

PRIMERS AND FUZES FOR CANNON.*

By Major ORMOND M. LISSAK, Ordnance Department, Instructor of Ordnance and Gunnery, U. S. M. A.

PRIMERS are the means employed to ignite the powder charges in guns.

They may be divided, according to the method by which ignition is produced, into three classes:

Friction primers.

Electric primers.

Percussion primers.

Combination primers are those so constructed that they may be fired by any two of the above methods. Primers that close the vent against the escape of the powder gases are called obturating primers.

All primers should be simple in construction, safe in handling, certain in action and not liable to deterioration in store. Electric primers in addition should be uniform as to the electric current required for firing.

The primer known as the *common friction primer*, formerly used in all cannon, is shown in Fig. 1.

The body *b* and the branch *d* are copper tubes. The tube *b* is filled with rifle powder, and is closed at its lower end by a wax stopper *a*. The tube *d* is filled with the friction composition, whose ingredients are chlorate of potash, sulphide of antimony, ground glass, and sulphur, mixed with a solution of gum arabic. Imbedded in the friction composition is the serrated end of the copper wire *c*, the other end of the wire being formed into a loop for attachment of the hook of the lanyard. The outer end of the tube *d* is closed over the flattened end of the wire, which is bent over into a hook, as shown, and serves to hold the wire securely in place except when a stout pull is given to the lanyard.

Screw Friction Primer.—This primer, Fig. 2, has a brass body *i* bored as shown. A pellet of friction composition *d* is molded around the shank of the serrated wire *g* just above the serrations. A paper cylinder *e* incloses the composition to prevent disintegration. The priming charge is composed of the two cylinders of compressed powder, *b* and *c*, and the loose rifle powder.

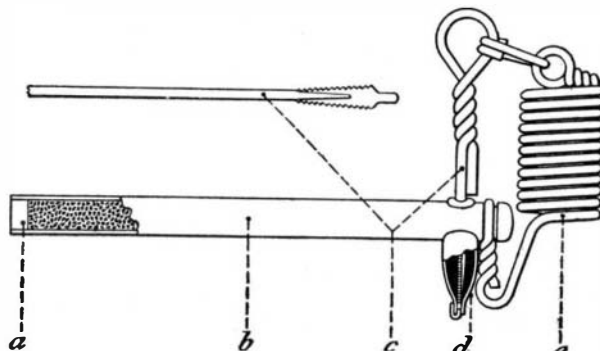


FIG. 1.

der, which facilitates ignition. The safety block *h*, soldered to the wire through the pellet, which might cause premature firing in transportation or handling. The conical brass gas check *f* is loose on the wire *g*. A brass cup *a*, shellacked in place, closes the mouth of the primer.

The primer is screwed into its seat in the gun. When, by the pull of the lanyard, the serrated wire is

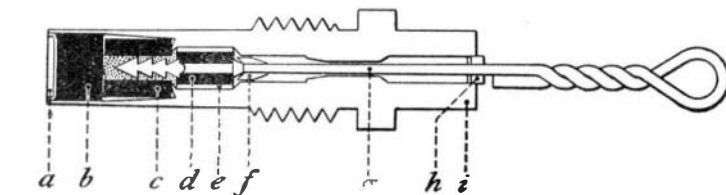


FIG. 2.

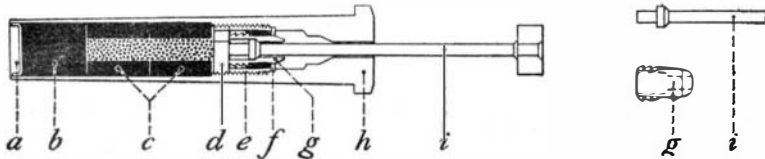


FIG. 3.

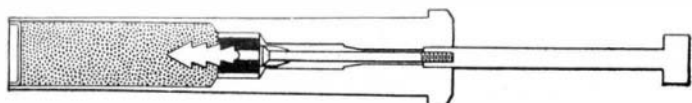


FIG. 4.

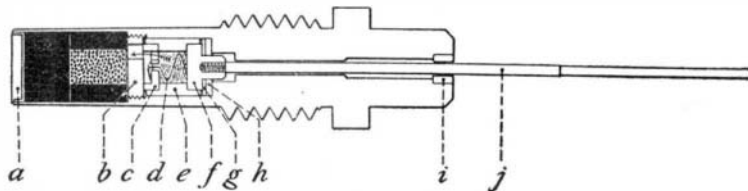


FIG. 5.

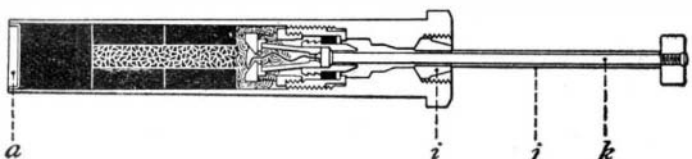


FIG. 6.

yard. The pull on the lanyard straightens out the hook, and draws the serrated wire through the friction composition, igniting it. The fire is communicated to the rifle powder in the tube *b*, and thence through the vent to the powder charge in the gun.

For use in axial vents, in order to prevent the primer being blown to the rear among the men of the gun detachment, a coiled copper wire *e* is added to the primer, one end of the wire being made fast to the top of the primer body, the other end to the loop for lanyard hook. The coil is extended by the pull of the lanyard, and the primer when blown to the rear remains attached to the lanyard.

Obturating Primers.—The primer above described is

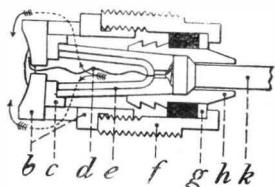


FIG. 7.

blown out of the gun by the explosion of the powder charge, leaving the vent open for the escape of gas. The disadvantage is overcome in modern practice by the use of obturating primers. The breech mechanisms of all guns now made are adapted to obturating primers, and the primer just described is no longer used in service cannon.

* Prepared for the cadets of the United States Military Academy and published in the Journal of the United States Artillery.

pulled quickly through the pellet of friction composition, ignition occurs. The gas check *f* comes to a bearing in the coned seat in rear and prevents the escape of gas through the body of the primer. The primer fits closely in its seat in the gun, and at discharge the thin walls of its mouth are expanded against the walls of the primer seat, preventing the escape of gas around the body of the primer.

This primer was formerly in use in all siege and seacoast cannon. It has been superseded in seacoast cannon by the combination primer described later, but its use will be continued in the 3.6-inch and 7-inch mortars.

To assist in increasing the rapidity of fire of all

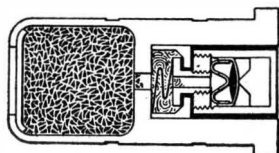


FIG. 12.

guns a primer that can be more readily inserted in the gun is required. The desired object has been attained by the addition of firing mechanisms to the breech mechanisms of most guns, the firing mechanisms being so designed as to permit the use of a smooth-sided primer that can be readily pushed into its seat. The head of the primer is firmly held by the firing mechanism, so that the primer cannot be blown out on the discharge of the piece. The firing wire is engaged and

pulled by a slotted lever actuated by the pull on the lanyard.

Friction Primer, Latest Pattern.—The primer, Fig. 3, has a body *h* of brass. The brass firing wire *i* passes loosely through the hole in the serrated cylinder *g*, the end of the wire being flush with the end of the cylinder when the nut on the wire bears against the interior shoulder of the cylinder. The friction composition, pressed into the brass case *e*, surrounds the cylinder *g* above the serrations. The vulcanite washer *f* holds the friction composition in place and prevents it from crumbling when the pull is applied. The nut *d*, screwed to a bearing on the case *e*, holds the assembled parts in place. Three holes through the nut permit the passage of the flame from the friction composition to the priming charge of powder.

When the wire *i* is pulled, ignition of the friction composition is effected. The conical end of the cylinder *g* is pulled to its seat in the body of the primer, and prevents escape of gas to the rear. Should the primer for any reason fail to fire, the wire *i* is now free to move forward without carrying the cylinder *g* and the friction composition with it, and therefore without danger of firing the primer in its reverse movement. In earlier models the teeth were formed on the wire, and it was found that when a primer had failed to fire it might be fired by an accidental reverse movement of the wire forcing the teeth quickly through the composition.

All metal parts of this primer are tinned to prevent corrosion.

Fig. 4 shows the more cheaply constructed drill primer of this form.

Electric Primers.—The electric screw primer, Fig. 5, is used in the 3.6-inch and 7-inch mortars, these guns being adapted for screw primers only. The single copper wire *j*, insulated with silk except at its outer end, passes through the vulcanite bushing *i* and the body of the primer to the brass obturating plug *f* into

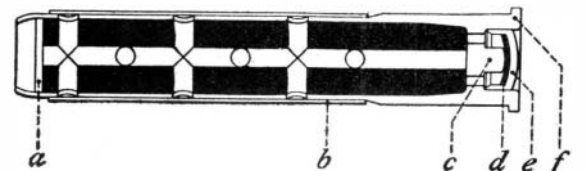


FIG. 8.

which it is screwed. The plug is insulated from the primer body by the vulcanite washer *h*, the leather washer *g*, and the vulcanite cylinder *e*. The platinum wire bridge *d*, 0.002 of an inch in diameter, is soldered to the plug *f* and to the brass washer *c*. The latter is put in electrical connection with the walls of the primer by the brass closing screw *b*. A small quantity of guncotton surrounds the platinum wire.

When the primer is inserted in the gun the base end of the wire *j* is grasped by the parts of an electric

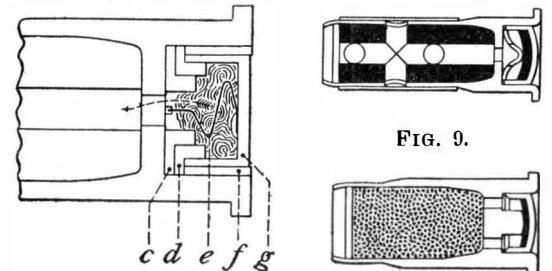


FIG. 9.

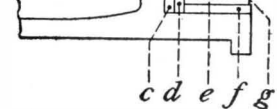


FIG. 10.

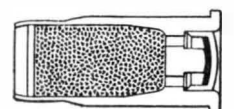


FIG. 11.

contact piece through which is passed in firing an electric current insulated from the gun. The current passes through the wire *j*, the platinum bridge and the body of the primer to the walls of the gun, and thence to the ground.

The passage of the electric current heats the platinum wire, igniting the guncotton and the priming charge of powder.

Another electric primer for use in a different breech mechanism is described after the 110-grain percussion primer.

Combination Electric and Friction Primer.—This primer is used in all seacoast cannon except those fitted for percussion firing.

The primer is shown complete in Fig. 6. The igniting elements enlarged are shown in Fig. 7. The parts of the friction elements of this primer are similar in construction and action to the parts of the friction primer shown in Fig. 3.

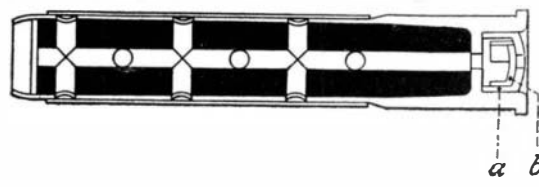


FIG. 13.

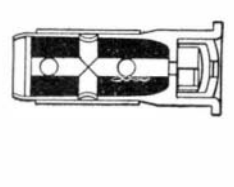


FIG. 14.

For electric firing the wire *k* is covered with an insulating paper cylinder *j* and enters the primer body through a vulcanite plug *i*. The wire is in electric contact with the serrated cylinder *h*, Fig. 7, but this is insulated from the primer body by the vulcanite washer *g* and the pellet of friction composition, a non-conductor of electricity.

The electrical elements of the primer are assembled in the metal case *f*. The head of the forked metal

support *e* is in contact with the headed end of the wire *k*, but not fastened to it. The forked end of the support is held in the vulcanite cup *c*. The brass contact nut *b*, screwed into the end of the case *f*, presses the assembled parts into intimate electrical contact. A platinum wire *d* is soldered to the head of the support *e* and to the contact nut *b*. An igniting charge of guncotton surrounds the wire.

The electric current enters the primer by means of the button on the outer end of the wire *k*, and passes through the primer and gun as described for the previous primer.

It will be observed that the friction elements of the combination primer are independent of the electrical elements, and that when one of these primers fails to fire by electricity it may still be fired by friction.

If, however, the primer fails in an attempt to fire it by friction, it will not generally be possible to fire it electrically since the cylinder *h*, which has been pulled into the head of the primer, is out of contact with the part *c* and the platinum wire bridge. The current will then pass directly from *h* through the primer body and gun to the ground.

The primer should in this case be at once removed from the vent, and not be again used.

The outer button and wire *k* may be turned without danger of breaking the platinum wire bridge *d*.

When an electric or friction primer fails to fire, it should be removed from the vent, and the wire bent down and around the primer to prevent attempts to use it again.

Percussion Primers.—The friction and electric primers described are used in guns in which the projectiles and powder charges are loaded separately, the primer being separately inserted in the breech block. Percussion primers, and the electric primer described with them, are, on the other hand, inserted in cartridge cases, in which are usually assembled both the projectile and the powder charge.

The essential parts of a simple percussion primer such as the cap in a small arm cartridge, are the primer cup, the anvil, and the percussion composition.

Formerly the percussion composition of all service primers contained a large percentage of fulminate of mercury. On account of the danger involved in handling mixtures containing the fulminate of mercury, its use as a primer ingredient in service primers manufactured at the Frankford Arsenal has been abandoned, and a mixture known as the H-48 composition is now employed.

This mixture contains the same ingredients as the friction composition, but in different proportions, as follows:

Chlorate of potash, 49.6
Sulphide of antimony, 25.1.
Ground glass, 16.6.
Sulphur, 8.7.

To insure the practically instantaneous ignition of smokeless powder charges, the addition of a small charge of quick-burning black powder is required. This may be inserted in the base of the smokeless powder charge, or may be contained in the primer. It is desirable, on account of the smoke produced by black powder, and the fouling of the bore, that the quantity of black powder used be limited to the smallest amount that will produce prompt and complete ignition of the smokeless powder. The minimum amounts required for different charges have been determined and, for fixed ammunition, are contained in the percussion and igniting primers. These primers are inserted in the head of the cartridge case, in the position occupied by the primer in the small arm cartridge.

Two sizes of percussion primers, the 110-grain and the 20-grain, have been adopted for all guns from the 1-pounder to the 6-inch Armstrong inclusive.

110-Grain Percussion Primer.—The body *f* is of brass, 2.63 inches long. A pocket is formed in the head of the case for the reception of the metal cup *e* containing the percussion composition *d*. Projecting up from the bottom of the pocket is the anvil *c* against which the percussion composition is fired. Two vents are drilled through the bottom of the pocket. The priming charge consists of 110 grains of black powder inserted under high pressure into the primer body around a central wire. The withdrawal of the wire after the compression of the powder leaves a longitudinal hole the full length of the primer. Six radial holes are drilled through the walls of the primer and through the compressed powder. The compression of the powder increases the time of burning of the priming charge and causes the primer to burn with a torch-like rather than an explosive effect, making the ignition of the smokeless powder charge more complete. The holes through the priming charge increase the surface of combustion and the mass of flame, and direct the flames to different parts of the charge of powder, thus facilitating its complete ignition. The paper wad *a*, shellacked in the mouth of the primer, and the tin-foil covering *b*, serve to keep out moisture and to protect the primer from the impact of the powder grains when transported assembled in cartridge cases.

This primer is used in cartridge cases for guns from the 6-pounder to the 6-inch Armstrong gun inclusive.

The 20-Grain Percussion Primer. shown in Fig. 9, length 1.1 inches, is used in cartridge cases for 1-pounder sub-caliber tubes, 1-pounder machine guns, and 1.65-inch Hotchkiss guns.

110-Grain Electric Primer.—This primer, Fig. 10, is similar in form to the 110-grain percussion primer just described, and has the same priming charge similarly arranged. Ignition is produced electrically through the brass cup *g* to which one end of the platinum wire *e* is soldered. The cup is insulated from the body of

the primer by the cylinder *f* and bushing *d*, both of vulcanite. The brass contact bushing *c*, to which the other end of the platinum wire is soldered, completes the electrical connection.

20-Grain Saluting Primer.—This primer, Fig. 11, costing less to manufacture than the 110-grain primer, is to be used in place of the latter with blank charges only. The primer contains a charge of 20 grains of loose rifle powder. As black powder only is used in blank charges, a smaller igniting charge answers.

The percussion primers and the electrical primer of the same form are so manufactured as to have a driving fit in their seats in the cartridge cases to which they are adapted, the diameter of the primer being from one and a half to two thousandths of an inch greater than the diameter of the seat. Special presses for the insertion of the primers are provided. The primer must not be hammered into the cartridge case. The primer seats in all cartridge cases using these primers are rough bored to a diameter about 20 per cent less than the finished size, and then mandreled to finished dimensions with a steel taper plug, to toughen the metal of the cartridge case around the primer seat. The toughening is necessary to prevent expansion of the primer seats under pressure of the powder gases, and consequent loose fitting of the primers in subsequent firings.

Combination Electric and Percussion Primer.—In Fig. 12 is shown a combination electric and percussion primer used in rapid-fire guns in the United States navy. Its construction can be readily understood from the figure. The insulation is shown by the heavy black lines. When fired by percussion the percussion cap is not directly struck by the firing pin, but by the point of a plunger forced inward by the blow.

Igniting Primers.—The igniting primers are for use in cartridge cases for sub-caliber tubes for sea-coast cannon not provided with percussion firing mechanism. They contain no means of ignition within themselves, but require for their ignition an auxiliary friction or electric primer which is inserted in the vent of the piece in the same manner as for service firing. The flame passes from the service primer through the vent in the breech block to the igniting primer in the head of the cartridge case. The flame from the service primer would not be sufficient to ignite properly the smokeless powder charge in the cartridge case, and, therefore, the igniting primer is added.

The 110-grain and the 20-grain igniting primers, Figs. 13 and 14, differ from the corresponding percussion primers in the substitution of the obturating cup *a* and obturating valve *b*, both of brass, for the percussion cup and anvil. The obturating cup *a* is provided with a central vent to allow passage for the flame from the auxiliary primer. The obturating valve *b* is cup-shaped, and has three sections of metal cut away from its top and sides to allow passage of the flame. The valve *b* has a sliding fit in the cup *a*, and when the pressure is greater in front of the valve than behind it, the valve is forced to the rear and the solid top of the valve closes the vent in the outer cup.

The valve is shown in section in Fig. 13, in the position it assumes after firing; and in elevation in Fig. 14, in its position before firing.

(To be continued.)

ANCIENT ECLIPSES.*

By P. H. COWELL.

THE results of recent discussion of ancient eclipses may for convenience be divided into three sections. The conclusion of each section depends upon the truth of the conclusions of the preceding sections, but not *vice versa*, that is to say, the results of the last section may be rejected without in the least impairing the validity of the earlier conclusions. The results are as follows:

(1) If an astronomer had been asked a year ago by a historian or a chronologist whether the tables of the sun and moon accurately accounted for the recorded phenomena of ancient eclipses, he could only have replied that the tables failed altogether to account for the solar eclipses; that they had been empirically altered so as to account for the observed times of certain lunar eclipses; and that the question whether the tables so altered accounted for the magnitudes of the same lunar eclipses had not even been examined. There seemed to be no possible modification of the tables that would bring them into harmony with the recorded solar eclipses, and it was therefore the received opinion that the historical accounts of these were untrustworthy. The first result is that two slight modifications of the existing tables will cause them to satisfy the records.

The modifications in question may be stated as follows: Define the nodical month as the mean period between one passage of the moon from south to north of the ecliptic and the next passage, and define the nodical year as the mean period between one passage of the sun from south to north of the plane of the moon's orbit and the next passage, purely periodic variations being left out of account. Then the eclipses show that the rate of change of length of both the nodical month and nodical year as given in the tables must be altered.

(2) The second section of the results is concerned with the question, "In order to alter the rate of variation of the nodical year, are we to alter the acceleration of the node or of the sun?" Now the motion of the node depends upon theory, and the same theory which accounts for its motion at the present time will

suffice to calculate its motion at any time during the last few centuries. The motion of the sun, however, is purely a question of observation. Unknown causes may easily be conceived as altering its motion. The second result is therefore to ascribe an acceleration to the sun's motion to account for the variation in the nodical year inferred from ancient eclipses, or in other words, we may leave out the word "nodical" in our statement and say, "The ancient eclipses indicate certain definite rates of change in the lengths of the month and year."

(3) We lastly require some physical explanation of the sun's acceleration. Here there are many possibilities. The ether may offer a sensible resistance to the passage of the earth; or an electro-magnetic theory of gravitation may compel us to take account of the small, but not infinitesimal, ratio between the velocity of a planet in its orbit and the velocity of light; or again, electrical theories of matter somewhat modify the old conception of mass, and with it the fundamental equations of motion on which planetary theory rests. But the explanation tentatively put forward at the April meeting of the Royal Astronomical Society is as follows: Let us suppose the acceleration of the sun to be due to a change in the length of the day caused by tidal friction. The tides check the rotation of the earth, lengthen the day, and therefore apparently increase all diurnal movements by the same fraction of their whole amounts. Introducing numbers for greater definiteness, let us suppose that in a century the day increases in length by a two-hundredth part of a second of time. Then in a century the sun's apparent rate of motion will increase by one part in seventeen million, which is exactly the change indicated by the eclipses. If, however, the moon's apparent rate of motion also increased by one part in seventeen million the acceleration would be ten times larger than that indicated by the eclipses.

But if the tides are checking the diurnal rotation of the earth, it follows from the principle of conservation of angular momentum that the moon must be receding from the earth, and absorbing the spin lost by the earth. This implies that the moon is really moving more slowly. It is impossible to make accurate calculations, for the action of the tides on an earth with oceans and continents of irregular shape cannot be computed, and it is impossible to say how the tidal action varies for different positions of the moon in its elliptic orbit. Hence we cannot say how far the action of the tides is distributed between changes in the length of the month and changes in the eccentricity of the moon's orbit. But it seems a plausible hypothesis that the large eccentricity of the moon's orbit was evolved somehow, presumably by tides, and that the eccentricity is therefore increasing, and calculation shows that if the rate of increase assigned to the eccentricity be about one-hundredth of a second of arc a century, the consequent change in the absolute angular velocity of the moon is such as to cancel nine-tenths of the apparent decrease in the length of the month, leaving the remaining one-tenth in agreement with the change inferred from ancient eclipses. This explanation, it should be clearly understood, only shows that certain correlated quantities are of the right order of magnitude: it is unable to prove or disprove an exact numerical relation.

In the remaining part of this article the basis of the conclusion of the first section is examined. That is the foundation, which must be rendered secure before interest can attach to any superstructure.

Let us select a definite eclipse, for instance, the eclipse of Thucydides in the first year of the Peloponnesian war. The record states that stars appeared. It is certain on the other hand that the eclipse, at the most, could only have been annular. There is therefore a strong presumption that Athens was not far from the central line of the eclipse, or in other words, at the time of conjunction in longitude as seen from Athens, the difference of apparent latitudes must have been small. The hypothesis that Athens was the place of observation has been objected to. This, however, is the natural interpretation of the passage in Thucydides; let us adopt it for the present and see where it leads. For Athens, therefore, let the difference of apparent latitude for the instant of apparent conjunction in longitude be computed from the present tables. The result is so large as absolutely to negative the possibility that stars could have been seen. Reserving the hypothesis that the record is untrustworthy as a last refuge in case of trouble, let us suppose for the present that the tables require alteration.

What kind of alteration is permissible? It has been argued in *Ast. Nach.*, No. 3682, on physical grounds, that only one unknown quantity may be introduced. Now against physical reasoning of this kind, strong objections may be urged. It proceeds necessarily on the assumption that the general nature of the problem of the apparent motions of the sun and moon is fully understood. It absolutely limits the investigation to the numerical determination of quantities connected with a preconceived theory, and it prevents, at the outset, the attainment of results of a new character. Now as the preconceived theory was entirely based upon two centuries of observation, there is no improbability in our knowledge being widened, when the period of observation is largely increased. In the whole of astronomy there is not a single case of a theoretical value of a secular term, that is to say, a term proportional to the square of the time, being confirmed by observation. This is because the series of modern observations is not yet long enough. Is it not possible that one or two centuries hence the ob-

* Nature.