Middle Articles

Death after Shipwreck

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This paper is a study of the hazards experienced by those passengers who had to enter the water when the liner *Lakonia* was abandoned at sea in December 1963 with the loss of 124 lives. The main purpose was to see whether many of the deaths were likely to have been caused by falls in body temperature during immersion, and whether people in the water acted in ways that would have increased or decreased the rate at which their temperatures fell. Recent laboratory experiments have shown that exercise accelerated and conventional clothing retarded the falls in body temperature of volunteers who were immersed for 20 minutes or more in water too cold for them to achieve thermal balance. A study of people's actions in an actual disaster was necessary to assess whether casualties would be appreciably reduced in future if this information was more widely distributed among potential victims of accidents at sea.

Sources of Information

Most of the information was obtained by sending questionaries to 23 passengers who had had to enter the water to escape from the burning ship. Eighteen of these were completed and returned, many with additional comments which the survivors had been invited to make about their experiences. In wording the questionaries care was taken to avoid indicating that any particular answer was expected. Use was also made of general accounts of their experiences which had been given, usually within seven days of the disaster, by these survivors and by 152 of the passengers who left the ship in lifeboats. Further information about the circumstances of abandoning the ship was gained from written statements made within a few weeks of the accident by members of the crew of the *Lakonia.* Questions about the condition of survivors and of casualties at the time of rescue were answered by the captain and chief steward of the *Montcalm,* which played a major part in the rescue operation, and information about the casualties was supplied by a doctor who had examined the 58 bodies landed at Gibraltar. The previous medical condition of one passenger who lost his life was described by two general practitioners who attended him. It was anticipated that second-hand or hearsay reports of a disaster of this kind would not be reliable, and this was confirmed on occasions where first-hand and hearsay reports of the same event were supplied by different individuals. Consequently only statements made by people who actually witnessed or experienced particular events have been used in this account.

Details of the number of passengers and crew and of the loss of life in each group were obtained from a statement made to Scotland Yard on behalf of the shipping company. Water and air temperatures reported by other ships in the area of the accident, and the time of dawn, were supplied by the Meteorological Office.

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Information Obtained

General Description of Accident

Fire broke out at approximately 10 p.m. on 22 December 1963, when the *Lakonia,* carrying 648 passengers and 376 crew, was north of Madeira at lat. 35°15′N, long. 15°15′W. All the lifeboats that could be launched, 18 out of 24, left the ship by 1 a.m., leaving on board a number of people estimated by survivors at 150–200. Alcoholic drinks were available to these people at the ship's bar, and one survivor reports drinking several brandies, but there seems to have been little drunkenness. Nor does there seem to have been much if any panic among these people, the majority of whom went into the water between 3 a.m. and 6 a.m. as the fire spread, leaving on board only the captain and 14 elderly passengers who were eventually able to leave the ship after dawn in a life-raft dropped by an aircraft. The time of dawn, as noticed by survivors, will have been close to the time of "civil twilight," when there is enough light to define the horizon and to obscure all but the brightest stars. This was 6.37 a.m. in the area of, and on the morning of, the accident.

Rescue ships were in the area before dawn, stopped 1–2 miles (1.6–3.2 km.) away to pick up lifeboats, and then launched boats to rescue survivors in the water. A total of 88 bodies were picked up and there were 36 people who were missing and presumed dead, giving a total death role of 124, of whom 94 were passengers and 30 were crew.

Hypothermia as a Leading Cause of Death

Only 4 of the 124 deaths can be accounted for by known accidents on board the *Lakonia,* including one crew member drowned when he became entangled in ropes and two passengers trapped in a cabin. No reports were encountered of deaths in those lifeboats which were launched successfully. A number of people were tipped into the sea when launching-tackle broke as one boat was being launched, but there seem to have been few fatal injuries on this or other occasions, since it was reported at the inquest that only 3 of the 58 bodies landed at Gibraltar showed external evidence of serious ante-mortem injury (necropsies were not performed), two having fractured skulls and one a broken neck. Many of the other bodies had bruising under the chin, and it was suggested that they might have been knocked out by their life-jackets striking them under the chin as they jumped into the water.

Questions to survivors showed that a number of people did jump into the water from a height of at least several feet. Of the 15 survivors who could answer the question whether they had seen more people jump into the water or climb down to water level five said that they saw more people climb down than jump. However, seven of the survivors had themselves jumped in, some from the deck of the ship, without sustaining injury; the other 11 had climbed down. Three survivors mentioned spontaneously that when they were swimming or floating in the water their life-jackets rode up and chafed under their chins, and it would seem that chafing of this kind could readily account for the marks noticed under the chins of the dead. This, together with the absence of any report of a broken jaw among the dead, makes it unlikely that blows under the chin from life-jackets were violent enough to cause much if any loss of life. This conclusion is supported by direct evidence, described later, of deaths occurring after some hours in the water. Three of the bodies landed at Gibraltar had been mauled by large fish, but there is no reason to disagree with the opinion expressed at the inquest that these attacks took place after death. Sixty-six bodies were either landed elsewhere than at Gibraltar or were never recovered, and, assuming that the proportion of serious injuries among them was the same as among those landed at Gibraltar, only seven deaths can be attributed to injury besides the four on board the *Lakonia,* leaving approximately 113 deaths to be accounted for in other ways.

The only indication of anyone having difficulty in keeping afloat is the statement of one survivor that he was gripped and pulled under by someone immediately after he entered the water. There were therefore probably few cases of drowning due to panic or forcible immersion ; the taking of sleeping-tablets the evening before might have contributed to incidents of this kind. Statements by survivors and rescuers agree that all survivors and dead wore life-jackets, the only exception noted being the captain, who had given his to a passenger. Three of the 18 survivors who returned the questionary reported that they were unable to swim and had floated in their life-jackets until rescued, so the life-jackets were clearly able to support non-swimmers in the existing wind and sea conditions. A strong north-east wind had been blowing the previous day but had largely died out during the evening before the fire broke out and was followed by light winds during the night and the next day. Two survivors said that there was enough swell to cause them some difficulty as they were swimming clear of the ship, but after dawn the sea was calm and the weather sunny.

The water temperature was, however, low enough for serious hypothermia to be expected to develop in many people immersed for several hours. The mean water temperature reported in the area at noon on the day before and the day after the *Lakonia* was abandoned was 17.9° C., and the mean air temperature 15.7° C. Temperatures during the night would have been rather lower, but it is unlikely that the sea temperature would have fallen below 17° C. The survivors' answers to questionaries provide strong indications that many of them did experience serious falls in body temperature. Thus 14 of the 18 survivors answering the question whether cold or fear of drowning was their main worry while they were in the water said that cold was a major worry, and eight of these said that cold was or became their main preoccupation as time went on. Three of them mentioned that they were shivering uncontrollably just before or after being taken from the water, and one of these had only a hazy recollection of the actual rescue. Two other survivors had no recollection at all of being rescued.

There are only two first-hand accounts of people who lost their lives, and both describe progressive mental confusion, helplessness, and probably unconsciousness developing after some hours in the water. In the first a survivor reports that he and an unidentified woman clung to the same deck-chair floating in the water and that after some hours in the water, after dawn, she became delirious and then apparently lost consciousness and floated away. A more detailed account is provided by the wife of a man of 59 who entered the water with him at 4.40 a.m. and swam with him to a raft which they both clung to. By dawn he was muttering incoherently and was very pale. She supported him but had to let go at intervals to adjust her own life-jacket, and 20 to 30 minutes after dawn (approximately two and a half hours after entering the water) while she was doing this, he drifted away. This man had for many years had a cough and attacks of shortness of breath and wheezing during exertion, particularly in the cold weather. Since chest *x*-ray films (1952 and 1957) and E.C.G. (1952) had been normal and he had had acute bronchitis two to three months before the accident, it is likely that he had suffered from chronic bronchitis with bronchospasm. Rescuers believed that most of the 15 dead on the *Montcalm* were alive though in a state of collapse when rescued and died either while being taken to the *Montcalm* in the ship's boats or after reaching the *Montcalm.* These facts taken together indicate strongly that immersion hypothermia was the main hazard faced by those in the water and led to most of the deaths.

Duration of Survival in the Water and Immediate Cause of Death

Most of the survivors were picked up during the morning and early afternoon after the *Lakonia* was abandoned, and though there is one record of a woman being rescued at 4.55 a.m. the next day it is unlikely that many people were left alive in the water after mid-afternoon on the day of the accident. Many deaths in fact must have occurred long before then, since there are numerous reports of large numbers of bodies being seen in the water during the morning, and one survivor gives a clear account of seeing bodies in the water at dawn (approximately 6.37 a.m.). Since most people entered the water between 4 and 6 a.m., while a few had been tipped in from lifeboats at about midnight, most deaths must have occurred within 15 hours of immersion and many within seven hours or less.

As regards the immediate cause of death, the most important evidence is the observation of a rescuer that small waves were washing over the faces of the dead in the water. Though the life-jackets supported conscious people it seems that they could not have prevented drowning once hypothermia had caused helplessness or unconsciousness.

Action Taken By Survivors in the Water

Survivors were asked whether, after getting clear of the burning ship, they had swum for the rescue ships, had floated and waited for rescue, or had swum about in an attempt to keep warm. Of the 18 who answered 10 said that they had swum. Two of these had done so in order to keep warm, and two in an attempt to reach the rescue ships, while the other six gave no reason except, in one case, a desire to get away from the area even though no rescue ships were visible. Of the eight who did not swim three were unable to swim, and one of these states that he moved about in an attempt to keep warm.

Clothing Worn in the Water by Survivors and by the Dead

Survivors who had been in the water were asked whether they had worn normal clothing on entering the water or had put on clothing or taken off a part of their clothing. Of the 18 who answered the majority, 11, had neither taken off nor put on clothing except for removing their shoes, but had entered the water in whatever they happened to be wearing on deck. Of these, one woman stated that she was wearing evening dress and the accounts given by the others show that most women wore a dress or a coat and skirt and that most men wore jacket and trousers and often a sweater, with underclothing. Five people had taken off clothing before or just after entering the water ; one of these had taken off his jacket and trousers, two had taken off a jacket only, one trousers only, while in the fifth case the clothing removed was not specified. Two people said that they had put on clothing, one woman having put on a jersey suit and raincoat in one case and an overcoat in the other. Those who wished to put on extra clothing seem to have had no difficulty in obtaining it either from their own cabins or, when these were cut off by the fire, from other people's. A report by a rescuer confirms that many of the men picked up were wearing jackets and trousers and the women dresses, while others were in underclothing only. He also reports that some were in night-clothes and others were naked.

As regards the dead, photographs of 51 of the dead landed at Gibraltar show that 12 were unclothed or were very lightly clothed, wearing night-clothes or underclothes, with sometimes a shirt or cotton dress over them. Thirty-nine wore some kind of coat, jacket, or sweater and probably shorts or trousers, though this could not always be confirmed, as some photographs showed only the upper part of the body. In some of the first group clothing may have been removed before the photographs were taken, but a rescuer in the *Montcalm* reports seeing much the same range of clothing on the dead at the time they were recovered, varying from none to full suits, the latter being more common. Many of the dead landed at Gibraltar appeared, so far as could be judged from the photographs, to be overweight.

Advice Given to Survivors

No formal advice seems to have been given about wearing clothes or about swimming versus floating in the water, though variable advice was given by other passengers. In reply to a question about this 14 out of 18 survivors said they had received no advice of any kind, two had been advised to take off heavy overclothing, one to keep moving in the water but to keep on as much clothing as possible, and another to keep on his shirt and trousers.

Ages of Those who Survived Immersion and Those who Died

Fifteen out of the 18 passengers who survived and returned questionaries gave their age. The youngest of these was 14, the oldest 65, and the mean age 47.0 years. The ages of 50 of the dead passengers were available ; the youngest of them was 10, the oldest 79, and the mean 60.8 years.

Vomiting and Cramp

No specific questions were asked about vomiting or cramp, but two survivors spontaneously mentioned being sick at the time they were taken from the water, and one of them said that most other people rescued from the water were also sick, though the sea was calm by then. A rescuer reports that most of the dead taken on board the *Montcalm* had their mouth, nose, and ears coated with vomit.

One man reported that he had cramp during his last 30 minutes in the water before rescue, but said that it did not prevent him from swimming towards, and climbing on to, the rescue boat.

Discussion

It may appear surprising at first sight to conclude that hypothermia led to the deaths of most, perhaps as many as 113, of the 124 who died, considering that the accident took place in relatively warm waters and that rescue ships were in the area within a few hours. This finding is, however, reasonably consistent with studies on wartime shipwrecks (Molnar, 1946 ; Ungley, 1948 ; McCance, Ungley, Crosfill, and Widdowson, 1956), which indicated that few people survived for more than seven hours in water at approximately 15° C.

Perhaps the most important finding of the present study is that many of the people who had to enter the water from the *Lakonia* inadvertently took action that would have accelerated the rate at which their body temperature fell. Thus, although all of the 150–200 people who entered the water seem to have had life-jackets which enabled them to float in safety, many swam aimlessly, some of them in an attempt to keep warm.

Early experiments on the effect of exertion on body temperature in the water appeared to give conflicting results, Glaser (1950) suggesting on the basis of theoretical considerations and a brief experiment that swimming should help to maintain body temperature, but Pugh and Edholm (1955) suggesting the contrary on finding that a thin man's temperature fell more rapidly when he exercised than when he kept still. In a series of experiments on 20 naval volunteers (Keatinge, 1959, 1960 ; Cannon and Keatinge, 1960) the effect of exercise was in fact found to vary with the duration of immersion and the water temperature, and to some extent with the intensity of the exertion, but, provided the water was too cold for a particular individual to achieve heat balance and the immersion lasted 20 minutes or longer, exercise almost invariably increased the rate at which the deep body temperature fell. This was true whether men were clothed or not, whether they were fat or thin, whether they were initially hot or cool, and whether the water round them was artificially stirred or was still. Such experiments can, of course, be carried out only on fit and healthy people, but these are the only group likely to be capable of prolonged exercise in any case. There seems little doubt that many of those who swam unnecessarily after leaving the *Lakonia* accelerated their falls in body temperature by doing so.

As regards the effect of clothing, experiments with a copper manikin showed that damp clothing can provide considerable thermal insulation (Hall and Polte, 1956), and the experiments on naval volunteers (Keatinge, 1960) showed that even completely immersed clothing greatly reduced the falls in body temperatures of men in the water. Most people entered the water from the *Lakonia* wearing whatever they happened to have on, and it is probably fortunate that it was night and the air cool so that most of them were reasonably warmly dressed. Even so, some took off clothing and many did not take the opportunity to put on extra clothes, which would have reduced their loss of heat in the water.

The action taken by many of those leaving the *Lakonia* shows that common sense is a bad guide on these points. Many intelligent people are in fact bound to expect exercise to help to maintain their body temperature in water knowing that it does this in air, and to regard clothing in the water simply as an encumbrance to swimming. Accurate advice on these points might save a substantial number of lives in a future accident of this kind even if it led to only moderate reductions in the rate of body-cooling in the water, since many of those who died after leaving the *Lakonia* succumbed shortly before or even after rescue. In fact, some of those who survived were fortunate to do so, as they had apparently reached a severe degree of hypothermia by the time they were rescued.

The time that people survived in the water and the apparent degree of chilling experienced by those who survived varied greatly. This was probably due largely to variations in fatness, since there is abundant evidence that people with a thick layer of subcutaneous fat lose heat less rapidly than thin people in cold water, and may even be able to maintain their body temperature indefinitely in water at 15–18° C. (Pugh and Edholm, 1955 ; Carlson, Hsieh, Fullington, and Elsner, 1958 ; Keatinge, 1960). A surprising finding is that some of those who died after the *Lakonia* sank appear to have been fat, and so might be expected to have survived. Their age may have been a factor in their failure to survive, since the average age of a sample of passengers who died was 60.8—13.8 years older than that of a sample of passengers who survived—and there is evidence that old people have less ability to increase heat-production, and perhaps to decrease heat loss, than younger people do in a cold environment (Horvath, Radcliffe, Hutt, and Spurr, 1955). Another factor may have been vomiting, which occurred in most of those who died and many of those who survived. The vomiting was presumably due to seasickness, perhaps aggravated by the swallowing of salt water. There seems to be no experimental evidence of the effect of nausea and vomiting on heat balance ; but vomiting is well known to cause vasomotor changes, and these might well increase the rate of heat loss from the body in cold water. Alcohol may, of course, be dangerous during shipwreck by impairing judgment, but the alcohol consumed by some passengers before they left the *Lakonia* is not likely to have hindered their survival in the water and may even have helped, since even in substantial amounts it does not appreciably increase the heat loss of people in cold water, though it greatly reduces their discomfort (Keatinge and Evans, 1960)..

There is probably little more that rescuers could have done to improve people's chances of survival after taking them out of the water. It is well established that the deep body temperature continues to fall for a time after people are removed from cold water and that this can cause death unless the fall is cut short by a hot bath. A number of people seem to have died after rescue on this occasion, but if a hot bath is to save life it must probably be available within 20 minutes, and this seems impracticable when rescues are carried out by ships' lifeboats. Nor does it seem likely that different life-jackets would have greatly increased the number of people saved. Though the life-jackets did not seem to prevent waves from washing over the faces of, and presumably drowning, those who had lost consciousness, no ordinary life-jacket can wholly avoid the risk of this happening if waves of any size are present, and once people have chilled to the point of unconsciousness in the open sea they must stand little chance of survival.

It may be of some comfort to those whose friends are exposed, or who are themselves liable to be exposed, to this sort of situation to know that hypothermia is probably one of the less unpleasant ways of dying. For instance, preliminary immersions before the experiments on naval volunteers, including a 26-minute immersion in water at 1.6° C., were found to be unpleasant but not intensely so ; in the main experiments (Keatinge, 1959) five naval ratings underwent 20-minute immersions in water at 5° C., which caused falls in body temperature of up to 3.6° C. in the thinnest man, with clouding either of consciousness or memory in two men and intense shivering in all of them, but all completed the planned series of five immersions each though given the chance to withdraw.

Need for Advice

The present findings imply that a substantial part of the loss of life from immersion hypothermia could be avoided if knowledge of its hazards and practical physiology was more widespread. The problems of survival after shipwreck are complex and no simple advice can be universally right, but present knowledge does make it possible to provide advice simple enough to be widely remembered yet accurate enough to help survival in a great many cases. It seems clear that potential victims of immersion should be advised first to put on warm clothing, if possible, as well as their life-jackets, and that once clear of the ship they should float still unless they can see land or a raft or rescue ship close enough to reach by swimming. It might be argued that clothing makes it more difficult for the wearer to climb on to rescue craft. However, there will normally be rescuers to assist, and in any case a lightly clothed person who is severely chilled is likely to have more difficulty than a heavily clothed person who is not. As regards exercise, it might be argued that survivors will often need to swim to keep afloat, but craft of all sizes normally have enough life-jackets, as the *Lakonia* did. Apart from the effect of exercise on body temperature, rescue on the open sea will usually be quicker and easier if survivors in the water keep together near the sinking ship, and rescuers know that they can expect to find them there, than if they spread out over a wide area, as those leaving the *Lakonia* did.

It might be argued that advice about immersion is unnecessary, since it should be possible to send everybody off sinking ships on life-craft. Whatever ought to happen under ideal conditions, only 53% of the lifeboats in British ships sunk in the 1939–45 war were ever launched (McCance *et al.*, 1956), and the proportion of boats launched by the *Lakonia* (75%) compares favourably with this. As pointed out in a recent review (Lee, 1965) replacement of lifeboats by inflatable life-crafts might increase the proportion of people evacuated dry from sinking ships, but it seems safe to assume that so long as ships sink some of the people on them will have to enter the water. In fact, a great many of the immersion accidents in peacetime involve small boats which normally carry no life-craft at all. Hypothermia is likely to play a major part in causing deaths after such accidents, since the waters around Britain, for instance, and much of northern Europe and America, are colder even in summer than those in which the *Lakonia* was abandoned (Hutchins and Scharff, 1947). The Registrar-General's Statistical Review for 1962 shows that in that one year in the waters round England and Wales alone there were 72 deaths due to submersion of the occupant of a small boat, 48 due to other water-transport injury by submersion, and also 778 cases listed simply as accidental drowning but probably including deaths caused or contributed to by hypothermia. There seems considerable scope for simple advice to reduce this loss of life.

Summary

The probable cause of the heavy loss of life when the liner *Lakonia* was abandoned near Madeira has been investigated by questioning survivors and others concerned in the incident.

Only approximately 11 of the 124 deaths could be accounted for by injury or by accidents in the *Lakonia*. All the pasengers had life-jackets, and the reports provide strong evidence that most of the other 113 deaths were caused by immersion hypothermia leading to helplessness and unconsciousness with drowning only a terminal event.

Ten out of a group of 15 people who had survived immersion and were able to swim had swum about, eight of them aimlessly or in the belief that it would keep them warm.

Most people who entered the water were wearing warm clothes, but some wore night-clothes or nothing at all. Five out of 18 had taken off outer clothing before entering the water.

In view of experimental evidence that exercise normally accelerates the rate at which the body temperature falls during cold immersions lasting 20 minutes or more, and that warm clothing greatly retards body-cooling in the water, the findings suggest that loss of life at sea could be significantly reduced by advising those at risk to put on warm clothing before entering the water and to float still unless they can see land or rescue ships close enough to be reached by swimming.

I am indebted to the survivors, to Captain E. J. Kempton and Chief Steward A. Sproxton, of the *Montcalm*, to Dr. C. Isola at Gibraltar, to two family doctors, who had attended one of the passengers who lost his life, for answering questions and volunteering much important information ; and to representatives of the Greek Line, the owners of the *Lakonia*, for providing access to documents in their possession.

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Development of Jet Injection and its Application to Intralesional Therapy in Dermatology

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Injection with needle and syringe has a number of disadvantages: it is nearly always painful and may be frightening to children; one cannot be certain of the volume of material that is actually injected; and the whole procedure takes a considerable amount of time.

It is not surprising that alternative techniques have been sought. The most suitable method which has been developed seems to be the use of high-pressure jet injectors, which throw the material to be injected with considerable force through a very fine nozzle. The emergent column of liquid or jet has a very narrow diameter, and its high velocity enables it to penetrate the skin and deeper tissues with ease. The injection is invariably pain-free, the patient experiencing only a fine "flick" sensation at the injection site.

Several instruments have been developed and used for treatment in many conditions other than purely dermatological diseases. The Hypospray (Hingson and Figge, 1952) is probably the most widely studied of such instruments. This employs single-dose Metapules containing up to 1 ml. of solution, and has been used for the administration of antibiotics (Hirsh *et al.*, 1948), immunization (Hughes *et al.*, 1949), the treatment of diabetes (Perkin *et al.*, 1950), and rheumatoid arthritis (by intra-articular injection) (Ziff *et al.*, 1956), and finally for dental anaesthesia (Margetis *et al.*, 1958).

A more recent development is the small dose Dermojet developed by Krantz (Krantz, 1960). This places a small fixed volume of approximately 0.04 ml. of solution into the skin and is used mainly for local anaesthesia. Krantz also suggested its use in intradermal local therapy as well as vaccination. The instrument is semi-automatic and can deliver up to 30 injections a minute.

The instruments mentioned above and other experimental models can deliver only a single dose, from sterile sealed ampoules, as in the Hypospray, or from a small reservoir, as in the Dermojet. A considerable advance was made with the development of multiple-dose instruments—for example, the Presso-Jet (Warren *et al.*, 1955) and the Hypospray Multi-dose Jet Injector (Towle, 1960).

These instruments were designed to deal with the problem of large-scale protection of populations exposed to smallpox and cholera during epidemics and at times of disaster, such as floods or earthquakes, when rapid techniques are urgently required. These injectors are similar in principle to the single-dose instrument, but instead of being "hand-cocked" they are loaded by hydraulic systems driven by an electric motor, and were used with considerable success in mass inoculation campaigns in America (Warren *et al.*, 1955) and East Pakistan (Towle, 1960).

A more recent development is the dental jet injector (Stephens and Kramer, 1964), which employs a reciprocating piston connected to the compressed-air source of the dental table. This instrument is more flexible than those mentioned above. Both the pressure, and hence the depth of the injection, and the volume of the injection are variable between wide limits. It appears to be very effective, particularly for dental anaesthesia.

Apart from the speed and the absence of pain, these instruments do not resemble conventional needles and syringes, and

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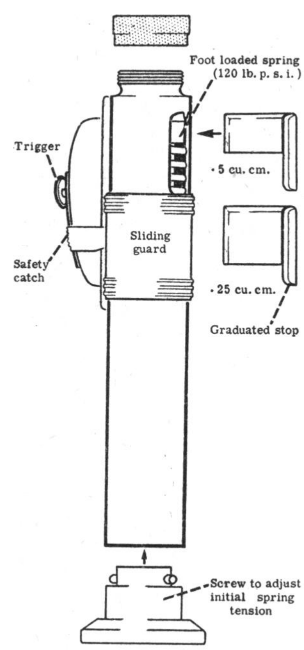

FIG. 1

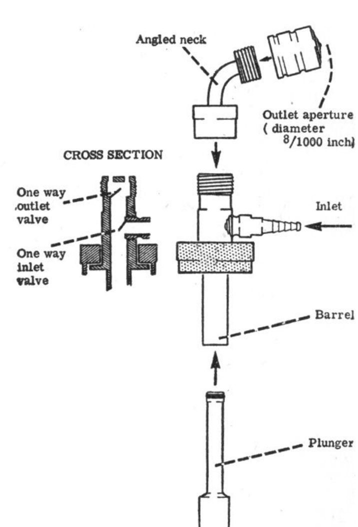

FIG. 2

FIG. 1.—The Porton Needleless Injector. The syringe (Fig. 2) when assembled is screwed into the top of the syringe handle. Dose is determined by the graduated stops which arrest the travel of the piston in the handle. Depth of injection is controlled by adjusting the initial tension on the spring with the screw. The foot-operated priming mechanism is not illustrated here. FIG. 2.—Syringe components of the Porton Needleless Injector. The plunger is screwed to the piston when the injector is assembled. The inlet valve is connected to a reservoir containing the material to be injected.