THE PACKAGING OF FRAGILE SERVICE EQUIPMENT

BY

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The details of the pack for a Marconi radar unit are reproduced by courtesy of Export Packing Service, Ltd.

INTRODUCTION

Packaging in its various forms has long been recognized by man as a necessity. From very early times until the present day he has found it to be the only way in which his goods can be carried conveniently from place to place, even though the ' package ' may consist only of a bundle tied with a humble piece of string.

In the course of time traders have found that if their goods are packaged attractively and securely they find a more ready market. The customer is not only attracted by sales appeal on the wrapper, he also recognizes that his purchases are more likely to be received in as good a condition as when they left the craftsman's hands. Many traders have recognized also that a carefully planned and scientifically designed package is safer and cheaper, in the long run, than one made up in a slipshod manner. Savings in breakage and deterioration have allowed them to expend more on the employment of specialists to advise or control their despatch departments.

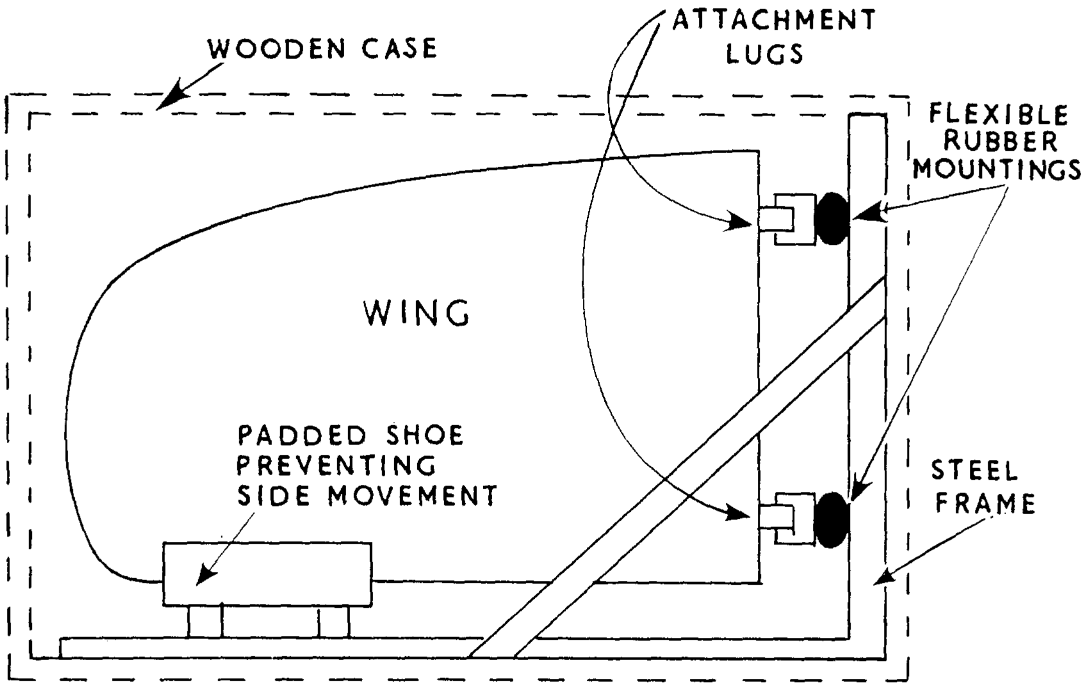

FIG. 1—AEROFOIL SUSPENDED IN CONTAINER

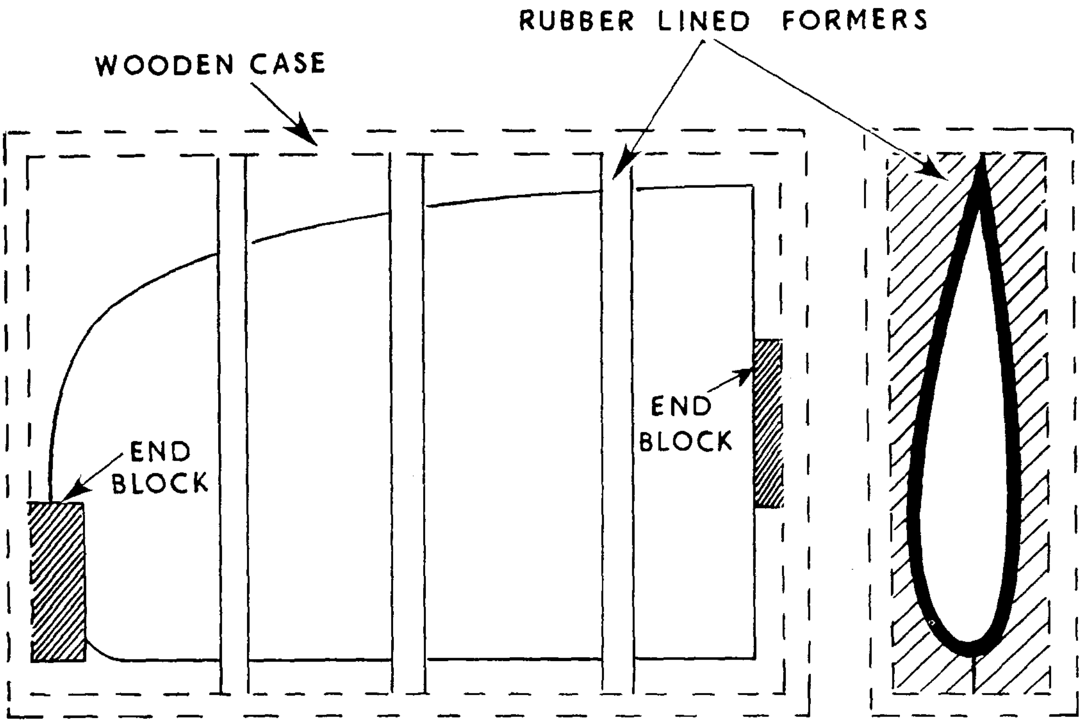

FIG. 2—A LESS EFFICIENT METHOD

Service Requirements

In the Services we are not concerned with the attractiveness of our packaged stores, but their serviceability is vital. If the term ' logistics ' is to have any meaning, then every item in our stores complement must be as well preserved as economy will permit. Fortunately much of this preservation can be achieved by the application of paints and greases, and the various chemical processes now in common use by manufacturers ; but we are still faced with the hazards of transport, and the protection of those items which cannot be treated by temporary or permanent preservatives. These problems are many and varied, and can be solved only by serious scientific consideration of all the relevant factors. This includes the careful assessment of all materials which are available for use in packaging—their cost, chemical content, hygroscopic properties, resistance to deterioration and fracture, weight, and in fact every characteristic which will influence the design of a package of the maximum efficiency at the lowest possible cost. The designer must also study the effects of shock loading on the package and reduce the risk of damage to the contents to a minimum, consistent with economy, the dimensions of the completed package, and the hazards which it is reasonable to assume that the container will have to face.

In this country and the United States of America packaging problems have been recognized and resolutely tackled by scientific research. The wisdom of this policy has been amply demonstrated by the economies and improved supply conditions achieved during the Second World War, and more recently in Korea. This does not mean, however, that the end of the road has been reached. A good deal remains to be done, particularly in the promulgation of all the information now available in the various research laboratories, through the media of instructional courses, publications and other means. Furthermore, it is necessary, if we are to achieve maximum economy in this field, to obtain full collaboration between package designers and manufacturers at an early stage in production of equipment. It frequently happens that a completed assembly is virtually unpackable because no consideration has been given to the provision of securing points (which could in many instances be added without affecting the structure) or the assembly has not been sufficiently ' broken down ' to permit economical packaging. To quote a recent example, the removal of a W/T antenna from the fin of an aircraft permitted reduction of the package capacity by 10 per cent. No technical objections were raised by the manufacturer but the delay in supply and packaging could have been avoided by preliminary discussion.

PACKAGING TO RESIST SHOCK

Experience has proved, particularly in the packaging of aerofoils, that the more successful designs are those which permit suspension of the component within the container, utilizing existing strong points in the structure of the component. The advantages of this method are two-fold, in that stressing of the fragile aerofoil skin is avoided and the effects of distortion of the outer container due to bad handling are minimized. A typical example of the use of this method in the packaging of an aircraft wing is illustrated in FIG. 1. FIG. 2 shows the alternative, less efficient method which must be adopted if suspension points are not accessible on the component. In the latter case all shock loading is transmitted direct to the wing skin, the effect being reduced as much as possible by cushioning pads fitted into the securing blocks formed to the contour of the wing. As the main structure is of thin light alloy the cushioning must necessarily be extensive to provide a degree of safety.

The Impact Load Factor

The method illustrated in FIG. 1 cannot always be applied ; in fact, it is the exception rather than the rule. Moreover, an assembly such as a radio transmitter contains units which are extremely fragile and the package must be designed to protect the weakest member. Obviously some knowledge of the degree of fragility, or susceptibility to shock, is necessary for the designer to provide adequate cushioning. This is described as the Impact Load Factor and is given in terms of '*g*'. Thus, a unit described as having an I.L.F. of 40*g* should safely withstand shock stressing from all loads up to a maximum of 40 times its own weight. The Impact Load Factor can be determined by one of three methods :—

(*a*) By the manufacturer during development,

(*b*) By testing the assembly to destruction,

(*c*) By assumption.

It is apparent that some degree of accuracy is necessary since the value of the I.L.F. determines the deflection required in the cushioning to absorb shock loading in excess of the safe figure. Assumption of the I.L.F. is unwise since errors either way will lead to unnecessary expenditure, either in breakages, or in high packaging costs with attendant increases in package volume and weight. Some assemblies are much too costly to be subjected to destruction tests, and in any case several tests are required to obtain conclusive results. It is therefore of vital importance, as stated earlier, for the manufacturer to regard package design as a primary stage in the development of a prototype—in other words, to recognize packaging as part of the production process.

Standard 'Test Drops'

For the purposes of standardization of package testing it has been agreed that test drops should be as follows :—

For packages up to 150 lb in weight	4 ft. 6 in.
For packages between 150 lb and 250 lb	3 ft.
For packages between 250 lb and 500 lb	2 ft.
For packages above 500 lb	1 ft.

This provides the designer with a fixed target, so that with the assistance of a series of Dynamic Load/Deflection curves relating to the approved cushioning materials, together with the weight of the item and the surface area which he may safely place in contact with the cushion, he is in a position to design a package with reasonable hope of success.

The relationship of the Impact Load Factor to a drop of a given height is given by the formula :—

$$\frac{2h}{d} = \text{I.L.F., where } h = \text{height in inches,}$$
$$d = \text{deflection of cushion in inches.}$$

This formula holds good irrespective of weight or structure.

Example of a Packaging Calculation

For instance, if the designer is required to pack an item weighing 50 lb and the I.L.F. is stated to be 40, the test drop will be 4 ft. 6 in. and cushioning will be required to provide deflection to absorb all loads in excess of 40*g*.

$$\text{From the formula,} \quad d = \frac{2h}{\text{I.L.F.}} = \frac{2 \times 54}{40} = 2{\cdot}7 \text{ in. deflection.}$$

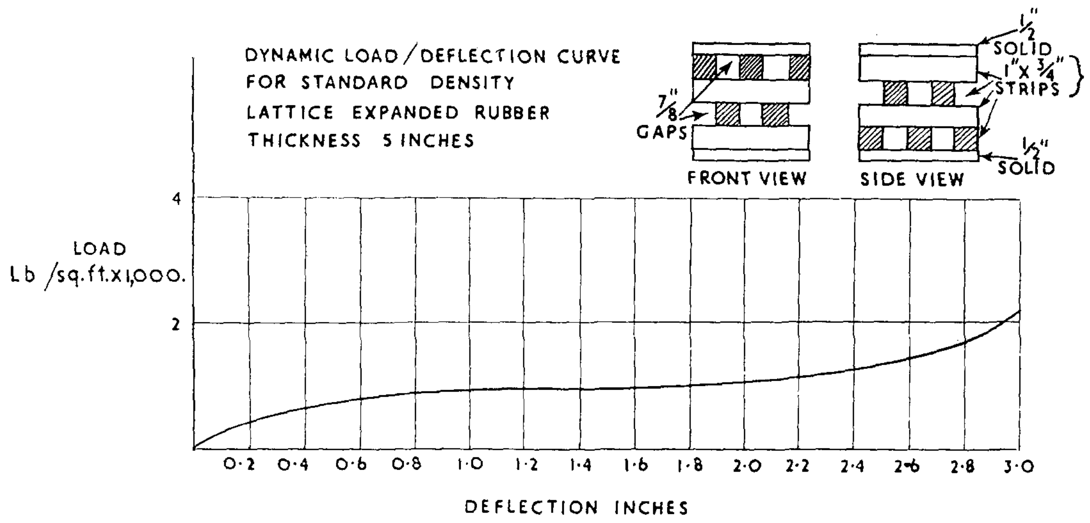

FIG. 3—A DYNAMIC LOAD/DEFLECTION CURVE

Consulting the series of Dynamic Load/Deflection curves a suitable material is found which will give this deflection. The curve is reproduced in FIG. 3.

To allow for static pre-loading of the cushion, additional deflection of, say, 0·25 in. makes total deflection 2·95 in. From the curve, the load intensity for this deflection is 2,000 lb/sq. ft. To find the area of cushion required, the basic formula $L = \frac{K.WH}{A}$ is employed, where

L = Load intensity
W = Weight of item in lb.
H = Height of drop in feet
A = Area of cushion in square feet
K = Constant, which by practical tests has been found to be 7 for solid rubber and 8 for pre-formed lattice rubber.

$$\text{Then } L = 2{,}000 = \frac{8 \times 50 \times 4{\cdot}5}{A}$$

$$A = \frac{8 \times 50 \times 4{\cdot}5}{2{,}000} = 0{\cdot}9 \text{ sq. ft. of 5 in. lattice rubber.}$$

This area of cushioning must be placed on every face of the item on which it is expected shock loading will be imposed, therefore for an ' all-way ' package containing a rectangular item a total of 5·4 sq. ft. of cushioning will be required. It will be appreciated then that errors in judgment or calculation in the assessment of I.L.F. values are liable to be costly and lead to unnecessarily large packages if the values are exaggerated.

Typical Package for Radar Equipment

The requirements of this pack are as follows :—

(*a*) Protection of the equipment from corrosion for a prolonged storage period,

(*b*) Packing of equipment (which weighs 120 lb and is rated at 75*g*) to withstand a clear drop of 3 ft. on all faces and angles in accordance with the Inter-Services Schedule of Tests.

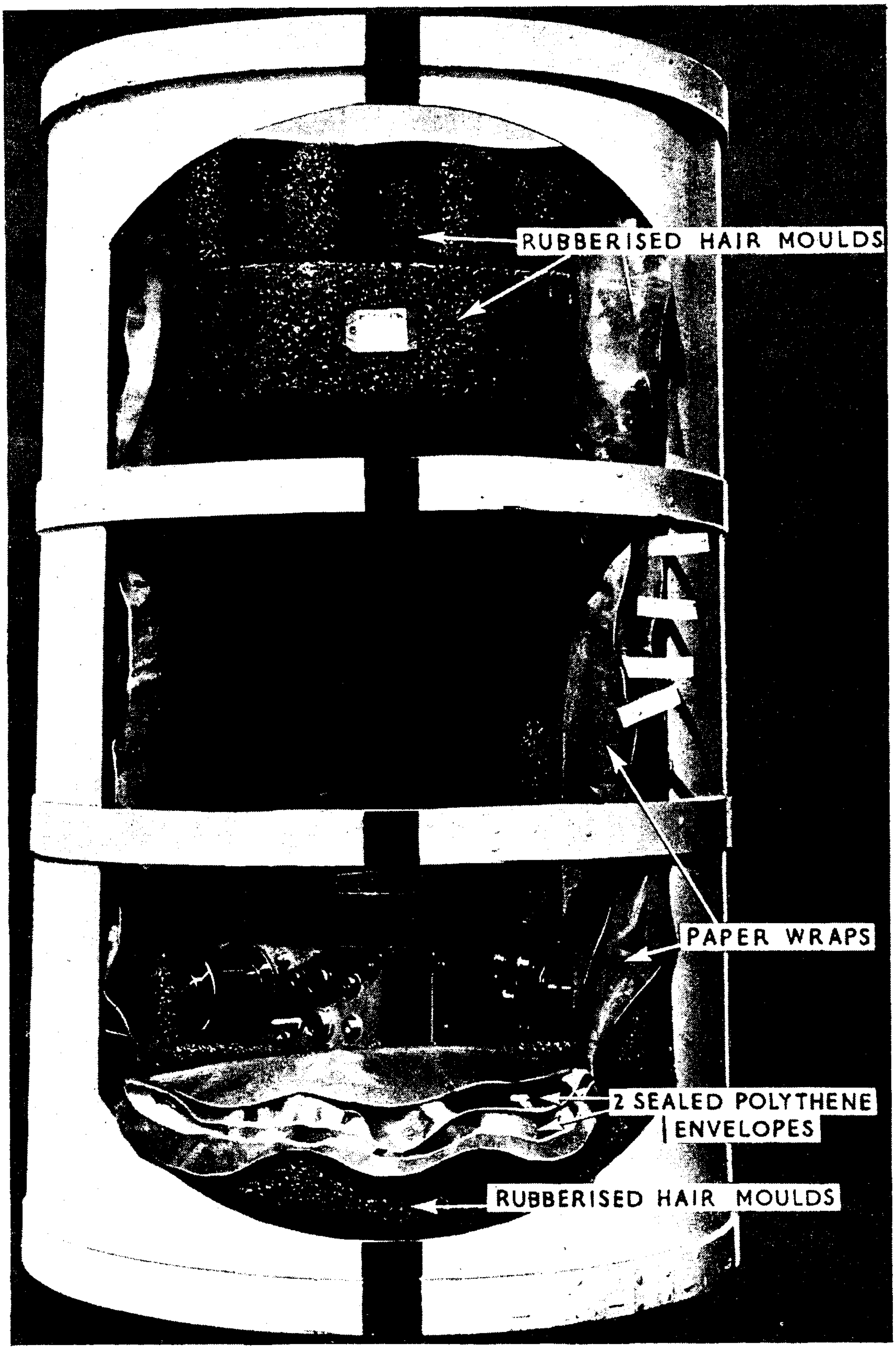

FIG. 4—SECTION OF PACK FOR MARCONI RADAR UNIT

(*a*) is met, internally, by enclosing the equipment in a ' Moisture-Vapour Barrier ' consisting of two sealed polythene envelopes each 5/1,000 in. thick, having a low ' Moisture-Vapour Penetration Rate ', and including a desiccant. Externally, the outer container is treated against rot and insect attack with copper naphthanate solution ;

(*b*) is met by encasing the equipment in rubberized hair moulds, prior to its insertion in a ply barrel, the composite thickness of the moulds being carefully calculated to produce the necessary deflection and energy absorption to maintain 75*g*. The inner mould conforms internally to the shape of the equipment, and so absorbs all projections which might damage the moisture vapour barrier, which is introduced between the two moulds. Paper wraps, both within and without the polythene envelopes, give additional protection from possible puncture to the barrier.

CONCLUSION

From the foregoing remarks it will be seen that much serious thought is being given to the protection of Service equipment. Space does not permit more than a brief mention of the many other aspects which are engaging the attention of research scientists. They range over a wide field, covering such problems as fungus attack on textiles, wood rot, moisture-vapour penetration of packages, the chemical content of preservatives, effects of tropical and arctic conditions on materials, and a host of others, all of which have a direct bearing on safe and economical packaging. We should therefore take full advantage of the results of this heavy expenditure in labour and materials and avoid destruction of costly packaging, unless it is absolutely necessary for practical considerations.

The introduction of new materials is now permitting a reduction in the bulk of packages, and costly and inflammable preservatives are being replaced wherever possible by cheaper, fire-resistant plastics. This means that the well-founded objections so often raised against the carriage of packaged stores in H.M. ships are gradually being reduced, and it may well be that in the not too distant future they may be completely overcome by even more advanced and efficient methods.