STRIPPABLE PLASTIC COATINGS FOR THE PRESERVATION OF VALUABLE EQUIPMENT

by

LIEUTENANT (E) N. W. LEVERETT, D.S.M., R.N.
Naval Ordnance Department

and

MR. S. FRITH, Commissioned Ordnance Officer,
Staff of Flag Officer, Reserve Fleet.

This article deals with the developments which led to the adoption of plastic coatings now being used in the preservation of upper-deck equipment in ships of the Reserve Fleet, details of the materials and equipment used, and a description of the process as applied to the packaging of gunnery equipment.

Experience during the Second World War showed that the major factor in the deterioration of stores and equipment which had been left unattended was the effect of the moisture vapour present in the atmosphere. Experiments have shown that if the relative humidity of the atmosphere surrounding an equipment can be kept below 30%, deterioration due to rusting and oxidation is negligible. Another factor, especially in the tropics, is the effect of mould growth.

One antidote to these ill-effects, developed during the war, was the institution of the tropical-packaging of stores, in general achieved by enclosing the stores together with a quantity of desiccant, in an impermeable envelope. The outside package usually consisted of a material resistant to fungoid attack. This process was applied commercially by a number of firms, both in the United States and in Britain.

In U.S.A. attention was turned to the packaging of larger equipments, such as aircraft, and the process was developed commercially. The moisture-vapour-proof barrier took the form of a strippable plastic film which could be applied by ordinary paint-spray apparatus. The materials were resins with ethyl-cellulose or vinyl bases in conjunction with ketone or other solvent vehicles. A similar plastic having webbing properties was developed concurrently. This plastic, together with the solvent vehicle employed and a suitable size of aperture in the spray gun nozzle, issued in long silky fibres capable of bridging gaps up to 10 in. square, forming a web-like surface. The webbing could be built up to a consistency strong enough to form a base for spray application of the exterior coating materials.

These materials had the important property of being easily stripped from any surface without the use of solvents or other agents. The problem of packaging large equipments of irregular contour was thus simplified and the process was adopted by the U.S. Army for long-term preservation of Army equipment, and by the U.S. Navy for the preservation of ships " in inactive status." The U.S. Navy Bureau of Ordnance drew up a specification for the materials, O.S.3602 and commenced a programme of preservation pending the introduction of the longer-term method of preservation by " steel-canning." A further refinement of the process has since appeared, using a heavy exterior

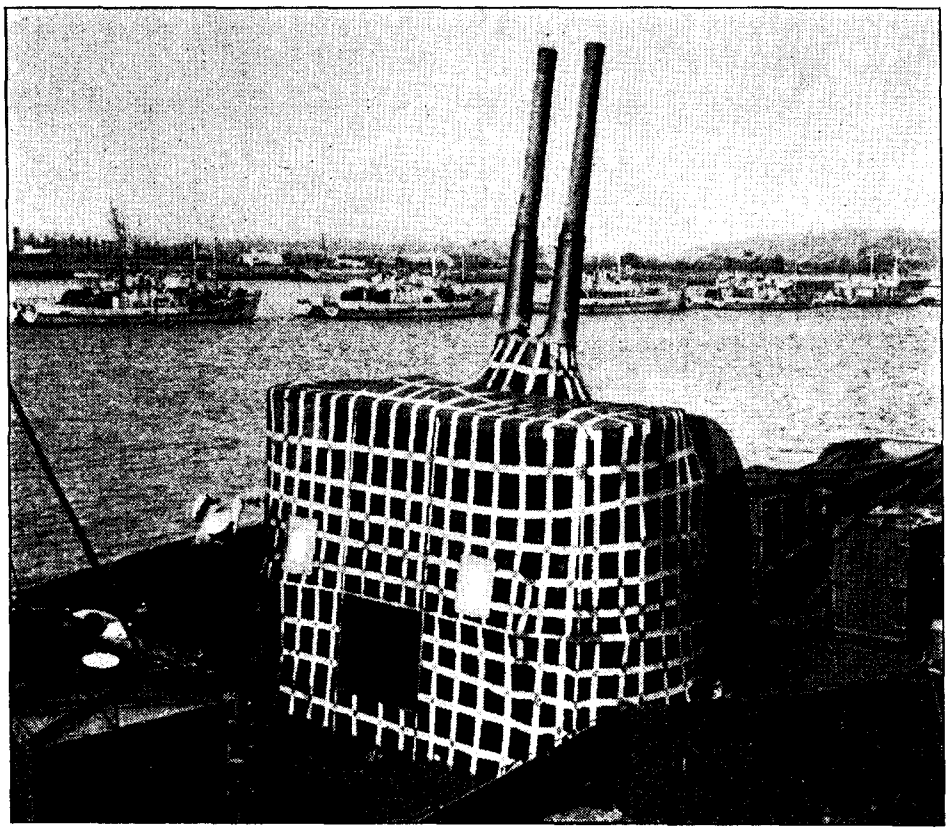

FIG. 1.—REAR OF 4 IN. TWIN MK. XIX MOUNTING SHOWING COMPLETION OF PRELIMINARY TAPING

coating of gilsonite or bitumastic to increase the durability and decrease the permeability of the envelope. A life of 5 years is claimed for this type of envelope, but has not yet been established by the U.S. authorities.

The first trial of this type of preservation in the U.K. was made by the Navy, and an aircraft, coated by a material consisting of a chlorinated polythene, Halothene, produced during the war for tropical packaging purposes by Messrs. Imperial Chemical Industries, was shipped to Singapore and back in early 1946. This test was moderately satisfactory, although it was evident that the material was insufficiently plasticised and required some modification.

Subsequently Messrs. I.C.I. were asked by the Admiralty to investigate the possibility of modifying Halothene to give a web-type coating similar to the American O.S.3602.

The firm were unable to produce a webbing agent from materials produced in this country, and have not been successful to date. Stocks of the American material, poly-vinyl butyral were, however, available in the U.K., surplus to other requirements and in sufficient quantity to cover the proposed Admiralty programme of preservation.

Full-scale trial of Halothene

A trial demonstration of Halothene and this webbing-lacquer on a mock-up at the firm's research establishment at Slough proved so satisfactory that it was decided to hold a full-scale trial. A 4.7 in. Mk. XXII gun-mounting and a range-finder director in H.M.S. *Kempenfelt* were packaged at Chatham by the Halothene process and the trial continued throughout the severe winter of 1946-47. The envelopes stood up well against the effects of high winds and rain. Although some punctures did appear, these were patched and the

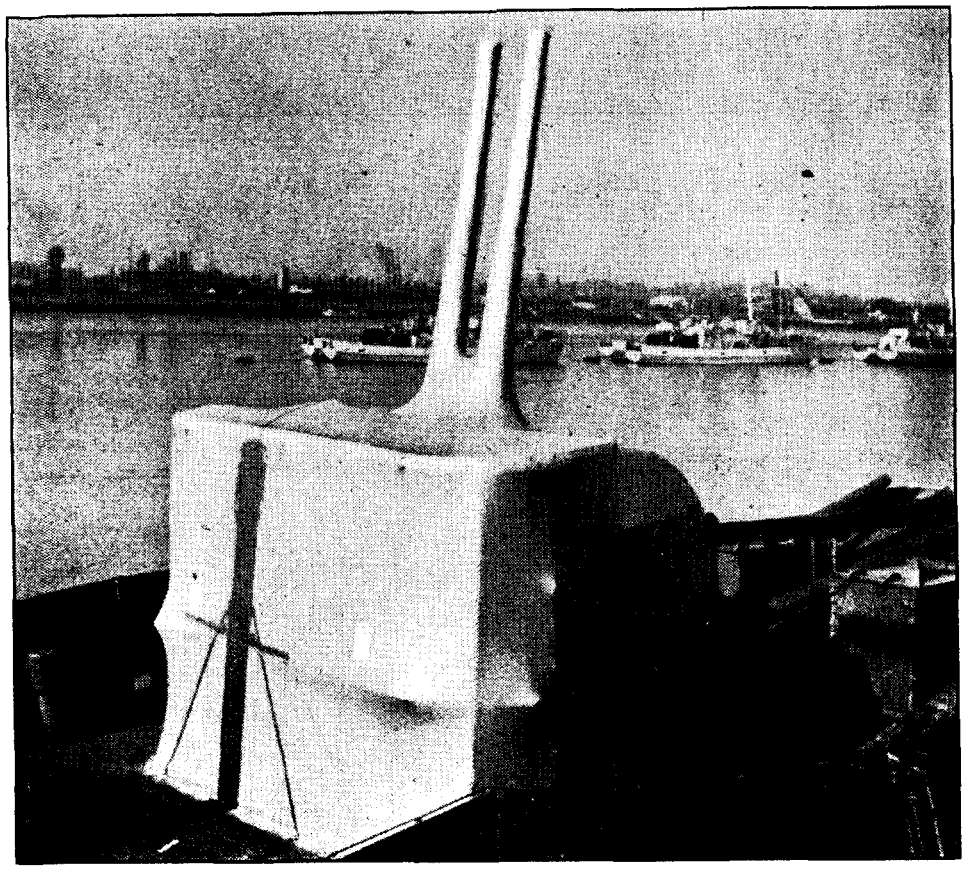

FIG. 2.—4 IN. TWIN MK. XIX MOUNTING. COMPLETED EQUIPMENT

relative humidity within the envelope of the 4.7 in. gun-mounting remained below 40%. The range-finder director was not quite so successful as no attempt at patching was made after the first few months, because projections on the director had been insufficiently padded causing undue chafing and the punctures spread. The humidity rose, but quite gradually, and the condition of the director remained visibly unchanged. The Americans had once reported that there were slight grounds for the belief that the envelope would be attacked by hungry seagulls, but the species in Chatham dockyard showed no great enthusiasm for the potential banquet set before them.

When the trial was concluded in February, 1947, the 4.7 in. gun-mounting had suffered no deterioration and the bright steel test pieces hung inside the envelope were in a perfect condition. One serious defect appeared however—at low temperatures the envelope became brittle and easily cracked. Most of the punctures seemed to be attributable to this property and it was obvious that the process would be unsuitable unless the defect could be remedied.

Further research by Messrs. I.C.I. resulted in a modified form of Halothene coating applied over a film of latex composition. This produced a much stronger and more durable envelope and, incidentally, reduced the thickness of the Halothene film required for the same moisture-vapour-transmission rate. A trial of this modified form of coating on a complex-shaped mock-up at Slough successfully withstood the conditions of the severe cold encountered in March, 1947, suffering no embrittlement and remaining perfectly pliable and tough.

On the strength of this trial it was decided to adopt the modified Latex-Halothene process and to proceed with a programme of preservation of upper-deck equipment in ships of the Reserve Fleet.

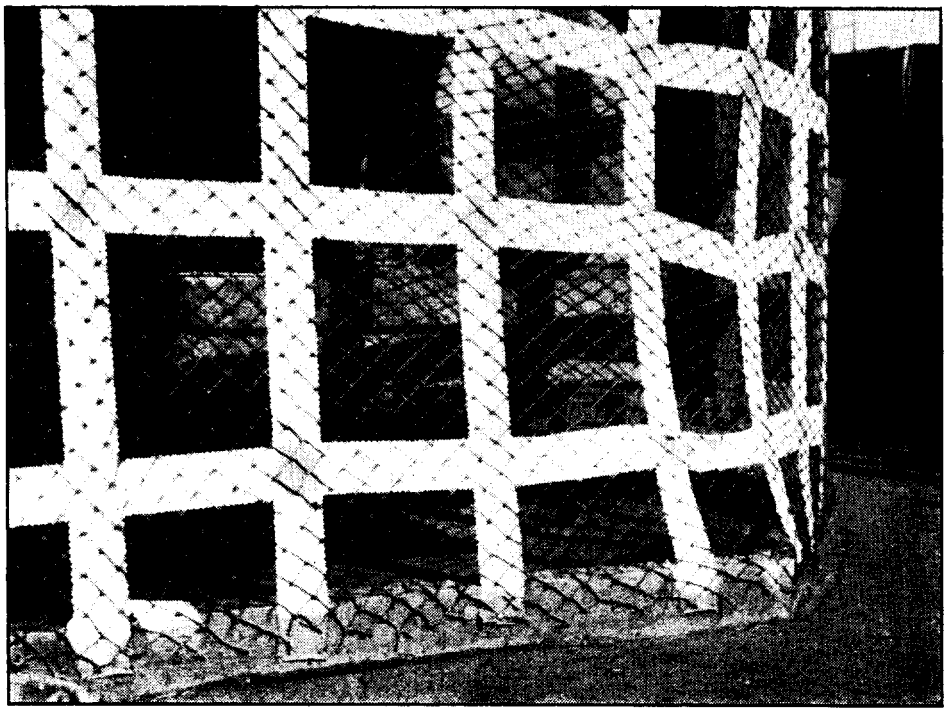

FIG. 3.—VIEW SHOWING METHOD OF DECK SEALING

A nucleus of ten teams consisting of ordnance artificers, shipwrights, seamen, and stoker-mechanics were trained in the use of paint-spraying equipment in conjunction with the lacquers and compositions involved in the process, at Messrs. I.C.I's works at Slough, and work started in selected ships of the Reserve Fleet at Portsmouth, Devonport, Harwich, and Chatham.

Details of Materials

The original Halothene was produced in two grades, black and white, and was applied in alternate coats, finishing with white to avoid excessive heat absorption due to solar radiation. The Halothene lacquers required hydrocarbon (toluene or xylene) solvents for spray application. The modified grade of Halothene is pigmented in black and aluminium, the latter being considered more effective than white in reflecting active solar radiations. Incidentally, the aluminium top-coat should be a complete deterrent even to the hungriest seagulls.

The webbing lacquer, poly-vinyl butyral, is used in conjunction with acetone as a solvent vehicle. Most commercial spray-equipment manufacturers produce a spray gun with a nozzle set-up capable of applying the webbing lacquer.

The latex compound is also sprayable. It should not, however, be applied direct to a metal surface as the stabilising agents in the compound cause corrosion.

THE PROCESS AS APPLIED TO THE PACKAGING OF GUNNERY EQUIPMENT

A moisture-vapour-proof joint at the deck is provided by surrounding the equipment with a wooden boundary bedded down to the deck with Luting or Bostick compound to form a seal. The timber surround is pulled well down by steel bolts spot-welded to the deck.

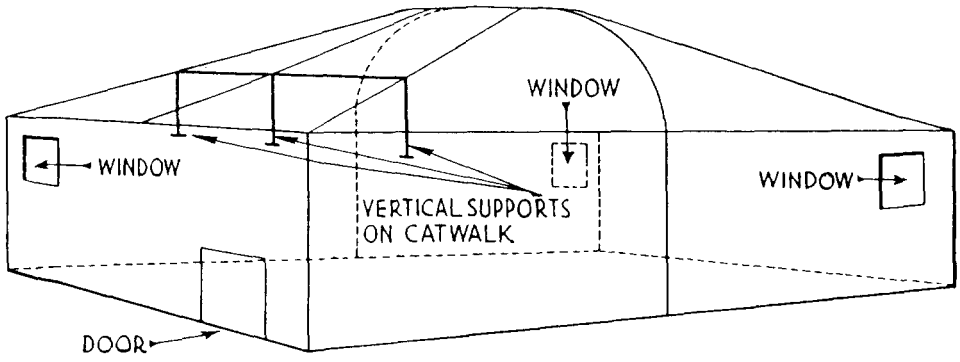

FIG. 4

All projections on the equipment are padded to prevent chafe, and the open areas which require covering by webbing lacquer prior to coating with the other covering materials are taped up by fabric tape to form open squares measuring about 10 in. × 10 in. This is the area which can be bridged by the webbing lacquer under fairly calm conditions, but to facilitate application in the open, netting of $\frac{1}{2}$ in. mesh is secured over the network of tapes.

Constructing the framework

The netting and tape can be rigged more efficiently if a light steel framework is first erected, conforming to the general contour of the open areas of the equipment. Perspex windows mounted on calico are positioned by attaching them to the tapes. Two windows are usually adequate for each equipment.

To provide for subsequent entry into the envelope for inspection of the equipment packaged, or renewal of desiccant, an entry port or manhole consisting of a square wooden frame is attached to the wooden boundary or the steel framework concurrently with its preparation.

Typical examples of the method of framing and the position of the door are shown in Fig. 4 and 5.

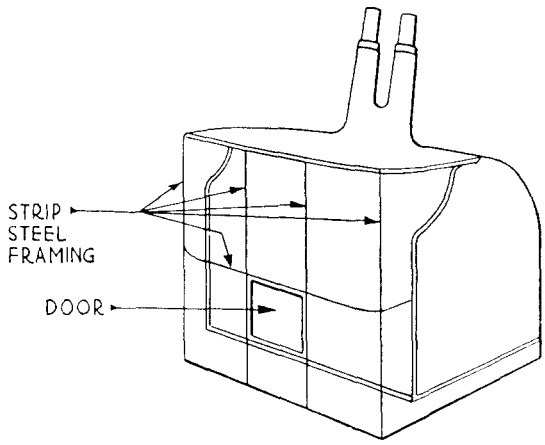

FIG. 5

At the position where the envelope joins the gun-shield, spunyarn may be stretched tightly in place as a border, and in some cases a light wooden batten has been used. This bordering assists in producing even tension on the netting and provides a neat junction at the intersection of the envelope and shield. The border, including part of the gun-shield adjacent to it, is brush-coated with black Halothene, which acts as an adhesive to keep the netting in place, and prevents contact of the subsequent water-based latex coat with the gun-shield.

Use of Webbing Lacquer

The completed framework is sprayed obliquely with webbing lacquer, which requires a special type of spray nozzle and needle valve. The surface of the resulting " cocoon " should be fairly coarse and of reasonable thickness, since it must form the base for all successive coats. Care must be taken to ensure

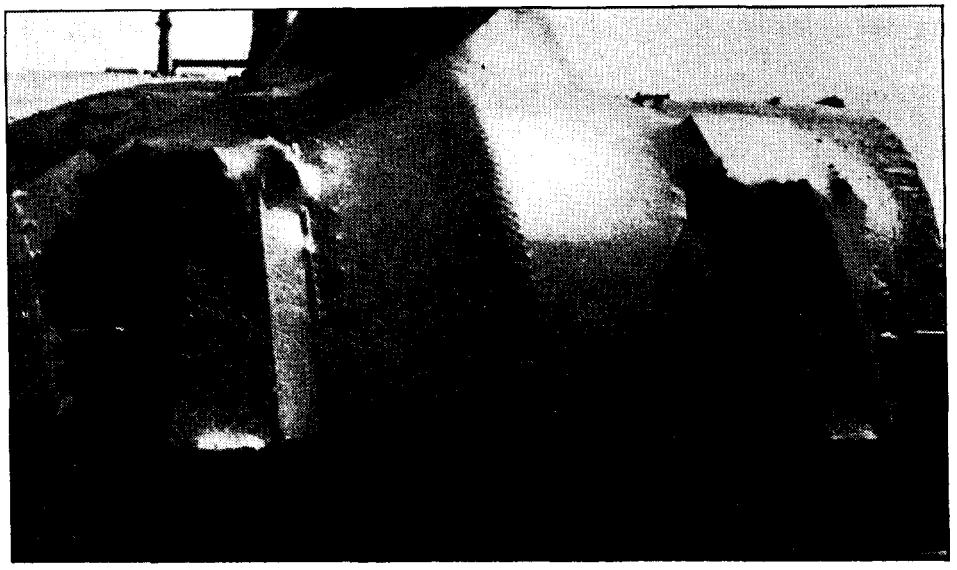

FIG. 6.—4 IN. TWIN MOUNTING. FRONT PART OF MOUNTING SPRAYED WITH LATEX

correct atomization of the webbing lacquer, otherwise wetting of the cocoon surface will occur with the consequent formation of holes. Canvas screens rigged to form a wind shield are of advantage during this process.

Spraying with Latex

The extreme edges of the webbing lacquer cocoon are brushed with Halothene to seal them in place and the covering is ready for the initial latex coat. Although the same spray gun and nozzle set-up can be used for both latex and Halothene it is advisable to set aside separate spray guns and accessories for each material to avoid any contamination of one with another. Distilled water may be added to the latex as a thinner if necessary, the quantity of water never exceeding $\frac{1}{4}$ by volume of that of the latex composition. The initial latex coat is sprayed "wet" to ensure that it penetrates the webbing. Observation through the perspex windows can show whether the black latex has penetrated the webbing and that, when dry, there are no pin-holes in the envelope. A further four coats of latex are sprayed on, each successive coat being allowed to dry, since if the water content does not evaporate before application of a subsequent coat, it causes blisters in the envelope which can lead to cracking. The five latex coats build up to a thickness of 0.020 in. to 0.025 in.

When the outer latex coat is dry, Halothene strip-lacquer is applied in alternate coats of black and aluminium (in order to ensure even overall coverage of each coat), finishing with the aluminium. A total of 6 coats is applied, giving a thickness of about a further 0.025 in. over the webbed areas. Metal surfaces forming part of the envelope require no webbing or latex, and a thickness of 0.010 in. to 0.015 in. only of Halothene is applied.

Distribution of Desiccant

After completion, the envelope is cut to allow removal of the door and the interior is ventilated to dispose of volatile fumes. Desiccant is distributed around the equipment in bags and open trays. A rough formula for the quantity of basic desiccant is given by a modification of the Standard British formula for the quantity of desiccant in a package, developed by the Controller of Chemical Research and Development of the Ministry of Supply.

The standard formula is :—

$$W = \frac{ARM}{60} + \frac{D}{2}$$

where W = Weight of basic desiccant in pounds.

R = Moisture vapour transmission rate of envelope in grams/sq. metre/24 hours.

M = Required life of the package in months.

D = Weight in pounds of hygroscopic materials within the envelope.

A = Area of moisture vapour barrier in square feet.

The moisture-vapour-transmission rate of the Latex-Halothene envelope is estimated at 0.5 g/100 sq. in/24 hr. Therefore R = 7.8 g/sq. m/24 hr. The life of the package, *i.e.*, the period between inspections and renewal of desiccant is assessed at 12 months.

$$\therefore \qquad W = 1.55\,A + \frac{D}{2}$$

$$\textit{i.e.}, \text{ roughly } W = 1.5\,A + \frac{D}{2}$$

Re-activation of the desiccant is easily carried out by heating in an oven at a temperature of from 300°F. to 350°F. Sufficient time should be allowed for the full re-activation to take place. The temperature of the oven falls while moisture is passing off and returns to normal when the desiccant is completely re-activated. When silica gel is used as a desiccant the quantity required may be reduced by about one-third.

A dial-reading hair hygrometer is hung in the vicinity of one of the windows, together with one or two bright steel test-pieces, to provide data for a " packaging log " which is kept for each equipment.

After the insertion or renewal of desiccant the door is finally sealed in place by tape and Halothene applied by brush or spray. The edges of the opening may be delineated by a black line to facilitate subsequent removal.

Sealing possible Leaks

All other possible leaks into the packaged equipment must be sealed, attention being given to gun-support doors, voice-pipes, and cable-glands. Doors in gun-supports are sealed with Luting and secured by strongbacks, the final seal being effected by a brush-coat of Halothene. Sighting ports in gun-shields are treated in a similar way. For record purposes the dates of the final sealing of the envelope and any subsequent opening-up of the equipment are stencilled on the envelope.

All the materials used with the exception of latex-compound are inflammable in their fluid state due to the volatile solvents used, and every precaution against fire must be observed during spraying operations. When dry, the Halothene coat is virtually non-inflammable.

The packaging materials must be stowed at a fairly even temperature and should not be exposed to temperatures of less than 32°F. Below this temperature the latex withdraws from solution in the distilled water.

Average coverages of the materials, determined by trial on various equipments, are as follows :—

Webbing Lacquer	5 sq. yd/gall.
Latex composition (5 coats)	3 sq. yd/gall.
Halothene (6 coats)	4 sq. yd/gall.

GENERAL LAY-OUT, CARE AND MAINTENANCE OF THE SPRAYING EQUIPMENT

The spraying equipment consists of :—

(i) Portable Air Compressor,
(ii) Air Transformer and Filter,
(iii) Pressure Container, and
(iv) Spray Gun.

(i) *Portable Air Compressor*

The types of portable air compressors used by the Reserve Fleet are Diesel- or petrol-driven, supplying 100 cu. ft. of air/min. at 100 lb/sq. in. pressure. This is sufficient to supply four spraying equipments working together ; the general lay-out of one standard equipment is shown in Fig. 8.

(ii) *Air Transformer and Filter*

The air transformer and filter is designed to reduce the pressure of air supplied from the compressor to a steady value required by the spray equipment, at the same time removing all impurities and moisture.

Two gauges are fitted at the top of the transformer, one registering the pressure of the incoming air and the other the controlled pressure of the discharge to the spraying equipment. This pressure is governed by the regulator control valve which is of the sprung-piston and pilot-valve type (Fig. 7).

Air entering the filter passes into an inner chamber tangentially at A and develops a rotary motion, passing to the bottom of the filter B, where a sudden reversal in direction and reduction in velocity allows water which has been deposited on the wall of the inner chamber to fall to the bottom where it can be drained off. The bulk of the condensed water is removed in this first pass.

The air, which is now free from all but very finally divided particles, passes upwards through an annular chamber C containing a stack of metal baffle plates with a gauze filter E at each end. The plates are so arranged to compel the air to take a tortuous path with violent reversals of direction. At each change of direction the remaining water adhering to dust particles is thrown out

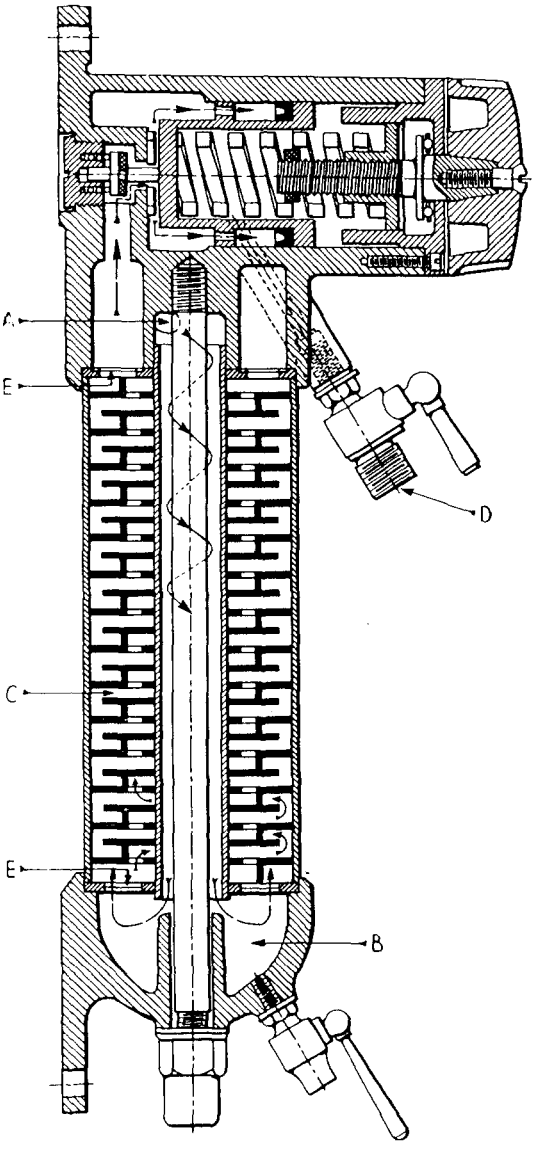

FIG. 7.—AIR TRANSFORMER AND FILTER

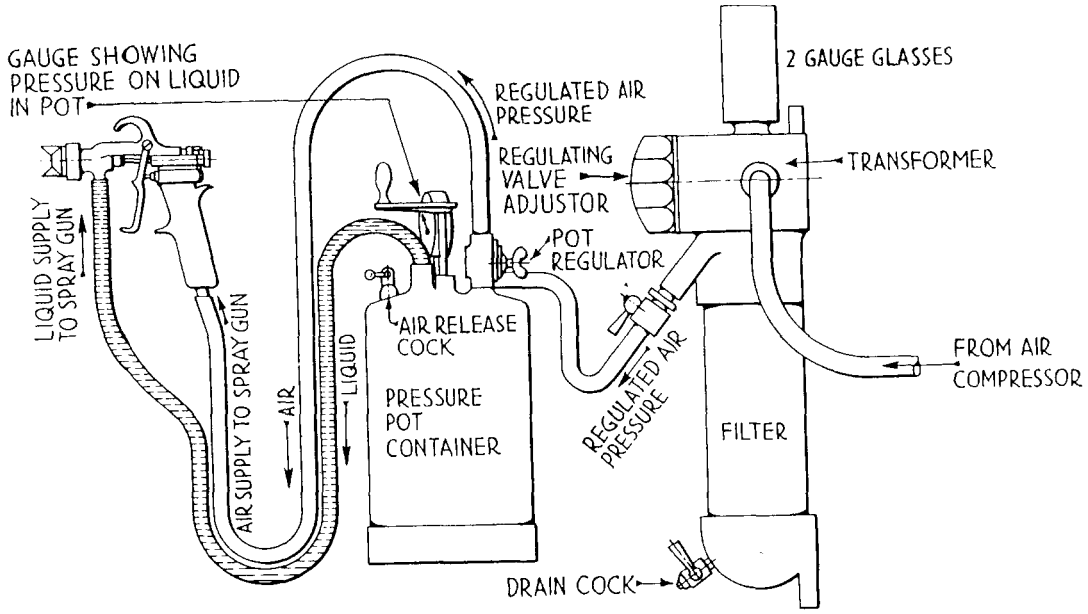

FIG. 8.—LAY-OUT OF STANDARD EQUIPMENT

and adheres to the metal plates or to the walls of the chamber. The water particles drain gradually to the sump during static periods. The stack of baffles is easily removable for periodical cleaning, when dust and foreign matter may be wiped off the plates.

(iii) *Pressure Pot Container*

The pressure pot container (Fig. 8) is a reservoir for the fluid to be sprayed, which is kept under pressure by a by-pass from the transformer pipe-line. The pressure on the fluid is controlled by a regulator on the pot, and registers on a pressure gauge. The cover of the container is secured by clips. Mounted on the cover are the air supply pipe from the transformer, pressure regulating valve, paddle agitator, pressure gauge, fluid supply pipe and connection, safety valve and an air cock.

The container is filled to about 4/5th of its volume, the cover clipped down firmly and the pressure inside is regulated to the correct value by the regulating valve. After use, the container should be cleaned and if any impurities in the fluid are suspected they should be strained before spraying.

(iv) *The Spray Gun*

The spray gun is supplied with compressed air from the transformer through a connection at the base of the handle, and with fluid from the pressure container through a connection just behind the nozzle cap. The barrel of the gun has three chambers, one at the top controlling the shape of the spray, a centre chamber containing the fluid supply valve and the lowest the air supply valve. The gun is fitted with a hook by which it can be hung up when not in use.

When the trigger is pressed air and fluid are allowed to flow through the gun. The air passes from the lowest to the top chamber, where it is distributed through two passages, one to the butterfly webs of the air cap, and one to the centre of the cap, air from the latter atomising the fluid issuing from the fluid nozzle. A fine setting of fluid supply is obtained by an adjusting knob at the rear of the centre chamber. Rotation of this knob moves the fluid supply valve towards or away from its seating, reducing or increasing the quantity of fluid passing through the nozzle.

The supply of air to the two opposed butterfly webs of the air cap is regulated by an adjusting knob at the rear of the top chamber. Rotation of this knob reduces or increases the air supply through the valve to the webs in a similar way to the fluid adjusting knob, changing the shape of the spray between the extremes of conical and fan-shaped. The plane of the fan may be changed from horizontal to vertical by rotating the air cap through 90°.

Operation of the Equipment

Absolute cleanliness is essential for efficient operation. General cleaning solvent, supplied by Messrs. I.C.I. may be used to clean equipment and fluid lines handling Halothene or webbing lacquer, and a mixture of ammonia and water is suitable for cleaning equipment handling latex composition.

If the gun is not properly cleaned, dried material forms around the fluid nozzle tip or in the air nozzle and results in a faulty spray. The material may be removed by a brush or a cloth after soaking in general cleaning solvent. It is important to avoid the use of metal instruments to clean the air or fluid nozzles. The orifices are carefully machined and slight scoring or damage causes a faulty spray. The first movement of the trigger should move the air valve to admit air to the nozzle before any fluid passes. Working parts of the gun should be oiled daily with a light oil.

Webbing lacquer should be sprayed from a distance of about 3-5 feet.

Weather conditions vary the distance of application and air and fluid pressures, but the following settings should give good results in moderate weather conditions with no wind :—

Pressure of air at spray gun	45 lb/sq. in.
Pressure on fluid in container	2½ to 5 lb/sq. in.

A finishing coat of finer texture may be obtained by increasing the air pressure at the gun to 60 or 65 lb/sq. in.

Latex composition and Halothene are best sprayed from a distance of 8 to 10 inches. Greater air pressures are required and average figures for good results are as follows :—

Pressure of air at Spray gun	70 lb/sq. in.
Pressure on fluid in container	12 to 15 lb/sq. in.

THE "COCOON" PROCESS

As this article goes to press, the Latex-Halothene process has been replaced in the Reserve Fleet by the "Cocoon" process, which is similar in principle but uses vinyl resin plastics. The basic raw materials are imported from the U.S.A. and processed in the U.K. by a British firm under licence.

This process has been found more suitable for the Reserve Fleet because it is easier and quicker to apply and the materials are stronger. One webbing coat and two coats of plastic only are required to give a thickness of ·030 in. to ·040 in. compared with eleven coats of Latex and Halothene. The plastic coats are dyed alternately red and yellow as a coverage guide, the materials for the two coats being identical. An additional coat of approximately ⅛ in. thick of gilsonite mastic is applied over the plastic by a special spray gun, through which the mastic is forced by a compressed-air-operated pump. A final coat of aluminium is sprayed over the mastic when dry. The plastic itself has such good webbing properties that if mixed with a small proportion of webbing agent it may be applied direct to the netting with no primary web-coat. The plastic dries very quickly and no drying time between coats is necessary. The

plastic should, however, be given some hours to harden completely before the mastic is applied. This is no great disadvantage since at this stage the package is well able to withstand exposed conditions and may safely be temporarily ignored if it is more convenient to apply the finishing coats later. The strength of the materials allows the wooden boundary seal to be dispensed with by spraying plastic direct on to the steel deck previously coated with an adhesive sealing compound. For the same reason, fewer tapes and less steel framing are required.

Future developments

Packaging by strippable plastic coatings presents a possible solution to the problem of the deterioration of equipment in open storage, both in the U.K. and abroad. The " Cocoon " process is being adopted concurrently by the Army, and may be used in future for the protection of gunnery equipment in open storage abroad.

Messrs. I.C.I. have recently developed a process using a sprayed bituminous coating over either Latex or Halothene. The latter system will shortly receive a trial for the preservation of naval aircraft, for which purpose at present Halothene only is used.

The Ministry of Supply is conducting trials of various strippable spray-coating processes and assessing their qualities with a view to preparing a material specification.