United States Patent

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[54] **DEVICE FOR PARTICULARLY CONTINUOUS CHECKING AND/OR INDICATION OF CURVATURES ARISING IN GUN BARRELS**

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** .....**356/154,** 33/46 AT, 356/152, 356/138

[51] **Int. Cl.** **G01b 11/26**

[58] **Field of Search**.....356/138, 152, 153, 154; 73/162; 33/46 AT

[56] **References Cited**

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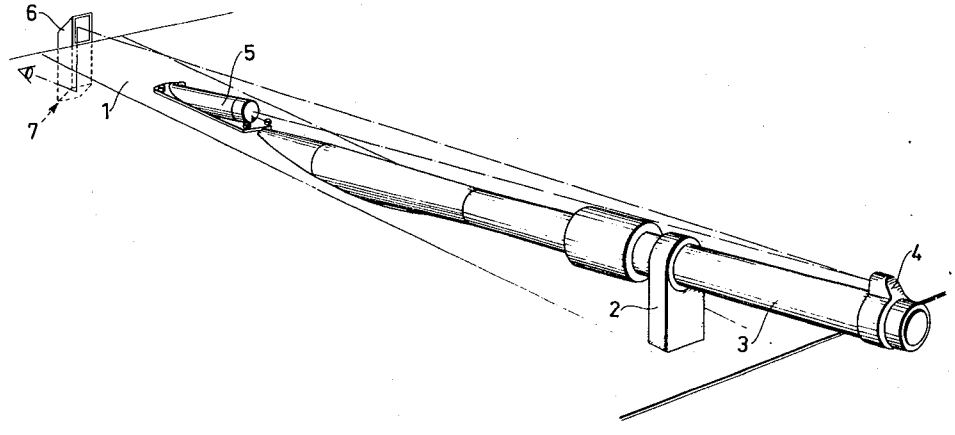
Attorney—Hane & Baxley

[57] **ABSTRACT**

A device for sensing for a curvature in a gun barrel, comprising a reflector fixedly mounted near the muzzle of the gun and a source of light and detector means fixedly mounted near the rear portion of the gun barrel, is provided.

5 Claims, 6 Drawing Figures



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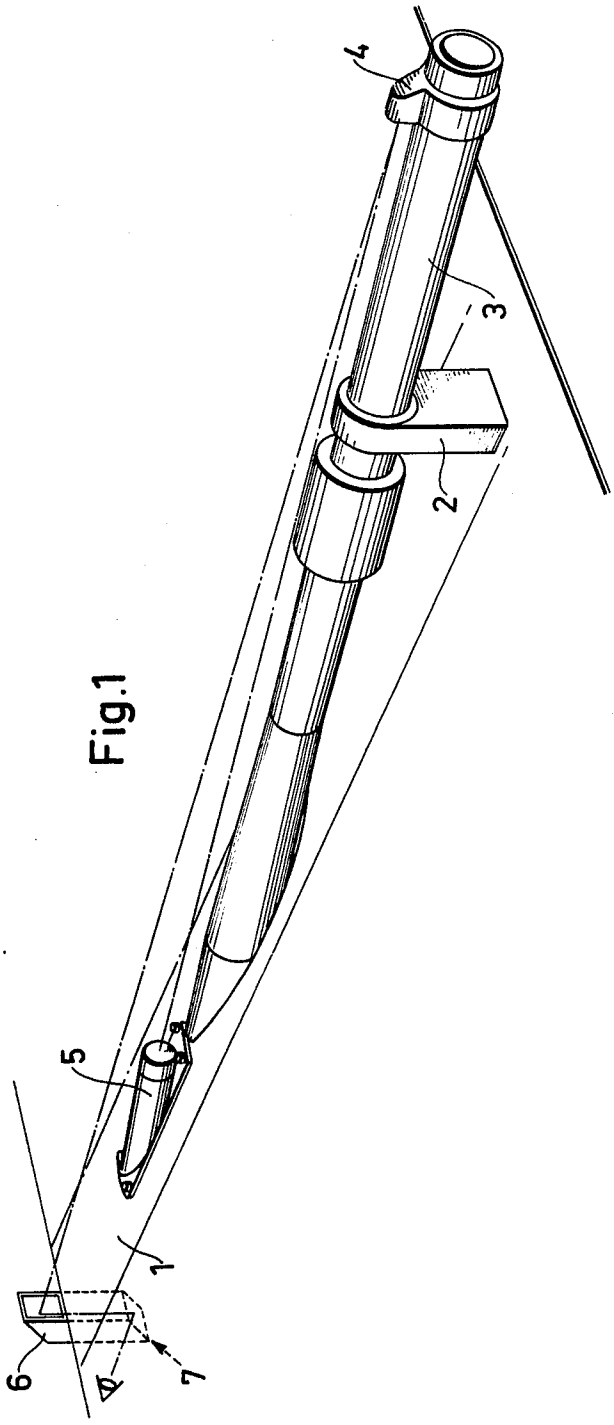

Fig.1

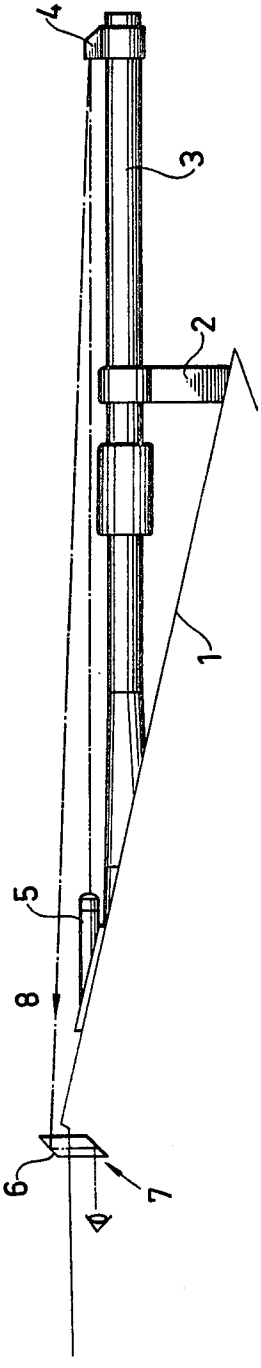

Fig.2

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Fig. 4

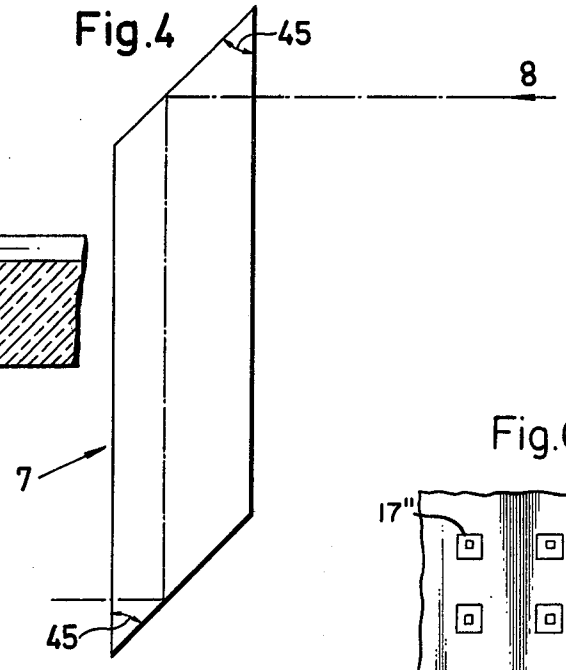


Fig. 5

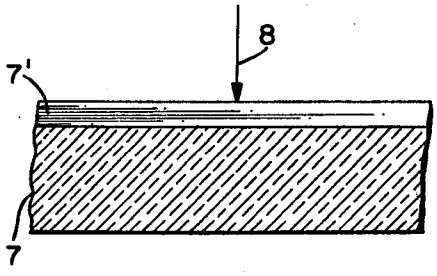


Fig. 6

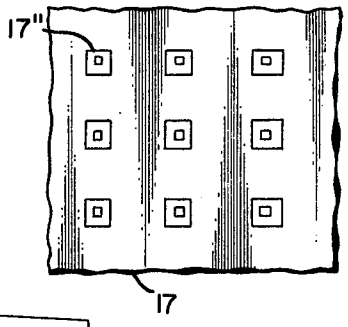
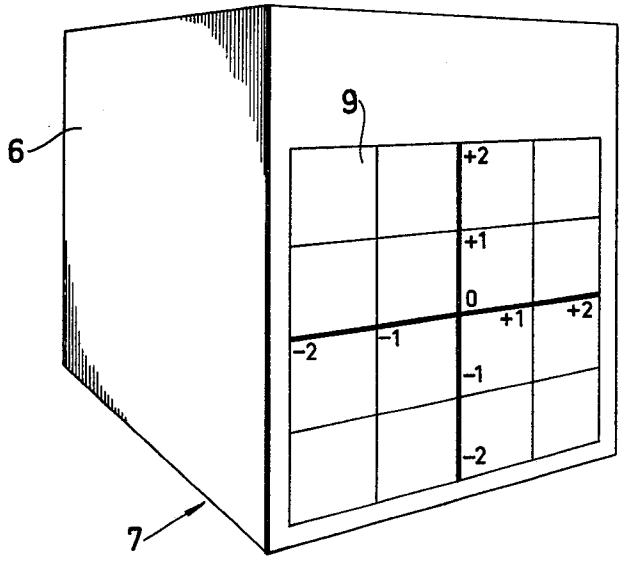


Fig. 3



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DEVICE FOR PARTICULARLY CONTINUOUS CHECKING AND/OR INDICATION OF CURVATURES ARISING IN GUN BARRELS

The present invention relates to a device for preferably continuously checking and/or indicating the occurrence of curvatures in gun barrels.

In the endeavor to obtain greater precision in heavy firearms, the influence of factors which were previously considered of little account has now taken on a greater importance. One such factor is the occurrence of curvatures in gun barrels. The example chosen to illustrate the present invention involves a gun mounted to a modern armored vehicle in fixed relationship thereto, whereby the gun is brought onto the target by maneuvering the vehicle, and thus also the gun, into the correct firing position.

It has been discovered that a gun barrel which is preferably straight when entering service can become curved as a result of a number of different factors. The barrel may become curved, for example, as a result of purely mechanical influences, although thermal influences are more usually the cause. The barrel may be subjected to thermal influences in a number of different ways, for example by being exposed to strong rays of sunshine which heat one side of the barrel to a greater extent than the other side thereof, thereby causing the hotter side of the barrel to expand to a greater extent than the cooler. It will readily be perceived that this will cause the barrel to bend. Similarly, a hot barrel is liable to be cooled unevenly by rain or wind, causing one side of the barrel to be influenced more strongly than the other.

Irrespective to the cause of a curved barrel, the curve in the barrel causes the muzzle portion to deviate from true in relation to the position of the muzzle of a straight barrel. By the position of the muzzle is meant the direction of a line which coincides with the longitudinal axis of the barrel at the muzzle thereof and which determines the direction in which the projectile leaves the barrel.

Those curvatures which are liable to occur as a result of thermal influences in a gun barrel of the type used in an armored vehicle cannon of the type referred to are usually measured in "lengths," each length corresponding to a deviation of 1 meter at a distance of 1,000 meters from the muzzle of the gun, and may thus be said to correspond to a milliradian(mrad). In order to be tolerated, the curvature should lie within 2 milliradians and is normally compensated for by making corrections in the associated gun aiming or sighting system.

For the purpose of adjusting the gun sighting means in relation to the long axis of the barrel there have previously been used optical arrangements in the form of telescopic devices cooperating with reflecting means mounted on the forward end of the gun barrel. An example of such arrangements is described, for example, in the German patent specification No. 232,771 and the Swedish patent specification No. 132,757. These specifications, however, do not discuss the problem of checking or indicating the possible occurrence of barrel curvatures. The known arrangements may be designated "passive" arrangements, since the operator himself must view index markings or the like through a telescopic arrangement and establish whether or not there is any deviation between the long axis of the barrel, said axis being assumed to be a straight line, and a sighting means used for aiming the weapon.

In contradistinction hereto, the present invention relates to a device for checking and/or indicating curvatures occurring in a gun barrel, wherein the barrel is checked for possible curvatures and the curvature indicated in an active manner so that the result can be seen directly on an appropriate display device, for example a ground glass plate presenting a coordinate network in which an illuminated point shows the deflection at the muzzle readable directly in two coordinate directions, normally horizontal and vertical directions — for transfer in an appropriate manner to the sighting means of the weapon.

With an arrangement according to the invention there is used, similarly to known gun sighting arrangements, a mirror which is fixedly mounted on the forward portion of the gun barrel. However, in contradistinction to the arrangements used in the aforementioned gun sighting means in which the mirror, by virtue of its position, serves to indicate the straight line axis of the gun barrel, the mirror or corresponding reflecting surface of the present invention fixed to the muzzle of the gun barrel serves to indicate the angular position of the muzzle in relation to a support structure carrying the gun and associated barrel and in relation to which the gun always takes a fixed position.

The present invention is mainly characterized by a source of light fixedly mounted to the rear portion of the gun barrel and adapted to throw a narrow beam of light against the reflecting surface of a reflecting means situated preferably at right angles to the axis of the barrel, which reflecting means is mounted in a fixed position in relation to the muzzle of the barrel so that, subsequent to the beam of light being reflected against the reflecting surface, the beam of light strikes a detector means situated preferably at the rear portion of the barrel and also fixed in relation to said barrel, said detector means, in cooperation with a display means, which may be embodied with said detector means, is constructed to disclose possible changes in direction of the muzzle of the gun barrel in relation to the position of the muzzle of the barrel when straight, by causing the magnitude and direction of the change to be disclosed on the display means.

The invention will now be described in more detail with reference to the accompanying drawings, further characterizing features of the invention being disclosed in conjunction therewith.

FIG. **1** is a perspective view of the upper portion of an armored vehicle having a gun fixedly mounted on the vehicle and a device constructed in accordance with the invention adapted to disclose the presence of curvatures in the barrel.

FIG. **2** is a side view of the device illustrated in FIG. **1**.

FIG. **3** is a view of a display device in the form of a ground glass plate showing spots of light projected thereon.

FIG. **4** shows a prism forming part of such a display device.

FIG. **5** shows a portion of a ground glass plate covered with a phosphor and FIG. **6** shows part of a matrix of photoconductive elements.

In the following the invention is particularly described by way of example as applied to the type of gun used in the Swedish armored vehicle type S, in which the gun has a fixed position in relation to the

vehicle and where sighting of the gun is effected by maneuvering the entire vehicle to a position in which the gun is brought to bear on the target, this position being established by sighting means which do not form part of the invention and which is thus not shown. In FIG. 1 the generally flat upper portion of the armored vehicle is identified by the reference numeral 1 and the gun is held at the front end thereof in fixed relationship with the vehicle by means of a support 2 and has its rear end in fixed relationship to the vehicle by not shown means. At the muzzle of the barrel 3 is mounted a reflecting means 4, in which a reflecting surface is maintained in a fixed position in relation to the muzzle of the barrel 3 and preferably and suitably generally perpendicular to the geometrical axis of the muzzle, this axis constituting the axis of the gun barrel at the muzzle and determining the direction in which the projectile leaves the gun. As mentioned in the aforegoing, the barrel 3 is liable to become curved by mechanical and/or thermal influences and the muzzle of the gun will thus change its direction to cause thereby the direction in which the projectile leaves the gun to change in relation to the armored vehicle and the sighting means by which the vehicle and gun are aligned with a target while assuming that the muzzle of the gun has a position which corresponds to the position of a perfectly straight barrel.

When the muzzle portion of the barrel changes its position as a result of a curvature in the barrel 3, the change (angular change) is transmitted to the reflecting surface in the means 4. By constructing the means 4 as a steel member having a reflecting surface in the form of a highly polished section thereof and securely mounted to the muzzle of the barrel 3 by press fitting or some other appropriate manner a guarantee is obtained that the position of the reflecting surface in relation to the armored vehicle will disclose the direction in which the projectile leaves the muzzle of the barrel 3.

Mounted in the vicinity of the rear portion of the barrel 3 in a fixed position in relation to the support structure 1 is a light beam source 5 which is adapted to project a very narrow beam of light accurately fixed in relation to said support structure. For this purpose, the source 5 may include a light emitting means and shutters, and also other devices known from conventional projectors and the like. Since the nature of the light beam source 5 does not constitute a part of the invention, no detailed description thereof is necessary, the one requisite being that the arrangement transmits a very narrow and thin beam of light, fixed in direction, towards the reflecting means 4, where the beam of light is returned in approximately the same direction back to the source of light, to there strike a detector 6,7, which suitably constitutes at the same time a display device. As will be seen from FIG. 1, the arrangement illustrated therein is such that the beam of light from the source 5 passes substantially in the same direction as the axis of the barrel 3 towards the reflecting means 4 and then, generally in the same direction as said axis of the barrel 3, back to the detector means 6,7. It will readily be perceived that it is not necessary to obtain exact parallelism between the beam of light passing to and from the reflecting means 4 and the axis of the barrel, but that small deviations may be tolerated and taken into account when finally aligning and fixing the devices 4,5 and 6,7.

The narrow beam of light emitted from the source 5 should comprise electro-magnetic waves of such length as to behave as visible light with respect to refraction and reflection. For purely practical reasons, essentially only visible light radiation, infrared radiation and ultraviolet radiation are envisaged for use with the device of the present invention. For the sake of simplicity, only beams of visible light are discussed in respect of the exemplary embodiment, although modifications can be made when using infrared and ultraviolet radiation, these modifications being described hereinafter.

In the exemplary embodiments of the invention, the detector means 6,7 comprises a prism in the form of a parallelepiped with end surfaces of for example 45° to the longitudinal direction of the prism, as shown in FIG. 4. A beam of incident light is identified with the reference numeral 8 and is reflected against the upper end surface which inclines at 45°, to then pass down in the longitudinal direction of the prism and be reflected at the lower end surface, also inclined with 45°, towards the side surface 7 of the prism 6. When using visible light, the section 7 may be in the form of a ground glass surface and provided, in the manner illustrated in FIG. 3, with a coordinate network, in which each unit along the horizontal and vertical axis corresponds, for example, to one milliradian. It is easy to obtain in such pattern of coordinates disposed on a ground glass plate a digital valuation of the position of the dots of light, as is well known and which will be discussed in more detail hereinafter.

Before the described device can be used to check and indicate the presence of curvatures in the barrel, the various arrangements must first be aligned and set before being taken into use. Subsequent to fixedly positioning the reflecting means 4 on the muzzle section of the barrel 3, the light source 5 is aligned so that the projected narrow beam of light (in this case visible light) strikes the reflecting means 4 and is reflected back to the detecting means 6. The positions of the light beam source 5 and/or the detector means 6,7 are set by setting means (not shown) so that in the case of a straight barrel, established by close examination, the beam of light projected from the source 5, subsequent to being reflected by the means 4 and subsequent to the reflecting from the prism 6, meets the ground glass plate 7 at the zero point thereof. Subsequent to aligning the different arrangements as aforedescribed, and subsequent to having arranged for the light spot 9 to fall on the zero point of the plate 7, and subsequent to locking the arrangements 4,5 and 6,7 in their respective positions in a reliable manner by means of devices not shown, the checking and/or indicating device is ready for use. The device can either be used continuously or at intervals to check the barrel with respect to the presence of curves therein.

When the spot of light 9 from the light a path source 5 (FIG. 3) falls onto the zero point of the ground glass plate (the center point of plate 7) there are obviously no curves in the barrel which would cause the direction in which the projectile leaves the barrel to deviate from the direction the projectile would take in a barrel which was perfectly straight. If, on the other hand, the spot of light 9 takes a position which does not coincide with the zero point on plate 7 it is obvious that the barrel is curved to an extent which would cause the projectile to take a path different to the one it would take from a

perfectly straight barrel. In the case illustrated in FIG. 3, where the spot of light 9 occupies the upper left hand quadrant, it is obvious that the curvature would cause a deviation of − 1.5 milliradians horizontally and + 1 milliradian vertically, which in practice would mean a deviation from the target of 1.5 meters to the right horizontally and 1 meter down vertically when the range of the target is 1,000 meters since the scale is divided into milliradians.

The described device can also be adapted for use with infrared and ultraviolet radiation, by causing the beam 8 to strike immediately before the plate 7 on a device which converts infrared or ultraviolet radiation to visible radiation, which can be achieved by using, for example, suitable phosphors. Accordingly, FIG. 5 shows a portion of the plate 7 covered with a lamine 7 of phosphors.

The described and illustrated detector means with prism 6 for reflecting the beam 8 in the manner indicated has been used so that the operator viewing the plate 7 is protected from being struck by projectiles, since the plate 7 is located inside the armor on the vehicle. When such protection is not necessary, the beam 8 from the reflecting means 4 can be passed direct to a ground glass plate.

It is obvious that the arrangement using the plate 7 is not the only means by which an indication of the straightness of the barrel can be given. For example, a number of photoconductive elements of e.g., CdS material can be arranged in a square matrix and connected to two ammeters via resistors having specific values for each point, and in which the photoconductive elements are connected to voltage sources of suitably polarity. The ammeters disclose the horizontal position (H) and the vertical position (V) are also indicating the direction in which the muzzle deviates from true, i.e. to the left or to the right, up or down. With the embodiment shown in FIG. 3, the meter H would indicate −1.5 on the scale, which has the center point 0 in the center to show horizontal deviations to the right, and the other meter V having the same scale would show + 1, to indicate the vertical deviation downwards. FIG. 6 shows a portion of the top of a substrate 17 with photoconductive element 17'' exposed to receive light.

It is also possible to use a scanning means which, for example, scans ground glass plate in the manner of a television camera and counts the scanning lines and separate sections of each scanning line and gives the result for an encountered point, which thereby interrupts the scan, in digital form on electronic counters.

Irrespective of the type of display device used, an indication of the presence of a curve in the gun barrel will be given and the necessary corrections can be made on the associated sighting means to compensate for the error caused by the curved barrel.

The invention is not restricted to the described and illustrated embodiments, but can be modified within the scope of the following claims.

I claim:

1. A device for sensing for a curvature in a gun barrel comprising a reflecting means fixedly mounted on the gun and near the muzzle thereof, a source of light fixedly mounted to the rear portion of the gun barrel for projecting a narrow beam of light against said reflecting means, and a detector means fixedly mounted with respect to said gun barrel near the rear portion thereof, said detector means being aligned with respect to said reflecting means to intercept a reflected light beam, said detector means comprising a display means for displaying the point of impingement of said reflected light beam, said display means including means for giving an indication of the deviation of a reflected light beam from a position when the gun barrel is straight.

2. A device according to claim 1, characterized in that the display means comprises a ground glass plate provided with a coordinate network and positioned to receive the beam of light reflected by the reflecting means, wherewith an indication is given in the form of a light spot on the plate.

3. A device according to claim 2, characterized in that the ground glass plate, on the side struck by the reflected beam of light, is provided with a coating of a phosphor material which, when the light is in the form of infrared and ultraviolet light causes it to be converted to visible light.

4. A device according to claim 1 wherein said detector means includes a matrix of photoconductive elements connected to said display means.

5. A device according to claim 2 characterized in that the detector means includes a parallelpipedic prism whose end surfaces are inclined at approximately 45° to the longitudinal axis of said prism and the display means is formed on a side of said prism parallel to said longitudinal axis to deflect the reflected beam of light through a protecting wall while displacing the light laterally.

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