July 9, 1963 E. LUNDBLAD 3,096,544

HIGH PRESSURE VESSEL WITH PUNCH

Filed June 5, 1961

Fig. 1

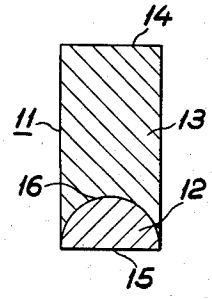


Fig. 2

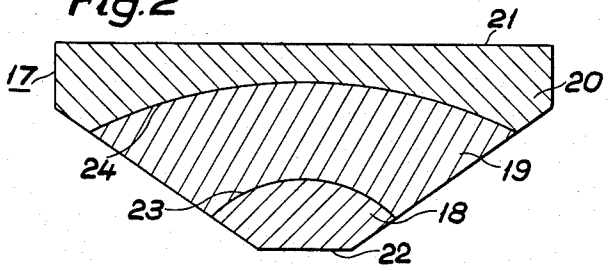
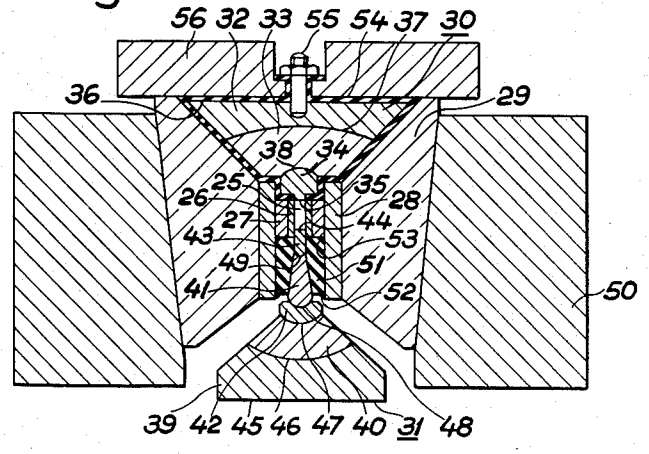


Fig. 3



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HIGH PRESSURE VESSEL WITH PUNCH

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If a cylindrical punch is pressed against an underlayer or in some other way loaded in the direction of the symmetry axis, it will crack when the pressure becomes equal to or greater than the compression strength of the punch material. It is known that a punch of the same material, shaped as a truncated cone with the smaller of the parallel surfaces of the cone of the same size as the pressure surface of the said cylindrical punch, withstands a higher pressure directed against the smaller surface than the cylindrical punch does. The more tapered the cone is, the better will be the capacity of the punch to withstand pressure.

Since the top, or pressure surface, of punches, for example if the punches are used for high pressure vessels generating pressure of a magnitude of 10,000 atm. and over, is often subjected to considerable wear and defacing forces, the punches are often manufactured from cemented carbides or similar hard materials. Taking into account that the other parts of a punch do not generally become worn or defaced to the same extent as its top or pressure surface and that materials resistant to wear are often expensive and difficult to machine, it is desirable to compose the punch of at least two parts, one of which is arranged at the top of the punch and consists of a material resistant to wear and defacement, for example a cemented carbide, and one or several other parts arranged a little way from the top and consisting of less resistant materials, for example tool steel or other steel. Even if the punch is made from only one material, it is often advantageous to divide it into several parts. If, therefore, the punch is damaged in those portions where it is subjected to particularly great stresses, it is under such circumstances unnecessary to replace the complete punch, but only such a part or parts containing the damaged portions.

The object of the present application is a high pressure vessel comprising a pressure room and at least one punch directed towards the pressure room. The high pressure vessel according to the invention is characterised in that the punch comprises at least two parts arranged along a double-curved, for example substantially spherical, contact surface. The double-curved surface is a non-developable surface. The punch usually has the shape of a solid revolution, such as a body with substantially cylindrical or conical shape. It is advisable that the centre of curvature of the double-curved surface coincides substantially with the symmetry axis of the punch. In a punch with several spherical contact surfaces, the centres of curvature for the contact surfaces may with advantage substantially coincide so that the contact surfaces are substantially concentric.

It has been found that a punch in which adjacent parts are arranged along double-curved contact surfaces is capable of withstanding a considerably higher pressure in the high pressure vessel than a corresponding punch where the adjacent parts are arranged along flat contact surfaces. In a conical punch with flat contact surfaces between the parts, cracks usually arise which are parallel to the symmetry axis of the cone, and these appear at a considerably lower pressure than is the case with a corresponding solid punch of one material.

The invention will be more closely explained with reference to the accompanying drawing which shows different

embodiments as example of punches for high pressure vessels according to the invention.

FIGURE 1 shows a cylindrical punch consisting of two parts with a spherical contact surface between the parts provided to be applied in an opening to a cylindrical high pressure room.

FIGURE 2 shows a conical punch consisting of three parts with spherical contact surfaces between the parts, provided to be applied in a conical opening to a conical high pressure room or in a conical opening leading to a high pressure room.

FIGURE 3 shows a high pressure vessel according to the invention, in which the pressure is generated by a punch which has both conical and cylindrical parts.

The cylindrical punch **11** according to FIGURE 1 consists of parts **12** and **13**. The surfaces **14** and **15** are flat and perpendicular to the symmetry axis of the cylinder. The contact surface **16** between the parts is spherical and its centre of curvature is situated on the symmetry axis of the cylinder. The part **12**, which is intended to be turned towards the inner side of the pressure room may, for example, be of a cemented carbide such as Carboloy 999 (General Electric Co.) and the part **13** of tool steel such as the tool steel C550 (Fagersta Bruk AB, Sweden) or SAE/AISI A2 with a hardness of RC55.

The conical punch **17** according to FIGURE 2 consists of the parts **18**, **19** and **20**. The surfaces **21** and **22** are flat and perpendicular to the symmetry axis of the cone. The contact surfaces **23** and **24** between the parts **18** and **19** and between the parts **19** and **20**, respectively, are spherical and concentric. The centres of curvature of the contact surfaces coincide with the symmetry axis of the cone. The part **18**, which is intended to be turned towards the inner side of the pressure room, may for example be of a cemented carbide such as Carboloy 999 (General Electric Co.) and the part **19** of tool steel of desired hardness, such as the tool steel C550 (Fagersta Bruk AB, Sweden) or SAE/AISI A2 with a hardness of RC55 and the part **20** of another tool steel such as the tool steel RO7155 (AB Bofors, Sweden) with a hardness of RC55.

The high pressure vessel according to FIGURE 3 comprises a cylindrical room **25** limited by the pipe **26** and both the punches **30** and **31**. The radial walls of the high pressure vessel, besides the pipe **26**, consist of a number of parts concentric with this, namely the cylindrical parts **27** and **28** and the partially conical part **29**. On the outside the part **29** is supported by an internally conical movable casing **50** which, for example with a hydraulic press, may be forced upwards thus giving the radial walls a supporting pressure. The punch **30** is arranged on a supporting base **56**, which in its turn is supported by a fixed support, not shown. The punch **30** has a conical portion essentially consisting of the parts **32** and **33** and a cylindrical portion consisting of the part **34**. The surfaces **35** and **36** are flat and perpendicular to the symmetry axis of the punch. The contact surface **37** between the parts **32** and **33**, as well as the contact surface **38** between the parts **33** and **34**, is spherical. The surfaces **37** and **38** are concentric. The centres of curvature for the contact surfaces lie on the symmetry axis of the punch and the radius for each of the spherical contact surfaces **37** and **38** is the same as the diameter of the respective sphere segment, the spherical boundary surface of which is formed by the respective contact surface. The punch **31** is movable. The pressure in the room **25** is generated for instance by the punch **31** being advanced upwards by a hydraulic press, not shown. The punch **31** has conical portions consisting of the parts **39**, **40** and **41** and externally cylindrical portions consisting of the parts **42** and **43**. The surfaces **44** and **45** are

flat and perpendicular to the symmetry axis of the punch. The contact surface **46** between the parts **39** and **40**, the contact surface **47** between the parts **40** and **42**, the contact surface **48** between the parts **42** and **41** and the contact surface **49** between the parts **41** and **43**, are all spherical. The surfaces **46**, **47**, **48** and **49** are concentric. The centres of curvature of the contact surfaces lie on the symmetry axis of the punch and the radius for each of the spherical contact surfaces **46**, **47**, **48** and **49** is the same size as the diameter of the respective sphere segment, the spherical boundary of which is formed of the respective contact surface.

Around the parts **41** and **43** of the lower punch is arranged a supporting body **51** which may have the form of a sleeve. The material in the supporting body consists of rubber or some other similar material having great and continual compressibility, for example, natural rubber ("Quality 190" from Trelleborgs Gummifabrik AB). When the punch **31** is advanced upwards, the supporting body **51** of the part **48** is subjected to a pressure with the consequence that the supporting body exercises supporting pressure on the punch. Sealing rings **52** and **53** of toughened steel are arranged at the outer edges of the supporting body. The outer vertical surface of the part **42** is made to fit the inner cylindrical surface of the tube **28** and its upper part is bevelled to correspond with the surface of the packing ring **52** which is turned towards the part **42**. The piston **30**, apart from minor portions and parts of the cylinder **26**, is as seen from the figures, surrounded by an electrically insulating material **54**, for example mica or paper, the purpose of which is to enable electric current to be led into the pressure room via the bolt **55**. The current is led off through the lower punch and further to the outer side of the apparatus where contacts may suitably be arranged so that a closed current circuit may be maintained. Within the pressure room, the current may for example be conducted by a metal thread or spiral enclosed in the material to be treated which thread or spiral is in contact with the parts **34** and **43** on respective punches.

Of course, the upper piston, like the lower piston **31**, may be made movable and provided with a punch which can be pushed into the pressure chamber so that the pressure in the chamber can be generated by both the punches being pressed in. The upper piston may then e.g. be performed as the lower piston **31** with a supporting body like the body **51** surrounding the parts of the piston nearest the pressure room.

As examples of materials suitable for use for the metallic parts of the high pressure vessel according to FIGURE 3 may be mentioned: for the tube **26**, tool steel WKE Brilliant (Fagersta Bruk AB, Sweden) or SAE/AISI T4 with a hardness of RC 60, for the part **27**, WKE Brilliant or SAE/AISI T4 with a hardness of RC 65, for the part **28**, tool steel C550 (Fagersta Bruk AB) or SAE/AISI A2 with a hardness of RC 62, for the part **29**, tool steel C 550 or SAE/AISI A2 with a hardness of RC 55, for the member **50**, tool steel RO 7155 (AB Bofors, Sweden) with a hardness of RC 55, for the parts **34**, **41**, **42** and **43** of the pistons, a cemented carbide Coromant H 5 (Sandvikens Jernverk AB, Sweden) or Carboloy 999 (General Electric Co.), for the parts **33** and **40**, tool steel C 550 or SAE/AISI A2 with a hardness of RC 55 and for the parts **32** and **39**, tool steel RO 7155 with a hardness of RC 55.

The double-curved surface does not have to be spherical as shown in the example, but may for example even be ellipsoidal or paraboloidal. If there are several contact surfaces within one punch these do not necessarily

have to be concentric according to the example. In order to obtain a good contact along the common surfaces, these surfaces may with advantage be treated so that the surfaces are very even. Normally no joining arrangements are required for the different parts within a punch, but if necessary they could be joined together by mechanical arrangements such as screws, by soldering, gluing or the like.

I claim:

1. High pressure vessel comprising means forming a pressure space and at least one punch directed towards the pressure space, said punch being symmetrical about an axis running through the pressure space and comprising at least two parts engaging along a contact surface, said contact surface being a doubly curved surface the centre of curvature of which substantially coincides with the axis of symmetry of the punch and is situated on the side of the contact surface turned towards the pressure space.

2. High pressure vessel as claimed in claim 1, in which said punch is provided with several doubly curved contact surfaces with substantially coincident centres of curvature.

3. High pressure vessel as claimed in claim 1, in which said doubly curved contact surface is a spherical surface.

4. High pressure vessel comprising means forming a substantially cylindrical pressure space, means surrounding said pressure space comprising a pressure absorbing casing along the envelope surface of the space and a pair of opposed punches at the end surfaces of the space, at least one of said punches being symmetrical about an axis running through the pressure space and being movable towards the other punch and comprising at least two parts engaged along a contact surface, said contact surface being a doubly curved surface the centre of curvature of which substantially coincides with the axis of symmetry of the punch and is situated on the side of the contact surface turned towards the pressure space.

5. High pressure vessel comprising means forming a substantially cylindrical pressure space, means surrounding said pressure space comprising a pressure absorbing casing along the envelope surface of the space and a pair of opposed punches at the end surfaces of the space, at least one of said punches being movable towards the other punch, each of said punches being symmetrical about an axis running through the pressure space and having a substantially conical part, said substantially conical part comprising at least two integral parts engaging along a contact surface, said contact surface being a doubly curved surface the centre of curvature of which substantially coincides with the axis of symmetry of said punch and is situated on the side of the contact surface turned towards the pressure space.

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