Photographing the Bore of a Rifle

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A NEW type of camera has been designed and built at the Bureau of Standards which takes a photograph upon a continuously moving motion-picture film of the interior surface of the bore of a .30-caliber service rifle barrel. This camera promises to supply a new and important method for studying the deterioration of the surface of the bore which results from use. The rate and manner in which erosion takes place is an important factor in determining the life of a gun barrel. To study this, it is necessary to have a convenient method of examining, preferably with magnification, the changes of the interior surface of the bore which result from firing.

The methods previously used have serious disadvantages. For guns of sufficiently large bore, it has been customary to make casts of the interior surface which can be conveniently studied after withdrawal from the barrel. The cast necessarily can not reproduce all the characteristics of the surface of the bore which it is desired to examine. For the .30-caliber rifle, it is difficult to make a cast and it has been the usual procedure to split the barrel. When a rifle barrel is split for examination, no further firings can be made with that particular barrel. To provide a method without these objections, the camera to be described was designed. It permits the interior surface of the barrel to be photographed on a strip of motion-picture film. If a permanent record is not desired, any portion of the interior can be examined by a microscope which forms a part of the camera. All this can be done easily and without the mutilation of the barrel.

The method of operation of the camera will be made clear from Figure 3, which shows the details of the optical system. The tube *P*, shown in broken lengths, is a brass tube which slides easily into the rifle barrel. It is somewhat longer than the barrel to be photographed. In this tube, there are three lenses placed as shown in the diagram. The three lenses form a periscopic system similar in principle to that used on a submarine. At the front end of the periscope tube, there is a right-angle reflecting prism. If it were not for this prism, the line of vision of the periscope would be along the axis of the bore, but the prism reflects the light and turns the line of sight at right angles. Consequently, the periscope views the portion of the interior surface of the bore which is directly under the prism.

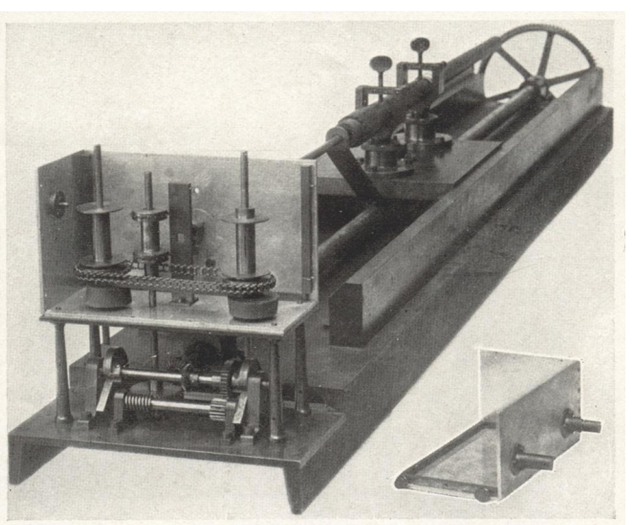

Figure 1. View of Complete Camera

The periscope is of unit magnification and forms an erect image of natural size on the motion-picture film at *F*. The prism at the front end of the periscope is so close to the surface of the bore that, necessarily, only a small portion can be photographed at a time. If the periscope tube is held stationary, and the barrel moved along over it, different parts of the interior surface will come into the field of view of the periscope. This will cause the image on the film to move and, if the film were stationary, the image would be blurred. But, if the rollers carrying the film are turned at such a rate that the film moves at the same speed as the gun barrel, the image and the film will move together and there will be no blurring. An electric lamp small enough to enter the bore is shown at *L*. It supplies the illumination by which the photograph is taken.

The complete camera is shown in the first illustration. The rifle barrel slides on ways as shown, and is moved by a lead screw similar to that on a lathe. The two spools on which the film is wound are clearly shown at the end nearer the observer. The spools are provided with spring take-up devices to hold the film taut, and the film is actually moved by the toothed roller which can be seen between the two gears. This toothed roller and the lead screw are connected by gearing so that film and barrel move along at the same rate. The use of the toothed roller is necessary as, if the gearing were connected with one of the rollers, the film would not move uniformly and its rate would depend upon the amount of film wound on the roller.

The second illustration gives reproductions of photographs taken with the camera. The barrel photographed was a badly eroded machine-gun barrel. The approximate dimensions of the area shown in each photograph are 3-16 x 1 inch. In making the reproductions, the photographs have been magnified. The width of each exposure corresponds to approximately one-sixth of the circumference of the bore. The first exposure is taken near the breech, the second midway along the length of the barrel, and the third at the muzzle end. The lands and grooves can be distinguished clearly, somewhat inclined to the horizontal because of the twist. In the first exposure, the lands are almost worn away and the bore is filled with small cracks resembling those

in crazed china. The photographs taken farther from the breech show the lands more distinctly and a great deal of erosion in the bottom of the grooves.

To make a visual examination of the barrel, the motion-picture film is removed. A microscope is placed in the prolongation of the axis of the periscope to examine the image of the surface of the bore, which normally falls on the film. The image formed by the periscope is not magnified, but with the microscope any desired magnification can be introduced. A magnification of from twenty to forty diameters is found to work satisfactorily. In some respects, the visual examination is more satisfactory than the photographic method. The photographic reproduction is in black and white and this necessarily reduces the contrast. With the microscope, one clearly sees the small cracks which are very dark, the higher parts of the surface which are polished, and the bright fragments which have been stripped from the jacket of the bullet. At times, near the breech, one sees places where a relatively large piece of metal has been torn bodily from the barrel. It is most interesting to study the manner in which the erosion changes as one proceeds from the breech to the muzzle.

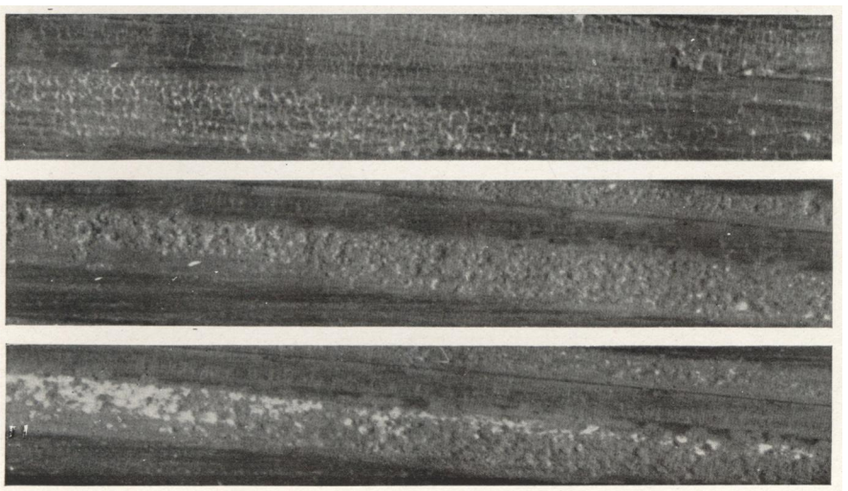

Figure 2. Photographs Made with Gun-barrel Camera

These photographs show the interior of the bore of a badly eroded 0.30-caliber machine-gun barrel. The actual dimensions of the area shown in each photograph are 3/16 x1 inch. *Upper*: exposure made near the breech. *Middle*: exposure made near middle of barrel. *Lower*: exposure made near muzzle of barrel.

The camera described is the first one which has been built. It represents a well-developed model but is not to be considered as representing the final form if additional instruments were to be built. The present camera photographs only one-sixth of the circumference at a time. If a second camera were to be constructed, the barrel would be rotated as it moves along the periscope. With this change, the entire surface of the barrel would pass before the periscope in a single excursion from the breech to the muzzle and, with appropriate motion of the film, a single photograph would show the complete interior of the bore.

This camera operates only on the service rifle or machine-gun barrel. A similar camera can, of course, be applied to large guns as well. As a matter of fact, the problem is less difficult for a one-pounder or fieldpiece than for the smaller barrel. It is at once apparent that very careful design was necessary in order to make all parts of the periscope and the source of illumination small enough to enter a bore only .30 inches in diameter. With the advantages of this relatively simple method of examining the bore, it is to be expected that important new information regarding erosions will be acquired.

Other Uses of Periscopes

The development of this camera represents one of the many interesting applications of the periscope principle. The war has made everyone familiar with the periscope as developed for use on the submarine, but it is not generally understood that this type of optical system has had many other interesting applications for civil as well as military purposes. The surgeon has long been familiar with the use of the periscope for examining the throat or other body cavities.

Frequently, large castings such as steam turbine housings have extensive interior surfaces which must be machined. It is now the custom to examine these carefully with a periscope before any work is done on them. Before this was the case, a great deal of time and money might be expended upon a piece only to discover that it was all wasted because of the existence of a blowhole in a critical position.

The use of periscopes has been proposed to permit the engineer to read the water-gage on a tall water-tube boiler from the furnace floor. In fact, this last illustration is but one of many in which a man's efficiency and convenience may be increased by a periscope which enables him to see a remote mechanism without changing his position. Another similar application has been proposed to enable the motorman on a street car to have a complete view of the rear platform.

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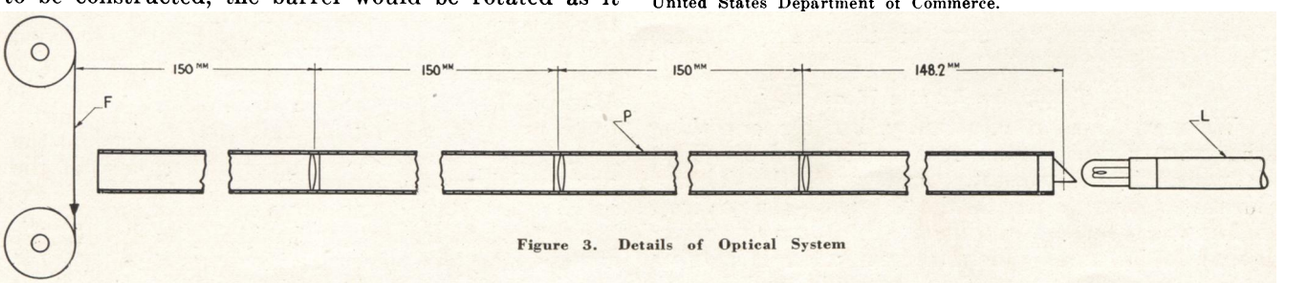

Figure 3. Details of Optical System