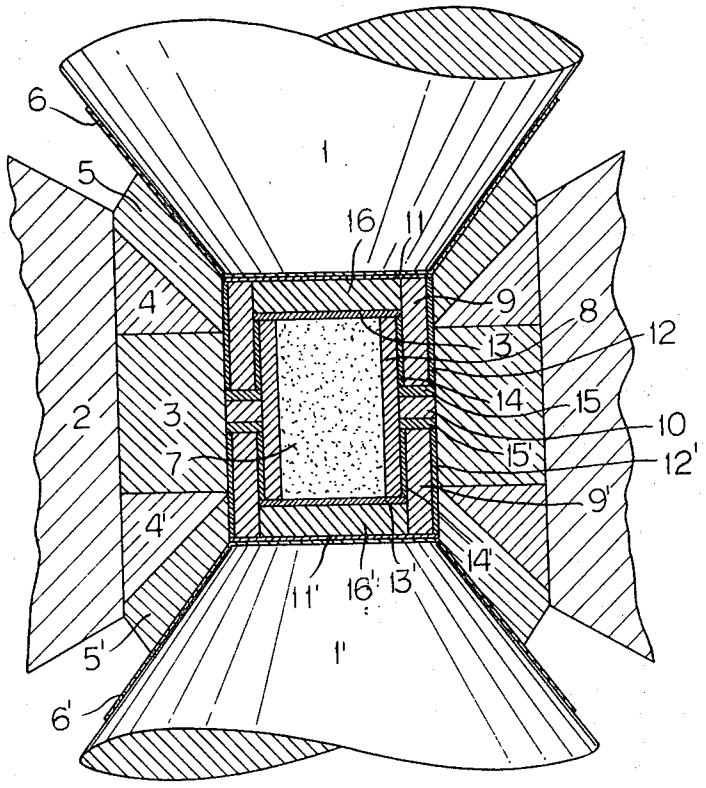
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ULTRAHIGH PRESSURE APPARATUS

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ULTRAHIGH PRESSURE APPARATUS

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ABSTRACT OF THE DISCLOSURE

A dual punch high pressure apparatus in which the punch members are coated with a thin metal or alloy of between one millimeter and two millimeters thickness.

The present invention relates to improvements of ultrahigh pressure apparatus particularly of a large type and more particularly to the protection of the punches in an ultrahigh pressure apparatus consisting of punches and a die or an ultrahigh pressure apparatus of a polyhedral type enclosed with a plurality of truncated punch surfaces.

Ultrahigh pressure apparatus used for the production of diamonds or the like tends to be gradually made larger to improve their economical efficiency by increasing the yield per run or to obtain very high quality diamonds. However, there are various difficulties in enlarging such ultra high pressure apparatus as uses an oil pressure press, for example, of more than 2,000 tons for its pressure generating source. In order to obtain favorable results, it is necessary to properly solve those difficulties one by one.

Among those problems, particularly the larger the punch and die made usually of sintered tungsten carbide, the more difficult and expensive the manufacture of them. Their strength is less sufficient than that of small types. It may be said that the success or failure of the manufacture or experiment depends on its durability. Almost all punches and dies of such small type as, for example, of an outer diameter up to about 100 mm. are made of sintered tungsten carbide and are not so difficult to make. As they become larger, first the die with a diameter larger than that of the punch becomes difficult to make. There has been made by the Inventor an attempt to use dies made of tool steel, high speed steel or die steel instead of the sintered tungsten carbide, it has become possible to use a die made of steel for the production of diamonds by placing a hollow cylinder of rigid alumina with low compressibility or a substance of the same properties in contact with the inner wall of a die of steel so that the pressure and the temperature generated in the center may be reduced in the hollow cylinder. It is very easy and very economical to make dies of steel. But punches of steel have considerably lower durability than those made of sintered tungsten carbide and are not found to be better than the latter.

In order to improve the durability of such large expensive punches insufficient in strength, the Inventor has made various experiments from which it has been found that the protective coating of the present invention is very effective.

The present invention is a high pressure apparatus having at least two punches characterized in that each punch is coated with a protective coating made of tough metals or alloys at least 1 mm. thick on all of the surface of the punches included in a high pressure chamber formed by the punches and a die preferably including an outer part of the high pressure chamber.

The above protective coating may be formed unitarily or formed dividedly into several parts which are applied as they are or as welded so that the thickness of each part may be properly varied in the use.

As examples of tough metals or alloys which may be used as the material of the coating according to the present invention, there are mentioned iron, mild steel, annealed mild steel and alloy steel, copper and its alloys, aluminium and its alloys, nickel and its alloys and titanium and its alloys.

When the thickness of the protective coating is less than 1 mm., the aimed effect cannot be obtained.

The upper limit of the thickness of the protecive coating is varied depending upon punch size and surface area of punch end, but a thickness of up to 3 mm. may be used.

The form and function of the apparatus of the present invention shall be explained in detail with reference to the drawing which shows a sectional view of the essential part of the apparatus according to the present invention.

In the drawing, **1** and **1'** are respectively upper and lower punches, **2** is a die made of a steel, **3** is a hollow cylinder of alumina sintered so that there may be substantially no pores and **4** is refractory material or metal ring supporting the alumina vertically under the pressure transmitted through a gasket **5** or **5'** from the conical surface of the punch and at the same time reinforcing the side of the punch. **6** or **6'** is a protective coating of the present invention about 1.2 mm. thick, made of mild steel, formed to the same shape as the punch surfaces, in close contact with the punch and extending in the end part to the outside of the hole diameter of the die to prevent the punch from coming into contact with the die and damaging the shoulder part of the die. **7** is a reaction chamber in which graphite and a catalyst metal are placed when, for example making diamonds. **8, 9** and **9'** are cylinders made of sintered refractories which are a heat-proof and electrically insulating substance and **10** is an insulating ring of refractories to insulate the vertical circuit and act as an extension of the alumina **3. 11, 11', 12** and **12'** are respectively a disk and cylinder of mild steel and of the same outer diameter. The disk is welded in the form of a lid for the cylinder . **13, 13', 14** and **14'** are respectively of the same forms. Nickel plate 2 mm. thick is used for the disks **13** and **13'. 15** and **15'** are rings made of soft steel for electrically connecting the cylinders **12** and **12'** and **14** and **14'**, respectively. In heating the reaction chamber, an electric current is passed from the punch **1** through the parts **11, 12, 15, 14, 13, 7, 13', 14', 15', 12'** and **11'** in the order mentioned to the punch **1'**.

Meanwhile, the reaction materials are directly heated by generated joule heat and the reaction chamber is heated indirectly by the heat generated not only in the cylinder parts **12** and **12'** and **14** and **14'** but also in the connecting rings **13** and **13'** and **15** and **15'** in the course. In such case, the temperature of the reaction chamber can be kept very uniformly by properly selecting the electric resistance of each part.

As a result of making many experimental production with such apparatus as is mentioned above and larger apparatus, the following remarkable functions and effects can be obtained by coating on punches with the protective coating made of tough metals or alloys at least 1 mm. thick according to the present invention.

(1) There is substantially no such disadvantage that, due to the temperature rise and very high pressure by the heat transmitted from the reaction chamber and the heat generation of itself, the punch will be damaged more or less at the tip and will be cracked, broken or damaged in the shoulder part. For example, with the damage of only the tip of the punch if it progresses to any extent, the punch will become impossible to use. Therefore, the present invention is very effective. This is because the

heat and the pressure are diffused so quickly in the thick protector that the punch is subjected to no partial overloading.

(2) For a slight inclination, even if the die is not substantially adjusted to be returned to horizontal, the punch will not be damaged. In the case of a large apparatus, when an unbalanced force is made to act by the inclination of the die, the durability tends to reduce very much. An application for a patent on the method of adjusting such an inclination has been already filed. It shall not be described in detail here. However, it is more effective to use both protector and adjusting device. The destruction of the punch by the inclination is likely to occur in the part of the conical part in contact with the shoulder of the die rather than in the tip part. It is well considered that the protector protects the punch also against the action of the unbalanced force occurring in the case that the parallelism of the tip surfaces of the punches is not perfect.

(3) In the case that the position of the die is vertically displaced with respect to the upper and lower punches or in the case that the charge is too small or is inclined, the conical surface of the punch is prevented from coming into direct contact with the die. If it comes into contact, as the punch is made of sintered tungsten carbide, the shoulder of the die will be crushed and the durability will be reduced.

(4) The protector smooths the deformation and the extension of the agalmatolite gasket 5. In case there was no protector at all and the punch was pushed into the die, when its entry was measured with a displacement meter, a discontinuous curve was drawn in most cases and a loud noise was made. But, when the protector was fitted, the noise and accompanying discontinuous displacement reduced and the pressure could be applied very smoothly.

An embodiment shall be described in the following.

In the employed die, the diameter of the tubular part was 130 mm., the diameter of the tip of the punch was 65 mm. and the angle of the taper of the tip was 33 degrees. The thickness of the protector was 1 mm.

(1) The case of using the protectors formed undividedly and those formed dividedly in the tip parts and welded together was compared with the case of not using them. Diamond synthesizing experiments were made with about 10 punches. The average durability was more than 180 runs with the above mentioned two kinds of protectors but was less than 50 without them. However, in the case of using the protectors, the press load was seen to tend to increase by several percent.

(2) In the experiments made varying the thickness, with 1.2 to 1.5 mm., the results were substantially the same but, with more than 2 mm., the press load was required more than 10% higher and it was disadvantageous.

(3) Further, in order to reduce the above disadvantage, the thickness of each part was varied so that the necessary part might be thick, that is, the part at the tip requiring the greatest protection might be thick and the part on the side might be rather thin (with a difference of about 0.2 to 0.4 mm.) to be used in combination, rather favorable results were shown and the protectors were endurable to two uses. As the protector was extended when the pressure was applied, when the protector was of the same thickness over all, the thickness in the tip part was short in the second use and the protector was endurable to only one use. Further, even when the protector formed dividedly in several parts was used not jointed together by welding or the like, or the parts of the protector were only placed together, a considerable effect was recognized.

The above described experiment was made on such so-called piston cylinder type apparatus as is exemplified in the drawing. But the effect of the protector of the present invention is not limited to the protection of truncated conical punches of piston cylinder type very high pressure apparatus. It is needless to say that, even in such polyhedral type very high pressure apparatus having no die as so-called tetrahedral-anvil apparatus and cubic anvil apparatus, in case protectors are formed to the same forms as of the punches and are applied to coat the surfaces of the punches, the same effect as in the above mentioned embodiment can be expected.

What I claim is:

1. An ultrahigh pressure apparatus having at least two punches characterized in that each punch is coated with a protective coating made of tough metal at least 1 mm. thickness on all of the surface of the punch to be included in a high pressure chamber formed by the punches and a die preferably including an outer part of the high pressure chamber.

2. An ultrahigh pressure apparatus as claimed in claim 1, wherein the protective coating is formed of a unitary construction.

3. An ultrahigh pressure apparatus as claimed in claim 1 wherein the tough metal is selected from iron, mild steel, annealed mild steel and alloy steel, copper and its alloys, aluminium and its alloys, nickel and its alloys and titanium and its alloys.

4. The invention of claim 1, wherein the protective coating is formed of plural portions.

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