

HOWITZER ANCHOR SPADE

The present invention relates to towed howitzers, which are sometimes referred to as field or artillery guns. The invention provides a means for increasing the stability of towed howitzers and reducing the extent of rearward movement of such howitzers under the recoil forces when the howitzer is fired. Howitzers generally have a recoiling ordnance (barrel and breech mechanism) mounted on a trail assembly and having a firing platform and/or one or more rearwardly extending trail legs, and it is known to fit anchor spades to the rearward ends of such trail legs which engage or dig into the ground under the recoil forces when the gun is fired. Such anchor spades may also be fitted to firing platforms. The present invention is intended to provide an improved design of anchor spade particularly for lightweight howitzers that have a recoil management system.

Many modern conventional towed howitzers generally have an ordnance with a barrel of 105mm or 155mm internal diameter, and the substantial weight of the trail assemblies in these howitzers helps stability. For example the typical weight of a conventional 155mm howitzer might be 18,000 pounds with a recoiling mass of 7,000 pounds, and excessive movement of the trail assembly is usually avoided because of the significant energy required to overcome the inertia of the mass of the howitzer which is high in relation to the firing impulse. Also the suitable design and management of the recoil braking system will aid stability.

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However modern armies now require howitzers that are significantly lighter than conventional howitzers, but without loss of performance. Lightweight howitzers can be deployed more rapidly, towed by lighter motorised vehicles and can be more readily transported by military aircraft or slung under military helicopters. These are all important benefits for rapid deployment forces, which play an increasingly important role in modern armed conflicts.

The requirement for lightweight howitzers, for example for 155mm howitzers weighing less than 9000 lbs but with the same ordnance and firepower performance, creates considerable design challenges to maintain stability of the howitzer in recoil. Much of the weight saving is to be made in the trail assembly and with a trail assembly weighing only 4,900 lbs and a recoil mass of 4,100 lbs, much less energy is required to overcome the inertia of the lightweight howitzer. Such a lightweight howitzer, if of conventional design would not be sufficiently stable during firing and there would be a much greater tendency for the howitzer to move rearwardly. Also the movement of the recoil forces pivoting about the point where the spade engages the ground is not, in the case of lightweight howitzers, balanced by the counter-balancing moment of the weight of the howitzer acting through the centre of gravity of the howitzer. Accordingly the howitzer will tend to jump or bounce. An improved anchor spade design that will readily dig in, stay dug in, and which does not cause excessive rearward movement, will help to reduce this jumping and bouncing.

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This instability is unacceptable if excessive. For example, excessive rearward movement of the firing platform and/or the trail assembly and howitzer may endanger the safety of the gun crew, some of whom during firing stand to the rear of the howitzer, between the trail legs if present. Also excessive movement, particularly if the howitzer is fired at a high traverse angle and low elevation angle, can cause the howitzer to rotate about one or other of the trail legs if present. This can make it difficult and time consuming to re-emplace the howitzer for firing the next round on target. For operational reasons sustained accurate firing is essential.

PCT application WO89/06778 describes a means of managing the recoil of a lightweight howitzer by mounting the recoiling mass, which includes the ordnance, on a curvilinear recoil track to produce an increased stabilising moment.

The present invention has as its object the provision of a lightweight anchor spade fitted to the rear end of each of the trail legs or to the firing platform, which for most soil types will, under the force of recoil, readily dig into the ground and not dig itself out under further recoil force. It is also an object of the present invention to reduce rearward movement of the howitzer during recoil, and to provide a howitzer that can be readily pulled out of the ground by the gun crew after firing.

According to the present invention there is provided an anchor spade for fitting to the rear end of a trail leg of a howitzer or to the firing platform for engaging and digging into the ground under the rearward recoil forces of firing, which anchor spade comprises a

rearwardly facing blade plate having a tip digging into the ground under the forces of recoil and a rearwardly facing top plate mounted above the blade plate so as to be generally parallel with the level of the ground when the anchor spade is embedded in the ground, wherein the spade blade angle (as defined below) lies in the range 35° to 55° and the spade forward angle (as defined below) lies in the range of 80° to 100° .

The blade plate is preferably planar.

For the purposes of this patent application the "spade blade angle" means the acute angle of the blade plate (or of that part of the blade plate adjacent the tip) to the general level of the ground, and the "spade forward angle" means the angle between the rearward direction of the general level of the ground and the line between the tip of the blade plate and the rearward extremity of the top plate.

It has been shown that the anchoring effect of the anchor spade is a function of the vertical penetration of the tip of the blade plate below the ground surface (referred to herein as "the effective depth"). Until the anchor fails, for example by digging itself out under further recoil forces, the greater the effective depth the greater will be the anchoring effect, and in general, further rearward movement of the anchor will be reduced for greater effective depths. Experiments with some anchors (particularly those in use with lightweight towed howitzers having a pair of trail legs) have shown that for a given area of spade blade, the effective depth has a greater anchoring effect than the width of the spade blade.

It has been found by theoretical analysis and confirmed empirically that the optimum spade blade angle for a range of soil types is about 45° . At angles significantly above 45° the effective depth is increased but there is a tendency, when the anchor spade is first put in place and the howitzer fired, for the tip of the blade plate either to scrape along the top of the ground or to plough up the top soil in the ground and thereby produce unacceptable rearward movement of the howitzer. If the anchor spade is already fully embedded there is a possibility that the greater the spade blade angle the greater the possibility of the anchor digging itself out of the ground. Also at higher spade blade angles there is a tendency for the anchor plate to rotate about the tip of the blade instead of digging into the ground. This can put excessive loads on the blade plate and cause failure.

With spade blade angles of less than 45° the effective depth is reduced which means that a longer and hence heavier spade plate is required for the same anchoring effect. Also, when the anchor is first put in place and fired, a lower spade blade angle is likely to cause greater rearward movement of the howitzer to achieve the same effective depth and anchoring effect.

The top plate acts to limit the extent to which the anchor spade will dig into the soil during recoil so that the anchor spade can be readily removed by the gun crew during displacement of the howitzer. Some existing anchor spades for 155mm howitzers have a long top plate to ensure rapid displacement, which produce a spade forward angle of about 135° .

Experiment has shown that for some howitzers the magnitude of the spade forward angle is more significant to the mode of failure of the soil than is the spade blade angle. In some soil conditions with a spade forward angle significantly above 90° , the anchor spade will readily dig into the ground during recoil but when the top plate rests on the ground surface further recoil forces (for example resulting from subsequent firings) can result in the anchor spade digging itself out of the ground. Not only will this produce unacceptable additional rearward movement but will also decrease the effective depth and hence accentuate the failure which can become catastrophic. Analysis of the means of failure in this case (i.e. when the anchor spade digs itself out of the ground) shows that a shear failure plane is set up between the compacted soil in the anchor plate (i.e. between the top plate and blade plate) and the looser soil to the rear. This shear failure plane is approximately along the line between the rearward end of the top plate and the tip of the blade plate, hence the importance and significance of the spade forward angle. For some soil characteristics the spade forward angle may be critical. Ideally it should be the maximum possible to ensure ready removal of the anchor spade but less than the critical value producing shear failure.

Experiment has demonstrated that for typical soil condition the optimum spade forward angle is about 90° . For lightweight towed howitzers a spade forward angle in the range 90° – 110° , or preferably 90° – 100° , will operate satisfactorily if the soil is the character of clay and digging-out of the howitzer may be difficult.

On the other hand in loose soil conditions, where the anchor spade can be more easily removed by the gun crew, a spade forward angle in the range 70° – 90° , or preferably 80° – 90° , will operate satisfactorily. With a spade forward angle of less than 90° the shear plane acts to increase penetration of the blade plate.

Initial spade dig-in is improved by increasing the pressure between the tip of the spade blade and the ground. This can be achieved by sharpening the blade tip and/or by reducing the width or line of action of the edge of the blade plate that engages the ground. The width or line of action of the blade plate can be reduced by removing an area of the tip of the blade plate, either centrally along the tip edge or symmetrically either side at the tip of the spade blade angle, or by otherwise shaping the tip of the blade plate.

Many modern towed howitzers have at least two rearwardly extending trail legs and an anchor spade according to the present invention may be fixed to the rear end of such trail legs by any convenient means. A single anchor spade according to the present invention may be fitted to howitzers that have a single trail leg assembly, for example having a pair of bowed trail legs joined at the rear. Some howitzers dispense with trail leg assemblies and may instead rely on the firing platform which engages the ground during firing to transmit recoil forces to the ground. One or more anchor spades according to the present invention may be fitted to the firing platform.

The blade plate preferably extends at the blade plate angle to a height close to the plane of the top plate, so as to provide a maximum length of blade plate at the design spade blade

angle. In this arrangement the blade plate extends at the design spade blade angle for virtually all the effective depth.

However in another arrangement, the blade plate extends at the design spade angle for between one half and the whole of the effective depth, in which case the blade plate may be fixed to or positioned in close proximity to the top plate by means of an approximately vertical plate, which may comprise an integral part of the blade plate or top plate.

An arcuate plate may be substituted for the vertical plate, having a radius varying from as much as a half to a third of the blade plate length to a small fraction thereof.

It has been found that for a lightweight howitzer having a pair of trail legs and a recoil management system of the kind described in PCT Application No WO89/06778, and which weighs approximately 9000 lbs with a recoiling mass of 4,100 lbs, satisfactory anchor spade performance can be achieved for all magnitudes of charge and most soil conditions with a spade width of approximately 28 inches, and a maximum effective depth of 25 inches, and with a spade blade angle of approximately 45° extending for most of the effective depth. Optimum spade forward angle is 90° .

Normally a howitzer will be more stable when fired directly ahead (i.e zero traverse) and if the trail legs are provided, these are often splayed out symmetrically to the rear of the howitzer. The recoil forces in each trail leg would in this case be approximately equal. However when fired in maximum traverse, unequal recoil forces are transmitted through



the trail legs to the ground, and one of the trail legs will be subject to greater recoil forces than for similar firings at zero traverse. There is therefore a tendency for each leg to move backwards to a different extent, and for the howitzer to tend to rotate about one of the trail legs. It has been found that fitting one or more ribs, known as grousers, on the rearward facing surface of the blade plate extending into the volume between the top plate and blade plate will reduce sideways movement of soil across the blade plate. The grousers are preferably vertical, and act in a similar manner to groynes on beaches to help prevent lateral movement of sand across a beach. Also the fitting of stiffeners on the forward or outside face of the anchor spade helps reduce sideways movement of soil across the blade plate as well as strengthening the anchor spade. The use of grousers has been shown to reduce the rearward movement of the anchor spade and trail legs at most traverse angles including zero traverse. At maximum traverse the grousers also reduce the tendency of the howitzer to rotate about one of the trail legs.

The blade plate and top plate (and vertical plate if present) may be formed from one single metal plate or from separate plates. A single metal plate may be bolted or welded to the end of a trail leg or to the rear of a firing platform. In one arrangement two anchor spades according to the present invention are welded or bolted to the rear of a firing platform, and are disposed symmetrically either side of the rearward direction.

In another arrangement of the anchor plate suitable for fixing to the rear of a howitzer trail leg, the top plate and blade plate are separately and independently fixed to the trail leg. The blade plate is pivotally connected about a point at or near to the forward end of the

blade plate, and fixing and locking means are provided for fixing and locking the blade plate relative to the top plate and trail leg, the top plate and blade plate are separately and independently fixed to the trail leg. The blade plate is pivotally connected about a point at or rear to the forward end of the blade plate, and fixing and locking means are provided for fixing and locking the blade plate relative to the top plate and trail leg, either in a lower operational (i.e. firing) configuration or in an upper stowage configuration with the blade plate directly under, substantially parallel to and adjacent the top plate. The fixing or locking means may comprise a removable retention pin arranged to fit a hole in the trail legs which can be aligned with either a first hole in the blade plate for operational (i.e. firing) configuration or a second hole in the blade plate for the stowage configuration.

In this arrangement, and when displacing the anchor spade after firing, the retention pin may be removed from the first hole to allow the blade plate to pivot to facilitate removal of the blade plate from the ground. The pivot pin may also be removable so that if the anchor blade cannot be readily removed from the ground it can be unfixed from the trail legs by removing the pivot pin.

A rearwardly extending towing arm, known as a lunette, may be removably fixed to the top plate of the anchor spade. This allows the howitzer to be towed in the rearward direction, and when the blade plate is in its stowage configuration adequate ground clearance is provided.

In order to more fully understand the present invention the following embodiments are described by way of example with reference to the drawings in which:

Figure 1 is a schematic drawing of a 155mm lightweight towed howitzer having two linear trail legs symmetrically positioned, in operational configuration, one either side of the rearward direction, and to which anchor spades according to the present invention may be fitted.

Figure 2 is a simplified schematic cross-section drawings of an anchor spade in its operational configuration for fitting to the rear of a pair of trail legs of a lightweight towed howitzer. Figure 2 illustrates the geometrical characteristics of an anchor spade according to the present invention but excludes much of the detail such as the means for stowing the anchor spade and the stiffeners and grousers.

Figure 3 is an isometric projection of one embodiment of an anchor spade according to the present invention suitable for fixing one each to the rear of the trail legs of a 155mm lightweight howitzer having two trail legs, and which shows the rearward face of the anchor spade.

Figure 4 is another isometric projection of the embodiment of Figure 3 showing the forward face of the anchor spade.

Figure 5 is an isometric view of an anchor spade similar to the embodiment of Figures 3 & 4 for fixing to the rear of the trail legs of a 155mm lightweight towed howitzer, but showing detail of the fixing of the anchor spade and lunette to a trail leg.

Figure 6 is an isometric projection of a different embodiment of anchor spade according to the present invention for fixing one each to the rear of the trail legs of a 155mm lightweight towed howitzer, showing the rear face of the anchor spade.

Figure 7 is another isometric projection of the anchor spade shown in Figure 6.

Figure 8 is a side elevation of the anchor plate shown in Figures 6 & 7.

Figure 9 is a drawing of 105mm light howitzer having a pair of bowed trail legs that are joined together at the rear of the trail legs, and to which a single anchor spade according to the present invention may be fixed.

Figure 10 is an isometric projection of an anchor spade according to the present invention which is suitable for fixing to the joined trail legs of the light howitzer shown in Figure 9.

Figure 11 is a top view of the anchor spade shown in Figure 10.

Figure 12 is a side view of the anchor spade shown in Figure 10.

Figure 13 is a bottom view of the anchor spade shown in Figure 10.

Figure 14 is a schematic isometric projection of the firing platform of a lightweight howitzer, which may not have trail legs, showing a pair of anchor spades according to the present invention.

Figure 15 is a side view of the firing platform and anchor spades shown in Figure 14.

Figures 16, 17 and 18 show three different isometric projections of an anchor spade according to the present invention fixed to the trail leg of a different 155mm lightweight towed howitzer.

For the purposes of the description of the embodiments of the invention, the direction in which a howitzer is fired when at zero traverse is referred to as the 'forward' direction. Recoil is therefore in the 'backward' or 'rearward' direction and the blade plate and top plate face rearwardly. In practice, with a howitzer having a pair of trail legs, the legs are positioned rearwardly symmetrically and either side of the line of recoil at zero traverse (i.e. rearward direction). The angle of offset from line of recoil can vary from 20° to 35° , and is always less than the angle of traverse. For the purposes of this description the direction of the forces transmitted along the trail legs and the direction of movement of the trail legs under the recoil forces is also referred to as "rearward" or "backward".

As illustrated in Figure 2 the anchor spade 1 comprises a blade plate 2 connected via a vertical plate or portion 7 to a top plate 5 at the forward end of the anchor spade 1. The anchor spade is fixed to the rear end of a trail leg (not shown in Figure 2) of the howitzer. The spade blade angle is shown as angle μ in Figure 1 and is approximately 45° . The blade plate 2 has a sharpened blade plate tip 3 for easier digging-in into the ground under recoil forces. In Figure 2 the anchor spade 1 is shown resting with its sharpened spade blade tip touching the ground 4. This is typical of the position of emplacement of the anchor prior to initial firing or manual dig-in. To improve initial and subsequent penetration of the blade plate 2 into the ground, the width or length of line of action of the tip 3 in the transverse direction in contact with the ground 4 is reduced. This has the effect of increasing the pressure between the blade plate tip 3 and the ground 4.

The top plate 5 is approximately horizontal to the ground when the spade anchor in the emplacement position prior to initial firing. The rearward extremity 6 of the top plate 5 is located directly above the spade blade tip 3, so that the spade forward angle β is 90° .

In operation, and prior to the first firing from a given howitzer emplacement, the spade anchor fixed at the rearward extremity of the respective trail leg is positioned generally as shown in Figure 2 with the top plate horizontal, the spade blade angle μ at 45° , and the spade forward angle β at 90° . It is usual in practice for the spade anchor to be dug in to the ground to a limited extent prior to initial firing. Generally a hole is dug (not shown) perhaps to a depth of about 6 inches into which the sharpened spade blade tip 3 is



positioned. The positioning of the spade blade tip 3 in this hole does not significantly affect the orientation of the spade anchor relative to the ground.

Upon firing of the howitzer, recoil forces are transmitted through the trail legs to the anchor spade 1. The magnitude of the recoil force transmitted through the trail legs will depend on many factors, such as the elevation and traverse of the howitzer, the extent of the firing charge, the mass of the recoiling parts and trail assembly, the recoil management system, stiffness of the trail legs and the extent to which recoil energy is transmitted through a base plate (not shown) upon which the howitzer is mounted when in its firing configuration. In general maximum recoil energy is transmitted through one of the trail legs when the howitzer is fired at minimum elevation, maximum traverse and maximum charge.

The recoil forces act to drive the spade blade tip 3 into the ground. The effective depth of the anchor is the vertical distance of the spade blade tip 3 under the ground surface, and this effective depth increases as the anchor spade is driven into the ground under the action of recoil forces. The extent to which the effective depth is increased during any one or a number of firings will also depend on the soil conditions. Digging-in may continue until the top plate 5 comes into contact with ground surface 4. The reaction of the horizontal top plate 5 engaging the ground 4 will resist further digging-in of the anchor spade 1. In this way the top plate 5 only comes into full effect when the effective depth approaches its maximum.

An anchor spade having a spade forward angle β of approximately 90° will minimise the risk of the spade digging itself out under further or additional recoil forces, consistent with making the anchor spade readily removable from the ground by the gun crew. A longer top plate 5 may facilitate easier removal of the anchor spade from the ground, but a spade forward angle β of greater than 90° and for certain soil conditions a shear failure plane will be set up along the line from the spade blade tip 3 and the rearward end 6 of the top plate 5. Failure along this shear plane causes the anchor spade to dig itself out of the ground, which will reduce the effective depth and accelerate the failure.

The embodiment illustrated in Figures 3 and 4 is a specific howitzer anchor spade designed and manufactured for a 155mm lightweight towed howitzer having a pair of trail legs. In this embodiment the blade plate 2 has a generally vertical plate 7. In the arrangement shown, the vertical plate 7 and the blade plate 2 are formed from an integral sheet of metal. The top plate 5 is rigidly fixed to rear extremity of the trail legs (not shown). The spade blade angle is 45° and extends at this angle for about two thirds of the perpendicular distance between the spade blade tip 3 and the top plate 5. This embodiment of the invention has a pair of stiffeners 8 fixed to the forward face of the blade plate 2 and vertical plate 7. Although in this embodiment the vertical plate 7 extends for about one third of the maximum effective depth of the anchor spade, it may be of any convenient size and need not be vertical. It is not essential to the operation of the invention and as will be described later in relation to, for example, Figures 6, 7 & 8, may be dispensed with. Also the vertical plate 7 may be replaced by an arcuate plate with any convenient radius. The presence of the vertical plate 7 reduces the length of the spade blade 2 and hence may

limit the digging—in effect of the blade plate, but on the other hand the presence of the vertical plate 7 may reduce the rearward movement of the anchor spade and trail legs.

Two parallel fixing plates 15, located on the forward face of the anchor spade, are fixed one each to stiffeners 8. These plates 15 also extend vertically above the top plate 5 and each have two holes, a firing retention hole 10 and a pivot hole 11. Also shown is a semicircular stowage retention hole 12. The rear extremity of the trail leg (not shown) fits between the pair of parallel plates 15 and a pair of pivot pins (not shown) allow the blade plate 2 and vertical plate 7 to be pivotally mounted on the rear extremity of the trail leg. It will be understood that in the embodiment shown in Figures 3 & 4 the top plate 5 and blade plate 3 (with vertical plate 7) are separately and independently mounted and fixed to the trail legs.

When in its operational or firing configuration as shown in Figures 3 & 4, the firing retention holes 10 align with corresponding fixing holes (not shown) in the rear extremity of the trail leg. Two retention pins (not shown), one each in association with each fixing plate 15, fix the blade plate 2 and vertical plate 7 to the trail legs, so that there is no relative movement between the top plate 5, blade plate 2 and trail leg when in this operational configuration.

In order to remove the anchor plate of Figures 3 & 4, when fully embedded in the ground, the retention pins which pass through the firing retention holes 10 of the fixing plates 15 are removed. This allows the spade blade 2 and vertical plate 7 to pivot about the pivot

pins located in the pivot holes 11, and hence allows the blade plate 2 to be moved relative to the trail legs and thereby aid removal of the blade plate 3 and vertical plate 7 from the ground. In extreme soil conditions, such as wet clay it is sometimes not possible readily to remove the blade plate 3 and vertical plate 7 by this means. In these circumstances the pivot pin may be removed thereby detaching the blade plate 3 and vertical plate 7 from the trail legs and top plate 5. In this way the howitzer may be moved clear of the anchor spade(s), which will allow room for the anchor spades to be dug out separately if necessary.

When the anchor spades have been successfully removed from the ground, the blade plate 3 and vertical plate 7 may be placed in the upper stowage position generally parallel to and under the top plate 5 by rotating the blade plate 2 and vertical plate 7 so that the semicircular stowage retention holes 12 are positioned below the fixing holes in the trail legs. The retention pins are then inserted in the fixing holes in the trail legs, and the semicircular stowage retention holes 12 engage the retention pins to retain the blade plate 2 and vertical plate 7 in the upper stowage position.

In the embodiment of Figures 3 & 4 the blade plate tip 3 is both sharpened and shaped by cutting away a proportion in the centre of the cutting edge and chamfering the edges either side of the blade plate tip 3.

Grousers (not shown in Figures 3 and 4) may be fitted to the anchor spade shown in Figures 3 and 4.

Figure 5 shows an anchor spade very similar to that of Figures 3 and 4, but showing detail of the trail legs 16 to which the anchor spade 1 is fixed in a manner similar to that described for the embodiment shown in Figures 3 & 4. In the embodiment of Figure 5 the stowage retention holes 12 are complete holes and not semicircular as in Figures 3 & 4. To fix the blade plate 2 in the stowage position the retention pins are removed from the firing retention holes 10 and from the lined fixing holes in the trail legs, and the blade plate 2 rotated upwards until the stowage retention holes 12 are in line with the fixing holes. Insertion of the retention pins will then fix the blade plate 2 in its stowage position.

The embodiment of Figure 5 shows a lunette or towing arm 17, which has a towing eye 20 and is fixed to the top plate 5. A pair of anchor handles 18 are fixed to the upper surface of the top plate 5 to assist in removing the anchor spade from the ground for displacement of the howitzer. The trail leg 16 shown in Figure 5 also has a pair of trail leg handles 19 used for lifting and locating the trail leg 16.

Figures 5 and 6 show a pair of parallel grousers 9 fitted onto the internal rearward facing face of the blade plate 2 and vertical plate 7. The grousers extend longitudinally generally in the rearward direction. The grousers have the effect of increasing the moving functional force required to cause soil to move laterally across the blade plates when dug into the ground. This acts to help prevent rotation of the howitzer about one of the trail legs which could happen when firing the howitzer on uneven ground or at high traverse angles. The grousers shown in Figures 5 and 6 may equally well be fitted to the embodiment described

with reference to Figures 3 and 4. Any convenient number of grousers 9 may be fitted to the blade plate 2 and vertical plate 7. They may extend over the whole length of the blade plate and vertical plate, or may be limited to any lesser length on one or other or both of the blade plate and vertical plate. The grousers shown in Figures 5 & 6 may be of any convenient height above the surface of the blade plate 2 and/or vertical plate 7, sufficient to prevent lateral movement of the soil over the blade plate 2 and/or vertical plate 7.

In another embodiment of the invention (not shown) the stiffeners 8 on the forward face of the blade plate 2 and/or vertical plate 7 may be dispensed with, or one of much smaller size employed. Instead the grousers 9 are strengthened so that they can also act as stiffeners.

The embodiment shown in Figures 6, 7 and 8 have a pair of parallel grousers 9 positioned on the blade plate 2 longitudinally and symmetrically about the centre line of the anchor spade.

In the embodiment of Figures 6, 7 and 8 the blade plate 3 has an arcuate portion 21 in place of a vertical plate 7 of other embodiments, at its forward end. The arcuate portion 21 has a radius which is a small fraction of the length of the blade plate 2. This allows blade plate 2 to extend at the optimum spade blade angle of 45° for most of the effective depth of the anchor spade.

Figures 10–13 show an example of an anchor spade according to the present invention suitable for fixing as a single howitzer anchor spade to a 105mm light towed howitzer having a pair of bowed trail legs that are joined at their rear end. The anchor spade is preferably wider than the embodiment shown in Figures 6, 7 and 8, and the role of the three grousers 9 may be more significant than the grousers of the embodiment of Figures 6, 7 and 8. Because there is only one anchor spade for the howitzer the grousers 9 together with the friction force of the soil acting on the width of the compacted soil between blade plate 2 and top plate 5 act to prevent rotation of the howitzer particularly at high traverse angles of firing.

In some arrangements of light towed howitzers, trail legs are not present and the recoil forces are transmitted through a firing platform.

Figures 14 and 15 show a schematic view of a pair of anchor spades according to the present invention fitted to the underside of a firing platform 22.

In the embodiment shown the top plate 5 of the anchor spades 1 are fixed by any convenient means to the underside of the firing platform 1. The anchor spades face rearwardly and are symmetrically located either side of the rearward recoil direction. The anchor spades are each fitted with four vertical grousers 9.

Figures 16, 17 and 18 show an anchor spade similar to that shown in Figures 10 to 13 fitted to a different form of trail leg 16. The top plate 5 of the anchor spade 1 is fixed by any convenient means to the underside of the rear extremity of the trail leg.

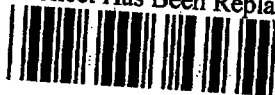
Preferably the means for fixing the anchor spade to the firing platform or trail leg, in the embodiments shown in Figures 14 & 15 and in 16, 17 and 18 respectively allows the anchor spade 1, or at least the blade plate 3 thereof, to be disconnected from the firing platform 22 or trail leg 16 respectively.

In all the embodiments of the invention described above the blade forward angle is 90° and the spade blade angle is 45° .

**CLAIMS**

1. An anchor spade for fitting to the rear end of a trail leg or to a firing platform of a howitzer, the anchor spade being for engaging and digging into the ground under the rearward (as hereinbefore defined) recoil forces of firing, the anchor spade comprising: a rearwardly facing blade plate having a tip for digging into the ground under the forces of recoil and a rearwardly facing top plate mounted above the blade plate so as to be generally parallel with the ground, in use, when the blade plate is embedded in the ground wherein the spade blade angle (as hereinbefore defined) lies in the range from 35° to 55° and the spade forward angle (as hereinbefore defined) lies in the range from 70° to 110° .
2. An anchor spade according to claim 1 wherein the blade plate is planar.
3. An anchor spade according to either claim 1 or claim 2 wherein the spade blade angle is about 45° .
4. An anchor spade according to any one preceding claim wherein the spade forward angle lies in the range from 90° to 110° when used with a lightweight (as hereinbefore defined) howitzer.
5. An anchor spade according to claim 4 wherein the spade forward angle lies in the range from 90° to 100° .
6. An anchor spade according to either claim 4 or claim 5 wherein the spade forward angle is about 90° .
7. An anchor spade according to any one preceding claim from 1 to 3 wherein the spade forward angle lies in the range from 70° to 90° when used in loose soil conditions.
8. An anchor spade according to claim 7 wherein the spade forward angle lies in the range from 80° to 90° .





9. An anchor spade according to either claim 7 or claim 8 wherein the spade forward angle is about 90° .
10. An anchor spade according to any one preceding claim wherein the tip of the blade plate is sharpened.
11. An anchor spade according to any one preceding claim wherein the blade plate is tapered towards the tip so as to reduce the width of line of action of the tip which engages the ground.
12. An anchor spade according to any one preceding claim wherein the tip of the blade plate has one or more areas removed from the edge so as to reduce the line of action which engages with the ground.
13. An anchor spade according to claim 12 wherein the one or more areas are symmetrically disposed on the blade tip.
14. An anchor spade according to claim 13 wherein there is a single centrally disposed area which is removed.
15. An anchor spade according to any one preceding claim wherein the blade plate extends to a height close to the plane of the top plate.
16. An anchor spade according to any one of preceding claims 1 to 14 wherein the blade plate extends at the spade angle for between one half and all of the blade effective depth (as hereinbefore defined).
17. An anchor spade according to claim 16 wherein there is an immediate portion extending between the upper end of the blade plate remote from the tip and the forward end of the top plate.





18. An anchor spade according to claim 17 wherein the intermediate portion is a planar portion extending approximately perpendicularly to the top plate.
19. An anchor spade according to claim 17 wherein the intermediate portion is an arcuate portion.
20. An anchor spade according to claim 19 wherein the radius of curvature of the arcuate portion is between one half and one third of the length to a small fraction of the length of the blade plate.
21. An anchor spade according to any one of preceding claims 17 to 20 wherein said blade plate and said intermediate portion are formed integrally.
22. An anchor spade according to any one preceding claim wherein the rearward face of the blade plate has one or more ribs which extend into the volume between the top plate and blade plate.
23. An anchor spade according to claim 22 wherein the ribs are substantially perpendicular to the plane of the blade plate.
24. An anchor spade according to any one preceding claim further including stiffening ribs on the forward and/or outside face thereof.
25. An anchor spade according to any one preceding claim wherein the top plate, blade plate and intermediate portion, if present, are integrally formed from one plate.
26. An anchor spade according to any one of preceding claims 1 to 24 wherein the top plate and blade plate are formed from different metal plates and are joined together in a fixed relationship.





27. An anchor spade according to any one preceding claim further including pivot means at or near to a forward end of the blade for pivotal connection to a gun in use and, fixing and locking means for fixing and locking the blade plate in position relative to the top plate.
28. An anchor spade according to claim 27 wherein the fixing and locking means comprises alternative positions wherein the blade plate may either be locked in a first operational position or locked in a second stowage position.
29. An anchor spade according to either claim 27 or 28 wherein the blade plate is moveable independently of the top plate.
30. An anchor spade according to any one of preceding claims 27 to 29 wherein the fixing and locking means comprises a removable retention pin which fits, in use, into alternatively alignable holes in a mounting plate on the anchor spade and in gun trail arms in either operational or stowage positions.
31. An anchor spade according to any one preceding claim wherein the blade plate has a width of approximately 28 inches: a maximum effective depth of approximately 25 inches: a spade blade angle of about -45° : and, a spade forward angle of about 90° .
32. An anchor spade according to any one preceding claim further including a howitzer towing arm fitted to the top plate.
33. A howitzer having two trail legs and having an anchor spade according to any one of preceding claims 1 to 32 fitted thereto.
34. A howitzer having a single trail leg assembly and having a spade anchor according to any one of preceding claims 1 to 32 fitted thereto.





35. A howitzer according to either claim 33 or 34 wherein the top plate and the blade plate of the anchor spade are separately and independently fitted to the trail leg.
36. A howitzer according to any one of preceding claims 33 to 35 wherein the trail leg or legs are provided with pivot means to allow the blade plate to pivot relative thereto.
37. A howitzer according to claim 36 further provided with locking means to allow the blade plate to be locked in either a first operational position or a second stowage position.
38. A howitzer according to claim 37 wherein the locking means comprises a removable retention pin.
39. A howitzer according to either claim 37 or 38 wherein the blade plate in the stowage position is substantially parallel to and adjacent the top plate.
40. A howitzer having one or more spade anchors according to any one of preceding claims 1 to 32 fitted to a firing platform thereof.
41. A howitzer according to claim 40 wherein there are two anchor spades which are fixed to the firing platform and disposed symmetrically either side of the rearward direction (as hereinbefore defined).
42. An anchor spade for fitting to the rear end of a trail leg or to a firing platform of a howitzer, the anchor spade being for engaging and digging into the ground under the rearward (as hereinbefore defined) recoil forces of firing, the anchor spade being substantially as hereinbefore described with reference to the accompanying description and Figures 1 to 5; or Figures 6 to 8; or Figures 9 to 13; or 14 and 15; or Figures 16 to 18 of the drawings.
43. A howitzer having an anchor spade fitted to the rear end of a trail leg or to a firing platform of said howitzer, the anchor spade being for engaging and digging into the ground



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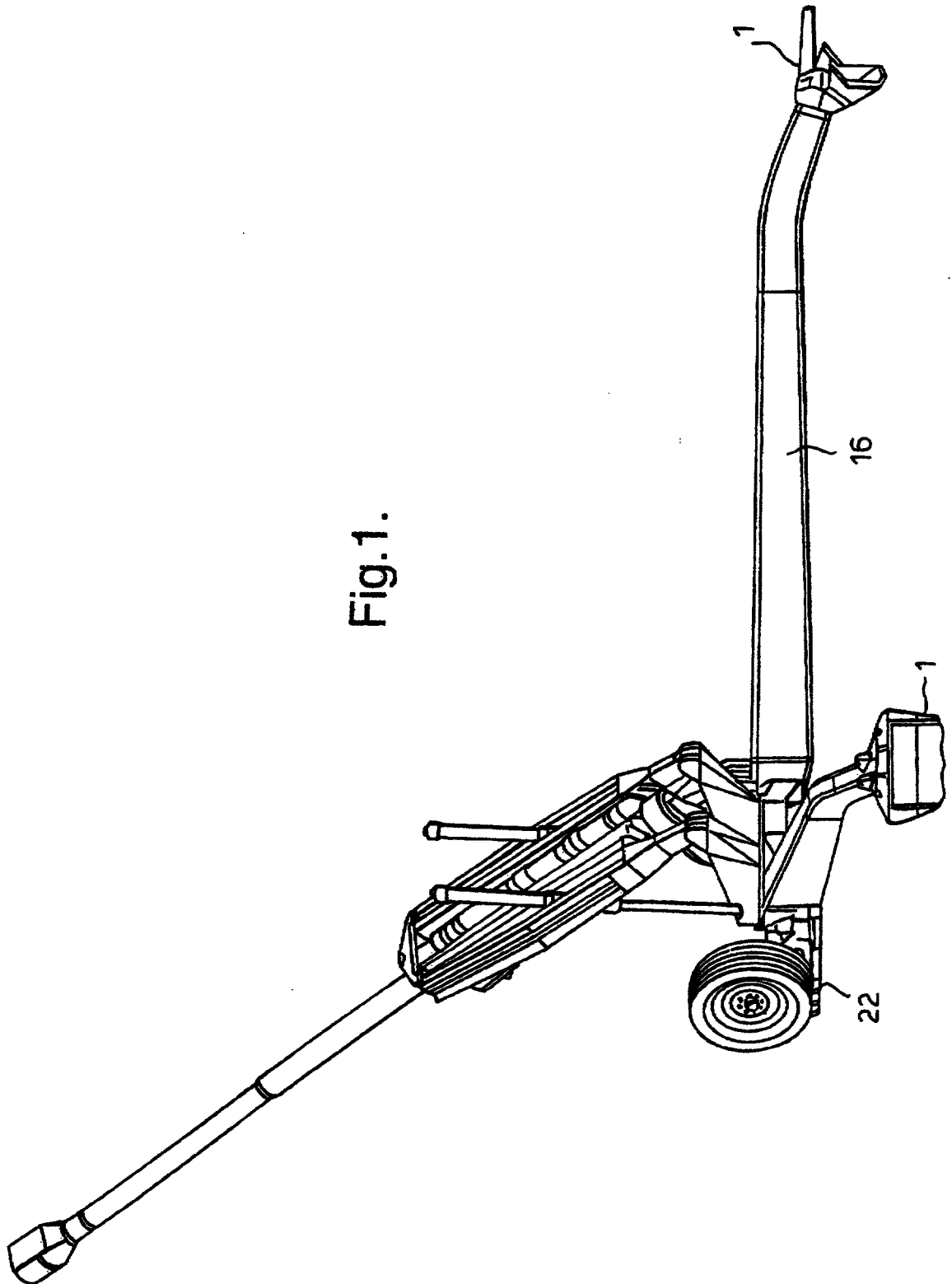
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under the rearward (as hereinbefore defined) recoil forces of firing, the howitzer and anchor spade being substantially as hereinbefore described with reference to the accompanying description and Figures 1 to 5; or Figures 6 to 8; or Figures 9 to 13; or 14 and 15; or Figures 16 to 18 of the drawings.



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Fig.1.



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Fig.2.

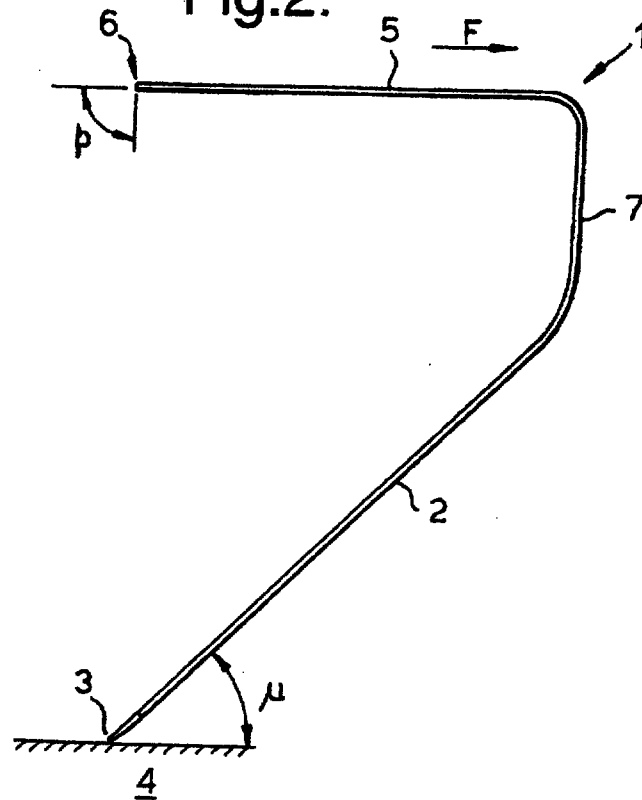
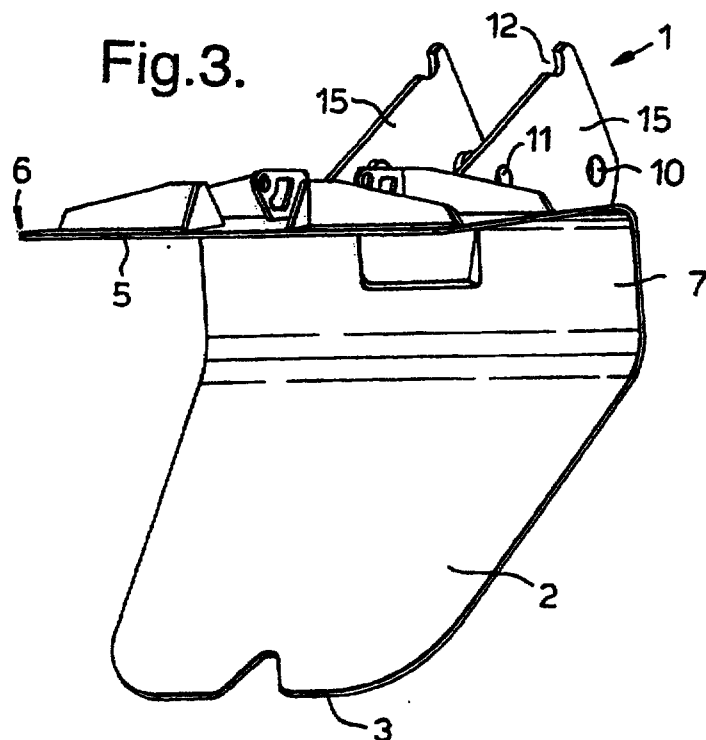


Fig.3.



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Fig.4.

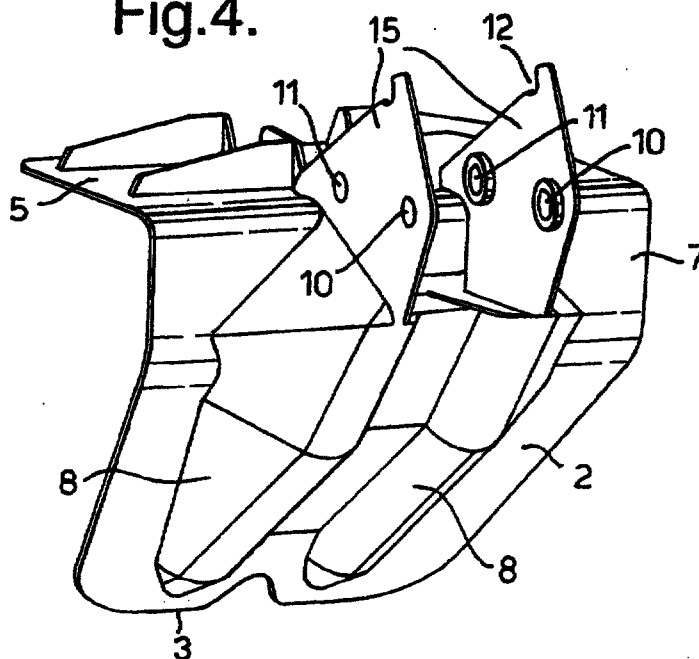
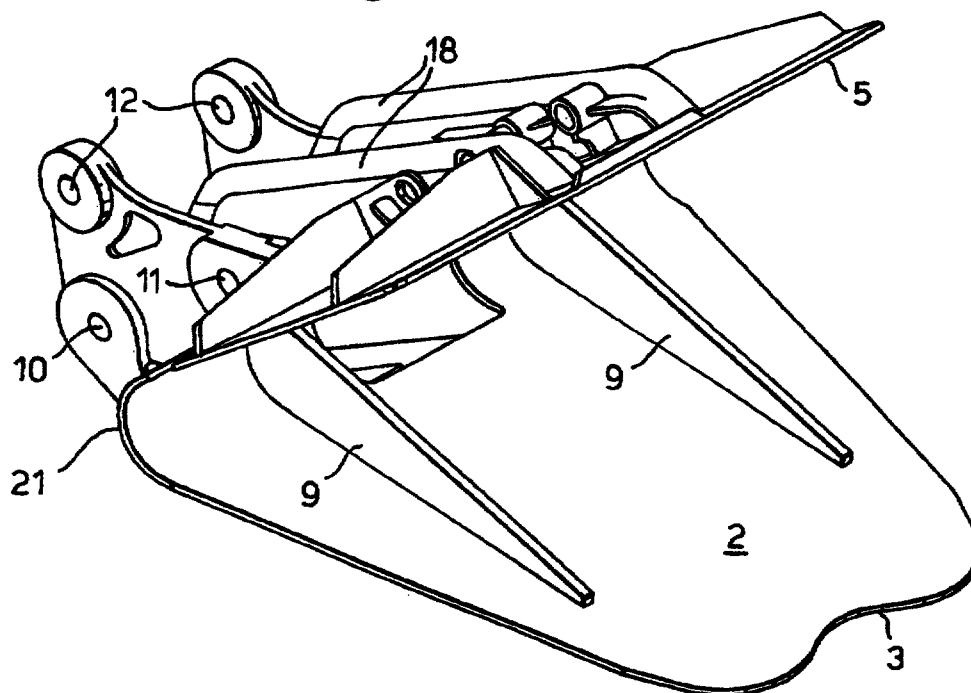


Fig.6.



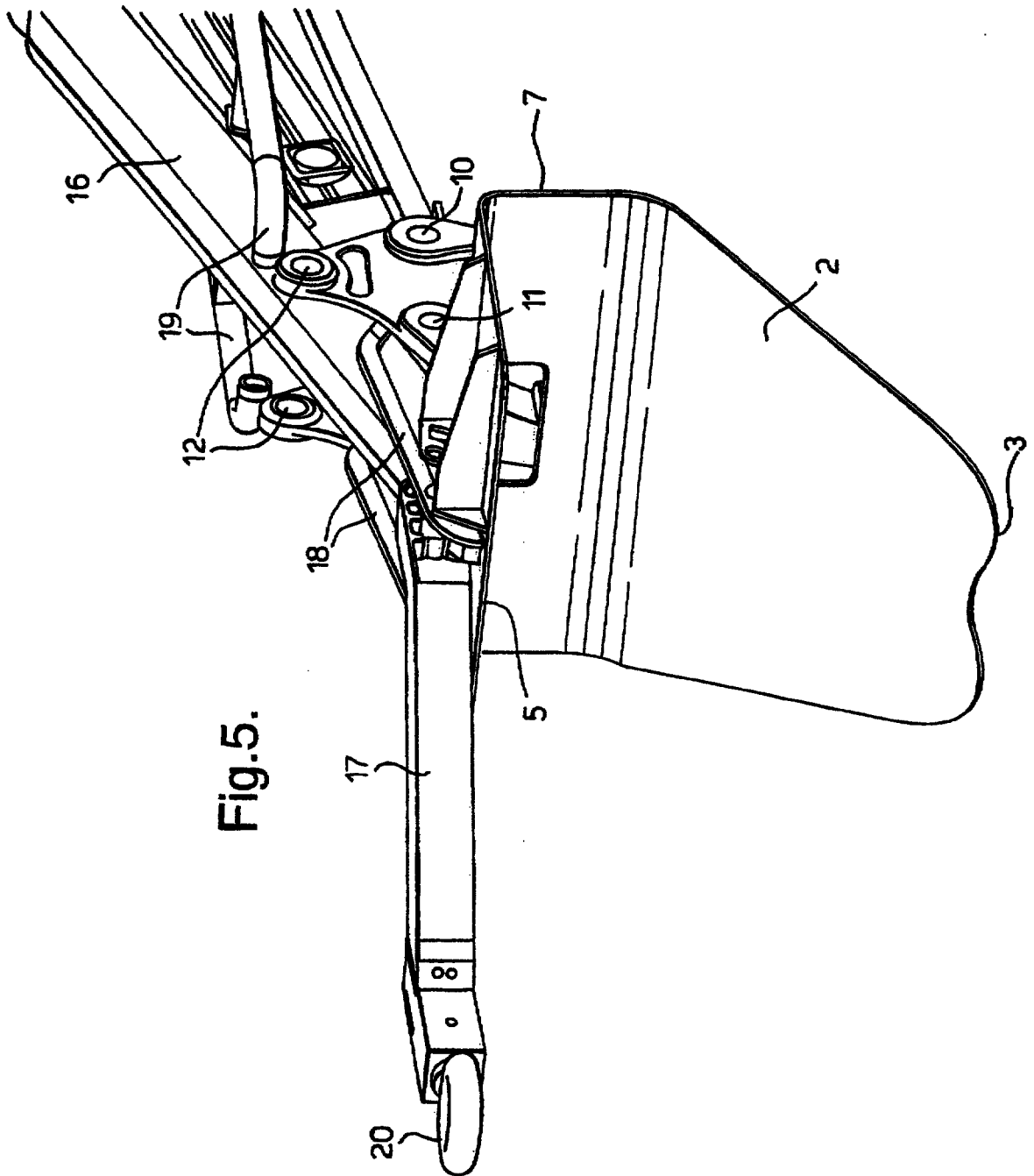


Fig. 5.

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Fig.7.

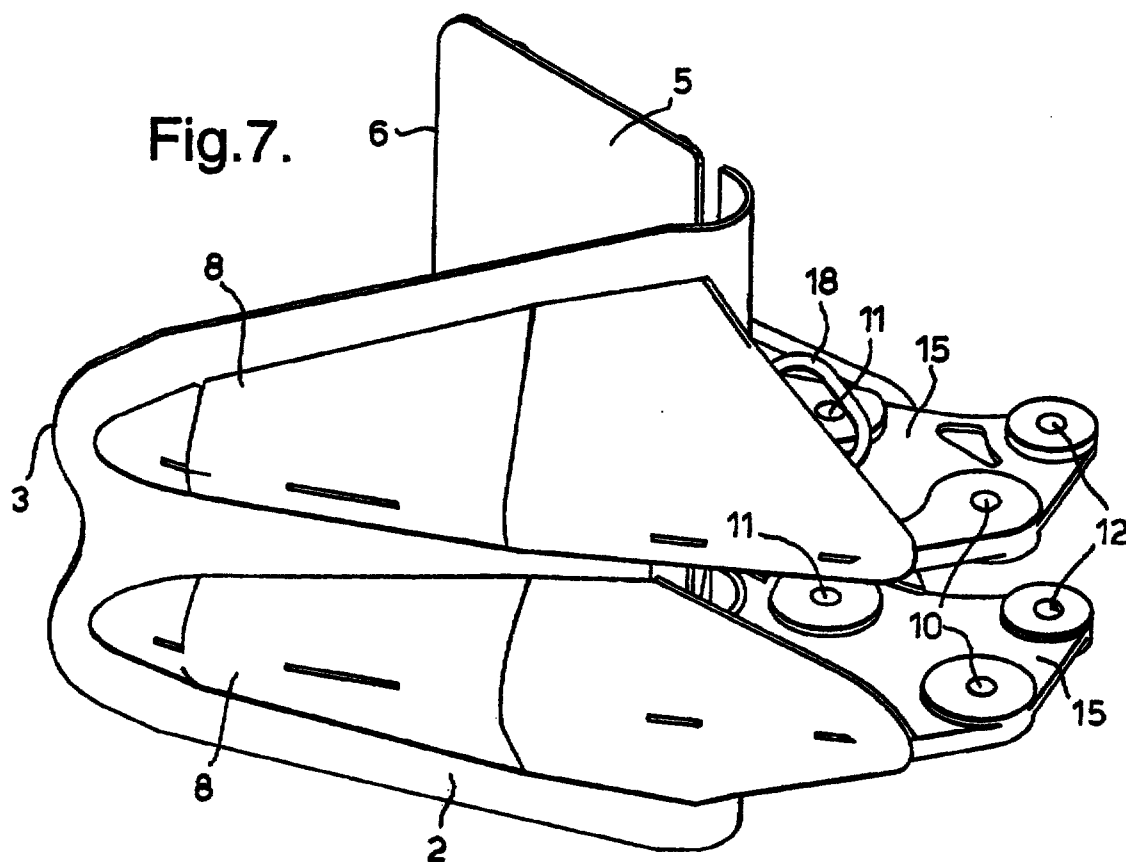


Fig.8.

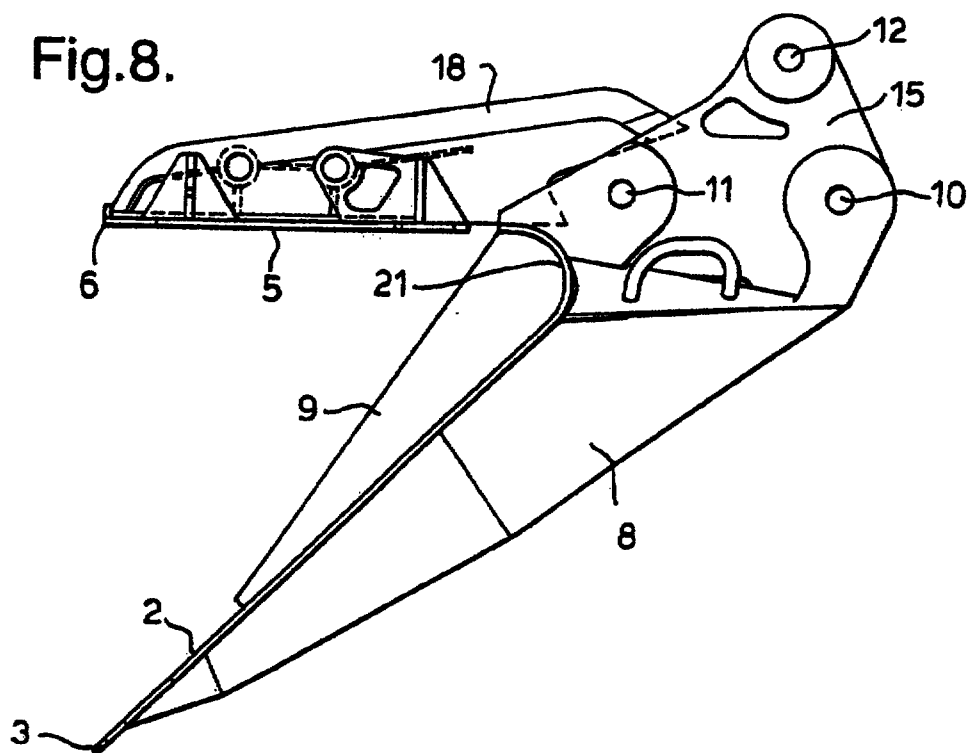
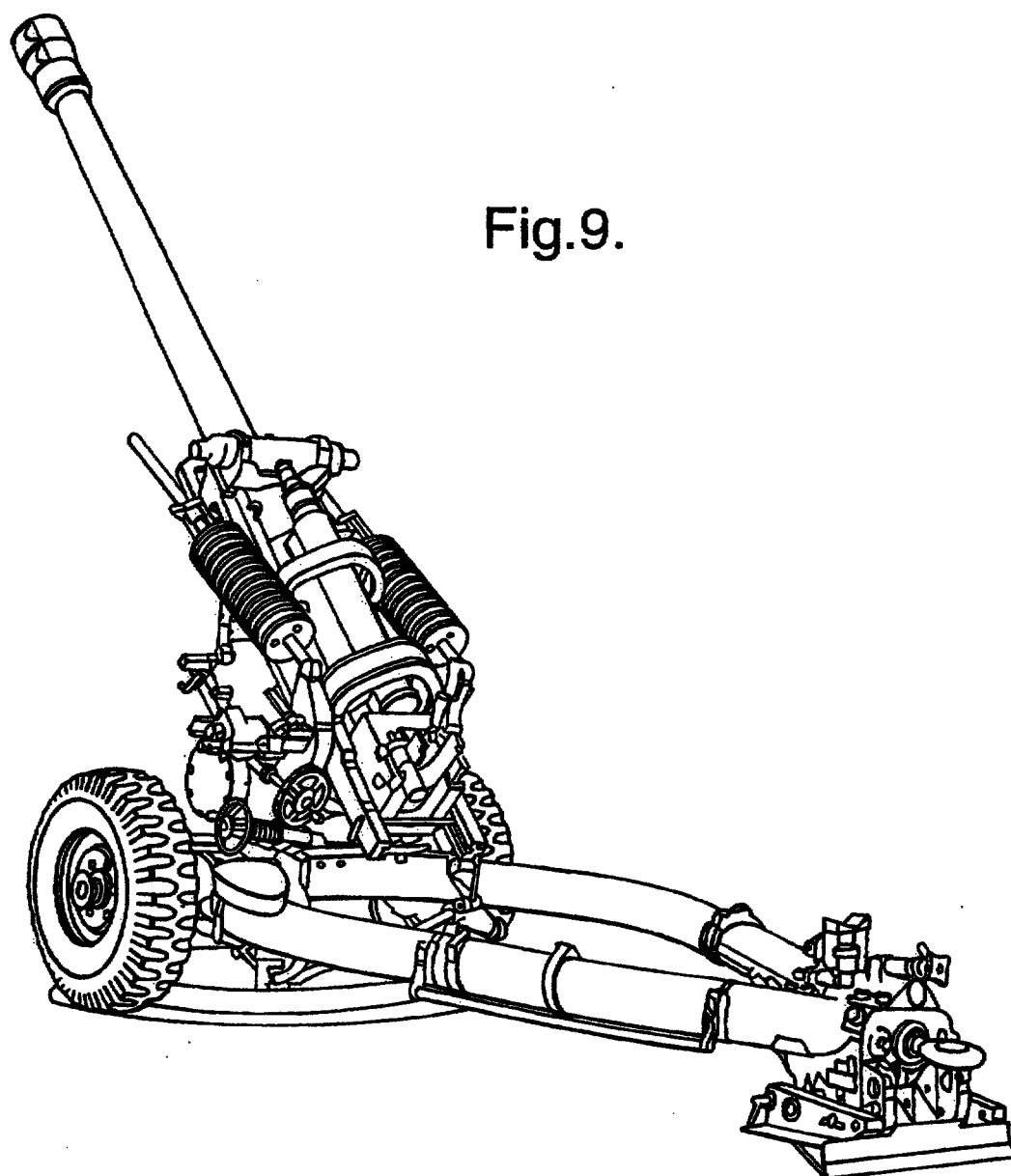


Fig.9.



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Fig.10.

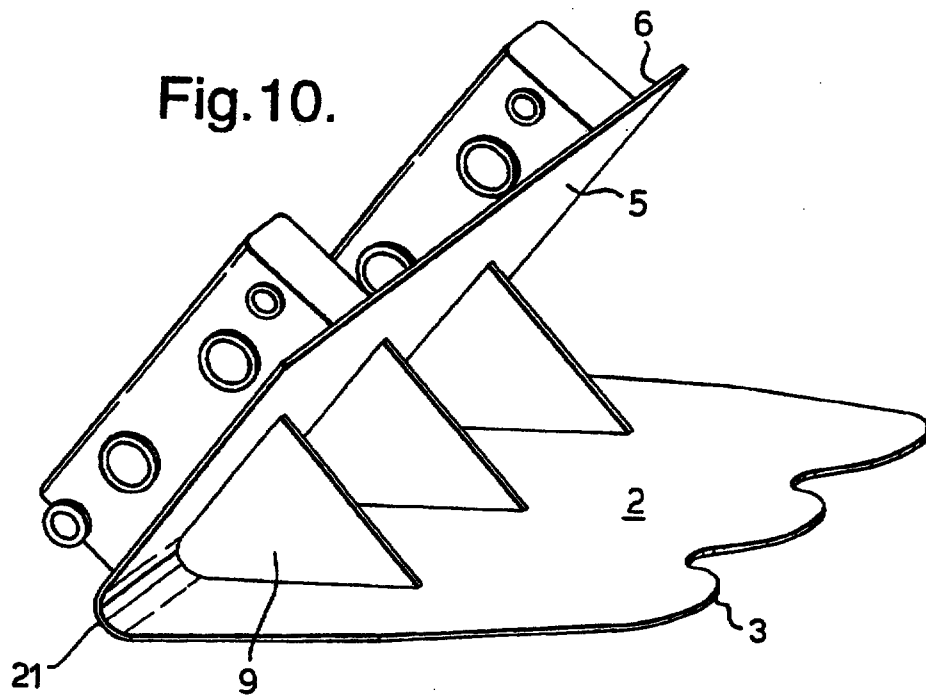


Fig.11.

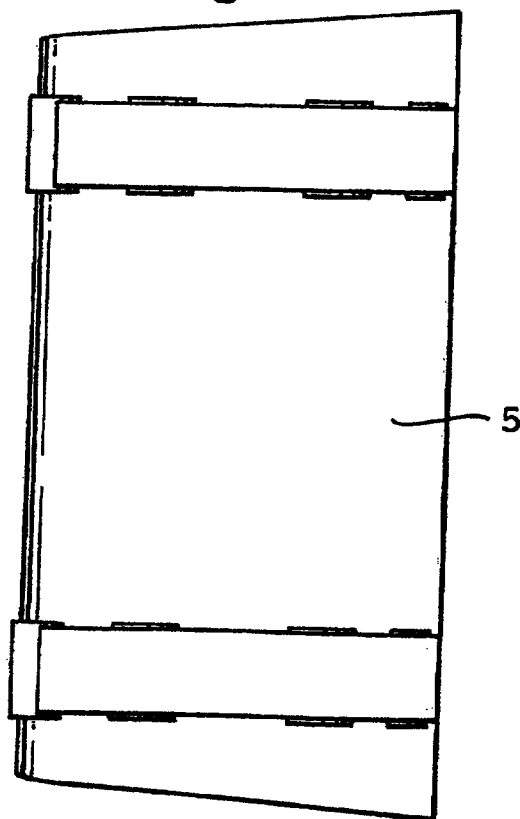


Fig.12.

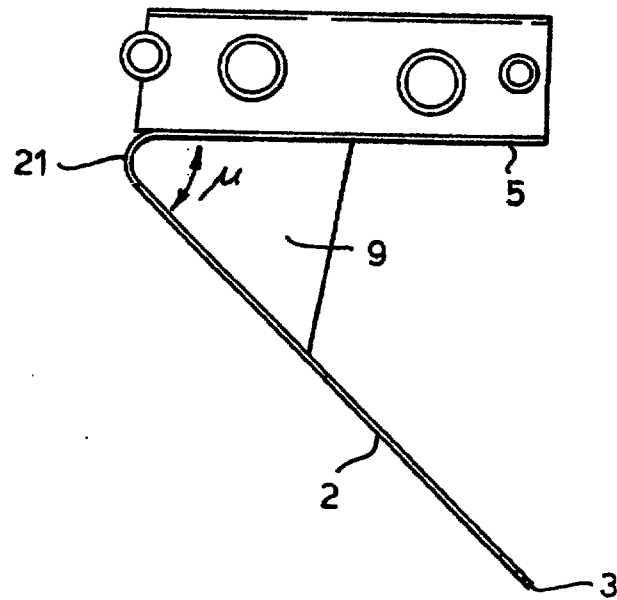


Fig.13.

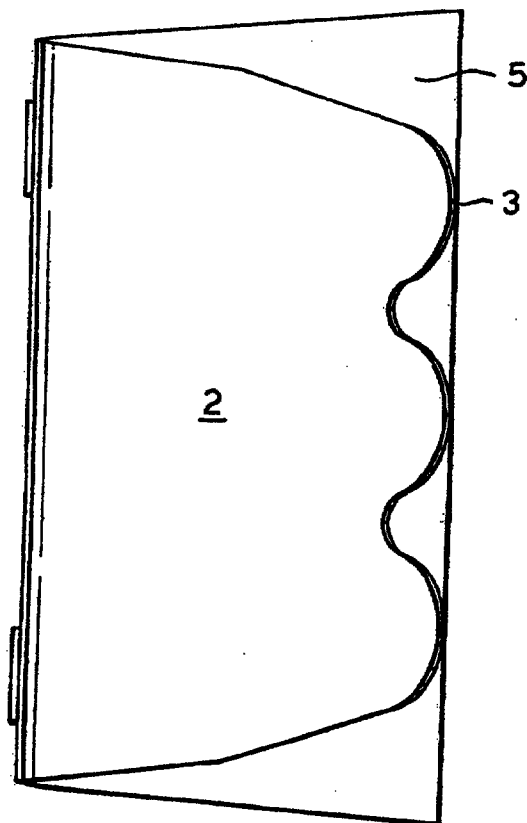


Fig.14.

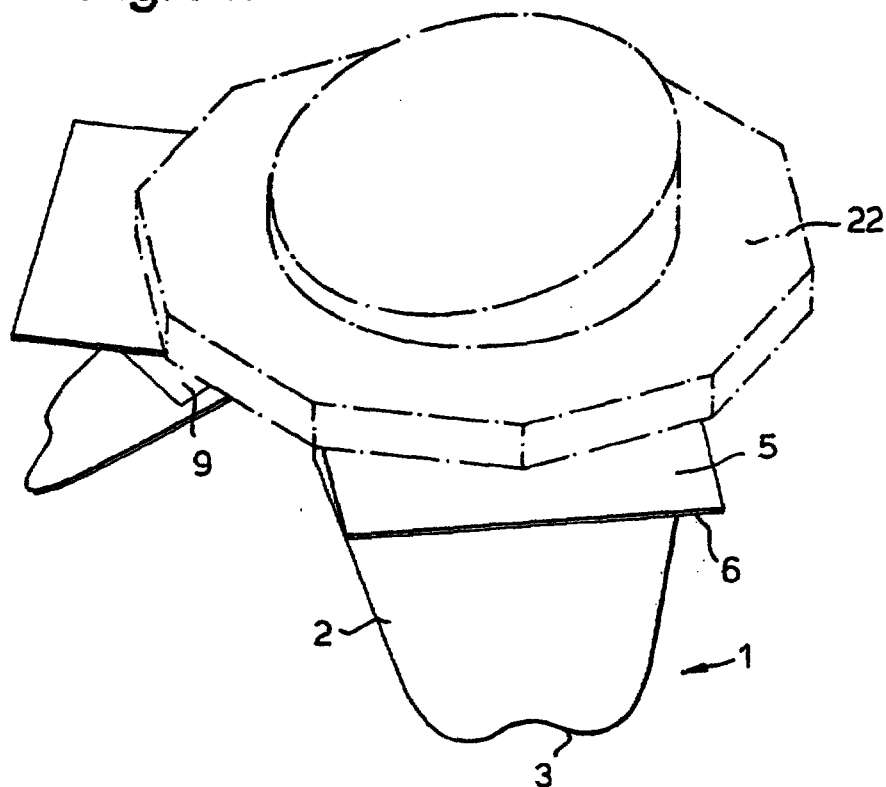


Fig.15.

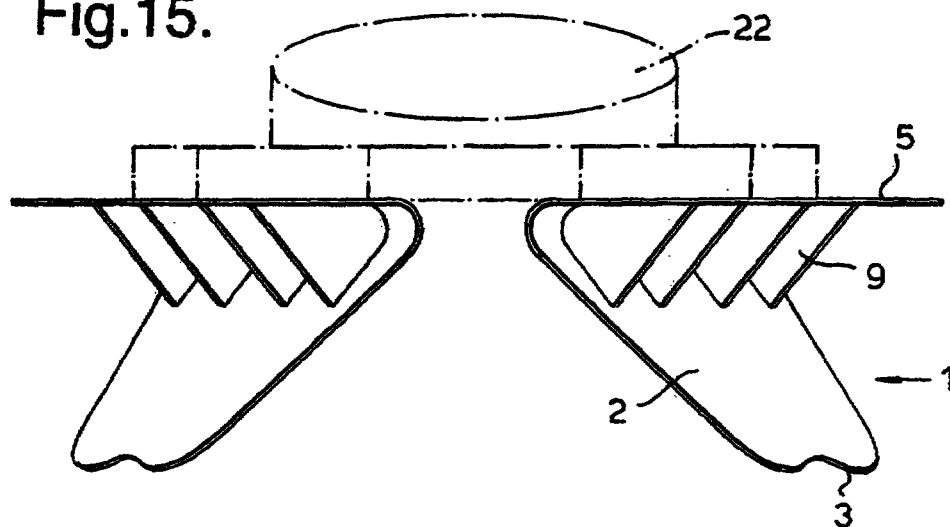


Fig.16.

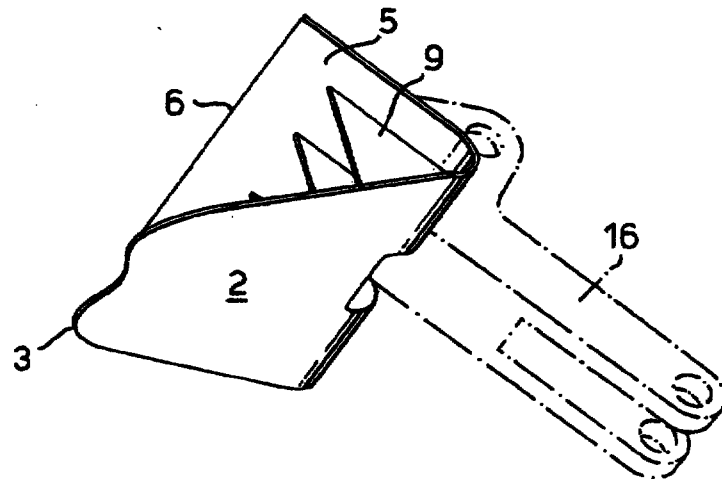


Fig.17.

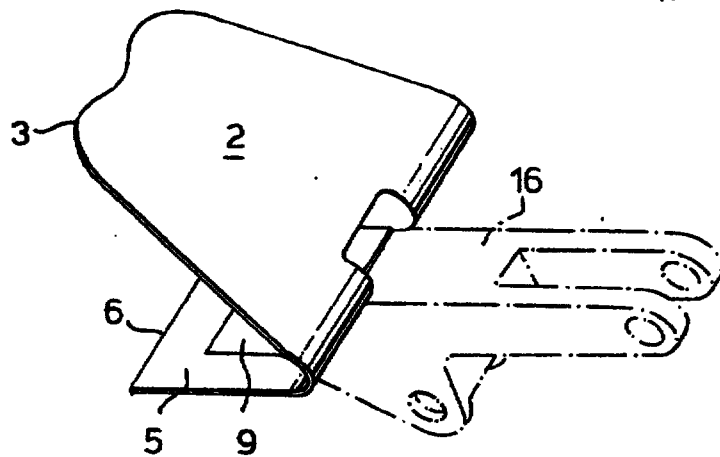
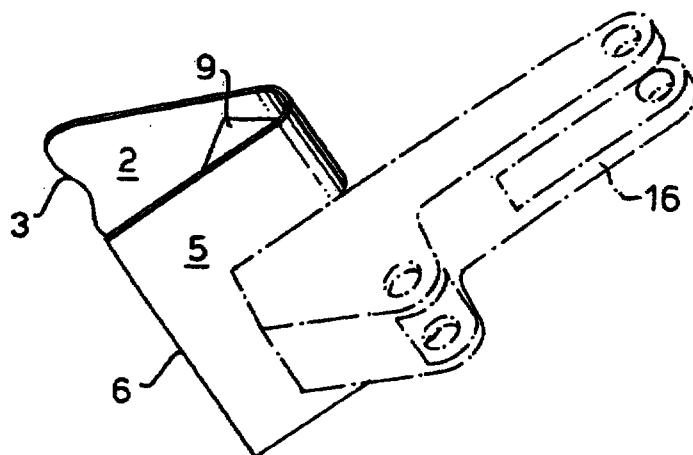


Fig.18.



HOWITZER ANCHOR SPADE

The present invention relates to towed howitzers, which are sometimes referred to as field or artillery guns. The invention provides a means for increasing the stability of towed howitzers and reducing the extent of rearward movement of such howitzers under the recoil forces when the howitzer is fired. Howitzers generally have a recoiling ordnance (barrel and breech mechanism) mounted on a trail assembly and having a firing platform and/or one or more rearwardly extending trail legs, and it is known to fit anchor spades to the rearward ends of such trail legs which engage or dig into the ground under the recoil forces when the gun is fired. Such anchor spades may also be fitted to firing platforms. The present invention is intended to provide an improved design of anchor spade particularly for lightweight howitzers that have a recoil management system.

Many modern conventional towed howitzers generally have an ordnance with a barrel of 105mm or 155mm internal diameter, and the substantial weight of the trail assemblies in these howitzers helps stability. For example the typical weight of a conventional 155mm howitzer might be 18,000 pounds ^(8182 kg) with a recoiling mass of 7,000 pounds ^(3182 kg) and excessive movement of the trail assembly is usually avoided because of the significant energy required to overcome the inertia of the mass of the howitzer which is high in relation to the firing impulse. Also the suitable design and management of the recoil braking system will aid stability.

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However modern armies now require howitzers that are significantly lighter than conventional howitzers, but without loss of performance. Lightweight howitzers can be deployed more rapidly, towed by lighter motorised vehicles and can be more readily transported by military aircraft or slung under military helicopters. These are all important benefits for rapid deployment forces, which play an increasingly important role in modern armed conflicts.

The requirement for lightweight howitzers, for example for 155mm howitzers weighing less than 9000 lbs ^(4091 kg) but with the same ordnance and firepower performance, creates considerable design challenges to maintain stability of the howitzer in recoil. Much of the weight saving is to be made in the trail assembly and with a trail assembly weighing only ^(2227 kg) 4,900 lbs ^(1864 kg) and a recoil mass of 4,100 lbs, much less energy is required to overcome the inertia of the lightweight howitzer. Such a lightweight howitzer, if of conventional design would not be sufficiently stable during firing and there would be a much greater tendency for the howitzer to move rearwardly. Also the movement of the recoil forces pivoting about the point where the spade engages the ground is not, in the case of lightweight howitzers, balanced by the counter-balancing moment of the weight of the howitzer acting through the centre of gravity of the howitzer. Accordingly the howitzer will tend to jump or bounce. An improved anchor spade design that will readily dig in, stay dug in, and which does not cause excessive rearward movement, will help to reduce this jumping and bouncing.

angle. In this arrangement the blade plate extends at the design spade blade angle for virtually all the effective depth.

However in another arrangement, the blade plate extends at the design spade angle for between one half and the whole of the effective depth, in which case the blade plate may be fixed to or positioned in close proximity to the top plate by means of an approximately vertical plate, which may comprise an integral part of the blade plate or top plate.

An arcuate plate may be substituted for the vertical plate, having a radius varying from as much as a half to a third of the blade plate length to a small fraction thereof.

It has been found that for a lightweight howitzer having a pair of trail legs and a recoil management system of the kind described in PCT Application No WO89/06778, and which weighs approximately 9000 lbs^(4091 kg) with a recoiling mass of 4,100 lbs^(1864 kg), satisfactory anchor spade performance can be achieved for all magnitudes of charge and most soil conditions with a spade width of approximately 28 inches^(71 cm), and a maximum effective depth of 25 inches^(63.5 cm) and with a spade blade angle of approximately 45° extending for most of the effective depth. Optimum spade forward angle is 90°.

Normally a howitzer will be more stable when fired directly ahead (i.e zero traverse) and if the trail legs are provided, these are often splayed out symmetrically to the rear of the howitzer. The recoil forces in each trail leg would in this case be approximately equal. However when fired in maximum traverse, unequal recoil forces are transmitted through

As illustrated in Figure 2 the anchor spade 1 comprises a blade plate 2 connected via a vertical plate or portion 7 to a top plate 5 at the forward end of the anchor spade 1. The anchor spade is fixed to the rear end of a trail leg (not shown in Figure 2) of the howitzer. The spade blade angle is shown as angle μ in Figure ² and is approximately 45° . The blade plate 2 has a sharpened blade plate tip 3 for easier digging-in into the ground under recoil forces. In Figure 2 the anchor spade 1 is shown resting with its sharpened spade blade tip touching the ground 4. This is typical of the position of emplacement of the anchor prior to initial firing or manual dig-in. To improve initial and subsequent penetration of the blade plate 2 into the ground, the width or length of line of action of the tip 3 in the transverse direction in contact with the ground 4 is reduced. This has the effect of increasing the pressure between the blade plate tip 3 and the ground 4.

The top plate 5 is approximately horizontal to the ground when the spade anchor in the emplacement position prior to initial firing. The rearward extremity 6 of the top plate 5 is located directly above the spade blade tip 3, so that the spade forward angle β is 90° .

In operation, and prior to the first firing from a given howitzer emplacement, the spade anchor fixed at the rearward extremity of the respective trail leg is positioned generally as shown in Figure 2 with the top plate horizontal, the spade blade angle μ at 45° , and the spade forward angle β at 90° . It is usual in practice for the spade anchor to be dug in to the ground to a limited extent prior to initial firing. Generally a hole is dug (not shown) perhaps to a depth of about 6 inches into which the sharpened spade blade tip 3 is

CLAIMS

1. An anchor spade (1) for fitting to the rear end of a trail leg (16) or to a firing platform of a howitzer, the anchor spade (1) being for engaging and digging into the ground (4) under the rearward recoil forces of firing, the anchor spade (1) comprising: a rearwardly facing blade plate (2) having a tip (3) for digging into the ground (4) under the forces of recoil and a rearwardly facing top plate (5) mounted above the blade plate (2) so as to be generally parallel with the ground (4), in use, when the blade plate (2) is embedded in the ground (4) wherein the spade blade angle (μ), herein defined as the acute angle of the blade plate (2) (or of that part of the blade plate (2) adjacent the tip (3)) to the general level of the ground (4), lies in the range from 35° to 55° and the spade forward angle (β), herein defined as the angle between the rearward direction of the general level of the ground (4) and the line between the tip (3) of the blade plate (2) and the rearward extremity of the top plate (5), lies in the range from 70° to 110° .
2. An anchor spade (1) according to claim 1 wherein the blade plate (2) is planar.
3. An anchor spade (1) according to either claim 1 or claim 2 wherein the spade blade angle (μ) is about 45° .
4. An anchor spade (1) according to any one preceding claim wherein the spade forward angle (β) lies in the range from 90° to 110° when used with a lightweight howitzer.
5. An anchor spade (1) according to claim 4 wherein the spade forward angle (β) lies in the range from 90° to 100° .
6. An anchor spade (1) according to either claim 4 or claim 5 wherein the spade forward angle (β) is about 90° .



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7. An anchor spade (1) according to any one preceding claim from 1 to 3 wherein the spade forward angle (β) lies in the range from 70° to 90° when used in loose soil conditions.
8. An anchor spade (1) according to claim 7 wherein the spade forward angle (β) lies in the range from 80° to 90° .
9. An anchor spade (1) according to either claim 7 or claim 8 wherein the spade forward angle (β) is about 90° .
10. An anchor spade (1) according to any one preceding claim wherein the tip (3) of the blade plate (2) is sharpened.
11. An anchor spade (1) according to any one preceding claim wherein the blade plate (2) is tapered towards the tip (3) so as to reduce the width of line of action of the tip which engages the ground (14).
12. An anchor spade (1) according to any one preceding claim wherein the tip (3) of the blade plate (12) has one or more areas removed from the edge so as to reduce the line of action which engages with the ground (4).
13. An anchor spade (1) according to claim 12 wherein the one or more areas are symmetrically disposed on the blade tip (3).
14. An anchor spade (1) according to claim 13 wherein there is a single centrally disposed area which is removed.
15. An anchor spade (1) according to any one preceding claim wherein the blade plate (2) extends to a height close to the plane of the top plate (5).



16. An anchor spade (1) according to any one of preceding claims 1 to 14 wherein the blade plate (2) extends at the spade blade angle (μ) for between one half and all of the blade effective depth, the blade effective depth being herein defined as the vertical penetration of the tip (3) of the blade plate (2) below the ground surface (4).
17. An anchor spade (1) according to claim 16 wherein there is an intermediate portion (7) extending between the upper end of the blade plate (2) remote from the tip (3) and the forward end of the top plate (5).
18. An anchor spade (1) according to claim 17 wherein the intermediate portion (7) is a planar portion extending approximately perpendicularly to the top plate (5).
19. An anchor spade (1) according to claim 17 wherein the intermediate portion (7) is an arcuate portion.
20. An anchor spade (1) according to claim 19 wherein the radius of curvature of the arcuate portion is between one half and one third of the length to a small fraction of the length of the blade plate (2).
21. An anchor spade (1) according to any one of preceding claims 17 to 20 wherein said blade plate (2) and said intermediate portion (7) are formed integrally.
22. An anchor spade (1) according to any one preceding claim wherein the rearward face of the blade plate (2) has one or more ribs (9) which extend into the volume between the top plate (5) and blade plate (2).
23. An anchor spade (1) according to claim 22 wherein the ribs (9) are substantially perpendicular to the plane of the blade plate (2).
24. An anchor spade (1) according to any one preceding claim further including stiffening ribs (8) on the forward and/or outside face thereof.



25. An anchor spade (1) according to any one preceding claim wherein the top plate (5), blade plate (2) and intermediate portion (7), if present, are integrally formed from one plate.
26. An anchor spade (1) according to any one of preceding claims 1 to 24 wherein the top plate (5) and blade plate (2) are formed from different metal plates and are joined together in a fixed relationship.
27. An anchor spade (1) according to any one preceding claim further including pivot means (11) at or near to a forward end of the blade for pivotal connection to a gun in use and, fixing and locking means (15, 10, 12) for fixing and locking the blade plate in position relative to the top plate.
28. An anchor spade (1) according to claim 27 wherein the fixing and locking means (15, 10, 12) comprises alternative positions wherein the blade plate (2) may either be locked in a first operational position or locked in a second stowage position.
29. An anchor spade (1) according to either claim 27 or 28 wherein the blade plate (2) is moveable independently of the top plate (5).
30. An anchor spade (1) according to any one of preceding claims 27 to 29 wherein the fixing and locking means (15, 10, 12) comprises a removable retention pin (not shown) which fits, in use, into alternatively alignable holes (10, 12) in a mounting plate (15) on the anchor spade (1) and in gun trail arms (16) in either operational or stowage positions.
31. An anchor spade (1) according to any one preceding claim wherein the blade plate (2) has a width of approximately 28 inches (71 cm): a maximum effective depth of approximately 25 inches (63.5 cm): a spade blade angle (μ) of about 45° : and, a spade forward angle (β) of about 90° .



32. An anchor spade (1) according to any one preceding claim further including a howitzer towing arm (17) fitted to the top plate (15).
33. A howitzer having two trail legs (16) and having an anchor spade (1) according to any one of preceding claims 1 to 32 fitted thereto.
34. A howitzer having a single trail leg assembly and having a spade anchor (1) according to any one of preceding claims 1 to 32 fitted thereto.
35. A howitzer according to either claim 33 or 34 wherein the top plate (5) and the blade plate (2) of the anchor spade (1) are separately and independently fitted to the trail leg (16).
36. A howitzer according to any one of preceding claims 33 to 35 wherein the trail leg or legs (16) are provided with pivot means (11) to allow the blade plate (2) to pivot relative thereto.
37. A howitzer according to claim 36 further provided with locking means (15, 10, 12) to allow the blade plate (2) to be locked in either a first operational position or a second stowage position.
38. A howitzer according to claim 37 wherein the locking means (15, 10, 12) comprises a removable retention pin (not shown).
39. A howitzer according to either claim 37 or 38 wherein the blade plate (2) in the stowage position is substantially parallel to and adjacent the top plate (5).
40. A howitzer having one or more spade anchors (1) according to any one of preceding claims 1 to 32 fitted to a firing platform (22) thereof.



41. A howitzer according to claim 40 wherein there are two anchor spades (1) which are fixed to the firing platform (22) and disposed symmetrically either side of the rearward direction (as hereinbefore defined).

42. An anchor spade (1) for fitting to the rear end of a trail leg (16) or to a firing platform (22) of a howitzer, the anchor spade (11) being for engaging and digging into the ground (4) under the rearward (as hereinbefore defined) recoil forces of firing, the anchor spade (1) being substantially as hereinbefore described with reference to the accompanying description and Figures 1 to 5; or Figures 6 to 8; or Figures 9 to 13; or 14 and 15; or Figures 16 to 18 of the drawings.

43. A howitzer having an anchor spade (1) fitted to the rear end of a trail leg (16) or to a firing platform (22) of said howitzer, the anchor spade (1) being for engaging and digging into the ground (4) under the rearward (as hereinbefore defined) recoil forces of firing, the howitzer and anchor spade (1) being substantially as hereinbefore described with reference to the accompanying description and Figures 1 to 5; or Figures 6 to 8; or Figures 9 to 13; or 14 and 15; or Figures 16 to 18 of the drawings.





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(54) Title: HOWITZER ANCHOR SPADE ✓

(57) Abstract

An anchor spade for fitting to the rear end of a trail leg or to a firing platform of a howitzer is described, the anchor spade being for engaging and digging into the ground under the rearward recoil forces of firing, the anchor spade comprising: a rearwardly facing blade plate having a tip for digging into the ground under the forces of recoil and a rearwardly facing top plate mounted above the blade plate so as to be generally parallel with the ground, in use, when the blade plate is embedded in the ground, the spade blade angle lying in the range from 35° to 55° and the spade forward angle lying in the range from 70° to 110°.

