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SURVEYING OF UNDERGROUND TUNNELS AND CHAMBERS

Filed Oct. 23, 1957

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Fig. 1

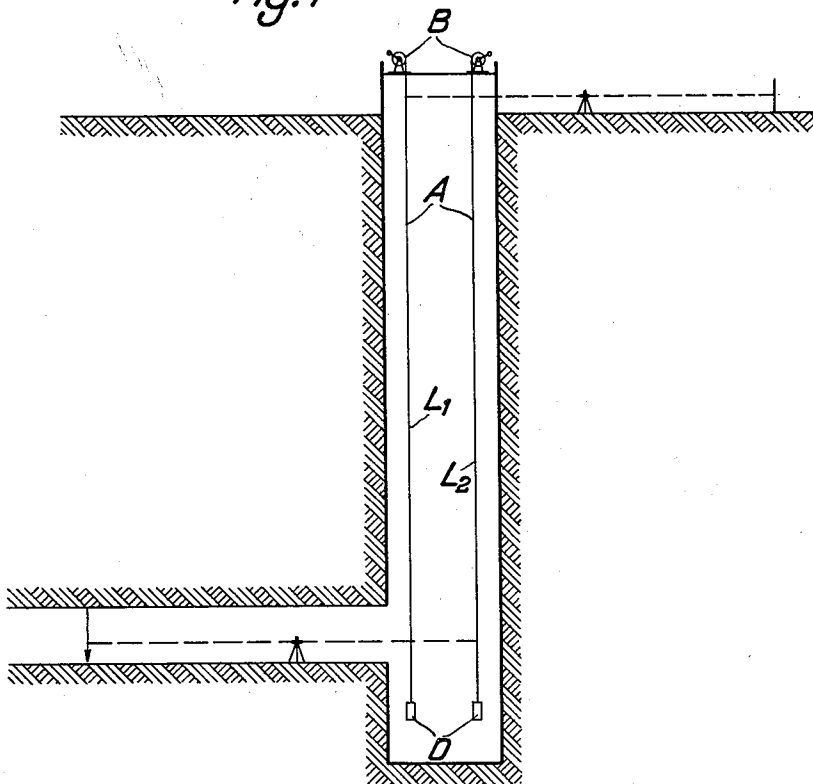
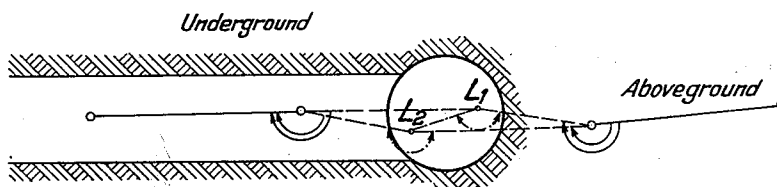


Fig. 2



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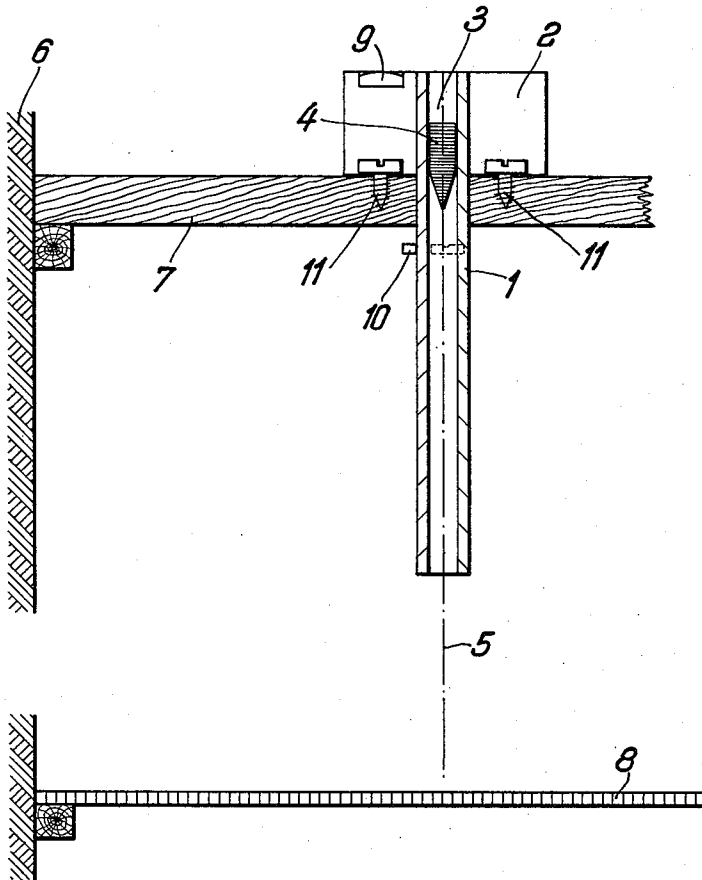


Fig. 3

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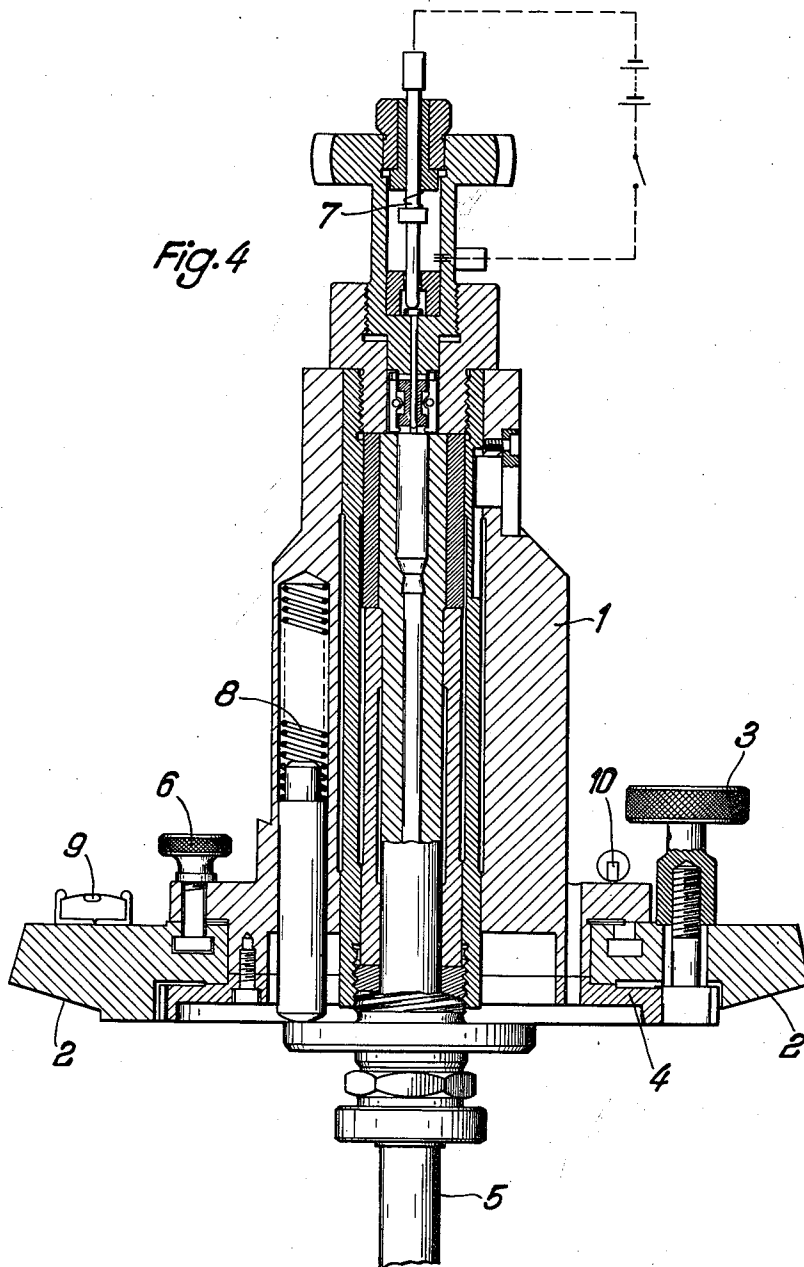
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3 Sheets-Sheet 3



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SURVEYING OF UNDERGROUND TUNNELS AND CHAMBERS

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13 Claims. (Cl. 33-1)

This invention relates to new and useful improvements in the surveying of underground tunnels and chambers. The invention more particularly relates to an improved method and apparatus for effecting the plumbing operation in this surveying.

In surveying underground tunnels and chambers, as for example, in order to have the tunnels or chambers meet or intersect in the desired manner in mines, a line or direction is first laid out above the ground and must then be transferred below the ground to mine level. For this purpose, points must be established exactly vertically below predetermined positions at the ground level above the shaft way. The establishing of the points exactly vertically below the positions is referred to as plumbing and in underground surveying, two points are generally established directly vertically below two corresponding positions at the ground level above the shaft in order to effect the transfer of the direction line. This is generally referred to as "shaft double plumbing."

The plumbing has been conventionally effected with plumb lines having plumb weights at their ends to keep the lines taut. Relatively large vertical distances are often encountered in underground surveying, and the plumb lines were conventionally made of crucible-steel wire having a thickness of about 1 mm.

Plumbing with the use of these conventional plumb lines, however, presented difficulty, as the accuracy would be adversely effected by air currents, water dripping and vibration caused in the mining operation. These adverse effects would tend to increase as the depth increased.

In order to obtain a fair accuracy with the use of these mechanical plumb lines, it was generally necessary, particularly at greater depths to interrupt the mining, including the haulage operations in the vicinity, and to shut off the blowers and ventilating system in order to prevent the undesirable air currents. This of course, is highly undesirable and expensive. Furthermore, the adverse effects do not terminate immediately upon stopping the equipment. If, for example, the ventilating fan is shut off or throttled for the plumbing operation, the airflow does not stop immediately, and it may require many hours before the same diminishes a sufficient amount to prevent adverse interference with the plumbing operation. Additionally, the shutting off of the fans and the ventilating system jeopardizes the safety of the underground operation and aside from the difficulties caused by the underground operation, such as the haulage on the plumbing, the physical presence of the plumbing severely interferes with these operations.

It has been calculated that 75 to 85% of the orientation errors which occurred in the surveying were due to error encountered in the plumbing operation. Tests have shown that large errors of 4 to 17 minutes in arc have resulted with airflow currents of as low as 0.3 to 2.7 meters per second velocity.

The change in the suspension point is a particularly dangerous source of error in the plumbing operation. This may easily take place as a result of the elasticity and stiffness of the plumb wire. The stiffness of the plumb wire and the torsional oscillations of the plumb weight furthermore effect a suspension of the plumb wire in long, drawn-out, i.e. elongated spirals. This bending

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from the perpendicular results in an uncertainty as to location of a different extent depending on the plumb weight and the thickness of the wire.

Another source of error is that the oscillations observed do not constitute pure pendulum oscillations. The movements influenced by drafts of air or dripping water, result in jerking movements of the plumb wire which can almost always be observed upon shaft plumbing.

Furthermore, particularly at greater depths there is the possibility of twisting to the plumb plane due to air pressure acting solely on one side. If only a single plumb weight is used it always has the same drift and thus, despite great precision of measurement, always causes orientation errors.

In view of these many disadvantages, attempts were constantly being made to develop a more dependable plumbing method. These attempts included the use of free falling balls, the magnetic theodolite, optical measurements such as with the Zeiss directive plummet, and the use of gyroscopic devices. None of these developments, however, proved to be a truly satisfactory solution to the problem.

One object of this invention is a novel plumbing method which overcomes the abovementioned disadvantages.

This and still further objects will become apparent from the following description read in conjunction with the drawing in which:

FIG. 1 diagrammatically shows a vertical section of a conventional plumbing operation in the surveying of underground tunnels and chambers.

FIG. 2 is a diagrammatic plan view corresponding to FIG. 1, and

FIG. 3 and FIG. 4 diagrammatically show an embodiment of an apparatus for effecting the plumbing in accordance with the invention.

In accordance with the invention, it has been found that the abovementioned disadvantages may be overcome and the plumbing may be very accurately effected with the establishment of a point vertically below a predetermined position by firing a projectile vertically downwardly from the predetermined position into a target positioned at the level at which the point is to be established and using the puncture point in the target as the point, as for example, for the aiming of the surveyors angle-measuring instrument thereat.

The target is preferably in the form of a horizontal surface which may be readily pierced by the projectile leaving a small hole and which may be maintained horizontally in the shaft, as for example, mounted on a bracket.

The projectile is preferably fired downwardly through a rifled barrel having a right handed twist with a muzzle velocity in excess over about 1,000 meters per second. The detonation of the firing charge is preferably effected electrically in order to avoid any errors which might be caused by mechanical shock in mechanical detonation.

Referring to FIG. 1, the principal of shaft double-plumbing (double-plumbing down of coordinates) is diagrammatically shown. A line or direction is established above the surface between the points 2 and 3, the point 2, for example, being marked by a conventional surveyor's pole, and the surveyor's angle-measuring instrument such as theodolite or transit is positioned at the point 3. Underground in the shaft, the shaft line or axis is marked by the points 6 and 7, plumb line marking the point 7, and another surveyor's angle-measuring instrument such as a theodolite or transit being positioned at the point 6.

Two plumb lines A having the plumb weights D are lowered in the shaft by means of the winches B. One of the plumb lines is designated 1 and the other 2. At the surface, using the angle-measuring instrument at point 3, the angle line extending between the points 2 and 3

makes with the line of point 3 and the plumbline 1 and the angle formed by the line of points 2 and 3, and the line of point 3 and the plumbline 2 are measured. In the same manner, using the angle-measuring instrument at the point 6 underground, the angle between the line of points 6 and 7 and the line between the point 6 and the plumbline 1 and the angle formed between the line of points 6 and 7 and the line of point 6 and the plumbline 2 are measured. As may be readily seen from FIG. 2 if the plumblines 1 and 2 are perfectly vertical, the line from above the ground may be transferred and easily laid out below the ground from the measured angles.

In accordance with the invention, the surveying is effected in the identical manner except that in place of the plumblines 1 and 2, projectiles are fired vertically downwardly into a target consisting of soft wood in the form of a horizontally pierceable surface. The angle of measurement at the surface is taken to the points of firing and the angle-measurement below the surface is taken to the pierced points that the projectile has made in the target.

Referring to FIG. 3, the firing of the projectiles may be effected with a gun having a rifled barrel 1 provided with right handed twist. The barrel is positioned in a support mount 2 which is mounted on a supporting frame 7 extending across the shaft 6. The projectile 4 is positioned in the chamber of the gun and is fired by an explosive charge 3, which is electrically detonated. The charge is preferably a high charge sufficient to give the projectile a muzzle velocity of at least 1,000 meters per second. The mount 2 as shown is positioned on the supporting frame 7 by means of the leveling screws 11, by which the angle of the barrel 1 may be adjusted. The gun is provided with two levels, 9 and 10, of high sensitivity, so that by adjustment of the leveling screws 11, the barrel 1 may be exactly positioned in a vertical position. The levels may, for example, be spirit levels, and level 9, may for example, be a box level while the level 10 is a double-crossed tube level. In the shaft at the level of the tunnel at which points 6 and 7 of FIG. 1 are established, a target in the form of a pierceable horizontal surface is extended across the shaft. The target being supported, for example, on brackets. With the gun in position and the barrel 1 being adjusted to a precisely vertical position, the charge 3 is electrically detonated and the projectile 4 is fired at a high velocity of over 1,000 meters per second. The projectile travels downwardly and pierces target 8 at a point directly vertically below the barrel so that in effect the axis of the barrel 5 forms a plumbline which would extend through the puncture hole. The angle-measurement below ground is then made to the punctured point and the angle-measurement above the ground to the axis of the barrel. With the high velocity of the projectile there is a minimum of deviation of the shot from the vertical. The right-hand twist of the rifling in the barrel imparts a clockwise rotation to the projectile so that the coriolis forces caused by the rotation of the earth are counteracted. If, of course, operation were effected in the southern hemisphere, a left hand rifling twist would be used.

Referring to FIG. 4, the gun is shown in more details. The barrel casing (1) is pivoted in the stand plate (2) and may be revolved with aid of the knurled pinion (3) on the gear wheel (4). After every shooting, the barrel casing should be turned through 90 degrees. For this purpose, the barrel casing is provided with a graduation. By three clamping screws (6), a fast connection is obtained between the barrel casing (1) and the stand plate (2). A pre-leveling of the stand plate is carried out with a box-level, while the fine leveling is executed by the leveling of a double-crossed tubular level, attached to the barrel casing (1).

The cartridge (7) is composed of a brass case with the projectile and the percussion cap for the electric ignition. This is an anvil percussion cap, the capsule of which is iso-

lated against the case. The current flows from the bottom of the percussion cap through the electric detonator composition above the anvil to the case. The percussion cap contains a conductive detonator composition, the explosive constituent of which being the lead salt of the trinitroresorcinol. The charge amounts for example to 0.4 gr. The resistance of the percussion cap lies between nearly 20 and 500 ohms. The percussion cap can already actuate at a voltage of 4 volts. For the true ignition, however, a voltage of 12 volts is necessary. At the resistance control of the percussion cap, only a voltage of 1.2 to 1.5 volts shall be present. The cartridge contains a powder charge of nearly 5 grs. of smokeless powder of the type as commonly used in cartridges for hunting or infantry rifles. The repulsion, occurring at the ignition of the powder charge, are accommodated from the steel springs (8).

In all other respects, the surveying is effected in the conventional and well known manner.

While the invention has been described in detail with reference to the specific embodiments shown, various changes and modifications will become apparent to the skilled artisan which fall within the spirit of the invention and scope of the appended claim.

I claim:

1. In the surveying of underground tunnels and chambers using an underground point in situ in an unobstructed vertical shaft as reference point relative to a predetermined position vertically directly thereabove, the improvement for establishing the underground point vertically directly below the predetermined position vertically directly thereabove at a remote distance therefrom which comprises firing a projectile vertically directly downwardly from the predetermined position thereabove into a target positioned at the level at which the underground point is to be established at said remote distance to form a puncture point in the target whereby said puncture point may be used in situ underground as the underground point for surveying.

2. Improvement according to claim 1 in which said projectile upon firing is guided precisely vertically downwardly and is rotated during travel to counteract the coriolis forces caused by the rotation of the earth.

3. Improvement according to claim 1 in which said target is defined by a pierceable horizontal surface.

4. Improvement according to claim 1 in which said projectile is imparted a clockwise rotation during said firing.

5. Improvement according to claim 4 in which said projectile is fired with muzzle velocity of at least 1,000 meters per second.

6. Improvement according to claim 2 in which said projectile is fired by electrical detonation.

7. Improvement according to claim 2 in which said projectile is fired with a muzzle velocity of at least 1,000 meters per second.

8. Plumbing device for surveying underground tunnels and chambers which comprises a high velocity long range gun having a rifled barrel with a right hand twist, a support mount for holding said gun with its barrel pointed downwardly and means including a precision level for adjusting said barrel to a precise vertical position.

9. Plumbing device according to claim 8 in which said gun is capable of firing at a muzzle velocity of over 1,000 meters per second.

10. Plumbing device according to claim 9, in which said gun includes electrical detonating firing means.

11. Plumbing device according to claim 8 and a combination therewith a target having a pierceable surface and means for maintaining said target horizontally fixed in a mine shaft.

12. In the surveying of underground tunnels and chambers using an underground point in situ in an unobstructed vertical shaft as reference point relative to a predetermined position aboveground, the improvement for estab-

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lishing the underground point vertically directly below the predetermined position aboveground at a remote distance therefrom, which comprises firing a projectile vertically directly downwardly from the predetermined position aboveground and registering the point of intersection of the vertical path of said projectile with a plane positioned at the level at which said underground point is to be established at said remote distance whereby the point of intersection may be used in situ underground as said underground point.

13. In the surveying of underground tunnels and chambers using two spaced-apart underground points in situ in an unobstructed vertical shaft as reference points relative to two spaced-apart predetermined points aboveground, the improvement for establishing the two spaced-apart underground points vertically directly below the cor-

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responding two spaced-apart predetermined points aboveground at a remote distance therefrom, which comprises firing two projectiles vertically directly downwardly from the corresponding two spaced-apart predetermined points aboveground and registering the points of intersection of the vertical paths of said projectiles with a horizontal plane positioned at the level at which said two spaced-apart underground points are to be established at said remote distance whereby the points of intersection may be used in situ underground as said underground points.

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