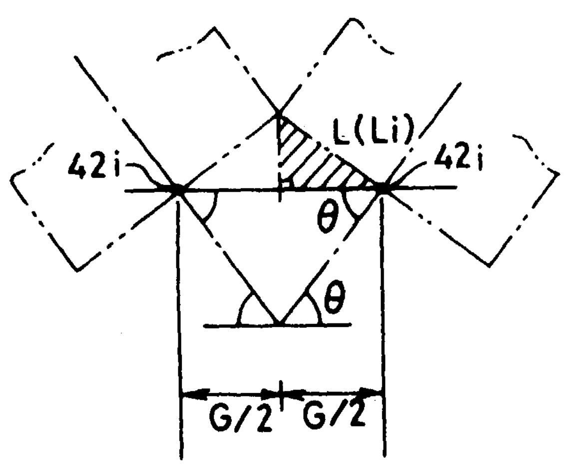

42i
L(Li)
42i
θ
θ
G/2
G/2

FIG.12

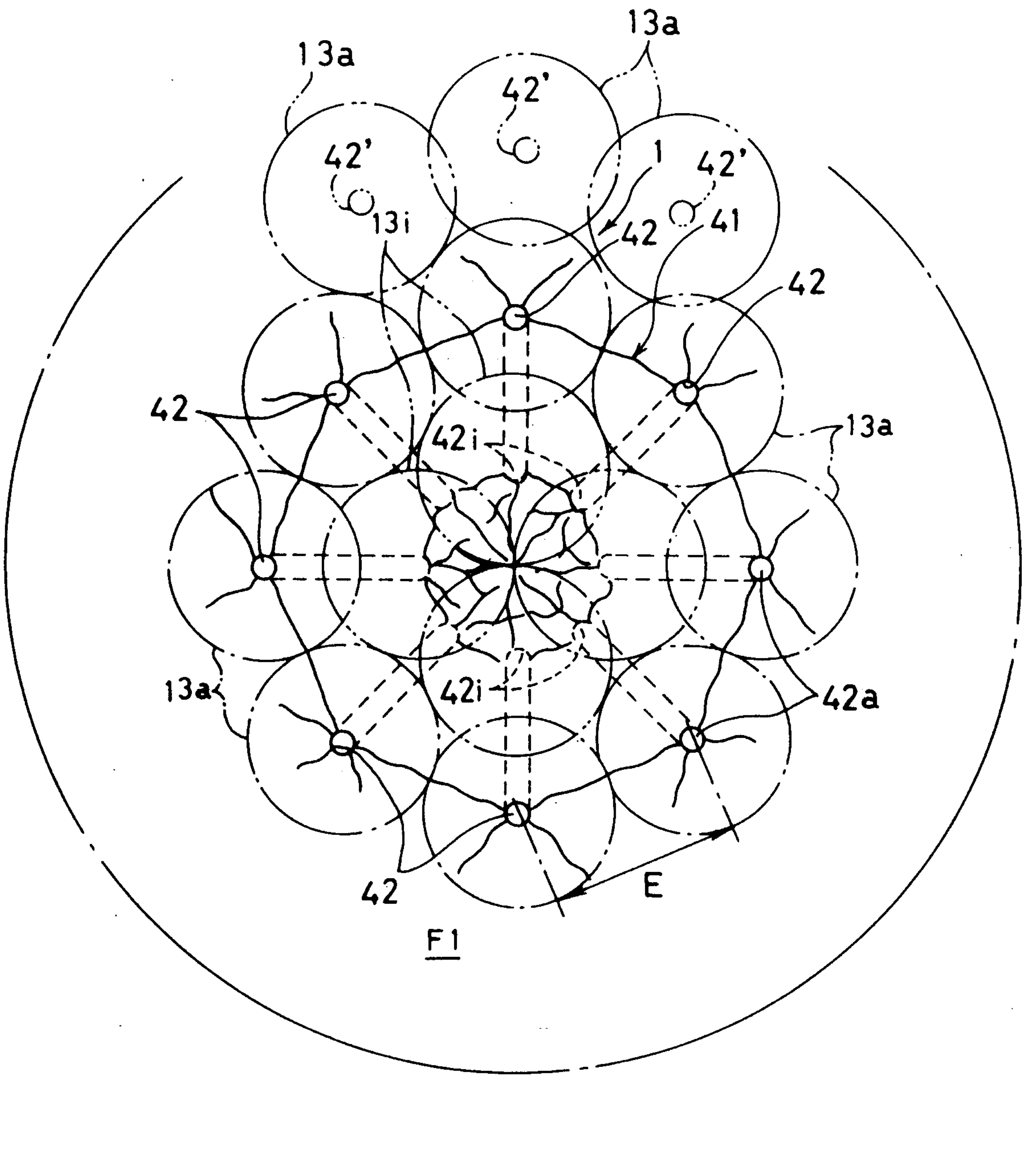


FIG.13

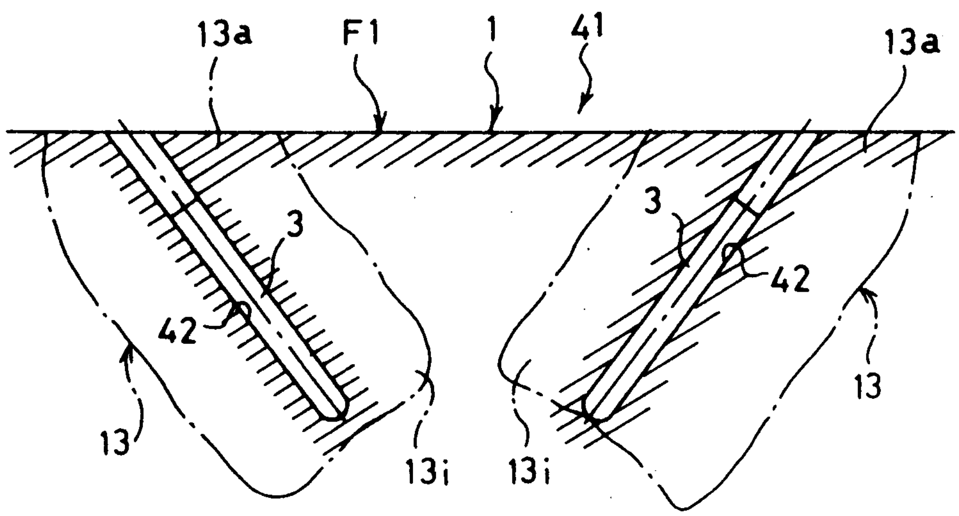


FIG.14

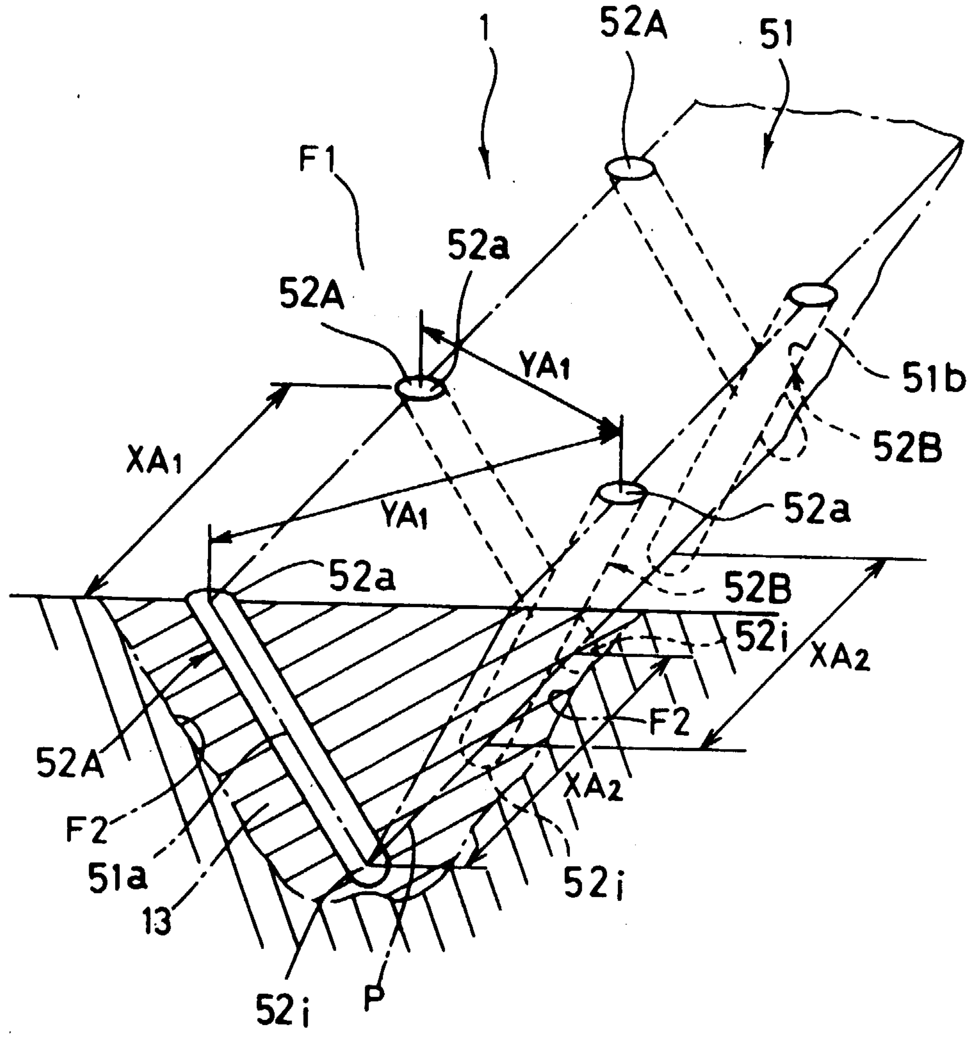

1
52A
51
F1
52a
52A
YA1
51b
XA1
52B
YA1
52a
52a
52B
52i
XA2
52A
F2
F2
XA2
51a
13
52i
52i
P

FIG.15

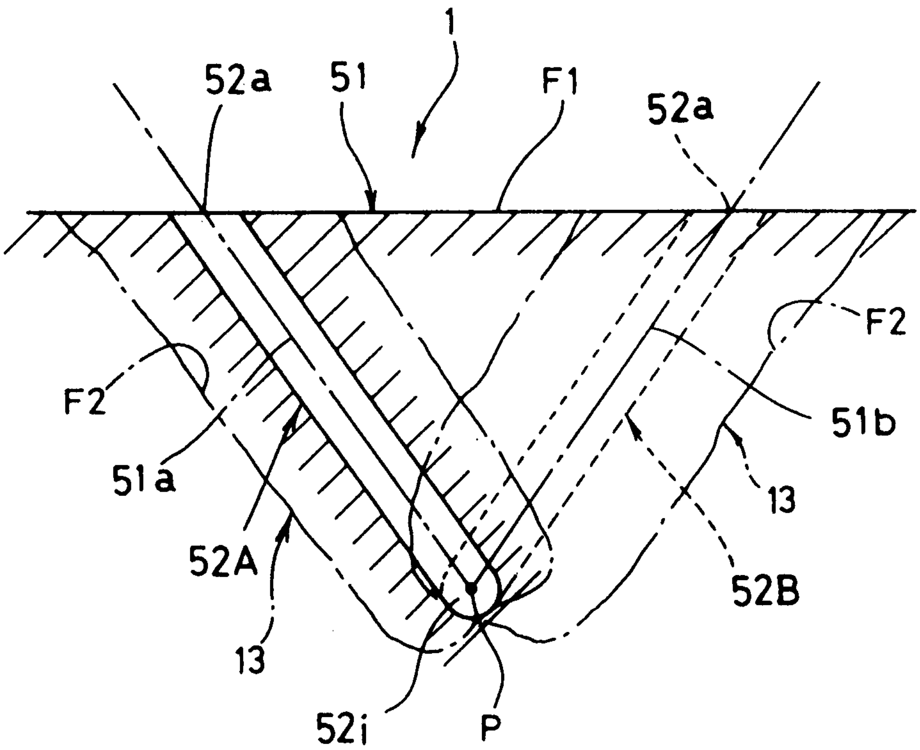


FIG.16

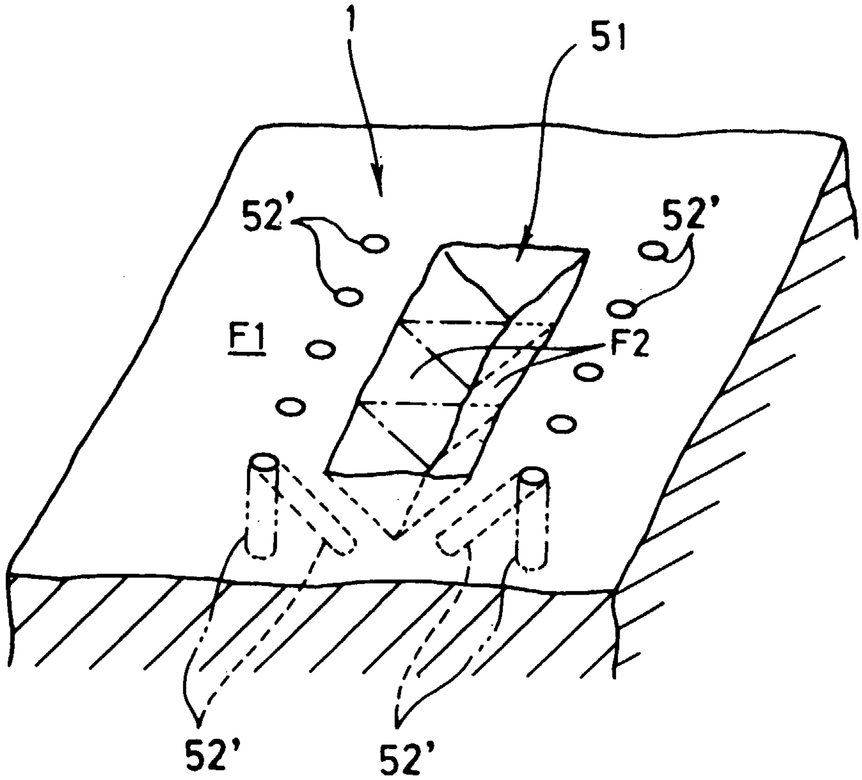


FIG.17

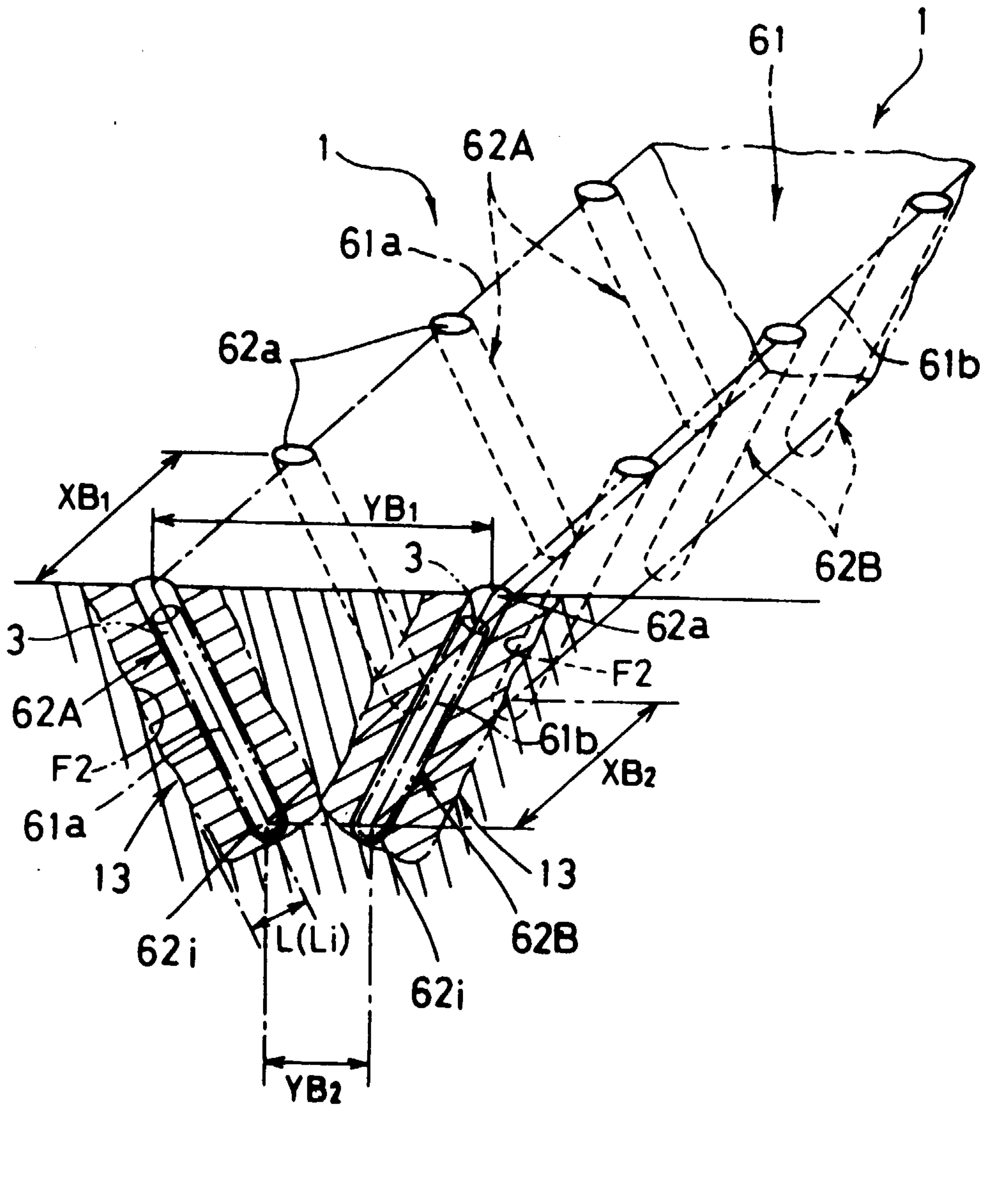

61
1
1
62A
61a
62a
61b
XB1
YB1
3
62B
3
62a
F2
62A
F2
61b
XB2
61a
13
13
62i
L(Li)
62B
62i
YB2

FIG.18

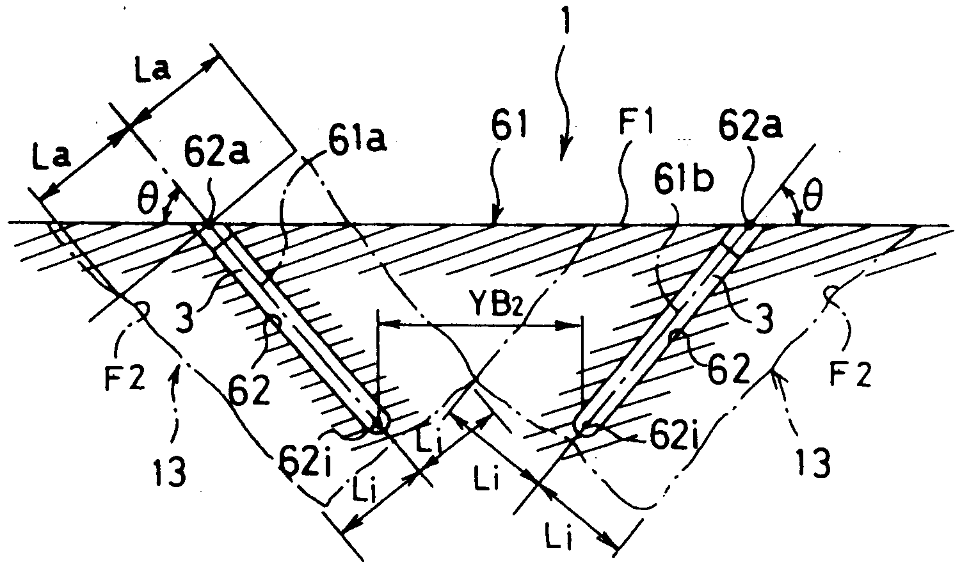

1
La
La
62a
61a
61
F1
62a
61b
θ
θ
3
3
F2
F2
62
62
YB2
13
13
62i
62i
Li
Li
Li
Li

FIG.19

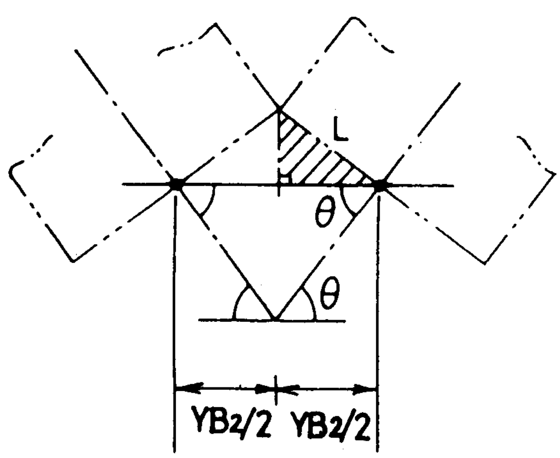
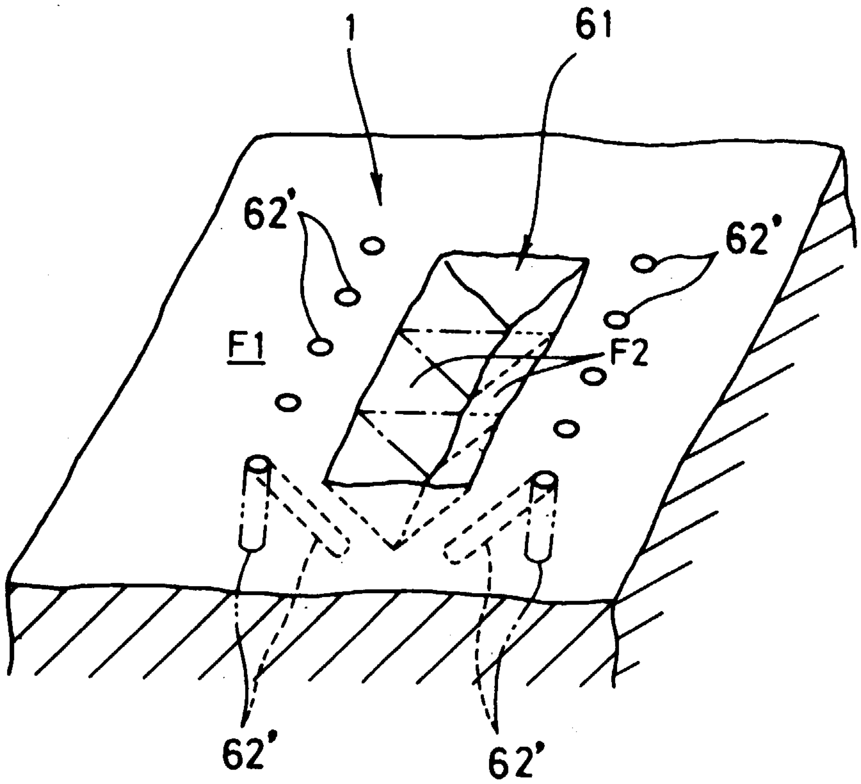

L
θ
θ
YB2/2
YB2/2

FIG.20



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP96/02140

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl^6 B28D1/00, E21C37/18

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int. Cl^6 B28D1/00, E21C37/18

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Jitsuyo Shinan Koho	1925 - 1996
Kokai Jitsuyo Shinan Koho	1971 - 1996
Toroku Jitsuyo Shinan Koho	1994 - 1996

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP, 7-145698, A (Hitachi Zosen Corp.), June 6, 1995 (06. 06. 95)(Family: none)	1 - 16

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
August 7, 1996 (07. 08. 96)	September 17, 1996 (17. 09. 96)
Name and mailing address of the ISA/ Japanese Patent Office	Authorized officer
Facsimile No.	Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)