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INCENDIARY, TRACER AND EXPLOSIVE BULLETS.

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The ingenuity of civilized man has been as actively employed in the manufacture of complex small arms projectiles as of larger shells and bombs but while in previous wars the use of incendiary, tracer and explosive bullets fired from rifles and machine guns was only on a very limited and experimental scale, in the present war, as the result of increase in mechanization and aerial conflict, they are employed more extensively. An explosive or shell bullet has been described as a hollow bullet, charged with explosive or incendiary material, to act on a small scale in the same manner as large shells, and it is designed by its composite character, slender casing and explosive charge to break up on impact in the tissues or elsewhere. As surgeons we are not concerned with its effect on petrol tanks, intricate machinery, armour plating or ammunition deposits, but it is necessary to familiarize ourselves with the structure, component parts and effects of such projectiles in order to fully appreciate the nature of the wounds they produce.

HISTORICAL.

In 1822 the first shell bullets were invented by a Captain Norton. They were of two types, one containing fulminating powder and the other gunpowder. The bullets were elongated, rounded at both ends and had lateral
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projections to fit the grooves of the rifle. They had a central cavity, one-third of the width of the bullet, extending from the nose almost to the base. As they were designed for use with the old muzzle loaders of their day, they required, as can be imagined, considerable care and time to insert them thus reducing their effect. Their tactical value was never determined.

After the introduction of the breech loading rifle in 1858, about 1862 the Metford shell bullet was designed and adopted for the Enfield rifle. It still possessed the blunt nose of its predecessors and contained fulminating powder in a cavity, closed at the apex by a wax plug and at the base by a wooden plug; during the passage of the projectile through the muzzle the basal plug compressed the powder and wax and the subsequent impact of the bullet on even a sheet of paper sufficed to detonate it. The bullet was 1.06 inch in length and 0.55 inch in diameter and weighed 582 grains filled, of which 57 grains was detonating powder. Similar incendiary and explosive bullets, some of which possessed percussion caps, were invented and adopted at that time by the armies of Austria, Bavaria, Prussia, Russia and Switzerland.

In the Great War of 1914-18 the Germans designed an explosive small arms bullet of a much more complex structure. It was not employed to any extent and its disruptive effect on the tissues is not recorded. At the present time the Germans employ a variety of explosive incendiary bullets, incendiary bullets and tracer bullets in addition to solid core machine-gun bullets. These incendiary and tracer bullets tend to fragment readily against obstacles either before reaching the tissues or in the tissues themselves. Some of the bullets contain phosphorus and produce burning of the tissues.

Fig. 1 shows (a) the construction of the ordinary solid core armour-piercing Mauser 7.92 mm. rifle and machine-gun bullet for comparison with (b) an explosive incendiary bullet of the same calibre, containing both incendiary and explosive compound but lacking an armour-piercing nose cap. Fig. 2 shows (c) an incendiary bullet containing phosphorus, also Mauser 7.92 mm.; it possesses a steel armour-piercing nose cap with elongated and narrowing tail; and (d) a tracer bullet with short steel armour-piercing nose cap and a small copper cartridge case, almost identical in size and appearance with that of a 0.22 bullet set at the tail behind the nose cap and containing the tracer compound. All four bullets shown in figs. 1 and 2 have a gilded steel casing and lead lining, the gilding being of a copper-zinc alloy. The explosive incendiaries are copper coloured at the tip, the remainder being oxidized black; the tracers have a black oxidized tip and the remainder is copper coloured; the phosphorus incendiaries and the solid core bullets are copper coloured throughout. The tracers may be recognized in flight by the bright light they emit in the early stages and the incendiaries may ignite on impact with floors, walls and other obstacles. It is usual for these projectiles to be loaded in series and the proportion of different types is a matter of tactics.
Fig. 1.—(a) German solid core bullet and (b) German explosive incendiary bullet, 7.92 mm. Mauser, 1941. Reproduced by the permission of "Game and Gun."

Fig. 2.—(c) German armour-piercing incendiary bullet and (d) armour-piercing tracer bullet. Reproduced by the permission of "Game and Gun."
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Case Reports.

Four men were admitted to hospital at 10.30 hours on June 13, 1941, having sustained gunshot wounds, the result of enemy action, less than one hour before. One was injured by a solid core machine-gun bullet, two by portions of tracer bullets and one by an incendiary bullet. They gave the history that an enemy aircraft, presumed to be a Junkers 88, emerged without warning from cloud and machine-gunned their Nissen hutted camp, from a height of just over 100 feet. The flash from the machine gun was described by the men as rather brighter than usual (tracer bullets), and they stated that in some cases the bullets, after penetrating a roof or door, exploded on striking the floor; two of the men thought it was probable that they had been wounded by parts of the same bullet, and this was in keeping with clinical findings, one having been injured by the armour-piercing nose cap of a tracer and the other by a tracer-compound cartridge case. In three cases of wounding by incendiary and tracer bullets the projectiles had perforated the roof of the hut before penetrating the tissues.


Injury.—G.S.W. left leg. Compound fracture of tibia and fibula, lower third, with marked comminution of bone and disruption of soft tissues.

 Projectile.—Armour-piercing nose cap of phosphorus incendiary bullet.

Examination.—There was a wound of entrance in the calf of the leg posteriorly, approximately 1 inch in diameter, and what appeared to be a wound of exit approximately 2 inches in diameter on the antero-medial aspect of the lower third of the leg. There were the usual signs of a comminuted fracture, though little evidence of shortening. When the primary shell dressing was removed, the lower wound emitted a cloud of grey smoke which had no characteristic odour. The left foot was colder than the right.

Operation.—11.00 hours same day. Anaesthetic N₂O-O₂-ether. Excision of skin edges, opening of the track of the bullet and irrigation with weak dettol, followed by saline; despite prolonged irrigation the lower wound continued to emit puffs of smoke, in the manner of a cigarette smoker, each time its lips were opened. This continued for almost fifteen minutes. The bullet was not located; moreover the resemblance of the lower wound to a typical exit wound suggested a perforating wound without retained missile. Sulphonamide powder and a vaseline gauze dressing were applied, the alignment of the limb corrected and plaster of Paris applied, with a window for inspection over the lower wound.

Progress.—When examined next day, the wound smoked slightly. Sulphonamide was given orally and antitetanic serum injected. The wound became septic and there was a profuse offensive discharge. When the patient was able to travel, X-ray examination (fig. 3) showed the retained armour-piercing nose cap of an incendiary bullet.

Plaster was reapplied on five occasions at three-weekly intervals. The discharge decreased and, in five months, the fracture was partly united and the patient walking in plaster. After six months, union was firm, and after seven months the bullet was removed.


Injury.—G.S.W. right shoulder.

 Projectile.—Armour-piercing nose cap of tracer bullet.

Examination.—There was a penetrating G.S.W. in the right scapular
Fig. 3 (Case 1).—Radiograph showing comminuted fracture of tibia and fibula, armour-piercing nose cap of phosphorus incendiary bullet, and scattered fragments of lead lining.

Fig. 4 (Case 2).—Radiograph showing armour-piercing nose cap of tracer bullet superficial to the scapula.
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The track was 6 inches in length, the wound of entrance being small and situated below and medial to the inferior angle of the scapula. There was only a very moderate degree of disruption of muscle.

X-ray examination (fig. 4) showed the nose cap of a tracer bullet in the right scapular region.

**Operation.**—11.45 hours same day. Anaesthetic N₂O-₃-ether. The skin edges were excised and the track partially opened up. It was found to pass superficial to the scapula, notching the medial border and passing upwards and laterally for a distance of 6 inches. A probe was passed up to the nose cap and the projectile removed through a short incision directly over it. The complete track was irrigated with weak dettol which removed some straw and other debris. Sulphonamide powder was inserted and sutures were introduced but not tied.

**Progress.**—The wound remained clean. The sutures introduced at operation were tied on the seventh day. The stitches were removed on the
seventeenth day, when the wound was almost completely healed, and the patient returned to full duty on the twentieth day.

Injury.—G.S.W. right buttock.
Projectile.—Tracer compound cartridge case.
Examination.—There was a wound of entrance in the right buttock with a track about 5 inches long, extending upwards and outside the pelvis.
X-ray examination (fig. 5) showed the compound cartridge container of the tracer bullet in the gluteal muscles.
Operation.—12.30 hours same day. Anaesthetic N₂O₃-ether. Excision of the wound of entrance and damaged muscle, cleansing of the track with weak dettol and saline. Removal of the projectile, in this case the compound cartridge container of a tracer bullet, and finally application of sulphonamide powder. There was a moderate degree of muscle disruption.
Progress.—No sepsis. Wound sutured secondarily on the eighth day. Stitches removed eighteenth day. Returned to unit on twenty-ninth day, fit for duty.

**DISCUSSION.**

In such a short series of cases as this it is not possible to express any conclusions on the effects of incendiary and tracer bullets and, when larger series are available, there is rarely time to do more than give urgent attention. From the nature of the projectiles, in these cases, there was a tendency to more severe wounding. The friability of the incendiary and tracer bullets is demonstrated in all cases. A comparison of the projectiles with the X-ray films demonstrated the possibility of radiographic diagnosis of the type of projectile.

The appearance of smoke from a wound suggests the presence of phosphorus in the tissues and the treatment recommended, though not actually employed in Case 1, is to inactivate the phosphorus with 1 per cent or 2 per cent copper-sulphate solution, to continue irrigation, and to pick out any accessible fragments. The impression gained from treating Case 1, taking into consideration the early opportunity to deal with it, and the exhibition of sulphonamide powder, was that there ensued a greater degree of sepsis than in ordinary solid-core bullet wounds. This was probably due to the destructive effect of the phosphorus on the tissues. It is possible that the steel sheath of the bullet may have perforated the limb, causing an explosive effect, as there was a wound of exit as well as entrance and only the nose cap was retained.

**SUMMARY.**

1. The nature of explosive incendiary, incendiary and tracer bullets is described briefly and their development traced from more primitive projectiles of a similar nature.
2. Three cases of wounds caused by incendiary or tracer bullets are described.
3. The projectiles are illustrated by drawings and X-rays and the injuries and treatment are described.
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REFERENCES.