The Ericsson Bulletin

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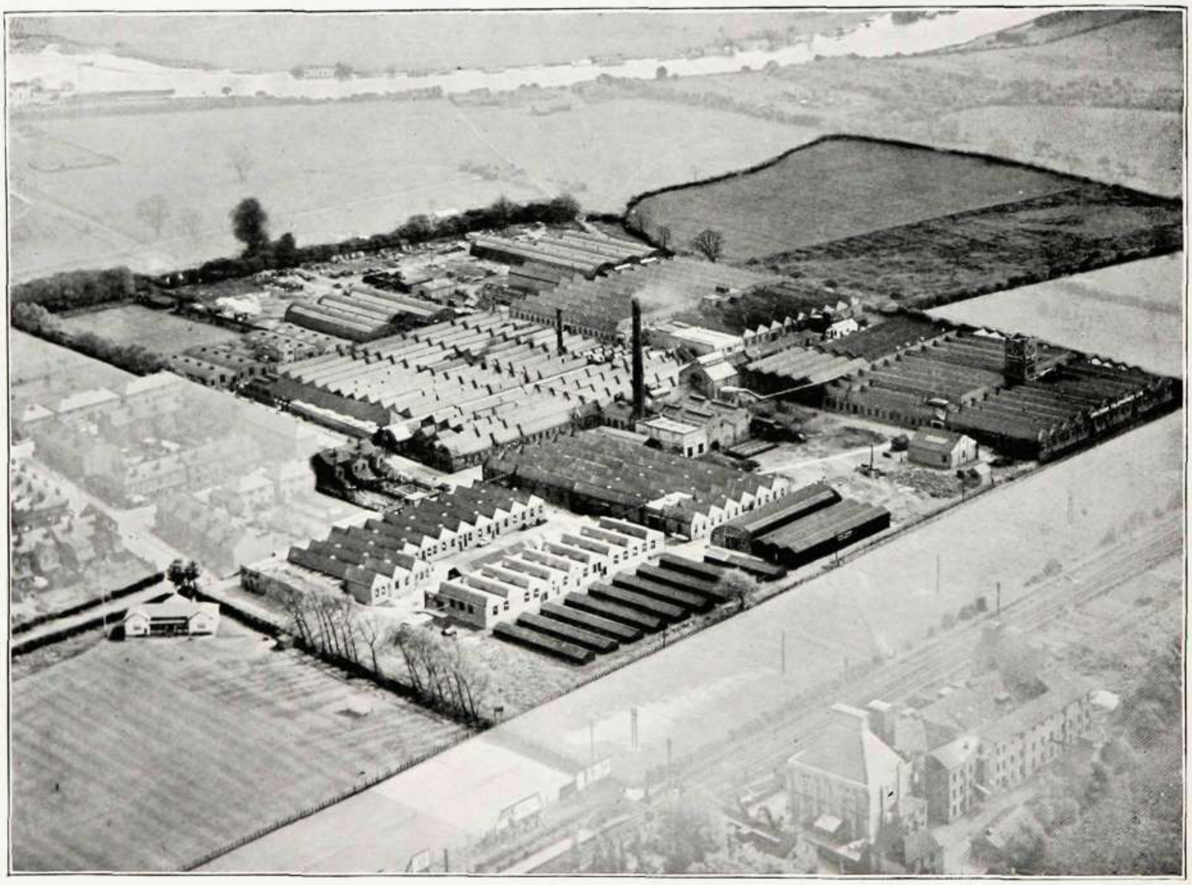


Aerial View of The Ericsson Works, Beeston, Nottingham

Relay Lag Timers for Workshop Use

ONLY very rarely is an automatic switching circuit encountered which does not make use of one or more slow operate or slow release relays ; in fact approximately 20% of the relays in the main switching circuits of an exchange have one or other of these slow characteristics.

Although the circuit design is such that close timing is avoided wherever possible, each relay must conform nevertheless to definite maximum and minimum limits, which are recorded in order to enable circuit designers to know the capabilities of each design of relay at their disposal.

These limits have of necessity to be wide enough to cover all the variables encountered under normal commercial methods of production, but it is usual to take advantage of the residual screw to effect a control of the magnetic circuit, thus preventing relays from being passed out if they are near either maximum or minimum limit. This procedure necessitates the timing of all slow operate and slow release relays and the marking on the relay label of a figure representing the residual screw length found to be most suitable for that relay.

The timing of such large batches of relays represents an important item in the work of the test section of a relay department, and the choice of instrument to be used for the purpose is worthy of considerable thought.

There are many well known instruments which are used for measuring relay lags, but the majority of these are not suitable for workshop use. The oscillograph, of course, is for laboratory work only, and the various instruments using the ballistic galvanometer are comparatively slow and in addition require care in handling.

The ideal workshop relay timer must have robustness, be easy to operate, easy to read, readily portable, operate off standard battery voltage, and preferably consist of standard telephone equipment parts to ensure spares always being available.

The instrument developed by the Company for workshop use satisfies the foregoing conditions and has been found to require very little maintenance.

DESCRIPTION OF TIMER.

The timer makes use of a 100-cycle reed as a time base, the reed relay being a development of the 400-cycle busy tone relay used on P.A.X. switchboards. The reed operates a relief relay which has a contact output ratio of 50% make/break, and at the commencement of the period to be measured a contact of this relay drives a counting relay chain, the drive circuit being broken at the end of the period.

The relay chain consists of 5 pairs of counting relays, thus being able to register a maximum period of 50 milliseconds (m/s). Every complete cycle of the chain is registered by one step on a rotary line switch, the wipers of which control an indicator, advancing the reading by 50 m/s for each step. The intermediate indications between 0 and 50 m/s are controlled from contacts of the chain relays.

The indicator is of the stencil type, using standard switchboard lamps for illumination.

The control keys are of the lever type, and the circuit arrangements are such as to enable the timing of operate or release functions, and make or break actions of the relay under test.

In addition it is arranged that a relay may be released by a short circuit ; or series resistance and spark quench circuits may be added.

A general view of the timer is shown in Figure 1.

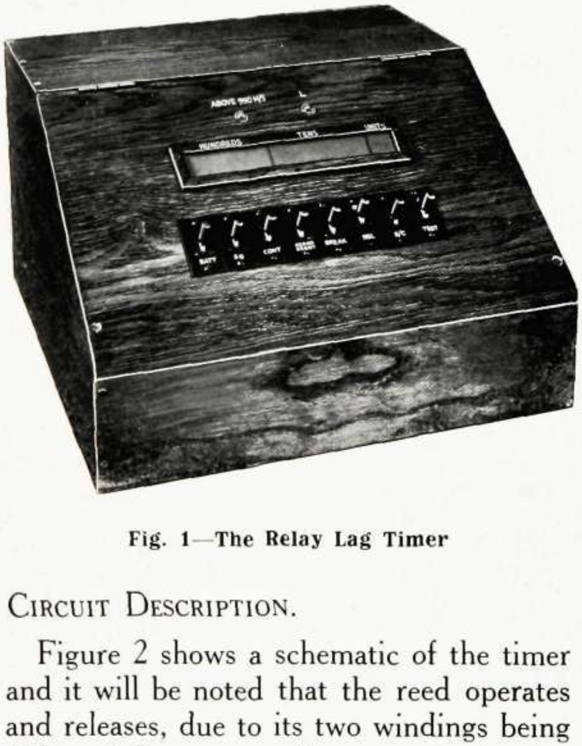


Fig. 1—The Relay Lag Timer

CIRCUIT DESCRIPTION.

Figure 2 shows a schematic of the timer and it will be noted that the reed operates and releases, due to its two windings being differentially connected, as soon as battery is connected via the battery key.

The reed controls relay RD, and contact RD2 controls the counting relays S, SA and A, AA etc., but the throwing of key TT determines when relay RD shall operate.

Assuming that an operate lag to a relay " make " contact is to be measured, key OP is thrown and a circuit is prepared for feeding current to the relay under test from R+ terminal, key SC normal (contacts 1 and 2), key OP operated, key SC normal (contacts 4 and 5) awaiting the closing of contact SA3. Negative potential is already on R– terminal.

When key TT is thrown, relay RD operates, followed by relay CX, which at CX1 completes the RD2 feed circuit to the counting relays. The first make of RD2 operates relay S, and the first break operates relay SA in series with S. After the operation of SA the period commences to be timed, for as mentioned above, the closing of contact SA3 completes the circuit of the relay under test.

Contact SA1 switches through the RD2 feed circuit to relay A which operates on the make period, relay AA operating on the break. Contact AA2 further extends the feed circuit to the B, BB relay pair, and so on until a period of 50 milliseconds has been counted, whereupon the cycle is repeated. The rapid release of each counting pair is ensured by the use of a " kick out " winding *c-d* in addition to disconnecting the operating winding *a-b*.

It will be noted that when key TT was thrown, bringing in relay CX, relay CY operated via AA3, when the first 10-millisecond period was marked off. The operation of CY steps the HU switch one step, and a similar movement of this switch takes place at every operation of relay AA.

Assuming the relay under test completes a circuit via its " make " contact in 80 milliseconds, relay SZ will operate via contact SA2, SZ201, key Rel. normal, key B normal, RC terminal, make contact of relay under test, to earth.

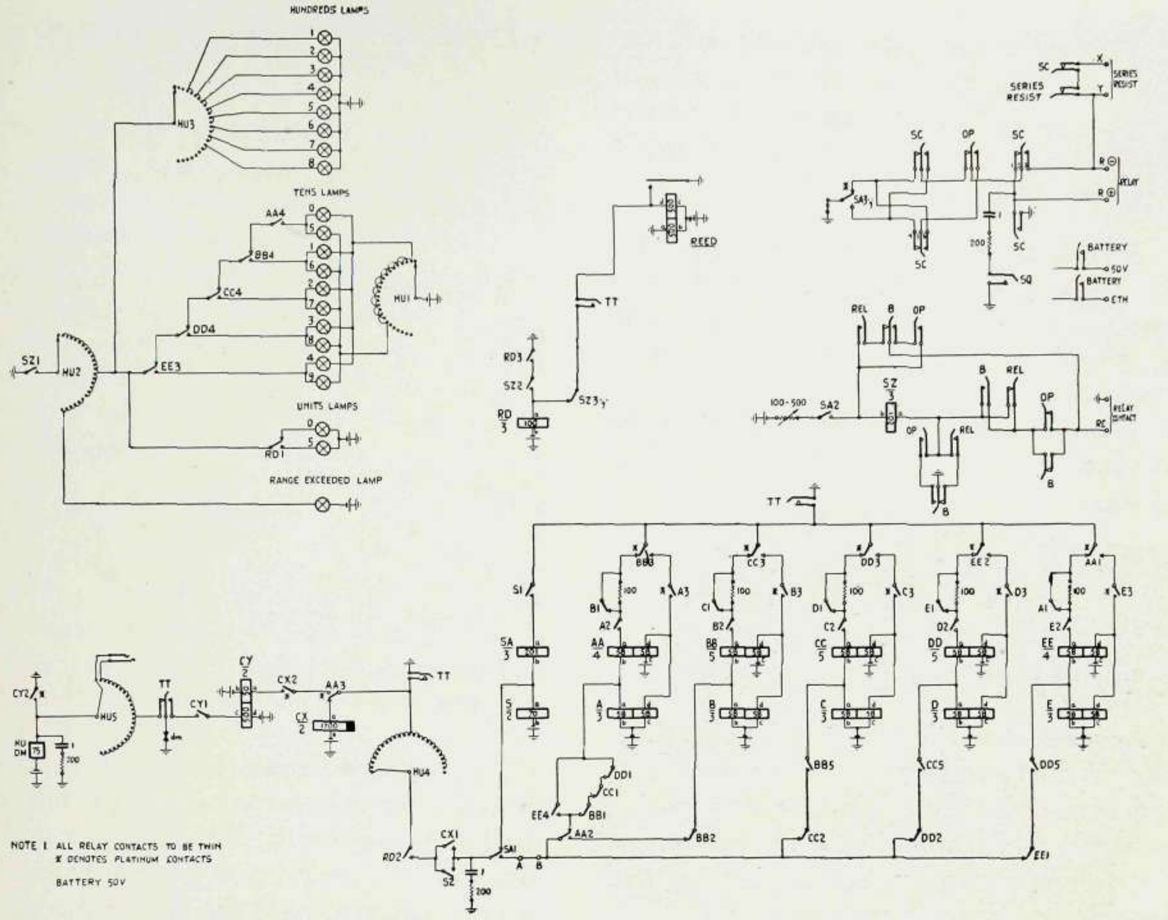


Fig. 2—Circuit of the Relay Lag Timer

The operation of SZ disconnects relay RD from the reed at SZ3, and at SZ1 completes the lamp display circuit. The lamp display will at this stage show the number of steps taken by the HU switch together with the particular pair of counting relays last operated by contact RD2.

It will be noted that the operate lag of relay SZ is added to the lag of the relay under test, and the former lag is controlled at 10 milliseconds, thus, the 80 milliseconds lag of the relay, plus 10 milliseconds for SZ is indicated by the fact that switch HU has taken two steps and relays D and DD are operated, showing 80 milliseconds on the display indicator.

If relay RD is operated at the instant SZ is brought in, RD is held, and the " 5 " units lamp glows, thus taking advantage of the fact that the operate and release of RD are two distinct five-millisecond periods.

In cases where a frequency controlled A.C. supply is available, it is convenient to use this as the time base and to take advantage of certain circuit simplifications resulting therefrom.

Many of these timers both A.C. and D.C. have been in use in the Company's relay departments for a number of years, and have proved a very satisfactory type for workshop use.

The Works Manufacturing Progress System

WHEN Ericsson Telephones Ltd. first entered the automatic telephone exchange field, the management soon realized that the amount of work involved, through the new project and the general development of telephone apparatus and equipment, would be so great that the existing method of piloting the work through the factory was totally inadequate, and that some other and more efficient means was necessary.

A new scheme was carefully worked out and, with inevitable modifications to suit changing circumstances, the original is still in use to-day.

Anyone who is in any way familiar with our products will agree that an enormous task confronted the originators in preparing a scheme which would effectively shepherd through the works the numerous and variable items we manufacture.

When it is realized that we make such widely different things as telephone exchanges and paint, totalisators and metallic powders, indicator systems and red lead, carrier current networks and time recorders, and that our telephones include intercommunicating systems, hotel and mining systems, small switchboards with four, six, twelve, twenty, forty, sixty, etc., lines, wall and table telephones of many designs ; that the orders received per month average 700, and that the orders placed on the works for making and assembling approximate 100,000 per year, it will be conceded that the progress and output system must be comprehensive and exacting.

The scheme commences to function immediately an order arrives at the factory. A " production card " is made out for each " F. order " i.e. an order from the sales department to make or supply. One

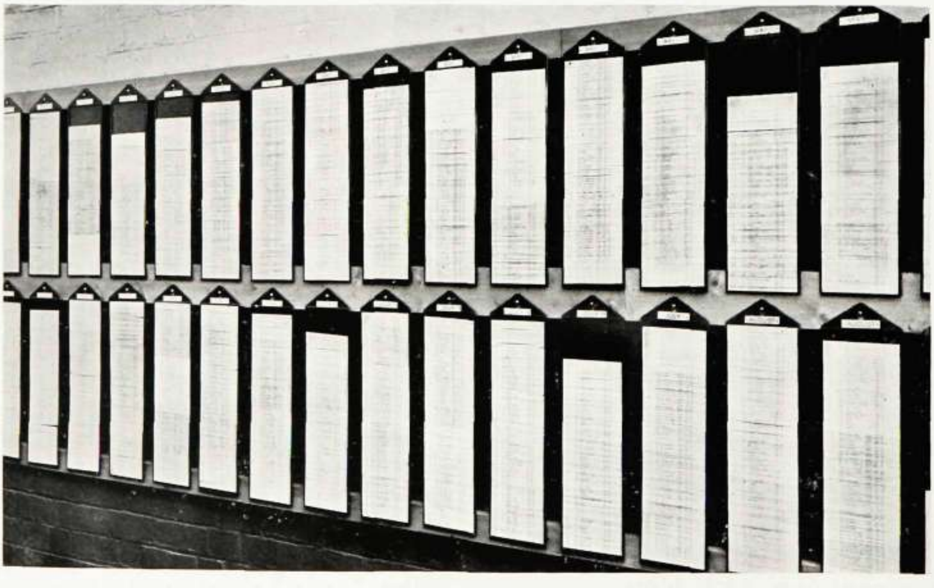


Fig. 1—The Progress Panels in the Wall

of the chief functions of the production card is to show the required weekly deliveries against the order. It gives the quantities and values required per week, the amount overdue if any and the accumulative total of deliveries. In addition to the production card data, two sets of statistics are compiled, a " weekly statement " and a " monthly report ".

The weekly statement deals with values only. It gives the total value of orders received during the week, the total value of deliveries posted and not posted on the production cards, the total value of orders in the shops at the beginning of the week, the total value of deliveries made during the week, the net value of orders in the factory, the total value of orders in the factory, the total value of orders closed, the total value of deliveries on closed orders, and the total deficiency on closed orders.

The monthly report deals with the orders in five groups, viz. :—Post Office (general and exchange), general (including totalisators), foreign (including those for the Crown Agents for the colonies), Australia and New Zealand, and stock. It gives particulars of the F. order numbers, the total quantity of items on the orders and their description, the quantity and value to be delivered per order during the month, the quantity and value per order outstanding (including the current month's delivery), the quantity and value overdue (if any), the works order number for each F. order item, and the date each order is closed.

On the walls of the progress office the " F " order number, and the quantity and description of each item on each " F " order, are displayed on narrow wooden strips in panels headed with the name of the month in which the items fall due. The panels are made up for several months ahead, and are continually being added to. The correct month for posting the strips is obtained from the production card for the " F " order. Figure 1 shows a general view of these panels and Figure 2 a " close-up ". As the items are completed, the strips are removed from the panels, the date entered in the monthly report, and the production card removed from the " live " file.

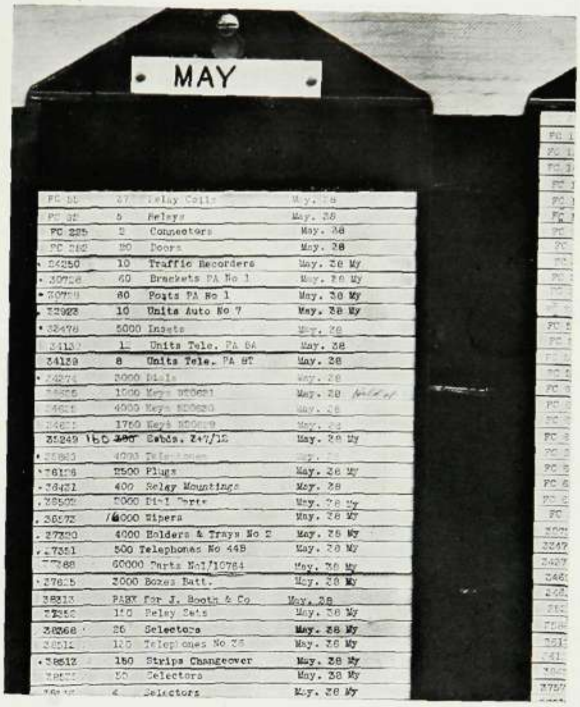
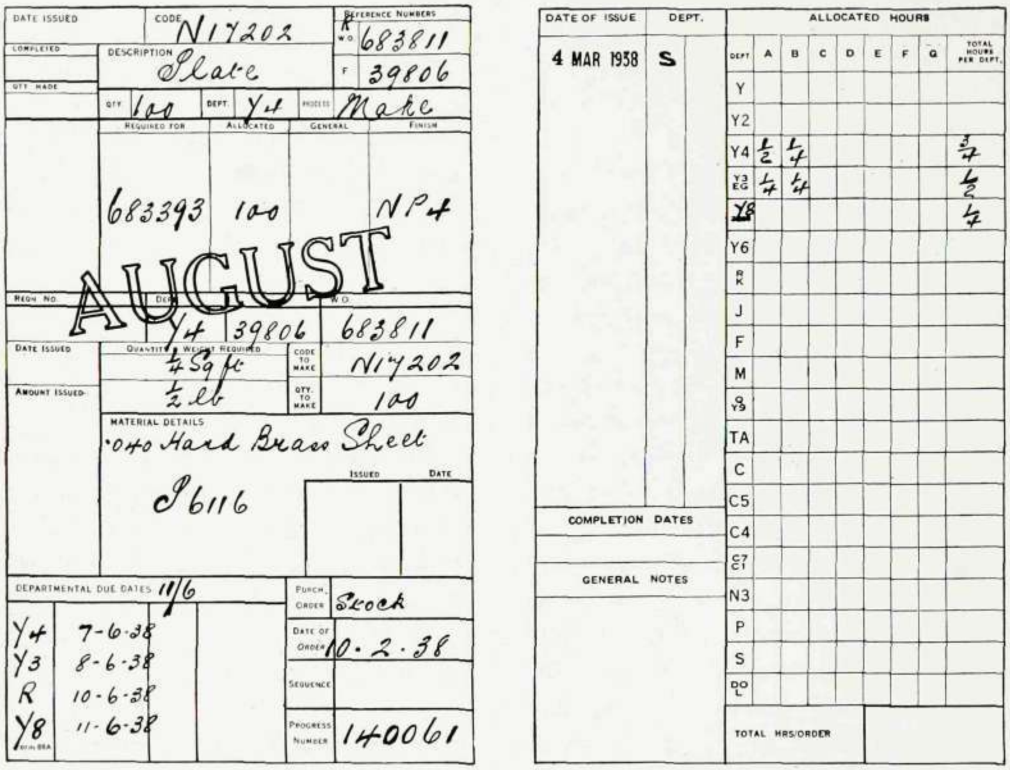


Fig. 2—Close-up of part of a Progress Wall-Panel

The various orders to make, assemble, provide, modify, etc., piece parts and assemblies in the shops are written out in the works order office (W.O.O.) The information is obtained from one of the following sources ; the " F " order, the " F " order circular (a more detailed list, giving codes, etc., not shown on the " F " order), or the shop specification. The latter is used chiefly for exchange work.



DATE ISSUED

CODE N17202

REFERENCE NUMBERS

W.O. 683811

F 39806

COMPLETED

DESCRIPTION Plate

QTY MADE

QTY 100 DEPT. Y4 PROCESS Make

REQUIRED FOR	ALLOCATED	GENERAL	FINISH
683393	100		NP4

AUGUST

REQN NO.	DE		W.O.
	Y4	39806	683811

DATE ISSUED

QUANTITY WEIGHT REQUIRED ¼ Sq ft

CODE TO MAKE N17202

AMOUNT ISSUED

½ lb

QTY. TO MAKE 100

MATERIAL DETAILS ·040 Hard Brass Sheet

P6116

ISSUED	DATE

DEPARTMENTAL DUE DATES 11/6

Y4	7-6-38
Y3	8-6-38
R	10-6-38
Y8	11-6-38

PURCH. ORDER Stock

DATE OF ORDER 10.2.38

SEQUENCE

PROGRESS NUMBER 140061

DATE OF ISSUE 4 MAR 1938

DEPT. S

COMPLETION DATES

GENERAL NOTES

ALLOCATED HOURS

DEPT	A	B	C	D	E	F	G	TOTAL HOURS PER DEPT.
Y								
Y2								
Y4	½	¼						¾
Y3 EG	¼	¼						½
Y8								¼
Y6								
R K								
J								
F								
M								
Q Y9								
TA								
C								
C5								
C4								
C7 C1								
N3								
P								
S								
DO L								
TOTAL HRS/ORDER								

Fig. 3—Front and Back of a Progress Slip (½ size)

A works order (W.O.) is made out for each main item on the "F" order, etc., and given a number in a particular series denoting that the item is to be delivered to the warehouse for shipping. These numbers are usually referred to by an imaginary letter code, "MA" in the case of exchange work, and "MI" in all others. Should any of the items be a stocklist item, a print of the stocklist is obtained, and a special form (No. 80) is pasted on it. The two together become a "material sheet". At the top of this sheet, the works order number, the "F" order number and the quantity required are given.

The material sheet has a number of columns which are filled in at various stages of its life in the factory. In the first case the quantity of the sub-items on the stocklist is put in the "quantity to make" column. The sheet is then sent to the general stores, where, if there is sufficient quantity of the required item in stock, the word "stock" is stamped in the column reserved for the "making" works order number. The sheet is then returned to the W.O.O. where orders in a different series to those for main items (MB or MC) are allotted to the remaining sub-items.

A works order consists of four main forms , 88A, 88B, 88C and 88D. The first one measures 8″ x 5″, whilst the other three are 5″ x 3″ in size, and each has a distinctive colour. Form 88A is really the official progress slip which subsequently goes to the works progress office and is illustrated in Figure 3, front and back. At the top of the slip are given, amongst other information, the code, drawing number, etc., of the item, its description, the W.O. number, the "F" order number, the quantity required, the department to which the work is allotted and the process it has to undergo. Form 88B is a duplication of the top portion of 88A. Copies in four different colours are made and circulated to various departments. Form 88C is the requisition for raw material, and form 88D is a duplicate of 88C and is for use in the machine shops.

Three copies of form 88A, the " progress slip ", are sent to the works progress department, one yellow, one red and one white. The slips which are for orders placed on the machine shops are immediately sent into the planning department to have the amount of time the work will take recorded on the back of the yellow slip. An example is shown in Figure 3 back. When the slips are returned, all those appertaining to one order are sorted and put into their correct sequence, according to the way in which they affect each other, and in which they should be placed on the factory. When this has been done, the slips are numbered consecutively (sequenced) to denote their order in the arrangement for future reference, and stamped with the name of the month in which they fall due. The range of sequence numbers is written on the F. order and entered in a register.

The next step is the important one of determining the dates when the actual work in the factory on each separate operation shall commence. In cases where the item to be made is a regular product, a chart is used which gives the relationship between the parts, and the time they normally take in their passage through the various departments. The delivery date is ascertained from the " F " order and is placed on the slip for the main item.

For items for which no plan charts are available the following dating procedure is used. The final date is obtained and placed on the slip. From a chart giving

Fig. 4—View of the Progress Office

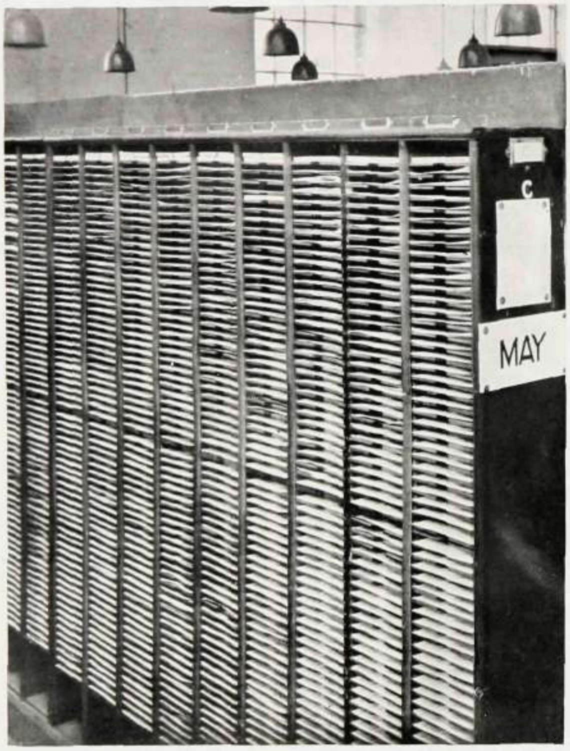


Fig. 5—Progress Slips for Orders when first placed in rack

particulars which have been arrived at by taking the known times of a large number of items and averaging them, the time required in the assembly shops is noted, and the commencing date for the final assembly is also written on the slip.

The particulars for piece parts, i.e., the manufactured as against the assembled parts, are derived from the times given on the backs of those slips which have previously been sent to the planning office. (These times, incidentally, are obtained from the factory piecework data).

After dating, the red and white copies of making order slips are sent to the general stores where the raw material, etc., is queried. Both slips are returned to the progress office, when the material is available.

The next step is to register the sequence number against the W.O. number, and, until the red and white slips are returned from stores, all the information for this and subsequent stages is obtained from the yellow slip. Registers for each type of works order (in numerical order) are kept.

The date when the work should be in the department is then entered in a diary. Every day this diary is inspected, and the appropriate orders are issued to the section controlling the loading of certain key departments. The capacity of these departments in man-hours is known, and the amount of time for each order placed in the departments is entered on a card.

Normally, by this time the red and white slips have been returned from the stores, and the three slips are now ready for the time when they are to be issued.

At one end of the progress department sixteen racks containing approximately 35,000 pigeon holes are situated. (Figure 4). On each of certain of these racks the name of a month appears, and all orders other than stock orders are placed in these racks according to the name of the month stamped on the orders.

Certain pieces of equipment which are standard in themselves, e.g. banks, protectors, fuses and fuse mountings, and 3000 type relay parts, but which vary in quantity per order, are arranged to flow in a regular manner to avoid undesirable peaks in shop loading. This method has been found particularly useful during the recent period of intense activity.

When the time arrives for the work to be issued, the yellow slip is sent to the department concerned, and the white slip is placed in a dated pigeon hole in the departmental progress rack corresponding to the due date of the first department. The red slip remains in the main rack.

The departmental progress rack is in the works progress office and is similar in construction to the main progress rack. It is the one on the right in Figure 4. A series of pigeon holes is allocated to each department in the factory. Each pigeon hole bears a number ranging from 1 to 31 (days), and at the top of each sub-division the name of the month appears. The object of the rack is to enable anyone to see at a glance the number of orders due from any department on any particular day, and to see how many orders are overdue.

As the work is completed in the departments, the yellow slip is returned by the shops to the progress office for transfer to the next department or, when no more work is to be done on that order, for the completion of the order to be posted in the works order register.

The progress of the work through the factory is watched from the main racks, and on the top of each of these, three works exchange lines and two direct lines to the stores are terminated on switchboard jacks. Several operators equipped with headsets are continually examining the red slips, and when one shows an overdue date the department concerned is queried to ascertain the reason and, if possible, to clear the trouble and to accelerate the speed of the output.

Figure 5 gives a close up view of the progress slips for orders waiting in the main rack for the starting date, and Figure 6 shows the same orders nearing completion. The large decrease in number, and their worn appearance testifies to the use made of them.

Fig. 6—The Same Orders as in Fig. 5 nearing completion

The majority of orders are adequately controlled by this method of superintendence, but special cases arise which have to be treated individually. For this purpose specially trained experts are employed to watch their progress through the factory.

In dealing with a subject with such far-reaching activities, it is impossible to cover all of them in one article. Such organizations as stock and store-keeping, engineering layouts and purchasing procedures all affect the system, but no doubt sufficient has been written to show some of the many problems involved in piloting work through the factory.

New Projects

SOME time ago the directors of Ericsson Telephones Ltd. decided to expand the scope of manufacture to include two entirely new projects, namely, the production of a highly dispersive red lead and of high grade metallic powders. The Company has obtained the sole rights for the British Empire, under strong patents, for the manufacture and sale of these highly specialized and valuable processes. Whilst seemingly at variance with our normal telephone production they form a very appropriate expansion of our enamel and varnish manufacturing business which, established 10 years ago, has proved such a success.

Both projects are now approaching the production stage and it is felt that some details of the new red lead material (which is referred to herein as "Vaprolite") might be given in the present issue, by means of the summary of a lecture recently given by a member of the Company's staff before paint manufacturers and research chemists and which has been widely published in various technical journals.

A subsidiary company under the name Micro-Lead Products (Ericsson) Ltd. has been formed to handle the manufacture and sale of red lead, litharge, pure lead, etc., under the Vaprolite process, and suitable agencies arranged.

VAPROLITE RED LEAD.

The recent report of the Corrosion Committee (4th Report 1936 Iron and Steel Institute) has directed much attention to the outstanding merit of red lead as a rust-inhibiting pigment, for paints used as primers. Scientific tests have endorsed the experiences gained from the centuries-old usage of this pigment for the protection of ferrous materials used in civil and marine constructional work. The confidence placed in the efficiency of red lead for this purpose has been demonstrated by the large proportion of costly and important steel structures, for the painting of which, this type of material is specified.

Much research has also been devoted to the behaviour of different painting schedules, and whilst difficult to generalise, it would appear that after the removal of the mill scale a red lead priming coat, followed by subsequent coats of iron oxide base paint, form a protective finish of a very high order. Very satisfactory results have been obtained using an aluminium paint finishing coat in addition.

When red lead manufactured by the earlier methods was used in paint form, it possessed two marked disadvantages, namely :—

1. Comparatively large particle size, resulting in low covering power, rapid settling rate and general difficulty in application.
2. Low chemical purity as regards Pb_3O_4 content, the pigment containing a high proportion of the monoxide, litharge. Due to the reaction between the PbO and the linseed oil, fairly rapid setting takes place and results in a gel formation. Such paints must be used within a short period after mixing as they become almost unusable after a few days.

Developments in the manufacture of red lead for painting purposes have therefore had two main objects in view, namely, the reduction of particle size, and the increase in chemical purity so that the litharge content is small. Such pigments have been produced successfully for some years under the name of "non-setting" red leads, which have resulted in ready mixed pastes and paints becoming a practicable proposition. The properties of these pigments are widely appreciated and understood, being covered by official specifications, such as that issued by the British Standards Institution, No. 217.

Notwithstanding the progress which has been made, research workers have continued their efforts to produce a red lead which has even finer particle size with further increased covering power and facility in storage and use. Such red leads are often referred to as the 'highly dispersed' type. Various methods have been proposed or used in order to obtain this increased fineness of division such as :—

1. The mechanical agitation of the molten lead during oxidization.
2. The use of air and steam jets playing on or through the molten lead, or directed against a thin stream of molten lead to obtain atomization of the metal.
3. The use of mechanical grinding arrangements simultaneously with the heating.
4. By vaporization of lead in a high-temperature furnace, whence the volatilized metal is oxidized under controlled conditions.
5. By electrolytic processes.
6. By treatment of fine-grade lead carbonate.

Dr. R. Maier and his associates have succeeded in producing, on a commercial scale, a new red lead which possesses remarkable properties, and arrangements for the manufacture of the material in this country have been completed by the subsidiary company Micro-Lead Products (Ericsson) Ltd., and there is no doubt that the product will form a very useful contribution to the solution of some of the paint makers problems in connection with red lead paints.

In simple principle the "Vaprolite" process consists in vapourizing lead in an electric arc furnace, the finely divided particles being introduced into a large chamber. Here, under controlled conditions of temperature and with a special circulating system, the metal is converted into red lead in the presence of oxygen. By varying the temperatures and quantity of oxygen present, red lead containing any desired proportions of litharge can be obtained, but the main object of the process is the manufacture of the practically pure tetroxide with low monoxide content, specially suitable for the manufacture of paints.

THE PROCESS.

Pig lead is introduced into an electric melting furnace where, by automatic control, it is maintained in a suitable molten condition. From here it is fed at a constant rate through pipes, heated to the same temperature as the melting furnace, into a main vapourizing furnace. The latter is of special design, and is heated to a very high temperature by means of a three-phase carbon arc which vapourizes the molten lead as it enters the furnace. The vapourized metal is drawn, by means of fans, into a large precipitation chamber, where it comes into contact with the oxygen. The chamber is jacketed, and is heated to the required temperature by hot gases produced in a separate gas burner. Thus, combination between the lead and oxygen takes place under controlled temperature conditions. During the reaction the lead oxides are circulated vigorously by a powerful fan and arrangements are provided for regular tests which are taken to ensure that the apparatus is regulated to give the desired composition. The red lead is finally passed into the lower half of the precipitation vessel, where the pigment settles so that it can be removed and packed by worm conveyor.

It will be appreciated that the accurate control of temperatures, rates of flow and pressures are essential features to successful operation of this type of plant. An elaborate system of pyrometer and other electrical devices has been incorporated to ensure that constant and the optimum conditions prevail, at each stage of the process.

The pure oxygen required for the reaction is manufactured by a special plant, which is located in an adjoining building. Here, air is drawn from the atmosphere through a stand pipe by moderate suction produced by a rotary blower.

The air is then passed through two washing towers in tandem. A constant stream of caustic potash solution descends from sprayers at the top of the towers, through iron rings to the base, so that the incoming air is freed from carbon dioxide by contact with the large surface of alkaline solution, which is constantly circulated by means of pumps. The purified air then enters the inlet side of a three stage compressor where a pressure of 50 to 60 atmospheres is attained.

To separate the air into oxygen and nitrogen under normal running conditions, the compressed air enters the first heat exchanger, which consists of two similar sections. These perform two functions. Firstly the incoming compressed air is cooled to about—60°C, by the copper tubes through which it passes being entwined with those conveying the outgoing oxygen and nitrogen, which are at a very low temperature—incidentally, the oxygen and nitrogen thus become warmed so that they leave the apparatus at approximately atmospheric temperature. Secondly, the moisture present in the compressed air is frozen and deposited in the tubes where defrosting is carried out.

At this stage the highly compressed air has been reduced, by heat exchange, to a temperature which is sufficiently low to permit liquefaction to take place, namely about —145°C.

This liquefaction occurs in the medium pressure air liquefier where both sources of compressed air are passed through nozzles, to expand considerably down to a much lower pressure of 5 atmospheres. The temperature becomes reduced appreciably to about —180°C. according to the well known Joule-Thomson effect, that is, loss of temperature due to internal work expended in free expansion of a gas. The air at this temperature liquefies in a mist form, condenses on the baffle plates and collects at the bottom. This liquid is rich in oxygen (about 50%) as the more volatile nitrogen ascends to the top of the chamber, where it passes over a coil through which liquid oxygen from the rectifier flows and, in addition, a series of tubes actually pass up into the liquid oxygen. The rich nitrogen vapours are thereby condensed and are collected in an annular trough.

The oxygen and nitrogen-rich liquids are next passed into the rectifying section at about atmospheric pressure where they trickle downwards over a series of baffle plates. Nitrogen, being more volatile, evaporates more rapidly, and in so doing absorbs latent heat from the liquid gases, lowers the temperature of the liquid as it travels downwards so that practically pure (95%) liquid oxygen collects at the bottom of the rectifying section, while gaseous nitrogen ascends to the top. The return path of the nitrogen gas is through the second and first heat exchangers where it cools the incoming compressed air, as previously described, being finally returned to the atmosphere at approximately normal temperature and pressure. The liquid oxygen from the base passes through a spiral coil where it is evaporated, while cooling the nitrogen gas which surrounds it in the liquefying section. The oxygen gas passes through the second and first heat exchangers in a similar manner to the nitrogen, and on leaving the apparatus is stored in a gasometer.

The main features claimed for this direct process of manufacturing red lead are :—

1. The continuous introduction of raw material into a highly heated furnace, at a rate suited to the volatilizing capabilities of the furnace, and vapourization of the metal by allowing it to drip on to a heated surface, under conditions giving rise to what is known as the ' Leidenfrost ' effect. (This effect is similar to that given when drops of water are allowed to fall on a hot plate. The liquid drops are carried by a surrounding envelope of vapour and evaporation is completed with almost explosive violence when the heat penetrates the vapour into the liquid).
2. The provision of additional heating surfaces in those parts of the furnace in contact with the gases.
3. The use of an electric arc furnace having a heated hearth so that the required temperature may be attained, independent from the introduction of metal, which volatilizes immediately on entering the furnace, and this is ensured by introducing the lead at a suitable rate. An effect results similar to that with superheated steam which contains no suspended particles of water and is termed ' dry '. Volatilized lead in this condition produces, upon precipitation, a very pure and finely divided oxide.

The process can be arranged for the production not only of pure red lead, Pb_3O_4, but of litharge, PbO, and intermediate grades of the highly dispersed type. If inert gas is substituted for oxygen, finely divided metallic lead can be produced and this is applicable, also, to other metals.

Technical Properties of Vaprolite Process Red Lead.

The microscopic appearance of the vaprolite pigment taken at a magnification of 1,200 diameters shows that the lead oxide consists of a proportion of very small particles, in the order of 1·5 mu diameter, together with a proportion of large conglomerates 10mu diameter, which are comprised from a number of small particles forming a type of crystal aggregate.

A similar micrograph of non-setting red lead, complying with B.S.I. Specification 217, shows a predominance of particles in the order of 6 mu, and which are more solid in appearance and only a small proportion would seem to be built up of a number of smaller particles. Ordinary red lead to B.S.I. Specification 217 shows much larger particles, which are in the order of 15 to 20 mu.

The main point of importance to the paint manufacturer is how these pigments behave when ground with a vehicle under normal conditions. Quite obviously, the initial size of the conglomerates is relatively unimportant, provided that they divide and disperse readily in the vehicle when processed with commercial equipment.

Micrographs of various materials, in paint form, show how the pigments behave when ground in oil. In order to obtain a broader impression of the effect, the magnification is reduced to 720 diameters.

Vaprolite red lead, ground in paste form in raw linseed oil for 30 minutes in a modern edge runner mill shows extremely uniform particle size of diameter 1·5 mu and less, and the absence of any more than 1·5 mu in diameter is apparent. The conglomerates have divided up and the individual particles of which they were composed have dispersed uniformly in the oil. When ground under the same conditions but passed through a granite triple roll mill a small improvement in dispersion is noticeable but it is evident that the main division of the conglomerates occurs readily with simple grinding methods. It is thus concluded that in vaprolite red lead, any apparent large particles result from a light coalescence of smaller ones which form a group.

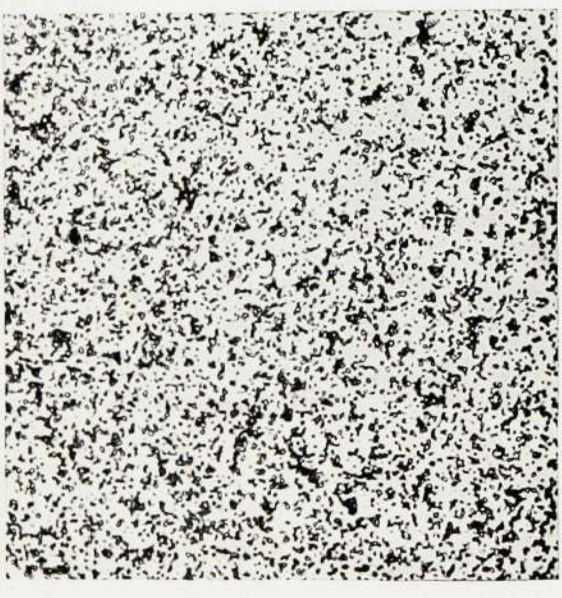


Fig. 1—Vaprolite Pigment x750

To get further comparisons, the pigments already referred to were ground in 9 : 1 pigment oil ratio, through a triple roll mill, and in order to obtain an indication of the effect of prolonged grinding, the pastes were passed through the mill four times, using a constant setting. The final effect, when examined microscopically, is seen in Figure 1 which shows the extremely small and well dispersed particles of vaprolite pigment under these conditions at 750 magnifications. Figure 2 is a similar micrograph of ordinary red lead, to B.S.I. Specification. The prolonged grinding has had little effect on the larger sized particles, and similar results were observed with the non-setting red lead.

It will therefore be seen that although the vaprolite red lead has high original average fineness, the advantage shown in this respect is even more marked after grinding, because of the constitution of the larger particles. It should be noted that the sieve test is no indication of average fineness of red lead made by vapourization methods. The tendency is for about 1% of the pigment to remain on a 240-mesh sieve owing to the lightly adhering particles tending to form conglomerates. The micrographs indicate that coarse particle tests should be carried out after pigment dispersion, by commercial methods.

This point may be investigated further by X-ray examination, for example, vaprolite red lead giving ·8% residue on 240-mesh sieve was examined in this manner together with non-setting red lead giving ·16% residue on the same sieve. The X-ray diffraction patterns indicate that the characteristics of the diagrams are the same and the number of interference lines are equal in position, widths and relative distances, showing that the chemical constituents of the two materials are the same.

The spots however indicated that in the case of the non-setting grade there are a large number of particles which are greater than 10 mu whereas these are not apparent in the case of the vaprolite product. X-ray rotation diffraction patterns would not, of course, indicate a conglomerate of small particles. The great importance of particle size in relation to other properties of red lead will be seen from the following :—

DRY BULK

In the dry powder form, the very low relative weight of a given volume of vaprolite red lead forms a striking illustration of its fineness of subdivision. This results not only from the small average particle size but also from the orientation of the particles forming the larger aggregates, as illustrated clearly in the micrographs. The weight per 100 ml. of vaprolite powder varies from 105-150 grammes, that is, an apparent dry density of 1·05 to 1·5. This variation results from the proportion of fine particle aggregates which are present and has no relation to the average particle size. Normal B.S.I. red leads weigh about 300 grammes per 100 ml. that is, an apparent dry density of approximately 3, and the volumes occupied by 75 grammes of the two individual pigments are 50 ml. and 25 ml. respectively.

The practical importance of this feature of the highly dispersed red lead is, mainly, as a simple indication of the very fine particle size. High dry bulk may be regarded as a measure, though not a direct one, of the settling properties of the pigment when in paint form.

BULKING VALUE.

When ground or mixed with liquid, the bulking value of vaprolite is normal, that is, it possesses the true specific gravity for Pb_3O_4. Similar weights of red lead and oil yield the same final volume, regardless of subdivision, according to simple principles of physics. Mixtures of 30 grammes of red lead and 46 ml. of water using vaprolite pigment and B.S.I. standard non-setting quality, show that both yield a total volume of 50 ml. Thus 30 grammes of red lead occupies a volume nearly equal to that of 4 grammes of water, its specific gravity therefore being approximately 9·0.

It will be noted however that, even when wet the high bulk of the dispersed quality is marked. The apparent volume occupied by the pigment after settling is 22 ml. as compared with 12 ml. for the non-setting material, corresponding to apparent bulk densities of 1·36 and 2·5, which is of a similar order to that when in the dry form.

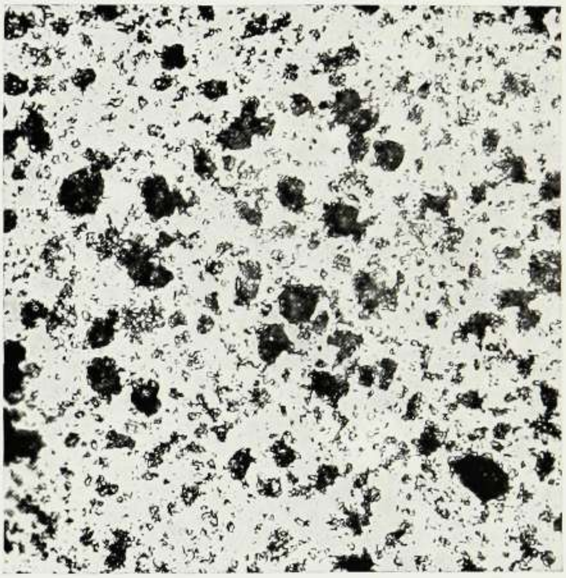


Fig. 2—Ordinary Red Lead Pigment x750

In order to determine whether this ratio is maintained after grinding to ensure dispersion of particles forming conglomerates, similar tests have been carried out with fully ground samples in various media. It was established definitely, that the ratio was at least maintained, for example, known weights of pigment ground in oil were diluted with benzine to ensure rapid settling in a low viscosity medium, and it was confirmed that similar results were obtained whether the pigments were ground or simply mixed in the vehicle.

COLOUR.

The colour of vaprolite is rather more orange in cast than normal red lead.

Lovibond tintometer analyses of dry samples are as follows :—

	Orange	Red	Yellow	Brighter than Standard
Vaprolite ..	13·3	—	·7	1·4
B.S.I. Non Setting	14·0	·3	—	1·4
B.S.I. Ordinary ..	9·0	5·1	—	1·2

These differences in colour values are not an important consideration, commercially, seeing that red leads are used chiefly as inhibitive priming coats, or are tinted to desired shades. It is generally accepted that coarser red leads incline more to the red shades, but this cannot be regarded as an entirely reliable indication of particle size.

CHEMICAL COMPOSITION.

It will be appreciated that red lead manufactured by direct combination between the metal and oxygen should be capable of being produced in a very pure state. The vaprolite process employs electrical heating so that there is no danger of contamination by products of combustion and no auxiliary heating devices are introduced in which the lead oxide comes into contact with gas other than pure oxygen.

The impurities present therefore depend on the quality of the lead used. The empire produced metal to be used for the vaprolite process in this country has the following typical analysis :

Lead ..	99·99236
Bismuth ..	·00004%
Silver ..	·00050%
Copper ..	·00070%
Antimony ..	·00260%
Tin ..	·00110%
Arsenic ..	·00070%
Zinc ..	·00100%
Iron ..	·00100%

The minute amounts of impurities are present, in similar quantities after the lead is converted into the oxides.

The proportion of free litharge in vaprolite red lead is low and complies with B.S.I. Specification 217 in this respect. The Pb_3O_4 content, estimated from the PbO_2 analysis by standard methods, is 97-98% as compared with minimum 93·15% which is specified. Analyses are taken regularly, during manufacture, to ensure that the high tetroxide content is maintained and that the process gives great uniformity in composition.

TECHNICAL PROPERTIES IN PAINT FORM.

Fine particle size and ease of dispersion in simple media are pigment characteristics which are the main objectives of the colour manufacturer. These properties are widely appreciated by those concerned with the production of paints and much progress has occurred in the general conception of pigment dispersion as distinct from grinding. Red lead has high specific gravity, compared with the majority of other pigments and the importance of its particle size in paint and paste form is therefore specially marked. The micrographs have shown the fine state of vaprolite pigment and the excellent dispersions which result. It will be seen from the tests which are to be described that the effect of these features is so marked that an entirely new product results, as distinct from a normal technical improvement. The differences are for the most part such that they can be detected readily by visual or other elementary means.

Covering Power.

The covering or hiding power of paint is generally determined with practical trials by measuring the amount of material necessary to give a coating of certain obscuring value, over a definite area. The conditions of application and the type of surface usually give slightly varying results.

Two typical tests which were adopted clearly demonstrate the increased hiding power of vaprolite.

(*a*) *By brushing*—Sheets of black fibre were prepared having areas of 4, 8, 16 and 24 square inches. Sets of these were coated uniformly with red lead paints by brush. Each sample of paint consisted of 1 lb. of pigment to 6 oz. of raw linseed oil, triple roll mill ground. One gramme was applied in each case, measured by increase in weight of the specimen.

After drying, the specimens were examined by three observers, independently, and it was agreed that vaprolite material gave a minimum 50% increased hiding power, as compared with non-setting red lead to B.S.I. specification—for example, the 24 sq. inch. vaprolite specimen was matched against the 16 sq. inch. ordinary specimen.

(*b*) *By spraying*—Draughtboard hiding power charts were sprayed with red lead paints of similar proportion and the increases of weight were noted. The charts were sprayed with light and heavy coatings, using vaprolite and non-setting red lead to B.S.I. specification, triple roll mill ground in the proportion 2 parts pigment to 1 part raw linseed oil, by weight. In the series of charts examined it was seen that—

3·2 gms. sq. ft. vaprolite fully equals 5·8 gms. sq. ft. non-setting ;

5·97 gms. sq. ft. vaprolite barely equals 15·43 gms. sq. ft. non-setting ;

13·63 gms. sq. ft. vaprolite fully equals 26·50 gms. sq. ft. non-setting.

The pattern was fully obscured with 13·63 gms. sq. ft. of vaprolite whereas at 26·5 gms. sq. ft. the non-setting permits the dark squares to be faintly discernable.

Therefore it is apparent that by the more even application of the pigment by spray, vaprolite material has twice the hiding power of non-setting red lead, as supplied to standard specification. Prolonged grinding in paint form has little or no effect on this ratio and confirms microscopic observations, that particle size reduction cannot be obtained by ordinary methods of paint grinding. The increased hiding power ratio was maintained when comparative tests were carried out on a variety of metal, wood and other surfaces.

Tinting Strength.

Paints made from mixtures of white and red lead are recommended and used for certain purposes and here the fine particle size of vaprolite material is further illustrated by higher staining power.

When 5 parts each of vaprolite and non-setting red lead were ground with twenty parts of white lead paste under equal conditions, the following tintometer values were observed—

	Orange	Red	Yellow	Brighter than Standard
White Lead—Vaprolite	10	—	1	1
White Lead—Non Setting ..	6	2·6	—	1

It will therefore be seen that the highly dispersed pigment has about 30% greater tinting strength.

Settling Rate.

Lead oxide pigments possess a relatively fast settling rate on account of their high density. The methods which may be adopted to improve red lead paints in this respect are either to incorporate suspending agents or to attain well dispersed pigment of fine particle size. This latter course is naturally to be preferred in order to maintain purity and composition. Most paint specifications require pure red lead, free from admixture, apart from the oil, driers and volatile solvent. As a simple test, paints were produced with ratio 1 lb. pigment to 6 oz. raw linseed oil and after grinding, they were passed through a single roll mill to ensure favourable test conditions. Tubes were filled to a height of 15 cms. with the paints produced. The length of the column of clear, pigment free oil which appeared at the surface, was measured from time to time. Typical results observed were :—

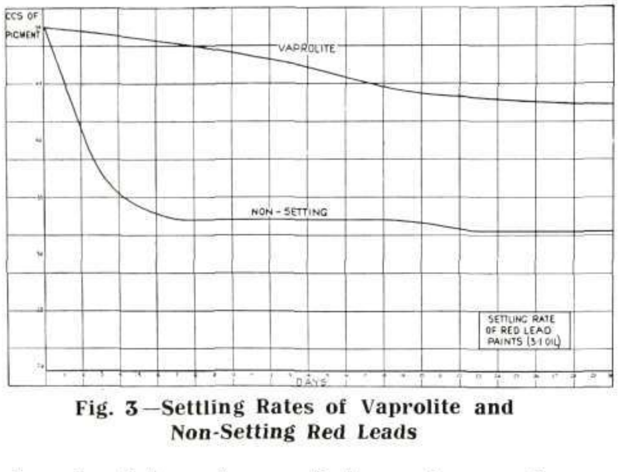


Fig. 3—Settling Rates of Vaprolite and Non-Setting Red Leads

	After 2 days.	After 5 days.
Vaprolite ..	Not measurable.	0·2 cms.
B.S.I. Non-Setting	1·4 cms.	5·0 cms.
B.S.I. Ordinary ..	2·7 cms.	7·5 cms.

Figure 3 illustrates a further test on paints made in 3 : 1, pigment : raw oil ratio by weight. The curve shows the level to which the pigments sink over a period of thirty days on 50 c.c. samples. The paints were again ground, in bulk, in a triple roll mill followed by single roll mill finishing and comparisons are between vaprolite and non-setting red lead.

It will be seen that in the case of ordinary non-setting pigment, a total of about 33% of the paint has become pigment-free within seven days whereas the vaprolite paint shows 4% of clear oil only. The level after one month is practically stable, the readings being :—

Vaprolite ..	6½ ccs. clear oil.	43½ ccs. pigmented.
Non-Setting	18 ccs. clear oil.	32 ccs. pigmented.

Figure 4 shows the condition of the samples at the end of the test. The ratio of the apparent bulk occupied by the dispersed pigment, after settling, is thus about 1·4 times higher for the new product, than for ordinary red lead.

Similar settling test using 2 : 1, pigment : oil ratio paint, showed that after 31 days the comparison was maintained, pigments having settled to a level of 29 ccs. vaprolite, 19 ccs. non-setting grade. The tests were extended to other proportions and similar results were shown.

Finely divided and well dispersed pigments produce paints which are higher in viscosity and this results in slower settling rates. The marked superiority of the new material in both settling rate and final settling volume is due to the excellent dispersions obtained from its manufacture into paint under ordinary conditions.

NON-SETTING PROPERTIES.

It is established that the setting and thickening properties of red-lead linseed-oil paints are due to the reaction which takes place between the lead monoxide present and the oil. Lead soaps are formed which in a short period render the paint useless owing to the hardness which develops in the thickened mass. Research workers including Kinscher, Ragg and Lederer have investigated this problem. It was found that with red leads containing more than $5 \cdot 4\%$ of free monoxide, litharge, that the setting rate was rapid and marked. This figure is now regarded as being the intermediate proportion between red leads of the setting and non-setting types. B.S.I. specification requires a minimum PbO_2 equivalent of $32 \cdot 5\%$, corresponding to a Pb_3O_4 content of $93 \cdot 15\%$. Vaprolite red lead, as previously stated, gives a considerably higher figure than this but other processes also yield similar results.

It is difficult to produce coarse red leads with low free litharge content owing to the difficulty in completely oxidizing the large particles. In fact, fine particle size in the order of 2-6 mu would appear to be essential for the production of high grade non-setting red leads. H. Grohn refers to the difficulty in reducing the free monoxide content in a red lead having particle size 5-15 mu whereas with a 2-6 mu type, a Pb_3O_4 content of $98 \cdot 5\%$ was obtained.

Chemical analysis however, is not regarded as the only factor in determining non-setting properties. Other research workers have proved that the size and shape of the particles are important factors, so that, two red leads of equal low litharge content do not necessarily exhibit the same degree of non-setting properties. This is specially marked in the case of vaprolite red lead where the extremely small spherical particles, produced without grinding during manufacture, yield very stable results over long storage period. In addition the low settling rate and high apparent bulk which are due to the dispersion of the vaprolite pigment result in the accentuation of its non-setting properties. Paints from this material may be stored under normal conditions for periods of over 12 months, after which they can be readily remixed by hand to a condition hardly distinguishable from freshly ground paint.

Another indication of the effect of dispersion on storage can be obtained by comparing paints which are mixed ; with others which are well ground. For example a 6 : 1 paste made from vaprolite pigment and raw linseed oil by mixing, will oxidize very rapidly at the surface when stored in a half filled container, so that a heavy skin of oil is formed within a week or two. On the other hand when the pigment is ground in the oil and observed under similar conditions it will remain free from surface skinning for several weeks.

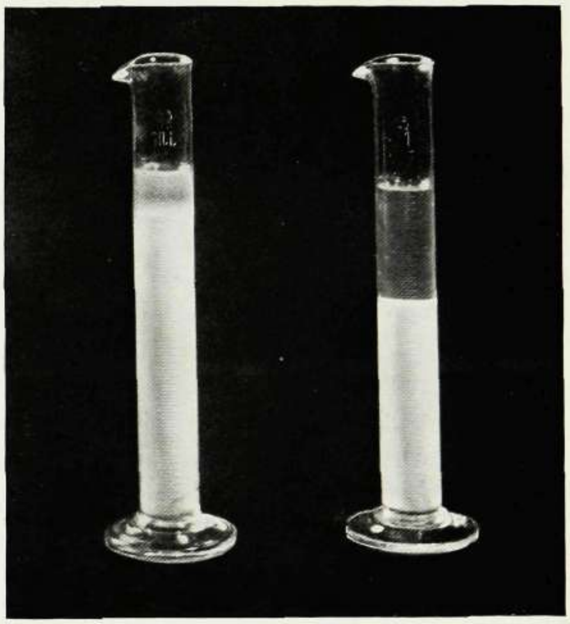


Fig. 4—The Test Tubes at the end of the Test for Fig. 3

Highly dispersed pigments give increased oil absorption and this is marked in the case of vaprolite. Tested by the B.S. 217 method in which the pigment and oil are pasted until a coherent mass is obtained, the new process pigment requires approximately 15% by weight whereas normal red leads will mostly require oil in the order of $8\text{-}11\%$. When the oil is incorporated mechanically so that the pigment is well dispersed, vaprolite will give a much lower absorption figure and a stiff paste is formed with as little as 6% of raw linseed oil. This is due to the breaking up of the particles forming nuclei.

The improvement in settling and non-setting properties result in a type of red lead paint being available which can be stored in a manner similar to ordinary pigments over long periods, ground ready for use in oil. The high covering power and fineness gives great ease of application with a finish of excellent appearance. Frequent stirring is not necessary because of the long suspension period and even after several months, the product may be hand stirred with an ease that is a definite characteristic. Exporters and overseas stockists of red lead paints find these aspects to be specially advantageous.

The drying time of the paint is a little faster than normal owing to the increased hardness given to the oil film by the larger surface of pigment exposed. Freedom from large particles results in pigment continuity. When conditions permit spray application the fullest advantage is gained from the unique suspension and covering power.

PASTES.

In considering the most suitable proportion of pigment to oil, the storage period and purpose of the product should be taken into account. The highly dispersed red lead forms pastes with raw linseed oil which are very stable, and simple to mix with additional oil. In this form the product is more convenient to handle than by pigments in the dry form.

Experience has shown that the following range meets most of the conditions normally required.

Paste. 12 pigment : 1 raw linseed oil, edge runner mill ground. This is suitable for supply to paint makers who intend to use the product for the manufacture of ready mixed red lead paints. The paste can be hand mixed for a period of up to three months, but machine mixing may be necessary after this period as the product stiffens somewhat in time.

Paste. 9 pigment : 1 raw linseed oil. This is the recommended proportion for paste intended for long storage periods of 6-12 months and which may be mixed or thinned by simple hand stirring.

When the proportion of pigment is reduced to 6 : 1 ratio, an oil layer gradually forms on the surface but this is relatively small in proportion. This type is recommended for shipment to tropical countries where storage conditions are adverse and uncertain periods may elapse prior to use.

PROTECTIVE VALUE AGAINST CORROSION.

The most important property of red lead in paint form is its function as a protective priming coat for ferrous structures. It cannot be regarded as a pigment having great decorative value.

Authoritative reports which include details of tests on red lead paints, showing their comparative value for the prevention of rust, have definitely established the outstanding merit of this pigment. The 4th report of the Corrosion Committee and the 15th report of the committee of the Institution of Civil Engineers are comprehensive publications which are valuable sources of reference. The superior results given by the finer non-setting red leads, as compared with coarser varieties, have been proved by numerous tests, of which, the A.S.T.M. Havre de Grace bridge-test is one of the best and most widely accepted.

It is therefore established that the pigments composed of a large proportion of particles of about 1·5-2 mu diameter have better protective value. The larger surface of pigment results in greater uniformity, opacity and improvement of the properties of the film produced with the linseed oil. The protected surface is more completely in contact with the particles of red lead and the danger of weak or exposed spots is avoided.

Red lead made by the direct vaprolite process is chemically similar to ordinary non-setting red leads. The material, as illustrated however, contains very few large particles, being composed almost entirely of those which, weight for weight in paint, give greatest protection. It is therefore evident that the new process material will be more efficient in rust prevention. The production of a red lead without the inclusion of a proportion of the larger, as distinct from the coarser particles, is a logical method of obtaining improved protective value, and this is the conclusion obtained from the intensive research carried out on the subject.

This has been proved with laboratory tests and by extended trials by important continental Government Departments. Reports received agree that the protection is equal, when applied by brush, even using 1/3 less weight of pigment, compared with non-setting red lead.

Regarding the question of under water protection of iron, experience indicates that red lead containing a high proportion of litharge gives superior results. Reference to this point is given in the 15th Report, Institution of Civil Engineers. Paints containing such a pigment present great difficulties in use, becoming hard or stringy within a short time. The dangers in practice are obvious, unless supervision and control are well maintained, and grinding or mixing into paint-form is done within a short period before use.

A number of methods are available to overcome these difficulties, such as those referred to by Dr. Sabin and others. The additional hardness retention, when immersed, may be obtained by the use of high Pb_3O_4 red lead paint into which the desired proportion of litharge is mixed just prior to use. Others claim that equal results may be obtained by using the pure red leads, with a proportion of bodied oils and driers, to obtain increased hardness.

The direct method of making lead oxides as indicated, is especially adaptable to the production of highly dispersed red leads containing litharge, if specified. However, when manufactured by the vaprolite process, such red leads set with normal rapidity so that they must be used within a short period. High litharge content should not necessarily be associated with coarser red leads or with those made only by the earlier methods.

The extended use of litharge-containing red leads would no doubt promote mixing or grinding on site, instead of by paint manufacturers under modern and well controlled conditions. The practice is therefore to be deprecated.

GENERAL.

The purity of red lead made by the direct process commends its use to many industries, such as glass and pottery glaze manufacture. Here the absence of iron, except in minute traces, is essential for the manufacture of clear products, free from colour tint.

The highly dispersed red lead is also attracting much interest in electric accumulator plate manufacture. The increased surface of pigment exposed to the acid, results in a marked increase in the electrical capacity per lb. of plate.

Telephone Coupling Unit for Mine Circuits

SINCE the Ericsson 'Telephone Coupling Unit' was described on pp. 31-32 of the January 1937 issue of the Ericsson Bulletin, two improvements have been effected. One of these concerns the type of component used, the other tends to improve ring-through facilities.

After collaboration with the research department of Messrs. Westinghouse we have replaced the two separate rectifier units by a single finless assembly coupled with a series resistance. This new combination has the same electrical performance as the original shunt device, but a standard matched assembly is now obtained where formerly selection and matching had to be done as part of the process of manufacture of the coupling unit. The use of a series resistance coupled with a 'back to back' rectifier has an advantage, because the resistance acts in a very similar manner to a swamp resistance in an electrical indicating meter, smoothing out the effect of minor changes in the resistance of the unit due to temperature changes, ageing, etc. The new rectifier unit has the same load rating as the superseded units and used in this manner its performance will be very stable indeed. The more compact assembly permits a saving in space and a reduction of about a third in the size of the coupling unit is thus obtained.

The Coupling Unit in Case

The Coupling Unit without Case, for fixing in Large Switchboards

When the coupling unit was first developed, considerable difficulty was experienced in defining the worst conditions to be met. Acceptance tests have obviously to regard the most extreme conditions which can occur in practice and provide some margin of safety. A survey of the situation with the additional information obtained after the introduction of the original unit shewed that the standard initially fixed was unnecessarily restrictive and hence it has been found possible to improve the ring-through without impairing the safety of the device. The resistance arms of the series impedance have been reduced to a quarter of their original value, the capacitance arms remaining unchanged. As it is the resistance arm which has the main influence on performance at ringing frequency, where service conditions limit the voltage to little if any above that required for operation, this reduction is a considerable advantage. Thus, where omnibus circuits are concerned, the usefulness of the telephone coupling unit is appreciably extended.