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TROPICAL TESTING ESTABLISHMENT
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THE BEHAVIOUR OF PAINTS IN THE TROPICS

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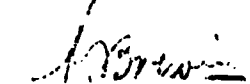
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TROPICAL TESTING ESTABLISHMENT,
PORT HARCOURT, NIGERIA

The Behaviour of Paints in the
Tropics

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publication:


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November, 1961.

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THE BEHAVIOUR OF PAINTS IN THE TROPICS

SUMMARY

This report summarises the results obtained from a large number of trials involving the exposure of paints and related materials to a variety of tropical climatic conditions in West Africa. The trials were carried out by the Tropical Testing Establishment in Nigeria.

1. GENERAL INTRODUCTION

The adverse climatic conditions of the tropics reduce the efficiency and accelerate the deterioration of paints primarily designed for use in temperate countries. High ambient temperatures affect paints in store as they favour settlement of the pigment and gelation of the medium inside the containers. High relative humidities retard the drying of paints and various factors connected with tropical climates have a considerable effect on the durability of the coatings. In addition, the labour available for painting is often unskilled, resulting in inadequate surface preparation prior to painting and incorrect application of the paint itself.

The requirements of paints for use in the tropics have been discussed by Footner and Murray (43) and are summarised as follows:

- (i) Satisfactory storage characteristics for reasonably long periods at temperatures up to 140°F. Settling of pigment should be only slight and the sediment should be capable of being easily re-dispersed; there should be no fattening or gelation of the medium.
- (ii) Good application characteristics to offset the limitations of unskilled labour.
- (iii) Good drying properties without 'after-tack' under conditions of high humidity. The film should not skin-dry or wrinkle.
- (iv) High durability under tropical conditions of exposure.

The factors responsible for the breakdown of paint films in the tropics are the same as those encountered in temperate regions, but they are usually more intense (44). As a general rule, therefore, although the effective life of a paint is considerably reduced by exposing it to tropical conditions, the order of durability of a series of paints will be approximately the same in the tropics as in temperate regions. The relative effect of the various tropical climatic conditions on the breakdown of paints varies from one locality to another, but one or more of the following factors is normally involved:

- (i) The greater intensity of actinic radiation in areas with intense sunshine accelerates the breakdown of a paint vehicle by photo-chemical action and induces a rapid change in the colour of light-sensitive pigments. This effect is one of the main factors involved in the deterioration of paints. The first sign of breakdown is usually loss of gloss, with fading in some cases, and this is inevitably followed by chalking. Paints with dark-coloured pigments are usually found to be more durable than light-coloured paints (44), possibly because increased absorption of /the

the solar radiation by dark pigments confers some protection on the vehicle.

- (ii) Exposure to intense sunlight may cause painted surfaces to reach high temperatures, with consequent rapid embrittlement of the film as a result of accelerated polymerisation of the vehicle.
- (iii) Rapid and wide temperature changes accompanied by differential expansion and contraction of the paint film and its substrate will increase the danger of cracking of an embrittled film. In the hot dry tropical regions, the diurnal variation in the temperature of a painted surface can be very high. This large variation in temperature often results in a periodic condensation of water on the paint film, causing it to chalk, craze and peel in a shorter period than in temperate climates.
- (iv) Intermittent rain followed by periods of sunshine tends to promote chalking of paint films.
- (v) High relative humidities and heavy rainfall accelerate the corrosion of metals with inadequate or too permeable coatings and provide conditions very favourable for the growth of mould and algae.
- (vi) High atmospheric salinities in the areas of tropical surf beaches result in very rapid breakdown of paint films, particularly on metal surfaces where corrosion of the substrate is involved (see Section 4).

The conditions referred to above apply particularly to paints exposed out of doors. The breakdown of paints used for interior purposes in the tropics is much less rapid and their effective life is not significantly less than in temperate climates.

During the period August, 1948 to August, 1958, the Tropical Testing Establishment (T.T.E.) of the Ministry of Supply, based at Port Harcourt in Nigeria, conducted a large number of trials on various types of paints and related materials at several exposure sites, selected so as to cover a wide range of tropical climatic conditions. In the course of these trials, many paints were examined to assess their durability under conditions of tropical exposure, and the results obtained were reported at the conclusion of each trial (1 - 39). As a result of the decision to close the Tropical Testing Establishment in September, 1958, all the paint specimens still on exposure had to be withdrawn during the month prior to the closure. Several of the trials were therefore terminated before the scheduled completion dates; in one case (38) arrangements were made to continue the trials in West Africa jointly by the Nigerian Federal Institute of Applied Research at Oshodi, near Lagos, and the West African Building Research Institute at Accra, Ghana.

In this report, the results of the various trials are discussed under the following headings, for convenience:

- (i) Paints applied to metal surfaces (Section 4 and Appendix A)
- (ii) Paints applied to wood surfaces (Section 5 and Appendix B)
- (iii) Paints applied to asbestos cement (Section 6 and Appendix C)
- (iv) Paints applied to plaster walls and concrete (Section 7 and Appendix D)
- (v) Varnishes (Section 8 and Appendix E)
- (vi) Fungus-resisting paints (Section 9 and Appendix F)
- (vii) Fungicidal varnishes and lacquers (Section 10 and Appendix G)
- (viii) Anti-fouling paints (Section 11 and Appendix H)

/(ix)

- (ix) Anti-teredo paints (Section 12 and Appendix I)
- (x) Composition preservative on paints (Section 13 and Appendix J)
- (xi) Storage of paints in the tropics (Section 14 and Appendix K)

2. EXPOSURE

2.1 Exposure Sites

All paint specimens were exposed at one or more of the sites described in Section 2.1.1 to 2.1.11; these provided a wide range of tropical climates. The location of some of these sites is shown in Fig.1 and some general views are given in Figs. 2 to 10. Table 1 summarises the conditions at the main sites:

Table 1

Main Exposure Sites

Site	Conditions	Details in Section
Control Room, Port Harcourt	Temperature and relative humidity maintained at $70^{\circ} \pm 5^{\circ}\text{F}$ and $65 \pm 5\%$ respectively.	2.1.1
Base Depot, Port Harcourt	Warm and humid but providing conditions of good tropical storage.	2.1.2
Town Site, Port Harcourt	Warm, humid, heavy rainfall, moderate sunshine, mild industrial atmospheric pollution.	2.1.3
Jungle Site, Nkpoku, Nr. Port Harcourt	Warm, humid, shady. Conditions very favourable for biological attack.	2.1.4
Marine Site, Lagos	Warm, humid, heavy rainfall, intense solar radiation, high concentration of airborne salt.	2.1.5
Desert Site, Kano	Hot and dry, low rainfall, intense solar radiation.	2.1.6

Subsidiary exposure sites are described in Sections 2.1.7 to 2.1.11.

2.1.1 Control Room, Port Harcourt

In some of the trials, 'control panels' were provided by the sponsors or were prepared at T.T.E. to serve as standards in assessing the degree of deterioration of specimens at the exposure sites. These 'control panels' were stored in the dark in a room in the T.T.E. laboratories which was maintained for most of the time at $70 \pm 5^{\circ}\text{F}$ and $65 \pm 5\%$ relative humidity. The panels were removed for short periods only, for comparison with the exposed panels under inspection.

2.1.2 Base Depot, Port Harcourt

This was a room in the T.T.E. laboratories at Port Harcourt, of permanent brick and concrete construction and with a palm-thatched roof.

The temperature and relative humidity were remarkably constant. The seasonal variations in temperature and relative humidity were 75° to 95°F and 70 to 95% respectively but the diurnal variations were considerably less (approximately 10°F and 10% R.H.). There was no air-conditioning but during the day the windows were open and there was good ventilation. Conditions simulated good tropical storage. Views of the exterior and interior of the building in which the specimens were stored are shown in Figs. 4 and 5.

2.1.3 Town Site, Port Harcourt

This was an open compound in Port Harcourt, a town in the rain-forest belt of Southern Nigeria. Temperature and relative humidity were both high and the diurnal and seasonal variations were small. Temperatures ranged from 70° to 95°F and relative humidities from 70 to 95 per cent. Annual rainfall was about 95 inches and most of this fell in the wet season from April to October. There was mild industrial atmospheric pollution, mainly from a railway and a coal-burning power station about quarter of a mile distant from the site. A general view of the town site is shown in Fig.2 and in Fig.3 is the compound in which the specimens were exposed.

2.1.4 Jungle Site, Nkpoku, Near Port Harcourt

This site was in the coastal rain-forest belt of Southern Nigeria, approximately twelve miles north of Port Harcourt. The diurnal temperature range was only about 10° (maximum 85°F, minimum 75°F). Relative humidities were high, the daily maximum being over 95 per cent and the minimum about 80 per cent, except for a very short period at the beginning of the year when it might fall to 60 per cent. Annual rainfall was about 95 inches. Conditions were very favourable for both insect and fungal attack and in the clearing, where sunlight penetrated for a few hours each day, algal growth developed, often in symbiotic union with fungal growth. The clearing was approximately thirty by twelve yards (Fig.6) and as the surrounding trees were about a hundred feet high the specimens were exposed to direct sunlight for only a few hours in the middle of the day.

Specimens exposed in the jungle undergrowth were protected from direct sunlight and the full force of the rain, which at times was very heavy.

2.1.5 Marine Site, Lighthouse Beach, Lagos

This site was situated on a tropical surf beach about four miles from Lagos. There was little seasonal variation in temperature and relative humidity; the daily temperature maximum was generally between 80° and 90°F, and the minimum between 70° and 75°F. The relative humidity variation was from a maximum of over 85 per cent to a minimum of 70 to 80 per cent. The annual rainfall was about 70 inches, the rainy season generally lasting from March to October. There was an average of about seven hours of bright sunshine a day and the effect of solar radiation was accentuated by strong reflection from the sand and the sea. The atmosphere was very corrosive, being heavily laden with salt from the surf spray which was blown inshore by the constant, prevailing south-west wind. The concentration of airborne salt, however, fell off rapidly on moving inland from the surf line; at two hundred yards it was only one quarter and at four hundred yards one twelfth of the value at the fifty-yard site, as measured by the 'wet-cloth method' (45). For this reason, the distance of the specimens from the surf line was usually specified. This high atmospheric salinity (approximately 3 mg NaCl/cubic metre) in conjunction with constant inshore winds, intense actinic radiation and high ambient temperature and relative humidity provided one of the most corrosive natural exposure sites on record (45).

A general view of the marine site is shown in Fig.7 and of the 200-yard compound in Fig.8.

2.1.6 Desert Site, Kano

This site was situated on open ground in the hot dry region of Northern Nigeria (Fig.9). During the dry season the ground was almost bare and the grass which grew during the short rainy season (June to September) was kept short. Solar radiation was intense, with sun temperatures of the order 170° to 180°F (black bulb in vacuo) and total radiation intensities up to 360 B.Th.U/ft²/hour being recorded. The highest ambient temperatures occurred in April and May, when they were of the order 105° to 110°F associated with minimum temperatures of about 70°F. At the beginning of the year when the Harmattan, a very dry, dust-laden wind from the desert, was blowing from the north, it was considerably cooler (maximum 80° to 85°F, minimum 40° to 50°F), and at this time the relative humidity was extremely low (maximum 50 per cent, minimum 5 per cent or even less). During the wet season, the relative humidity ranged from a minimum of about 60 per cent to a maximum of 100 per cent. The annual rainfall at Kano was about 34 inches, most of which fell in the three months July to September. There was generally an absolute drought from November to May.

2.1.7 Harbour Site, Port Harcourt

This was a concrete structure erected in the river harbour area and locally referred to as the 'dolphin' (Fig.10). The dolphin was about two hundred yards out from the wharf and about half a mile south of the town site. The creek was bounded by mangrove swamps. Conditions at this site were approximately the same as those of the town site with some additional mild atmospheric pollution from shipping. Panels supported on a wooden frame were exposed by fixing the latter to the flat concrete top of the dolphin which was about six feet above high-water mark. The specimens faced north (towards the wharf).

2.1.8 Wilmot Point, Lagos

This site was inside the lagoon area near Lagos. Although climatic conditions were similar in most respects to those at the marine site (Section 2.1.5), there was much less wind and sun spray. The salinity of the atmosphere was little more than one tenth of that at the marine site (45). Specimens were exposed to the atmosphere above the high-water mark by attaching them to a wooden wharf. The lagoon site (Section 2.1.11), where specimens were partially or totally immersed, was immediately below this wharf.

2.1.9 Bonny River, Port Harcourt

This was the immersion site in the harbour area at Port Harcourt, surrounded by mangrove swamps and containing decomposing vegetation. It was a brackish tidal creek, about forty miles up-river from the sea, and the rise and fall of the tide was up to five feet. The salinity of the water varied from 1 to 2.5 per cent (see Appendix B). Specimens exposed to 'wind/water conditions' were positioned so that they were immersed at high water and exposed to the atmosphere at low water. 'Totally immersed' specimens were placed 12 to 18 inches below the low-water mark.

2.1.10 Opobo Immersion Site

This was in a tidal creek south of Port Harcourt where teredo activity appeared to be much lower than in the water of the harbour area at Port Harcourt. The salinity of the water here was also much lower than at the latter site, varying between 0.10 per cent NaCl in May and 0.38 per cent in August (9).

2.1.11 Lagoon Site, Lagos

This was the immersion site at Wilmot Point (see Section 2.1.8), a backwater inside the Lagos Lagoon. During the wet season, a large area of forest country drained into the lagoon giving an overlay of fresh water. The salinity of the water at a depth of five feet varied from about 0.24 per cent Na Cl in the rainy season to about 2.5 per cent in the dry months (December to March) (46). Specimens were exposed at this site under 'wind/water conditions' or 'fully immersed' as described in Section 2.1.9.

2.2 Methods of Exposure

Paints were normally exposed on small panels of metal or wood supported on stands so that the panels faced south and were at an angle of 45° to the horizontal. The height of the specimens above ground level varied from three to five feet. Where other conditions of exposure were required, details are given in the appropriate sections of the report. The stands were constructed of steel or wood and the panels were fixed in such a way as to avoid bi-metallic contact or conditions which would affect the normal rate of deterioration of the paint films. The method of fixing the panels was particularly important where both they and the stands were of steel, since any direct contact was always liable to lead to accelerated corrosion of the paint substrate and reduce the effective life of the paint. In such cases, the method normally adopted was to grip each corner of the steel panel between fibre washers attached to the frame by steel bolts, care being taken to avoid any contact between the fixing bolts and the panels.

In testing paints in the jungle undergrowth (for resistance against fungal attack), it was fairly common practice to expose them on stands in a vertical position to minimise the deposition of extraneous matter on the paint film, thus eliminating a source of nutrient for fungus which would lead to confusing results. In any case, in the absence of direct sunlight, orientation at 45° and facing south was unimportant.

Painted panels for exposure under water were fixed to wooden or steel frames which were in turn securely fastened to a raft or to a rigid structure such as a wharf. The latter method was used where exposure to 'wind/water conditions' (see Section 2.1.9) was required.

Photographs of some of the specimens on exposure are given in Figs. 11 to 34.

2.3 Meteorological and Hydrographic Data

At the town, jungle and marine sites, records of maximum and minimum temperatures and relative humidities, maximum solar temperatures (black bulb in vacuo), numbers of hours of sunshine and inches of rainfall were obtained from standard instruments placed near the specimens on exposure. For the desert site, records were obtained by courtesy of the Nigerian Meteorological Department from its station about one mile from the exposure site. In the base depot and jungle undergrowth, records of maximum and minimum temperatures and relative humidities only were maintained. All these records were averaged over ten-day periods and produced in the form of line graphs for each of the exposure sites. Typical data for a complete year (1957) are given at the end of this report.

In connection with the anti-fouling and anti-toredo paint trials, some hydrographic data for the Bonny River, Port Harcourt, were obtained and figures for salinities, pH values and temperatures are given in Appendix L.

3. ASSESSMENT OF DETERIORATION

Deterioration of the paint films was assessed by visual examination at regular intervals during exposure, the methods adopted being based on the outdoor exposure assessment procedure of the Chemical Inspectorate at its Glascoed Station (40). Various failures of the paints were recorded in terms of numerical units 0 - 4, 0 representing no change and 4 a bad failure. The degree of gloss of the film was assessed as follows:

- 0 - High (cellulose or enamel) gloss
- 1 - Oil-paint gloss
- 2 - Medium gloss
- 3 - Eggshell
- 4 - Matt

Defects such as colour range, chalking, cracking, flaking, blistering, etc. were recorded using the following scale:

- 0 - No failure
- 1 - Very slight failure
- 2 - Slight failure
- 3 - Definite failure
- 4 - Bad failure

The extent of biological attack was usually assessed by a mycologist and, where possible, the species of fungus were identified.

4. PAINTS APPLIED TO METAL SURFACES

4.1 Introduction

The paint systems were exposed on metal substrates at various sites to examine their behaviour under different conditions of tropical exposure. Details of the paint systems tested are given in Appendix A and some of the specimens on exposure are shown in Figs. 11 to 20.

The effectiveness of a paint system on steel was assessed mainly by its ability to prevent rusting. The usual factors associated with degradation of paint (chalking, blistering, fading, etc.) were also noted, but a measure of the protection afforded was most readily obtained by assessing the rusting that had taken place. For this, measuring the area affected by rusting and/or rust staining might be sufficient but a more precise evaluation was obtained by weighing panels both before painting and after stripping paint and rust at the end of the exposure period. The loss in weight of the panels as a result of corrosion was expressed in grams per 100 sq. cm of surface area. After stripping the residual paint with xylene (3, 13), rust was removed by soaking the panels for fifteen minutes in a 15 per cent solution of sulphuric acid containing 0.4 per cent of "Stannine" inhibitor. The rate of corrosion of unprotected mild steel panels, determined in the same manner, for various exposure sites is given in Table 2 (45).

/Table 2

Table 2
Rate of Corrosion of Unprotected Mild Steel

Exposure Site	Rate of Corrosion loss in g/100 cm ² /month
Jungle Clearing	0.10
Marine : 50 yd	5.60
Marine : 200 yd	2.35
Desert Site	0.028
Wilnot Point (Fisheries)	0.33
Lagoon Site, wind/water zone	6.7
Lagoon Site, total immersion	4.5

The very high rate of corrosion at the marine site as compared with the other aerial exposure sites was caused by the high atmospheric salinity in the vicinity of the surf beach. At this site in particular, the normal sequence in the breakdown of paint films, viz. loss of gloss, chalking, cracking, blistering, etc., was followed by rusting of the steel substrate with a consequent accelerated breakdown of the paint.

4.2 Individual Trials

4.2.1 Berkeley Green Bergermaster Gloss Enamel with Undercoat (Lewis Berger and Sons, Ltd.)

This enamel, based on a co-polymerised styrene medium, was claimed to have better gloss retention than normal gloss paints. To examine its behaviour under tropical conditions, timplate panels were exposed at three sites in Nigeria for periods varying from eight to twenty-seven months (Ref.3). The panels, 6 inch x 4 inch, were painted at T.T.E. as described in Appendix A.1, and were exposed as shown in Table 3.

Table 3

Site	Date Exposed	Duration of Exposure (months)
Jungle Clearing	19.4.50	27
Marine (50 yd from surf line)	6.6.50	8
Marine (200 yd from surf line)	6.6.50	8
Desert	5.5.50	13

The painted timplate specimens behaved in a manner similar to the corresponding wooden panels (see Section 5.2.1) as regards gloss retention, colour change and chalking but the amount of superficial algal and fungal growths was rather less than on the latter. After six months, the gloss had almost disappeared and, after a year, total loss of gloss was

/accompanied

accompanied by heavy chalking at the sunny sites. Heavy biological growth developed on the paint exposed in the jungle.

Although this material was not tested in conjunction with other gloss paints, there was no evidence to suggest that it was superior to the latter in its gloss-retaining properties.

After a year's exposure, rust had formed in small blisters on some areas of the panel at the jungle site. Slight rusting at the edges of the panel after five months exposure at the marine site developed rapidly and spread over the panel. The specimens at this site were withdrawn after eight months exposure when rusting was assessed as heavy. At the desert site, blistering of the paint was reported after five months and slight rusting at the suspension holes after eight months; at this stage the blistering had disappeared. No further development of rusting or blistering was noted during the remainder of the trial at the desert site.

4.2.2 Pammel Synthetic Enamel Paint with Undercoat (Blundell Spence & Co. Ltd.)

The effect of tropical exposure on this synthetic enamel over an approved undercoat was investigated by exposing painted mild steel panels at four sites in Nigeria for eighteen months (15). The enamel was based on a long-oil linseed oil pentaerythritol alkyl, pigmented with phthalocyanine blue and lead chrome. Further details of the system are given in Appendix A.2.

The panels (6 inch x 4 inch) were painted at T.T.E. and exposed at the marine site, both 50 and 200 yards from the surf line, on 24.8.53, in the jungle clearing on 29.8.53, and in the desert on 26.9.53.

At all three sites the painted steel panels behaved in a manner similar to the corresponding wooden panels (see Section 5.2.2) as regards gloss retention and colour changes, but there was no fungal attack on the steel panels at the jungle site. At the jungle and desert sites the specimens remained in very good condition except for dirt collection at the former and loss of gloss and fading at the latter. The gloss however was readily restored by cleaning and polishing.

No rusting of the panels at the jungle clearing or desert sites was reported throughout the trial. At the marine site, however, both 50 yards and 200 yards from the surf line, rusting commenced along the edges of the panels within five months of exposure. At the 50-yard site this rusting continued until, after 18 months, only a relatively small area of paint remained in the centre of the panel, there being a border of rust one inch wide around the panel and several rust spots in the central area. 200 yards from the surf line, where the atmosphere was less corrosive, breakdown was less severe and, after 18 months, rusting was still limited to a quarter-inch border around the panel with several rust spots towards the centre. Figure 35 illustrates the steel panels after eighteen to nineteen months exposure at the four sites. The corrosion at the two marine sites is clearly shown, as is the breakdown of the paint film taking place from the edges inwards. This suggests that adequate edge protection of the metal panels might have further delayed the breakdown of the paint film.

The protection afforded the mild steel panels by the paint system is shown in Table 4, which compares the total corrosion after eighteen to nineteen months exposure for the painted panels with the monthly rate of corrosion of unprotected mild steel at the same sites (45).

/Table 4

Table 4
Corrosion Rate of Painted and Unpainted
Mild Steel Panels

Site	Total Corrosion of Painted Panels after 18/19 Months (g/100 cm ²)	Corrosion Rate of Unprotected Mild Steel (g/100 cm ² /month)
Jungle clearing	0.32	0.10
Marine (50 yards)	25	5.60
Marine (200 yards)	1.9	2.35
Desert	0.34	0.028

4.2.3 General Purpose Paints (Red Hand Compositions Co.)

Two paint systems on galvanized iron and three systems on steel panels were exposed for two years at the marine site 200 yards from the surf line (17). On galvanized iron, the same primer and undercoat were used in conjunction with two different aluminium finishes; as the trial using steel panels was designed to assess the relative merits of three different primers, the undercoats and topcoats were the same in all cases. All painting was done in the U.K. and the panels were exposed on 21.2.56. Details of the paint systems are given in Appendix A.3.

At the end of the trial, the paint systems on galvanized iron were still in fairly good condition, apart from moderate chalking and a slight breakdown along the western edge in the form of blistering and flaking, and white corrosion of the substrate.

The painted steel panels commenced to rust along the western edges and the paint had started to blister in this region after six months exposure. Chalking, first observed after nine months, increased considerably towards the end of the trial and all systems were chalking heavily when the panels were withdrawn from the site. After two years exposure, the edge corrosion effect had increased considerably along the western sides of the panels and rusting had begun along the other three edges. This heavy rusting along the edges had caused delamination of the substrate and considerable flaking and blistering of the paint film. Rust staining had spread on to the paint film from the western edge and small areas of rust blistering could be seen on the panel surfaces. The specimens lost all their original gloss.

No significant differences were observed in the behaviour of these different systems either on galvanized iron or steel substrates.

4.2.4 War Equipment Paints (Trial sponsored by Ministry of Supply, Chemical Inspectorate)

This was a trial to assess the general behaviour under tropical conditions of paints from various manufacturers, formulated to the C.I. specification for War Equipment Paints (21). A list of the paints is given in Appendix A.4.

Mild steel panels (12 inch x 12 inch) were painted in the U.K. and exposed in a jungle clearing for thirty-four months. Each panel was divided by a vertical line into two equal portions, one portion being covered with one coat of primer and two coats of the finishing paint and the other with two finishing coats only. The painted panels were exposed on 18.11.54.

/At

At the end of the trial all the olive drab finishes showed considerable fading and the Arctic white finish chalked very badly. Deterioration had taken place on the halves of the panels on which no primer had been used, rusting and blistering being much in evidence. The other half of each panel which had been treated with red oxide primer was in better condition. The Arctic white paint deteriorated more rapidly than the olive drab materials and showed almost complete breakdown after thirty-four months when used without a primer. Details of the changes are given below.

The panels painted with olive drab finishes began to fade after about four months exposure and fading increased during the remainder of the trial; after approximately one year most of them were assessed as considerable failures in this respect. All the olive drab finishes showed slight biological attack and the Arctic white finish darkened considerably after about sixteen months as a result of heavy dirt collection.

Chalking of the Arctic white finish commenced after two months and was assessed as heavy after two years. Only negligible chalking of the olive drab finishes was recorded at intervals during the trial.

Very slight cracking of Specimen A4-1 began after sixteen months exposure and, at the end of the trial, this defect was recorded as very slight on Specimens A4-1, 3, 10, 11, 12 and 13 (all olive drab finishes, with or without primer, manufactured by I.C.I. or Lewis Berger). No chalking of any of the specimens was observed at any time during the trial.

At the end of the trial, considerable flaking of the Arctic white finish, without primer, (Specimen A4-17) was recorded. This defect was also noted to a very slight extent on five of the olive drab finishes, viz. A4-2, 6, 9, (with primer) and A4-11 and 18 (without primer).

Towards the end of the trial very slight blistering occurred on most of the specimens but the blisters were very small (1-2 mm). Only two specimens (A4-4 and 7) were entirely free from this defect. The Arctic white finish (A4-8 and 17) and Specimens A4-1 and 9 (olive drab finishes with primer) were rather more affected than the others.

Only three specimens were entirely free from rusting throughout the trial, A4-3, 4 and 7 (olive drab finishes with primer). The remaining systems with primers (including the Arctic white system, A4-8) did not begin to rust until they had been exposed for twenty-seven months and, at the end of the trial, were generally assessed as only very slight failures. On the other hand, most of the systems without primers began to rust after only four months and showed a fair amount of rusting at the end of the trial. Notable exceptions were A4-10 (olive drab - I.C.I.), which did not show rusting until twenty-one months had elapsed and was only a very slight failure at the end of the trial, and A4-17 (Arctic white) which had rusted considerably after only four months and was a bad failure at the end of the trial (Fig.36).

Considerable dirt collection and slight water spotting were recorded on all the specimens.

Generally, the paint systems without primer showed deterioration after almost three years exposure in a warm, humid climate, rusting and blistering being fairly widespread. One system without primer, A4-10 (I.C.I. Ltd. Paint W.E., O.D.), was significantly better than the others and the most seriously affected of all was A4-17 (E. & F. Richardson Paint W.E., A.D., Arctic White). Of the systems with priming coats, A4-4 (Lewis Berger, Paint W.E. A.D., Olive Drab) and A4-7 (Burt, Bolton and Hayward, Paint W.E. A.D., Olive Drab) were superior to the others.

4.2.5 Ready Mixed Oil Paints (Trial sponsored by Ministry of Supply, Chemical Inspectorate)

Nine paints formulated either to the then existing B.S. specification or to the proposed new draft specification, CR/PVC/8880, were exposed at two sites for almost three years to examine their behaviour under tropical conditions (23). Mild steel panels, (2 inch x 12 inch) were painted according to the systems shown in Appendix A.5, one set being painted in the U.K. and a duplicate series at T.T.E. The panels were exposed in the jungle clearing on 17.11.54 and in the desert on 2.12.54.

In general, the paints to the draft specification were in a slightly better condition than those conforming with the existing B.S. specification, after three years' exposure to warm/humid or hot/dry conditions. All the materials faded at the desert site and many chalked heavily. At the jungle site all the paints supported heavy biological growth.

All the specimens began to lose gloss at the desert site after two to five months exposure. Further slow progressive loss occurred during the remainder of the trial. After thirty-two months, all the Red Oxide and Black finishes were assessed as slight failures but loss of gloss on the Light Brunswick Green finishes was rather more severe. There was no appreciable difference between the British Standard and the draft specification finishes nor between panels with one and two finishing coats. At the jungle site heavy fungal growth and dirt collection made the assessment of gloss rather difficult.

Fading of all specimens commenced at the desert site after only one months exposure. Severe fading of all the Light Brunswick Green finishes developed fairly rapidly (Fig.38) and at the end of the trial the draft specification formulations had faded rather more than those formulated to the existing B.S. specifications. The Red Oxide and Black finishes had generally faded only slightly, the two-coat systems tending to fade rather more than the one-coat. At the jungle site, all the Black finishes faded considerably towards the end of the trial. The Red Oxide specimens were reported to be fading after four months exposure but this was no longer observed at seven months when darkening first became evident; this increased during the remainder of the trial until all the Red Oxide finishes were assessed as bad failures in this respect. Both the one-coat Light Brunswick Green systems (A5-11 and 13) showed considerable fading while the corresponding two-coat systems (A5-12 and 14) darkened considerably.

Biological growth at the jungle site commenced during the first few months, and at the end of the trial all specimens had a fairly substantial and uniform coating of mould and algal growth associated with copious dirt and organic debris adhering to the surfaces (Fig.40). The growth was generally dark in colour, consisting of a mixture of various types of mycelia, spores, algal cells and filaments. The only fungi identified were Gliocladium roseum and Penicillium lilacinum.

At the desert site, chalking of all specimens commenced after two to six months and, in most cases, was fairly severe at the end of the trial. Specimens showing particularly heavy chalking were A5-10, 12, 14 and 18, but A5-1, 7, 8, 9 and 15 showed this defect to only a slight degree. Generally, the two-coat systems chalked more heavily than the one-coat and the finishes based on the draft specification less than those to the B.S. Specifications.

Slight checking of two specimens at the jungle site (A5-4 and 6) and two at the desert site (A5-6 and 18) occurred. System A5-5 checked rather more extensively at the desert site. Most of the paints affected by checking were Red Oxide finishes and all of them were B.S. Specification paints.

/Considerable

Considerable cracking of both panels of systems A5-5 and 11 and slight cracking of one panel of system A5-17 had taken place before the panels were put on exposure. The latter was exposed at the jungle site; the duplicate of this system exposed at the desert site was in good condition. At the end of the trial five more panels at the jungle site had cracked: A5-5, 6, 11 and 12, were assessed as bad failures (Fig.39) and A5-3, 4, 15 and 17 as slight. (These were all B.S. specification paints except A5-15). The entire surfaces of two of the former (A5-6 and 12) were covered with cracks (Fig.37). At the desert site, five more panels, apart from A5-5 and 11, showed cracking at the end of the trial but it was only very slight. The systems affected were A5-6, 12, 13, 17 and 18 (all B.S. specification paints except A5-13).

At the jungle site, three specimens (A5-10, 15 and 16) showed very slight flaking and one (A5-2) considerable flaking at the end of the trial. The latter (two coats Postans Red Oxide to draft specification) began to flake after only four months exposure. Three specimens (A5-13, 16 and 18) blistered very slightly towards the end of the trial; A5-2 commenced to blister after sixteen months but was assessed as only a slight failure at the end. Blistering on A5-17 (one coat of black finish to B.S. specification) was first observed after over two years exposure but it developed rapidly and this specimen was regarded as a considerable failure at the end.

At the desert site, three panels (A5-12, 13 and 18) rusted very slightly and one (A5-11) considerably. With the exception of A5-11, the rusting was not recorded until the last stages of the trial. At the jungle site, eleven panels showed rusting at the end of the trial, seven only very slightly (A5-2, 5, 6, 13, 15, 16 and 18). Rusting was heavier on the other four (A5-4, 11, 12 and 17) and was associated with the cracking of the paint films. Most of the panels at this site did not show any rusting until they had been exposed for over two years. Generally, rusting at both sites was associated more with paints formulated to the B.S. specifications.

The most successful systems were A5-1, 7, 8 and 14 (all formulated to proposed new draft specification) and the worst were A5-11, 12, 5 and 6 (all B.S. specification paints).

4.2.6 Ready Mixed Oil Paints (2nd Trial sponsored by Ministry of Supply, Chemical Inspectorate)

This was an extension of the previous trial (see Section 4.2.5). The same paint systems were used (Appendix A.5) but in this part of the trial, all the mild steel panels were painted in Nigeria and tested for only two years (27). The panels were exposed in the jungle clearing on 8.3.56 and in the desert on 9.3.56.

The results obtained did not confirm those of the previous section, since there was no significant difference between paints to the existing B.S. specification and those formulated to the revised draft specification.

All specimens commenced to lose gloss after one to three months at both exposure sites, although in the jungle clearing the loss was, at least partly, a result of considerable dirt collection. This, together with the heavy biological growth which developed, made assessments at the jungle site difficult throughout the trial. The initial gloss rapidly disappeared at the desert site and after about six months no trace of it remained on most specimens. Systems A5-5 and 6 were slightly better than the rest.

/All

All specimens began to fade after about six months at the desert site, and after two years all the Light Brunswick Green panels showed heavy fading. The Red Oxide specimens were only moderately and the Black finishes only slightly affected in this respect. At the jungle site, slight fading of all the specimens was reported during the first three months and again after twenty-one months, but slight darkening after about a year was recorded. However, the assessment of colour change at this site was complicated by the dirt collection and fungal growth which developed.

Very heavy dirt collection and a considerable amount of biological growth was reported on all the specimens in the jungle clearing. The latter consisted of a mixed algal and fungal coating, mainly superficial, and was in close association with organic debris adhering to the surfaces.

Chalking commenced at the desert site after four to six months exposure and at the end of the trial was moderate to heavy on all panels except A5-1. The latter (one coat Postans Red Oxide to draft specification) showed this defect only slightly.

Very slight checking was reported on four specimens (A5-4, 7, 15 and 17) after approximately one years exposure at the jungle site but it was not detected at the end of the trial. Systems A5-5 and 11 showed slight checking at the final inspection; slight checking of systems A5-12 and 14 and heavy checking of A5-6, noted early in the trial, later developed into cracking. No checking was observed at the desert site. At the end of the trial, two panels at the jungle site (A5-12 and 14) showed slight cracking and one (A5-6) severe cracking (Fig.41). The latter (two coats of Postans Red Oxide to the B.S. specification) also cracked slightly at the desert site. Very slight flaking of two specimens at the jungle site occurred (A5-7 and 9). At the desert site, very slight blistering of five panels (A5-3, 5, 6, 14 and 18) observed in the early stages of the trial disappeared soon afterwards and was not recorded again.

At the end of the trial three of the Light Brunswick Green panels at the jungle site (A5-11, 12 and 14 (Smith and Walton)) had rusted very slightly.

Only one system (A5-6) showed severe breakdown and this was in the form of cracking.

4.2.7 Paints for Harbour Use (Robert Brown & Co. Ltd.)

Four paint systems considered suitable for tropical harbour installations were exposed at the town site, Port Harcourt, for 21 months and at the harbour site for 19 months (32). Details of the systems are given in Appendix A.6: they were applied to mild steel panels 6 inch x 4 inch at T.T.E. and were exposed at Port Harcourt on 11.10.56 and at the harbour site on 20.12.56.

All the paints lost gloss and chalked but there was no serious breakdown of any system. The metallic paint appeared to be the most satisfactory.

The non-metallic paint systems, A6-1, 2 and 3 started to lose gloss after three to six months exposure and at the town site very little remained after twenty-one months. At the harbour site the first two systems showed only slight loss of gloss after eighteen months but A6-3 was rather worse in this respect. The metallic paint system (A6-4) showed no loss of gloss during the first fifteen months and at the end of the trial it was only slight at both sites.

/Fading

Fading of systems A6-1, 2 and 3 commenced after about six months and at the town site became heavy on all three. At the harbour site, systems A6-1 and 3 were only slightly faded after eighteen months; A6-2 had faded rather more. The surfaces of all the specimens at both sites collected a considerable amount of dirt but this was mainly superficial and easily wiped off. After six months exposure, a biological examination showed the presence of the fungus Pullularia sp. on all the panels but the growth was only light and the paint films were not damaged.

Systems A6-1, 2 and 3 commenced to chalk after about six months, and at the end of the trial heavy chalking of all three were recorded. System A6-4 chalked only slightly at the town site but rather more at the harbour site.

No serious breakdown of any of the systems in the form of chalking, cracking, flaking, blistering or rusting was recorded throughout the trial.

4.2.8 Experimental Metallic Paints (W. and S. Leigh, Ltd.)

Two metallic paints were exposed for two years at four different sites to compare the performance of a conventional aluminium paint with one in which the main pigment was micaceous iron oxide (33). The paints, details of which are given in Appendix A.7, were applied to steel panels 8 inch x 6 inch, both at T.T.E. and in the U.K. The panels were exposed in the desert on 5.6.56, at the town site on 12.6.56, in the jungle clearing on 29.6.56, and at the marine site 200 yards from the surf line on 18.7.56.

Both systems were very successful even under the highly corrosive conditions of the marine site, and during the two years exposure only very minor changes were noted in the specimens. Slight changes of colour observed were probably connected with the dirt which collected on the surfaces, especially at the jungle and desert sites. Slight chalking of both systems was recorded at the desert site but A7-2 (micaceous iron oxide) chalked rather more towards the end of the trial at the marine site. System A7-1 (aluminium) blistered slightly at the marine site during the latter stages of the trial. On the whole, the micaceous iron oxide paint proved to be slightly superior to the one based on aluminium.

4.2.9 Commercial Paints (International Paints, Ltd.)

This was a trial to assess the behaviour of commercial paints under hot damp tropical conditions (35). The paints, which are described in Appendix A.8, were applied to mild steel panels, 12 inch x 6 inch, in the U.K. and were exposed for eighteen months at Port Harcourt town site. The date of exposure was 17.1.57.

Slight changes of colour and considerable loss of gloss and chalking occurred, but otherwise there was no serious breakdown.

All specimens lost their initial high gloss fairly rapidly; after nine months it had been lost almost completely in most cases. Only two systems, the green and black Sunlight Enamels (A8-9 and 10), showed any superiority in gloss retention, having lost only a slight amount of gloss after nine months. They had however lost rather more at the end of the trial.

Most of the specimens appeared to fade to some extent during the initial stages of the trial, but darkening was recorded on some (especially /the

the white and aluminium finishes). However, the assessment of change of colour was influenced to some extent by loss of gloss and dirt collection.

Very slight fungal growth developed on the white finishes and rather more on the red oxide and P.C. red. The green, black and aluminium panels did not appear to support fungal or algal growth. The short oil alkyd, white specimen (A8-14) developed a superficial covering of heavy green algal growth (Fig.42).

Most of the finishes began to chalk after about four months exposure. However, the two aluminium systems (A8-6 and 12), although showing very slight chalking during the first few months, did not exhibit this defect at all at the end of the trial. After eighteen months, all the red oxide and white panels were chalking considerably, as were all the 'Episeal' finishes with the exception of the aluminium.

No serious breakdown of any of the paint films occurred in the form of chalking, cracking, flaking, blistering or rusting during the whole period of exposure.

During the course of this trial the hardness of some of the paint films (A8-3, 5, 11 and 14), was measured by the standard scratch test apparatus, in which gradually increasing weights were applied to a ball-ended stylus which was drawn slowly over the painted surface, the load causing penetration of the film being determined. The resistance to impact of the same specimens was also measured by dropping loaded steel balls on to the surface from increasing heights until fracture of the film occurred. These tests were carried out on extra specimens supplied by the sponsors at the request of T.T.E. in an attempt to evaluate the use of objective physical methods for assessing paint film deterioration. It was found that the hardness of the films did not change significantly during the eighteen months exposure; the two 'Episeal' finishes (A8-3 and 5) were slightly harder than either of the others both before and after exposure. The resistance to damage by impact of all four specimens decreased during the eighteen months exposure, the decrease of A8-14 (short oil alkyd, white) being large and rapid and of A8-3 (Epilote ester, green) only slight. The other two were intermediate in value.

4.2.10 Chlorinated Rubber Paints (Tretol Ltd.)

This trial was carried out in two parts (8, 12) and was designed to study the effect of chlorinated rubber as a vehicle of anti-corrosion paints. The paints were applied at T.T.E., as described in Appendix A.9, to mild steel panels 4 inch x 2 inch, and the panels were then exposed to the corrosive atmosphere of a tropical surf beach for fifteen months and immersed in lagoon water of low salinity for ten months. Details of exposure are given in Table 5.

/Table 5

Table 5

Site	Date Expired	Duration of Exposure (months)
Marine (50 yd from surf line)	28.4.52	15
Marine (200 yd from surf line)	28.4.52	15
Wilmot Point, Lagos	22.9.53	10
Lagoon Site, Lagos (wind/water zone)	21.9.53	10
Lagoon Site, Lagos (total immersion)	21.9.53	11

The paint system appeared to be very effective in its corrosion-inhibiting properties under severe conditions of exposure.

During the first nine months exposure at the marine site, very little deterioration of the paint occurred apart from slight darkening of the colour. However, after twelve months, extensive checking had developed and at the 50-yard site there was also some cracking. Slight blistering and small rust spots associated with the blisters had appeared at both the 50-yard and 200-yard sites. After fifteen months, the system showed severe cracking (Fig.43) but blistering was still only slight and the panels showed only slight corrosion.

The specimens on aerial exposure at Wilmot Point, Lagos remained in very good condition throughout the ten months exposure period (Fig.45).

In the wind/water zone at the lagoon site, the general condition of the paint appeared good after ten months (Fig.45). The surface became slightly infested with barnacles after three months but there was little further increase in fouling during the remainder of the trial. When the specimen was withdrawn from exposure, about two per cent of the surface was covered with small blisters caused by rusting of the substrate under the paint film. When the barnacles were removed, it was found that the paint film had been damaged where they had been attached and rusting had commenced at the damaged areas.

The panel totally immersed at the lagoon site became much more heavily encrusted with barnacles, about seventy-five per cent of the surface being covered after eleven months. As in the case of the wind/water exposure, rusting had commenced at the areas where the barnacles had been attached. Where the paint was still visible, it was in good condition and, on removal of the paint film, it was found that the steel below these areas of unfouled paint was still completely free from corrosion.

The protection conferred to the mild steel panels by the paint system is shown in Table 6, which compares the total corrosion after the panels were withdrawn from the exposure sites with the monthly rate of corrosion of unprotected mild steel at the same sites (45).

/Table 6

Table 6

Corrosion Rate of Painted and Unpainted Steel Panels

Exposure Site	Total Corrosion of Painted Panels (g/100 cm ²) (Exposure time in brackets)	Corrosion Rate of Unprotected Mild Steel (g/100 cm ² /month)
Marine : 50 yd	0.71 (15 months)	5.60
Marine : 200 yd	0.56 (15 months)	2.35
Wilmot Point	0.40 (10 months)	0.33
Lagoon : wind/ water }	0.25 (3 months) 1.61 (10 months)	6.7
Lagoon : total immersion }	0.45 (3 months) 14.82 (11 months)	4.5

In the wind/water zone of the lagoon site where corrosion of unprotected mild steel is higher, the protection afforded by the paint was much greater than in the totally immersed condition. However, the high corrosion rate in the latter case was undoubtedly influenced by the activity of the barnacles mentioned above.

4.2.11 'Avaro' Silica/Graphite Paints (C.R. Averill, Ltd.)

This trial was also carried out in two parts (7, 13); painted panels were exposed at the same sites (Section 4.2.10) to observe the effect of paints containing silica and graphite on the corrosion of steel under tropical conditions. Mild steel panels, 4 inch x 2 inch, were painted at T.T.E. as described in Appendix A.10 and exposed as shown in Table 7.

Table 7

Site	Date Exposed	Duration of Exposure (months)
Marine (50 yd from surf line)	28.4.52	15
Marine (200 yd from surf line)	28.4.52	15
Wilmot Point, Lagos	22.9.53	10
Lagoon Site, Lagos (wind/water zone)	21.9.53	10
Lagoon Site, Lagos (total immersion)	21.9.53	11

The results showed that the paints provided very limited protection to steel exposed to corrosive surf beach atmospheres and immersed in water of low salinity.

All the specimens exposed at the marine site faded slightly and lost most of their gloss during the first three months, System A10-5 being the most affected.

At this stage, slight breakdown of the systems had commenced, as evidenced by rust staining along the western edges of most panels.

After three months at the 50-yard site, System A10-1 (primer only) showed the most serious breakdown in the form of considerable blistering and rusting and System A10-2 (primer and undercoat only) showed some flaking. System A10-3 (silica/graphite, medium grey finish with primer and undercoat) generally appeared to provide the best protection. After twelve months most panels showed fairly heavy rusting, approximately fifty per cent of the surfaces being affected, although the rusting was much less severe at the 200-yard site (Fig.44 shows specimens after fifteen months exposure). At this site, no cracking of the paint films was apparent but slight blistering developed on A10-2, 3, 4 and 5. At the 50-yard site, blistering and cracking were in evidence on all panels especially round the edges. Breakdown of most of the systems appeared to have developed at the edges and spread inwards but A10-5 was rusted fairly uniformly over about 70 per cent of the surface.

During the first three months at Wilmot Point there was little deterioration except for rusting of panel A10-1. For the remainder of the specimens, rusting commenced much later and was mainly confined to the edges of the panels. After ten months about 70 per cent of the surface of A10-1 was rusted and the remainder were moderately rusted (5 - 25 per cent of the surfaces). There was no noticeable difference in the protective effect of the four finishes (Fig.45).

At the lagoon site, the specimens in the wind/water zone and those fully immersed had commenced to rust after three months and were beginning to foul with barnacles. After ten months, barnacles covered about 75 per cent of the panels and heavy rusting had developed. There was no appreciable difference in the appearance of the specimens (Fig.45).

The protection conferred on the steel panels by the paint systems is shown in Table 8, which compares the total corrosion after the panels were withdrawn from the exposure sites with the monthly rate of corrosion of unprotected mild steel at the same sites (45).

/Table 8

Table 8
Corrosion Rate of Painted and Unpainted Steel Panels

Exposure Site	Total Corrosion of Painted Panels (g/100 cm ²) (Exposure time, in months, in brackets)						Corrosion Rate of Unprotected Mild Steel (g/100cm ² /mth)
	A10-1	A10-2	A10-3	A10-4	A10-5	A10-6	
Marine : 50 yd	2.46 (15)	0.47 (15)	1.61 (15)	1.61 (15)	3.15 (15)	2.19 (15)	5.60
Marine : 200 yd	0.39 (15)	0.18 (15)	0.35 (15)	0.54 (15)	0.20 (15)	0.26 (15)	2.35
Wilmot Point	3.02 (10)	1.19 (10)	1.56 (10)	0.83 (10)	2.87 (10)	2.08 (10)	0.33
Lagoon : wind/water	0.40 (3)	0.46 (3)	0.56 (3)	0.94 (3)	3.17 (3)	0.44 (3)	6.7
	20.83 (10)	14.85 (10)	18.03 (10)	18.63 (10)	10.35 (10)	10.15 (10)	
Lagoon : total Immersion	-	2.95 (3)	0.46 (3)	-	-	2.80 (3)	4.5
	19.40 (11)	-	23.71 (11)	32.50 (11)	21.33 (11)	23.28 (11)	

It will be observed in Table 7 that the extent of corrosion of the painted panels was generally higher at Wilmot Point than at the more highly corrosive marine site (50 yard compound). This anomalous result may be explained by the fact that the painting and siting of the specimens were carried out at different times and the panels at Wilmot Point may have been subject to splashing. Corrosion at Wilmot Point was comparable with that which would be expected with unpainted mild steel exposed for the same period. This indicates no protection by the paint system.

4.2.12 Painted Steel and Aluminium Panels (Trial sponsored by the Inter-services Panel for Co-ordination of Research and Development on Paints and Varnishes)

Various paint systems, listed in Appendix A.11, were exposed for three years in the jungle clearing and the progress of deterioration was recorded (2). The paints were applied in the U.K. to mild steel and aluminium panels, 12 inch x 6 inch, and were exposed on 28.5.48.

The least protection on steel was provided by the single-coat system DL.6119 and the two-coat system DL.5517/6030. The other two-coat systems were also poor. The three-coat system DL.6112/6113/6114 gave the best protection of all but the other three-coat systems were also good.

The single-coat systems DL.6114 and DL.6119 provided the least protection on aluminium. Some breakdown also occurred with the single-coat systems DL.6116, DL.6117, DL.6118 and DL.6121, but DL.6123 and DL.6130 provided good protection as single coats. Generally, there was /little

little to choose between the two and three-coat systems on aluminium. They all gave good protection with the exception of DL.6120/6121 which showed slight breakdown.

All the specimens lost gloss and the initial glossy surfaces had become matt after three years exposure. Discolouration was a fairly general fault in the initial stages of the trial and most of the finishes had faded after three years. The most seriously affected in this respect were those with paints DL.6123 and DL.6030 as the top coats, viz: A11-7, 8, 20, 21, 22 and 23. There were signs of fungal growth after six months on most of the surfaces and, after two years, fungal growth, which was mainly superficial, had developed on all but three of the specimens. Pestalotia sp. and Pullularia sp. were the predominant fungi identified. The specimens which were free of fungus at this stage were A11-7, 14 and 23.

Chalking was a common defect and was present in varying degrees on all specimens. The paints which chalked most heavily were DL.6114, DL.6118, DL.6116 and DL.6123. DL.6114 commenced to chalk after only four months, and after twelve months, all but one of the panels (A11-5) showed some chalking. Generally, the paint DL.6117 chalked least.

Checking was confined to paint DL.6116 (specimens A11-4, 15 and 16), being most extensive on the steel panel (A11-4). Checking was first observed after only four months exposure and at the end of the trial it had developed into slight cracking on all three specimens.

Flaking had commenced on five specimens after twelve months exposure, viz: A11-6, 8, 17, 18 and 22. After three years, flaking was heaviest on A11-8, 17, 18 and 22 but was also present on A11-2, 6, 11, 12, 13 and 23.

Blistering was in evidence to some degree on all the specimens at the end of the trial, and even before the panels were placed on exposure it was recorded on all the specimens coated with DL.6116, DL.6117, DL.6118 and the two aluminium panels with DL.6030 (A11-22 and 23). After twelve months, all but A11-1 and 12 showed blistering. Paint DL.6123 was least affected at the end of the trial.

After twelve months exposure, the blistered areas of two of the steel panels (A11-5 and 8) had developed considerable rusting and there was slight rusting on A11-6. After three years, there was heavy rusting of A11-5 and 8, slight rusting of A11-6 and 7 and only very slight rusting of A11-2, 3 and 4. Only one steel panel (A11-1) was free from this defect.

Of the paint systems on aluminium panels, A11-10 (DL.6114, single-coat system) broke down almost completely after about eighteen months and large areas of the underlying aluminium showed white corrosion. After twenty-one months, corrosion of the substrate had commenced under the paint on three more panels (A11-18, 19 and 16). At the end of the trial, seven of the fifteen aluminium panels showed corrosion of the underlying metal. This was heavy on A11-10 and 17 (single-coat systems), where there was almost a complete breakdown of the paint film, and less heavy on A11-12, 14, 16, 18 and 19 (all single-coat systems except A11-18 which was the two-coat system DL.6120/6121).

4.2.13 Painted Light Gauge Steel Panels (Trial sponsored by the Tropicalisation Panel of the Ministry of Supply Metal Finishing Committee)

This was part of a comprehensive trial of ferrous and non-ferrous metals protected by surface treatments (6). Light gauge steel panels treated in various ways were painted with commercial general purpose paints designated "good" and "poor" quality and were exposed at two sites for two years. The

/paints

paints were applied to the panels (6 inch x 4 inch) in the U.K. and were exposed in the jungle clearing on 8.5.51, and at the marine site, 200 yards from the surf line, on 23.5.51.

At the jungle site most of the painted panels remained in good condition throughout the trial, slight rust only occurring on some of the panels with the thinnest metal coatings beneath the paint. This rusting was mostly associated with "poor" paint. At the marine site, heavy rusting occurred on many of the panels with thin metal coatings: there was little distinction between the "good" and the "poor" materials. Specimens exposed at the marine site inside a ventilated box remained in very good condition with only a trace of rust on two of the specimens with "poor paint".

4.2.14 Painted Steel Plates (Trial sponsored by the British Iron and Steel Research Association in collaboration with the Ministry of Supply Metal Finishing Committee)

This trial was arranged to investigate the effect of the type of finishing coat, primer and pretreatment of metal on the protection of steel. The treatments, which are described in Appendix A.12, were applied in the U.K. to steel plates (15 inch x 10 inch) and exposed at two sites for eight and a half years (19). The plates were exposed on 23.12.48 in the jungle clearing and on 28.11.48 at the marine site 200 yards from the surf line.

The greatest deterioration was associated with primer 336/3 but, otherwise, there was very little correlation between the extent of deterioration and the type of paint used at either exposure site.

At the jungle site, rusting was confined to the pickled steel panels and none of the metal-coated specimens showed any deterioration other than slight blistering and flaking of the protective paint. On most of the pickled panels fine blisters appeared immediately after exposure and the blistering became moderate-to-heavy after two years. This was followed by some flaking after about three years. Fine blisters also appeared on the terne-coated and aluminium-sprayed panels at an early stage and the former showed slight flaking after about seven years. The paint on all the galvanized panels showed fine blistering shortly after exposure and flaking became severe at the edges of two of them (A12-20 and 24) after seven years. All the pickled panels started to rust during the first year and this was accompanied by considerable rust staining of the paint. The amount of rust on the panels thereafter remained fairly constant during the remainder of the trial. The aluminium-sprayed and galvanized panels remained free from rust, but slight rust staining of one of the terne-coated specimens (A12 - 18) was observed after seven and a half years. No white corrosion products of the metal coatings on the panels was observed throughout the trial. After three years, all the specimens had heavy lichenous and algal growths on their surfaces and this made subsequent observations on the condition of the paint films difficult and, perhaps, not very accurate. The amount of growth fluctuated with the seasons but remained generally as a complete mat for the remainder of the trial. Finish 403 was associated with the heaviest and 402 with the lightest biological growths.

At the marine site, the pickled steel rusted heavily and rusting had commenced on the terne-coated panels at the end of the trial. All specimens showed various degrees of flaking of the paint film. Chalking of most of the finishes commenced after about three months and became generally heavy as the trial progressed. Erosion of many of the paints was also evident at the end of the trial. Blistering was reported on all /specimens

specimens on at least one occasion during the trial, the least affected in this respect being three of the aluminium-coated panels (A12-13, 15 and 17) which all showed fine blistering on only one occasion. All the pickled panels showed varying degrees of blistering and flaking, the former having commenced almost immediately after being exposed and the latter after about three years. The paint was flaking on all specimens at the end of the trial. Rust and rust staining of the paint surfaces appeared on all the pickled specimens within a few weeks of exposure and this increased steadily throughout the trial. The amount of rust on the various specimens differed considerably; at the end of the trial, from five to fifty per cent of the surface of most panels was affected by rusting. Slight rusting of the terne-coated specimens commenced after one year (A12 - 18) and three years (A12 - 19), and although it increased somewhat during the remainder of the trial it did not become serious. The aluminium-sprayed and galvanized panels remained free from rust throughout the trial. White corrosion products appeared on all the metal-coated panels at some time during the trial; they were very friable and washed off easily and were only recorded when the specimens were inspected after a dry spell of weather. On some specimens, more than twenty-five per cent of the surface was covered with these white corrosion products at intervals during the trial but all specimens were free from them when the trial ended.

When arranged according to the extent of rusting, the pickled panels (i.e. without a protective metal coating) fell into the following order:

Jungle Site: A12 - 1 (least rusting), 10, 6, 11, 2, 7, 3, 9, 12, 8, 4 and 5 (most rusting).

Marine Site: A12 - 3 (least rusting), 2, 11, 1, 12, 4, 8 and 7 (most rusting).

These results indicate that, at both sites, Primer 336/3 is the least effective in preventing rusting and Finish 403 is the least effective of the finishing coats. Finish 401 was associated with the least rusting at both exposure sites.

4.2.15 Priming Schemes for Metallic Coatings (Trial sponsored by the British Iron and Steel Research Association)

The effect of type of priming paint on the protection of steel was investigated by exposing painted panels and fabricated specimens of complex shape (Fig.18) at the marine site for nineteen months (30). Normally such a trial should last several years but it had to be terminated prematurely because of the closure of T.T.E.

The pretreated panels, 15 inch x 10 inch, and complex shapes were painted at T.T.E. as shown in Appendix A.13 and were exposed 200 yards from the surf line on 10.1.57.

The metal-sprayed panels showed no breakdown of the metal coatings and only a few paint failures, the latter being confined to fine blisters and erosion of the paint on some of the aluminium-sprayed panels (Fig.46). Of the uncoated steel panels, those which had been grit-blasted and painted showed far fewer paint failures than those on which the pre-treatment had been pickling, weathering and wire-brushing (Fig.47).

Of the painted complex shapes (all of which were metal coated) only those on which Primer 589 was used showed any breakdown. This was most severe on the aluminium-sprayed specimen (A13 - 19), considerable corrosion of the metal coating having commenced (Fig.48).

/Or

Of the four priming paints tested, Primer 589 was by far the least satisfactory in providing protection for both metal-sprayed and uncoated steel panels and complex shapes. When painting the specimens it had been observed that this primer was very difficult to mix, was too thick for easy brush application, and dried or at least skinned over too rapidly to allow a good finish to be obtained. There were no obvious differences in the protective properties of the other three primers during the nineteen months exposure period.

4.2.16 Protective Paints for Structural Steel (Jenson and Nicholson Group)

The behaviour of commercial paint systems for the protection of structural steel under tropical conditions was assessed by exposing specimens at four sites in Nigeria for about seventeen months (36). The paint systems, which are described in Appendix A.14, were applied to mild steel panels 12 inch x 6 inch at T.T.E. and were then exposed at the town site and in the jungle clearing on 7.2.57, in the desert on 8.2.57, and at the marine site 200 yards from the surf line on 9.2.57.

There was a very marked loss of gloss and slight fading on all specimens at the town, marine and desert sites which could be attributed to the effect of strong sunlight; at the jungle site, the gloss soon became obscured with biological growth and dirt collection, and the finish appeared to darken as a result of staining. All the specimens soon showed chalking at the town, marine and desert sites and this defect was generally assessed as severe at the end of the trial. Slight cracking of specimens A14 - 1 (red lead primer) and A14 - 3 (red lead/white lead primer) at the town and marine sites and of A14 - 3 at the jungle site developed towards the end of the trial; no cracking was reported at the desert site. Rusting of specimens A14 - 1 and 3 commenced at the town site after thirteen months; after seventeen months, it was still generally slight but rather heavier on A14 - 3 than on A14 - 1. At the more highly corrosive marine site, rusting of all three systems commenced after about ten months and at the end of the trial was generally fairly well advanced, all three systems being more or less equally affected. No rusting was observed at the jungle or desert sites.

In general, System A14 - 2 (zinc chromate/red oxide primer) appeared to provide rather more protection than did the other two, being free from cracking at all sites and preventing rusting at the town site for seventeen months. However, at the marine site, it showed no superiority over the other two systems in resisting the onset and development of corrosion of the metal.

The red lead and red lead/white lead primers originally supplied by the manufacturer for this trial were unsatisfactory as regards drying properties, and further supplies had to be obtained before it was possible to adhere to the painting schedule, viz. twenty-four hours drying between each coat.

4.2.17 Admiralty Paint Systems (Trial sponsored by Admiralty Chemical Department)

Fourteen paint systems comprising combinations of two primers, a standard undercoat and seven formulations of a standard topcoat were exposed on a tropical surf beach for over three years (20). The paint systems, listed in Appendix A.15, were applied in the U.K. to steel panels 12 inch x 12 inch and these were exposed 120 yards from the surf line on 20.2.54.

The systems with Red Lead primer were generally in a better condition than those with Cream Rustodian, but little difference between the seven modifications of the topcoat was apparent.

Most of the specimens commenced to chalk after three to four months, although four of them (A15 - 3, 4, 13 and 14) were free from this defect or only slightly affected during the first twelve months exposure. At the end of the trial, A15 - 6, 7, 10, 11, 12, 13 and 14 showed only slight, and the remainder heavy, chalking. During the first seven months, all the panels with the exception of A15 - 13 showed slight blistering; this became generally heavy towards the end of the trial on all specimens but rather less severe on A15 - 2, 10, 12 and 14. All specimens showed cracking at the end of the trial and this defect was particularly severe on A15 - 4, 6, 10 and 12 where the cracks generally followed the brush marks. These four specimens commenced to crack after only three months exposure. On the other hand, A15 - 13 did not show this defect at all during the first three years and was only slightly affected at the end of the trial.

Rusting was apparent on all panels after only two months exposure and progressively increased for the remainder of the trial. Rusting generally commenced at the edges of the panels and spread inwards until five to eight per cent of the surfaces of the Red Lead and approximately ten per cent of the surfaces of the Cream Rustodian specimens were affected. The latter were also heavily rust stained over about ninety-five per cent of the surface.

Flaking of two of the specimens with Red Lead primer (A15 - 7 and 11) and of several of the Cream Rustodian specimens occurred towards the end of the trial.

4.2.18 Service Paint Systems (Cellon, Ltd.)

Thirty-four Service paint systems on metals used in aircraft equipment were exposed for three and a half years on a tropical surf beach (39). The paint systems, which are listed in Appendix A.16, were applied in the U.K. to substrates of steel, cadmium-plated steel, aluminium, and magnesium. These were then exposed 100 yards from the surf line on 9.1.52.

After two years, some of the steel panels had disintegrated and at the end of the trial the rest were very heavily rusted. On non-ferrous systems, assessment of the relative merits of different paints was complicated by the widely differing amounts applied (See Appendix A.16). Aluminium panels to which both a primer and an undercoat had been applied were still in good condition at the end of the trial: those with a primer only were not so good. The magnesium panels were all corroding heavily.

The results obtained in this trial are more conveniently divided under the various substrate headings as follows:

(1) Aluminium Chalking on these panels was usually heavy and wide-spread with the exception of A16-1 and 4 (D.T.D. 766A Finish) where it developed to only a slight extent. All specimens showed some blistering at some stage but it was generally only slight. Exceptions were A16-2, 5, 7 and 11 (D.T.D. 63B, Grey Finish) where fairly heavy blistering had developed at the end of the trial. The best in this respect were A16-12, 13 and 14 (C.S. 2354 Undercoat and C.S. 2000E, Grey Finish). The substrate of specimens A16-2, 5, 7 and 11 (D.T.D. 63B, Grey Finish) showed heavy white corrosion after eight months, and during the last year of the trial A16 - 1 and 4 (D.T.D. 766A Finish) became fairly extensively corroded. The remaining specimens showed only a negligible degree of
/corrosion

corrosion. Specimen A16-11 (D.T.D.63B) was the only one which flaked to any substantial degree.

On aluminium, therefore, the finishing coat D.T.D.63B, Grey was the least successful, showing very marked blistering and corrosion of the metal. Of the other two-coat systems tested, the finish D.T.D. 766A was somewhat better but began to show some breakdown after about a year; finishes D.T.D.827, Grey, D.T.D.235A and S.097, Grey provided good protection for three and a half years. The three-coat systems, as might be expected, provided the best protection of all. The type of primer used appeared to have little effect on the protective qualities of the paint systems on aluminium.

(ii) Steel All the steel panels were heavily rusted at the end of the trial and many were beginning to disintegrate (Fig.49). Systems A16-15 to 20, with a primer and finishing coat only, were the first to fail and, in most cases, there was complete breakdown of the paint film and heavy rusting after little more than a year. Of these two-coat systems, the most successful were A16-20 (Primer S.X.41, Finish D.T.D.827, Grey) and A16-16 (Primer S.5179, Finish D.T.D.827, Grey). The multi-coat systems (A16-21 to 27), made up of two priming coats, one under-coat and two finishing coats, provided slightly more protection but all of these were heavily rusted after two years. A16-23 delayed the onset of rusting longer than the others but, otherwise, there was little to choose between the systems. Rusting of all the steel panels commenced so soon (after about two months in most cases) and became so extensive that the assessment of other defects of the paint soon became impossible. However, there appeared to be no significant difference between the various systems during the initial stages of the trial.

None of these paint systems applied to steel was particularly successful in protecting the metal against corrosion at the marine site, and two-coat systems consisting of primer and finish only were virtually useless.

(iii) Magnesium The paint systems applied to the three magnesium panels differed only in the primer used, in each case the undercoat being S.X.44, Brown and the finishing coat D.T.D.63B, Grey. Chalking commenced on all after two to three months and became heavy after about a year. Severe blistering developed on A16-28, (primer S.5179) but it was generally only slight on A16-29 and 30 (primers S.4853 and S.X.44). After only four months, flaking commenced on A16-28 but not until the last year of the trial on A16-29 and 30. In all cases, corrosion of the substrate commenced after about a year and became heavy towards the end of the trial; A16-28 was the most seriously affected.

Primer S.5179 therefore appeared to be the least satisfactory, but the thickness of coat applied was considerably less than for the other two. There was no significant difference between the performances of Primers S.4853 and S.X.44.

(iv) Cadmium-plated Steel White corrosion of the plating metal and rusting were heaviest on A16-32. On A16-33, slight white corrosion had appeared at the end of the trial but rusting was absent, while on A16-31, heavy white corrosion but only slight rusting had developed. In one respect, viz. 'flaking', A16-33 was inferior to the others. It was generally slight on A16-31 and 32 but severe on A16-33.

Although the results indicate that Primer S.X.41 provided the most protection, the weight applied was almost three times greater than in the case of the other two.

4.2.19 Paint Systems on Light Alloy (Trial sponsored by the Inter-Services Research Group)

Four types of paint were exposed to hot dry conditions at a desert site in Nigeria for three months (10). Light alloy panels 8 inch x 6 inch were each painted in two sections, one of which was designated "wet" to signify that this portion had been wetted during the application of the paint to simulate rain. Reference numbers of the paints are given in Appendix A.17 but no information on the type of paints was available except that they were required to Cellulose, Light Aluminium to D.T.D.766A, and to be rapidly and completely removed with solvents without damage to the cellulose finish. Painting was done in the U.K. and the panels were exposed in the desert on 24.12.53.

Very little deterioration took place during the short exposure period.

Before exposure, the "wet" half of each specimen generally presented a rather more mottled appearance than the other half. After three months exposure, slight chalking of the blue and red paints (A17-3 to 6) was recorded, the latter being rather more affected than the former; the "wet" halves of these systems (A17-3 and 5) chalked rather more than the other portions. The blue, red and black paints all showed slight loss of gloss.

4.2.20 Car Finishes (Trial sponsored by Messrs. F.I.A.T. Motors of Turin)

This trial was arranged to examine the resistance to tropical exposure of various paints used for car finishing, and to study the correlation between artificial weatherometer testing and natural weathering in the tropics (11). Eleven types of car finishes, listed in Appendix A.18, were exposed for six months at three sites in Nigeria. The finishes were applied in Italy to mild steel and light alloy panels, 5 inch x 3 inch. These were exposed in the jungle clearing on 29.10.53, in the desert on 17.11.53, and at the marine site 50 yards from the surf line on 25.10.53. At all the exposure sites, the specimens were exposed at 30° to the horizontal facing south instead of the usual orientation of 45°. This was in accordance with the general practice followed by the sponsors.

The sponsors also exposed a similar set of panels in a weatherometer at the F.I.A.T. Laboratories in Turin, for a total of five hundred hours, to a cycle consisting of sixty-four minutes exposure to light alone and sixteen minutes to light and water spray. After this treatment, the finishes showed little deterioration; there was a slight loss of gloss but this was restored by polishing (Fig.50).

The condition of the specimens at the jungle and desert sites also remained good throughout the six months exposure and little difference between the various finishes was apparent. At the jungle site, a light surface covering of algal growth developed during the first month and obscured the initial gloss. This growth increased somewhat during the following five months (Fig.50). At the desert site, there was little change in any of the specimens apart from slight loss of gloss of A18-10 (Orange Tractor Finish).

After one months exposure at the marine site, all the steel panels (A13-1 to 10) showed slight rusting and there was very slight blistering on all but A18-8 and 9 (lacquers). At this stage, A18-10 showed also some cracking and flaking of the paint but these defects were largely confined to the edges. The breakdown of the paint film (in the form of blistering /and

and cracking) and rusting of the panels progressed rapidly during the remainder of the trial. This generally spread inwards from the edges, but in the case of A18-10 extensive rusting developed over the whole surface of the panel. The latter specimen deteriorated much more rapidly than the others. After six months all the steel panels showed heavy rusting associated with blistering and cracking of the paint finishes (Fig.51). Most of the paint had flaked away from A18-10, resulting in heavy rusting and disintegration of the underlying metal.

The painted light alloy panel (Finish to D.T.D.772) remained in very good condition throughout the trial apart from slight loss of gloss and rust staining from the securing bolts.

Of all the paints, the Orange Industrial Tractor Finish gave the least protection and the Finish to D.T.D.772 on light alloy the best. Apart from this, there was little to choose between the various systems.

5. PAINTS APPLIED TO WOOD SURFACES

5.1 Introduction

Exposure trials of paints on wood substrates were conducted at various sites in Nigeria. The types of paint involved are detailed in Appendix B, and photographs showing some of the specimens on exposure are given in Figs. 11, 12, 13, 18 and 21-26.

5.2 Individual Trials

5.2.1 Berkely Green Bergermaster Gloss Enamel with Undercoat (Lewis Berger and Sons Ltd.)

This was the same enamel as that applied to tinplate panels in the trial described in Section 4.2.1. It was based on a co-polymerised styrene medium and was claimed to have better gloss retention than normal gloss paints. To examine its behaviour under tropical conditions, painted Iroko wood panels were exposed at three different sites in Nigeria for periods varying from twelve to twenty-seven months (3). The panels, 6 inch x 4 inch, were painted at T.T.E. as described in Appendix A.1 and were exposed as shown in Table 9.

Table 9

Site	Date Exposed	Duration of Exposure (months)
Jungle Clearing	19.4.50	27
Marine (50 yd from surf line)	6.6.50	12
Marine (200 yd from surf line)	6.6.50	12
Desert	5.5.50	13

/Although

Although this enamel was not tested in conjunction with other gloss paints, there was no evidence to show that the presence of co-polymerised styrene had imparted increased durability in gloss. Loss of gloss was fairly rapid at all the exposure sites and after six months the initial high gloss had almost entirely disappeared. After a year, total loss of gloss was accompanied by heavy chalking at the sunny sites. There was some discolouration after one year at the jungle and marine sites, the original green colour having assumed a more pronounced blue tint. Moderate chalking occurred after five months and heavy chalking after eight to twelve months at the marine and desert sites. Algal and fungal growths rapidly developed on the paint at the jungle site, a continuous film covering the surface after about nine months exposure, and it subsequently became very heavy. The growths, however, appeared to be taking place on foreign matter adhering to the surface of the paint rather than on the paint film itself.

5.2.2 Pammel Synthetic Enamel Paint with Undercoat (Blundell Spence and Co. Ltd.)

This was the same material as that applied to steel panels in the trial described in Section 4.2.2. To investigate the effect of tropical exposure on this synthetic enamel with approved undercoat, painted wood panels were exposed at four sites in Nigeria for eighteen months (15). Details of the enamel are given in Appendix A.2. The panels were painted at T.T.M. and were exposed in the jungle clearing on 29.8.53, in the desert on 26.9.53, and at the marine site, both 50 yards and 200 yards from the surf line, on 24.8.53.

Apart from loss of gloss and colour changes when exposed to direct sunlight, the paint remained in good condition throughout the trial. The original green colour tended to turn slightly blue at the marine and desert sites and darkened as a result of considerable dirt collection at the jungle site. At the marine site, all the gloss had disappeared after nine months and the paint was fading and turning slightly blue. At the desert site, loss of gloss and slight fading commenced after about a year's exposure. In both cases, however, the original gloss and colour could be largely restored by wiping with a damp cloth and polishing with a dry cloth, even after eighteen months exposure. At the jungle site there was considerable dirt collection and very slight fungal attack but the surface was readily cleaned with a damp cloth.

There were no indications of chalking, blistering, flaking or cracking at any of the exposure sites.

5.2.3 General Purpose Paints (Red Hand Compositions Co.)

Seventeen paint systems, covering a range of primers, undercoats and topcoats, were exposed to tropical climatic conditions in Nigeria for two years (17). The systems, listed in Appendix B.1, were applied in the U.K. to Abura wood (West African Hardwood); four of them were exposed indoors at the base depot and the remaining thirteen at the town site, Port Harcourt, on 10.4.54.

All the specimens exposed indoors were in very good condition after two years, the only apparent defect being slight yellowing of all four types of white finishing coats.

There was generally appreciable deterioration of the specimens exposed out of doors at the town site; several of the systems showed serious breakdown in the form of cracking and flaking. Extensive chalking also occurred and all the specimens supported biological growth.

During the first few months of exposure at the town site, all specimens showed a progressive loss of gloss. Cracking and/or flaking of /the

the paint films was first noted after a year's exposure on specimens B1-1, 2, 11 and 12 and, at this stage, all the specimens presented a dark, sooty appearance, partly as a result of dark fungal mycelium on the surfaces. In some cases, algal growth was also present. The biological growth was mainly superficial and easily removed with a damp cloth to reveal a clean paint film underneath. However, in some cases, mycelium of the fungus Botryodiplodia theobromae growing on and in the wood produced pycnidia (fruiting bodies) which, in developing, burst through the paint film causing pustules or small cracks.

After two years exposure, there was appreciable deterioration of most of the specimens and several of the systems showed serious breakdown. The main defects and the specimens affected are listed in Table 10.

Table 10

General Purpose Paints (Red Hand) after Two Years Exposure

Defect	Heavy on Systems	Moderate on Systems	Slight on Systems	Absent on Systems
Chalking	B1-1, B1-2, B1-11, B1-12, B1-13, B1-14, B1-15, B1-16, B1-17	B1-9, B1-10	B1-3, B1-4	-
Cracking	B1-1, B1-2, B1-14, B1-15	B1-12, B1-17	B1-3, B1-11	B1-4, B1-9, B1-10, B1-13, B1-16
Flaking	B1-1, B1-2, B1-14, B1-15, B1-16, B1-17	-	-	B1-3, B1-4, B1-9, B1-10, B1-11, B1-12, B1-13
Superficial Biological Growth (Mainly algal)	B1-4, B1-9, B1-11, B1-13, B1-14, B1-15, B1-16, B1-17	B1-3, B1-12	B1-1, B1-2, B1-10	-
Damage to Film by Pustules of <u>Botryodiplodia theobromae</u>	B1-9, B1-10, B1-11, B1-12	B1-3	B1-4, B1-13	B1-1, B1-2, B1-14, B1-15, B1-16, B1-17

The only paints which showed any appreciable resistance to chalking were B1-3 and 4 (Anticorrosive "Genpurac" and its modification). Six systems were bad failures as regards cracking and/or flaking. These were the Tropical White and the Fungicidal Tropical White (two coats) on Pink Wood Primer and the "Syndurac" Finish (including the three modifications "A", "B" and "C") with "Syndurac" Undercoat and Pink Wood Primer. Systems B1-1 and 2 (Tropical White and Fungicidal Tropical White) were the most resistant to biological growth.

The systems which showed the least general breakdown and which presented the best appearance after two years were B1-3 (two coats Anti-corrosive "Genpurac" over Pink Wood Primer) and B1-9 and 10 ("Syndurac" Finishing Paint over White Lead Primer and Modified "Syndurac" Finishing Paint over Pink Wood Primer, the same undercoat being used in each case). Specimen B1-4 (two coats of modified Anti-corrosive "Genpurac" over Pink Wood Primer) showed little physical breakdown but /the

the film turned almost black as a result of very heavy dirt collection and biological growth. There was also a considerable amount of dirt on many of the other specimens. Systems B1-1 and 2 (Tropical White and Fungicidal Tropical White - two coats - over Pink Wood Primer) broke down completely, the films having cracked and flaked off in large areas and lost their adhesion to the substrate.

5.2.4 Canadian Army Vehicle Prints Applied to Wood (Trial sponsored by the Canadian Army Liaison Establishment)

Yellow birch and white oak panels pretreated with three different preservatives (copper naphthenate, pentachlorophenol and chromated zinc chloride) and finished with three different enamels (alkyd, epoxy resin and chlorinated rubber) were exposed at three sites in Nigeria for from twenty-four to twenty-seven months to determine their serviceability under various tropical conditions (31). A list of treatments and enamels is given in Appendix B.2.

The panels, 12 inch x 6 inch, were prepared in Canada and were exposed at the town site on 5.5.56, and in the jungle clearing and at the marine site (50 yards from the surf line) on 24.1.56.

At all three exposure sites all the enamels applied to oak panels showed a marked tendency to check, crack and finally to flake (Figs. 54 to 57). This defect of the paint film was later observed to be almost entirely a result of splitting of the wooden substrate. Splitting did not occur so readily with birch panels. There was some indication that the chlorinated rubber modified alkyd enamel showed greater ability to resist the stresses caused by the splitting of the oak panels at the marine site.

Under exposure to strong sunlight, the epoxy resin enamel showed a much greater loss of gloss and tendency to fade and chalk than the alkyd and chlorinated rubber enamels during the first few months, but after twelve months all three had deteriorated to about the same extent.

Fairly extensive blistering occurred during the early stages of the trial on panels (especially birch) at the marine site (Fig. 58) while at the town site this defect was virtually absent. However, at the end of the trial, slight blistering was observed on a few of the panels at the town site while those at the marine site had recovered from this defect.

Generally, after cleaning and polishing the test surfaces, the enamels were still in good condition after more than two years exposure, except at the regions of the splits in the wood where cracking and flaking of the paint film had occurred.

Copper naphthenate and pentachlorophenol had an inhibitory effect on the development of pustules of the fungus Botryodiplodia theobromae but, otherwise, there were no obvious effects attributable to the use of the different preservative treatments.

At the jungle site, heavy superficial green algal and dark fungal growths developed on all panels to an approximately equal extent (Figs. 51 to 54). The growths were generally slight after six months, but after twelve months there were numerous pale green algal colonies and patches and streaks of dark mould growth, the latter having developed to a greater extent in the neighbourhood of the cracks in the substrate. Cladosporium sp. was the dominant fungus in the dark mould patches. The wood of most of the panels showed fungal decay, panel B2-9 being the most affected in this respect (Fig. 52). At the town and marine sites, biological growth was generally light; the chlorinated rubber modified alkyd base enamel appeared to be able to resist fungal attack better than the epoxy resin and alkyd enamels. At the town site, the biological growth appeared as numerous small black specks of Pullularia sp. but Curvularia sp. was also present and a few /the

the paint surfaces had sustained very slight damage due to pyonidia of the fungus Botryodiplodia theobromae which, in developing, had broken through the paint film from the substrate. The panels affected in this way were B2-1, 2, 9, 11, 13, 14, 22 and 23. With the exception of B2-9, therefore, none of the panels treated with copper naphthenate or pentachlorophenol were damaged by these erumpent pyonidia. At the marine site, the biological growth appeared as dark specks and patches consisting of clumps of ohrandyospores of Pullularia sp.

5.2.5 Experimental "General Purpose" and "High Grade" Finishing Paints (I. and S. Leigh Ltd.)

To evaluate the durability under tropical conditions of various experimental paint systems produced by Messrs. I. and S. Leigh Ltd., mahogany wood panels (8 inch x 5 inch) painted both in the U.K. and in Nigeria were exposed at four sites in Nigeria for two years (33). The paints are listed in Appendix B.3. The panels were exposed in the desert on 5.6.56, at the town site on 22.6.56, in the jungle clearing on 29.6.56, and at the marine site 200 yards from the surf line on 18.7.56.

There was no serious breakdown of the paints, the only real defects being progressive fading, loss of gloss and chalking, all of which were fairly general. Chalking was particularly severe on the Cream E.500 General Purpose Paint which failed badly even at the jungle site where chalking is not usually a problem. In general, the cream-coloured paints showed a greater degree of chalking than the other colours. Although biological growth was widespread on the panels exposed under jungle conditions, the growth was almost entirely superficial.

At all the exposure sites, there was a marked loss of gloss after only three months, especially on the systems without primers ("General Purpose" paints), and at the end of the trial (twenty-four months) the initial gloss on all the specimens had almost entirely disappeared. Most of the finishes progressively faded during the trial; this defect was generally more pronounced on the cream than on the red and green finishes and occurred to a greater extent at the sites with more intense sunshine (desert, marine and town sites). Chalking was a fairly general defect, commencing at the desert site after only three months exposure. Generally the cream coloured panels chalked much more heavily than the red and green. At the desert, marine and town sites, most of the panels showed heavy chalking except for B3-13, 16 and 17 which chalked only slightly or not at all. These three systems contained the high-grade finishes E.502 or E.503 in green or bright green colours. There was very little chalking at the jungle site, although, even there, the cream general purpose paint E.500 (System B3-1) failed badly in this respect. Chalking is not usually a problem at the jungle site which receives little direct sunlight. Biological growth was widespread on most of the panels at the jungle site but it was almost entirely superficial and was easily removed with a damp cloth. The fungal growth was found to consist almost entirely of Pullularia sp. but there was a considerable amount of green algal growth on most of the panels. Three of the panels painted in the U.K. with general purpose finishing coats E.500, Cream, E.501, Cream and E.501, Green (viz. specimens B3-1, 4 and 9), had sustained slight damage to the paint film caused by pustules of the fungus Botryodiplodia sp. which had originated on the wooden substrate and burst through the paint film. The systems bearing the least amount of biological growth were B3-1 (E.500 G.P. Paint, Cream) and B3-17 (E.503 High Grade Finish, Bright Green). At the town site, biological growth was much less dense but was slightly heavier on panels painted at T.T.E. than on those prepared in the U.K. The growth consisted almost entirely of sooty-looking Pullularia sp.; no Botryodiplodia sp. was identified nor was any algal growth present. Specimens most affected were B3-2, 3 and 5 (General Purpose Paints, E.500, Red Oxide and Green and E.501, Red Oxide); B3-1, which was chalking heavily, was free from biological growth at this site.

/Biological

Biological growth at the marine site was generally light and presented a black granular appearance, typical of Pullularia sp., although some Cladosporium sp. was also present. Specimens most affected were B3-2, 3 and 6 (G.P. Paints E.500, Red Oxide and Green and E.501, Green) and B3-12 (High Grade finish E.502, Green) but biological growth was absent on B3-1 which was chalking very heavily.

There was little serious breakdown on any of the specimens during the trial with the exception of system B3-12 (E.502 High Grade finish, Green) which developed extensive checking and cracking at the marine site and fairly heavy blistering at the desert site. These defects were observed only on the panels painted at T.T.E. and were absent on those painted in the U.K. The reason for this might have been the difference in atmospheric conditions during the painting and drying of the specimens. The higher humidities encountered at Port Harcourt (over 75 per cent) undoubtedly delay the drying of the paint films. One panel painted in the U.K., viz. B3-9 (E.501 G.P. Paint, Green with primer), showed very slight checking, cracking and flaking.

5.2.6 Commercial Enamels (Jenson and Nicholson Group)

Four commercial enamels, each with an undercoat and primer, were exposed for about eighteen months on wood panels at four sites in Nigeria to determine their behaviour under tropical conditions (36). Okeche panels, 8 inch x 6 inch, were painted at T.T.E. as described in Appendix B.4 and exposed at the town site and in the jungle clearing on 22.11.56, in the desert on 10.11.56, and at the marine site 200 yards from the surf line on 6.11.56

There was a progressive loss of gloss of all enamels at the town, marine and desert sites, and at the end of the trial most of the initial gloss had disappeared. At the town and marine sites, the cream enamel (B4-2) showed a more rapid initial loss of gloss than the other three finishes. At the jungle site, the gloss was soon obscured by an overall coating of dirt and biological growth.

Assessment of fading and darkening at the town and jungle sites was made difficult by dirt collection and fungal growth on the surfaces. At the town site, the blue-grey enamel (B4-3) faded slightly but the others had darkened, as was observed after cleaning off the surface film of dirt. At the marine site, the cream, blue-grey and green (B4-2, 3 and 4) enamels faded but only the blue-grey did so at the desert site. None of the enamels darkened at the marine and desert sites.

Extensive chalking occurred at the three sunny sites but none was noted in the jungle clearing. The green enamel, however, showed less chalking than the others and, in fact, was entirely free from this defect at the town site. Slight cracking of the white enamel was reported at the end of the trial at the town and desert sites; at the marine site, this enamel cracked rather more extensively. None of the other enamels showed this defect nor were any checking, flaking or blistering observed on any of the specimens.

5.2.7 General Purpose Paints (Red Hand Compositions Co. - 2nd Trial)

Twenty-four paint systems applied to wooden panels were exposed at three sites in Nigeria for about a year (38). Masawa panels, 18 inch x 11 inch, were painted in the U.K., as described in Appendix B.5, and were exposed at the town site on 12.6.57, in the jungle undergrowth on 13.6.57, and at the marine site 200 yards from the surf line on 20.6.57.

This trial would normally have lasted for at least two years but because of the closure of T.T.E. it had to be terminated prematurely. The specimens exposed at the town site were transferred to the Federal

Institute of Applied Research at Oshodi, near Lagos and those at the marine site to the West African Building Research Institute at Accra for a further period of exposure.

After about a year's exposure most of the paint systems showed little deterioration apart from loss of gloss, and darkening. These defects probably had a common origin in the gradual deposition of dirt and growth of fungus on the surface of the panels. Chalking also occurred on the specimens exposed at the sunny sites (town and marine). At the marine site, several paints showed slight cracking, one severe cracking and two severe flaking.

The Tropical White Fungicidal Paint showed serious physical breakdown in the form of checking, cracking and flaking; it also chalked badly.

The Modification to "Gempurac" White appeared to affect its dirt collecting properties, since, at all sites, the modified type had higher assessments for darkening and dirt collection than its unmodified counterpart.

All the specimens commenced to lose gloss soon after placing on exposure. At the town site, all systems had lost most of their initial gloss after thirteen months. In the jungle undergrowth, gloss retention was better except for specimens B5-7 ("Gempurac" White), B5-8 (Modified "Gempurac" White) and B5-19 (Tropical White Fungicidal); specimens B5-9 (White Gloss Paint) and B5-11 (Non-yellowing White) were superior to the others in this respect.

Slight fading was recorded on all specimens at the town site during the first few months of the trial but none was apparent when the panels were withdrawn at the end of the trial. It is probable that any fading at this stage was obscured by dirt collection and a thin film of dark fungal growth. The "Gempurac", Modified finish (B5-8), had darkened considerably as a result of a heavy deposition of dirt. Many panels at the jungle site darkened as a result of fungal growth and staining. Specimens B5-3 ("Syndurac" White Enamel), B5-9 and 10 (White Gloss Paint), B5-11 (Non-yellowing White) and B5-19 (Tropical White, Fungicidal) were only slightly affected. There were only slight changes of colour at the marine site on a few of the specimens.

The Tropical White, Fungicidal paint (system B5-19) chalked severely at the town site; other specimens showed varying degrees of chalking, in most cases very slight. At the marine site, also, varying degrees of chalking were reported, system B5-19 once again being assessed as a severe failure; systems B5-5, 17, 18, 20, 21, 22 and 23 (White Gloss Paint, Modified), B5-6 (Special Tropical White) and B5-19 (Tropical White, Fungicidal) were best in this respect, showing only very slight chalking.

At the town and marine sites, slight cracking was observed on some of the specimens but the only instances of severe cracking were on the Tropical White Fungicidal finish (B5-19) at the marine site and system B5-9 (White Gloss Paint with undercoat on A.S. Metallic Primer) at the town site. The former showed also severe checking at the marine site.

Flaking occurred on two of the specimens; system B5-20 (Modified White Gloss Paint with "Syndurac" undercoat and Pink Wool Primer) flaked badly at the town and marine sites and B5-19 at the marine site only (Fig.60). No breakdown of the paints in the form of cracking or flaking was reported at the jungle site.

Most panels at the town and jungle sites collected a fair amount of "dirt"; at the former site this consisted of a mixture of soot and dark fungal growth and at the latter almost entirely of fungal growth. At all sites, specimen B5-8 (Modified "Gempurac" White) was affected more than any other.

6. PAINTS APPLIED TO ASBESTOS CEMENT

6.1 Introduction

Exposure trials of paints on asbestos cement were carried out at various sites: the types of paint involved are detailed in Appendix C. Photographs showing some of the specimens on exposure are given in Figs. 24 and 27.

6.2 Individual Trials

6.2.1 Commercial Paints for Asbestos Cement (Red Hand Compositions Co.)

Commercial paints applied to flat asbestos cement sheets were exposed for two years at two sites in Nigeria (17). Five materials in all were tested (see Appendix C.1): four of them were subjected to outdoor exposure at the town site and the remaining one - an interior emulsion paint - was stored indoors at the base depot, Port Harcourt. The sheets were painted in the U.K. and were exposed on 10.4.54.

The specimen exposed indoors ("Redimul" Emulsion Paint, Interior, Semi-Gloss) showed very little deterioration after two years. Of the materials exposed out of doors, the two white paints, C1-2 ("Redimul" Emulsion Paint, Exterior, Semi-Gloss) and C1-3 (White Chlorinated Rubber Paint) showed considerable chalking; the former also showed some erosion but, otherwise, there was no serious breakdown of any of the paints.

6.2.2 Turnall Colourglaze (Turners Asbestos Cement Co. Ltd.)

Corrugated asbestos cement roofing sheets coated with Turnall "Colourglaze", an epoxy-resin-based paint, in four different colours (see Appendix C.2) were exposed at three sites in Nigeria for about a year (37). This trial would normally have lasted longer but it had to be concluded on the closure of T.T.E. The sheets were painted in the U.K. and were exposed in the desert on 4.8.57, at the town site on 13.8.57, and in the jungle clearing on 15.8.57.

At the sites with more intense sunshine (town and desert) there was heavy chalking and a rapid loss of gloss of all four specimens and considerable fading of the red, green and blue colours; these defects may have been promoted by the substrate. At the jungle site, there was no chalking or fading but all the specimens darkened as a result of heavy dirt collection and biological growth. At all three sites, the original gloss and colour were partly restored on polishing. Heavy biological growth developed on all the panels at the jungle site after only six months exposure. The red and green finishes appeared to inhibit algal growth to a greater extent than the cream and the blue but none of them was very resistant to biological growth in general. After a year's exposure at three different sites, there was no physical breakdown of any of the paints in the form of checking, cracking, flaking or blistering.

Although the trial was concluded before a proper assessment of the durability of these materials could be made, it did show that they soon lose their decorative value under the influence of strong sunlight. The heavy biological growth which developed, although it was mainly superficial and did not damage the paint film, presented an unsightly appearance.

7. PAINTS APPLIED TO PLASTER WALLS AND CONCRETE

7.1 Introduction

This section is concerned with the behaviour of plastic emulsion paints when exposed to tropical climatic conditions. An important aspect of the use of this type of paint in the tropics is the question of the stability of the emulsion on storage but this problem was not investigated at T.T.E.

Several different types of plastic emulsion paint (see Appendix D) were tested both indoors and in the open at several sites in Nigeria. The first three were conducted as local trials and no formal reports covering the final results were issued, although, in one case (Sissons' "Rapodex" Plastic Emulsion Paint), an interim report (16) covering six months exposure was circulated. The purpose of these three trials was to assess the value of plastic emulsion paints as a possible alternative to the use of Walpamur for the interior decoration of flats and houses at the T.T.E. residential site. Walpamur paint had never been entirely satisfactory for this purpose. The materials tested in these local trials were intended for interior use but, in order to obtain some indication of the relative values of the materials under more severe conditions, concrete blocks coated with the paints were exposed in the open, in addition to the interior decoration of plaster walls of permanent buildings. The compositions of these emulsion paints were not divulged.

In addition to the three local trials, a trial was sponsored by Jensen and Nicholson (36) which included polyvinyl acetate based emulsion paints in three colours for exterior use. The Red Hand Compositions Co. also submitted three systems for interior decoration and in two of these the finishing paint was of the emulsion type (17).

The paints for all five trials were supplied by the manufacturers either directly from the U.K. or through their agents in Nigeria and were applied in Nigeria by brushing on to concrete blocks or interior plaster walls.

A summary of the trials involving plastic emulsion paints is given in Table 11, which includes dates and duration of exposure, and a view of painted concrete blocks on exposure at the marine site is shown in Fig.28.

7.2 Industrial Trials

7.2.1 "Rapodex" Plastic Emulsion Paint (Sissons Bros. & Co. Ltd.)

The paint (see Appendix D.1) exposed on plaster walls and on concrete blocks inside permanent buildings remained in good condition at all the exposure sites for twelve months, except for slight chalking at areas exposed to direct sunlight (16).

/Table 11

Table 11

Paints Applied to Plaster Walls and Concrete

Name of Trial and/or Type of Paint Manufacturer or sponsor	Substrate	Where Painted	Exposure Sites	Date Exposed	Duration of Exposure (months)
"Rapodec" Plastic Emulsion Paint. Sissons Bros. & Co. Ltd.	Plaster	T.T.E.	P.H.	24. 5.55	12
	walls.		J.S.	30. 5.55	12
	Concrete		M.200	9. 6.55	12
	blocks		D.	9. 6.55	12
"Pentolite" Plastic Emulsion Paint. I.C.I. Ltd.	Plaster	T.T.E.	P.H.	19. 6.55	12
	walls.		M.200	21. 7.55	12
	Concrete		D.	31. 7.55	12
"Permacote" Plastic Emulsion Paint. Solignum Ltd.	Plaster	T.T.E.	P.H.	15. 8.55	12
	walls.		J.S.	27. 8.55	12
	Concrete		M.200	3. 9.55	12
	blocks		D.	20. 9.55	12
Polyvinyl Acetate based Emulsion Paints. Jenson and Nicholson Group.	Concrete blocks	T.T.E.	J.C.	22.11.56	9
			M.50	6.11.56	18
Commercial Paints for Plaster Walls etc. Red Hand Compositions Co.	Concrete blocks	T.T.E.	B.D.	10. 4.54	24

NOTES:

P.H. = Town Site, Port Harcourt
J.S. = Jungle Site
M.200 = Marine Site (200 yards from surf line)
D. = Desert Site
J.C. = Jungle Clearing
M.50 = Marine Site (50 yards from surf line)
B.D. = Base Depot Store, Port Harcourt

Specimens exposed out of doors on concrete blocks chalked heavily at all sites after twelve months and faded severely at the marine and desert sites. There was also considerable chalking at the marine site and the paint was generally in poor condition. Heavy biological growth developed on the specimens at the jungle site.

7.2.2 "Pentolite" Plastic Emulsion Paint (I.C.I. Ltd.)

The paint (see Appendix D.2) exposed on plaster walls and on concrete blocks inside permanent buildings remained in good condition at all the exposure sites for twelve months, except for slight chalking and fading at areas exposed to direct sunlight.

/Specimens

Specimens exposed out of doors on concrete blocks showed heavy chalking and fading at all sites. There was also considerable checking at the marine site and heavy biological growth at the jungle site.

7.2.3 "Pernacote" Plastic Emulsion Paint (Solignum Ltd.)

It was found that this material (see Appendix D.3) was not so easy to apply as Sissons' "Rapodoc" or I.C.I. "Pentolite" paints and there was a greater tendency for its pigment to settle out. It did not appear to have the same covering power as these other two paints tested during the same period and it certainly would not have tolerated the same degree of dilution.

The paint exposed on plaster walls and on concrete blocks inside permanent buildings remained in good condition at all the exposure sites for twelve months, except for slight chalking and fading at areas exposed to direct sunlight.

Specimens exposed out of doors on concrete blocks showed heavy chalking and fading at all sites. There was also severe checking at the marine site and heavy biological growth at the jungle site.

7.2.4 Polyvinyl Acetate Based Emulsion Paints (Jenson and Nicholson Group)

The paints exposed are listed in Appendix D.4. Those exposed at the jungle site showed no defect after nine months exposure. Shortly after this, they were submerged in the floods which affected the jungle site and no further observations were made (36).

At the marine site there was considerable chalking of all three specimens after nine months. Fading of the pale blue finish commenced at this stage and after twelve months it had completely faded to white. The red colour began to fade significantly after fourteen months. There was some erosion of all three paints after eighteen months.

7.2.5 Commercial Paints for Plaster, etc. (Red Hand Compositions Co.)

These paints are listed in Appendix D.5. After two years exposure in the base depot store, there was little change in the appearance of all three paints.

7.3 Conclusions

Of the plastic emulsion paints tested indoors, those manufactured by the Red Hand Composition Co. appeared to be the most satisfactory, showing no deterioration on concrete surfaces after two years exposure. These were white, alkali-resisting emulsion paints, but a third finish ("Matinto") which was not an emulsion paint produced similar good results. The remaining paints (Sissons, I.C.I. and Solignum) showed little deterioration after twelve months exposure indoors on plaster walls and concrete surfaces except for a general slight chalking and fading at areas exposed to direct sunlight, viz. around doorways, transoms and window-sills. On the whole, it was found that these paints were much simpler to apply than Walparum, were more durable and showed less chalking, but this may not justify the increased cost of the emulsion type of paint.

All the paints tested in the open tended to chalk heavily under the influence of direct sunlight and fading was a general failure. The latter defect was particularly severe on Jenson and Nicholson Pale Blue Emulsion Paint which turned white after twelve months at the marine site. Sissons' "Rapodoc", I.C.I. "Pentolite" and Solignum "Pernacote" plastic emulsion paints showed considerable checking after twelve months at the marine site and Jenson and Nicholson emulsion paints showed some erosion after eighteen months.

/None

None of the materials tested, therefore, appear to be sufficiently durable for exterior use in the tropics,

8. VARNISHES

8.1 Introduction

This section covers various types of varnishes exposed out of doors at a number of sites in Nigeria. Four different types were submitted by International Paints Ltd. (35) and one (Yacht Varnish) was included in the trial on Service Paint Systems. A series of experimental "Picture Varnishes" was submitted by the National Gallery for exposure at the desert site.

The types of material tested are listed in Appendix E and some of the specimens on exposure are shown in Figs. 13, 28 and 29.

8.2 Individual Trials

8.2.1 Commercial Varnishes (International Paints Ltd.)

Included in the trial on paints from this firm (Section 4.2.9) were four commercial varnishes (see Appendix E.1.). These were exposed on mahogany wood panels to hot damp tropical conditions for eighteen months (35). The panels, 12 inch x 6 inch, were painted in the U.K. and exposed at the town site, Port Harcourt on 17.1.57.

The 309 Yacht Varnish failed badly as a result of checking and cracking and the Episeal Varnish as a result of flaking. The Sunlight Varnish and Group 37 Varnish did not show any serious physical breakdown but the latter darkened considerably to a reddish-brown colour. None of the varnishes supported fungal or algal growth.

All four specimens lost their initial high gloss fairly rapidly and after twelve months it had entirely disappeared. The gloss was only partially restored on polishing the surfaces. Specimen E1-3 ("Group 37" Varnish) darkened considerably, changing to a fairly dark red-brown after about nine months exposure (Fig.64). Crowsfoot checking covered the whole surface of E1-1 ("309" Yacht Varnish) after nine months and this increased and developed into crowsfoot cracking during the remainder of the trial (Fig.62). Heavy flaking of E1-4 ("Episeal" Varnish) developed; this commenced at the rounded edges after about nine months and gradually spread towards the centre of the panel. After eighteen months, about 75 per cent of the varnish film had flaked off (Fig.65). Towards the end of the trial, only slight flaking of the other three varnishes was recorded, E1-1 and E1-2 at the rounded edges and E1-3 at the crack in the substrate below the top securing hole (Fig.64).

8.2.2 Yacht Varnish K.4929 (Cellon Ltd.)

This material was included in the trial of Service Paint Systems (Section 4.2.18) and was exposed on teak wood panels for three and a half years at the marine site (39). The varnish was applied in the U.K. as described in Appendix E.2, and the panels were exposed 100 yards from the surf line on 9.1.52.

Generally, the varnish showed moderately good resistance to breakdown in view of the severe conditions of exposure at the marine site. The most serious defect to develop on the varnish was chalking; this was considerable after twelve months and heavy after three and a half years. Slight blistering also occurred at stages during the trial and slight flaking was recorded

recorded when the specimen was withdrawn. A fair amount of algal growth was evident on the surface at certain stages in the trial but it was free from all biological growth at the end of the trial. Algal and fungal growths appear somewhat intermittently at this site.

8.2.3 Picture Varnishes (Trial sponsored by the National Gallery)

Nine different experimental Picture Varnishes submitted by the National Gallery were exposed under a perspex cover (to provide protection from the rain) for eight months at the desert site, to assess their general suitability for use in daylight-illuminated, heated picture galleries. The varnishes, described in Appendix E.3, were applied in the U.K. to aluminium foil, sand-blasted glass, and clear glass and were exposed on 29.12.56.

On clear glass, three varnishes were more successful than the others. These were (a) Polycyclohexanone with 10 per cent Sonpol, (b) Polymethacrylate and (c) Polyvinylacetate. On sand-blasted glass, however, two of these ((a) and (c)) crazed and cracked. On aluminium, the polymethacrylate varnish was the most successful but two others also showed little deterioration. These were Polycyclohexanone with 10 per cent Linseed Stand Oil and the same resin with 10 per cent Sonpol.

During the first six months, the polymethacrylate resin was far superior to all the others, being entirely free from yellowing, crazing, blistering and flaking and showing only slight cracking on sand-blasted glass. However, after a further two months exposure it appeared to lose adhesion to clear glass and peeled away from the substrate. The R.240 Silicone Resin had deteriorated most of all after six months, presenting a dark-brown opaque appearance with considerable blistering.

The first signs of deterioration were observed after ten weeks exposure when Specimen E3-4 (Mastic with 5 per cent Linseed Oil) showed slight crazing on the sand-blasted glass. Specimen E3-2 (R.240 Silicone Resin) yellowed considerably and even darkened to a brown colour on sand-blasted glass. As this change of colour was not apparent on the varnish applied to aluminium or clear glass substrates, it may be associated with some effect of the roughened surface of the glass. Slight yellowing was also noted on E3-4, 7 and 9 (on sand-blasted glass) and on E3-1, 3, 4, 5 and 7 (on clear glass).

After five months, the extent of deterioration of the varnishes obviously depended largely on the type of substrate used and these are considered separately below:

- (i) Aluminium: Specimens E3-3, 4, 7 and 9 had yellowed extensively and E3-1 and 6 only slightly. Slight crazing had developed on E3-1, 3, 4, 5, 6 and 7 and very slight cracking on E3-5. Blistering was extensive on E3-1, 2 and 3 and rather less on E3-4, 7 and 9. Only very slight flaking occurred on Specimen E3-5 (Polycyclohexanone with 10 per cent Linseed Stand Oil).
- (ii) Sand-Blasted Glass: Only two specimens (E3-2 and 5) yellowed and to only a slight degree. Extensive crazing occurred on four of the specimens (E3-1, 2, 3 and 4) and rather less on E3-6, 7 and 9. Only one specimen (E3-6) showed much cracking; this defect was observed on four others (E3-1, 5, 7 and 8) but only to a slight degree. Blistering was heavy on E3-1, 2, 3, 4 and 7 and slight on E3-5. The only case of flaking was on E3-1 where it was very slight.
- (iii) Clear Glass: Considerable yellowing of E3-1, 3, 4 and 7 occurred but it was only slight on E3-5. Four specimens (E3-1, 3, 4 and 7) showed extensive crazing and the last also cracked considerably; there was slight cracking on E3-1. One specimen (E3-1) /showed

showed heavy and three others (E3-2, 3 and 7) slight blistering but no flaking was observed.

The specimens on aluminium and sand-blasted glass substrates were withdrawn after six and half months exposure. Little change in their condition was evident during the last few weeks of exposure.

Specimens on clear glass were exposed for a total period of eight months. At the time of withdrawal, all specimens with the exception of E3-8 (Polymethacrylate Resin) had yellowed and, in addition, E3-2 had developed slight crazing, E3-4, 5 and 6 marked cracking and E3-1, 3 and 7 slight flaking. The most marked deterioration during the latter stages of the trial was in the case of E3-8 (Polymethacrylate Resin) which was peeling away in large areas from the substrate.

9. FUNGUS RESISTING PAINTS

9.1 Introduction

The warm, humid climate of the rain-forest belt of Southern Nigeria provides conditions very favourable for fungal and algal growth. Such growths, however, although they often appear in great profusion on painted surfaces, are usually mainly superficial and are easily removed on wiping with a damp cloth, causing no damage to the paint films. Nutrient is probably derived from extraneous materials adhering to the surfaces. More serious cases of fungal attack were observed in some instances and were attributed to the fungus Pullularia sp. which appeared to penetrate the paint film from above and produced dark stains on the paints. This was particularly unsightly on white or light-coloured paints and was not removed on cleaning the surface (Fig.66). Attack by Pullularia sp. was observed at both the town and marine sites, in spite of the intense sunlight at the latter. The most serious fungal attack of all, however, resulted from fungi, probably present on the wood before painting subsequently producing fruiting bodies which burst through the paint film from beneath. These fungal pustules were, in almost every case, caused by pycnidia of Botryodiplodia theobromae, which appeared to be particularly resistant to fungicides.

The efficiency of a fungus resisting paint was generally assessed by exposing it at the jungle site, near Port Harcourt, where algal and fungal growths were found to develop rapidly. Below are summaries of the trials involving such paints and details of the materials tested are given in Appendix F. Photographs of some of the specimens on exposure can be seen in Figs. 31 to 34.

9.2 Individual Trials

9.2.1 Fungus Resisting Paints (Jenson and Nicholson Group)

The efficiency of various fungus resisting paints was assessed by exposing painted wood panels in a tropical jungle clearing for nineteen months (14). The paint systems (Appendix F.1) consisted of an aluminium primer containing 15 per cent copper naphthenate and a white undercoat containing organic mercurial compounds. The topcoats included several combinations of two pigments, four media and a range of eight fungicides. The paints were applied to Oboshe wood panels, 8 inch x 6 inch, both at T.T.E. and in the U.K., and were exposed on 12.6.53.

Superficial algal and fungal growths developed in varying amounts on the surfaces of all the painted panels but they were easily removed by washing and did not appear to affect the paint surfaces. This growth was slight on panels painted with aluminium primer only and on the straight
/zinc

zinc oxide finishing coat containing no fungicide (Specimen F1-19), but it developed to at least a moderate degree on all the other specimens.

Damage to the paint films was caused by fungi, probably present on the wood before painting. These produced fruiting bodies which during development burst through the paint film from beneath. Such damage was most severe on panels painted with primer and undercoat only (Fig.67). It appeared to be independent of the presence or concentration of fungicide; indeed, some of the panels which showed no development of this fungus did not contain fungicide in the finishing coat (Specimens F1-1, 2, and 4).

Panels painted in the U.K. and sent to Nigeria for exposure behaved similarly to those painted at the exposure site as regards the development of superficial fungal growths and damage to the paint film by fungi developing from the wood surface.

Copper naphthenate dip treatment did not prevent the growth of fruiting bodies of the fungus Botryodiplodia theobromae on unpainted Obeche wood panels (Fig.68).

The presence of fungicides in these paints, therefore, appeared to have no beneficial value as inhibitors of the types of fungal and algal growths encountered at the jungle clearing exposure site.

9.2.2 Fungus Resisting Paints (I.C.I. Ltd.)

To determine the efficiency of five experimental fungus-resisting white gloss paints, painted Obeche wood panels were exposed for twelve months at the Port Harcourt town site and in the jungle undergrowth (22). The panels (8 inch x 6 inch) were painted as described in Appendix F.2, some in the U.K. and some at T.T.E., and were exposed on 17.4.56. Test panels were also exposed by I.C.I. Ltd. in a tropical test chamber at their Research Station at Jealotts Hill in the U.K. but no information is available on this part of the trial. The compositions of the paints or the fungicides incorporated in them were not divulged.

Treatment of the panels with a 2 per cent aqueous solution of the fungicide "Shirlan HA" before painting was ineffective as a preventive measure against the subsequent development of fungal synnemata and of Botryodiplodia fruiting bodies from the wood through the paint film. There was some evidence to suggest, however, that it might inhibit to some extent the development of pink staining of the paint. The various types of growth differed in sensitivity to the five paints, none of which inhibited all types of growth equally well. Some finishes controlled certain growths fairly well but none was generally successful.

None of the finishes controlled to any satisfactory extent the development of the dark mould growth on the surface of the paint. Finishes 'B', 'C' and 'D' inhibited its development to a moderate degree but finishes 'A' and 'E' did so only slightly.

Finishes 'A', 'B' and 'D' had no effect on the development of pustules caused by Botryodiplodia but the results suggested that these were partially inhibited, but not prevented, by finishes 'C' and 'E'.

Development of fungal synnemata was unaffected by finishes 'A', 'B' and 'D' but fairly well controlled by finishes 'C' and 'E'.

Pink staining of the paint was almost completely controlled by finishes 'A' and 'B', fairly well controlled by finishes 'C' and 'E' but unaffected by finish 'D'.

/At

At the jungle undergrowth site, superficial fungal growth was evident on most of the panels after only one month's exposure. This growth developed rapidly and soon formed a dark grey continuous coating on all the specimens (Fig.73) but it was generally fairly easily removed with a damp cloth. Fungal sporing structures developed from the wood substrate and burst through the paint films on most of the panels. These structures consisted of pustules of Botryodiplodia theobromae and Graphium synnemata which were often found to occur in close association with one another (Figs.70 and 71). Small patches of pink to violet staining appeared on many of the specimens and it appeared, on microscopic examination, to be associated with mycelium present on the paint surface.

At the town site, mould growth was much more restricted and there were only a few cases in which pustules and synnemata developed. One fairly severe case is shown in Fig.69. Surface mould growth was far less luxuriant and consisted almost entirely of Pullularia sp. (Fig.72).

Panels painted in the U.K. behaved in a manner similar to those painted at T.T.E. except that the former did not develop synnemata to any great extent.

9.2.3 Nuodex Fungicides in Paints (Trials sponsored by Ministry of Supply, Chemical Inspectorate)

The fungicidal properties of three different Nuodex products (Nuodex Super-Ad-It, Nuodex 321 SS and Phemox Oil Soluble) were assessed by incorporating each of them in two different paint systems and exposing painted mild steel panels in a tropical jungle for twenty-nine months (18). Pentachlorophenol was also incorporated in each of the two paints and similarly exposed for comparison. The panels (12 inch x 12 inch) were painted in the U.K. as shown in Appendix F.3 and exposed in the clearing and the undergrowth on 2.3.54.

The presence or absence of these fungicides in the paints had no apparent effect on the development of algal and fungal growths. Algal growth developed on all the panels during exposure, being first observed after about six months. After fifteen months it had formed a continuous coating over the paint films. Contrary to earlier experience, this growth was generally heavier on panels in the undergrowth than on those in the clearing. Mould growth, always associated with the algal coating, was found on all the specimens in the form of fungal mycelium and numerous fungal spores but it was not observed in quantity until the panels had been exposed for almost two years. In all cases, the algal and fungal growths were superficial and were readily removed from the paint surface with a damp cloth.

Deterioration of the paint films was greater in the jungle clearing than in the undergrowth and greater with the Primer and General Service Finishing Paint. At both sites, numerous small blisters developed which were more extensive on panels containing "Nuodex Super-Ad-It" as fungicide.

9.2.4 Fungicidal Paints (Trial sponsored by Ministry of Supply, Chemical Inspectorate)

The previous trial (Section 9.2.3) gave inconclusive results probably because the paints were applied exclusively to a mild steel substrate. A further trial (28) was arranged to compare the effectiveness of two of the fungicides (Nuodex Super-Ad-It and pentachlorophenol, the former in a higher concentration than before) incorporated in three different paint systems (based on alkyl resin, chlorinated rubber and linseed oil respectively). The paints were applied in the U.K. to mild steel (12 inch x 12 inch) and Western Red Cedar panels (12 inch x 6 inch), as described in Appendix F.4, and exposed for fifteen months in the jungle undergrowth. Exposure took place on 3.12.56.

/Development

Development of fungal growth was initially more rapid on panels without headcover but at the end of the trial there was little difference between the two types of exposure. Fungal growth was more prolific on paints applied to mild steel than on the same paints applied to Western Red Cedar. This is unusual, since a wooden substrate is generally regarded as being a possible source of nutriment for fungal growths. The explanation may be that this particular timber possesses fungicidal properties (42).

Growth was heaviest on the linseed oil based paint; it was equally extensive but not so heavy on the alkyd material. Very little growth developed on the chlorinated rubber paint but the metal panels coated with this material showed extensive deterioration in the form of loss of gloss, blistering and rusting; no blistering was observed on this paint when applied to wood.

"Super-Ad-It" fungicide strongly inhibited fungal growth during the first four months but, thereafter, the effect steadily diminished until, at the end of the trial, it was very slight. Pentachlorophenol had only a very slight inhibiting effect on the onset and development of fungal growth. This may be attributable to a rapid loss of the material by sublimation in the higher ambient temperatures of the tropics.

Although breakdown of the linseed oil and alkyd paint systems was far less severe than that of the chlorinated rubber, the two former systems, especially those containing pentachlorophenol, showed some blistering and rusting on the mild steel panels and there was a considerable amount of checking and cracking on some of the linseed oil paint specimens on mild steel. The alkyd base paint on mild steel retained its gloss for a longer period than any other combination of paint system and substrate.

9.2.5 Fungicidal Paints (Goodlass Wall and Co. Ltd.)

This trial (34) was designed to assess the fungus resisting characteristics of two paints containing, as a fungicide, the mercury salt of a long chain fatty acid. Keranti and Oboche wood panels (12 inch x 6 inch) were painted in the U.K. as shown in Appendix F.5, and were exposed (on 21.3.57) for sixteen months in the jungle clearing.

Biological growth began to develop within three months of exposure. The general pattern was the development of a dark film of superficial fungal growth interspersed with black spots due to clumps of chlamydo-spores of Pullularia sp. It was rather heavier on the paints containing no fungicide and heavier on the cream than on the corresponding green paints. Pycnidia of the fungus Botryodiplodia theobromae developed on the Oboche panels painted with systems containing no fungicide and burst through from the wood substrate, causing minute dark blisters on the paint film and subsequent flaking of the paint at these spots (Fig.74). Apart from this, there was no physical breakdown of the paints. In addition to the dark fungal growth, scattered green and grey patches of algae also developed.

The presence of this fungicide in paints, therefore, appears to inhibit but not prevent superficial fungal growth. There were indications that it might be effective in inhibiting the more destructive fungus Botryodiplodia theobromae which appears to have a high immunity to most fungicides. Thus, no specimen containing the fungicide under test showed any breakdown of the film as a result of pustules caused by Botryodiplodia theobromae but, on the other hand, none of the green paints on Keranti wood, whether containing fungicide or not, were affected.

/9.2.6

9.2.6 Fungicidal Paints (Jenson and Nicholson Group)

Five paints each containing a different fungicide, the nature of which was not disclosed, were exposed on wood panels for twenty months in the jungle clearing (36). The paints were applied at T.T.E., as described in Appendix F.6, to Obeche panels 8 inch x 6 inch. Some of the panels were pretreated by brushing with a 2 per cent aqueous solution of "Santobrite". Exposure took place on 22.11.56.

None of the fungicidal paints was effective in inhibiting fungal growth. After three months all the panels appeared very dirty as a result of mould growth and vegetable debris adhering to the surface. The mould was dark green in colour and was spread over small areas. It consisted of colonies of Cladocporium which appeared generally to be growing on surface contaminants. There were, however, discrete colonies not associated with such possible sources of nutrient. The growth was only superficial at this stage and could easily be removed with a damp cloth.

After nine months exposure, the mould growth was extensive and formed a continuous coating over the surfaces of the panels. Finish "DF" appeared to be slightly superior to the other as far as inhibition of the growth was concerned. At this stage, the fungal growth was not easily removed with a damp cloth and the paint films were stained.

The panels pretreated with a 2 per cent aqueous solution of "Santobrite" showed cracking of the paint film after eleven months exposure. There was also very slight cracking after nineteen months on most of the panels without "Santobrite" pretreatment. At the end of the trial the pretreated panels were in the same condition as the painted untreated panels.

No chalking, checking, flaking or blistering developed on any of the panels.

10. FUNGICIDAL VARNISHES AND LACQUERS

10.1 Introduction

Three trials involving the exposure of fungicidal varnishes and lacquers were carried out. The types of varnishes tested are listed in Appendix G.

10.2 Individual Trials

10.2.1 Nuodex Fungicides in Varnishes (Trial sponsored by Ministry of Supply, Chemical Inspectorate)

This was part of the trial of 'Nuodex Fungicides in Paints' (see Section 9.2.3). The same four fungicides (Nuodex Super-Ad-It, Nuodex 321.SS, Phemox Oil Soluble and Pentachlorophenol) were incorporated in varnish to specification TS.188, and the varnishes were exposed on mild steel panels for twenty-nine months in a tropical jungle (18). The percentages of fungicide added are shown in Appendix G.1. The varnishes were applied in the U.K. and were exposed in the clearing and the undergrowth on 2.3.54.

Algal growth developed on all the specimens but it was less heavy on the varnished than on the painted panels (Section 9.2.3.). Like the latter, growth was heavier on the panels exposed in the undergrowth than on those in the clearing. The growths were all superficial and were readily removed from the surfaces with a damp cloth. Algal growth first appeared on the panels after six months exposure in the form of green and grey colonies. At the end of the trial, mould growth was beginning to
/appear

appear on all the specimens and it appeared to be associated with the algal coating.

The presence or absence of fungicides in the varnish had no apparent effect on the development of algal and fungal growth on the specimens.

Rusting of the panels started to develop during the early stages of the trial and gradually increased in severity until, after twenty-nine months, 70-99 per cent of the surface areas in the clearing and 40-90 per cent in the undergrowth had rusted. The panels containing no fungicide and those with pentachlorophenol were the most affected and those with Nuodex 'Super-Ad-It' least affected in this respect at both sites.

10.2.2 Fungicidal Varnishes (Trial sponsored by Ministry of Supply, Chemical Inspectorate)

This was part of the trial on fungicidal paints described in Section 9.2.4. The effectiveness of the two fungicides, Nuodex Super-Ad-It and pentachlorophenol, was compared when incorporated into varnish to specification T.S.188 (28). The Super-Ad-It was in a higher concentration than previously (see Section 10.2.1); details are given in Appendix G.2. The varnishes were applied in the U.K. to hard aluminium panels (12 inch x 12 inch) and were exposed in the jungle undergrowth (on 3.12.56) for fifteen months.

All specimens, both with and without fungicide, remained free from algal and fungal growths throughout the trial, except for minute traces of colourless mycelium which were not readily detected by unaided vision. There was no physical deterioration of the varnish films.

10.2.3 Fungicidal Lacquers (Brandram Bros. and Co. Ltd.)

Two fungicidal lacquers (Lacquers 'B' and 'C'), containing PCMA (para-chlorometaxylenol) and "Captan" respectively, were exposed to hot, humid climatic conditions for up to ten months to assess their effectiveness in preventing fungal growth (29). Varnish, Special, Fungicidal, to Specification T.S.191B was used as a comparative standard.

The lacquers and varnish were applied at T.T.E., as described in Appendix G.3, to Nigerian Mahogany Plywood and Obeche panels. The panels were exposed at the base depot store on 26.3.57 and in the jungle clearing on 27.3.57. Those at the latter were withdrawn after five months but at the base depot they were left for ten months.

Neither of the two lacquers was effective for internal or external application. They did not appear to have any fungus inhibiting properties and were greatly inferior to the fungicidal varnish formulated to specification T.S.191B.

In the base depot store, the gloss of the two lacquers 'B' and 'C' appeared patchy after two weeks probably due to mycelial growth of the fungus *Penicillium* sp. The patches spread and after three to four months visible white fungal colonies appeared (Figure 75 shows the conditions of the panels after six months) and the gloss was very poor. After ten months, both lacquers had lost all their gloss apart from small traces and bore moderately heavy fungal growth. Lacquer C was worse than Lacquer B in this respect. The control finish (Varnish to T.S.191B) was superior to the lacquers in gloss retention and resistance to fungal growth. It showed patchiness after four months but there was no visible fungal growth until after ten months exposure, and then it was only slight. On the untreated wood control panel, mould growth increased from the first two weeks exposure and soon became heavy.

In the jungle clearing, both lacquers 'B' and 'C' had a considerable coating of mould growth within three weeks of exposure, while the control varnish was practically mould-free. After three months, only a trace of gloss remained on the lacquers while the control varnish was still good in this respect. At this stage, the latter was still free from mould growth, except for a few black perithecia towards the bottom of the panels. After five months, the lacquers 'B' and 'C' had completely disappeared from the faces of the panels which had been exposed to light and the surfaces of the panels had a coating of mould growth (mostly Botryodiplodia theobromae) and a fair amount of algal growth. A trace of lacquer remained on the sheltered sides which carried heavy fungal growth, rather more on Lacquer 'C' than on 'B'. However, on the control varnish, a fair amount of varnish still remained, although Botryodiplodia theobromae was growing through the film and appearing as minute black particles. Apart from this and a little algal growth on the upper edge, the control varnish was still fairly clean and in reasonably good condition.

11. ANTI-FOULING PAINTS

11.1 Introduction

Marine fouling, especially of ships' hulls, is a major problem in tropical waters. It causes damage to paints applied for the protection of the metal against corrosion, reduces the speed and increases the fuel consumption of ocean-going ships and is usually extremely difficult to remove. Paints for ships' hulls, therefore, require, in addition to good anti-corrosive properties, the characteristic of preventing or at least inhibiting the growth of marine organisms. Toxic agents, such as cuprous and mercury compounds, are usually mixed in with the pigments. The effectiveness of these compounds is undoubtedly associated with the rate of leaching, so as to maintain the toxic agent at the surface. This leaching effect limits the effective life of each application. Metallic copper powder has the disadvantage of possible galvanic action with the metal of the hull leading to an accelerated rate of corrosion.

Four trials on anti-fouling paints were carried out and Appendix H contains a list of the materials tested.

11.2 Results

11.2.1 Anti-Fouling Anti-Teredo Paint (Red Hand Compositions Co.)

The effectiveness of a copper-containing paint as an anti-fouling and anti-teredo (see Section 12.2.1) agent was assessed by total and partial immersion of painted Lagos Mahogany panels (12 inch x 6 inch) in the Bonny River, Port Harcourt for four months and full immersion at the Opobo immersion site for eight months (9). The paint was applied at T.T.E. as described in Appendix H.1, and the panels were exposed at Opobo on 2.4.53 and in the Bonny River on 23.6.53.

The paint delayed the onset of fouling to a small degree but it was not very effective as an anti-fouling agent.

At the Bonny River Immersion site, fouling of the panels, both in the wind/water zone and fully immersed, commenced after only two months exposure, while unpainted wood control panels fouled after three weeks. Subsequent fouling of both painted and unpainted panels increased rapidly (Fig. 76).

At the Opobo immersion site, there was no fouling of either the painted or unpainted panels after eight months exposure.

/11.2.2

11.2.2 Anti-Fouling Paint Systems (Red Hand Compositions Co.)

Six different anti-fouling systems (see Appendix H.2) on heavy gauge steel panels were evaluated by partial immersion in the Bonny River, Port Harcourt for nine months (17). The panels, 18 inch x 11 inch, were painted in the U.K. and immersed on 14.4.54.

None of the systems appeared to be very effective as anti-fouling agents. After three months exposure, all the paint finishes were in good condition, with the exception of system H2-4 (Zinc Chromate and Green Anti-Fouling Paint) which showed slight cracking, but considerable quantities of slimy fouling mechanisms together with a few barnacles had settled on all the panels. After six months, all specimens were heavily covered with these organisms, making examination of the paint surfaces impossible. Little change in the amount of marine growths occurred up to nine months and soon after this the specimens were lost.

11.2.3 Admiralty Experimental Anti-Fouling Paints (Trial sponsored by the Admiralty Central Dockyard Laboratory)

Fourteen Admiralty anti-fouling paints (see Appendix H.3) were exposed from a raft in the Bonny River, Port Harcourt for fifteen months to assess their resistance to fouling under tropical conditions (25). The paints were applied to mild steel panels, 10 inch x 6 inch, at T.T.E. and were exposed on 17.10.56.

All the paints fouled, the best (45P-1:1 Rosin/Aroclor pigmented with cuprous oxide) lasting for about sixty weeks. Four (44P, 161P, 161P Modified and U.S.N. Spec.121) were effective for fifty to fifty-four weeks and four (D/3/5, 44P Modified, 364P and D/3/2) for between sixteen and thirty-two weeks. The remaining five fouled less than four weeks after immersion.

Heavy chalking occurred on paints 44P Modified, D/3/2 and D/3/5 and slight chalking on 45P Modified, 161P Modified, 44P and 45P. The remainder showed no chalking throughout the trial.

Severe cracking was recorded on five paints (359P, 360P, D/3/5, 364P and 363P) after thirty-seven to fifty-four weeks immersion. On the remainder of the specimens, no cracking occurred, except possibly in the case of paints 45P and D/3/2 where it was noted at one inspection only but subsequently disappeared.

No abnormal blistering occurred on any of the paints. Fine and medium blistering covering 10 per cent of the surface area was noted on all specimens after about fifty weeks immersion, except for the U.S.N. Spec.121 paint for which it was not recorded until at least sixty weeks after exposure.

Generally, there was little flaking of the paints. The greatest loss of anti-fouling paint was due to chalking and consequent thinning of the paint film, but further loss of the anti-fouling (and anti-corrosive) film was caused by the cutting action of the growing barnacle shells.

Rusting, apart from that at panel edges, was associated almost entirely with damage to the paint film brought about by the growth of barnacle shells. In the case of 45P Modified, a few large barnacles had cut through the paint film causing pitting and rusting of the panel after forty-seven weeks exposure. On the panels coated with 359P, barnacles had cut through the paint film after thirty-seven weeks causing some flaking of the anti-fouling paint and rust where the anti-corrosive paint also was damaged. At the end of the trial, rusting and pitting were bad at the areas of barnacle damage. Rusting and pitting of the panels coated with paints 360P, 363P and 364P were extensive and these defects were generally associated with barnacle damage to the paint films.

/The

The anti-fouling performance of the paints was in the order shown in Table 12, below:

TABLE 12

Effective Lives of Admiralty Experimental Anti-Fouling Paints
(Fully immersed at the Bonny River Site)

Paint Type	Effective Anti-fouling Life (Weeks)		
45P	60 -	>65	(see Fig.77)
44P	50 -	54	(see Fig.77)
161P (Mod.)	50 -	54	
U.S.N. Spec. 121		50	(see Fig.78)
161P	37 -	54	
D/3/5		32	
44P (Mod.)	32 -	37 (8)	
364P		24	
D/3/2	16 -	24	
Pocoptic		4	
45P (Mod.)		4	
359P		4	
360P		4	
363P		4	(see Fig.78)

- NOTES: 1. Where two figures are given for the anti-fouling life, the second figure refers to the lower panel of the duplicate specimens immersed.
2. Paint 44P (Modified) fouled after eight weeks but subsequently cleaned and fouled again after 32/37 weeks.

11.2.4 Experimental Anti-Fouling Compositions (I.C.I. Ltd.)

Twelve experimental anti-fouling paints based on plasticised rosin and cuprous oxide (see Appendix H.4) were exposed from a raft in the Bonny River at Port Harcourt for twenty-seven weeks (26). The paints were applied at T.T.E. to "Tufnol" panels, 4 inch x 4 inch, and were exposed on 26.8.57.

Cracking of the paint film occurred on only a few specimens, viz. on two panels of H4-9 (plasticised rosin with 60 per cent cuprous oxide) during the first four weeks and on two panels of H4-10 (plasticised rosin with 40 per cent cuprous oxide and 1 per cent D.D.T.) during the first twelve weeks of exposure. When fouling began to develop, however, cracking was no longer visible and was not recorded in the latter stages of the trial. All paints became more or less heavily fouled after twenty-six weeks with the exception of H4-11 and J4-12 (plasticised rosin with 50 per cent cuprous oxide and 2 per cent mercury oxide) which were only slightly and H4-6 and H4-7 (plasticised rosin with 40 per cent cuprous oxide and 1.5 per cent mercury oxide) which were only moderately fouled. H4-12 was the best and H4-4 (rosin/oil with 30 per cent cuprous oxide) the worst as regards fouling. Figures 79 and 81 show the condition of the panels after twenty-six weeks immersion.

/11.3

11.3 Conclusions

The anti-fouling anti-teredo copper paint manufactured by the Red Hard Compositions Co. delayed the onset of fouling but did not prevent fairly heavy incrustations after four months exposure. This material was concluded to have low anti-fouling properties. The six paint systems tested in the second trial of Red Hard Compositions were similarly low in anti-fouling properties being heavily covered with marine organisms after six months exposure.

Of the I.C.I. experimental anti-fouling paints, the two most effective contained 2 per cent of mercury oxide in addition to 50 per cent of cuprous oxide and two more which were only moderately fouled contained 1.5 per cent mercury oxide in addition to 40 per cent of cuprous oxide. The addition of a small proportion of mercury oxide to cuprous oxide, therefore, seems to be beneficial in increasing the anti-fouling properties of these paints. However, from the condition of the panels coated with these I.C.I. compositions it appeared that none of the paints would have retained their effectiveness for much longer than twenty-seven weeks.

The Admiralty anti-fouling paint 45P containing 1:1 Rosin/Arcolor pigmented with cuprous oxide was the most effective anti-fouling paint tested at T.T.E.

12. ANTI-TEREDO PAINTS

12.1 Introduction

The ravages of shipworm and gribble on the hulls of canoes, small launches, wooden piers and water-transported timber has for long been a matter of great concern on the West Coast of Africa. Attack by shipworm can be immediately distinguished by the white shelly lining to the borings which may have a length of up to six feet and which never intersect. Gribble normally only burrow to a depth of half an inch or even less. The borings, however, are so close together that the outer layer of the timber is eventually entirely removed, thereby exposing a new layer to attack. Both types of organism may occur together and they can attack timber as high as midway between tidemarks or down to a depth of several hundred fathoms (41), the actual limits varying with the species. Some species require high salinity while others can survive in fresh water or even in air for a week or more. Muddy water or water contaminated with sewage is usually free from these organisms (41). Teredo larvae are said to swim downwards away from strong light but to remain in a dim light or even to migrate into an area of dim light from darkness. Consequently they tend to collect at an optimum light density and, in the zone of this intensity, attack will be greatest. The precise depth of this zone will depend on the amount of suspended matter, the clearer the water the deeper being the zone of maximum attack. In the absence of definite information on the actual light intensity at which larvae tend to collect, exposure panels for assessing teredo attack at the T.T.E. sites were placed generally at a depth of approximately two feet below the surface of the water. The species of shipworms occurring at Port Harcourt is referable to the genus Bankia. Teredo species in the strict biological sense are not found there but are abundant nearer the open sea.

Most types of timber are liable to attack by shipworm, the degree of susceptibility depending to some extent on the hardness of the timber. Lagos mahogany and yellow pine, for example, are known to be particularly susceptible to teredo attack and panels of these materials were used in trials at T.T.E. to assess the anti-teredo properties of paints. For supporting the panels under the surface of the water, either steel or iroko /frames

frames were employed, the latter being a timber which has shown a fair resistance to teredo attack.

The characteristic of a paint required to provide resistance to attack by teredo has not been definitely established. In particular, it is thought that a very durable rather than a toxic paint film may be the answer to protection against teredo attack. Anti-teredo action may be mainly mechanical in character. For example, samples of timber examined in the U.K. suggested that ordinary Admiralty Grey Paint protects against teredo, and attack commences when the paint film fails as a result of abrasion, flaking or cracking, thereby exposing the bare wood. The teredo larvae enter through cracks on the exposed areas which need only be minute. In testing alleged toxic anti-teredo paints, therefore, the provision of a second control coated with a good protective (non-toxic) paint in addition to an unpainted bare wood control is desirable (47).

Two trials were carried out involving the exposure of anti-teredo paints and a list of the materials tested is given in Appendix I.

12.2 Results

12.2.1 Anti-Fouling Anti-Teredo Copper Paint (Red Hand Compositions Co.)

This was the same material as described in Section 11.2.1 (see Appendix H.1). Its effectiveness as an anti-teredo coating was assessed by total and partial immersion of painted wood panels in the Bonny River, Port Harcourt for four months and full immersion at the Opobo site for eight months (9). The paint was applied to Lagos Mahogany panels, 12 inch x 6 inch, at T.T.E. and the panels were immersed at Opobo on 2.4.53 and in the Bonny River on 23.6.53.

After four months in the Bonny River, there was no teredo attack on the painted panels, although the unpainted wood control panels had sustained severe damage (Fig.82).

After eight months exposure under water at Opobo, there was no teredo attack on either painted or unpainted panels; the latter, however, had been attacked by gribble.

12.2.2 Admiralty Experimental Anti-Teredo Paints (Trial sponsored by the Admiralty Central Dockyard Laboratory)

Eight Admiralty underwater paints (see Appendix I) were tested as protectives against shipworm attack on yellow pine panels: exposed from a raft in the Bonny River, Port Harcourt for sixteen months (25). Five of these paints were primarily devised as anti-fouling compositions for use on steel (see Section 12.2.3) and the remaining three were experimental paints containing ground glass devised as anti-teredo protectives. The paints were applied at T.T.E. to yellow pine panels, 10 inch x 6 inch, and were immersed on 17.10.56. All the paints had settled to some extent and difficulty was experienced in stirring them before application. The ground glass compositions CFF/381/55 and CFF/382/55 were particularly bad in this respect.

After sixty-seven weeks, no teredo attack had developed on panels painted with four of the compositions viz. 45P, U.S.N. Spec.121, Picoptic and CFF/383/55 (ground glass formulation). There was only slight attack on panels coated with 44P, and Pamar. Panels coated with the remaining two compositions, CFF/381/55 and CFF/382/55 (ground glass formulations), were heavily attacked. All attack occurred initially at areas of exposed wood resulting from poor adhesion of the anti-teredo paint and breakdown of the exposed undercoat. There was no evidence of shipworms boring through intact paint to reach the wood.

/Details

Details of the condition of the paints are as follows:

I-1 (Type 44P) The paint was soft and chalking and tended to scrub off on cleaning. There was a small amount of flaking to the bare wood at the sharp edges of the panels.

I-2 (Type 45P) The wood was saturated with water and the grain was showing; but no bare wood was visible. Some paint was removed on cleaning the panels.

I-3 (Paint to U.S.N. Spec.121) The paint film was intact and the wood was dry. There was no cracking or flaking (Fig.83).

I-4 (Pocoptic) The topcoats were cracked and there was slight flaking near the panel edges but no bare wood was showing.

I-5 (Ground Glass formulation) Bad adhesion of the finishing coats to the undercoat resulted in the loss of the former during the early stages of the trial. After exposure, the undercoat was badly worn and damaged and areas of bare wood were visible (Fig.84).

I-6 (Ground Glass formulation) There was considerable flaking of the topcoat but the undercoat was intact except for small marginal areas.

I-7 (Ground Glass formulation) There was slight barnacle damage to the topcoat but the undercoat was intact and no bare wood was visible.

I-8 (Pomar) The paint was in good condition. There was, however, slight barnacle damage but this did not extend to the wood.

12.3 Conclusions

The Red Hand Compositions Co. Anti-fouling, Anti-teredo Copper Paint showed resistance to teredo attack in the creek waters at Port Harcourt and to attack by gribble at Opobo for at least eight months. The trial, however, should have been continued longer to determine the maximum period of resistance.

In the trial of Admiralty underwater paints, attack by shipworms occurred in all cases at areas where the wood had been exposed by loss or breakdown of the paint films. There was no evidence to show that the organisms had bored through the intact paint film to reach the wood. The most extensive damage occurred to those panels on which the paints failed to adhere to the wood. Four paints successfully prevented attack for sixty-seven weeks. Three of them - U.S.N. Spec.121, 45P and Pocoptic - were primarily devised as anti-fouling compositions and the fourth, an experimental ground glass composition (GPF/383/55), was formulated for anti-teredo evaluation only. Of the three anti-fouling paints, U.S.N. Spec.121 and 45P showed a high toxicity to marine growths while Pocoptic was virtually worthless in this respect.

13. COMPOSITION PRESERVATIVE ON PAINTS

13.1 Introduction

A series of trials was initiated by the War Office in 1943 with the object of inhibiting corrosion of metal ammunition boxes painted with wartime paint. One such trial was conducted by D.D.C.S., West Africa /Command

Command at the Ordnance Depot, Lagos, where ammunition boxes were sprayed with Composition Preservative to C.S.1663F and exposed for six months in a standard army store with a concrete floor. T.T.E. collaborated in this trial by exposing painted panels with and without preservative coatings to various climatic conditions for periods of up to eight months to determine whether the composition had any deleterious effect on the paints and to evaluate its corrosion-inhibiting effect under the more severe conditions at the outdoor exposure sites (1).

Two different ammunition paints each with and without a coating of the preservative were exposed on panels supported on stands at an angle of 45° to the horizontal (see Appendix J and Table 13). At the jungle site, the stand was placed inside an open-sided shed to give protection from rain and tree drippings and, at the marine site, the stand was placed under a high cover to provide protection from rain and, at the same time, allow a fair amount of access to sunlight.

TABLE 13

Composition Preservative on Paints

Substrate	Preparation of Specimens	Exposure Sites	Date Exposed	Duration of Exposure (Months)
Mild steel panels 12 inch x 12 inch	Painted in U.K. Composition Preservative applied by dipping at TTE exposure sites	(i) Jungle Site	27.8.48	8
		(ii) Marine: 200 yd	21.9.48	7
Painted Ammunition Boxes	Boxes sprayed with Composition Preservative at Ordnance Depot, Lagos	(iii) Ordnance Depot, Lagos	8.10.48	6

13.2 Results

At the jungle site, rusting of the white painted panels, both untreated and coated with the preservative composition (specimens J-1 and 2), commenced after about eight weeks exposure but progressed much more rapidly on the untreated panel (J-2). After six months, about 75 per cent of the surface of the latter had rusted while only 10 per cent of the treated panel (J-1) was affected. On the brown-painted panels (J3 and 4), blistering and rusting at the blistered areas commenced after about five months on the treated panel (J-3) and after six months on the untreated panel (J-4). After eight months, about 45 per cent of the surface of the untreated panel and 35 per cent of the treated panel was affected by rusting. At this stage, the surfaces of both the treated and untreated painted panels were evenly covered with small blisters. Only the brown-painted specimens supported mould growth and it was generally only slight. It first appeared on the treated panel (J-3) after three weeks and on the untreated sample (J-4) after eleven weeks and, throughout the trial, the former was more affected than the latter.

At the marine site, after only four weeks exposure, rust spots appeared on all the panels and, in the case of the white-painted specimens, 90 per cent of the surface of the treated and only 15 per cent of the untreated panel was affected at this stage. Rusting increased progressively thereafter until, at the end of the trial, most of the surface of both treated and untreated white panels had rusted and the remaining paint was heavily rust-stained. In the case of the brown-painted panels, the untreated panel was

/more

more affected by rusting after four weeks, an area of the centre of the panel having rust spots with pitting corrosion in the centre of each spot. At the end of the trial, the whole surface of both treated and untreated brown panels had rusted completely and no paint was visible.

In the Ordnance Depot at Lagos, the ammunition boxes sprayed with the preservative composition did not show any rusting after six months exposure. However, the treated surfaces did not dry properly and, except for small patches on the exterior of the boxes, they remained oily to the touch during the six months exposure period.

13.3 Conclusions

The results obtained from this trial were not very conclusive.

The preservative composition appeared to have little or no effect in delaying the onset of rusting at the outdoor exposure sites. In the case of the brown stoving paint, it had a slight effect in reducing the subsequent extent of rusting. Very conflicting results, however, were obtained with the white air-drying paint; under hot humid jungle conditions, the preservative reduced considerably the extent of rusting whereas, at the marine site, it had an accelerating effect on the corrosion of the underlying metal. It is not clear whether this was due to the airborne salt or to the more intense sunlight at this site. The preservative also seemed to encourage the growth of fungi.

Under conditions of good tropical storage in the Ordnance Depot at Lagos, the preservative had a definite inhibiting effect on the corrosion of painted steel ammunition boxes but it remained soft and 'oily' for at least six months, resulting in difficulties in handling the articles and possible contamination of the contents of the boxes and adjacent stores.

14. STORAGE OF PAINTS IN THE TROPICS

14.1 Introduction

The effect of tropical storage on various Service paints manufactured by Gallon Ltd. was assessed by storing them in the base depot at Port Harcourt for six months and returning them to the sponsors of the trial for examination (5). All the materials were contained in 4-oz metal cans with the exception of the Carrux Reducer (Specimen K-2) which was in a glass bottle. This storage trial was run in conjunction with an exposure trial on Service paint systems at the marine site, similar materials being involved in each case (see Section 4.2.18 and Appendix A.16). A list of the paints tested for storage stability is given in Appendix K. The trial was started on 5.11.52, and the cans were returned unopened to the U.K. on 6.5.53.

The robustness and suitability under tropical conditions of two types of five-gallon metal drums were assessed at various exposure sites (4). The Government pattern with a three-inch Farwig neck was compared with an experimental pattern based on B.S.S.814, having a screw cap instead of the normal press-fit cap. The experimental pattern was recommended by the Joint Non-warlike Stores Standardisation Sub-Committee dealing with Drums and Metal Containers for the Packaging of Service Paints, etc., and the object was to test a seal which could be re-made after removal of some of the contents thus allowing the residual material to be returned to store. Table 14 indicates the scope of the trial.

/TABLE 14

TABLE 14

Drums for Packaging of Service Paint

Specimens Exposed	Exposure Site	Conditions of Exposure	Date of Exposure	Duration of Exposure (Months)
<u>Type A.</u> Government approved pattern 5-gallon drum with 3 inch Farwig neck (press fit cap)	(i) Jungle Clearing	Exposed to sun and rain	22.12.51	9
	(ii) Jungle Undergrowth	Drums covered with tarpaulin to limit circulation of air	5.11.51	11
<u>Type B.</u> Experimental pattern 5-gallon drum based on B.S.S. 814 with screw-cap	(iii) Marine	Exposed to sun, rain and high atmospheric salinity	12.12.51	13
	(iv) Marine	Screened from direct sunlight and rain	12.12.51	13
	(v) Desert	Exposed to direct sun and rain	6.11.51	9
	(vi) Desert	Screened from direct sun and rain	6.11.51	9

The drums were filled with paint in the U.K. and sent to Nigeria by sea. After the initial examination at T.T.E., Port Harcourt, they were transported to the various exposure sites by lorry, the journey to the marine site requiring also the conveyance by lighter across two miles of water and, finally, carriage by porter for two miles to the exposure site. Some of the experimental pattern drums were opened at intervals, a little of the contents was poured away and the drums closed again to determine the efficiency of the screw-type closure under conditions simulating normal usage.

14.2 Results

14.2.1 Tropical Storage Trial of Service Paints (Cellon, Ltd.)

All the containers appeared to be in good condition when received at T.T.E., and there was no apparent change in their condition after six-months storage in the base depot, except for one specimen (K-15, Red Lead Primer) in which traces of paint were seeping from the lid of the tin.

The containers were returned unopened to the sponsors of the trial for inspection. After thorough stirring of the contents, they reported as follows:

"The S.097 Grey Stoving Enamel and the 2S.588 Red Oxide Primer (specimens K-19 and K-1) have gelled and D.4841 Aluminium (specimen K-23) showed a tendency towards gelation.

/K.5064

K.5064, Gray Enamel (K-14) and to a lesser extent GS.590, Etch Primer (K-9) produced "bitty" films.

S.093, Gray Stoving Enamel (K-20) gave a film deficient in gloss.

S.5177, Red Lead Primer (K-15) showed very heavy settlement, and was found to be impossible to redisperse.

All the other paints proved to be in a satisfactory condition for use."

14.2.2 Drums for Packaging of Service Paint

Three Type A drums (Government-approved type) were damaged on arrival at T.T.E., Port Harcourt, one having both inner and outer capsules detached, one with the outer capsule only detached and one with a large dent in the side and the top chime. During transportation to the exposure sites, further damage ensued, most of the drums sent to the marine and desert sites being dented. In addition, most of the type A drums but only one of the Type B (experimental pattern) showed leakage through the seals on arrival at the desert site. Three of the Type A drums in the jungle undergrowth developed leaks during the first six months exposure and two Type A drums at the jungle clearing leaked through damaged capsules.

Most of the specimens, both of Type A and B, showed some rusting. This was generally very slight at the desert and jungle sites but considerably heavier at the marine site.

Attempts to open Type B drums at one to two-monthly intervals were successful for about six months at the jungle undergrowth and desert (exposed sites). During this period the drums were opened three times but the bar broke away from the lid at the fourth attempt. In the jungle clearing, the drum was opened and resealed six times but breakage occurred at the seventh attempt after eight months exposure. At the desert site (sheltered), the drum was opened and closed satisfactorily throughout the trial. At the marine site, it was found impossible to unscrew the lid on any occasion and this was probably due to rapid corrosion of the threads as no paint had been poured from the drums to cause contamination of the thread and subsequent seizure of the lids.

It was concluded that the experimental type of drum was less likely than the approved type to suffer damage on rough handling which would involve the loss of the contents through the sealing caps. There was a pronounced tendency for the press fit capsule of the latter type to become detached or distorted with resultant loss of an effective seal. A fault with the experimental screw-type closure was the inadequate attachment between the bar and the screw-cap. The rivets were found to break easily if more than manual force had to be applied to overcome seizure resulting from hardening of the paint or corrosion in the threads. A further defect was the vulnerability of the feltine sercofine washers used for sealing the screw caps on the experimental drums. These were all considered unserviceable after the first opening. In spite of these weaknesses, the screw closure remained serviceable for six months or more under all conditions except at the highly corrosive marine site where the rapid onset of corrosion rendered the container unserviceable within a few weeks of exposure.

15. ACKNOWLEDGMENT

A number of the staff of Chemical Testing Establishment were concerned in carrying out this trial.

16. BIBLIOGRAPHY

1.	T.T.E. Report No.	65	Effect of Composition Preservative on Paints.
2.	"	"	177 Painted Panels (Steel and Aluminium).
3.	"	"	230 Bergermaster Paints.
4.	"	"	255 Drums, 5 gallon.
5.	"	"	265 Service Paints - Tropical Storage Trial.
6.	"	"	277 Metal Finishes - Tropical Exposure.
7.	"	"	292 Silica Graphite Paint Systems.
8.	"	"	299 Chlorinated Rubber Paints.
9.	"	"	334 Anti-Fouling and Anti-Teredo Paints.
10.	"	"	360 Paint Systems.
11.	"	"	373 Car Finishes - Tropical Exposure Trial.
12.	"	"	383 Chlorinated Rubber Paints.
13.	"	"	410 Silica Graphite Paint Systems.
14.	"	"	418 Fungus Resisting Paints.
15.	"	"	436 Pammel Synthetic Enamel Paint.
16.	"	"	448 Plastic Emulsion Paints (Sissons) - Tropical Exposure Trial.
17.	"	"	468 Paints, General Purpose.
18.	"	"	480 Nuodex Fungicides in Paints.
19.	"	"	557 Painted Steel Plates.
20.	"	"	569 Admiralty Paint Systems.
21.	"	"	582 Paints, War Equipment.
22.	"	"	586 Fungus Resisting Paints (I.C.I. Ltd).
23.	"	"	594 Ready Mixed Oil Paints.
24.	"	"	604 Admiralty Experimental Anti-Fouling Paints.
25.	"	"	613 Admiralty Experimental Anti-Teredo Paints.
26.	"	"	620 I.C.I. Anti-Fouling Compositions.
27.	"	"	632 Ready Mixed Oil Paints.
28.	"	"	633 Fungicidal Paints and Varnishes - Tropical Trial.
29.	"	"	634 Fungicidal Lacquers.
30.	"	"	670 Priming Schemes for Metallic Coatings.
31.	"	"	671 Canadian Army Vehicle Paints Applied to Wood (Tropical Trial).

32. T.T.E. Report No. 677 Paints for Harbour Use. Tropical Exposure Trial.
33. " " 678 Leigh's Paints. Tropical Exposure Trial.
34. " " 679 Fungicidal Paints (Goodglass wall).
Tropical Exposure Trial.
35. " " 680 International Paints and Varnishes.
Tropical Exposure Trial.
36. " " 682 Paints and Enamels.
37. " " 690 Turnall Colourglass. Tropical Exposure Trial.
38. " " 693 Paints, General Purpose.
39. " " 703 Marine Exposure of Some Service Paint Systems.
40. Chemical Inspectorate, Glasgow Outdoor Exposure Testing Section.
Report C1/R.71.
41. Ordnance Laboratories, Cawnpore, Pest Control Pamphlet No. 4,
May 1948, p.14.
42. Anderson A.E. and Sherrard W.C., J.Amer.Chem.Soc., 1933, 55, 3318.
43. Footner H.E. and Murray G., J. Oil Colour Chemists' Assoc., 1947, 30, 378.
44. Ministry of Supply and Department of Scientific and Industrial Research, "Tropic Proofing", London, H.M.S.O., 1949, page 22.
45. Ambler H.R. and Bain A.A.J., J. Appl. Chem., 1955, 5, 437-467.
46. T.T.E. Report No. 335 Preliminary Report on Corrosion of some Common Metals in Sea and Crack Water.

APPENDIX A

Paints Applied to Metal Surfaces

1. Bergermaster Paints (Lewis Berger and Sons Ltd.)

Serial No.	Paint System	Description
A1- 1	Undercoat (one coat) Berkeley Green Bergermaster Gloss Enamel (one coat)	- Copolymerised Styrene Medium

2. Pammel Synthetic Enamel Paint (Blundell Spence and Co. Ltd.)

Serial No.	Paint System
A2- 1	Green Undercoat (one coat) Pammel Synthetic Enamel, light fast Green (one coat)

Note. The general composition of the enamel was as follows:
Pigment (Phthalocyanine Blue, Lead Chrome and Blanc Fixe) - 25%
Non-volatile medium (Long-oil Linseed Oil, Pentaerythritol Alkyd) - 50%
Solvent and Driers - 25%

3. General Purpose Paints (Red Hand Compositions Co. Ltd.)

Serial No.	Primer	Undercoat	Finishing coat
A3- 1	As primer	Zinc Chromate, yellow	Extra Brilliant Aluminium Paint
A3- 2	Wash primer	Zinc Chromate, yellow	Extra Brilliant Aluminium Paint, Fungicidal
A3- 3	Special Steel Primer	Syndurac Undercoat	Syndurac Finishing
A3- 4	Zinc Chromate Primer, yellow	" "	" "
A3- 5	A.S. Metallic Primer	" "	" "

Note. The first two systems (A3- 1 and A3- 2) were applied to galvanized iron and the last three (A3- 3 to A3- 5) to steel panels.

APPENDIX A (Cont'd)

Paints Applied to Metal Surfaces

4. War Equipment Paints (Various Manufacturers: Trial sponsored by Ministry of Supply, Chemical Inspectorate)

Serial No.	Primer	Finishing Coat		
		Manufacturer	Specification	Colour
A4- 1	Red Oxide(DEF/1035)*	I.C.I. Ltd.	Pt. W.E. O.D.	Olive Drab
A4- 2	" "	" "	" " A.D.	" "
A4- 3	" "	Lewis Berger	" " O.D.	" "
A4- 4	" "	" "	" " A.D.	" "
A4- 5	" "	E. and F. Richardson	" " O.D.	" "
A4- 6	" "	" "	" " A.D.	" "
A4- 7	" "	Burt, Bolton & Hayward	" " A.D.	" "
A4- 8	" "	E. and F. Richardson	" " A.D.	Arctic White
A4- 9	" "	Denton and Jutsum	" " A.D.	Olive Drab
A4-10	None	I.C.I. Ltd.	" " O.D.	Olive Drab
A4-11	"	" "	" " A.D.	" "
A4-12	"	Lewis Berger	" " O.D.	" "
A4-13	"	" "	" " A.D.	" "
A4-14	"	E. and F. Richardson	" " O.D.	" "
A4-15	"	" "	" " A.D.	" "
A4-16	"	Burt, Bolton & Hayward	" " A.D.	" "
A4-17	"	E. and F. Richardson	" " A.D.	Arctic White
A4-18	"	Denton and Jutsum	" " A.D.	Olive Drab

Note. For Systems A4 - 1 to A4 - 9, one coat of primer and two finishing coats were used; for the remainder, two finishing coats only. Each panel was divided by a vertical line into two equal portions, one portion with and one without primer but the same finishing coat was on each panel e.g. System A4-1 shared a panel with A4-10.

*Formulation of Paint to Specification DEF-1035

(Paint, Priming, Red Oxide of Iron/Zinc Chrome)

The paint consists of a good quality varnish medium pigmented with red oxide of iron and zinc chrome and containing up to 10% (calculated on the pigment) of mineral suspending agent. The pigment must contain 60% of oxide of iron (as Fe_2O_3) and 4 15% of zinc chrome (4 6.4% CrO_3)

APPENDIX A (Cont'd)

Paints Applied to Metal Surfaces

5. Ready Mixed Oil Paints (Various Manufacturers: Trial sponsored by Ministry of Supply, Chemical Inspectorate)

Serial No.	Primer	Finishing Coat		Colour	No. of Coats
		Manufacturer	Specification		
A5- 1	(Red Lead, Priming	Postans Paints	CR/PVC/8880	Red Oxide	1
A5- 2	(B.S.S.1011, Type 1	" "	" "	" "	2
A5- 3	"	" "	BSS 295. Type H	" "	1
A5- 4	"	" "	" "	" "	2
A5- 5	"	" "	BSS 295. Type L	" "	1
A5- 6	"	" "	" "	" "	2
A5- 7	"	Lewis Berger	CR/PVC/8880	Black	1
A5- 8	"	" "	" "	" "	2
A5- 9	"	" "	BSS 294, Type 1	" "	1
A5-10	"	" "	" "	" "	2
A5-11	"	Smith & Walton	BSS 293. Type 1	(Light	1
A5-12	"	" "	" "	(Brunswick,	2
A5-13	"	" "	CR/PVC/8880	(Green	1
A5-14	"	" "	" "	" "	2
A5-15	"	Bryce Weir	CR/PVC/8880	Black	1
A5-16	"	" "	" "	" "	2
A5-17	"	" "	BSS 294. Type 1	" "	1
A5-18	"	" "	" "	" "	2

Note. One Series was painted in the U.K. by the Chemical Inspectorate and a duplicate series was painted at T.T.E.

Composition of Paints to B.S. Specifications

Ready Mixed Paints (Oil Gloss)					
	Red Lead, Ready Mixed Paint B.S. 1011, Type 1	Green B.S.293 Type 1	Black B.S.294 Type 1	Red Oxide B.S.295, Grade H.	Red Oxide B.S.295, Grade L.
Pigment (% of paint)	78 - 82	69 - 71	53 - 61	50 - 59	59 - 67
Argillaceous Matter (% of paint)	1/4	Included in pigment	Included in pigment	8	3
Thinners Turpentine or White Spirit (% of paint)	1/6	4 - 6	7 - 8	4 - 6	3 - 5
<u>Driers</u>	As required	As required	As required	As required	As required
<u>Linseed Oil</u> (Raw, Boiled or Refined)	Remainder	Remainder	Remainder	Remainder	Remainder
Composition of Pigment	Non-Setting Red Lead to B.S.217, Type C	Lead } Chrome } White } 50% Lead, } Prussian } Blue } Argillaceous } Matter } 5% Remainder- } Barytes }	Vegetable Black, 12-14% White Lead } 8% Argillaceous Matter } 8% Barytes }	Red Oxide of Iron to B.S.272	Red Oxide of Iron to B.S.272

APPENDIX A (Cont'd)

Paints Applied to Metal Surfaces

6. Paints for Harbour Use (Robert Bowran and Co.)

Serial No.	Primer	Undercoat	Finishing Coat
A6- 1	{ Eggshell { Red Lead	Undercoating Type 2 - Grey U.7 Undercoating Type 2 - for Portland Stone BSC 364	"Bowdura" Durable Gloss Paint - Portland Stone BSC 364
A6- 2	"	Undercoating Type 4 - for Portland Stone BSC 364	"Easiflo" Enamel - Portland Stone BSC 364
A6- 3	"	"Bowranite" Grade 222 Undercoating - for Portland Stone BSC 364	"Bowranite" Grade 222 Protective Paint - Portland Stone BSC 364
A6- 4	"	"Bowranite" Metallic Paint - Natural Grey.	"Bowranite" Metallic Paint Silver Grey.
<u>Note.</u> One coat each of primer, undercoat and finishing coat was applied to the panels; in the case of system A6- 1, one coat of each of the two undercoats was applied. Twenty four hours air-drying was allowed between successive coats. The edges of the panels were further protected with a narrow border of copal varnish.			

Eggshell Red Lead Primer: A primer containing 60% red lead in a linseed oil vehicle containing a small amount of hard resin to strengthen the film. Dries to an eggshell finish.

Undercoat, Type 2: A lead-based, general purpose undercoat. The pigment is calcium plumbate opacified with titanium dioxide and tinted to a suitable colour. The vehicle is a long oil varnish. Dries to an eggshell finish.

Undercoat, Type 4: Eggshell finish undercoat based on long oil alkyd resin, pigmented with fast chalk-resistant pigments.

"Bowranite" Grade 222 Undercoat: Similar to Grade 222 finishing paint but more highly pigmented and adjusted to dry to eggshell finish.

"Bowdura" Durable Gloss Paint: High gloss exterior finish, based on fast, chalk-resistant pigments without extender, finely ground in a long oil linseed oil/tung oil/maleic resin/alkyd resin varnish.

"Easiflo" Enamel: A synthetic enamel based on long oil alkyd resin, pigmented with fast, chalk-resistant pigments.

"Bowranite" Grade 222 Finishing Paint: High gloss exterior finish designed for use under conditions of atmospheric pollution by salt spray or chemical fumes - based on fast, chalk-resistant pigments, finely ground in a tung oil/phenolic resin varnish.

"Bowranite" Metallic Paints: Designed to give maximum protection to steel surfaces; based on micaceous iron oxide in a long oil alkyd varnish. The silver-grey finishing paint contains, in addition, aluminium powder.

APPENDIX A (Cont'd)

7. Experimental Metallic Paints (W. and S. Leigh Ltd.)

Serial No.	Primer	Finishing Coat
A7- 1	E.508 Metal Primer (2 coats)	E.509 Metallic Paint (2 coats)
A7- 2	E.508 " " (2 coats)	E.510 Metallic Paint (2 coats)
<u>Note</u> Priming coats dried for 48 hours before finishing coat applied.		

E.509 Metallic Paint: Metallic finish based on oleo resinous medium, pigmented with aluminium paste.

E.510 Metallic Paint: Metallic finish based on oleo resinous medium pigmented with micaceous iron oxide.

8. International Paints (International Paints Ltd.)

Serial No.	Primer	Finishing Coat		
		Type	Colour	Mean thickness of each coat (in.)
A8- 1	Brown Chromate	"Episeal"	Red Oxide	0.0010
A8- 2	" "	(Epikote ester	P.O. Red	0.0014
A8- 3	" "	medium)	Green	0.0010
A8- 4	" "	" "	Black	0.0012
A8- 5	" "	" "	White	0.0013
A8- 6	" "	" "	Aluminium	0.0006
A8- 7	" "	"Sunlight Enamel"	Red Oxide	0.0013
A8- 8	" "	(Long oil alkyd	P.O. Red	0.0012
A8- 9	" "	medium)	Green	0.0011
A8-10	" "	" "	Black	0.0013
A8-11	" "	" "	White	0.0015
A8-12	" "	" "	Aluminium	0.0005
A8-13	" "	Short oil alkyd	P.O. Red	0.0016
A8-14	" "	" " "	White	0.0016

Notes: Two coats of primer were applied to each panel, the average thickness of each coat being 0.0011 inch. This was followed by two coats of the appropriate finish.

APPENDIX A (Cont'd)

Paints Applied to Metal Surfaces

9. Chlorinated Rubber Paint (Messrs. Tretol Ltd.)

Serial No.	Primer	Finishing Coats
A9- 1	Chlorinated Rubber Red Primer (1 coat)	Chlorinated Rubber, Red, Finishing (1 coat) "Tretol" Chemiprufe Clear Lacquer (1 coat)

10. Silica/Graphite Paint Systems (Messrs C.R. Averill, Ltd.)

Serial No.	Primer	Undercoat	Finishing Coat
A10- 1	Red Lead/Graphite Primer	None	None
A10- 2	"	Silica/Graphite Natural Colour	None
A10- 3	"	"	Silica/Graphite Medium Gray Finish
A10- 4	"	"	Silica/Graphite Battleship Gray Finish
A10- 5	"	"	Aluminium/Graphite Finish
A10- 6	"	"	Silica/Graphite Dark Red Finish

Note One coat of each of the primer, undercoat and finishing coat were applied

Approximate Compositions

Paint (Linseed Oil Vehicles)	Total Pigment (% of paint, W/W)	Graphite (% of pigment)	Silica (% of pigment)
Red Lead/Graphite Primer	42.5	43.7	13.7
Silica/Graphite Natural	38.9	56.8	20.7
Silica/Graphite Medium Gray	37.8	31.8	23.4
Silica/Graphite Battleship Gray	27.0	31.7	23.8
Aluminium/Graphite	15.3	32.9	19.4
Silica/Graphite Dark Red	32.8	54.7	13.4

APPENDIX A (Cont'd)

Paints Applied to Metal Surfaces

11. Painted Steel and Aluminium Panels (Trial sponsored by the Inter-Services Panel for Co-ordination of Research and Development on Paints and Varnishes)

(i) Paints on Steel Panels

Serial No.	Painting System
A11- 1	DL.6112/6113/6114
A11- 2	DL.6112/6115/6118
A11- 3	DL.6112/6115/6117
A11- 4	DL.6112/6115/6116
A11- 5	DL.6119
A11- 6	DL.6120/6121
A11- 7	DL.6122/6123
A11- 8	DL.5517/6030

(ii) Paints on Aluminium Panels

Serial No.	Painting System
A11- 9	DL.6539/6113/6114
A11-10	DL.6114
A11-11	DL.6539/6115/6118
A11-12	DL.6118
A11-13	DL.6539/6115/6117
A11-14	DL.6117
A11-15	DL.6539/6115/6116
A11-16	DL.6116
A11-17	DL.6119
A11-18	DL.6120/6121
A11-19	DL.6121
A11-20	DL.6122/6123
A11-21	DL.6123
A11-22	DL.5517/6030
A11-23	DL.6030

APPENDIX A (Cont'd)

Paints Applied to Metal Surfaces

12. Painted Panels of Steel Treated and Coated in Various Ways (Trial sponsored by the British Iron and Steel Research Association in collaboration with the Ministry of Supply Metal Finishing Committee)

(i) Paints on Steel Panels, Pickled, Weathered and Wire-brushed

Serial No.	Priming* Paint	Finishing* Paint
A12- 1	300/3	404
A12- 2	300/3	401
A12- 3	300/3	402
A12- 4	300/3	403
A12- 5(J)	336/3	404
A12- 6(J)	336/3	401
A12- 7	336/3	402
A12- 8	336/3	403
A12- 9(J)	547/2	404
A12-10(J)	547/2	401
A12-11	547/2	402
A12-12	547/2	403

(ii) Paints on Steel Panels, Aluminium-sprayed (3 mils)

Serial No.	Priming Paint	Finishing Paint
A12-13(L)	336/3	404
A12-14	336/3	402
A12-15	336/3	403
A12-16	547/2	402
A12-17(L)	547/2	403

(iii) Paints on Steel Panels, Terne-coated, Hot-dipped

Serial No.	Priming Paint	Finishing Paint
A12-18	336/3	402
A12-19	547/2	403

(iv) Paints on Steel Panels, Galvanized and Phosphate-dipped

Serial No.	Priming Paint	Finishing Paint
A12-20	336/3	402
A12-21(L)	336/3	403
A12-22(L)	547/2	404
A12-23	547/2	402
A12-24	547/2	403

Note. Specimens marked (J) in the above tables were exposed at the jungle site only; those marked (L) were exposed at the marine site only; the remainder were exposed at both sites.

*Priming Paints

- 300/3 - Red Lead in Linseed Oil
- 336/3 - Burntisland Red, Zinc Chromate, Extender in Alkyd Medium.
- 547/2 - Zinc, Zinc Oxide in Alkyd Medium.

Finishing Paints

- 404 - White Lead in Oil, Tinted Off-White.
 - 401 - Dark
 - 402 - Aluminium
 - 403 - Fungicidal
- } No further information on these paints was disclosed.

APPENDIX A (Cont'd)

Paints Applied to Metal Surfaces

13. Priming Schemes for Metallic Coatings (Trial sponsored by the British Iron and Steel Research Association).

Serial No.	Substrate	Priming Paint	Finishing Paint
A13- 1	(Steel Panels, aluminium	589	412
A13- 2	(sprayed (2 mils)	593	412
A13- 3	"	594	412
A13- 4	"	596	412
A13- 5	"	None	412
A13- 6	(Steel Panels, zinc	589	412
A13- 7	(sprayed (2 mils)	593	412
A13- 8	"	594	412
A13- 9	"	596	412
A13-10	"	None	412
A13-11	(Steel Panels, pickled,	589	412
A13-12	(weathered and fire-brushed	593	412
A13-13	"	594	412
A13-14	"	596	412
A13-15	Steel Panels, grit-blasted	589	412
A13-16	"	593	412
A13-17	"	594	412
A13-18	"	596	412
A13-19	(Steel complex shapes	589	412
A13-20	(aluminium-sprayed (2 mils)	593	412
A13-21	"	594	412
A13-22	"	596	412
A13-23	(Steel complex shapes	589	412
A13-24	(zinc-sprayed (2 mils)	593	412
A13-25	"	594	412
A13-26	"	596	412

Note. One coat of primer was applied and allowed to dry for 48 hours before applying one coat of finishing paint. The latter was allowed to dry for a further 48 hours before exposing.

14. Protective Paints for Structural Steel (Jenson and Nicholson Group)

Serial No.	Primer	Finishing
A14- 1	Red Lead Primer (3/576/9)	Battleship Grey Finishing Paint
A14- 2	Zinc Chromate/Red Oxide (2/470/34)	"
A14- 3	Red Lead/White Lead (A.560/233/1)	"

Notes: 1 Two coats of each of the primers and one coat of the finishing paint were applied to each of the panels, the drying time between each coat being 24 hours.

2 The numbers in brackets indicate the manufacturer's paint serial number.

APPENDIX A (Contd.)

Paints Applied to Metal Surfaces

15. Admiralty Paint Systems (Trial sponsored by the Admiralty Chemical Department)

Serial No.	Primer	Undercoat	Finishing		Lab.No.
			Type		
A15- 1	Red Lead	(Standard Light	(Light Grey Topcoat		204A/53
A15- 2	Cream Rustodian	(Grey Undercoat	(Admiralty Specification		"
			(DNC/M/73		
A15- 3	Red Lead	"	"	"	1003A/53
A15- 4	Cream Rustodian	"	"	"	"
A15- 5	Red Lead	"	"	"	1004A/53
A15- 6	Cream Rustodian	"	"	"	"
A15- 7	Red Lead	"	"	"	1023A/53
A15- 8	Cream Rustodian	"	"	"	"
A15- 9	Red Lead	"	"	"	1091A/53
A15-10	Cream Rustodian	"	"	"	"
A15-11	Red Lead	"	"	"	1274A/53
A15-12	Cream Rustodian	"	"	"	"
A15-13	Red Lead	"	"	"	-
A15-14	Cream Rustodian	"	"	"	-

Note. One coat each of primer, undercoat and finish was applied. The primers were (a) Red Lead Admiralty Pattern No. 5368 and (b) Cream Rustodian (Laboratory No. 1601A/52).

APPENDIX A (Cont'd)
Paints Applied to Metal Surfaces

16. Service Paint Systems (Cellon, Ltd.)

Serial No.	Substrate	Primer*		Undercoat		Finishing Coat*	
		Type	oz/sq.yd.	Type	oz/sq.yd.	Type	oz/sq.yd.
A16-1	Aluminium, (solvent-cleaned)	S.5179	0.35	None	-	D.T.D. 766A	0.5
A16-2	"	S.5179	0.45	"	-	D.T.D. 63B, Grey	1.175
A16-3	"	S.5179	0.425	"	-	D.T.D. 827, Grey	0.975
A16-4	"	S.4853	0.475	"	-	D.T.D. 766A	0.55
A16-5	"	S.4853	0.4	"	-	D.T.D. 63B, Grey	1.15
A16-6	"	S.4853	0.4	"	-	D.T.D. 827, Grey	0.8
A16-7	Aluminium, (pretreated to D.T.D.915A)	S.X.41	1.1	None	-	D.T.D. 63B, Grey	1.25
A16-8	"	S.X.41	1.15	"	-	D.T.D. 235A	1.1
A16-9	"	S.X.41	1.2	"	-	D.T.D. 827, Grey	0.85
A16-10	"	S.X.41	1.225	"	-	S. 097, Grey	1.45
A16-11	"	S.X.41	1.225	"	-	D.T.D. 63B, Grey	1.45
A16-12	Aluminium, (solvent-cleaned)	C.S.1870C	3.2	C.S.2354	1.6	C.S. 2000E, Grey	2.8
A16-13	"	6K.590	2.3	C.S.2354	1.0	C.S. 2000E, Grey	2.8
A16-14	"	D.N.C/M/76	2.9	C.S.2354	1.25	C.S. 2000E, Grey	3.5
A16-15	Steel, solvent (cleaned and treated with No. 0 Emery cloth)	S.5179	1.25	None	-	D.T.D. 63B, Grey	1.05
A16-16	"	S.5179	0.5	"	-	D.T.D. 827, Grey	1.05
A16-17	"	S.4853	0.425	"	-	D.T.D. 63B, Grey	1.05
A16-18	"	S.4853	0.45	"	-	D.T.D. 827, Grey	0.85
A16-19	"	SX.41	1.025	"	-	D.T.D. 63B, Grey	1.1
A16-20	"	SX.41	1.2	"	-	D.T.D. 827, Grey	1.0
A16-21	"	C.S.1870C	3.2	C.S.2354	1.25	C.S. 2587, Grey	3.425
A16-22	"	C.S.1870C	3.1	C.S.2354	1.175	C.S. 2000E, Grey	3.4
A16-23	"	C.S.1870C	4.5	C.S.2354	1.625	C.S. 2587, Matt, Grey	3.2
A16-24	"	6 K.590	6.1	D.N.C/M/78 Grey	1.9	D.N.C/M/73, Grey	3.625
A16-25	"	S.4923	1.85	D.N.C/M/78 Grey	1.8	D.N.C/M/73, Grey	3.55
A16-26	"	B.S.1011, Type 1	3.8	D.N.C/M/78 Grey	1.5	D.N.C/M/73, Grey	3.95
A16-27	"	D.N.C/M/76	3.05	D.N.C/M/78 Grey	2.4	D.N.C/M/73, Grey	3.9

*See Page 71 for Key.

/A16-28

APPENDIX A (Cont'd)
Paints Applied to Metal Surfaces

16. Service Paint Systems (Gellon, Ltd) (Cont'd)

Serial No.	Substrate	Primer*		Undercoat		Finishing Coat*	
		Type	oz/sq.yd.	Type	oz/sq.yd.	Type	oz/sq.yd.
A16-28	(Magnesium pretreated to D.T.D.911A	S.5179	0.375	S.X.44, Brown	1.0	D.T.D. 63B, Grey	1.0
A16-29		S.4853	0.6	S.X.44, Brown	0.975	D.T.D. 63B, Grey	1.05
A16-30		S.X.44	1.25	S.X.44, Brown	1.0	D.T.D. 63B, Grey	1.5
A16-31	(Cadmium Plated steel, cleaned and treated with No. 0 emery cloth	S.5179	0.45	None	-	D.T.D. 63B, Grey	1.0
A16-32		S.4853	0.4	"	-	D.T.D. 63B, Grey	1.2
A16-33		S.X.41	1.25	"	-	D.T.D. 63B, Grey	1.025

Notes: 1. One coat each of primer, finishing coat and undercoat (where applicable) was applied except for A16-21 to A16-27 inclusive, each of which had two priming coats, two finishing coats and one undercoat.

2. The edges of all panels were protected with K.3825 Aluminium Paint.

*See Page 71 for Key.

APPENDIX A (Cont'd)

Paints Applied to Metal Surfaces

*Primers and Finishes

Type No.	Batch No.	Description
S.5179	-	One solution etch primer
S.4853	5422C	Two solution etch primer
S.X.41	5240A 5237A	Universal primer to specifications D.T.D.63B, 260B, 314A, 754, 768 and 796.
6.K.590	3790B	Red oxide primer for steel
S.4923	3766C	Red lead primer for steel
S.X.44	5237A	Universal primer to specifications D.T.D.63B, 235A, 260B, 314A, 517, 754, 768, 772 and 796
S.X.44 (Brown)	1361A	Universal primer to specifications D.T.D.63B, 260B, 314A, 754 and 911A
D.N.C/M/76	5996A	-
B.S.1011 (Type 1)	4983C	-
D.T.D.766A	6570B	-
S.097	-	Low-bake urea melamine alkyd finish

Note. Batch No. 5237A of Primer S.X.41 was applied to Specimen A16- 11 only.

17. Paint Systems on Light Alloy (Trial sponsored by Inter-Services Research Group)

Paint System			
Serial No.	Code Letter	Colour	Remarks
A17- 1	A	White	"Wet"
A17- 2	A	White	-
A17- 3	B	Blue	"Wet"
A17- 4	B	Blue	-
A17- 5	C	Red	"Wet"
A17- 6	C	Red	-
A17- 7	D	Black	"Wet"
A17- 8	D	Black	-

Note. Each panel was painted in two sections, one of which was designated "Wet" on the back of the panel.

18. Car Finishes (Messrs. F.I.A.T., Turin)

Finishing Paints			
Serial No.	Substrate	Series No.	Type
A18- 1	Mild Steel	I	Synthetic Enamel Finish
A18- 2	"	II	"
A18- 3	"	III	"
A18- 4	"	IV	"
A18- 5	"	V	"
A18- 6	"	VI	Lacquer
A18- 7	"	VII	"
A18- 8	"	VIII	"
A18- 9	"	IX	"
A18-10	"	X	Paint for Industrial Tractors
A18-11	Light Alloy	XI	Finish to D.T.D. 772

APPENDIX B

Paints Applied to Wood Surfaces

1. General Purpose Paints (Red Hand Compositions Co. Ltd.)

Serial No.	Primer	Undercoat	Finishing Coat
B1- 1	Pink Wood Primer	Fungicidal Tropical White	Fungicidal Tropical White
B1- 2	" " "	Tropical White	Tropical White
B1- 3	" " "	Anticorrosive, "Gempurac"	Anticorrosive "Gempurac"
B1- 4	" " "	Anticorrosive, Modified.	Anticorrosive Modified.
B1- 5	" " "	"Synparex" Enamel White, Undercoat	"Synparex" Enamel White, Finishing.
B1- 6	" " "	"Synparex" Enamel White, Undercoat	"Synparex" Enamel White, finishing modified.
B1- 7	" " "	"Syndurac" Enamel White Undercoat	"Syndurac" Enamel White, Finishing.
B1-8	" " "	"Syndurac" Enamel White, Undercoat	"Syndurac" Enamel White, Finishing Modified.
B1- 9	White Lead Primer	"Syndurac" Undercoat	"Syndurac" Finishing.
D1-10	Pink Wood Primer	" " "	"Syndurac" Finishing, Modified.
B1-11	Pink Oil Wood Primer	" " "	"Syndurac" Finishing
B1-12	A.S. Metallic Primer	" " "	" " "
B1-13	" " "	None	" " "
B1-14	Pink Oil Wood Primer	"Syndurac" Undercoat	" " "
B1-15	" " " "	" " "	"Syndurac" Finishing, Modified "A".
B1-16	" " " "	" " "	"Syndurac" Finishing Modified "B"
B1-17	" " " "	" " "	"Syndurac" Finishing Modified "C"

Note. The four systems B1- 5, 6, 7 and 8 were exposed indoors in the base depot store and the remainder out of doors at the town site.

APPENDIX B (Cont'd)

Paints Applied to Wood Surfaces

2. Canadian Army Vehicle Paints Applied to Wood

Serial No.	Substrate	Preservative Treatment of Wood	Primer	Enamel Topcoat
B2- 1	Yellow Birch	None	(Alkyd Primer	A
B2- 2	" "	"	{ to Spec. 1-GP-	B
B2- 3	" "	"	{ 84Pa	C
B2- 4	" "	Copper naphthenate	{ (Formulation	A
B2- 5	" "	"	{ detailed	B
B2- 6	" "	"	{ below)	C
B2- 7	" "	Pentachlorophenol	"	A
B2- 8	" "	"	"	B
B2- 9	" "	"	"	C
B2-10	" "	Chromated zinc chloride	"	A
B2-11	" "	"	"	B
B2-12	" "	"	"	C
B2-13	White oak	None	"	A
B2-14	" "	"	"	B
B2-15	" "	"	"	C
B2-16	" "	Copper naphthenate	"	A
B2-17	" "	"	"	B
B2-18	" "	"	"	C
B2-19	" "	Pentachlorophenol	"	A
B2-20	" "	"	"	B
B2-21	" "	"	"	C
B2-22	" "	Chromated zinc chloride	"	A
B2-23	" "	"	"	B
B2-24	" "	"	"	C

Preservative Treatment. The panel was dipped for three minutes in copper naphthenate (2% copper), pentachlorophenol (5% in mineral spirits) or chromated zinc chloride (10% in water) and dried.

Primer, Alkyd, Air-drying (for wood): Specification 1-GP-84Pa

Ingredient	% by weight
Rutile titanium dioxide (97% TiO ₂ ; Al ₂ O ₃ treated)	4.12
Carbon black	0.19
Barytes (96% Ba SO ₄)	9.26
Amorphous silicon dioxide	13.95
Diatomaceous silica	13.95
Alkyd Resin	42.40
(50% solids in mineral spirits; 35% phthalic anhydride	
46% soya fatty acids: Z-Z ₂ viscosity)	
Nylone	15.23
Anti-skinning agent	0.10
Cobalt naphthenate, (6%)	0.50
Lead naphthenate, (24%)	0.40

APPENDIX B (Cont'd)

Paints applied to Wood Surfaces

Enamel Topcoats

- A. Enamel, Alkyd, Air-drying, Gloss: Specification I-GP-98P, Type 1
- B. Epoxy Resin Enamel
- C. Enamel, Modified Alkyd, Quick-drying, Gloss: Specification I-GP-116P

Ingredient	by weight in enamel		
	A	B	C
Hydrated yellow iron oxide (82.5% Fe_2O_3)	2.84	2.84	5.07
Lampblack	1.16	1.16	-
Carbon black	-	-	0.86
Rutile titanium dioxide (94% TiO_2 ; $\text{SiO}_2\text{-Al}_2\text{O}_3\text{-ZnO}$ treated)	0.42	0.42	-
Rutile titanium dioxide (chalk resistant)	-	-	0.68
Chrome orange (70% PbCrO_4 , 30% PbO)	2.53	2.53	4.64
Chrome yellow (67% PbCrO_4 , 33% PbSO_4)	0.55	0.55	0.96
Alkyd Resin (50% solids in mineral spirits; 34% phthalic anhydride; 49% Linseed fatty acids; W-Y viscosity)	85.00	-	-
Epoxy Resin (50% solids in xylene; short oil soya acid number 2.5, T viscosity)	-	85.00	-
Alkyd Resin (60% solids in toluene; 34% phthalic anhydride; 40% linseed fatty acids)	-	-	50.17
Aromatic Solvent	6.41	-	3.00
Chlorinated rubber, (10 cps)	-	-	7.60
Xylene	-	-	24.11
Mineral spirits	-	6.41	-
Dioctylphthalate	-	-	0.74
Epichlorhydrin	-	-	0.17
Anti-skinning agent	0.10	0.10	0.20
Cobalt naphthenate (6%)	0.28	0.28	0.50
Lead naphthenate (24%)	0.71	0.71	1.30

APPENDIX B (Cont'd)

Paints Applied to Wood Surfaces

3. Experimental General Purpose and High Grade Paints (W. and S. Leigh Ltd.)

Serial No.	Primer	Undercoat	Finishing coat
B3- 1	None	None	E. 500 G.P. Paint, Cream(3)
B3- 2	"	"	" " " Red Oxide(3)
B3- 3	"	"	" " " Green(3)
B3- 4	"	"	E. 501 G.P. Paint, Cream(3)
B3- 5	"	"	" " " Red Oxide(3)
B3- 6	"	"	" " " Green(3)
B3- 7	E. 507 Wood Primer(1)	"	E. 501 G.P. Paint, Cream(2)
B3- 8	" " " (1)	"	" " " Red Oxide(2)
B3- 9	" " " (1)	"	" " " Green(2)
B3-10	E. 507 Wood Primer(1)	E. 506, Cream (1)	E. 502, Cream (2)
B3-11	" " " (1)	" , Pink (1)	" , Red Oxide (2)
B3-12	" " " (1)	" , Green (1)	" , Green (2)
B3-13	" " " (1)	" , Green (1)	" , Bright Green (2)
B3-14	E. 507 Wood Primer(1)	E. 506, Cream (1)	E. 503, Cream (2)
B3-15	" " " (1)	" , Pink (1)	" , Red Oxide (2)
B3-16	" " " (1)	" , Green (1)	" , Green (2)
B3-17	" " " (1)	" , Green (1)	" , Bright Green (2)
B3-18	E. 507 Wood Primer(1)	E. 506, Cream (1)	E. 504, Cream (2)
B3-19	E. 507 Wood Primer(1)	E. 506, Cream (1)	E. 505, Cream (2)

Notes. The panels painted at T.T.E. were pretreated with 2. "Shirlan" solution (aqueous). Each coat of paint was allowed to dry overnight and lightly sanded before applying the next coat. A complete duplicate series was painted by the Sponsors in the U.K. and sent to Nigeria for exposure.

Serial Nos. B3- 1 to B3- 9 were "general purpose" (G.P.) finishes and B3-10 to B3-19 "high grade" finishes.

The numbers in brackets in the table indicate the number of coats of each paint applied.

E. 500 General Purpose Paint. Long Oil Oleo - resinous medium, suitably pigmented to give optimum performance in the particular colour used.

E. 501 General Purpose Paint. Oil modified synthetic resin base, suitably pigmented.

E. 502 and E. 503 High Grade Finishes. Alkyd based materials suitably pigmented, varying only in processing.

E. 504 and E. 505 High Grade Finishes. Similar to E. 502 and E. 503, included for comparison purposes.

APPENDIX B (Cont'd)

Paints Applied to Wood Surfaces

4. Commercial Enamels (Jenson and Nicholson Group)

Serial No.	Primer	Undercoat	Finishing Coat
B4- 1	White (A/613/169/4)	White (A/613/169/5)	White Enamel (B.638/2/1)
B4- 2	"	Cream (A/613/169/6)	Cream Enamel (B.638/3/1)
B4- 3	"	Grey (A/613/169/7)	Blue-grey Enamel (B.638/4/1)
B4- 4	"	Green (A/613/169/8)	Green Enamel (B.638/5/1)

Notes. 1. The obeche panels were prepared in the U.K. and sent to Nigeria with the edges and backs protected with aluminium paint. The paint systems consisted of one coat of white primer followed by two coats of the appropriate undercoat and, finally, one coat of the finishing enamel. An interval of 24 hours drying time was allowed between successive coats.

2. The numbers in brackets indicate the manufacturer's paint serial number.

5. General Purpose Paints (Red Hand Compositions Co. Ltd. - 2nd Trial)

Serial No.	Primer	Undercoat	Finishing coat
B5- 1	None	None	White gloss paint (2)
B5- 2	"	"	"Synparex" White Enamel (2)
B5- 3	"	"	"Syndurac" White Enamel (2)
B5- 4	"	"	Synthetic Enamel, White (2)
B5- 5	"	"	White Gloss Paint, Modified (2)
B5- 6	"	"	Special Tropical White (2)
B5- 7	"	"	"Genpurac" White, (2)
B5- 8	"	"	"Genpurac" White, Modified (2)
B5- 9	A.S. Metallic Primer (1)	Gloss paint U/C, White (1)	White Gloss Paint (1)
B5-10	" (1)	"Syndurac" White U/C (1)	" (1)
B5-11	Pink Wood Primer (1)	None	Non-yellowing White (1)
B5-12	" (1)	"	Synthetic Enamel, White (1)
B5-13	" (1)	"	"Syndurac" Enamel, White (1)
B5-14	Wood Primer (1)	"	"Syndurac" Enamel, White (1)
B5-15	Pink Wood Primer (1)	"	White Gloss Paint (1)
B5-16	Wood Primer (1)	"	White Gloss Paint (1)
B5-17	Pink Wood Primer (1)	"	White Gloss Paint, Modified (1)
B5-18	Wood Primer (1)	"	" " " (1)
B5-19	None	"	Tropical White Fungicidal (2)
B5-20	Pink Wood Primer (1)	"Syndurac" White U/C (1)	White Gloss Paint Modified (1)
B5-21	" " " (1)	" " " (1)	" " " (2)
B5-22	" " " (1)	None	" " " (2)
B5-23	" " " (1)	Gloss Paint U/C, White (1)	" " " (1)
B5-24	" " " (1)	" " " (1)	White Gloss Paint (1)

Note. The face of each panel was divided longitudinally into two equal portions each of which was painted with a different system. The figures in brackets refer to the number of coats applied (U/C = undercoat).

APPENDIX B (Cont'd)

Paints Applied to Wood Surfaces

Composition of Finishing Coats

Finishing Coat	Medium		Pigment	
	Type	%	Type	%
White Gloss Paint	Oil Modified Alkyd Resin	41	100% Rutiox Titan White	33
"Synparex" White Enamel	Wood Oil/Phenol Formaldehyde Varnish	49.5	83% Rutiox Titan White 17% Zinc Oxide	30
"Syndurac" White Enamel	Oil Modified Alkyd Resin	40	100% Rutiox Titan White	26
Synthetic Enamel White	Oil Modified Alkyd/Maleic Resin	38	100% Rutiox Titan White	28
White Gloss Paint, Modified	Oil Modified Alkyd Resin/Stand Oil	47	67% Rutiox Titan White 33% Zinc Oxide	30
Special Tropical White	Modified Penta Alkyd Resin/Stand Oil	41	36.5% Rutiox Titan White 63.5% Zinc Oxide	41
"Genpurac" White	Oil Modified Alkyd Resin/Stand Oil	44	35% Rutiox Titan White 43.5% Zinc Oxide 21.5% China Clay	45
"Genpurac" White Modified	Oil Modified Alkyd Resin/Stand Oil	43.5	38.5% Rutiox Titan White 43% Chalk 17% Barytes 1% Zinc Oxide	45.5
Non-Yellowing White	Modified Penta Alkyd Resin	44	19.5% Rutiox Titan White 80.5% Zinc Oxide	41
Tropical White, Fungicidal	Treated Linseed Oil	21	54% Zinc Oxide 46% Barytes	74

APPENDIX C

Paints Applied to Asbestos Cement

1.

1. Commercial Paints for Asbestos Cement (Red Hand Compositions Co.)

Serial No.	Paint System
C1- 1	"Redimul", Emulsion Paint, Interior, Semi-Gloss (2 coats)
C1- 2	"Redimul", Emulsion Paint, Exterior, Semi-Gloss (2 coats)
C1- 3	Chlorinated Rubber Paint, White (2 coats)
C1- 4	Asbestos Roof Paint, Green (2 coats)
C1- 5	Asbestos Roof Paint, Green, Modified (2 coats)

Note. The interior emulsion paint (C1- 1) was exposed in the Base Depot only and the other four at the Town Site only.

2. Turnall Colourglaze (Turners Asbestos Cement Co. Ltd.)

Serial No.	Paint System
C2- 1	"Turnall Colourglaze" Red, (Symbol No. 61)
C2- 2	"Turnall Colourglaze" Westmorland Green, (Symbol No. 74)
C2- 3	"Turnall Colourglaze" Cream, (Symbol No. 75)
C2- 4	"Turnall Colourglaze" Sky Blue, (Symbol No. 72)

Note. These paints were based on epoxy resins, and were air-cured.

APPENDIX D

Paints applied to Plaster Walls and Concrete

1. Plastic Emulsion Paint (Sissons Bros. & Co. Ltd.)

Serial No.	Paint System
D1- 1	"Rapodeo" Plastic Emulsion Paint, Duck Egg, Satin Finish (one coat of paint diluted 4:1 by volume (paint:water) and one coat diluted 8:1)
<u>Note:</u> The coverage was approximately 60 sq.yd/gallon on plaster walls and 40 sq.yd/gallon on rough concrete surfaces.	

2. Plastic Emulsion Paint (I.C.I.Ltd.)

Serial No.	Paint System
D2- 1	"Pentolite" Plastic Emulsion Paint, Adam Green (one coat of paint diluted 5:1 by volume (paint:water) and one coat diluted 10:1)

3. Plastic Emulsion Paint (Solignum Ltd.)

Serial No.	Paint System
D3- 1	"Permacote" Plastic Emulsion Paint, Opaline Green/Pastel Blue mixed 1:1 by volume.
D3- 2	"Permacote" Plastic Emulsion Paint, Suntan
<u>Notes.</u>	1. One priming coat (paint diluted 4:1) and one finishing coat (same paint diluted 6:1) were applied. 2. The Opaline Green/Pastel Blue was exposed at the town and jungle sites only and the Suntan at the marine and desert sites only. 3. The coverage was approximately 60 sq yd/gallon.

APPENDIX D (Cont'd)

Paints Applied to Plaster Walls and Concrete

4. Polyvinyl Acetate Based Emulsion Paints (Jenson and Nicholson Group)

Serial No.	Paint System			
	Type	Manufacturer's No.	Colour	No. of coats
D4- 1	Plastic Emulsion Paint (P.V.A. Base)	3/694/200	White	2
D4- 2	"	3/694/12	Pale Blue	2
D4- 3	"	3/694/443	Red	2
<u>Note:</u> Two coats of paint (undiluted) were applied with 24 hours drying time between each coat.				

5. Commercial Paints for Plaster Walls (Red Hand Compositions Co.)

Serial No.	Primer	Finishing Paint
D5- 1	"Matinto", Flat, Priming	"Matinto" Flat, Finishing, White
D5- 2	Alkali-resisting Emulsion Paint, Priming	Alkali-resisting Emulsion Paint Finishing, White, Semi-gloss.
D5- 3	Alkali-resisting Chlorinated Rubber Paint, Priming	Alkali-resisting Emulsion Paint Finishing White, Flat.
<u>Note:</u> One coat of primer and one coat of finishing paint were applied.		

APPENDIX E

Varnishes

1. International Varnishes (International Paints Ltd.)

Serial No.	Priming Coat	Finishing Coat
E1- 1 E1- 2 E1- 3 E1- 4	Same Varnish as for finishing coat but "thinned 15% with appropriate solvent.	"309" Yacht Varnish Sunlight Varnish "Group 37" Varnish "Episeal" Varnish
<u>Note:</u> One coat of primer and two finishing coats were applied. The average thickness of each finishing coat was 0.0010 Inch.		

"309" Yacht Varnish - Linseed/tung oil modified phenolic resin

Sunlight Varnish - Medium/long oil alkyd

"Group 37" Varnish - Amine adduct cured epoxide

"Episeal" Varnish - Epoxy ester

2. Service Paint Systems (Cellon, Ltd.)

Serial No.	Varnish Systems
E2- 1	One thin coat of Varnish K.4929 followed by three full coats of Varnish K.4929 (Yacht Varnish, oil length 3:1)

APPENDIX E (Cont'd)

Varnishes

3. Picture Varnishes (Trial sponsored by the National Gallery)

Serial No.	Varnish System		
	Resin	Oil	Solvent
E3- 1	Dammar	10% Linseed Stand Oil	White Spirit
E3- 2	R.240 Silicone Resin	-	-
E3- 3	Dammar	10% Sonpol	White Spirit
E3- 4	Mastic	5% Linseed Oil	Turpentine
E3- 5	A.W.2	10% Linseed Stand Oil	White Spirit
E3- 6	A.W.2	10% Sonpol	"
E3- 7	Hydrogenated Dammar	10% Linseed Stand Oil	"
E3- 8	27H	-	Naphthenes B.Pt. 170- 190°C
E3- 9	A.Y.A.F.		10% aqueous alcohol

<u>Notes:</u> - Each of the above nine varnishes was applied to three substances, viz. (a) Aluminium foil, 0.025mm (b) Sand-blasted glass and (c) Clear glass (microscope slides). The films were applied by dip-coating to give a thickness of 20± 5 microns. - The resins designated A.W.2, 27H and A.Y.A.F. were respectively polycyclohexanone, polymethacrylate and polyvinylacetate compositions. - Sonpol was a sunflower stand oil from which linolenic esters had been removed by Solvent segregation.
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APPENDIX F

Fungus Resisting Paints

1. Fungicidal Paints (Jenson and Nicholson Group)

Serial No.	Finishing Coat		
	Pigment	Medium	Fungicide
F1- 1	23.3% TiO ₂	37.9% extra long linseed oil penta alkyd. 8.0% Pentalyn G	Nil
F1- 2	" "	37.9% extra long linseed/wood oil penta alkyd. 8.0% Pentalyn G	Nil
F1- 3	" "	37.9% long linseed oil penta alkyd. 8.0% Pentalyn G	Nil
F1- 4	" "	45.9% medium long linseed oil glycerine alkyd.	Nil
F1- 5	" "	As for F1-3	0.5% organic mercurial (10% Hg)
F1- 6	" "	"	2% pentachlorophenol
F1- 7	" "	"	2% dichlor-m-xyleneol
F1- 8	" "	"	0.07% organic mercurial (47.5% Hg)
F1- 9	" "	"	0.05% triethyl tin hydroxide
F1-10	" "	"	0.36% copper-8-quinolinolate
F1-11	23.3% of 4TiO ₂ :1ZnO	As for F1-4	0.5% organic mercurial (10% Hg)
F1-12	23.3% of 2TiO ₂ :1ZnO	"	"
F1-13	23.3% of 1TiO ₂ :1ZnO	"	"
F1-14	23.3% TiO ₂	As for F1-3	5% Sulphur
F1-15	"	"	0.25% mercuric chloride
F1-16	23.3% of 4TiO ₂ :1ZnO	"	0.5% organic mercurial (10% Hg)
F1-17	23.3% of 2TiO ₂ :1ZnO	"	"
F1-18	23.3% of 1TiO ₂ :1ZnO	"	"
F-19	Straight Zinc Oxide Oil Paint to B.S.S. 277.		Nil

- Notes.** 1. One coat of primer (aluminium-pigmented wood oil phenolic varnish containing 15% of copper naphthenate) and one coat of under coat (white alkyd base) containing 0.5% organic mercurial (10% Hg) were applied to the panels and these were followed by one coat of each finish detailed above, twenty-four hours drying time being allowed between each coat. In addition, one panel with primer only and one with primer and under coat only were exposed.
2. The finishes in the table above contained 30.8% solvents and driers.
3. The panels of obeche wood were sent from the U.K. by the sponsor or the trial with the backs, ends and edges painted with two coats of aluminium paint.
4. In addition to the panels painted in Nigeria, a series of duplicate specimens painted by the sponsor in the U.K. was exposed under the same conditions.

APPENDIX F (Cont'd)

Fungus Resisting Paints

2. Experimental Fungus Resisting White Gloss Paints (I.C.I. Ltd., Paints Division)

Serial No.	Primer	Undercoat	Finishing Coat
F2- 1	{ Aluminium Wood Primer	White	White Gloss containing fungicide "A"
F2- 2		undercoat	" " " " "B"
F2- 3		"	" " " " "C"
F2- 4		"	" " " " "D"
F2- 5		"	" " " " "E"
F2- 6		"	White Gloss containing no fungicide

Notes:

1. The paint systems consisted of one coat of aluminium primer, one of undercoat and one finishing coat, a period of 24 hours drying being allowed between each coat. The specimens were aged for seven days before exposure.
2. A second series of specimens was prepared by using the same paint systems (F2-1 to F2-6) on panels which had been treated by brushing with a 2% aqueous solution of "Shirlan Na"
3. A third series of specimens with the same paint systems was prepared and painted by I.C.I. Ltd., in the U.K. and sent to Nigeria for exposure.

3. Nuodex Fungicides in Paints (Trial sponsored by Ministry of Supply Chemical Inspectorate)

Serial No.	Primer	Finishing Coat	Fungicide
F1- 1	CS.1370E	(Primer and General Service	Nil
F1- 2	"	(Finishing Paint to CS.2000E	2.0% Pentachlorophenol
F1- 3	"	"	0.5% Nuodex "Super-and-It"
F1- 4	"	"	0.5% Nuodex 321.SS
F1- 5	"	"	0.075% Phemox Oil Soluble(25%)
F1- 6	CS.2307	(Primer and Telecommunication	Nil
F1- 7	"	(Equipment Finishing Paint	2.0% Pentachlorophenol
F1- 8	"	to CS.2305	0.5% Nuodex "Super-and-It"
F1- 9	"	"	0.5% Nuodex 321.SS
F1-10	"	"	0.075% Phemox Oil Soluble(25%)

Note: One coat each of primer and finishing paint were applied.
Nuodex "Super-and-It" is diphenyl mercuric dodeceny succinate.

APPENDIX F (Cont'd.)

Fungus Resisting Paints

4. Fungicidal Paints (Trial sponsored by Ministry of Supply, Chemical Inspectorate)

Serial No.	Paint System		Substrate
	Paint Base	Fungicide	
F4- 1	White Gloss Paint, Alkyd Base	1.5% Nil	Mild Steel
F4- 2	"	1.5% Super Ad-It	" "
F4- 3	"	2% Pentachlorophenol	" "
F4- 4	White Gloss Paint, Chlorinated Rubber Base	Nil	" "
F4- 5	"	1.5% Super Ad-It	" "
F4- 6	"	1% Pentachlorophenol	" "
F4- 7	White Gloss Paint, Linseed Oil Base	Nil	
F4- 8	"	1.5% Super Ad-It	
F4- 9	"	2% Pentachlorophenol	
F4-10	White Gloss Paint, Alkyd Base	Nil	Western Red Cedar
F4-11	"	1.5% Super Ad-It	" "
F4-12	"	2% Pentachlorophenol	" "
F4-13	White Gloss Paint, Chlorinated Rubber Base	Nil	" "
F4-14	"	1.5% Super Ad-It	" "
F4-15	"	2% Pentachlorophenol	" "
F4-16	White Gloss Paint, Linseed Oil Base	Nil	" "
F4-17	"	1.5% Super Ad-It	" "
F4-18	"	2% Pentachlorophenol	" "

Note: Two coats of paint were applied to each panel. In the fungicidal systems, the second coat only contained the fungicide.

APPENDIX F (Cont'd.)

Fungus Resisting Paints

5. Fungicidal Paints (Goodlass Wall & Co. Ltd.)

Serial No.	Substrate	Primer	Undercoat	Finishing Coat	Fungicide
F5- 1	Meranti	"Glossinol"	Undercoating	"Glossinol" Synthetic	Absent
F5- 2	"	Aluminium	"Glossinol" Cream	Enamel Finishing	Present
F5- 3	Obeche	Wood	Ref.257/3F	Cream, Ref.88/4F	Absent
F5- 4	"	Primer	(2 coats)	(1 coat)	Present
F5- 5	Meranti	Ref.149/6F	Undercoating	"Glossinol" Synthetic	Absent
F5- 6	"	(1 coat)	"Glossinol" Green	Enamel Finishing	Present
F5- 7	Obeche		Ref.257/24F	Middle Permanent Green	Absent
F5- 8	"		(2 coats)	Ref.88/30F	Present

Note: In the fungicidal paint systems, the Fungicide (mercury salt of a long chain fatty acid) was present in all four coats.

6. Fungicidal Paints (Jenson and Nicholson Group)

Serial No.	Primer	Undercoat	Finishing Coat
F6- 1	Aluminium Grey Primer(Ref.2/364/66)	White Undercoat (Ref.1/613/169/5)	Finish "AF" Ref.D.638/1/1
F6- 2	"	"	" "BF" Ref.D.638/1/1
F6- 3	"	"	" "CF" Ref.D.638/1/3
F6- 4	"	"	" "DF" Ref.D.638/1/4
F6- 5	"	"	" "EF" Ref.D.638/1/5

- Notes:
1. Obeche panels were supplied by the sponsor of the trial from the U.K. with the backs and edges painted with aluminium primer. The test faces were painted with one coat of primer, two of undercoat and one of finishing coat. In addition, panels were prepared using finishes "AF" and "BF" on wood pretreated by brushing the test surfaces with a 2% aqueous solution of "Santobrite".
 2. Each of the finishing coats "AF" to "EF" contained a different fungicide, the nature and concentration of which were not divulged by the sponsors.

APPENDIX G

Fungicidal Varnishes

1. Nuodex Fungicides in Varnishes (Trial sponsored by Ministry of Supply Chemical Inspectorate)

Serial No.	Varnish System	Fungicide
G1- 1	Varnish to Specification T.S.188	Nil
G1- 2	"	2% Pentachlorophenol
G1- 3	"	0.5% "Super Ad-It"
G1- 4	"	0.5% Nuodex 321.SS
G1- 5	"	0.75% Phemox Oil Soluble 25%

2. Fungicidal Varnishes (Trial sponsored by Ministry of Supply, Chemical Inspectorate)

Serial No.	Varnish System	Fungicide
G2- 1	Varnish to Specification T.S.188	Nil
G2- 2	"	1.5% Super Ad-It
G2- 3	"	2% Pentachlorophenol

Note: Only one coat of varnish was applied to each panel.

3. Fungicidal Lacquers (Brundram Bros. & Co. Ltd.)

Serial No.	Varnish System
G3- 1	Lacquer "B", containing parachlorometaxylenol (PCMX) as fungicide.
G3- 2	Lacquer "C", containing "Captan" as fungicide
G3- 3	Varnish, Special, Fungicidal, to Specification T.S.191.B

Notes.

1. At the base depot, the varnishes were applied to the internal surfaces of door panels which had been wiped free from fungus. The coverage was approximately 1½oz./sq.yd.
2. For exposure in the jungle clearing, panels of mould-free Obeche wood were treated with two coats of the lacquers allowing 24 hrs. drying time between coats. The coverage was approximately 2½oz./sq.yd.

APPENDIX H

Anti-Fouling Paints

1. Anti-Fouling and Anti-Teredo Paint (Red Hand Compositions Co.)

Serial No.	Primer	Finishing Coat
H1-1	Copper paint (1 coat)	Anti-Fouling Anti-Teredo copper Paint (1 coat)
Note: The panels were air-dried for 48 hours after the finishing coat had been applied.		

2. Anti-Fouling Paint Systems (Red Hand Compositions Co.)

Serial No.	Paint System
H2-1	Laterac System with Red Boottopping
H2-2	Laterac System with Anti-Fouling Plastic Finish
H2-3	Metabond System with Red Boottopping
H2-4	Zinc Chromate System finished with Green Anti-Fouling
H2-5	Zinc Chromate System finished with Green "Syndurac" Synthetic Enamel
H2-6	Laterac System finished with W.W. Anti-Fouling

APPENDIX H (Cont'd)

Anti-Fouling Paints

3. Admiralty Experimental Anti-Fouling Paints (Trial sponsored by Admiralty Central Dockyard Laboratory)

Serial No.	Paint System		
	Type	Plant No.	Description
H3-1	44P	CPP/367/55	3:1 Rosin/Aroclor pigmented with cuprous oxide
H3-2	44P Mod	CPP/368/55	Reduced cuprous oxide with iron oxide added to maintain pigment/medium volume ratio
H3-3	45P	CPP/369/55	1:1 Rosin/Aroclor pigmented with cuprous oxide
H3-4	45P Mod	CPP/370/55	Reduced cuprous oxide with iron oxide added to maintain pigment/medium volume ratio
H3-5	161P	CPP/371/55	3:1:1 Rosin/Aroclor/Bedesol Stand oil varnish pigmented with cuprous oxide
H3-6	161P Mod	CPP/372/55	Reduced cuprous oxide with iron oxide added to maintain pigment/medium volume ratio
H3-7	U.S.N. Spec.121	CPP/373/55	1:1 Rosin/Vinylite VYHH, plasticised with tricresyl phosphate, pigmented with cuprous oxide
H3-8	Pocoptic	CPP/374/55	2:1 Rosin/A - Stage phenolic resin plasticised with tricresyl phosphate, pigmented with cuprous oxide
H3-9	Blue A/F D/3/2	CPP/375/55	Cuprous thiocyanate and mercurous chloride in Pocoptic medium, tinted to dark blue with Prussian Blue and black
H3-10	Blue A/F D/3/5	CPP/376/55	Light blue version of D/3/2
H3-11	359P	CPP/377/55	Cuprous sulphide in Pocoptic medium
H3-12	360P	CPP/378/55	Cuprous sulphide and cuprous thiocyanate in Pocoptic medium
H3-13	363P	CPP/379/55	Cuprous sulphide in 44P medium
H3-14	364P	CPP/380/55	Cuprous sulphide and cuprous thiocyanate in 44P medium

Note. 1. Three coats of undercoat were applied to the panels in the U.K. For the U.S.N. Spec.121 finish, a vinyl red lead undercoat was used and, for all the other finishes, Admiralty "Pomar" Anti-corrosive Paint.

2. Two coats of each finishing paint were applied at T.T.E. with an interval of 24 hours between coats.

APPENDIX H (Cont'd)

Anti-Fouling Paints

4. Experimental Anti-Fouling Compositions (I.C.I. Ltd., Paints Division)

Serial No.	Paint System			
	Vehicle	Cuprous Oxide(%)	Iron Oxide(%)	Additions
H4-1	Plasticised rosin	40	10 to 20	-
H4-2	Rosin/Phenol-formaldehyde/oil	40	"	-
H4-3	Rosin/oil	28	"	-
H4-4	"	30	"	-
H4-5	Plasticised rosin	40	"	1.5% mercury oxide
H4-6	As for H4-5 but less soluble	40	"	"
H4-7	"	40	"	"
H4-8	Plasticised rosin	50	"	-
H4-9	"	60	"	-
H4-10	"	40	"	1.0% D.D.T.
H4-11	"	50	"	2.0% mercury oxide
H4-12	As for H4-11 but less soluble	50	"	"
<u>Note:</u> 1. No undercoat was used and only one coat of finishing paint.				

APPENDIX I

Anti-Teredo Paints

Admiralty Experimental Anti-Teredo Paints (Trial sponsored by Admiralty Central Dockyard Laboratory)

Serial No.	Paint System		
	Type	Plant No.	Description
I-1	44P	CPP/367/55	3:1 Rosin/Aroclor, pigmented with cuprous oxide
I-2	45P	CPP/369/55	1:1 Rosin/Aroclor, pigmented with cuprous oxide
I-3	U.S.N. Spec.121	CPP/373/55	1:1 Rosin/Vinylite VYHH, plasticised with tricresyl phosphate, pigmented with cuprous oxide
I-4	Pocoptic	CPP/374/55	2:1 Rosin/A - Stage phenolic resin plasticised with tricresyl phosphate, pigmented with cuprous oxide
I-5	Ground Glass Formulation	CPP/381/55	Ground glass in 1:1 Rosin/Aroclor medium at approximately 1:1 pigment/medium ratio.
I-6	"	CPP/382/55	Ground glass in plasticised chlorinated rubber medium at approximately 1:1 pigment/medium volume ratio
I-7	"	CPP/383/55	As for 45P with some cuprous oxide replaced by ground glass
I-8	Pomar	CPP/384/55	Standard Admiralty Anti-corrosive paint (used as control sample)
<u>Note.</u> 1. The undercoats were applied to the panels in the U.K. For the U.S.N. Spec.121 finish, a vinyl/red lead undercoat was used and, for all the other finishes, Admiralty "Pomar" anti-corrosive paint. 2. Two coats of each finish (including I-8 "Pomar") were applied at T.T.E. with an interval of 24 hours between coats. 3. The specimens were immersed at the exposure site 24 hours after the final coat was applied.			

APPENDIX J

Composition Preservative on Paint

Serial No.	Paint System	Further Treatment
J-1	Paint p.f.u., Ammunition, White Air-drying to CS.1973	Composition, Preservative to C.S.1663F (1 coat)
J-2	"	Nil
J-3	Paint p.f.u., Ammunition, Brown, Stoving, to C.S.1975	Composition Preservative to C.S.1663F (1 coat)
J-4	"	Nil
<u>Note.</u> 1. The panels were painted in the U.K. One coat of the Composition, Preservative was applied at T.T.E. by dipping and draining for two hours immediately before placing on exposure. 2. At the Lagos Army Ordnance Depot, painted ammunition boxes were treated by spraying with the composition under test.		

APPENDIX K

Storage of Paints in the Tropics

Tropical Storage Trial of Service Paints (Cellon, Ltd.)

Serial No.	Manufacturer's Ref.No.	Specification No.	Description
K-1	2.S.588	-	Red Oxide Primer
K-2	-	T.S.4930	Cerrux Reducer
K-3	K.4929	-	Yacht Varnish
K-4	S.X.44	-	Brown Second Coat
K-5	-	DNC/1/76	Yellow Primer
K-6	S.4923	-	Red Lead Steel Primer
K-7	-	DNC/M/73	Grey Finish
K-8	-	DNC/M/78	Grey Undercoat
K-9	6.S.590	-	Etch Primer
K-10	-	C.S.1870C	Red Oxide Primer
K-11	-	C.S.2587	Grey Matt Finish
K-12	-	C.S.2587	Grey Glossy Finish
K-13	-	C.S.2354	Grey Undercoat
K-14	K.5064	DTD.827	Grey Enamel
K-15	S.5177	BS.1011	Red Lead Primer
K-16	5.S.590	-	Two Solution Etch Primer
K-17	S.X.44	-	Yellow Primer
K-18	S.X.41	-	Green Primer
K-19	S.097	ES.631	Grey Stoving Enamel
K-20	S.093	DTD.235A	Grey Stoving Enamel
K-21	D.4949	DTD.63B	Grey Finish
K-22	K.5075	C.S.2000E	Grey Finish
K-23	D.4841	DTD.766A	Aluminium

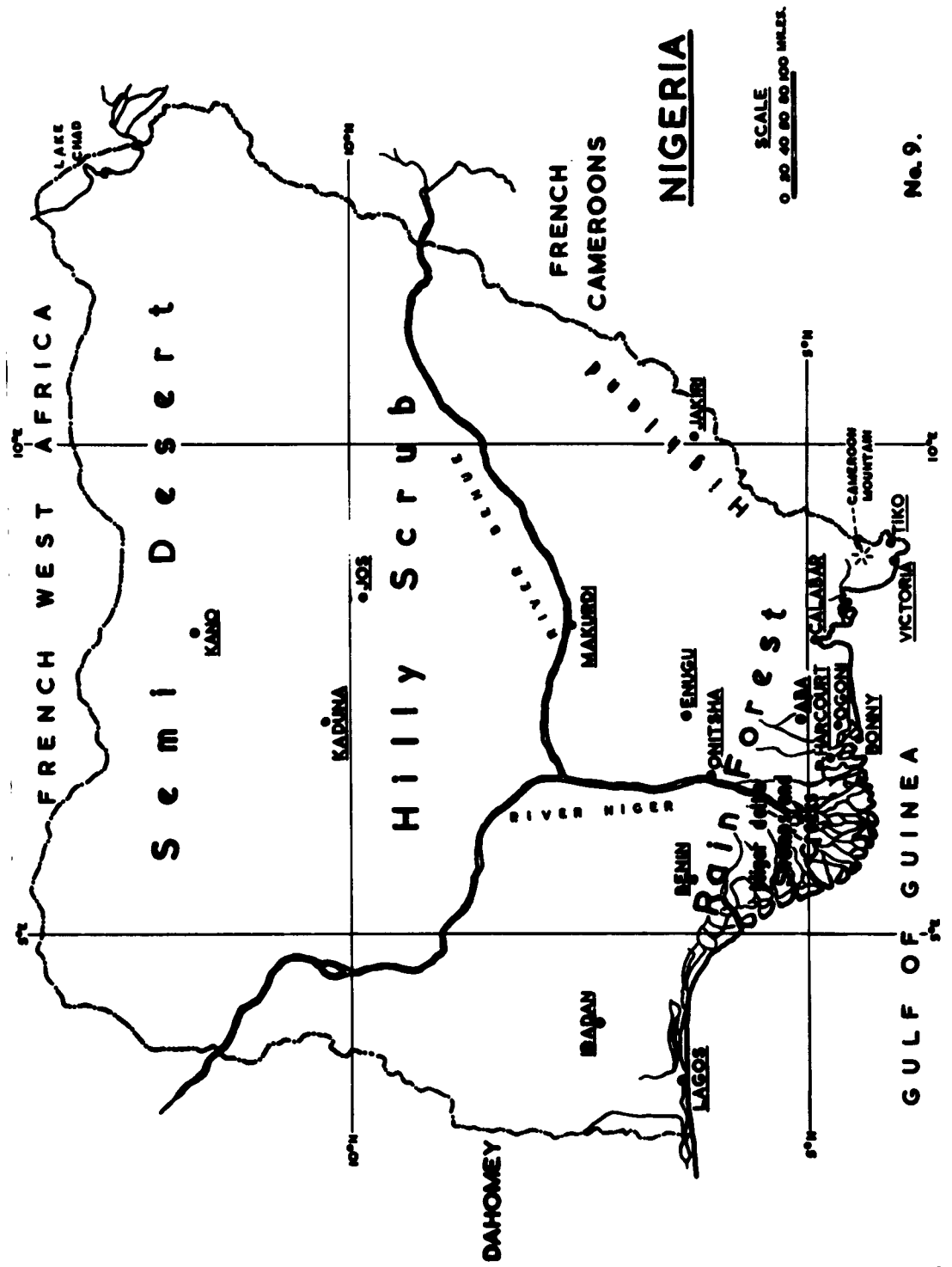


FIG. 1



Fig.2 General view of town site, Port Harcourt. Specimens were placed in an open compound behind building at right centre of the photograph (see Fig.3). The base depot store (Fig.4) was part of the large building in centre of photograph.



Fig.3 General view of exposure compound at town site, Port Harcourt.



Fig.4 Exterior of base depot store, Port Harcourt.



Fig.5 Base depot store, Port Harcourt (interior).



Fig.6 General view of jungle clearing, Nkpoku. The jungle undergrowth site was approximately 50 yards behind and to the left of this clearing.



Fig.7 General view of marine site, Lagos. The compound shown at right centre of photograph was 50 to 100 yards from the surf line. Specimens exposed in the compound behind building in the centre were approximately 200 yards from the surf line (Fig.8)

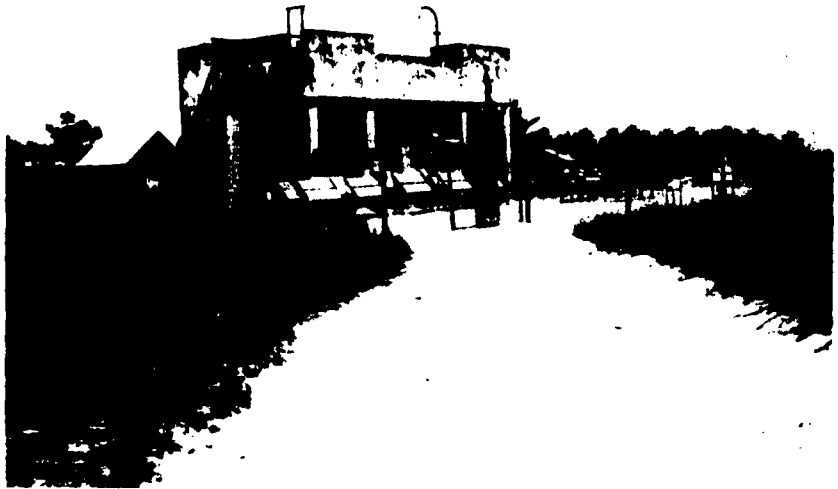


Fig.8 General view of exposure compound 200 yards from surf line at Lighthouse Beach, Lagos (Marine Site - 200 yd).



Fig.9 General view of desert site, Kano.



Fig.10 General view of the dolphin in the Bonny River,
Port Harcourt (Harbour Site).



Fig.11 Ready Mixed Oil Paints (Trial sponsored by Ministry
of Supply, Chemical Inspectorate) exposed at the
desert site, Kano.



Fig.12 Experimental Paints (W. and S. Leigh Ltd.)
exposed at the town site, Port Harcourt.



Fig.13 Experimental Paints
(W. and S. Leigh Ltd.)
exposed in the jungle
clearing, Nkpoku.



Fig.14 Paints and Varnishes (International Paints Ltd.)
exposed at the town site, Port Harcourt. (Photo-
graph taken after 14 months exposure.)

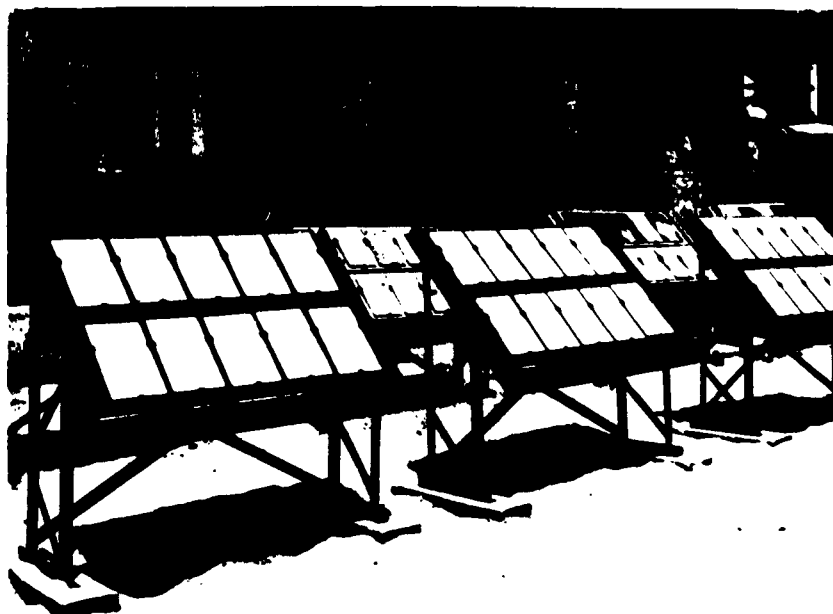


Fig.15 Priming Schemes for Metallic Coatings (Trial
sponsored by the British Iron and Steel Research
Association). Panels exposed at the marine site
(200-yard compound).

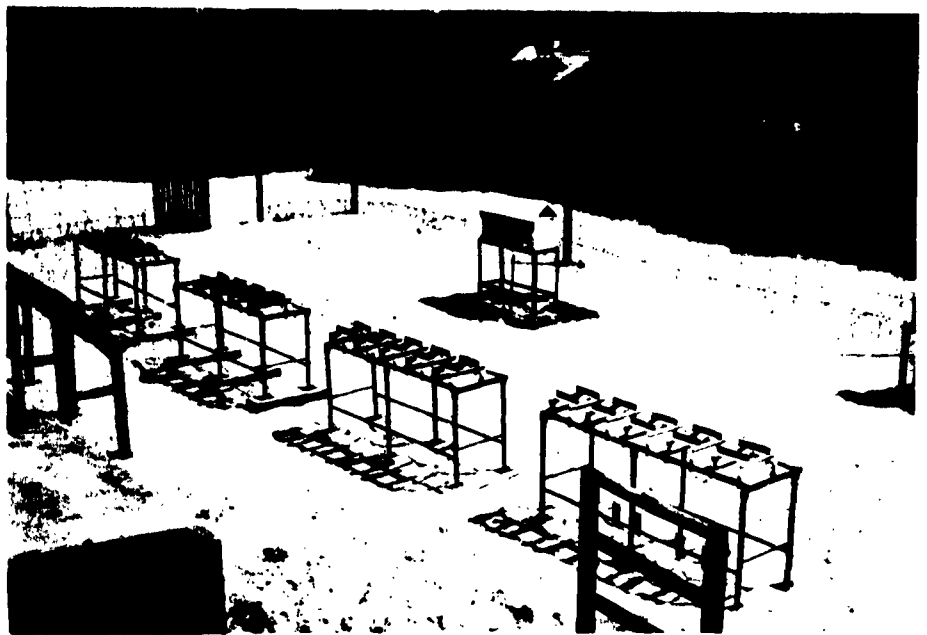


Fig.16 Priming Schemes for Metallic Coatings (Trial sponsored by the British Iron and Steel Research Association). Complex shapes on exposure at the marine site (200 yard compound).

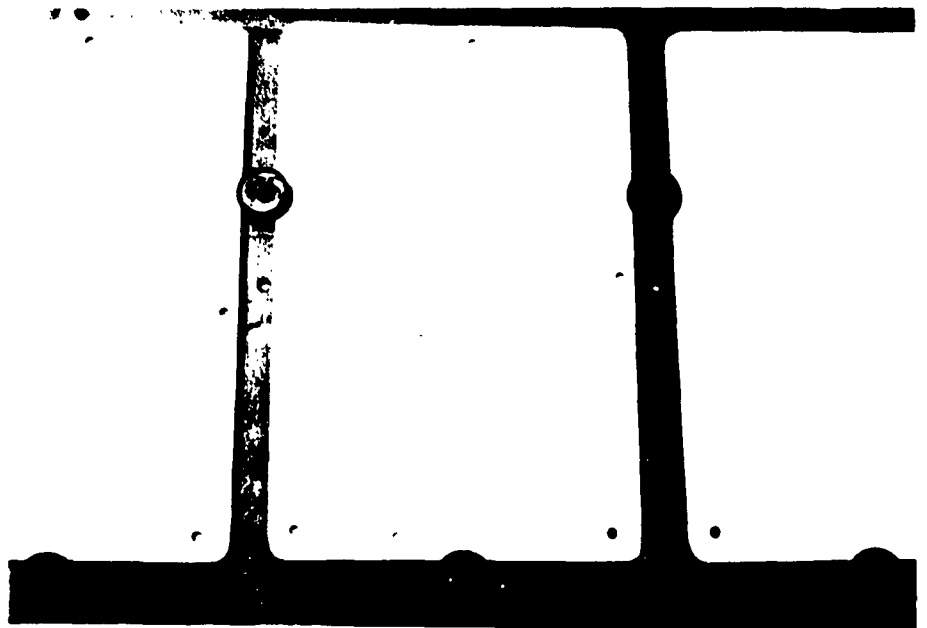


Fig.17 Priming Schemes for Metallic Coatings (Trial sponsored by the British Iron and Steel Research Association). The method of supporting the panels on the exposure stand is shown.

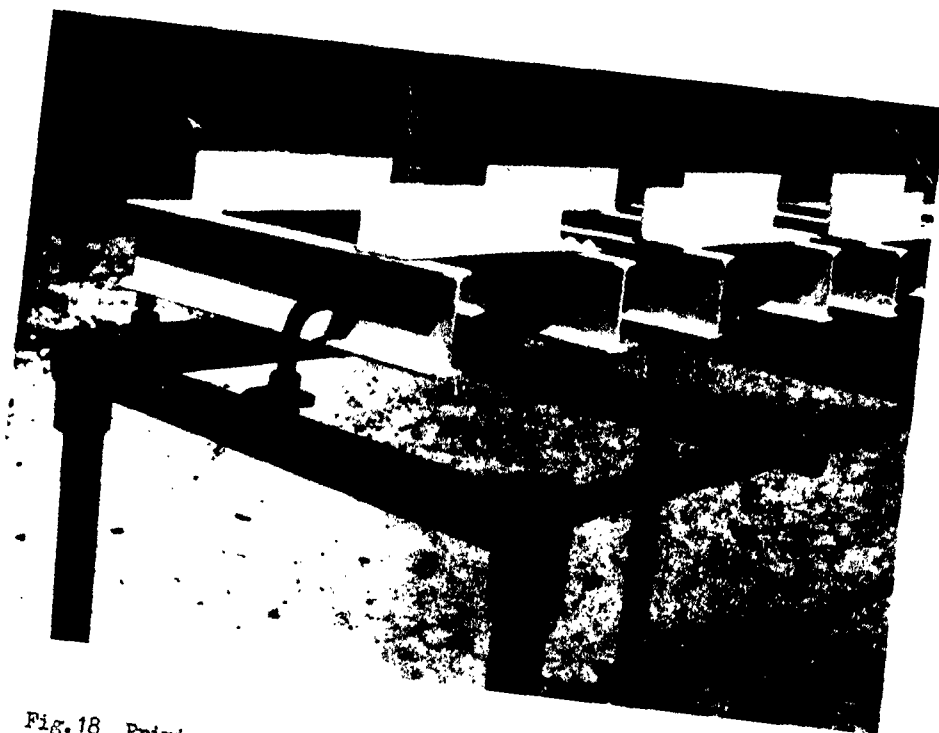


Fig.18 Priming Schemes for Metallic Coatings (Trial sponsored by the British Iron and Steel Research Association). The method of exposing the complex shapes is shown.

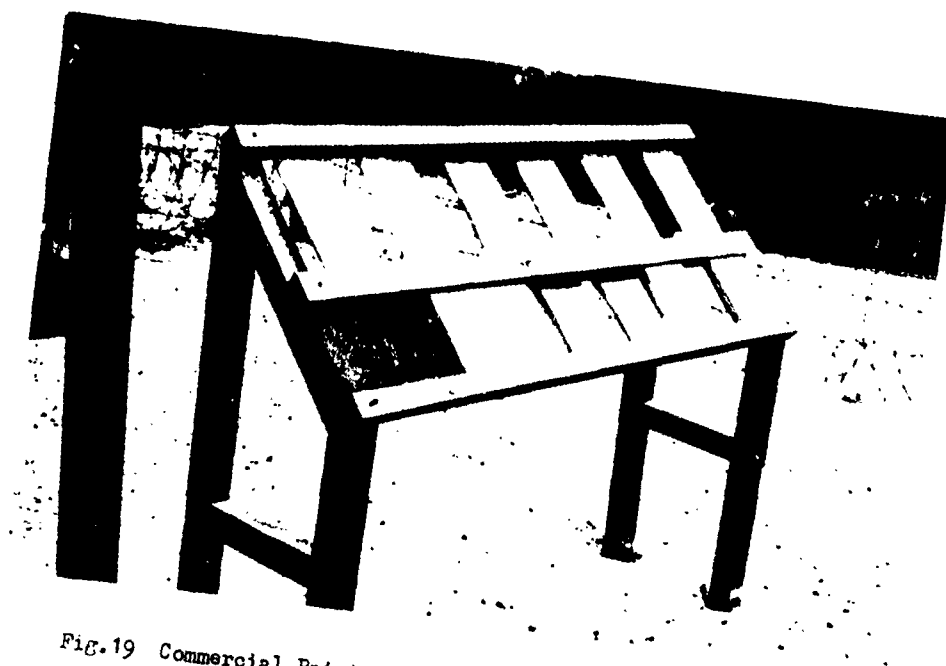


Fig.19 Commercial Paints and Enamels (Jenson & Nicholson Group) exposed at the marine site, Lagos. The steel panels with paints for the protection of structural steel are on the top row and the enamel coated wooden panels on the bottom.

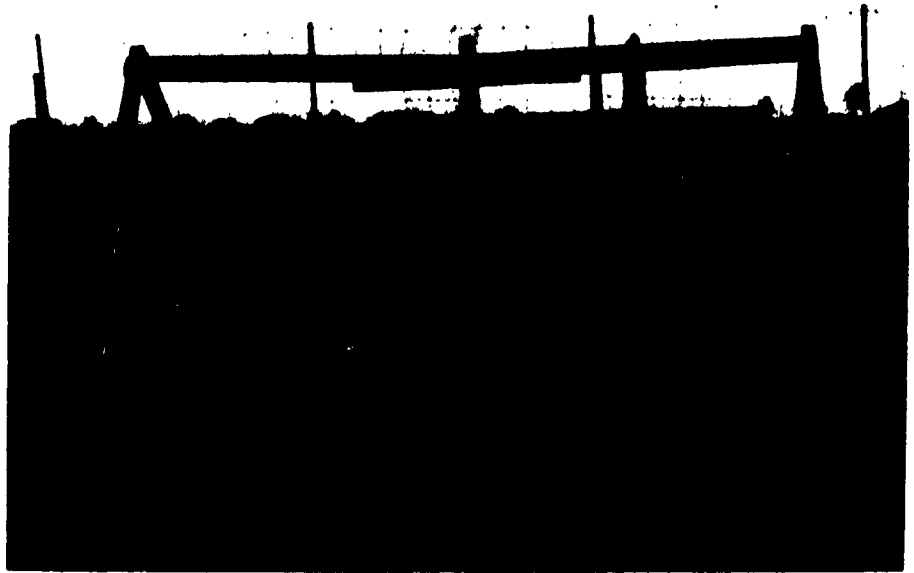


Fig.20 Admiralty Paint Systems (Trial sponsored by Admiralty Chemical Department) exposed at the marine site, Lagos.

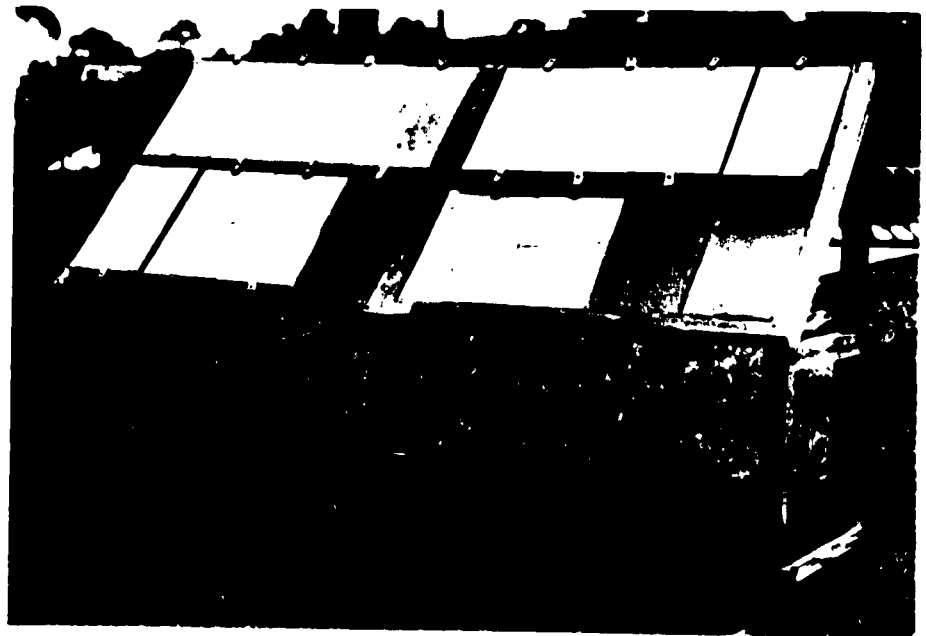


Fig.21 General Purpose Paints (Red Hand Compositions Co.) exposed at town site, Port Harcourt. The four panels on the right-hand side of the bottom row are asbestos cement and the remainder are wood. (Note heavy dirt collection on one of the wooden panels, Serial No. B1-4.)

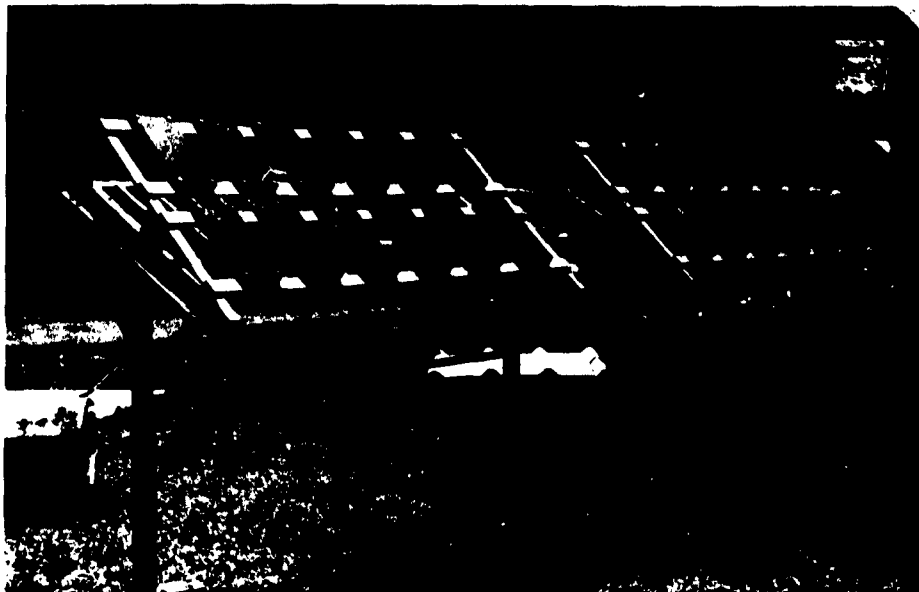


Fig.22 Canadian Army Vehicle Paints applied to wood
exposed at the town site, Port Harcourt.

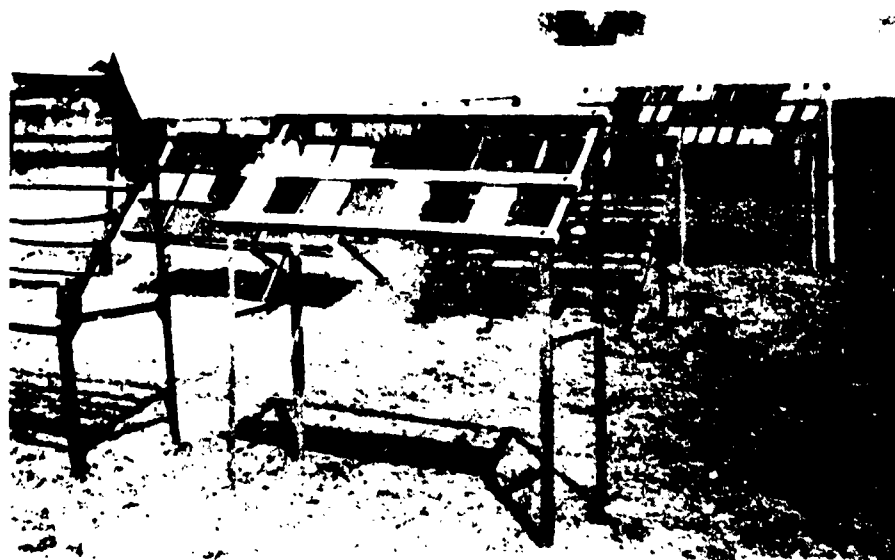


Fig.23 Commercial Enamels (Jenson and Nicholson Group)
exposed at desert site, Kano.

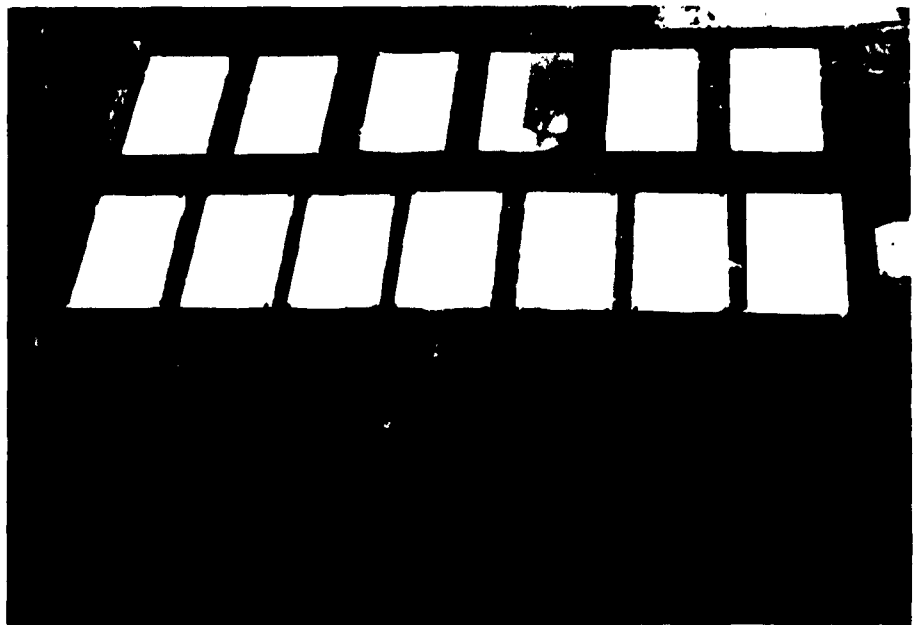


Fig.24 General Purpose Paints (Red Hand Compositions Co.
- 2nd Trial) exposed at town site, Port Harcourt.



Fig.25 General Purpose Paints (Red Hand Compositions Co.
- 2nd Trial) exposed in the jungle undergrowth.



Fig.26 General Purpose Paints (Red Hand Compositions Co.
- 2nd Trial) exposed at marine site, Lagos.

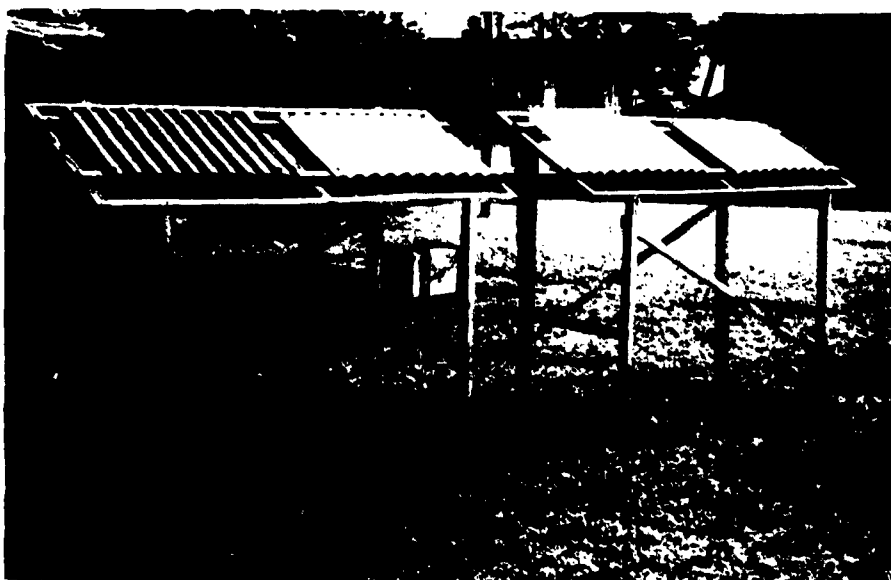


Fig.27 Turnall Colouglaze (Turner Asbestos Cement Co. Ltd.)
exposed at town site, Port Harcourt.



Fig.28 Plastic Emulsion Paints (Jenson & Nicholson Group)
exposed on concrete blocks at the marine site,
Lagos (50 yard compound).

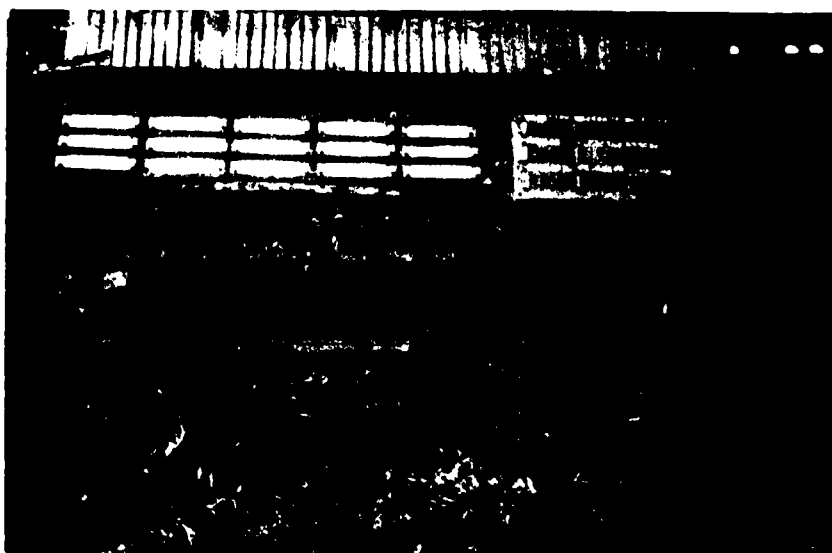


Fig.29 Picture Varnishes (Trial sponsored by the
National Gallery) exposed at desert site, Kano.



Fig.30 Picture Varnishes (Trial sponsored by the National Gallery). Specimens exposed on clear glass (microscope slides) at desert site, Kano.



Fig.31 Fungus Resisting Paints (I.C.I. Ltd.) exposed at town site, Port Harcourt.



Fig.32 Fungus Resisting Paints (I.C.I. Ltd.) exposed in jungle undergrowth, Nkpoku.



Fig.33 Fungicidal Paints and Varnishes (Trial sponsored by M.O.S., Chemical Inspectorate). Specimens exposed in jungle undergrowth.

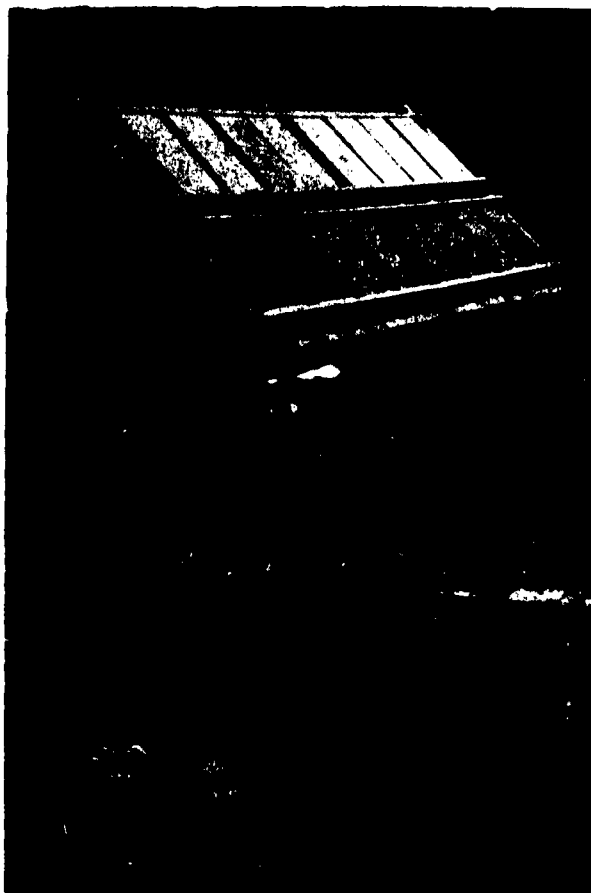
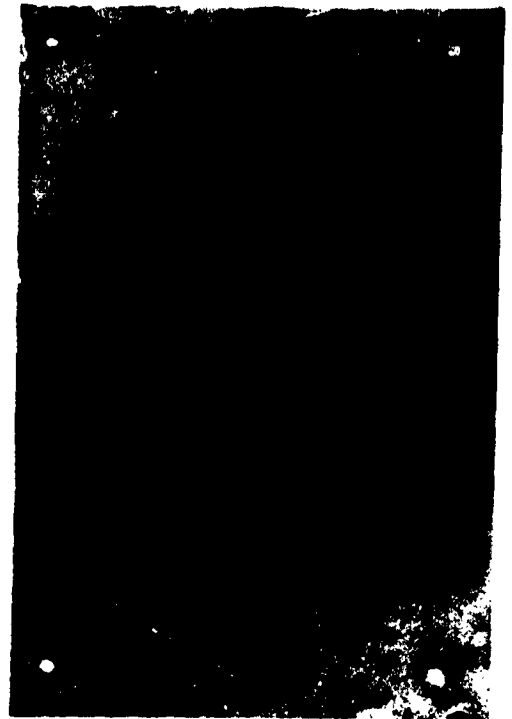


Fig. 34 Fungicidal Paints
(Goodlass Wall & Co. Ltd.)
exposed in the jungle
clearing, Nkpoku.



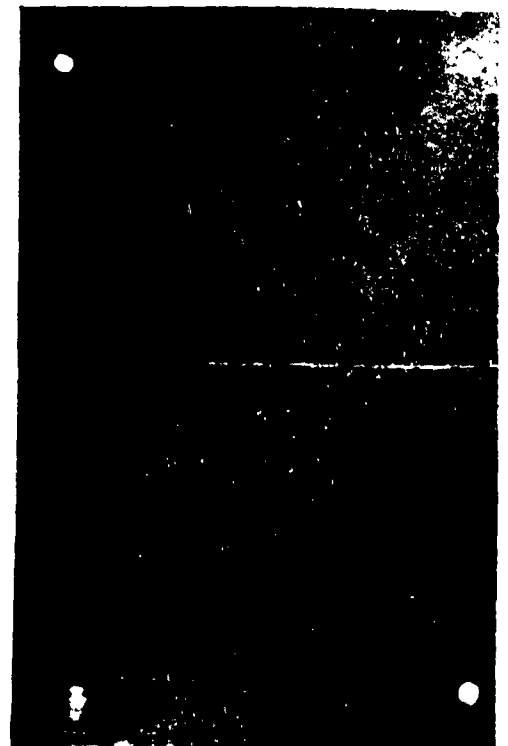
1



2



3



4

Fig.35 Pammel Synthetic Enamel Paint (Blundell, Spence & Co. Ltd.). Condition of painted mild steel panels at end of trial, i.e., after 18-19 months exposure. Panels 1, 2, 3 and 4 were exposed at marine (50 yd), marine (200 yd), jungle clearing and desert sites respectively. The lower halves of panels 3 and 4 have been polished.

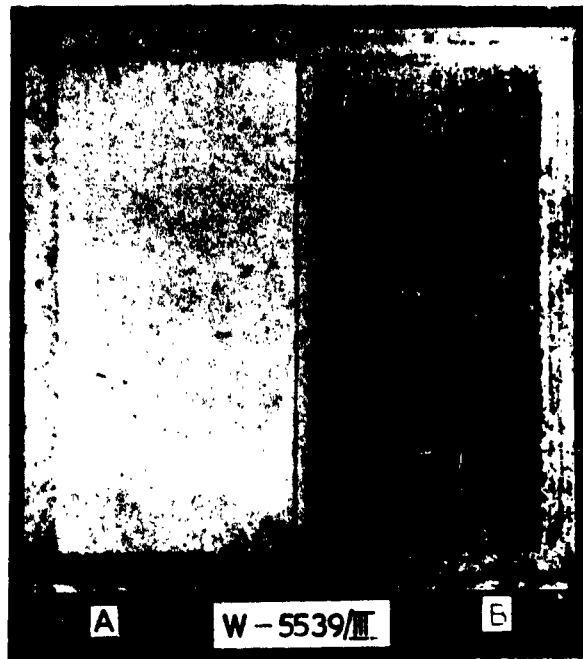
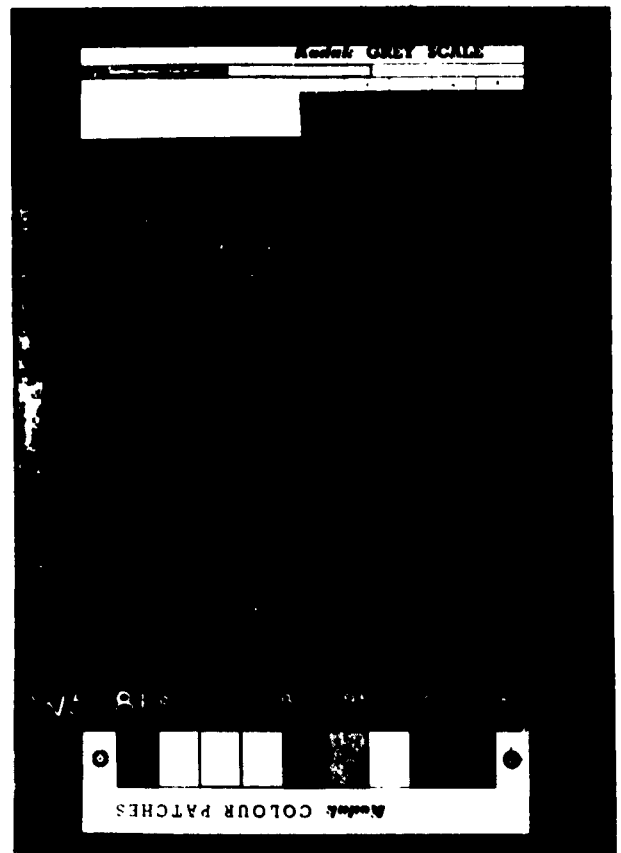


Fig.36 War Equipment Paints
(Trial sponsored by
M.O.S., Chemical
Inspectorate). Arctic
White finish after
approximately 34 months
exposure in jungle
clearing. (System A4-8
on left, A4-17 on right)
Note very heavy rusting
on portion without primer.

Fig.37 Ready Mixed Oil Paints
(Trial sponsored by
M.O.S., Chemical
Inspectorate).
System A5-6 after 34
months exposure at
jungle site showing
severe cracking.



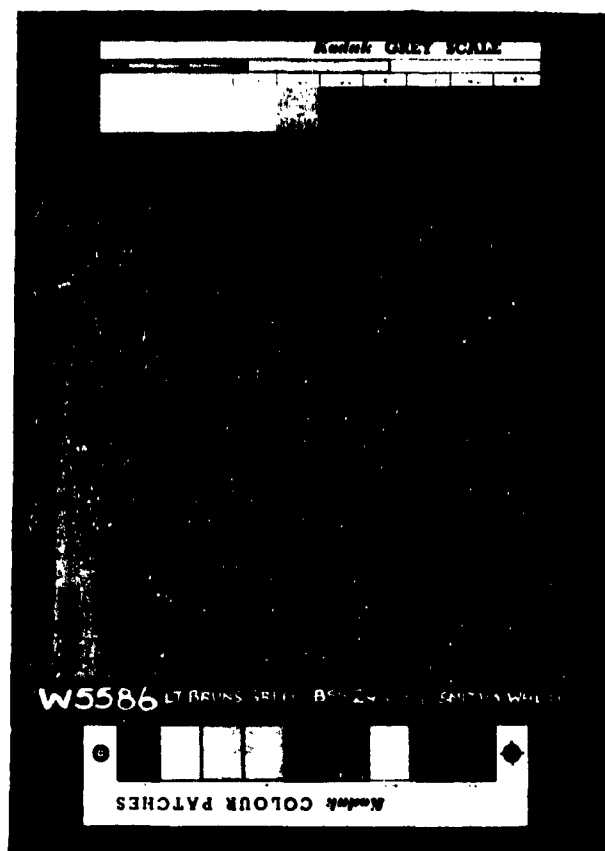


Fig.38 Ready Mixed Oil Paints
(Trial sponsored by M.O.S.,
Chemical Inspectorate).
System A5-11 after 32
months exposure at desert
site. Note severe cracking
and fading as compared with
duplicate panel at jungle
site (Fig.39).

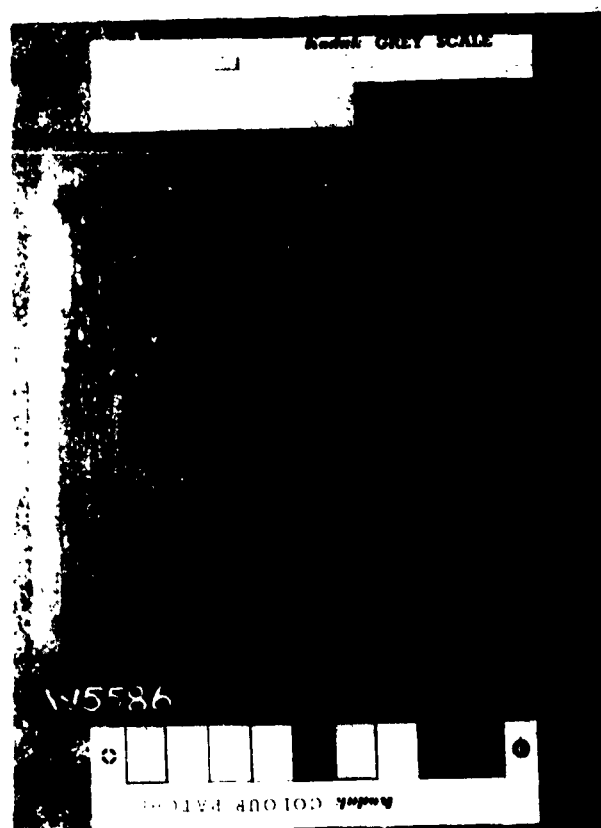


Fig.39 Ready Mixed Oil Paints
(Trial sponsored by
M.O.S., Chemical
Inspectorate). System
A5-11 after 34 months
exposure at jungle site
Note severe cracking.



Fig.40 Ready Mixed Oil Paints
(Trial sponsored by M.O.S.
Chemical Inspectorate).
System A5-7 after 34
months exposure at
jungle site, showing
heavy fungal and algal
growth.

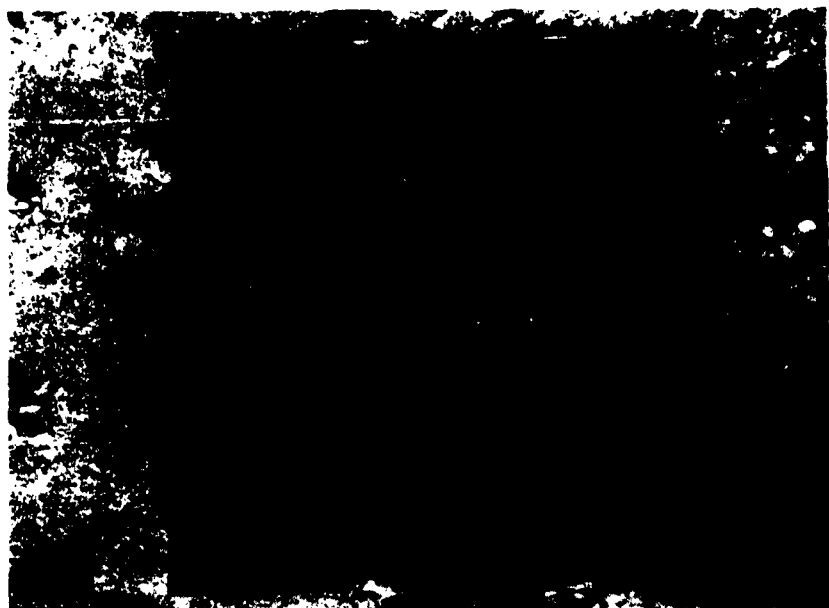


Fig.41 Ready Mixed Oil Paints (2nd Trial sponsored by M.O.S.,
Chemical Inspectorate). System A5-6 after 18 months
exposure at jungle site showing severe cracking.

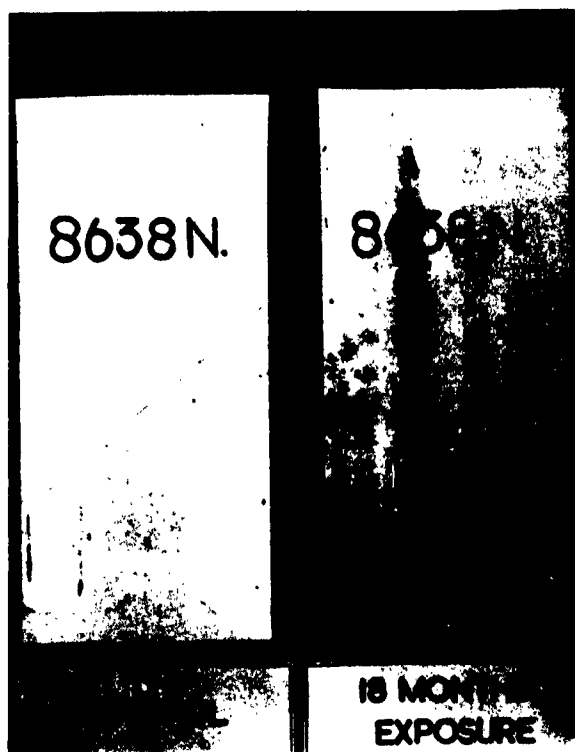


Fig.42 Paints and Varnishes (International Paints Ltd.). Specimen A8-14, after 18 months exposure at town site, Port Harcourt. Note heavy algal growth.

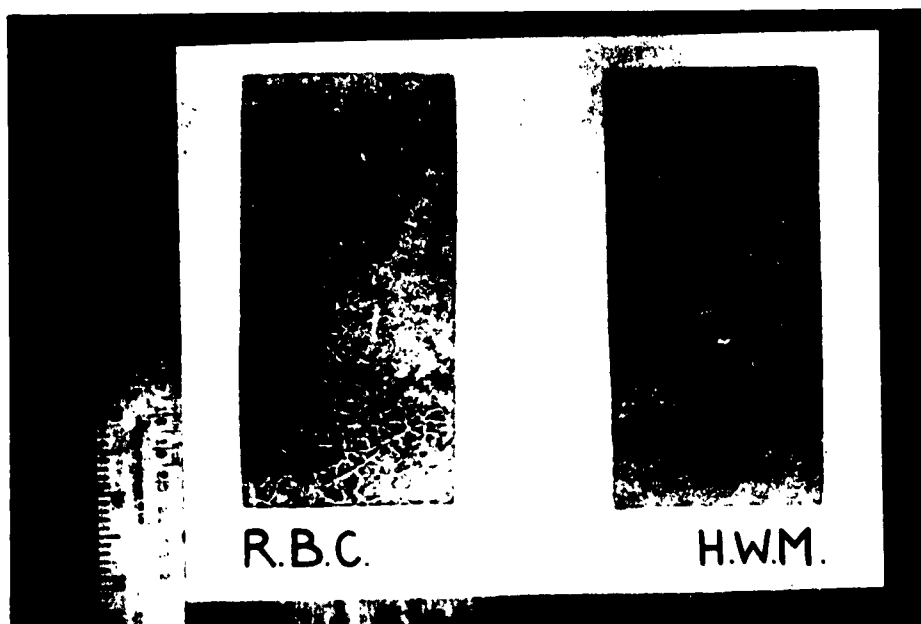


Fig.43 Chlorinated Rubber Paints (Messrs. Tretol Ltd.). Panels after 15 months exposure at the marine site showing severe checking and cracking (left hand specimen from 200 yd compound and right hand specimen from 50 yd compound).

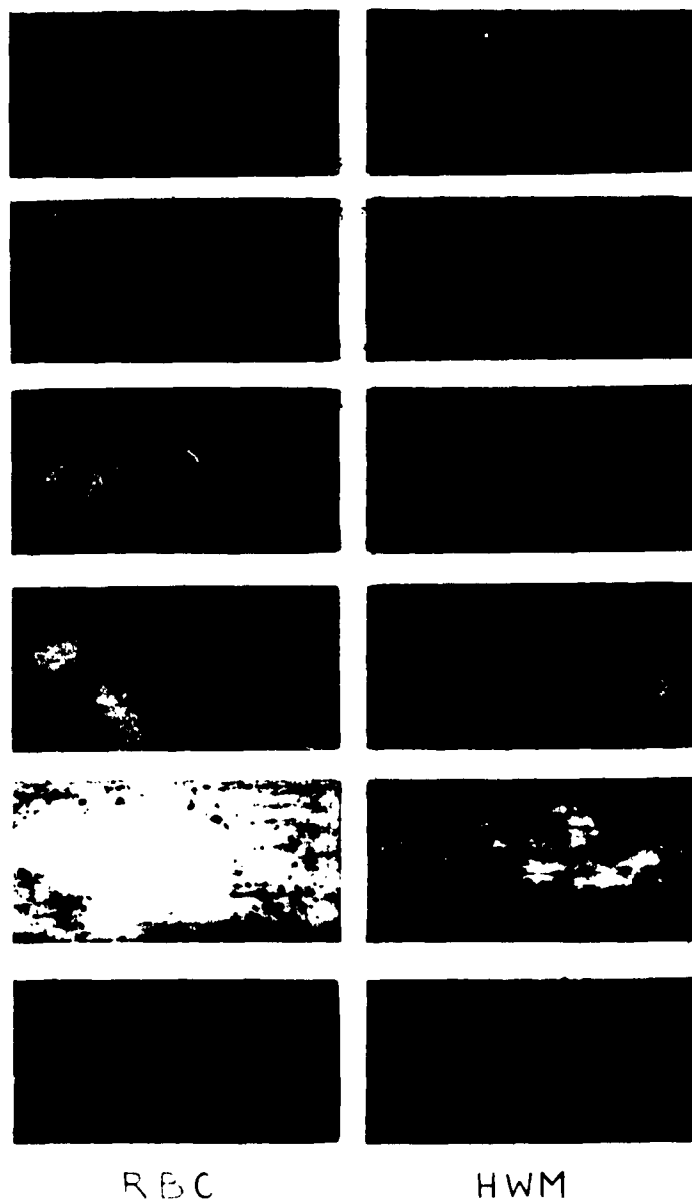


Fig.44 "Avare" Silica/Graphite Paints (C.R. Averill, Ltd.).
Systems A10-1 to A10-6 (from top to bottom) after
15 months exposure at marine site, Lagos. The
panels on the left were exposed 200 yards, and those
on the right, 50 yards, from the surf line.

"AVARC" & "TREETOL" PAINTS.
AERIAL WIND & WATER



Fig.45 "Avare" Silica/Graphite Paints (C.R. Averill, Ltd.) and Chlorinated Rubber Paints (Tretol, Ltd.) after 10 months exposure. The two columns on the left were exposed at Wilmot Point, Lagos and those on the right in the wind/water zone of the lagoon site. The order of the specimens is, reading from top to bottom, A10-1 to A10-6. The bottom row contains the Chlorinated Rubber Paints (System A9-1).



Fig.46 Priming Schemes for Metallic Coatings (Trial sponsored by the British Iron & Steel Research Association). System A13-1 after 19 months exposure at the marine site showing severe erosion of the paint.

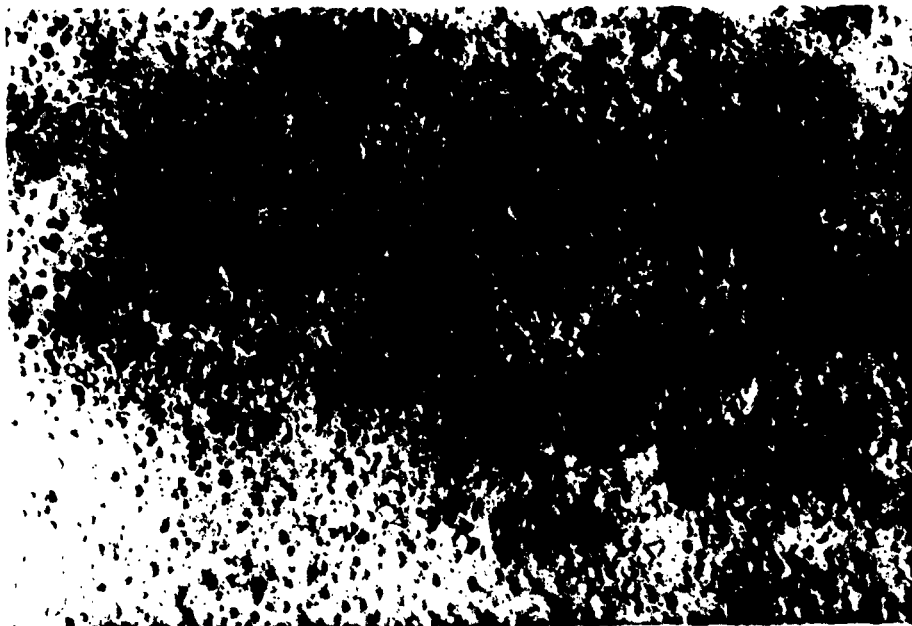


Fig.47 Priming Schemes for Metallic Coatings (Trial sponsored by the British Iron & Steel Research Association). System A13-12 after 19 months exposure at the marine site (enlarged view).

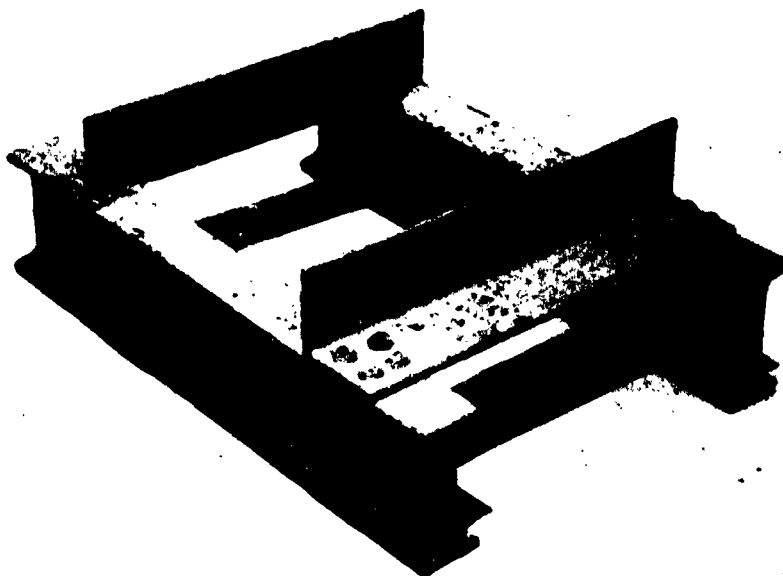


Fig.48 Priming Schemes for Metallic Coatings (Trial sponsored by the British Iron & Steel Research Association). System A13-19 after 19 months exposure at the marine site showing severe corrosion of the metal coating and breakdown of the paint system.

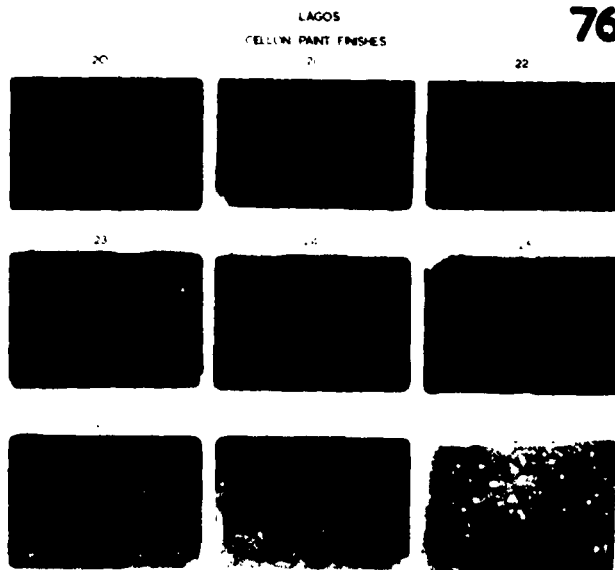


Fig.49 Service Paint Systems (Cellon Ltd.). Specimens A16-20 to A16-27 and A16-32 after $3\frac{1}{2}$ years exposure at the marine site, showing very heavy rusting of panels and almost complete destruction of the paint films.

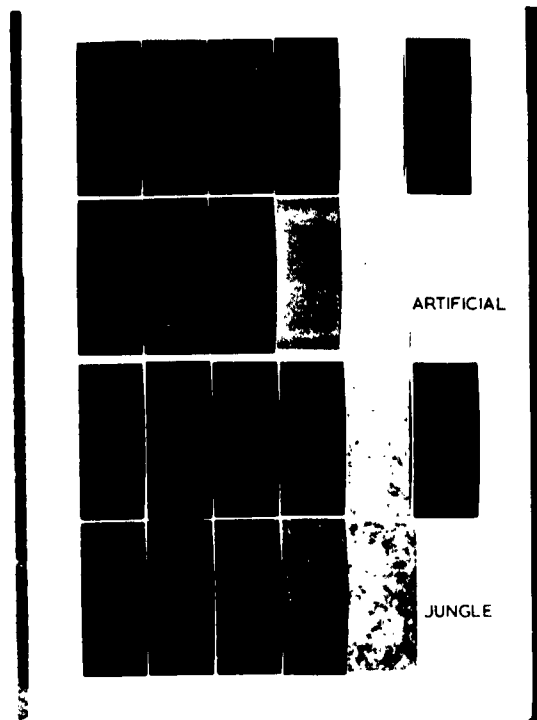
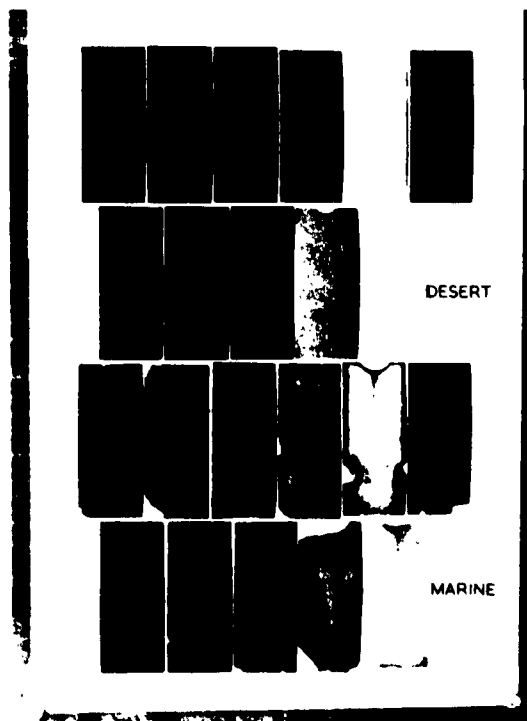


Fig.50 Car Finishes (F.I.A.T., Turin). The two top rows were exposed to artificial weathering tests for 500 hours and the two bottom rows were exposed in the jungle clearing, Nkpoku for 6 months. The specimens are in order from left to right and top to bottom.

Fig.51 Car Finishes (F.I.A.T., Turin). Specimens after 6½ months exposure at desert site (two top rows) and marine site (bottom rows). The specimens are in order from left to right and top to bottom.



JUNGLE CLEARING NKPOKU

27 MONTHS EXPOSURE



PANEL No 33

Fig.52 Canadian Army Vehicle Paints applied to wood.
System B4-9 after 27 months exposure at jungle
site, showing heavy fungal decay of wood.

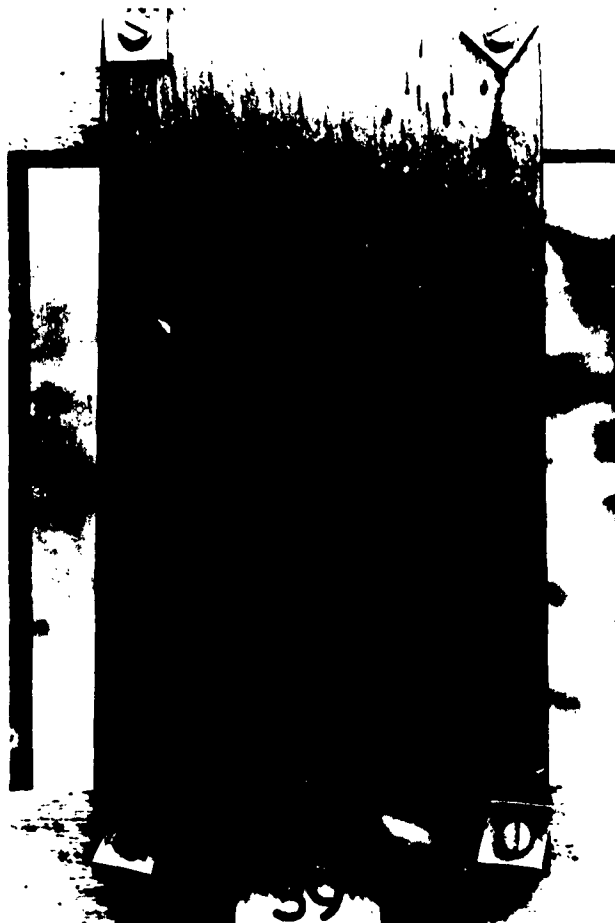
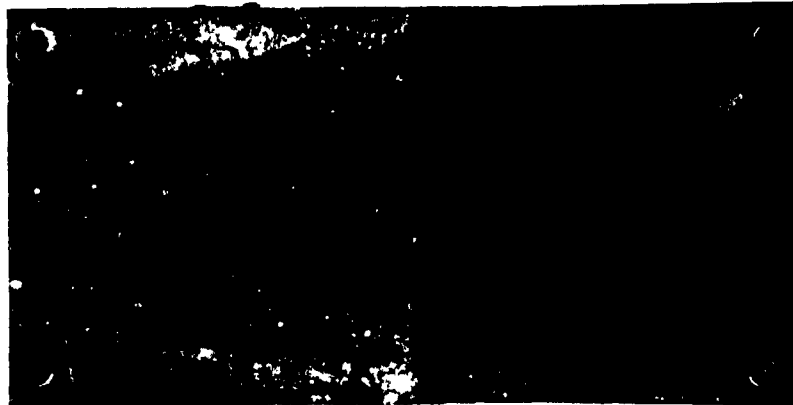


Fig.53 Canadian Army Vehicle
Paints applied to wood.
System B4-15 after 7
months exposure at jungle
site showing cracking of
the paint where the sub-
strate had split, and
heavy biological growth
at the regions of the
cracks.

JUNGLE CLEARING NKPOKU

27 MONTHS EXPOSURE



PANEL No 32

Fig.54 Canadian Army Vehicle Paints applied to wood.
System B4-8 after 27 months exposure at jungle site,
showing heavy biological growth on left hand side
and good condition of paint on right hand side
which was cleaned.

JUNGLE CLEARING NKPOKU

27 MONTHS EXPOSURE



PANEL No 42

Fig.55 Canadian Army Vehicle Paints applied to wood.
System B4-18 after 27 months exposure at jungle
site showing cracking of paint at areas where
substrate has split and heavy biological growth.
(The right hand side of the panel has been
cleaned.)

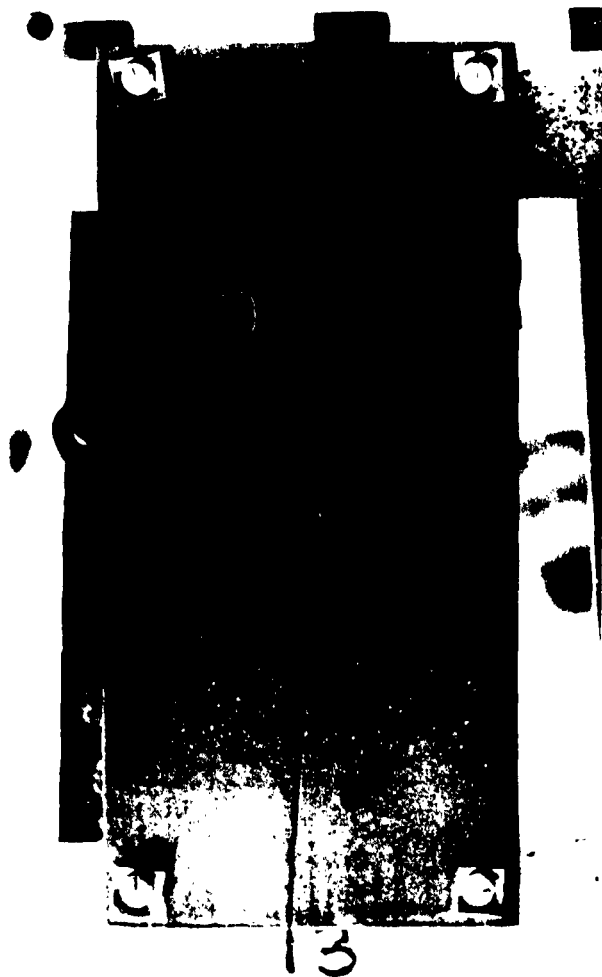
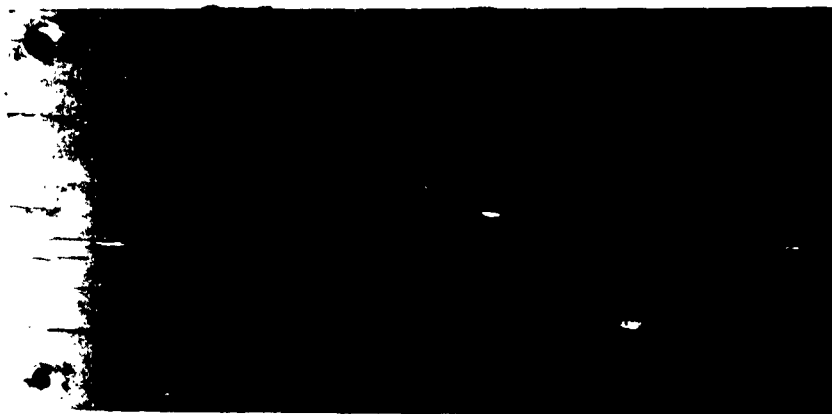


Fig.56 Canadian Army Vehicle Paints applied to wood. System B4-13 after 5 months exposure at marine site showing severe splitting of wood substrate.

SURF BEACH LAGOS

27 MONTHS EXPOSURE



PANEL No 17

Fig.57 Canadian Army Vehicle Paints applied to wood. System B4-17 after 27 months exposure at marine site, Lagos, showing cracking and flaking of the paint where the substrate had split. The right hand side of the panel has been cleaned.

TOWN SITE PORT HARCOURT

24 MONTHS EXPOSURE



PANEL No 92

Fig.58 Canadian Army Vehicle Paints applied to wood.
System B4-20 after 24 months exposure at town site,
Port Harcourt, showing cracking and flaking of
paint in areas where the substrate had split.
The left hand side of the panel has been cleaned.



Fig.59 Canadian Army Vehicle
Paints applied to wood.
System B4-12 after 5
months exposure at marine
site showing a typical
case of blistering.



Fig.60 General Purpose Paints
(Red Hand Compositions
Co. - 2nd Trial).
System B7-20 (left hand
side of panel) after
11½ months at marine site,
showing severe flaking.

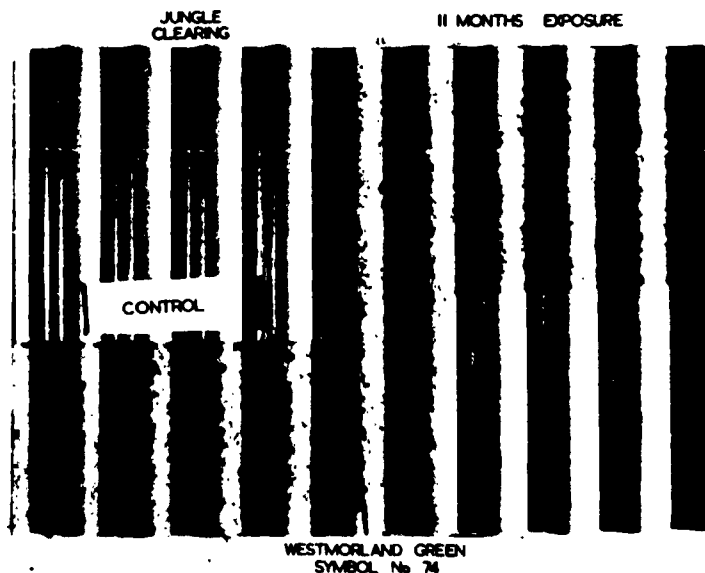


Fig.61 Turnall Colourglaze (Turners Asbestos Cement Co.)
Specimen C2-2 after 11 months exposure in the
jungle clearing showing heavy, superficial
biological growth, easily removed on washing.
(The bottom right hand corner has been cleaned.)

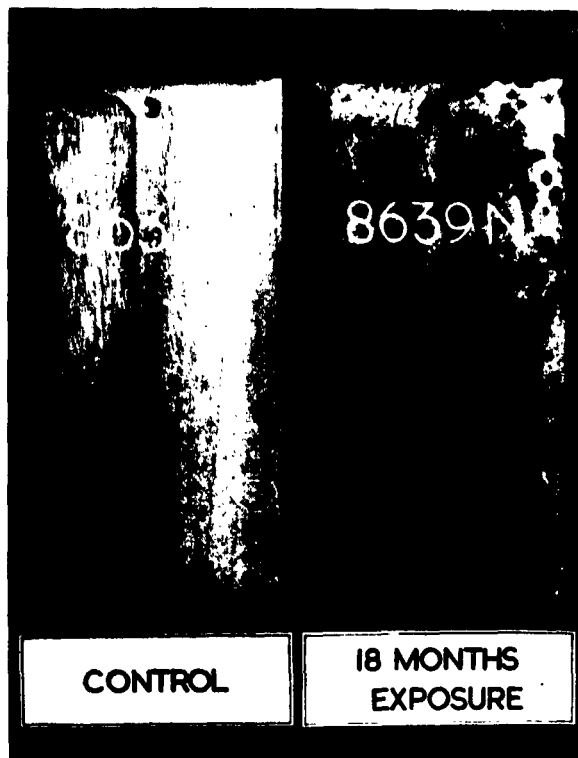
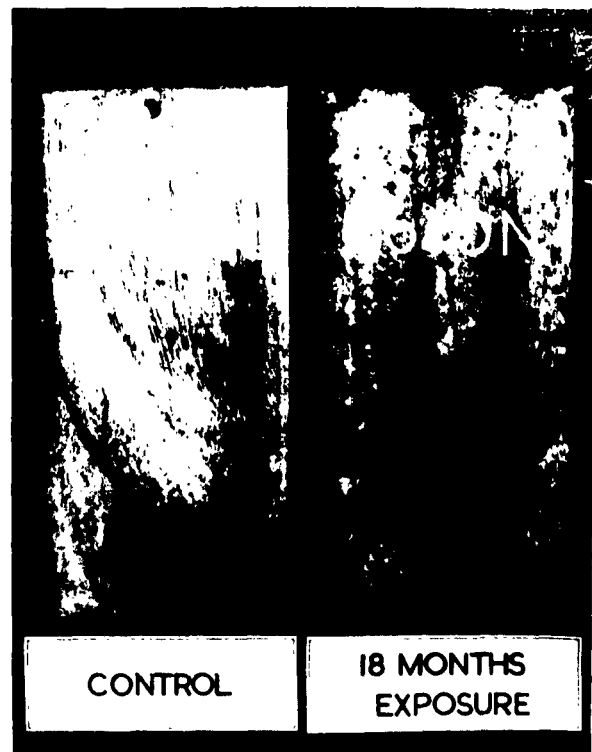


Fig.62 Commercial Varnishes
(International Paints,
Ltd.). E1-1 after 18
months exposure at town
site, showing extensive
checking and cracking.

Fig.63 Commercial Varnishes
(International Paints
Ltd.). Specimen E1-2
after 18 months exposure
at town site.



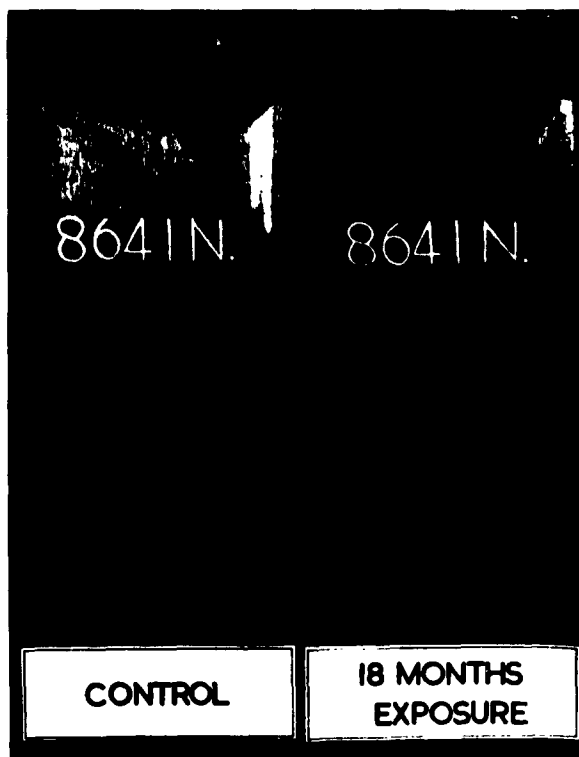
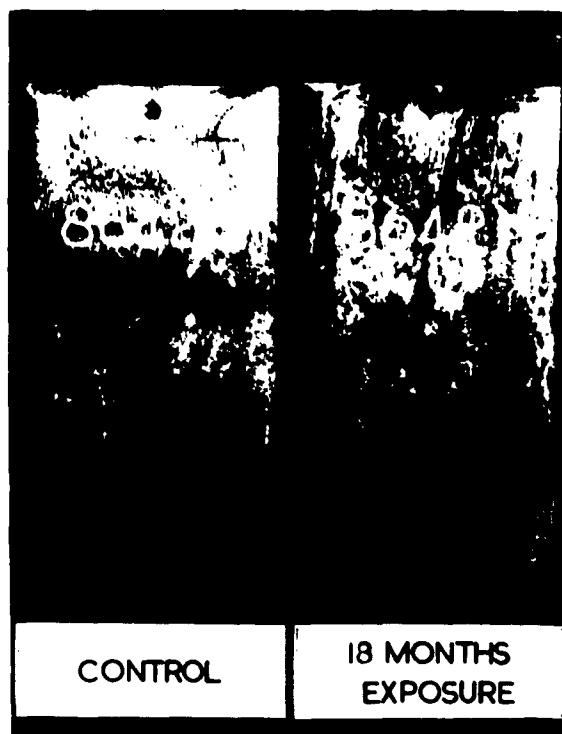


Fig.64 Commercial Varnishes
(International Paints Ltd.).
Specimen E1-3 after 18 months
exposure at town site,
showing considerable
darkening.

Fig.65 Commercial Varnishes
(International Paints Ltd.).
Specimen E1-4 after 18
months exposure at town
site, showing heavy flaking.



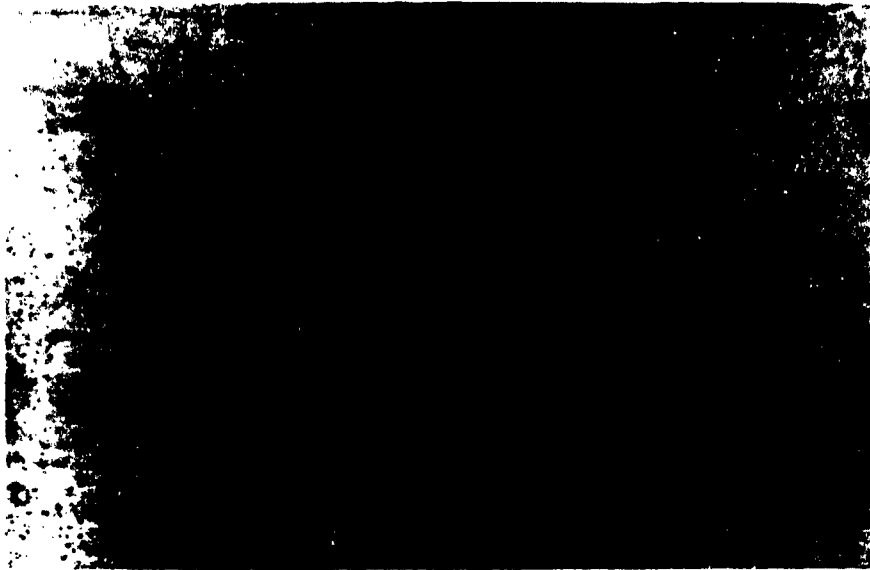


Fig.66 Damage to paint film on wood substrate caused by the fungus Pullularia after a year's exposure to sun and rain at the town site, Port Harcourt. (The lower right hand region of the panel has been cleaned.)



Fig.67 Fungus Resisting Paints (Jenson and Nicholson Group). Specimen with primer and white undercoat only, after 5 months exposure, showing fungal pustules breaking through the paint film.

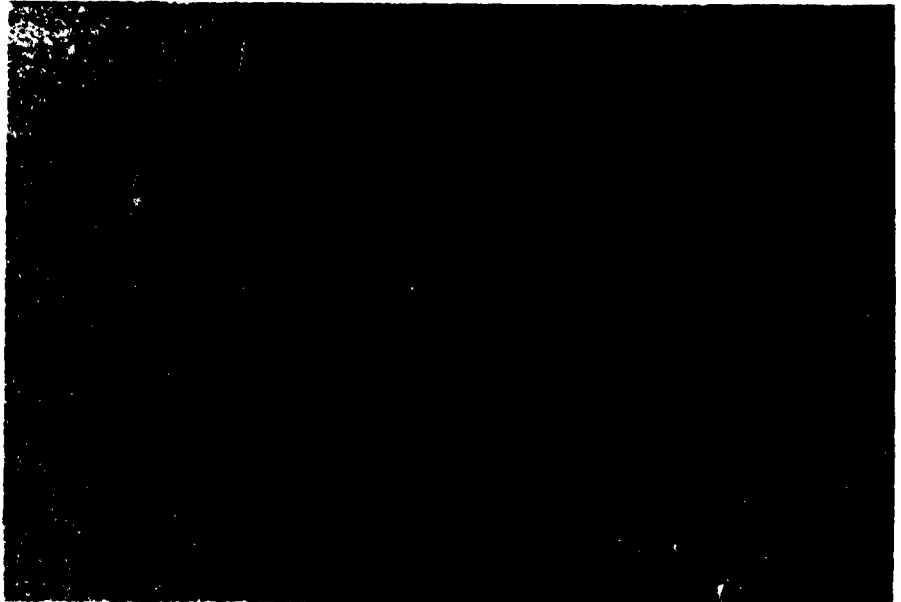


Fig.68 Development of pycnidia of Botryodiplodia theobromae on unpainted Obeche wood dipped in copper naphthenate for 1 hour and stored at 90% relative humidity.

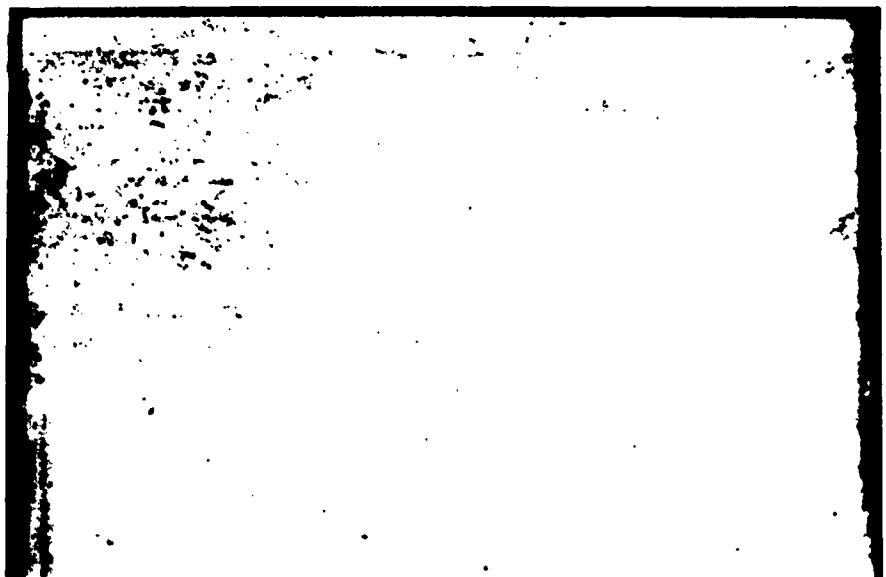


Fig.69 Fungus Resisting Paints (I.C.I. Ltd.). Specimen F2-5 (painted in U.K.) after 12 months exposure at the town site, Port Harcourt showing extensive breaking-up of the paint film by pustules of Botryodiplodia theobromae.



Fig.70 Fungus Resisting Paints (I.C.I. Ltd.). Specimen F2-6 showing rupture of paint film by pustules of Botryodiplodia theobromae growing from the wood substrate (enlarged view).

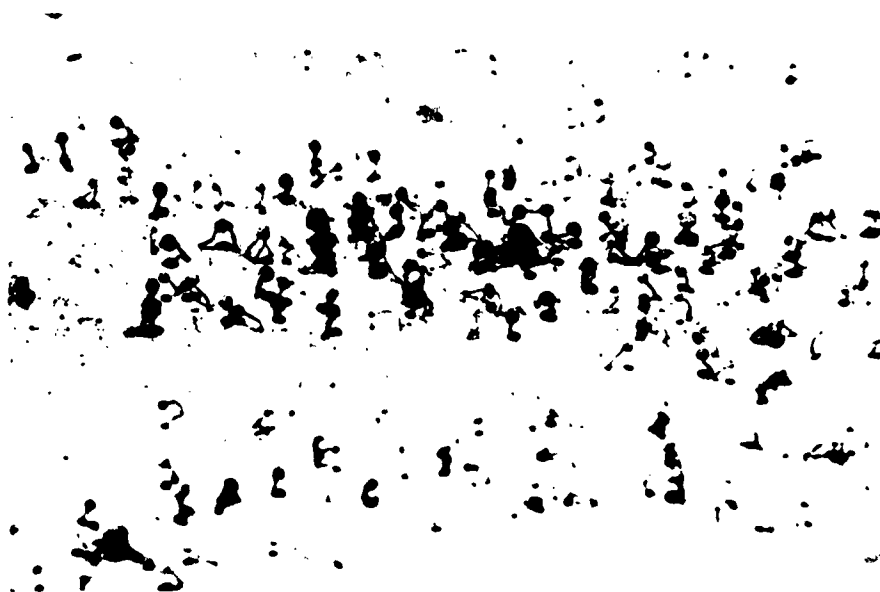


Fig.71 Fungus Resisting Paints (I.C.I. Ltd.). Enlarged view of paint film showing Graphium synnemata growing from the substrate.

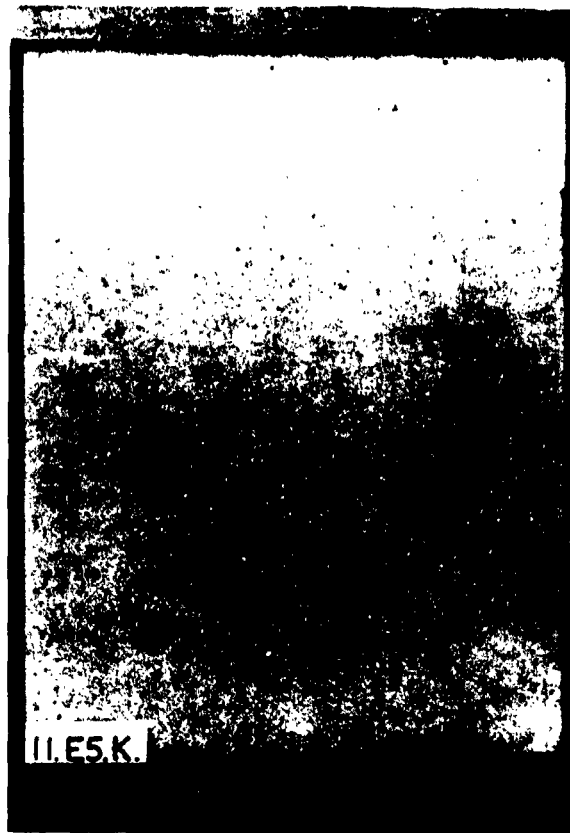
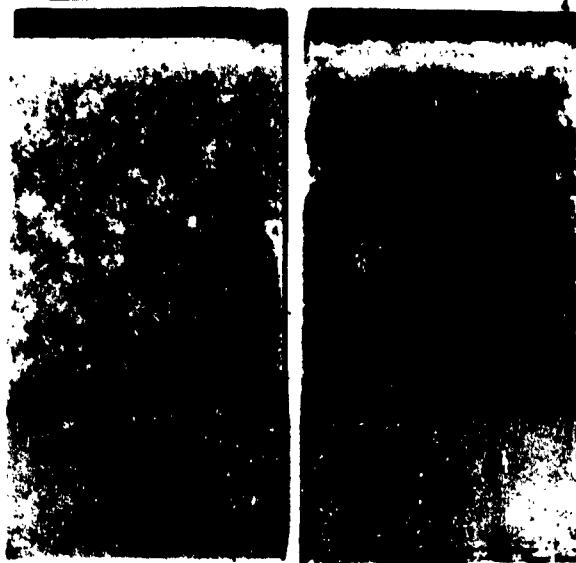


Fig.72 Fungus Resisting Paints (I.C.I.Ltd.). Specimen F2-6 showing patches of dark Pullularia on paint film after 3 months exposure at the town site, Port Harcourt.

Fig.73 Fungus Resisting Paints (I.C.I.Ltd.). Specimen F2-6 after 3 months exposure in the jungle undergrowth, Nkpoku, showing heavy, superficial mould growth.



16 MONTHS EXPOSURE



PANEL No | B1 | PANEL No B3

Fig.74 Fungicidal Paints
(Goodlass Wall & Co.Ltd.).
Systems F5-4 (on left)
and F5-3 (on right) after
16 months exposure in the
jungle clearing. The
damage to the paint film
caused by pycnidia of
Botryodiplodia theobromae
can be seen on the
cleaned portion of F5-3.

Fig.75 Fungicidal Lacquers
(Brandram Bros. & Co.
Ltd.) applied to
Nigerian Mahogany
plywood door panels at
base depot Port Harcourt
(6 months exposure).



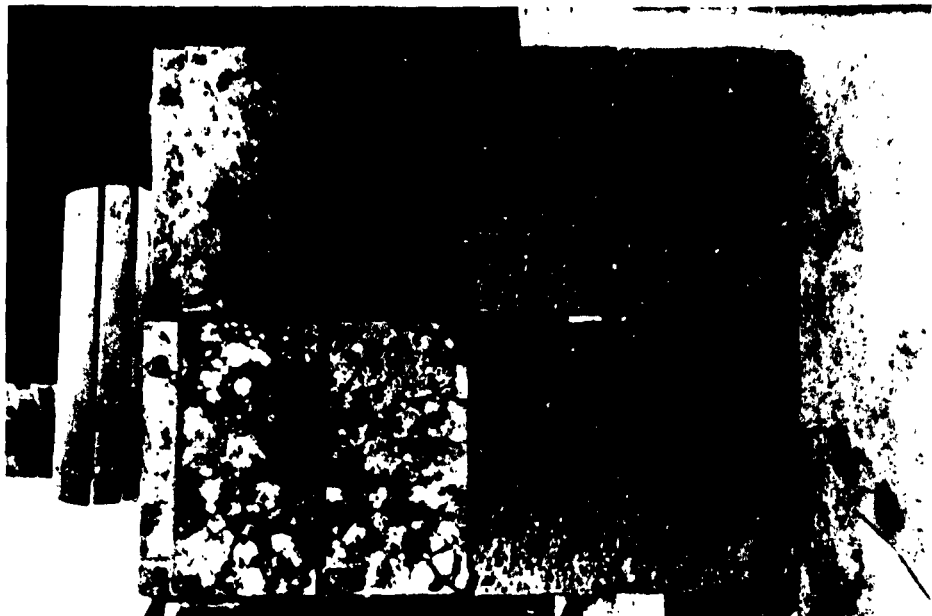


Fig.76 Anti-fouling, Anti-tarado Copper Paint (Red Hand Compositions Co.) after 4 months exposure in Bonny River, Port Harcourt. The four panels on the left were unpainted wood controls and the four on the right were painted. The four samples in the top row were exposed in the wind/water zone and the four at the bottom were fully immersed.



Fig.77 Admiralty Experimental Anti-fouling Paints after 66 weeks exposure. (Paint 44P on left, 45P on right.)



Fig.78 Admiralty Experimental
Anti-fouling Paints
after 66 weeks exposure.
(Paint 363P on left,
U.S.N.Spec.121 on
right.)

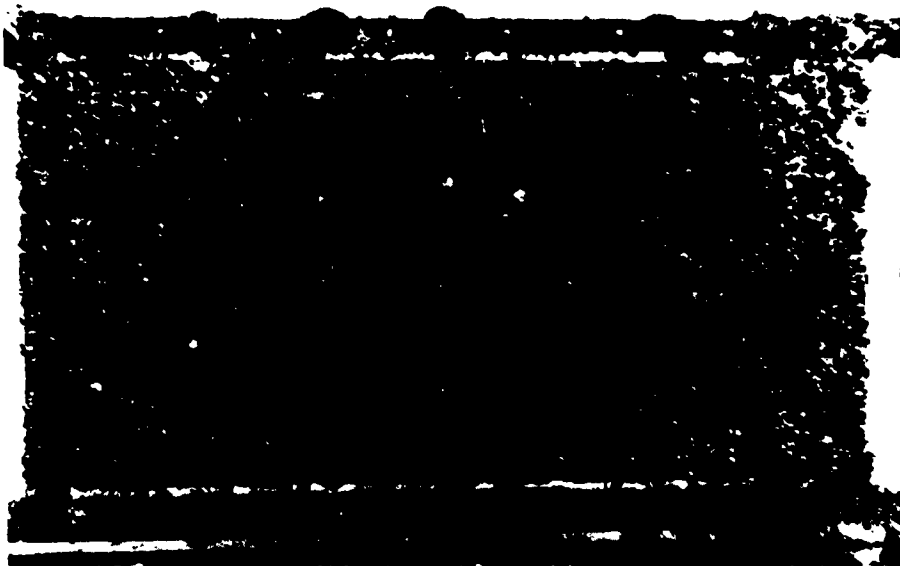


Fig.79 Experimental Anti-fouling Compositions (I.C.I.Ltd.)
after 26 weeks immersion in Bonny River (Frame 1).
For distribution of specimens, see Fig.80.

8	3	10	1	11	5
7	4	2	9	3	8
11	5	1	12	6	2

Frame 1

10	7	6	4	9	2
12	3	5	11	12	6
9	4	1	8	10	7

Frame 2

Fig.80 I.C.I. Experimental Anti-fouling Compositions.
Distribution of specimens on exposure frames
1 and 2. The numbers 1 to 12 relate to the
serial numbers of the twelve experimental
paints under test.

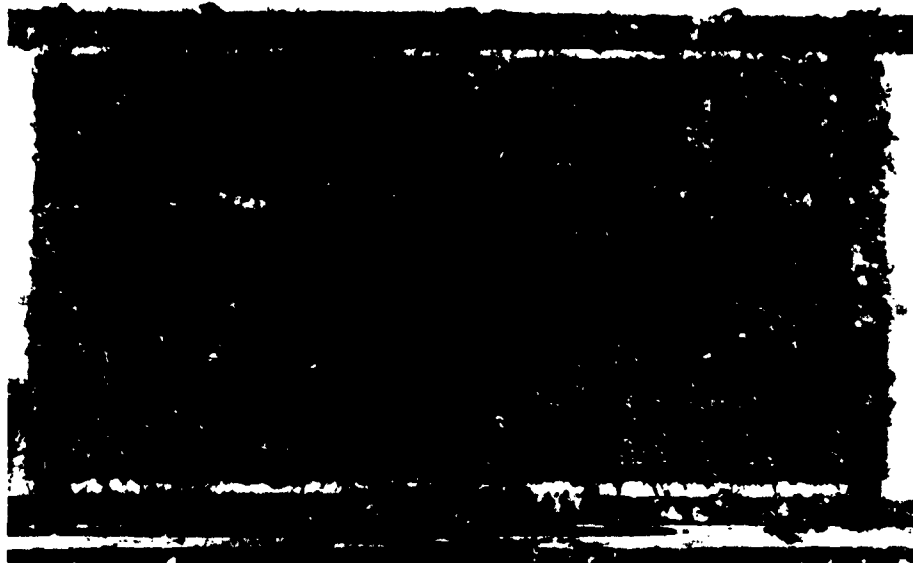


Fig.81 Experimental Anti-fouling Compositions (I.C.I. Ltd.)
after 26 weeks immersion in Bonny River (Frame 2).
For distribution of specimens, see Fig.80.

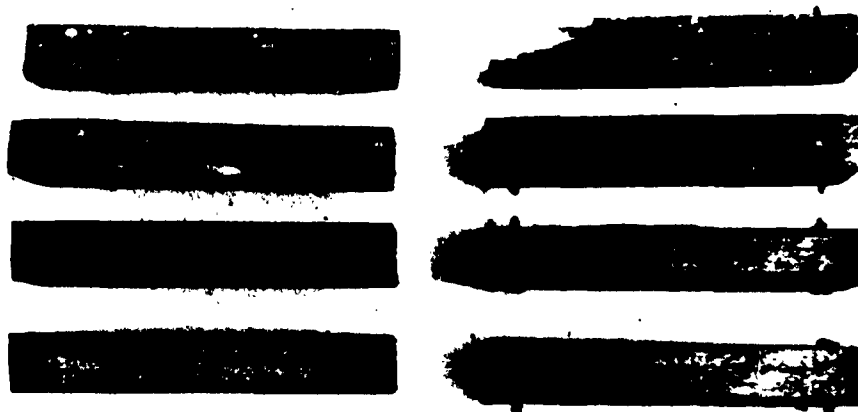


Fig.82 Anti-fouling Anti-teredo Copper Paint (Red Hand
Compositions Co.) after 4 months immersion in the
Bonny River, Port Harcourt. The panels have been
sectioned to reveal teredo attack. The four panels
at the top were unpainted wood controls and the four
at the bottom were painted. The four at the left were
fully immersed and those at the right were exposed in
the wind/water zone.

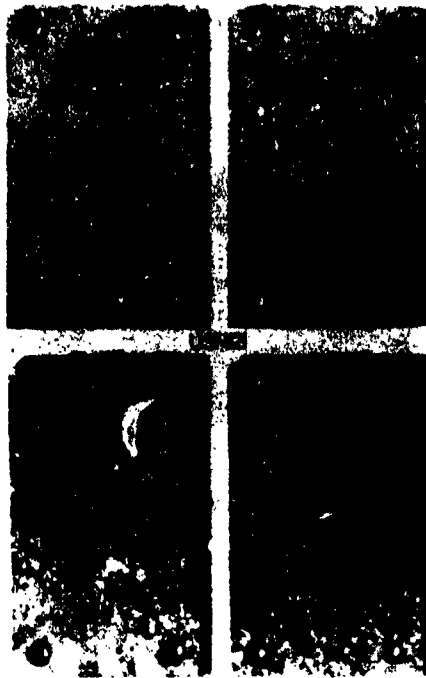


Fig.83 Admiralty Experimental Anti-teredo Paints. Condition of panels coated with paint to U.S.N.Spec.121 after immersion for 67 weeks in Bonny River, Port Harcourt and removal of marine fouling.

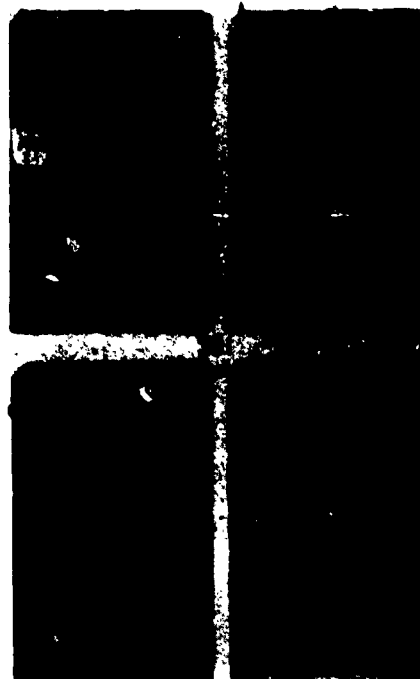


Fig.84 Admiralty Experimental Anti-teredo Paints. Condition of panels coated with System I2-5 (ground glass formulation) after immersion for 67 weeks in Bonny River, Port Harcourt and removal of marine fouling.

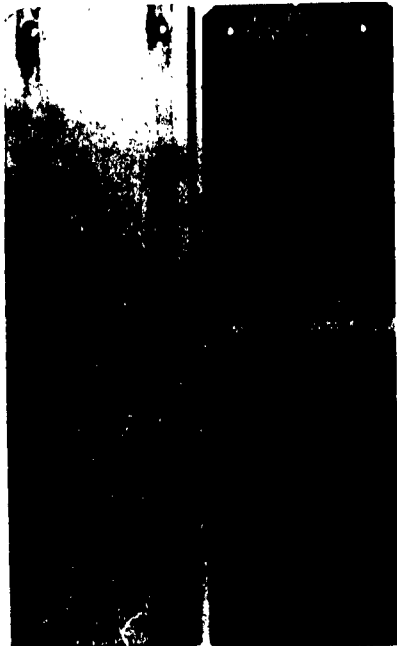


Fig.85 Admiralty Experimental Anti-teredo Paints. Sections of panels coated with paint to U.S.N.Spec.121 after 67 weeks immersion in Bonny River, Port Harcourt, showing absence of shipworm burrows.

Fig.86 Admiralty Experimental Anti-teredo Paints. Sections of panels coated with system I2-5 (ground glass formulatio after 67 weeks immersion in Bonny River, Port Harcourt, showing extensive teredo attack.



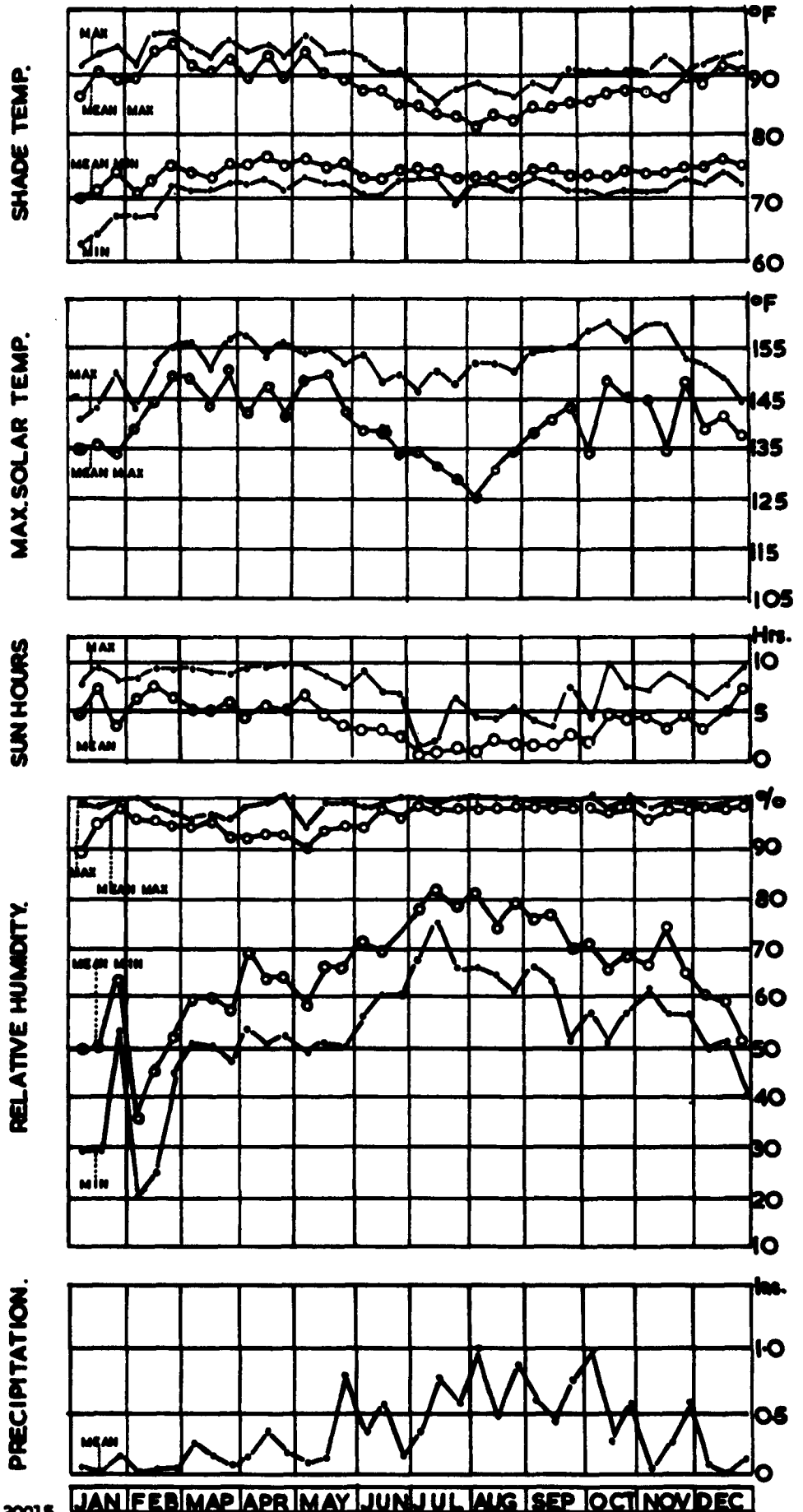
Table of Hydrographic Data - Bonny River, Port Harcourt

Period: October, 1956 - February 1958

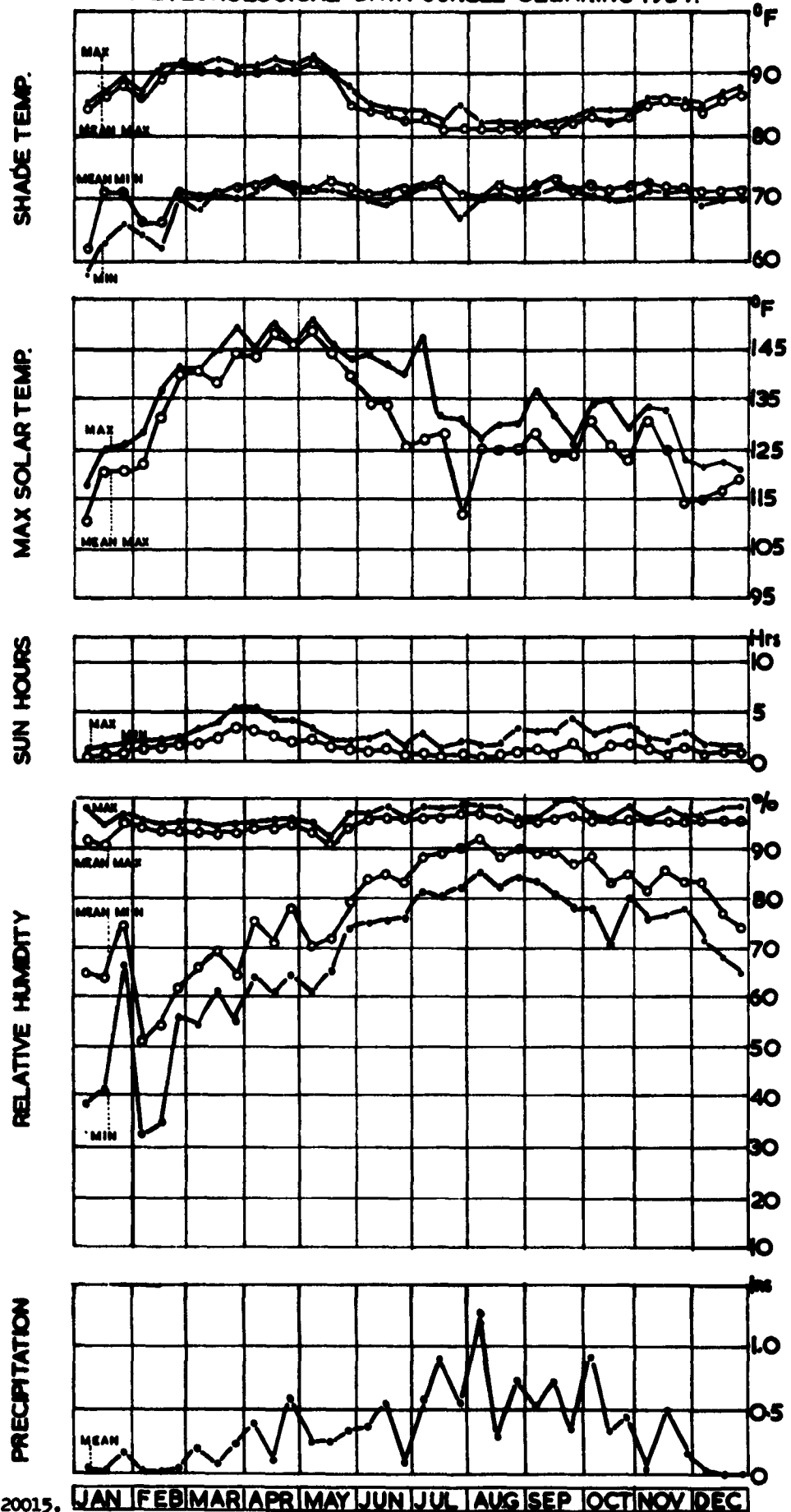
Date	State of Tide	Depth (ft)	Characteristics of Water		
			Salinity % NaCl	pH	Temp. °C
18.10.56	Low	Surface	1.64	7.8	27.0
25.10.56	High	"	1.70	7.8	27.0
1.11.56	Low	"	1.66	7.8	27.0
6.11.56	High	"	1.67	7.8	28.0
22.11.56	"	"	1.77	7.8	28.0
29.11.56	Low	"	1.65	7.8	28.0
6.12.56	High	"	1.62	7.8	28.0
13.12.56	Low	-	1.58	7.8	27.0
20.12.56	High	Surface	1.70	7.8	28.0
27.12.56	Low	"	1.62	7.6	27.0
11. 1.57	"	"	1.96	7.6	26.0
31. 1.57	"	"	2.22	7.6	27.0
7. 2.57	"	"	2.19	7.8	27.0
15. 2.57	"	"	2.28	7.8	28.0
21. 2.57	High	"	2.35	7.8	27.0
28. 2.57	Low	"	2.35	7.8	28.0
7. 3.57	High	"	2.41	7.8	28.0
21. 3.57	"	"	2.51	7.8	28.0
28. 3.57	Low	"	2.37	7.8	32.0
5. 4.57	High	"	2.37	7.8	28.0
16. 5.57	"	"	2.32	7.8	30.0
30. 5.57	Low	"	2.26	7.8	30.0
6. 6.57	"	"	2.18	7.8	29.0
13. 6.57	"	"	2.18	7.8	29.0
20. 6.57	Flood	"	2.11	7.8	29.0
27. 6.57	-	"	2.02	7.8	28.0
3. 7.57	High	"	2.08	7.6	28.0
10. 7.57	"	"	2.04	7.0	28.0
18. 7.57	"	"	1.76	7.6	28.0
25. 7.57	Low	"	1.60	7.2	28.0
29. 8.57	High	"	1.35	7.4	28.0
5. 9.57	Low	"	1.03	7.8	28.0
12. 9.57	High	"	1.14	7.2	28.0
19. 9.57	"	"	1.26	7.6	28.0
24. 9.57	Low	"	1.15	-	28.0
2. 1.58	"	"	1.46	7.2	29.7
8. 1.58	"	"	1.57	-	28.0
24. 1.58	High	"	1.77	7.0	29.0
30. 1.58	Low	"	1.63	7.2	29.0
11. 2.58	High	"	1.89	7.0	31.2
27. 2.58	High	"	2.05	7.0	30.0

Note. Vertical series of samples taken on a number of occasions showed that there was uniformity of temperature and salinity from surface to bottom at the site. Depth varied with tide from 10 to 15 feet of water.

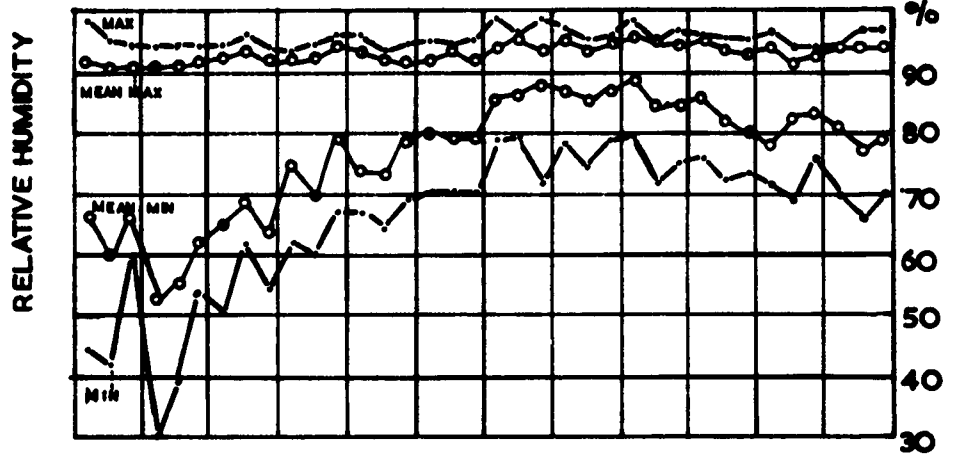
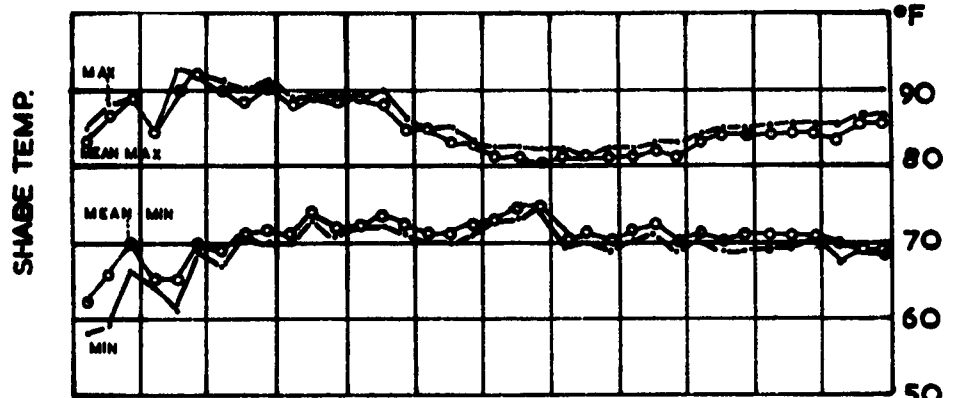
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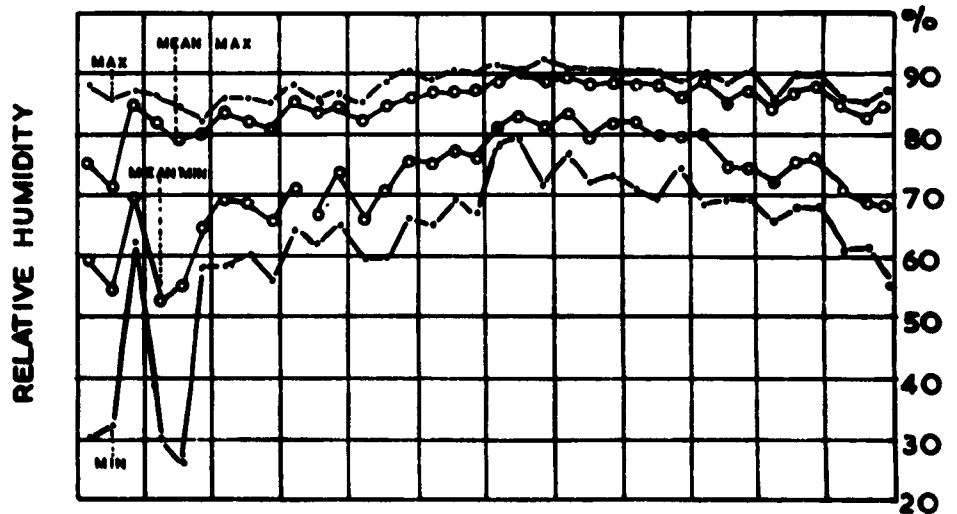
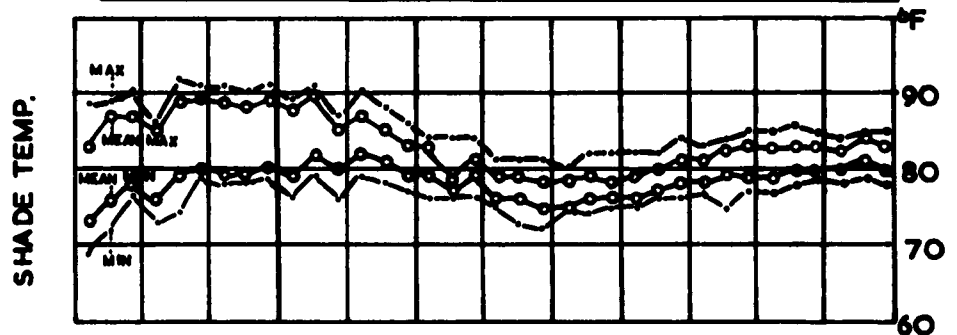
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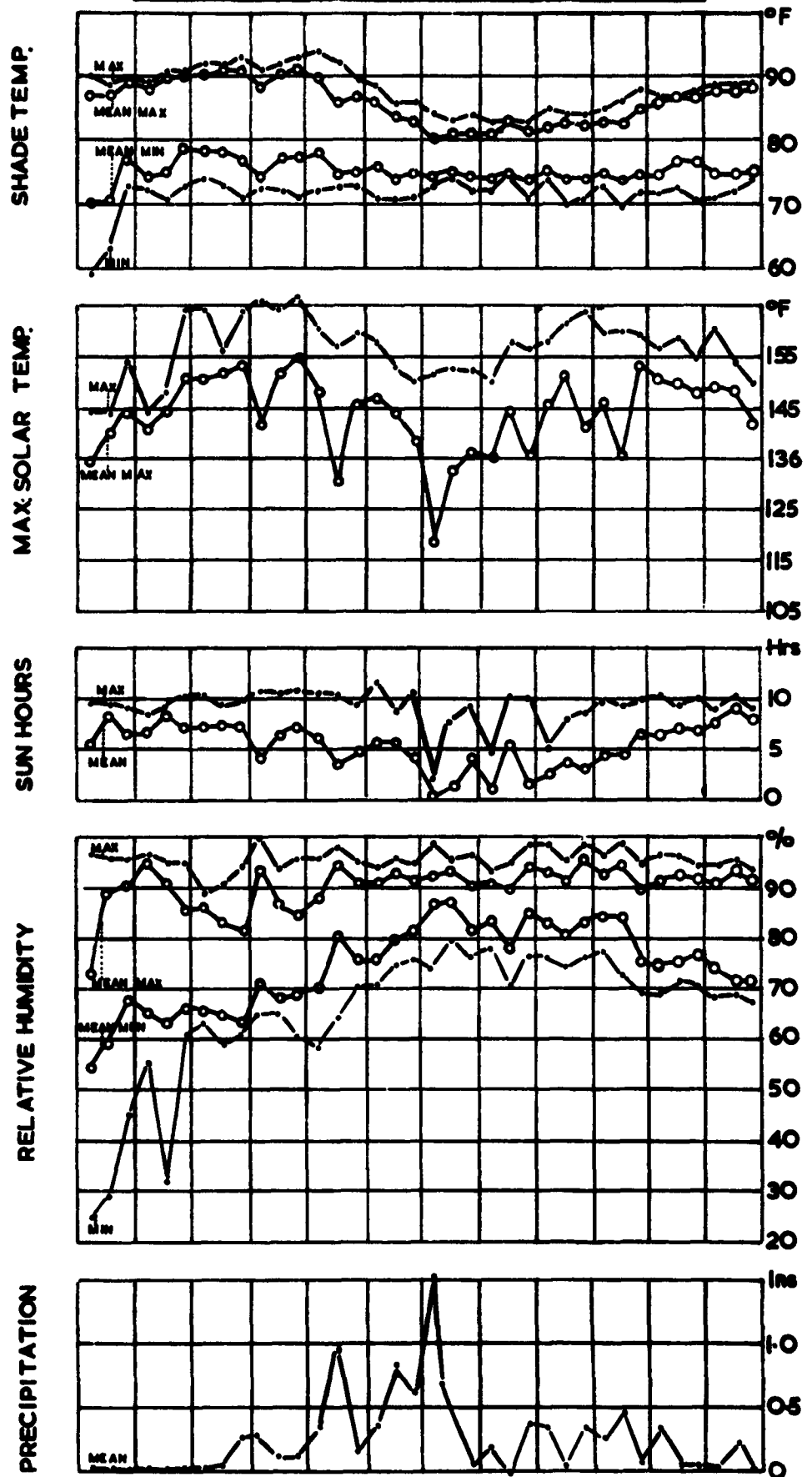
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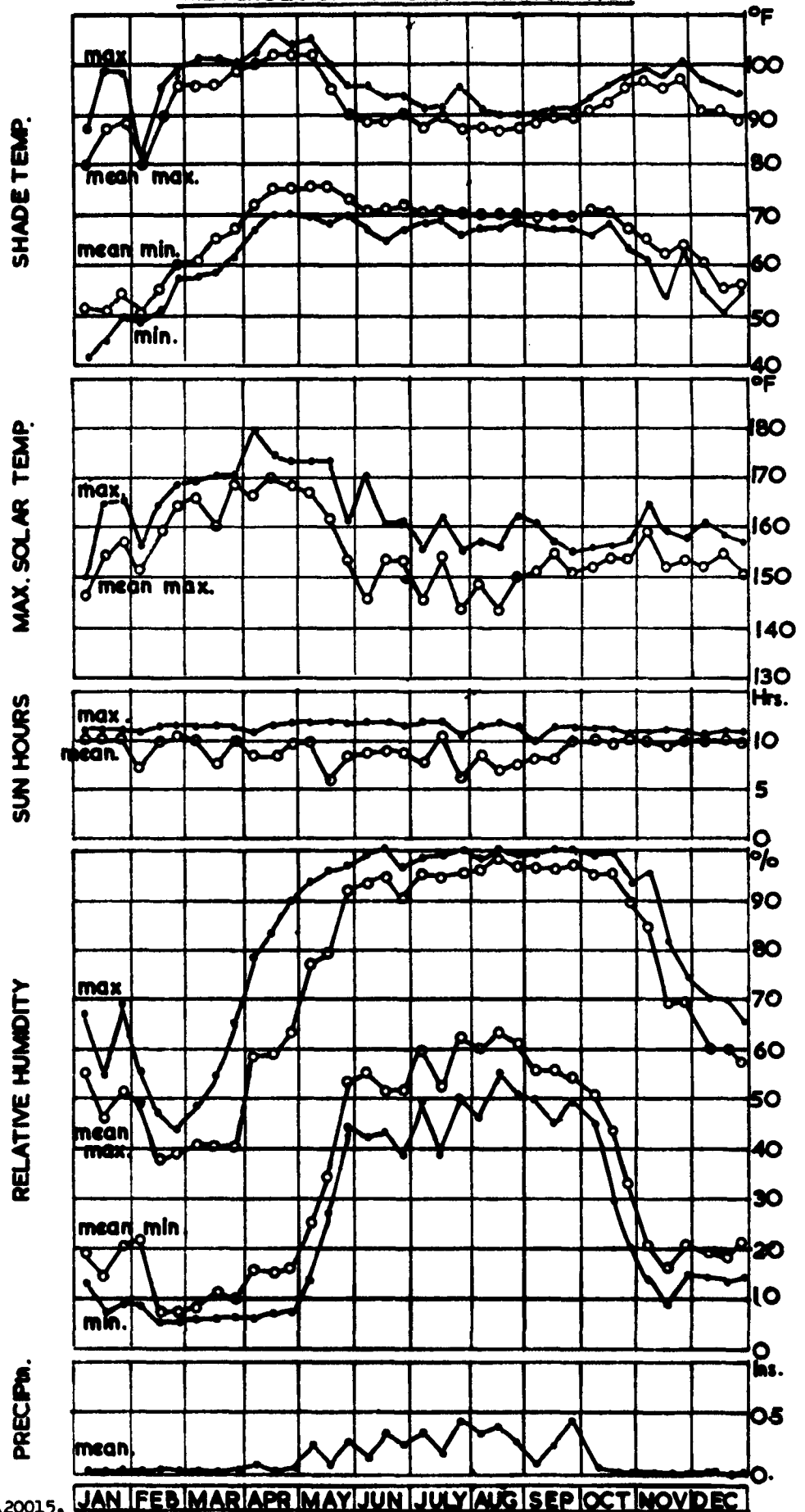
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