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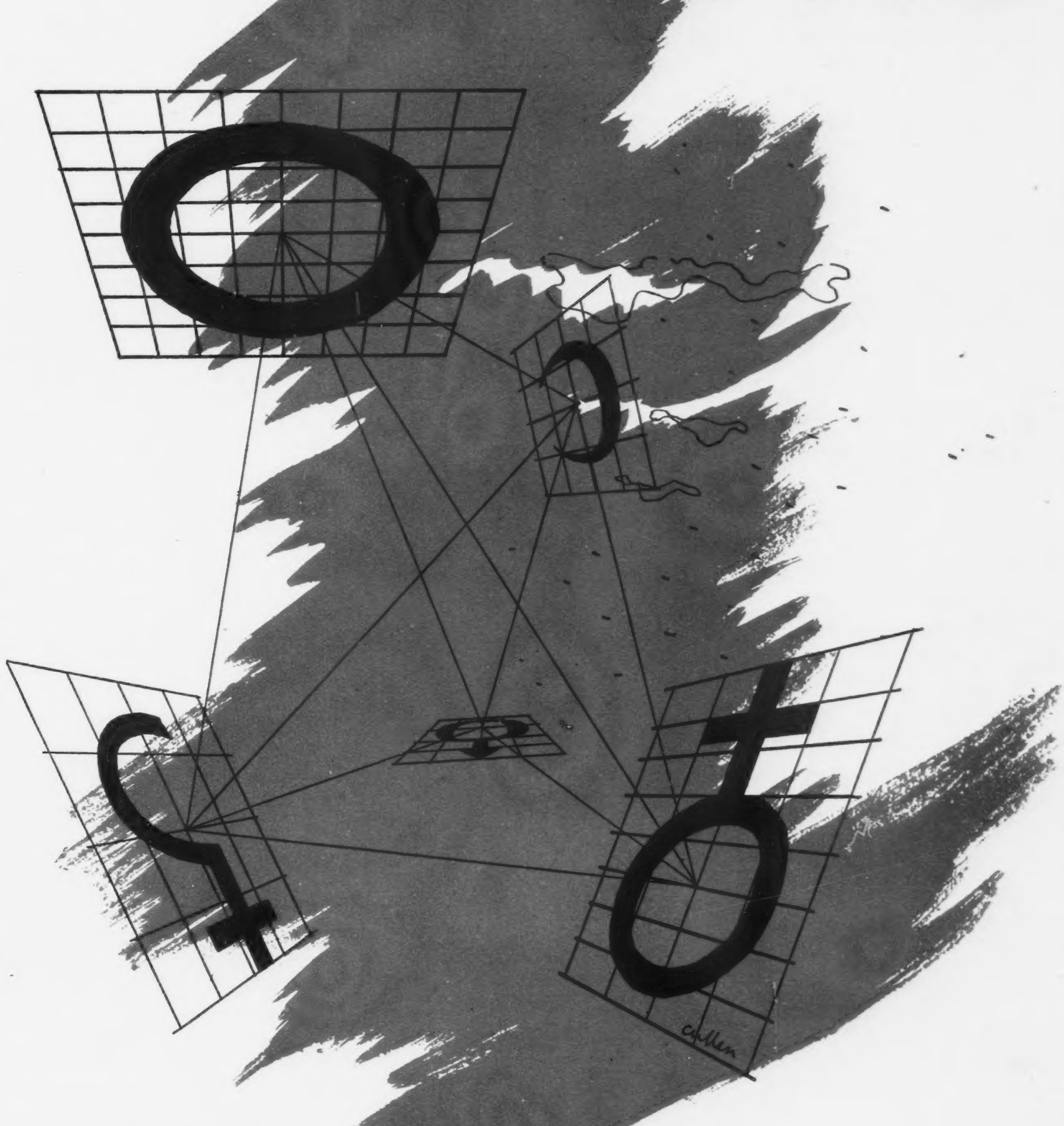

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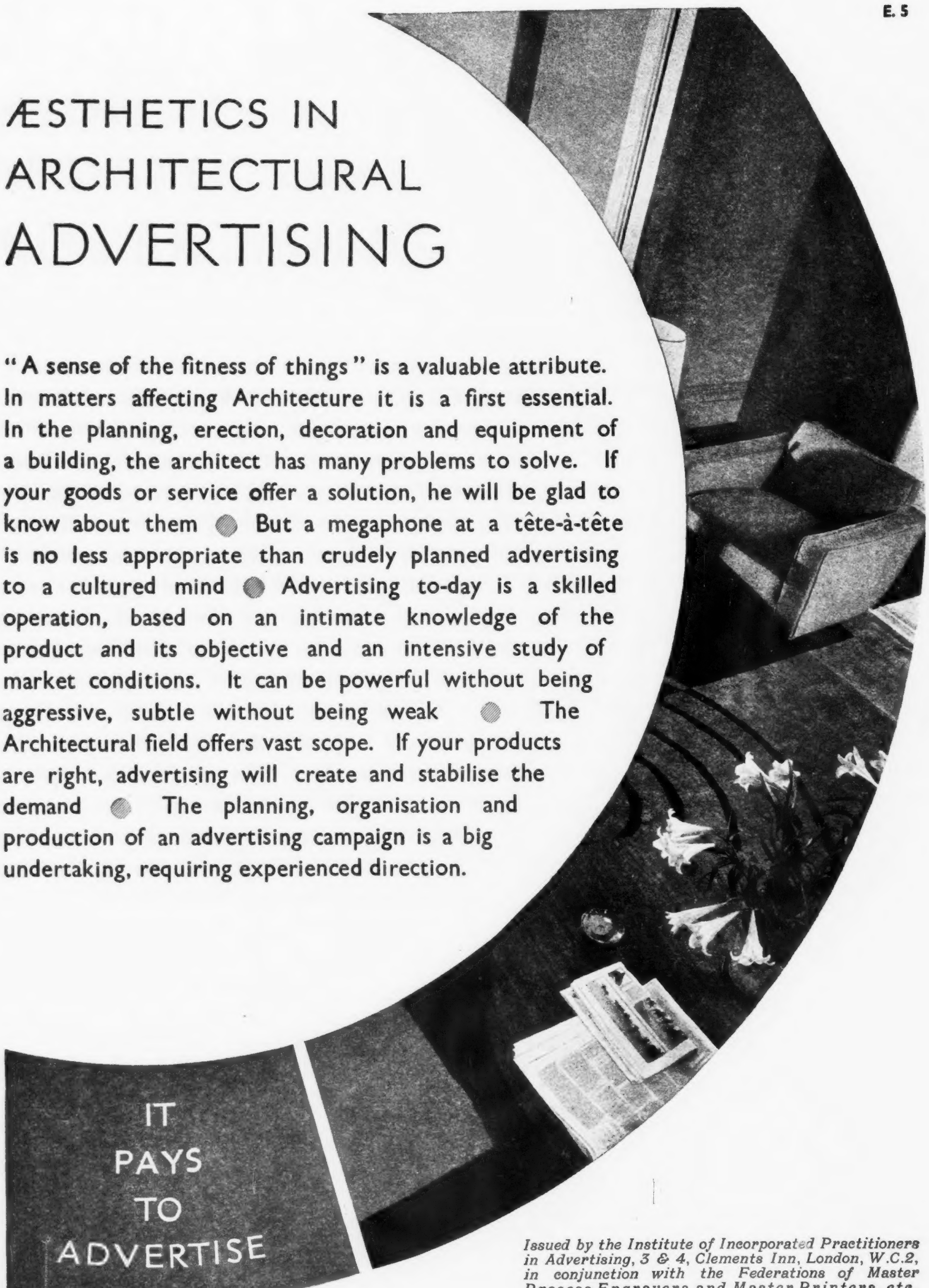

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A Magazine of Architecture & Decoration

Vol. LXXXI, No. 487 June 1937

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SPECIAL METALS ISSUE

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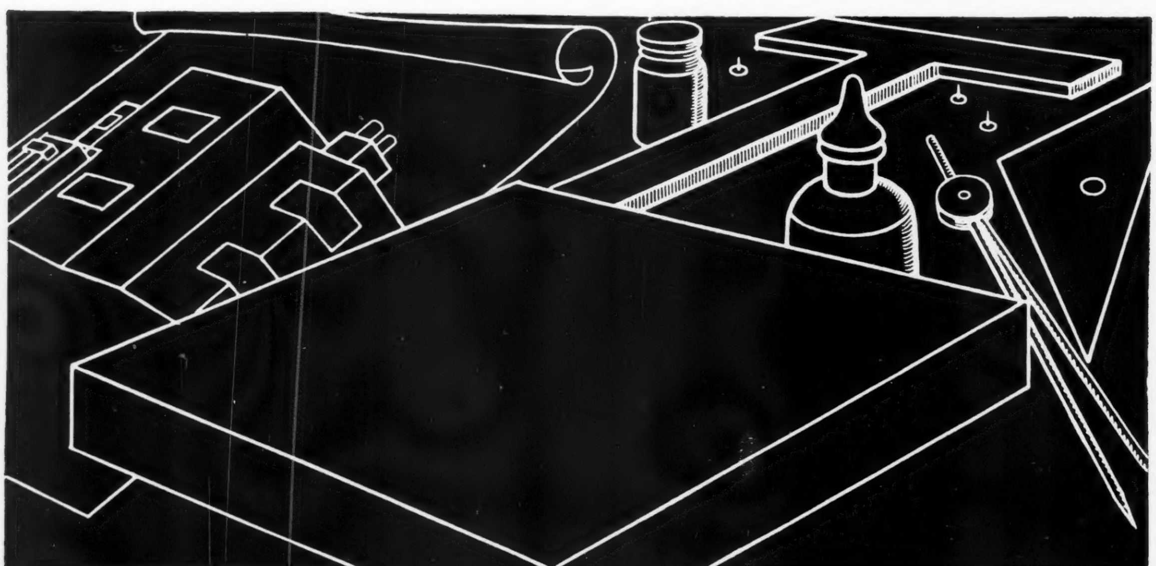

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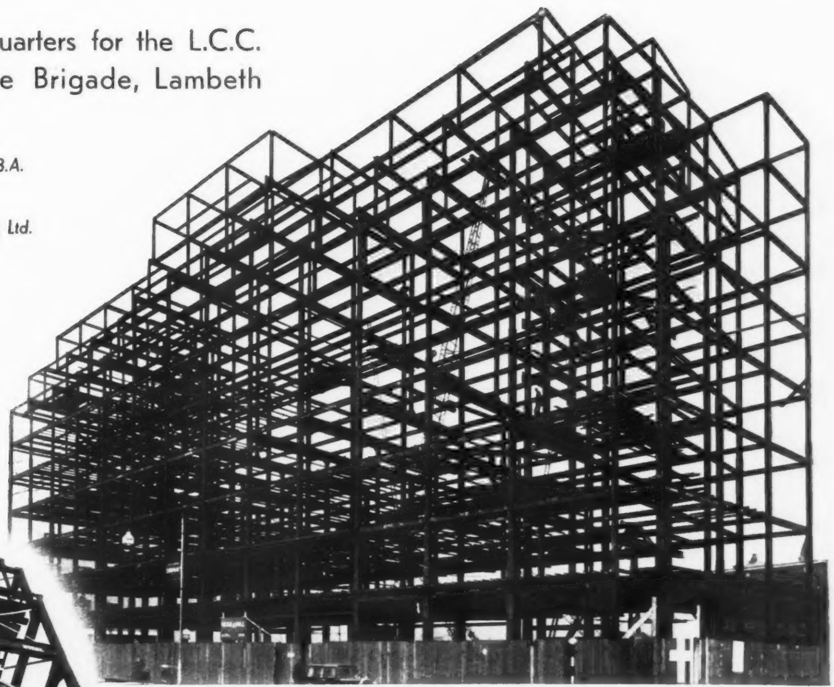

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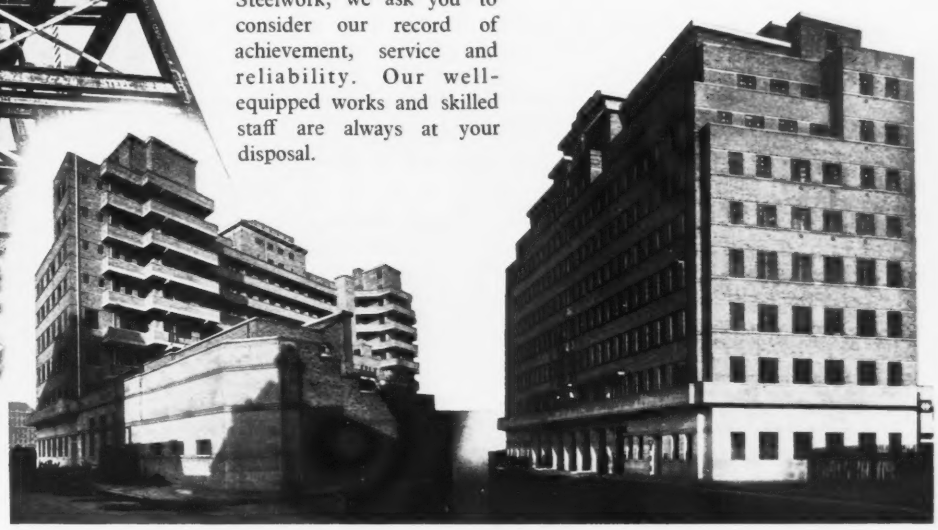

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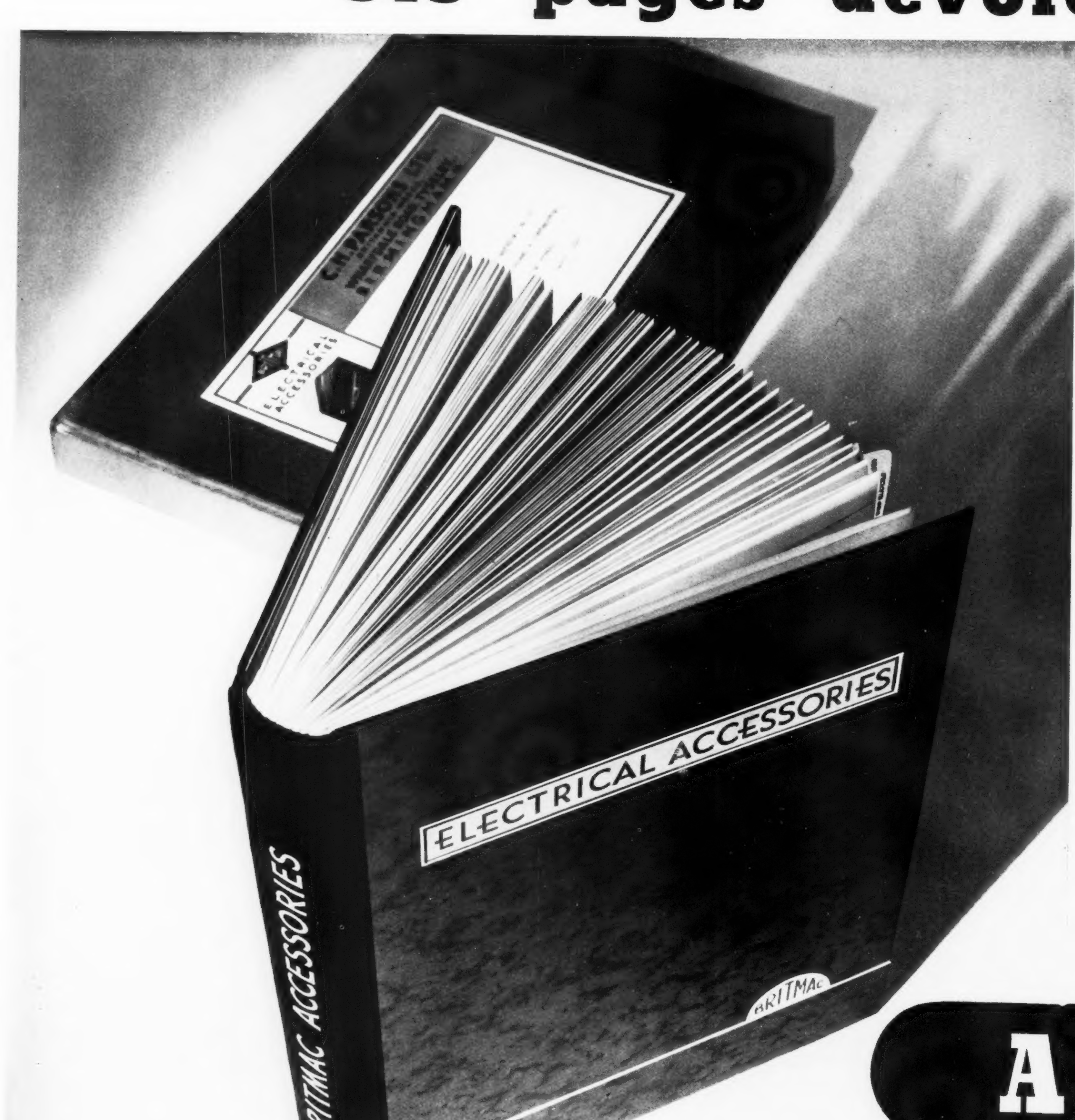

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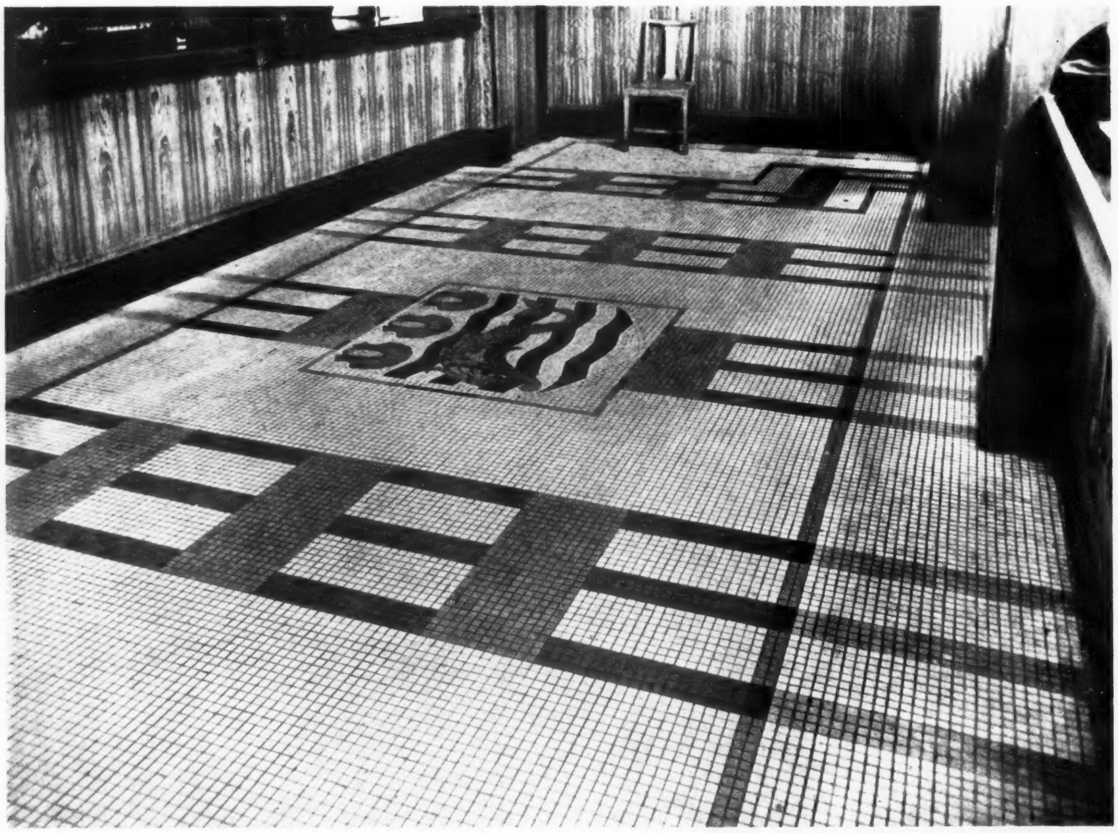

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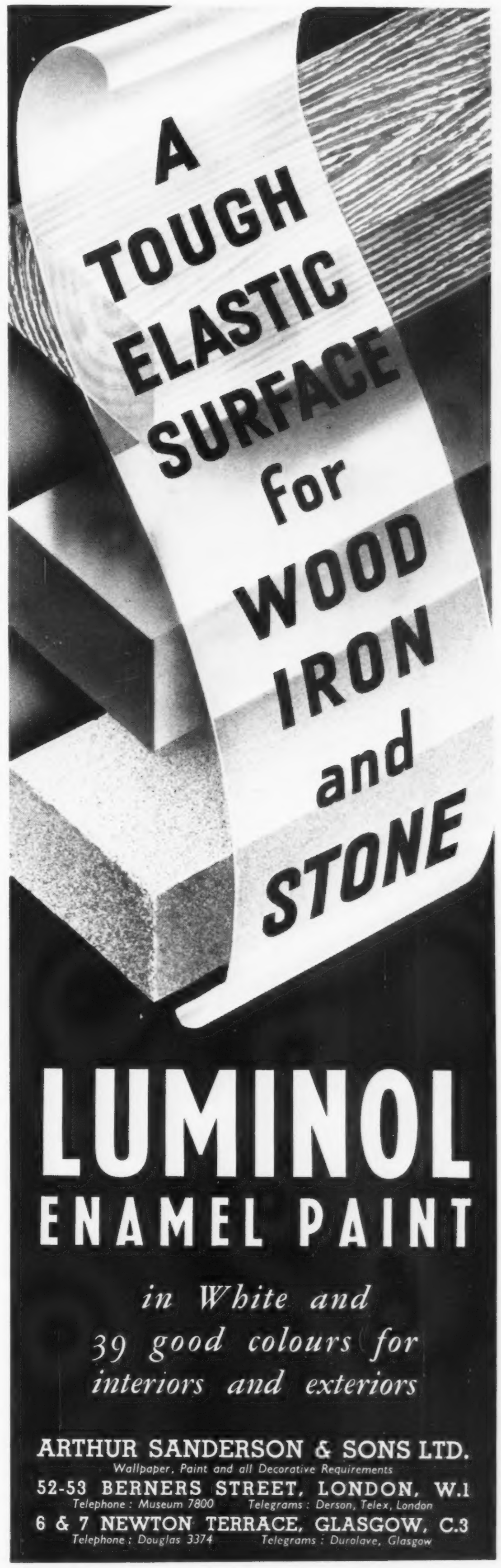

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The boilers at the office of the Bristol Aeroplane Company.

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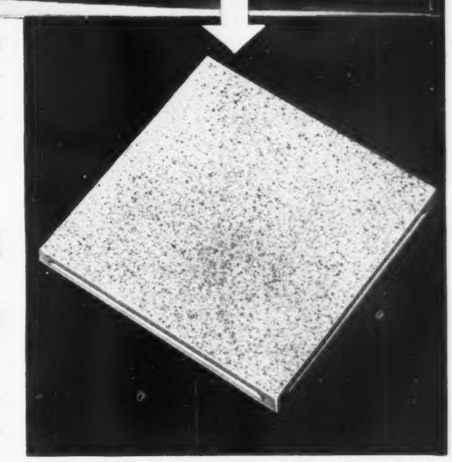

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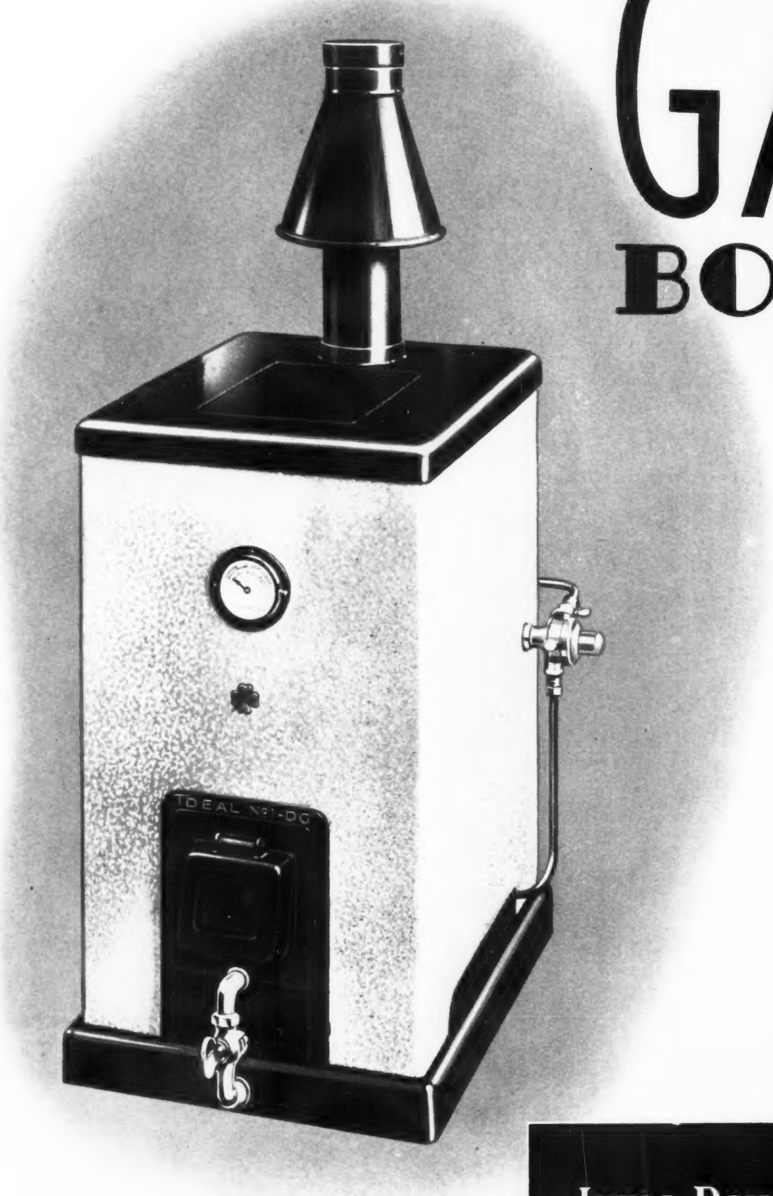

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M E T A L   I N   P R O D U C T I O N

In this special issue the uses of the metals employed in architecture (other than structurally) are described in relation to their characteristics—either natural or derived from the process of manufacture. This photograph, to introduce the issue, shows one manufacturing process in a steelworks: the tapping of the molten metal from the furnace on to the ladle.

FOREWORD

By the Editor

THE ground covered by this special issue is determined by the fact that it is planned to take its place in the series of special issues on different materials which THE ARCHITECTURAL REVIEW is producing from time to time. The first of this series, published several years ago, had as its subject "Steel and Concrete", steel being regarded chiefly as a structural material used either by itself or, with concrete, as reinforcement. In this issue, therefore, which has "Metals" as its title, the structural uses of steel are omitted as having been already covered. The issue deals with iron and steel to the extent that they are used in architecture in non-structural ways and with the other metals that are used in architecture: copper, aluminium, lead, zinc, nickel, and so on.

It is hardly necessary to say that, although these materials can be grouped under the one heading, each has its own peculiar characteristics that determine (or should determine) the manner in which it is used in architecture. It is the influence of these natural characteristics on design that has been emphasized throughout the pages that follow.

We like to believe nowadays that we have outlived the cultural attitude of a generation or two back that made it seem necessary to distort materials to imitate each other; and to regard the new materials that science made available as opportunities merely to carry out the same designs more cheaply. Nowadays we regard them as an opportunity to devise a more efficient design, to do things we had not been able to do before. We pride ourselves on using the abundance of materials to create their own new and characteristic effects and not to imitate the old.

So we can go further than merely be honest about materials being what they are; we can, with intimate knowledge of how they behave under different conditions, use them in such precise ways as will bring to their uses the efficiency and the inevitability that is the basis of good design. The diffusion of such knowledge is the aim of these special issues, and the close connection such knowledge has with the ability to design well is the basis on which the illustrations are chosen.

Another principle of modern architecture, beyond that of using materials in the way they demand to be used, is that of substituting for applied ornament the beauty of materials as such. It is more difficult to show it in illustrations, but the varied surfaces of metals, in the forms they logically take up, present the modern architect with a remarkable vocabulary of textures and colours of which his imagination has not yet exhausted the potentialities.

The plan of this issue is as follows: in the introductory article the various metals are introduced according to the period in history when they were discovered or (in the case of the alloys and the stainless steels) invented, and according to the progress that men made in learning to apply them in building. This article presents their general characteristics and, as the ease with which they can be mined, refined and distributed determines their economic availability, describes briefly their sources and methods of production; and there follows a diagrammatic map showing the distribution of metal mines over the world's surface. Next the metals are treated severally, and their characteristics and manner of use discussed in detail. To sum up this aspect of the subject a single architectural object is taken, the chair, and a series of contemporary chairs is illustrated to show how they derive their entirely different appearance from the particular metal and from the metal-working technique employed. Next is an article on metal finishes, followed by a pictorial section in which the classification is no longer according to the different metals but according to the uses to which they are put. In this section it has naturally not been possible to illustrate every use of metal or every type of design in each category. The illustrations are intended only as typical applications of the technique of metal design in architecture, selected to suggest what can be done and to point out the virtues of the better contemporary designs. The concluding section of the issue looks more into the future and discusses the manufacturing technique of Pressed Metal, a technique that has made great strides in recent years, which offers still greater possibilities to come, and which is very closely bound up in the way it operates with the modern use of standard mass-produced designs. Finally, an article discusses the progress of metallurgical research and the way this is responding to the demands the architect makes on the scientist.

Thanks are due to the manufacturers, associations and individuals who have been helpful in supplying information and in lending photographs, all of whom cannot be separately acknowledged. Thanks are also due to Mr. J. K. Winser, who has acted as editorial specialist consultant in the compilation of this issue, for his indefatigable efforts.

OCCURRENCE AND HISTORY

OF THE METALS USED IN ARCHITECTURE

By O. W. Roskill

It is not always realized that the use of metals was well advanced before the art of smelting was discovered. Copper, the earliest metal known to primitive man, was most certainly first discovered as native metal. During the last ice age in America the Lake Superior region was heavily glaciated, and in this area are outcrops of the very rich Lake Superior ores which contain native copper. The moraines resulting from these glaciers must have spread fragments of native copper over a large area south of the Great Lakes. It is known that the American Indians enjoyed a copper age during which the technique of working primitive tools and ornaments in native copper was quite highly developed.

In Egypt, also, the art of working native copper was considerably advanced. The Egyptians realized that their soft native copper became harder after it had been hammered for a long time and thus first discovered the advantages of cold working.

One of the most notable feats of the early Egyptian coppersmiths was the rain water drainage system in the temple of King Sa-hu-Re at Abusir. In this temple, built in 2750 B.C., 1,300 ft. of copper piping was laid, all of which was hammered from native metal.

The art of smelting was probably first discovered accidentally as a result of cooking food with a wood fire and using a hole dug in the ground to retain the heat of the fire. It would have been noticed that the ashes were of a crude metallic character similar to the native metal already known, and henceforth smelting, although preserving a relationship with magic, would have advanced rapidly. Copper and tin smelting were discovered in this way in England, but lead, which does not occur native, was probably first discovered as a result of working rich silver and lead ores for silver. The oldest known piece of lead work (now in the British Museum) is an Egyptian figure reputed to date from 3800 B.C. The Greeks were proficient in the arts of smelting and working lead; one of their earliest mining enterprises, which still exists at Laurium on the coast of Attica, brought considerable revenue to ancient Athens for some 300 years.

The Romans developed the use of lead considerably and at the time of the Roman occupation in Britain they were using lead piping and sheet lead in the construction of baths. The Roman practice of folding strips of sheet lead into the form of a pipe and then burning the edge along the seam was used in a modified fashion until the present method of extruding lead pipe was evolved.

Two other metals which are now in common use, nickel and aluminium, primitive man was unable to smelt, and the production of these metals was delayed till the end of the nineteenth century. Alloys of nickel and copper similar to " Monel metal " were, however, known in China in very distant times, for in 235 B.C. coins containing 20 per cent. of nickel and 78 per cent. of copper were in circulation there.

Iron was, of course, worked in early historical times in most parts of the world, and was widely used for decorative as well as utilitarian purposes. Puddled iron formerly used for blacksmiths' and constructional work has today been largely superseded, first by steel made in the Bessemer converter and more recently by open-hearth steel. With the recent erection of the new Corby steelworks, the basic Bessemer process has however returned to Great Britain in its most modern form, but this development is even yet not 75 years old.

COPPER

Apart from the native form, copper occurs combined with sulphur and iron in the ore known as chalcopyrite, while in less common ores, nickel and small amounts of gold and silver are met with. In ancient times the production of copper ore was centred in Cyprus, Spain, Germany and England.

The copper ore from Cyprus was known and used by the Egyptians, while it is claimed that the Spanish ore was also worked by them, the copper supplied for Solomon's temple coming from one of these two sources. The Romans later used copper from Cyprus, the name copper being derived via " cuprum " from Cyprus.

In early times rich pieces of copper ore were picked by hand, mixed with limestone and charcoal and smelted in crude furnaces. The hard, impure metal obtained in this way was then remelted with charcoal to give a soft pure metal.

Today the ore is concentrated by special processes and is smelted with limestone and coke in large furnaces; the basic process of smelting remaining unchanged. The metal still retains some impurities however, and when pure copper is required, a further stage of refining (corresponding to the remelting practised in the past) is necessary. Many modern refinery plants use the electrolytic process in which a copper sulphate solution is electrolyzed with a resulting deposition of pure copper on the cathodes, but fire refinery is still extensively used and has even recently been developed to give a copper with properties suitable for electrical purposes.

An interesting method of obtaining copper without smelting is used at Rio Tinto in Spain. Here a low grade copper ore containing much sulphur is laid out in heaps and sprayed with water. The sun and the atmosphere, together with the water spray, oxidize the ore slowly and as a result copper sulphate is formed. This soluble salt of copper is washed away in the drainage water and is led to large tanks containing scrap iron. The copper sulphate in solution reacts with the scrap iron, coating the iron with metallic copper which is then collected.

The main copper producers today are, in order, U.S.A., Chile, Canada, and Central Africa. This last source is of interest as being probably the most important mining field discovered in the present century. In Europe Spain still produces considerable quantities from mines which were first worked in Roman times. Germany produces a little from the Mansfeld Kupferschiefer, a peculiar black soft shale-like material which has been worked for several hundred years, but the production is not now an economic proposition. English production has practically ceased since the Cornish mines were worked out.

It is of some interest that in England the building trade takes a far smaller proportion of the total copper consumption than was the case in Germany, or is now the case in America. Apart from that used in brass, only about 5 per cent. of the total English consumption is used in the building trade as against 9 per cent. in America.

The present popularity in America of air-conditioning and domestic refrigeration is only made possible by the use of metals having high thermal conductivities, and the increasing consumption of copper and aluminium reflect the advantages these two metals offer in this respect.

In the last six months the price of copper has risen considerably, due largely to speculators taking advantage of an increased demand. Copper producers have realized however, that a steady price is more beneficial to them in the long run and they are opposed to the trend towards higher prices, which may lead consumers to substitute other metals in place of copper. In order to defeat the speculators therefore, the output has been increased to a maximum, and when the effect of this move is felt in the London market the price of copper may be expected to return to a more normal level.

IRON

Iron, the most important of all metals, is probably the second metal to have been smelted and used in any considerable quantity, so that it is legitimate to place it after copper in this article. Its history is extensive and should really form a separate section, but since its main use in the building industry is structural only a superficial summary is justified here.

Both the Assyrians and the Egyptians are known to have used the metal, and it was well known in Biblical times, for in Genesis IV–22 there is a reference to Tubal-cain who was an instructor in ironworking. The earliest smelting furnaces must have been mere holes in the windward side of a hill in which the ore could be heated together with charcoal or wood. It is interesting to note that smelting is still carried on today in almost the same way in the Catalan mines.

The most important ores are the oxides, of which three are used, Magnetite, Hæmatite, and Limonite. The carbonate Siderite is also important, and after special smelting treatment, the sulphide Pyrites is sometimes used. Owing to its rapid corrosion the metal does not occur in the native form to any large extent. Ores vary considerably in their iron content, but those containing less than about 25 per cent. cannot be worked economically, and relatively pure ores containing up to 60 per cent. are fairly common.

The earliest deposits to be worked were the Indian, but the Greeks probably obtained their iron from the Black Sea. This country today imports the greater part of its consumption from the very rich deposits in Spain and Sweden, but a substantial amount is produced in the Cleveland district of Yorkshire, Cumberland and Northampton. It is easier to carry the ore to the fuel than the fuel to the ore, and this accounts for the presence of the blast furnaces in South Wales, where there is no appreciable ore supply. It also explains the removal of the smelting industry from Sussex during the 18th century owing to the shortage of wood fuel and the introduction of coal and coke as a substitute. As early as 1611 Simon Sturtevant, and in 1618 Dud Dudley, produced both cast and wrought iron with coal, but opposition of the timber trade succeeded in delaying its regular adoption until Abraham Darby built the first coke-fired high furnace in 1735.

Cast iron was made in England as early as the 14th century, and wrought iron at about the same time, but there were no vital improvements until the latter part of the 18th century, and these were only in connection with the production of wrought iron. It was not until 1856, with the invention of the Bessemer converter, that present-day use of mild steel for structural and other purposes became a possibility. In 1864 the open hearth process was developed by the Martin Brothers in Hainault, and these processes hold the field to this day.

LEAD

Lead, which is generally associated with silver and zinc, occurs mainly in the form of the sulphide galena. This mineral is sometimes found in a well developed crystalline state taking the form of a cube, the face of which has a very high metallic lustre.

It is remarkable that the continent of Africa, which is otherwise very rich in all kinds of mineral wealth, is notably deficient in lead. Except for the small amounts in Northern Rhodesia and South West Africa, Africa has mines only in Tunis and Algeria for the production of lead ores, and has in many cases only managed to produce these with the aid of subsidies from the French Government.

The British Empire produces approximately 40 per cent. of the world's supply of lead; the most important of the Empire producers being Australia, which is followed (in order of importance) by Canada, India and Great Britain.

Great Britain was an important producer of lead in Roman times and although the production of lead ore has fluctuated considerably, the mines working in North Wales and Derbyshire today are the direct descendants of the Roman and Elizabethan workings of the past. A point of some interest is the recent reclaiming of the old Blobber mine. In a very large area of Derbyshire known as the "Wapentake of Wirksworth" the ancient miners had privileges which are still held. In the Wapentake the mineral rights of the land are vested in the Crown, and any miner may find and work a lead lode providing that he appears before the ancient Barmote and states a reasonable claim. For continuity of tenure he must do a certain amount of work on his claim every year otherwise the claim lapses as in the case of the Blobber mine. A condition of the working is that only dressed lead concentrates may be taken away from the mine; if spar or crude ore is removed the person owning the land on which the mine is situated is entitled to take his grievance before the Barmote. If the Barmote upholds the complaint the miner is dispossessed of his claim.

In Europe, Yugoslavia, Spain and Germany are the principal producers of lead, mainly from mining fields centuries old. Agricola's *De Re Metallica*, the classic book of medieval mining, was principally concerned with the Harz district in Germany.

The ores of Yugoslavia were known for centuries before the Trepca mine increased Yugoslavian production to such an extent that that country now ranks sixth in the list of world producers. As already mentioned, silver frequently occurs in conjunction with lead, and the Greek States of classical times, many of whom based their monetary systems on a silver standard, obtained a large part of their supplies from what is now Yugoslavia. The United States is the principal producer while Mexico ranks third in importance. In the U.S.S.R., in spite of attempts to increase production, the output of lead is less than that in Great Britain.

For centuries lead sheet was produced by casting molten metal on a sanded table; and even today, in China, tea chests are lined with lead sheet prepared in this way. The first known example of rolled sheet as against cast sheet in England dates from 1670. At this time sheet lead in addition to its use as a roofing material was employed for sheathing the bottoms of ships, and the first milled sheet was produced and used in this way for the Navy. Milled sheet, rolled down from "billets" of cast lead, is produced more quickly and cheaply than cast sheet though this is still sometimes preferred as it is said to be less liable to "creep."

There is a considerably greater use of lead in the building industry in Great Britain than is the case in the United States or on the Continent, approximately 15 per cent. of the total lead consumption being due to the building industry, whereas in America the comparable figure is only 6 per cent.

In addition to the direct use of lead sheeting and lead pipes indicated above, a considerable amount of lead is used as a base for paints.

In recent years the physical properties of lead pipes and sheet have been improved, due for instance to the use of tellurium—lead alloys and the ternary alloys developed by the British Non-Ferrous Metals Research Association. These contain small amounts either of cadmium and antimony or cadmium and tin. They provide a harder and stronger material as a result of which lighter weights of metal may be used. Tellurium lead has incidentally the advantage shown by copper of hardening with cold working.

ZINC

In general zinc occurs in the form of the sulphide known as sphalerite, usually in close association with galena. As a metal zinc does not figure in ancient times; the mixed ores of lead-silver-zinc and copper-zinc were worked for the lead, silver and copper rather than for the zinc. Probably the main reason for this indifference to zinc was that, unlike the other metals, it was not possible to smelt zinc by mixing the ore with charcoal and limestone.

In these days the association of lead and zinc results in a close linking of the prices of these metals, which has been clearly shown in recent months. As the price of lead increased zinc followed suit more slowly but more evenly, till at the moment the price of zinc is roughly twice as much as the average price during 1936. While to some extent this is also a result of speculation, the statistical position of the metal has greatly improved since the winter of 1936–1937.

Metallic zinc melts at 419° C. and has a boiling point of 918° C., whereas lead with the lower melting point of 327°C. has a much higher boiling point at 1525° C. This low boiling point of zinc has affected the metallurgy of the metal considerably, as at most ordinary smelting temperatures the metal is in the gaseous state.

In early times the art of smelting, though effective, was not sufficiently developed to collect the zinc vapour and condense it to metal, and it is only practicable to do this even in modern times with special retorts. Zinc has been obtained for many years by heating the ore mixed with carbon (either as coke or charcoal) and a flux—e.g. limestone—in closed retorts, the zinc vapour given off being cooled and the metal collected. This process, which was most highly developed in Belgium, was the only satisfactory means of obtaining zinc until the method of electrolyzing zinc sulphate solutions with the production of metallic zinc at the cathodes, was evolved in the early years of this century.

The U.S.A. is by far the largest producer of the zinc, nearly one-third of the world's total coming from this source in 1936. Australia and Canada come next, while Newfoundland and Rhodesia are of interest since their ores are richer in zinc than in lead. In most cases the reverse is the case and the production of zinc is of secondary importance. British production is now negligible, but Italy, Poland, Yugoslavia and Spain are all important producers. In Europe, Germany is now the most important zinc producing country and further intensive efforts are being made, particularly in the district of the Harz Mountains, to make Germany self-sufficient as far as zinc is concerned. This aim is likely to be achieved by 1940 but it entails the working of ore of low value which cannot be done economically under normal conditions.

As a result of the greater amount of zinc which is being made available in Germany, this metal is being intensively cultivated as *ersatz* material, to some extent replacing copper, of which the domestic production is not sufficient to meet the demand.

Zinc is extensively used for roofing as well as for gutters, flashings, down-spouts, etc., on the Continent, where it enjoys an excellent reputation. In this country its use is not so extensive as formerly, partly owing to erroneous impressions of its life, which for 14 gauge sheet properly laid is seldom less than 40 years. A further difficulty has been the shortage of good zinc workers.

ALUMINIUM

Although aluminium is contained in large amounts in all clays and was classified as an element nearly a century ago, the practical production of the metal was not achieved until nearly 1900 when the

Metal production under typical conditions. Top, underground: drilling prior to blasting in the Sudbury nickel mines. Centre, open gallery working in the Rio Tinto copper mines. Bottom, smelting plant in the same mines. The headpiece to this article illustrates the surface mining of aluminium ore (bauxite) in British Guiana.

increasing knowledge of electricity made possible the electrolytic production of the metal from a mixture of the oxide and fluoride. The present process was discovered simultaneously by Héroult, and by Hall in America, and consists in electrolyzing a solution of alumina in molten cryolite at 900° C. The alumina is electrolyzed between a carbon anode and an aluminium cathode, the aluminium from the electrolysis being deposited on the cathode. Alumina is the oxide of aluminium and cryolite is a double fluoride of aluminium and sodium.

Cryolite may be termed the key mineral of the aluminium industry as no other compound can satisfactorily act as a solvent of alumina at the required temperature. The importance of cryolite is enhanced by the fact that only one deposit of commercial quality is available and therefore the world output of aluminium depends on one mining area. This deposit occurs in Greenland at Ivigtut and the cryolite obtained here is shipped to aluminium works throughout the world. Although cryolite is not consumed in the electrolysis and may be used repeatedly, small amounts need to be added from time to time to counteract the natural wastage. In recent years the production of "synthetic" cryolite, e.g. by reaction of alumina and fluorospar, has been developed in certain countries such as Germany, Russia and Japan.

Aluminium was one of the latest metals to be produced on a commercial scale, and it has already developed a large field of uses. The future may however offer even greater possibilities since the reduction in the price of magnesium leads to expectations of further developments in the production of aluminium magnesium alloys for the engineering industries.

Bauxite, from which aluminium is produced, is of very general occurrence, but deposits relatively free from iron, which alone are suitable, are relatively scarce. The name is said to be derived from the Provençal town Les Baux, and France still produces nearly 30 per cent. of the world's needs. U.S.A., Yugoslavia, Hungary and Italy produce large quantities. Empire sources are mainly limited to British Guiana.

NICKEL

Nickel alloys, as already mentioned, were used as coinage metal by the Chinese at an early date, and it is very probable that the nickel-iron alloy of which some meteorites are composed was used in distant times and regarded with considerable awe. The suggestion has been made that the "Heaven sent" blades of the ancient warriors were in reality composed of meteoric iron containing nickel. Sword blades of such material would certainly warrant respect from an ordinary tempered steel blade.

Nickel was first produced as a metal in Germany in 1804 after the ores from which it was obtained had been regarded as useless. These ores were mistaken for copper-silver ores and when, after smelting, a brittle, friable metal was produced instead of silver, the German miners in disgust named the product *kupfer-nickel*, a reference to "Old Nick" who with his mischevious gnomes was said to have plagued the miners and bewitched the ores. This *kupfer-nickel* was in reality a mixed arsenide of nickel and iron possessing a curious metallic lustre and in appearance exactly the colour of a new penny. In the nineteenth century the supplies of nickel were very limited and the small amounts of nickel occurring in the serpentine rocks of Great Britain were mined.

The principal district in Great Britain was Cornwall, but Wales and Scotland also provided small amounts. The Russian deposits in the Ural mountains were also extensively worked at this time. In 1877 it was discovered that the French Island of New Caledonia contained nickel ores in quantity sufficient for working and after that time New Caledonia was the principal producer of nickel. Only small amounts of nickel were mined in America until the vast deposits at Sudbury, Ontario, were fully investigated after having been reported at a much earlier date.

When the Sudbury mines commenced working, the nickel was found to be difficult to extract from the ore, and when it was extracted the price paid for it was very low as there was practically no market for the metal. Subsequently the alloying of nickel with steel, resulting in many valuable new characteristics, was discovered, and since that time the Sudbury mines have become by far the largest producers of nickel. The increasing use of stainless steels (alloys containing nickel and chromium) in which the building industry has played a large part, has also contributed to the growth in demand for nickel.

The British Empire supplies approximately 85 per cent. of the world requirements of nickel, most of which comes from Sudbury, although a small amount is produced from Indian ores.

It is of interest to note that nickel, which is controlled almost entirely by one company, has not reflected the rise in base metal prices due to the rearmament policies of the European countries. The metal is of prime importance in armament work, but since there has been no market for speculation the price position has remained unchanged, although the producers are likely to reap the reward of their forbearance through rapid increase in consumption.

New Caledonia is the only other important producer, though Greece and Norway provide small amounts of ore, while the U.S.S.R. increased production by 100 per cent. in 1935 and now ranks third in world production.

TIN

Tin was used in bronze before it was obtained as a pure metal, largely owing to its occurrence together with copper. In the Cornish mines it is possible to find four metallic ores at different horizons of the mine. The ore of zinc, sphalerite, is commonly found at the surface in these mines; a little deeper, the zinc-bearing ores disappear but copper ores are found, usually in the form of chalcopyrite. At a greater depth copper gives way to tin and the oxide of tin, cassiterite, is the principal ore. Finally, at the greatest depth, tin is displaced by tungsten and the ore wolframite is found. If, of course, the mine is working a lode which has previously been eroded down to the level where copper and tin are found together, this ore would yield a bronze if smelted under certain conditions, and this was what generally occurred in the early mines in Cornwall. At a later date the copper ore was separated from the tin ore and on smelting separately the two different metals were obtained.

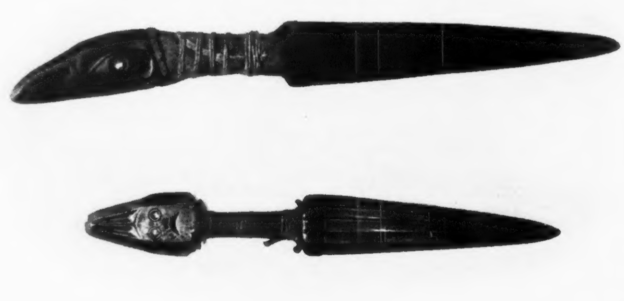
Tin is not of very wide occurrence owing to the fact that its ores are found only in large granite areas of a particular type. For example Scotland is largely composed of granite but no tin lodes are found, whereas in Cornwall, which does not show so much granite, many tin lodes are present. Perhaps the most interesting feature of the distribution of tin ores is that the United States of America possesses no domestic supply of tin.

Cassiterite is a chocolate brown mineral occurring in small grains and very resistant to attack by weathering, consequently when tin lodes are eroded by weathering the cassiterite is washed down to form part of the alluvium of the drainage system. In some parts of the world numbers of small lodes which are not individually rich in tin have been eroded in this way and the resulting tin ore found at the bottom of the river gravels is the world's most important source of tin.

The British Empire produces about 44 per cent. of the world's tin. Of this amount the Federated Malay States accounts for nearly 70 per cent., practically all from the so-called alluvial tin already mentioned. Nigeria is next in importance in the Empire, also producing alluvial tin, while India, Australia and Great Britain produce small amounts of lode tin. Apart from those mentioned above the following countries are the chief producers: Dutch East Indies, Bolivia, Siam, China, the Belgian Congo and Japan. Of these countries some lode tin is obtained from Bolivia, the Belgian Congo and Japan, but the others work entirely on alluvial deposits.

The main uses of tin are for coating steel with a thin sheet of the metal, i.e. tin-plating, for low temperature melting alloys and for bronze and gun metal.

The "silver paper" wrappings which were formerly of tinfoil, have been largely superseded by more economical foils such as aluminium, although some manufacturers still prefer to wrap their goods in tin-foil.



Primitive tools in bronze, from the British Museum.

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Car
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U.S.
Peru
N.R
S. A
Indi

ZINC

Canada, Mexico, N. Rhodesia, Russia, Newfoundland, Peru, Italy, U.S.A, Spain, Germany, Australia

TIN

Bolivia, Belgian Congo, Nigeria, Malay States, Gt. Britain, Siam, China, Dutch East Indies, Japan

LEAD

Canada, Gt. Britain, Greece, India, U.S.A., Spain, Russia, Jugoslavia, Peru, Germany, Australia, Poland

ALUMINIUM

U.S.A., Greece, Russia, Jugoslavia, British Guiana, Dutch Guiana, France, Italy, Greenland, Dutch East Indies

NICKEL

Canada, Norway, New Caledonia, Russia, Greece

COPPER

U.S.A., Peru, N. Rhodesia, S. Africa, India, Canada, Spain, Cyprus, Russia, Chile, Germany, Belgian Congo

IRON

OWING TO ITS VERY WIDE DISTRIBUTION IS OMITTED.

PLATE ii, *June* 1937

SOURCES OF METALS THR

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THROUGHOUT THE WORLD

IRON AND STEEL

EXCLUDING STRUCTURAL STEEL

By A. Crompton Roberts

Smiths working on the pair of wrought and repoussé gates designed in stainless steel by Reco Capey for the entrance to Burlington House.

Before the twentieth century iron and steel had no fundamental function in architectural construction, and were not related to its basic principles. Ironwork was of only secondary importance: even if its use as a protection in the form of gates, grilles, locks, and such work may be regarded as essential, it was invariably "applied," it never was an integral part of the whole scheme of the building.

Practically nothing exists today which might prove that iron and steel had any importance in the architecture of Greek or Roman times. We still possess many iron objects of the Roman period, such as arms and domestic pieces like candlesticks, tripods, etc.; but nothing fulfilling an authentic architectural purpose. It is interesting to discover that the ancient Briton had a decided superiority over the Romans in shipbuilding, owing to the fact that they used iron "pins" to fasten together the oak timbers of their vessels, and iron chains in place of the primitive Roman rope cables. But this can hardly be called an architectural use of iron, although it might not be unreasonable to deduce that iron was employed for building also; but, if that were so, the iron has long since rusted away.

It was in the Middle Ages, when craftsmanship had developed sufficiently for the blacksmith to express himself freely while bound by the nature of his material, that the first important ironwork was produced. The story of wrought iron in the Middle Ages is bound up with that of sculpture and painting; and it should be considered with them, as an expression of individual personalities. Later, the technical side developed rapidly, and to master the working of the metal became the chief object. In the seventeenth and eighteenth centuries, the skill of the blacksmith became more and more important; many works remarkable for their elegance were produced. But on the whole, the æsthetic requirements were neglected, or misunderstood, and, as each worker merely tried to show how clever his hand was, iron was as often as not fashioned without any reference to its own nature or the purpose to which it was to be put.

Then the discoveries of the nineteenth century replaced manual labour by mechanical power in the processes of metal fabrication. Hitherto unheard of forms, sizes, and weights of metal, were produced. But instead of the new discoveries changing the basis of design, the slavish imitation of past periods led only to industrialized reproduction of the old individual work and to the death of inspiration. The excesses of the "Art Nouveau" produced at last an absolute revulsion against "applied" decoration; this resulted in the sweeping away of all but the essential ironwork on recent buildings.

Slowly, a new conception of the uses of architectural ironwork has arisen: that of making it an integral part of the scheme of the building. There are now available an almost infinite variety of forms in which iron, or its stronger modern equivalent, mild steel, may be properly used.

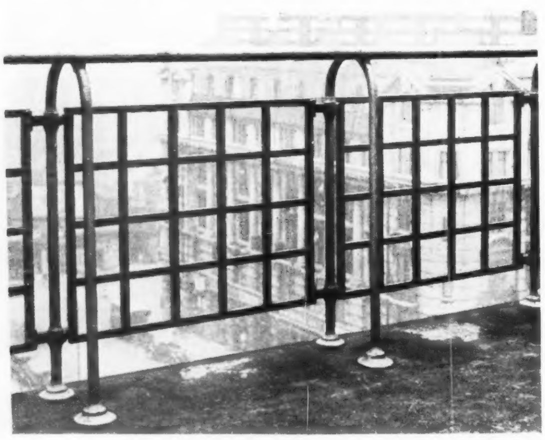
But why is it that design lingers so far behind the technique of metal production, when there is no process in the making of iron and steel that has not been established for at least twenty years? The trouble seems to be due to a lack of practical knowledge, and to an inherent conservatism. In the following paragraphs the chief processes of ironworking today and their possibilities are briefly reviewed, in the hope that they may have some influence towards a more rational use of iron in architecture.

The peculiar properties of iron and steel naturally condition the processes of their fabrication, and, therefore, what may or may not be done in using them for architectural designs. There are two chief kinds of iron, cast-iron and wrought-iron, each of which has its own special property and is suitable for different conditions and purposes. Roughly speaking, wrought-iron can be worked indefinitely and into an infinite number of shapes; while cast-iron has to be left much as it leaves the mould.

CAST-IRON

Castings in iron are prepared from what is commonly called "pig" iron; that is, iron which comes direct from the smelting furnace and is of a very hard and brittle texture. The objects to be made in cast-iron are first made as patterns, generally out of wood, and are pressed into damp sand, contained in iron frames or "casting-boxes". There are usually two of these frames, one on top of the other, each with registering points to ensure accurate alignment, the pattern being halfway between them, so that, when the boxes are separated and the pattern removed, the impression left by the pattern is not disturbed. After the removal of the pattern, a channel is cut in the sand, from the space left by the pattern, leading to a hole in the iron frame into which the metal will be poured. The two frames are now replaced and clamped together, and the metal poured, which when cool reproduces, except for a slight shrinkage, the original wood pattern.

To what architectural purposes may cast-iron properly be put? It is brittle, and therefore not suitable for thin sheets which are likely to fracture; also, thin work cannot be realized easily in cast-iron, for pouring is difficult, as the metal, having no weight or body to hold the heat, is likely to cool before it reaches the most distant parts of the casting-box; it may twist and fail to remain flat, and, once the metal is cool, this cannot easily be put right. Again, designers



should beware of combining thin parts with massive parts, as the thin may cool first and contract away from the larger.

The actual shape of the patterns is of first importance; they should be designed with a view to their removal from the sand without affecting the impression, in much the same way as a child removes its bucket from the seashore to make a sand-pie; if there is a projection on the inside of the bucket, it will obviously score the side of the pie. In certain circumstances, the box may be made in what is known as a piece-mould, to allow for those parts that will not "lift." But the principle is the same, and the surmounting of difficulties very often raises the cost considerably. Very often an architect's designs could have been carried out for half the cost if there had been an understanding of this principle; others would have been far more effective had all the potentialities of the casting processes been realized.

A final point about cast-iron designing: the weight of castings and, therefore, their cost, can often be reduced by the use of cores by which the casting is made hollow.

In casting iron, the quality of the metal is of great importance; if an iron has to be of fine surface texture and has to be machined, it should be of a light grey colour when broken across, and should be specified as " best foundry iron." The moulding itself depends almost entirely on the skill of the workers, the time spent in preparing the boxes, and on the choice of a suitable sand; hastily made moulds produce castings with poor edges and uneven surfaces.

There is no limit to the " tricks of the trade " which competent craftsmen can make use of when casting iron, but technical dexterity is something apart from art, and it is hardly necessary to enumerate them. Here only certain underlying principles are indicated. Since cast-iron withstands great pressure, it is of most use in the form of spindles, posts for supporting great weights, and so on, although when suitably designed it can be used for grids, balustrading and the like, in conjunction with wrought-iron. Cast-iron can be welded by the oxygen process, but this presents difficulties and should be avoided in general practice. The welding of cast to wrought-iron is still in an experimental stage. The surface texture of cast-iron makes it very suitable to take paint from the spray gun, as it is porous and the paint finds a good " tooth." Cast-iron also presents a high resistance to corrosion, and, although it will rust on the surface if left unprotected, it is far more durable than wrought-iron or mild steel.

Recent improvements in the composition of the metal for casting do not greatly concern the architect, but the "malleable castings" in which much of the inherent brittleness is overcome should be mentioned.

Cast-iron and wrought-iron are, from the designer's point of view, wholly different materials. The fireback (top), a late seventeenth century example from Kent (Victoria and Albert Museum), could only be made as a cast unit, while the decorative chevaux de frise on an eighteenth century party wall in Bedford Square (second illustration) could not possibly be anything but wrought iron. Later designers did not always appreciate this difference. The simple curves of the late eighteenth century balcony front (third illustration) are typical wrought shapes, but the numerous intersections of the bars are expensive to make, and this type of design was in many cases cast despite the unsuitability of such long thin members. The bottom illustration, from Peter Jones' new building, is a recent example in which the characteristics of the two forms of the metal are logically combined to give strength as well as convenience in production.

C A S T I R O N

The picture above, a cast iron post or " bollard " on a street island in Bloomsbury, shows in the most elementary form the simple, satisfactory shapes which derive naturally from the casting process. Casting can, however, also be used to produce the most elaborate contortions of metalwork, as in the example on the left : a Victorian lamp-standard from the Strand.

WROUGHT-IRON AND STEEL

These materials are available in such a multitude of forms that it will be necessary to sub-divide, beginning the survey with the composition of the metals and their production.

Very little pure iron is now used, and practically all so-called " ironwork " today is in fact made of mild steel. Mild steel is iron compounded with a controlled quantity of carbon, usually about 1 per cent. to 3 per cent.; it will not temper like true steels which have a much higher carbon content. Mild steel is used for all the parts of a building where high tensile strength is required, although it has not a high resistance to corrosion if unprotected.

Steel is " rolled " in the form of rectangular bars from $\frac{1}{8}$ in. in thickness and $\frac{1}{2}$ in. in width to several inches either way, the lengths being usually from 17 ft. to 18 ft. long. It is also possible to obtain bars with round, half round, and other simple sections that are suitable to the process. Sections that are " H " shaped and " angles," also " T," " channel," " U " and similar types are produced by " rolling " in the same way as ordinary bar metal.

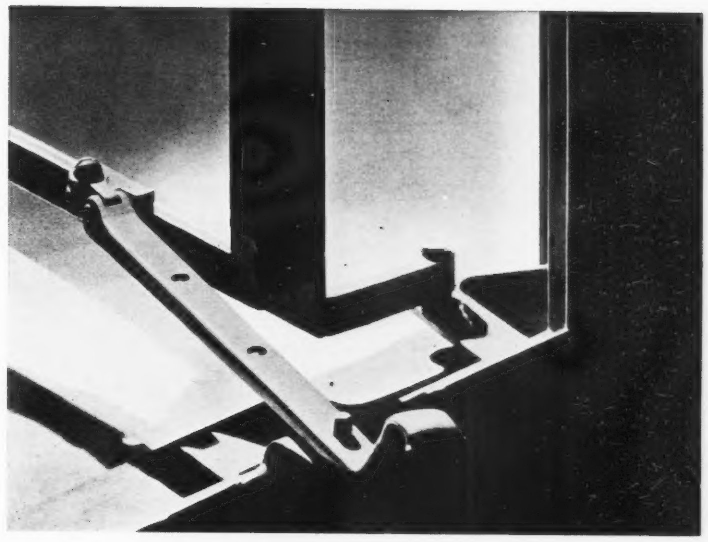
Sheet and plate steel is rolled hot also, the rollers being, in this case, flat, and not shaped as for bars and other sections. It is produced in a variety of thicknesses, the size of the sheets being normally 6 ft. by 3 ft. Progress has been made of recent years in " rolling " very soft steel for " deep drawing," a process that will be dealt with later in this article, and one which may have an important influence on future design since it enables " incredible " shapes to be made from the sheet metal.

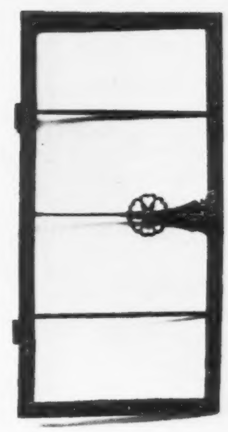
With the production of soft metal the question of " extruding " by which the hot metal is pushed through a shaped orifice instead of being passed between rollers, becomes of first importance: at the present moment, very little is now " extruded," owing to technical difficulties, but as these may be overcome in the near future, the possibility must be mentioned here.

The uses of wrought-iron are too numerous and well known to be set out in full here; it will be sufficient to consider certain aspects of its working that are often overlooked by the designer.

The apparent simplicity of intersecting bars of the same size is deceptive to the designer who has not learned from hard experience that intersections are an expensive item. It is important to realize that the bars have to be what is termed " halfed," i.e. a half-section cut out of each bar at the point of junction. This is even more important when balustrades are on the ramp. In designs, vertical bars are often shown passing through wider bars: if they are on the flat, the holes may be punched quite simply; but on the ramp they have to be accurately cut by hand at the correct angle, an operation requiring careful work if it is to be done efficiently. Nor is it generally realized that in staircasing the carrying of continuous horizontals round the flights is a much more difficult job than it appears on a drawing.

In the working of wrought-iron, perhaps no invention has had such an influence of recent years as the oxy-acetylene blowpipe. Even at the present moment, the real potentialities of the process are still untouched. The oxygen cutter can do much that no one has yet attempted. It is now used by some metalworkers to " imitate " forged work by cutting out of a heavy steel plate those shapes which were designed on a basis of hammering; no one will argue that it is illegitimate to use the cutter, but it is difficult to see why it should be used merely as an imitator and its possibilities as a direct instrument almost ignored. These tools will cut steel plates both thick and thin as easily as the proverbial knife goes through cheese, and with absolute accuracy, the work being cut directly from the design on the drawing board, following the principle of a pantograph.





The seventeenth century wrought-iron casement from Suffolk (Victoria and Albert Museum) on the right, although used for the same purpose as the normal type of today (above) depended for its relatively poor weather exclusion qualities on an entirely different system of metal-to-frame contact. The later development was only made possible by improvements in steel section rolling technique.

Wire

For the larger sizes round sections in steel bars are " rolled," but when the section becomes smaller, the metal is " drawn." " Drawing " consists of pulling by tension the cold metal through a tapered hole in a hardened steel plate, the diameter of which is slightly smaller at one end than the metal; the wire is at the same time lengthened and made thinner by this process. It is not necessary that the hole in the plate should be round; it is quite easy to draw irregular shapes which can be used for mouldings, although at the present time these are mostly made in metals other than iron and steel. Owing to certain technical difficulties, designs for irregular drawn steel should be made in conjunction with an expert who is actually engaged in the process of drawing.

Tubes

Alongside the production of wire is the drawing and rolling of steel tube, the uses of which have increased a thousandfold with the introduction of welding, both electric and oxy-acetylene, and by the use of tube produced by the process known as " solid drawn."

The various kinds of steel tube may be classified as follows: open seam rolled tube, welded seam rolled tube, cold solid drawn tube, hot solid drawn tube.

The use of open seam tube is limited to light work and the cheaper class of electrical conduits. Welded tube is mostly used for water and gas piping.

The most recent development is that of the cold solid drawn tube, the successful production of which alone makes possible the present designs of steel tubular furniture.

In designing for tubular work special attention should be paid to the bending of tube. This is effected by "loading" or filling the tube with a softer substance such as lead or sand so that the bending operation will not deform the shape of the tube; the filling is afterwards removed. Bends should not be made too sharp, or else there will be an appreciable flattening of the tube; where sharp corners occur it is advisable to use a mitre joint, which can either be brazed or welded. The whole question of the joining of tubes is complicated. Where a " first class job " is required, welding is the best method: and with the development of flash electric welding, which can now be done on the site while the work is being fitted, there should be a great increase in the production of architectural tube work. The flash method consists of making an electric arc between the two ends of the tubes to be joined, thereby raising the metal edge to welding heat; the two ends of the tube are then firmly pressed together and form a perfect weld joint. Very little cleaning-up is required afterwards, as there is practically no surplus metal. Oxy-acetylene welding can also be used in the usual way, but the result is not so neat in appearance; and brazing not nearly so strong, although simpler to do. The method of fixing tubular work deserves mention, especially where it is used for handrails; in that case, there should be a secret fastening inside the tube, so that there are no projections to catch the hand, and mention might be made of the London Passenger Transport Board for some excellent tube work to be seen in their newer Underground Stations.

Tubes can be cellulosed, painted, or metal sprayed, and for handrails there is a method of covering them with a thick skin of celluloid which produces a surface very pleasant to handle.

Sheet and Pressed Steel

The use of sheet steel in the form of " pressings " and " drawings " is beginning to find a wider appreciation among architects. What has been learned in the factory production of tin cans is now leading to more impressive uses, especially since the introduction from America of methods of producing soft metal without flaws or weak spots, by what is called " direct " rolling. Where the sections are simple the sheet metal is usually bent in a folding machine. For this, there must be straight edges. For more complicated shapes, the sheet—or strip—is pulled through a die, which forms it into the correct section.

The other method of making shapes from sheet steel, is that of pressing,* when a steel die is used. The fundamental principle is that of the pattern in the sand, which was mentioned in connection with cast iron, it must " lift " without catching the " die " or mould. The depth of the pressing is of importance since the deeper the work the greater the risk of piercing.

The history of the metal window industry is an interesting example of change brought about by improvement in production technique. Quite a lot of wrought iron metal windows were used in the early Cotswold work. These were invariably of flat section with welded corners. The outer edge of the corner was rectangular while the inner edge was generally rounded in order to stiffen the frame. They were usually hung on hooks and shut against the stone, giving a poor and draughty job. Even where wood frames were used, owing to the flexibility in one direction it was difficult to get a draught-proof bed against the rebates, particularly since at that time the value of edge contact as against flat to flat was not realized.

It was not until the development of rolling light sections was fairly advanced that the modern steel window became a possibility. As rolling has developed so it has become possible to make more and more complicated sections, designed to give rigidity and edge or point contact in at least two places to prevent the access of water. The most recent sliding windows utilizing a variety of special sections both for the gear and the window are an interesting example of development which is only possible as a result of improvement in rolling, and in some cases in rolling and pressing complex sections.

In America very light pressed steel windows have been developed and if the problem of rust-proofing can be dealt with it is quite possible that this will be the next development in connection with metal windows, again only made possible by improvement in pressing technique.

PRESERVATION OF IRON AND STEEL

It is hardly necessary to deal here with the well-known methods of preserving iron and steel from corrosion—painting, galvanizing, sherardizing and so on. The sheathing of metal with thick cellulose materials is however not so widely known and offers advantages for articles which are regularly handled.

The covering of handrail sections is only possible when the parts can be sent to the factory and require no fabrication afterwards. Celluloid is a permanent and pleasant surface, but the initial expense is high.

Spraying with molten metal by means of an oxygen spray-gun is one of the latest and most successful ways of combating corrosion. A thin wire is melted to a bead at one end by means of an oxygen flame, and another jet of oxygen under high pressure blows the tiny bead into molecules on to the surface of the iron. These fragments strike the iron at a tremendous speed and are splashed out; they adhere on to the iron simply by air pressure, but since they are so strongly forced on they are quite impossible to remove and protect the surface permanently.

The best weatherproof and stainless metal for spraying at the moment is an aluminium-magnesium alloy known as " Birmabright " and the life of a correctly sprayed work is said to be twenty to twenty-five years, although, of course, no thorough test of time has yet been possible. The chief difficulty in metal spraying is that the surface has usually to be sandblasted immediately beforehand and while this is comparatively easy in the factory under fair conditions, the work becomes more involved when it has to be done with portable plant on the site.

Since almost any metal that can be drawn into wire form can be used for spraying (unfortunately excepting, among a few others, stainless steels) the possibilities presented are very great. Zinc is already becoming standardized as it provides an ideal " tooth " for cellulose paint, but the colour effects of the various bronzes are at present almost untouched and there must be a whole field of discovery in new and stainless alloys. Undoubtedly with the simplification and improvement of the method the spraying of iron will become a standard practice.

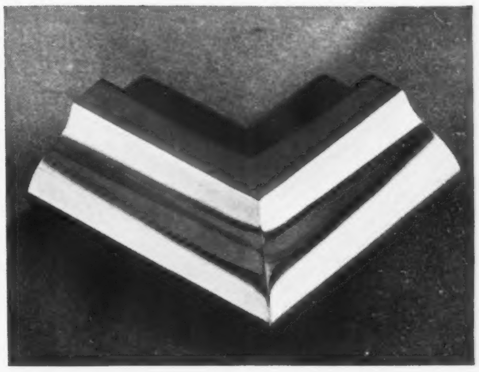
It may be interesting to mention here, before concluding this survey of iron and steel, the remarkable lasting qualities of most of the ironwork produced during the Middle Ages all over Europe and especially in Spain. It has been preserved for the most part without any protective coating of paint or other substance. Very often it has been entirely neglected, yet today is far less corroded than the majority of works ten to twenty years old under similar conditions. Although many explanations have been offered, and especially that of the purity of the iron used, it seems that a great measure of the preservation lies in the fact that modern blacksmiths obtain their metal almost to the exact size required while the smith of the Middle Ages had to rely on the swage and anvil, beating the metal out from almost the raw state. This continued beating of the metal gave it a very consistent texture, driving the molecules together, preventing porosity, and limiting the surface area which could come into contact with the oxygen in the atmosphere. In the modern mild steel, which is produced by rolling, the pores seem to be merely elongated and made even more open, thus inviting oxidization.

STAINLESS STEEL

By H. S. Hopcraft

SEVERAL types of stainless steel, alloys of iron, nickel and chromium are well known in the engineering trade, but the austenitic type of which " Staybrite " is one proprietary version is the one generally employed in architecture. Since there is still some misapprehension on the subject, it is perhaps worth noting again that the " stainlessness " of these steels is not due to any form of surface treatment, but is constant throughout the metal, the alloy behaving as a homogeneous solid. The mechanism of corrosion resistance is of extraordinary interest. Steel, containing chromium and nickel in the necessary proportions, possesses the peculiar property of spontaneously forming a protective surface film of molecular proportions when the newly-exposed surface meets the atmosphere. This passive film, like human tissue, is capable of reforming over

* The technique of pressed metal is dealt with in greater detail in a special article beginning on page 291.



Left, examples of "Staybrite" steel mouldings drawn on hardwood cases. Right, a specimen showing how mitres can now be welded and finished so as to show no visible joint.

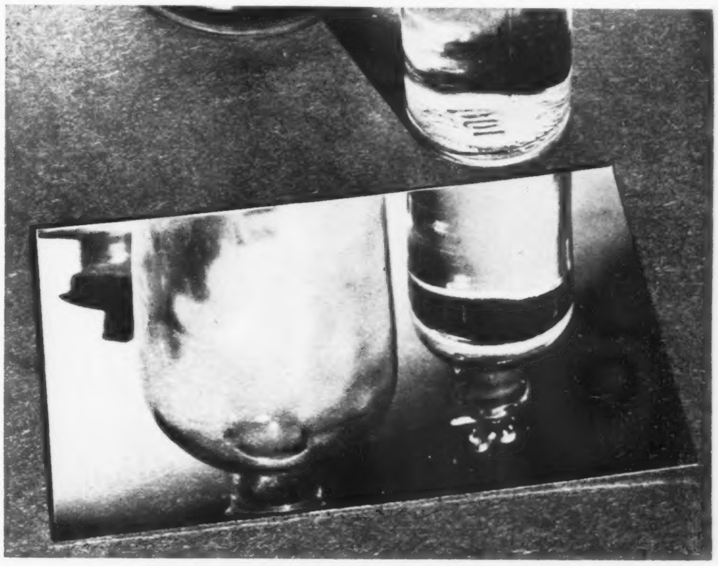
the surface if it is scratched or otherwise destroyed in any way, and it does this instantaneously. In considering this remarkable phenomenon, it should, however, always be borne in mind that the film is sub-microscopic and of only molecular thickness; and it should not be confused in any way with a separate metallic layer or coating artificially applied to the surface as in metal plating.

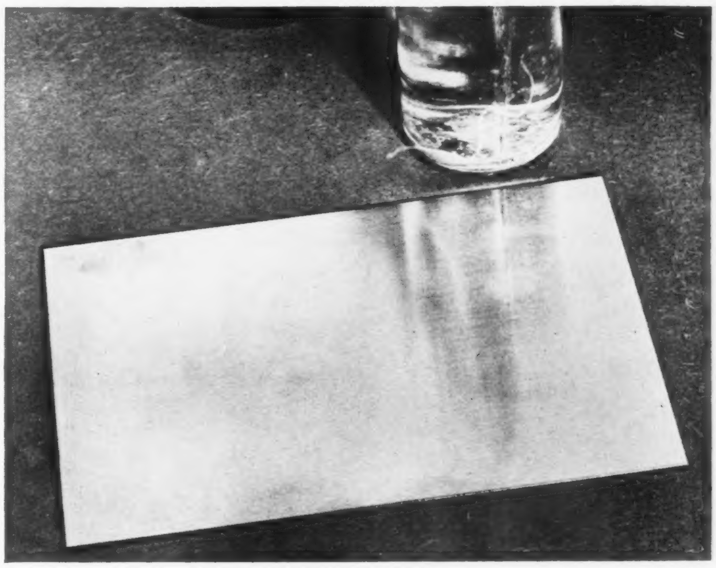
Austenitic chromium-nickel steels are resistant not only to ordinary atmospheric corrosion, but also to the attack of sea-water and even of acids. It is evident, therefore, that there is no risk of tarnishing in interior work, whilst external trim requires only that regular wash-down with soap and warm water which is given to glass: simply to prevent accumulation of the dirt and grease deposited from the atmosphere.

Stainless steel combines the toughness and strength of an alloy steel (40 tons/square inch tensile strength with an extension of 60 per cent. of the original length of the piece before fracture) with the workability of a non-ferrous metal. It is produced, for architectural use, in the form of sheets, strips and tubes of many sections in two finishes: either mirror or satin polished. The mirror finish is sometimes of value, but the soft satin polish is now more popular. In addition to the plain surfaces offered by the use of sheet and strip, a very wide number of sections are produced in the form of strip drawn on to wood backing, or rolled fillets, filled with lead. For balusters and decorative trim in general, tubes of different sections may be employed, whilst fittings such as door and window fasteners, lift gates, ornamental grilles and sun blind fittings are constructed either from bars, hot forged or cold wrought, or as castings.

Stainless steel may be used in almost any of the traditional ways in which one is accustomed to use wrought-iron or the non-ferrous metals. Like all new materials it presents problems of technique when first handled, but the natural increase of experience and the production of improved alloys has greatly simplified the working. As an example, the gateway by Reco Capey at Burlington House, combining wrought work with repoussé, shows the extraordinary intricacy of detail now possible. Incidentally it is one of the first important pieces of repoussé in the metal. For this purpose the metal is perhaps more difficult to work than

When first introduced stainless steel was generally highly polished, but the less well-known matt finishes are now technically possible. The two illustrations show, by means of the difference in the degree the bottles are reflected in the specimens, something of the difference in the texture obtainable.





other non-ferrous metals, but it has the advantage of strength and resistance to denting which was one of the causes of repoussé work dropping out of favour.

In America there has been considerable use of plain chromium irons, but these are not often used in this country, as they are more subject to corrosion than the austenitic steels, which alone should be used for architectural purposes. For most work an alloy containing 18 per cent. chromium and 8 per cent. nickel is used, but when the maximum ductility is required, it is usual to specify an alloy of iron with 12 per cent. each of chromium and nickel.

COPPER AND BRONZE

By A. G. McMullen

COPPER in its unalloyed state is prepared for manufacture in the form of cakes, billets, wirebars, ingots, and cathodes. Cakes of flat rectangular shape are for rolling into sheet and strip, round billets are for extruding and drawing into tubes, and wirebars are for rolling into wire. Cathodes (rough plates of copper direct from the electrolytic refining tank and lacking in mechanical strength), and ingots, unless remelted, are not used for fabrication, but for the production of alloys such as brass and bronze.

Sheet Copper

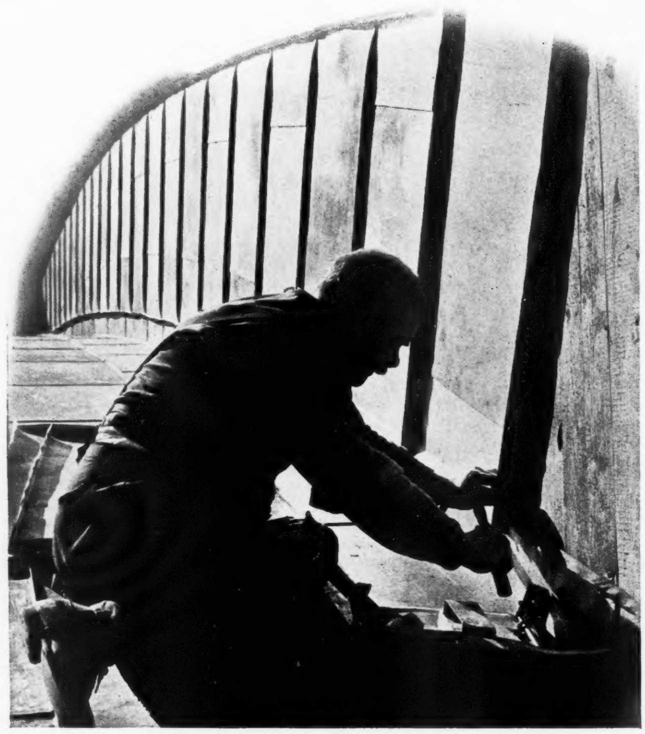
Cakes are converted into sheet by successive rolling operations in power-driven mills. The term " sheet " is generally applied to material which is more than 15 inches wide and which is cut to exact dimensions. All sheets are sold by weight and their cheapest form is in a basis area of 14 sq. ft. made up of any dimensions, (say 7 ft. by 2 ft. or 5 ft. 3 ins. by 2 ft. 8 ins.) and a thickness not less than 24 standard wire gauge (0.022 in.). Larger and/or thinner sheets cost more per lb. on account of their more costly production, but that is not to say that sheets of the basis area are necessarily the most economical size. For example, in roofing, larger sheets, though slightly more expensive in themselves, may show a total saving by reducing the number of joints and the labour of making them: 8 ft. by 3 ft. is a common size.

The cakes are first rolled red hot. Subsequent rollings are carried out with the metal in either a hot or cold state. When cold rolling is employed, the sheets are annealed, that is softened by reheating, between successive rolling operations to restore the ductility which is lost in cold working. Sheets finished by hot rolling are slightly rougher than those which are cold rolled, and the latter should therefore be used for any work in which a high polish is required with a minimum amount of effort.

Uses

Roofing and sheathing are the largest fields for the use of sheet copper in building, and it is unimportant whether the material is hot or cold rolled. If it is cold rolled it must be specified as " cold rolled annealed." In other words the temper is important, for the soft temper allows for the hardening which occurs when the metal is worked at joints, upstands, etc.

The traditional methods of roof jointing by " standing seam " and various types of wood rolls are based upon long experience of the



Fixing copper sheathing on the Horrbacka Girls' School, Stockholm.

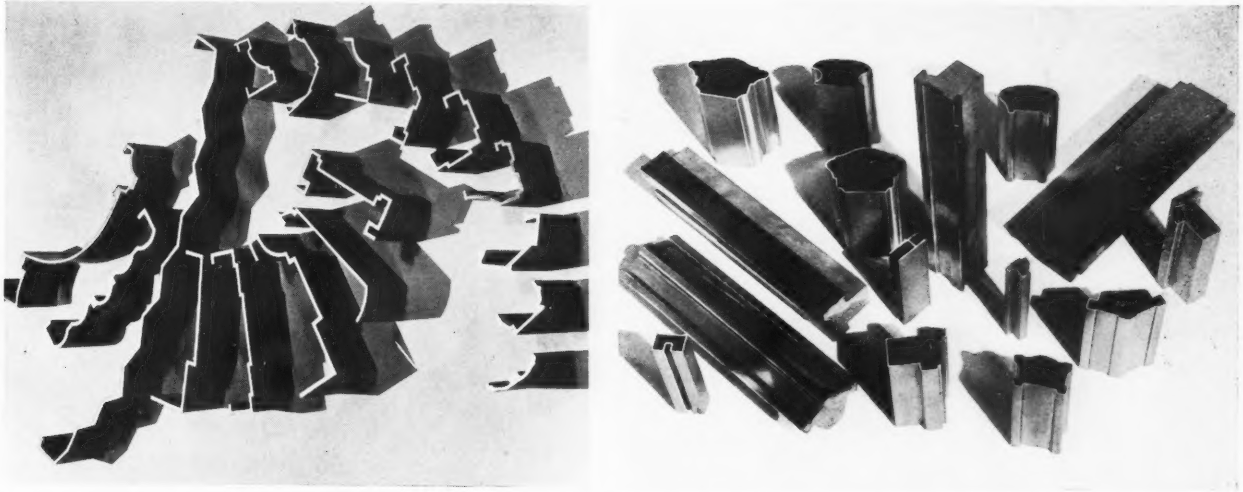
properties and working qualities of copper and need no further reference. From the design aspect, the chief points which stand out are these: (1) Copper roofing requires no drips, though drips are sometimes used to replace the usual double-lock cross welt at the head and tail of sheets. (2) It may be fixed upon any slope, from 1½ ins. in 10 ft. up to the vertical, without any fear of " creeping." (3) It may be fixed to a boarded roof or directly to concrete (an underlayer of felt is advisable in both cases). (4) It grows more beautiful with age by reason of its natural green patina. (5) Used in the customary 24 S.W.G. (16 oz. per sq. ft.) its weight is one-fifth of that of 5 lbs. lead—a fact worth consideration in large jobs where the effects of weight-saving in the covering may be apparent in the under-structure.

The suitability of the metal for the sheathing of vertical surfaces has given and will continue to give food for architectural thought. Experiments in completely copper-clad houses in America and Germany, the aims of which have been long life, absence of maintenance, and speed of erection, have so far fallen between the two stools of impractical details of construction and an unnecessarily conservative slavery to traditional design (see illustration on next page). As a sheathing to a brick-filled steel frame, copper was successfully used on the Vesterport building, Copenhagen, and although this is not "going the whole hog," there are possibilities in an all-copper "skin" preformed on, or applied *in situ* to, a cheap and quickly erected backing material.

To those impatient minds who find it hard to wait for the natural development of patina, it may be of interest that experiments have been made in accelerating its formation by artificial means. There is an open formula, perfected in America, for the spraying of copper *in situ* with successive coats of dilute ammonium sulphate, the success of which depends upon weather conditions at the time of, and immediately after, spraying, and the thoroughness of the preliminary cleaning of the metal. For these reasons the method obviously cannot be completely guaranteed, but some examples of the treatment in both

C O P P E R

The roof of the Chapter House of Liverpool Cathedral, covered in copper. Sir Giles Gilbert Scott, architect.



Bronze mouldings showing the difference between typical extruded types on the left and drawn types on the right. The possibility of linking together extruded units to make wide sections which would otherwise be difficult or extravagant to manufacture is illustrated by the largest of the sections on the left.

America and England, in which the above conditions have been fulfilled, have shown good results, and appear to be standing well the test of time. Those with an eye on large areas should go warily, for at present the full success of artificial patination appears to be more certain on small external areas such as cupolas, hoods, and small roofs, and to incidental internal decorative treatments of bronze or copper metal-work, where, in all cases, the process is easily controlled.

Strip copper

Sheet becomes strip when the material is produced in widths less than 15 ins., and of an indeterminate length up to 150 ft. or more, according to the guage. Strip is manufactured by cold rolling. To catalogue a few of the architectural uses of strip, mention may be made of damp-proof courses, flashings of all kinds, drips, valleys, cornice coverings, box gutters, and rainwater goods.

It is perhaps not generally realized that, used in 24 S.W.G., copper is a much cheaper material than 5 lbs. lead, and that there are no technical reasons against its use for flashings and the other incidentals mentioned above. For example, cement and lime mortar have no corrosive action on the metal. It is significant that in America and Scandinavia copper is much used even for many speculative houses—for all these incidentals and for rainwater goods.

In England the first cost of copper rainwater goods is considerably greater than that of similar goods in painted cast iron, but once installed their life is everlasting, and there is *no maintenance.* The Swedes have a highly developed technique for forming down-pipes, swan necks etc., from strip, but in this country a seamless drawn tube serves these purposes better. Gutters are, of course, folded up from strip to any required section. The fixing of both gutters and down-pipes can be particularly neat because no painting is required and down-pipes can be placed in chases in positions where damage to a pipe of any material is likely, such as in a loading bay.

Strip thinner than 0.006 ins. is usually called foil, and in thicknesses not less than 0.004 ins., can be produced by cold rolling in widths up to 12 ins. Greater widths cannot easily be obtained by cold rolling and only by electro-deposition can strips as wide as 30 ins. be manufactured in such small thicknesses as 0.004 and 0.003 ins. " Electro-sheet " of these dimensions weighing 2 or 3 ounces per sq. ft., has been employed in America and on the continent for " light gauge roofing " in which the strips are stuck down by means of a plastic bitumen. Electro-sheet is not yet produced or readily procured in England. Even if the production is developed here it is unlikely that light gauge roofing will replace the traditional methods and material, the architectural character of which it lacks, for buildings of importance. There are, however, possibilities in the use of foil as a protective finish to bituminous felt roofing and the cheaper grades of asphalte, for flat roofs not bearing traffic, and in buildings of an industrial or semi-permanent character. There are, too, obvious potential uses of foil for interior decoration when a satisfactory adhesive is forthcoming. At present, copper- and bronze-faced plywood and the spraying process known as " metallisation," provide the most satisfactory application for interior work.

Tubes

Tubes are manufactured from billets. The first hollow section is obtained by extrusion or by piercing a hole through the billet in a combined rolling and piercing machine. Extrusion is the process of *pushing* a billet of red-hot metal through a die. The first " hollow " is made by punching out the centre of the billet with a centre ram, and then extruding or squeezing out the rest of the billet through the annular space left between the centre ram and the sides of the die. Thereafter the tube, mounted on a steel bar, is drawn, or *pulled*, in its cold state through a succession of hard metal dies until the final bore, external diameter, and gauge of metal is achieved.

The accuracy of production now possible, and indeed demanded by the British Standard Specification for light gauge tubes (No. 659–1936), together with the invention and development of suitable jointing methods, has

Bronze welding on copper pipe for sanitary work. The cut section on the right shows the " swept " angles possible with this method.

Examples of the use of copper sheet. Top, a technique of copper sheathing, wholly new in itself but applied somewhat unfortunately to a typical German villa-type house. Centre, the figure of Martin Luther by Hans Wisse in the church at the Cologne Exhibition, showing the extent to which copper may be "raised" from the flat sheet. Bottom, Copper-faced plywood—used in this case for a door.

resulted in the substitution of light gauge tubes for the heavier gauges necessitated by screwed joints. The lighter gauges are amply strong enough for all the usual building purposes, such as hot and cold water supplies, heating and sanitation.

Compression joint fittings are now well enough known and accepted in their many forms. The capillary soldered joint is rapidly becoming a strong competitor in this country while in America it is definitely the most favoured. American and English experiences to date have proved this type of joint, in its various modifications, to be entirely satisfactory for small and medium sized tubes in the general run of building work where high stresses and vibration are unlikely. The Americans have extended the method to cover sanitation, manufacturing the fittings for soil pipes of 4 ins. diameter and larger, and including the necessary swept junctions in the range of capillary soldered fittings.

Development in this field has been made possible by the perfection of the process known as bronze welding which, in technique, lies between brazing and welding proper in that a bronze filler rod is used, the material of which is built up locally in the flared socket of the joint and is not caused to flow simultaneously over the wider area of the tightly fitting surfaces of a brazed joint. The advance in oxy-acetylene apparatus, and the correct composition of fluxes and of filler rods, with a melting point considerably below that of copper, have made this process both successful and economical. Several large one-pipe installations have been erected in London and elsewhere and these have amply demonstrated the advantages of lightness, and saving of space. The flexibility in the arrangement of the joints and the lightness of the pipe-work enables repeating batteries to be assembled on the bench and hoisted into position. The space saved by the smaller external diameters, absence of fitting lugs, and the closeness with which the pipes may be fixed to the walls of ducts, etc., has amounted to as much as the area of a "flatlet" in a large block of flats—no mean saving to clients who wish to squeeze the last inch into, and the last pound out of, the building.

Autogenous or fusion welding proper can, of course, be employed in exposed positions where a high finish in the natural metal, or plating, is required. The joints are then buffed down and are imperceptible as in tubular furniture of copper or copper-alloy.

COPPER ALLOYS

Copper alloys are manufactured into sheet, strip, tubes and architectural sections by processes similar to those employed for pure copper.

To the average architect the mention of "brass" summons up a mental pot-pourri of Victorian bedsteads, curtain rods, and candlesticks, while "bronze" evokes a more depressing symposium of Bank and Post Office metalwork and "B.M.A." door knobs. I would make a plea for brighter bronzes in architectural metalwork. There is in fact a wide range of very beautiful colours and finishes available. The so-called architectural bronzes are really mainly brasses or copper-zinc alloys, for bronze proper is a more expensive copper-tin alloy. The various colours are obtained by varying the proportion of copper to zinc, by adding a small percentage of another metal to the copper-zinc basis, or by combining copper with some metal other than zinc. Working from light to dark, there are the silvery colours of the "nickel silvers" (copper-zinc-nickel); the pale gold of brass containing 60 per cent. copper, 40 per cent. zinc plus ½ per cent. aluminium; the rather greener gold of the ordinary brasses (60–70 per cent. copper, remainder zinc); the golden colour of aluminium bronze (5 to 10 per cent. aluminium, remainder copper), the richer golds of the "gilding metals" (80–95 per cent. copper, remainder zinc) and phosphor bronze (copper-tin); and for those that like them, the much darker tones of "penny-bronze" (60/40 per cent. brass and 1 per cent. manganese) and the naturally or artificially tarnished surfaces of the brasses and gilding metals, which supply a large range of golden, green and red browns.

For castings, in which clear-cut profiles are required, a copper-tin alloy is the most satisfactory. Small percentages of lead and zinc may be added to the copper-tin basis for greater ease in machining if required. A typical composition often used for cast statuary, ornate door panels, plaques, etc., and for cast fittings, is 85 per cent. copper, 5 per cent. zinc, 5 per cent. lead, 5 per cent. tin.

For easy extrusion and forging by hot-stamping, brass, of which the basis composition is 60 per cent. copper and 40 per cent. zinc, is best. As the copper content increases extrusion becomes more difficult, so that architectural sections in the gilding metals have to be cold drawn from tubes or strip and for that reason lack some of the crispness of moulding characteristic of extruded sections.

In the form of sheet and strip the alloys in greatest use for decorative purposes are the gilding metals and the brasses, which allow easy folding into simple profiles.

The alloy products in greatest demand in architecture are extruded and drawn sections. Extruded sections are limited in width to about 6 ins., but can be built up by interlocking (see illustration, page 263), which is made possible by the accuracy of the extrusion process. Only "open" sections can be extruded and an apparently "closed" section, such as a handrail, has therefore to be built up of two open sections, or to be extruded open and afterwards closed up, when the scarcely perceptible joint can be arranged where it does not show. The thickness of extruded metal cannot be less than $\frac{1}{16}$ inch. Sections with thinner metal have to be drawn down from the original extruded section, folded up from strip, or, if of the closed type, drawn from an original tube. Extruded sections are generally supplied in lengths from 6 ft. to 12 ft., while drawn sections are usually limited to about 18 ft. for convenience of handling. Sections drawn from strip may be mounted upon hard wood cores, which give greater stiffness and often enable an invisible fixing to be obtained.

Extruded sections, having greater thickness and strength, may serve a definitely structural purpose. The actual strength, of course, varies with the alloy. For example, a tensile strength as great as 30-45 tons per square inch may be obtained with certain manganese bronzes. As all sections are sold by weight, it follows that the most complicated section costs little more than a simple one. This must surely warm the hearts of those who have sometimes found simplicity expensive. There are a large variety of stock sections, though it will generally be found that a purpose-made section costs little or nothing more if the order is of a fair size.

Extruded sections, if left untreated, have by nature a matt surface. For instance, "penny-bronze" finish is the natural matt manganese-oxide tarnish which is formed upon extrusion. On the other hand, drawn sections come from the draw bench with a bright surface.

The question of exact finish and its maintenance is the province of the architect and client. A highly polished surface out of doors will require more upkeep than a matt satin finish. In the United States and also in Germany, satin finish is widely employed on the gilding metals. It does not tend to show smears in the same way as a bright surface and requires only a periodical washing with soap and water, which is necessary whatever metal is used. A rub with car polish after cleaning will help to keep the finish. Lacquering serves little useful purpose out-of-doors in town atmospheres, but for interior fittings subjected to little wear and tear it has obvious advantages.

Space does not permit further enlargement on this subject, though much could be said of cast and spun metalwork and all those incidentals of interest to architects, from lightning conductors to fly screens and curtain tracks, in the manufacture of which copper and its alloys play so great a part.

NICKEL SILVER AND MONEL

By R. G. Rengert

The term "nickel silver" includes a wide range of alloys, all containing copper, nickel and zinc, which have been in regular use, throughout the world, for many years. The earliest known alloy of this class was produced by the Chinese many hundred years ago but it was not until the eighteenth or nineteenth centuries that nickel silvers became known to and adopted by European craftsmen.

In the earlier days of their development these alloys were known by the general term "German silver" and as such were used for spoons and forks and for "fancy goods" such as trinket boxes and candlesticks, often in highly intricate designs.

When electroplated ware became popular a hundred years or so ago, nickel silver became a favourite material for use as the base metal for silver plating and the frequency with which the letters E.P.N.S. are seen today is a reminder that large quantities are still absorbed in this way.

Within the last ten years or so, there has arisen a further use for nickel silver in the visible metalwork of buildings. The illustrations on this page indicate typical uses to which it is put in present-day architecture.

The alloy has been known by many names; silver bronze, nickel bronze, white metal, and German silver, although this has now dropped out of favour. The term nickel silver is now most widely used and has therefore been adopted for this article.

In the numerous alloys described as nickel silver the exact proportion of each constituent is governed by various considerations such as colour, corrosion-resistance, ease of manufacture, etc., required. Alloys for architectural work contain something between 10 and 20 per cent. of nickel.

Appearance

In present-day architecture, applied ornament, if permitted at all, is kept within strict limits, the architect relying for effect on the colour and texture of the material he uses. The natural appearance of a metal is, therefore, of greater importance than ever before.

The colour of nickel silver varies from a pale straw colour, with a low nickel content, to a pleasant white colour, with a high nickel content. The colour is soft and refined and has none of the hardness associated with some white metal finishes. Its best effect is brought out by giving the metal a sand-blasted or satin-finish, although if required the metal can be given a high polish.

The colour of the alloys is such that very satisfactory combinations can be made either with the brown bronzes, or with most types of natural wood work.

An interesting example of the possibilities of these contrasts is provided by the balustrading at the R.I.B.A. Building in London. Here the handrail is in nickel silver blended with brown bronze and surmounted by an ebonized hardwood capping. The balustrade consists of decorated and illuminated glass panels held in nickel silver uprights.

Rolling Monel metal sheet.

Durability

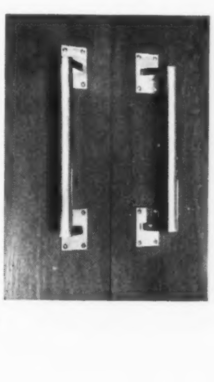
Nickel silver has a high degree of durability, an essential characteristic for architectural metalwork.

It is a solid metal and cannot, therefore, suffer from peeling, stripping or wearing away of the finish as badly plated metals frequently do, and the surface is not destroyed when small alterations and adjustments have to be made in the course of erection.

Nickel silver is held in stock in the form of sheet, strip, rod, castings and extruded sections. Extruded sections, of which there is a very large range available—from simple rounds, squares and hexagons to complicated interlocking shapes—will be found particularly suitable for building up balustrades, screens, grilles, handrails, doors, etc.

The metal presents no difficulties in drilling and machining and may be readily joined by the usual methods. Even heavy sections will take a considerable amount of bending without cracking.

Two examples of characteristic uses of nickel silver alloys. Left, a grille in the caretaker's office at Hornsey Town Hall designed by R. H. Uren. Right, door handles in 20% nickel silver.



Uses

When considering the use of nickel silver for work exposed to the weather it should be borne in mind that regular cleaning will be necessary if the metal is to retain its bright appearance.

The use of nickel silver for plumbing fittings calls for special mention. In recent years the material has been adopted widely for taps, towel rails and similar sanitary fittings in office premises, hospitals, public buildings, hotels and in fact for any type of building in which the fittings are likely to receive extra hard use, and for which a plated surface is not considered advisable. While plating is a sound finish for many purposes, its very thinness, from one ten thousandth of an inch to one thousandth of an inch, must render it liable to damage where there is risk of coarse scouring powders being used for cleaning purposes.

A nickel silver containing 18-22 per cent. of nickel has a good white colour which shows up well against the intense white of the fireclay with which plumbing fittings are generally used.

Taps of nickel silver will retain their original brightness after many years constant use.

An interesting example of this point is the use by the Birmingham Corporation of nickel silver for many hundreds of dwelling houses built under slum clearance schemes. Taps neglected by bad tenants, it was found, could be reconditioned quite simply and without removal.

MONEL METAL

Monel is an alloy of nickel and copper, containing approximately two-thirds nickel. It has been used in the engineering industries for some thirty years and its use has now been extended to the building trade.

Monel combines good strength properties—its strength is slightly greater and its toughness considerably greater than that of mild steel—with a remarkable resistance to attack by a wide range of corrosive materials. It has a good white colour, matching very closely that of standard silver.

Uses

The commonest uses for Monel in the building trade are found in kitchen equipment.

Monel is an excellent material for the tops of preparation and serving tables, ranges and, in fact, for all working surfaces. It resists corrosive attack by foodstuffs and anything else likely to be used in the kitchen. It is easily kept clean, it has no coating to chip or wear off and is not damaged by heat.

The range of standard sinks made throughout of Monel, suitable for general kitchen work and for bars and buffets also, is now well known.

ALUMINIUM

By R. W. Brooke

Fifty-three years ago, in 1884, a nine-inch high pyramid of aluminium was placed on the peak of the Washington Monument in the United States. This small 100 oz. casting of what was then considered a precious metal was claimed in a contemporary book to be " the largest piece of this metal ever cast in any country." Nine years later Sir Alfred Gilbert's statue of Eros in Piccadilly Circus was cast in aluminium and is probably the most intricate, apart from being the most beautiful, casting that has been made in the pure metal. These are among the earliest known uses of aluminium in architecture and bear witness to the ability of this comparatively new metal to withstand exposure to all kinds of weather. Both these early applications were made from commercially pure aluminium but since that time a number of aluminium alloys have been specially developed for architectural purposes. These alloys give still better resistance to weathering conditions and at the same time have increased strength and are easier to fabricate.

Aluminium welding. Fixing a flange to a large diameter tube.

Characteristics

Every metal has its own particular properties and it is only by a clear understanding of those properties both from the application and manufacturing standpoints that the best and most economical use of the metal can be made. The increasing use of aluminium and aluminium alloys in the building industry depends chiefly on the following characteristics of the metal. It is light in weight, the density (.098 lb. per cubic inch) being about one-third of that of other commonly used metals, such as steel, copper, bronze, etc. This quality of lightness makes it easy to transport, handle and erect, increases the practicable size of castings and extruded sections and in many cases simplifies the necessary structural supports. It is available in any quantity in every form in which metals are produced. It can be cast in sand or as gravity die castings or pressure die castings. It can be extruded through dies into lengths of simple or intricate section, from various types of moulding up to large structural shapes. It can also be drawn into square, round or streamline tubing. It can be rolled into plate, sheet, strip or foil. It can be forged, spun, pressed, handwrought, machined, polished and welded or riveted. There are a number of well-known alloys available with strengths ranging from 5 tons per sq. in. for the soft annealed commercially

ALUMINIUM

The Municipal Stadium at Cleveland, Ohio. Sheet aluminium is used for the louvre construction, as well as sheet and extruded mouldings for flashings and for the cornice light troughs. Walker and Weeks, architects.

pure metal up to 25 to 30 tons per sq. in. for certain of the heat-treated alloys. It is ductile and can be easily formed and cold worked. Its resistance to atmospheric corrosion is remarkable and even when attacked the products of corrosion are colourless and do not streak or stain any surrounding surfaces. Various finishes can be produced on the metal, of which the chief is the anodic treatment process whereby the resistance to corrosion, wear and abrasion is increased and the decorative appeal enhanced. Finally the metal is low in cost as a building material and its adoption eliminates painting, except in very special circumstances, and reduces maintenance costs to a minimum.

Eros: cast in 1893 within a few years of the first successful commercial production of aluminium. It is still probably the most complicated casting in the pure metal.

Though the commercially pure metal (over 99 per cent. pure) is widely used in the form of sheet and extrusions, it is not easy to cast, and both for castings and other cases where higher strength is required the metal is used in the form of various alloys. Of the aluminium alloys employed for architectural work those containing small percentages of silicon, manganese or magnesium are the most often used. The heat-treated aluminium copper alloys are generally only adopted where the maximum strength is required. There are a number of cases where aluminium alloys, owing to their light weight and other qualities, permit fabrication in metal which would otherwise be impossible. For instance, aluminium castings weighing up to 120 lbs. have been used externally on a number of buildings where similar castings in other metals would weigh up to or over 400 lbs. and would require special handling equipment.

Design Considerations

There are three points which should be remembered when designing for aluminium. First the coefficient of expansion of aluminium is higher than that of steel, copper, bronze, wood or glass and due allowance should be made for expansion and contraction where differences in temperature will be encountered, particularly where long lengths of sheet or extruded sections are used. Slip joints are often used or, where caulking is required, a plastic caulking material is specified. Secondly, the modulus of elasticity of aluminium and its alloys is about one-third that of steel and about two-thirds that of copper and the deflections of a beam under a given load will be inversely proportional. It is only rarely in architectural applications, however, that this property becomes of importance and in cases where minimum deflections are required they can be obtained by increasing the depth of the section while still saving at least one-half the weight compared with other metals. The third precaution to be taken is that dissimilar metals should not be in contact when the joint is liable to be exposed to moisture. Under such conditions galvanic corrosion may occur. To prevent this it is generally sufficient to use an insulator such as bituminous paint, varnish or lacquer, or to place fibre strips between the two metals. In some cases where steel is in contact with aluminium it is advisable to use galvanized or cadmium plated steel. The same precaution applies to aluminium in contact with wood. The moisture from the wood may promote attack on the metal but this can be avoided by painting the wood or aluminium with a suitable paint.

Though dry concrete or mortar has no effect on aluminium the same materials when wet may cause slight corrosion. To overcome this and at the same time to ensure a thorough bond when the metal is embedded in wet concrete it is advisable to protect the aluminium with paint or varnish.

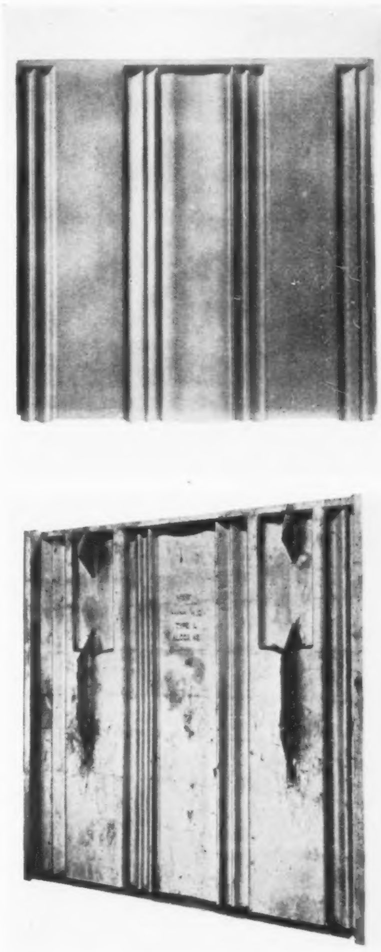
Castings

Aluminium alloy castings have been adopted for both internal and external decorative work, and among their applications are spandrels, grilles, statues, radiators, window cills, lighting fixtures and various fittings, such as door knobs and handles, window latches, etc. In tonnage, the biggest use has undoubtedly been in the form of spandrels, this term being used to mean the connecting link between windows from the cill above to the window head below. Particularly in the United States, these have been utilized on the facades of buildings originally for their ornamental effect but recently both for this and for structural considerations. Aluminium spandrels of simple or intricate design can be cast in thin plates of $\frac{3}{16}$ in. average thickness which are light in weight, easy to handle and erect, and materially reduce the dead load on the structural framework. A normal size for spandrels is 4 ft. by 5 ft. though larger sizes are sometimes used. The castings are sufficiently ductile to simplify fitting and have a high resistance to corrosion. One group of buildings in New York has 17 per cent. of its external surface in aluminium, largely in the form of spandrels, the total weight of metal being over 1300 tons, the equivalent in volume and cost to over 4000 tons of other metals. Recently, certain alloys have been developed which are specially adapted in the form of castings to the alumilite and other anodic treatment processes and these have been used, not only in buildings but on board ships and in railway trains.

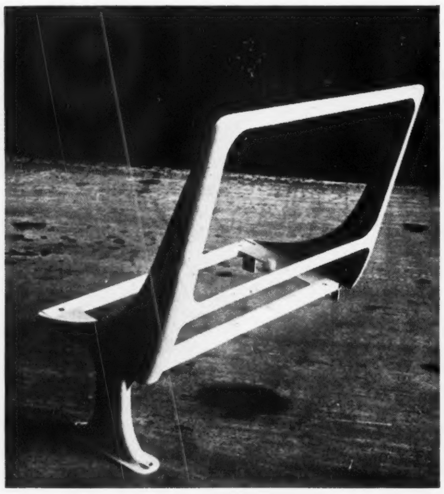
Extrusions

The extrusion process in which heated cylindrical billets of the metal are forced under hydraulic pressure through openings in dies is especially favourable for aluminium and its alloys. The metal is sufficiently plastic when heated to flow easily through dies of intricate section giving straitened lengths up to 32 ft. of extruded material with excellent surface finish and sharp corners. Aluminium alloy extrusions are used for casement sections, door frames, door plates, mouldings of all kinds, shopfront sections, handrails, louvres, step edgings, and for a great variety of angles, channels, rounds, squares, hexagons, etc. Sections can be designed so that they interlock with each other, thus simplifying erection. Extruded material is economical in use as the cost of the dies is small and there is an infinite variety of design.

When designing sections which will be extruded in aluminium it is advisable that the minimum thickness of the shape should be not less than $\frac{3}{64}$ to $\frac{5}{64}$ in. for sections up to 3 in. maximum dimension, or less than $\frac{1}{8}$ to $\frac{1}{4}$ in. for sections of 8 in. maximum dimension depending on the alloy used. Although very thin sections can be produced by cold drawing the extruded shape through a die, the cost is increased and there is greater danger of damage during finishing and erection. A thicker section is not only easier to extrude but has a better finish and in the long run is more economical. Designs having re-entrant



Back and front views of a cast aluminium window spandrel, a use of the metal which has been more fully developed in America.



As with iron (see the series of examples on page 258) the technique used in working aluminium must, to be logical, fundamentally affect the design produced. Left, an early American cast aluminium chair, which, if not beautiful to present taste, does at least exploit the casting process to the full. Centre, an example of modern casting. This design (a bus seat frame) could, perhaps, equally well have been welded up from angles and plate of the same metal. Incidentally, it is doubtful if any other metal could have been used to give such long thin sections in the cast form. Right, a welded tubular bus seat frame, utilizing the strength of high-tensile alloy tube.

or deep tongue sections require either special support for the die or else the material has to be cold drawn to shape after extrusion. With these limitations as to thickness and shape any section can be produced which can be contained within an 8 in. diameter circle, while in certain cases still larger sections are practicable.

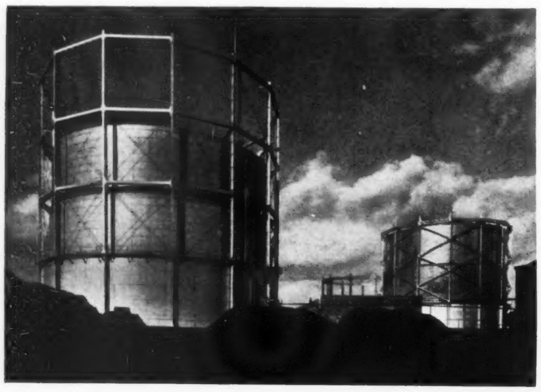
The unique opportunities offered by the extrusion process have on the whole been insufficiently appreciated by designers. Long lengths of extruded material are not only useful in themselves in fulfilling a number of functions with one section, but should also be considered as stocks for cutting into short pieces. For instance lever type door handles, instead of being cast can be cut from a length of extruded material of suitable cross section. Door handles for desks and cupboards can be made by cutting 3 in. to 4 in. lengths from an unequal limbed U shaped section. Window sills of any desired length can be cut from standard extruded sections. It is also worth stating that extruded material is an ideal basis for the anodic treatment process.

One of the predominant uses of extruded aluminium is in the construction of window frames of all types. Aluminium alloy window frames are strong, light, attractive in colour, do not require painting and are reasonable in cost. Among many installations they have been used in this country for the windows of the Cambridge University Library and for the Gerrard Street Post Office, London, and have been specified for the new Bodleian Library building at Oxford.

Sheet

The applications of sheet aluminium in the building industry are too numerous to deal with in detail. Broadly speaking sheet metal is used either to cover large flat areas or as stock from which various articles can be formed by the stamping, pressing and drawing processes. Typical of the former use are aluminium alloy doors built up from heavy gauge sheet and extruded sections, metal coated plywood for doors and panels, several types of aluminium roofing, heating panels, fascias, and all metal facades for buildings. The light weight, durable and attractive finish, and economy in first cost, erection and maintenance are the factors which influence the adoption of aluminium sheet for these purposes. The same factors are likely in the future to further the application of metal in the construction of walls and may render practicable prefabricated houses. In modern buildings the exterior walls are structurally unimportant except for protection and insulation. These purposes can be served by curtain walls, 4 in. or less in thickness, built up from metal and insulating material, the weight of wall and insulation averaging 10 to 25 lbs. per sq. ft. Aluminium sheet has been used with success in this type of wall, which has resulted not only in greater net rentable area, but a reduction in the structural steel framework necessary, and economies in cost and time of erection.

Sheet aluminium as a basis for the manufacture of various articles is rather beyond the scope of this survey. The various metal-forming operations such as spinning, pressing, drawing, etc., are, however, specially suitable for aluminium and its alloys and there is the additional advantage that the anodic treatment process offers a wide and attractive range of finishes. Lighting and heating fixtures in particular are often fabricated out of anodized sheet and in recent years the Alzak and Brytal processes for the production of highly reflecting, non-tarnishing surfaces on aluminium have opened up new possibilities in this direction. Though sheet aluminium has been used in the United States in very large quantities for the manufacture of chairs, it has not as yet been employed in England for this purpose, and present indications are that extruded material is more likely to be adopted here.



Two further uses of aluminium in building: above, as aluminium paint; right, in the form of foil for thermal insulation.

Foil

Although castings, extruded sections and sheet are the chief forms in which aluminium is used for architectural purposes there are two other applications of the metal which are of interest. Aluminium foil has a very highly reflective surface and advantage is taken of this fact in insulation where successive layers of crumpled or plain foil provide an exceptionally good heat insulating material. Not only is the weight of aluminium foil insulation negligible compared with other insulating materials but there is an absence of fire hazard and the insulation is moisture-and vermin-proof and easy to install. Aluminium foil as an insulating material has been in service now for a number of years in all climates and there is an increasing demand for it for the insulation of buildings.

Powder and Paste for Paint

Finally aluminium is used in the building industry for the production of aluminium paint. Until recently the minute thin flakes of aluminium used for paint were only available in the form of dry powder. But in the last few years a new method of manufacture has been developed by which the flakes are formed in a mixture of mineral spirits and the product sold in the form of aluminium paste suitable for mixing with various media for the production of paint. Aluminium paint prepared either from powder or paste has the remarkable property of " leafing ". The thin metallic flakes rise to the surface and overlap each other like fallen leaves, yielding a bright, highly reflecting, metallic surface, resistant to moisture, sunlight and corrosive conditions. The paint is extremely durable, light in weight, has a high covering power and remarkable opacity. Aluminium paint is used both for its protective and decorative qualities. After exhaustive tests in America it has been shown to be pre-eminent as a priming coat on timber, affording not only better protection to the wood but a longer life for the finishing coats applied over it. It can be used for interior and exterior application on almost every type of surface.

Anodic Treatment

Although in other countries, particularly in the United States, aluminium was used in large quantities for architectural work before the anodic treating process became well known, in Great Britain the increasing use of aluminium has coincided with the development of this process. Information on this process is given in the article on ***The Finishing of Metals*** and here it need only be said that while the process is applicable to the majority of aluminium alloys, certain alloys and processes have been specially developed to give the best results, and architects are advised to obtain particulars of these alloys from the manufacturing companies.

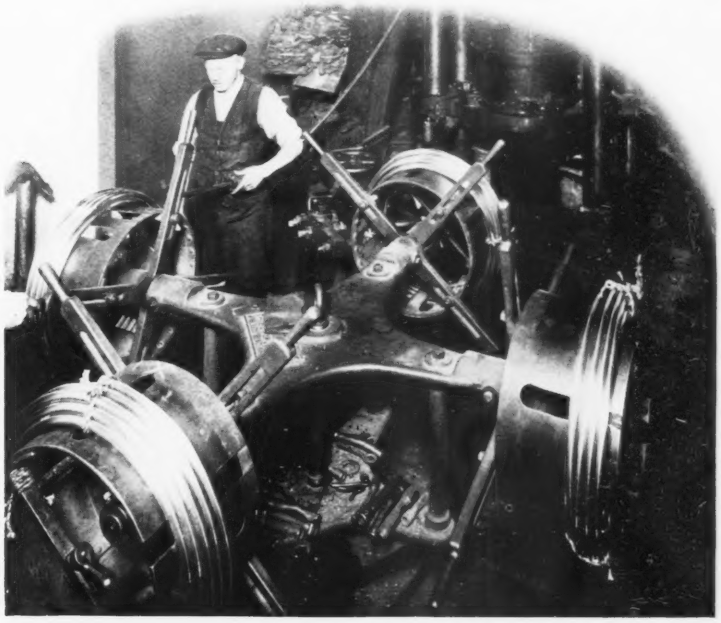
Where the highest quality of anodic finish is required the design should avoid welded joints. Only very expert welding technique and subsequent treatment of the weld can prevent slight variation in colour at the joint after anodizing.

Maintenance

One point of general importance remains to be mentioned. All materials of construction, including metals with their highly finished surface, when exposed to the atmosphere accumulate deposits of dirt. Even a surface such as glass collects dirt and glass windows need periodic cleaning. The accumulation of dirt on metal and other materials, while less noticeable in the early stages than on glass, is of greater ultimate consequence since the deposits, if allowed to remain, will not only disfigure but may cause corrosion of whatever material they rest on. It is easier and more economical to maintain a given finish by simple cleaning than to restore it after years of neglect.

LEAD
AND PEWTER

By E. L. Bird



Extruding and coiling lead pipe

In its traditional form lead is a cast product, but today its use in that form is mainly confined to ornamental work. The two principal forms are milled sheet and drawn pipe.

Lead is delivered from the mine in ¾ cwt. pigs and is called " virgin pig "—a term to distinguish it from metal containing remelted scrap. The pigs are melted and cast into flat blocks about 8 ft. square and 7 ins. thick. These are passed under heavy rollers some 25 to 30 times, until the thickness is reduced to 1 inch. The resultant sheet is then cut up into various lengths which are rolled again down to the commercial thicknesses. The process of rolling gives milled lead a crystalline structure different from that of cast lead.

Until the year 1797, pipe was made by bending sheet lead into a round, oval or square form and joining it with a soldered seam. Roman pipes so made are still in use in the mineral baths at Bath. The modern process is one of extrusion, or drawing, and results in a seamless pipe. Molten lead is poured into a hydraulic press and allowed to cool to about 500°F., when it is in a " malleable " state. The bottom of the press is then forced slowly upwards extruding the lead through a die which contains a central core. The resultant pipe is coiled immediately ready for sale. An ingenious form of press allows traps to be made by the extrusion process.

There is a fallacious belief that modern lead is not so satisfactory as old lead. This possibly arises from the occasional use of scrap lead mixed with virgin pig for making sheet. Scrap lead may contain other metals, such as the tin in solder, resulting in what is known as " hards." The presence of " hards " makes sheet lead liable to crack when bossed or otherwise worked. Most reputable manufacturers, however, use only virgin pig lead for making sheet. Similarly, there is a belief that old lead containing silver is better than the modern desilvered product. The presence of silver—in any case the proportion is very

Early examples of the use of lead: left, an Egyptian archaic lead figure from the British Museum—probably the earliest example known; right, a primitive lead ornament of monetary value.

small—makes no difference to the wearing or working qualities of the lead. The belief is doubtless due to the fact that old lead was used in cast sheet at least half an inch in thickness. The wearing qualities of old lead roofs (as on churches) is in fact due to the excessive thickness used, and not to the presence of silver.

Lead is heavy, soft enough to be cut with a steel knife, and very malleable. It can be worked to almost any shape, the process of working bringing about a change in the relative positions of molecules, so that internal stresses are not set up in the material.

It has a low melting point (621°F.), alloys easily with certain other metals, and is a good electrical conductor. It is an inert material and is unaffected by moisture, or atmospheric attack, except in the formation of a protective oxide skin. Its resistance to corrosion makes it suitable for lining vessels containing acids. Finally, it resists the penetration of X-rays.

Sheet Lead in Building

In building, the chief function of sheet lead is the exclusion of moisture. It may be in large areas as on roofs, or in small pieces at the innumerable " joints " of a building. Typical " joints " are the bases of chimney stacks and parapets, dormer abutments, the sides of skylights, the penetration points of vent pipes, flagpoles, etc. The admirable working qualities of lead, no less than its imperviousness and stability, make it the most suitable material for protecting " joints " of the most complicated shapes. The more typical flashings are well known, and as they can be found in text books, need not be dealt with here. The more unusual flashings, however, often call for considerable ingenuity and skill on the part of the craftsman. Not infrequently these plumbing problems are created by insufficient consideration of roof geometry by architects. The development of lead burning has recently simplified greatly the more awkward of these problems.

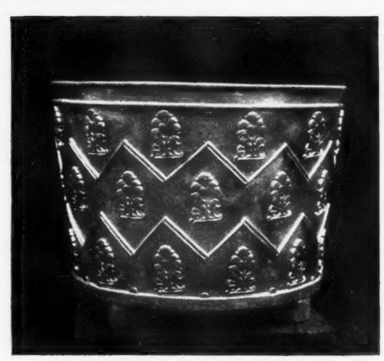
There are two conditions to be observed in designing and fixing sheet lead work. The first is prevention of capillarity by providing breaks in the capillary planes, that is, between adjacent lead surfaces, and the surface to which sheet lead is fixed. This condition and its application are sufficiently well known. The second condition is the prevention of creep resulting from thermal movements. The customary joints between sheets are designed to absorb these movements. It is not, however, generally realized that where lead is fixed on vertical or nearly vertical surfaces, defects from thermal movements are more likely to occur. Expansion plus weight is counteracted by contraction minus weight, and the consequent movement frequently results in the lead tearing. The secret of sound vertical fixing is to keep the unit pieces of lead small, plus a generous provision of secret tacks.

Lead is also used to prevent the movement of moisture in walls, both as dampcoursing and over openings in cavity wall construction. It is important in this connection to observe that new Portland cement mortar has a corrosive action on lead. The interleaving of lead with bituminous sheet in certain proprietary dampcoursings obviates this risk. Otherwise it is desirable to set and point lead in brickwork with lime mortar, or to protect it with bituminous paint. Lead is similarly corroded by certain gypsum plasters. Where lead pipe or lead sheathed electric wiring is in contact with such plasters, they are best protected by wrapping with bituminous sheeting, or painting with bituminous paint.

A recent important new use for lead in building is as a vibration absorbent. Pads of sheet lead either alone or combined with asbestos fabric are sometimes used under stanchion bases to absorb traffic vibrations. Lead is also used to prevent the transmission of vibration and noise from machinery to structures. For example the fixing bolts of lift machinery and guides are set in lead pipe let into the brickwork, or concrete (a very successful use is at the Dorchester Hotel).

Lead Pipe in Building

The first use of lead pipe for water supply work is lost in prehistory. A piece of lead pipe will, moreover, continue to perform this function indefinitely. There are two fixing requirements; the pipe must be adequately supported, and also protected against frost action. On this last question some recent research work by the British Non-Ferrous Metals Research Association arrives at the conclusion that by far the best preventative of frost bursting is intelligent planning and layout. Much could be learnt from American practice. In this country a domestic rising



Right, a cast lead tree pot designed by Stanley Hall, Easton & Robertson. Above, the pots modelled in sand just before casting. The " patterns " or models of the units from which the design is built up can be seen in the centre of the table. After casting the flat sheets are bent round and the joint lead-burned to form the pot. This technique of forming the pattern on the flat is characteristic of cast lead work, and is not used with other metals.

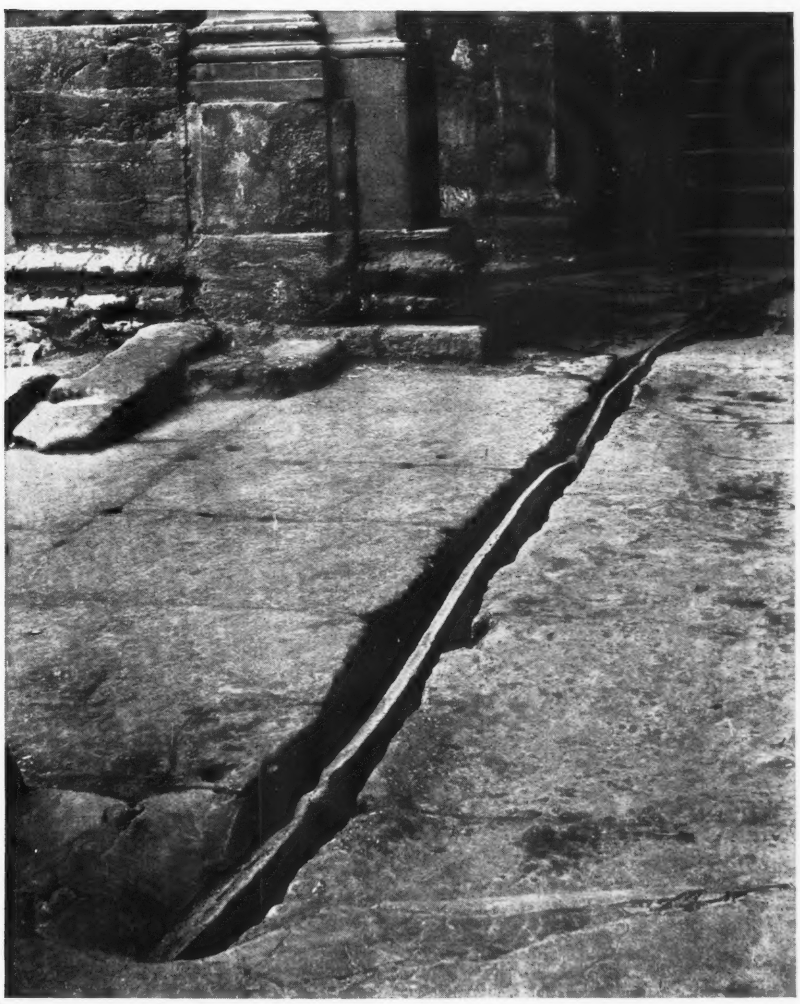
main is commonly taken up on the inside face of an external wall, exposed at the eaves sometimes even to the outside air, and carried across the joists of an open roof to a tank that is situated with no regard for warmth. In America the main is customarily carried below ground to a chimney stack up which it passes to a tank protected by insulation and so situated that it receives warmth from the stack. It is worth noting that the two layouts in a similar building use the same amount of pipe. Central heating is, however, the best preventative of frost bursting. It is desirable in any case to make provision for draining the rising main, the draw-off branches and the hot water system in case the building is unoccupied in cold weather.

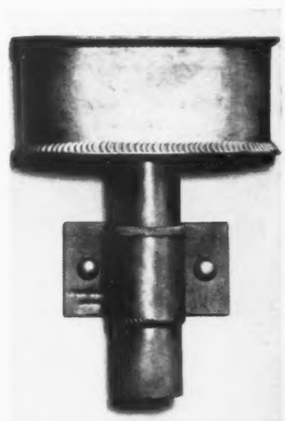
Certain soils, luckily not occurring very commonly, are liable to corrode lead buried in them. Peaty soils, some clays and made-up ground containing coal residues are the most dangerous. Preventive measures are spiral wrapping of the pipe with bitumen-impregnated felt, packing with chalk, limestone or old mortar or enclosing the pipe in troughs of creosoted or tarred wood.

The use of lead pipe in sanitary work is so well established and the technique of use so thoroughly understood that discussion here is hardly necessary. The principal feature of present day plumbing is its concealment. This has only been established as practice after all sorts of opposition have been overcome. The plumber liked his efforts at craftsmanship to be on view. The sanitary inspector objected to hidden wastes as being hard to inspect. A form of mental laziness in architects and builders led them to design the plumbing layout (or just to let it happen) after the building carcase had been completed. Concealment of plumbing requires consideration of every pipe by the architect in the early drawing-board stages of the job.

Concealed internal plumbing, as in bathrooms, is now common practice. Enclosed baths and pedestal basins have greatly helped in this. In large lavatories it is now usual to enclose behind inspection panels the mass of wastes, antisiphonage pipes and supplies below the basins. But enclosure of the main soil and waste systems inside the building is by no means established practice as yet. It is true that the pipe shaft for tall buildings is allowed by the London County Council and certain other authorities, but with the great majority of local authorities it is difficult to obtain permission for an internal vertical waste or soil pipe particularly where, as in small buildings, there is no pipe shaft. Yet such is the reliability of lead pipe that, given good workmanship, there is no reason why a concealed lead soil pipe should not outlast the building to which it is fixed. In other words any risk lies in the fixing and not in the material. Fixing is a matter of specification and supervision. There is, however, little doubt that the placing of waste systems on the outside faces of buildings will soon be a thing of the past. As an angry architect once said to a borough surveyor who had disallowed an internal waste system: "I don't wear my entrails outside, so why should my buildings do so?"

Roman lead pipes from Bath still in serviceable condition. The wiped joints are similar to those in use today, and the use of flat sheet seamed up to form a pipe was only discontinued in the last century.





A stack head, lead-burned, from milled sheet. The natural "overlapping scale" pattern produced by lead burning is used logically to form the decoration.

Cast Lead in Building

Until the invention of the milling process, sheet lead was made by casting on a flat sand bed or "casting table." Today this process is used almost solely for decorative work. Latterly it has been enjoying something of a renaissance. It is worth noting that hollow decorative forms in lead can be cast flat and afterwards bent to the required shape, a process not used with any other metal. In the making of such cast lead forms, the newly-developed process of lead-burning plays a useful part.

Alloys of Lead

Although it has long been known that lead alloys easily with other metals, it is only in recent years that special alloys of lead for specific purposes have been produced. There is one exception to this statement, namely solder, which is an alloy of lead and tin. Solders vary in their proportions, fine solder or "tinman's" consisting of equal parts of lead and tin and "wiping" solder two of lead to one of tin. The melting point of solder is lower than that of lead; it is this fact that makes the wiped joint possible as the solder can be in a molten state without melting the lead which is being joined. Yet the solder and lead enter into a combination which makes the whole become one homogeneous mass.

Lead-antimony is a comparatively hard metal, capable of taking a thread and one which is resistant to corrosion. These characteristics make it useful for sink fittings in chemical laboratories.

Two recent alloys are the ternary lead alloys and tellurium lead. The ternary alloys were developed by the British Non-Ferrous Metals Research Association and are made in two grades. No. 1 consists of 99.25 per cent. lead, 0.25 per cent. cadmium, and 0.5 per cent. antimony. Its principal use is for cable sheathing. No. 2 consists of 98.25 per cent. lead, 0.25 per cent. cadmium and 1.5 per cent. tin. It is specially suitable for water-pipe as its higher tensile qualities allow weights of pipe lower than in pure lead to be used for equivalent purposes.

Tellurium lead consists of ordinary soft lead to which has been added tellurium in a proportion of approximately one pound of tellurium to a ton of lead. This alloy has the peculiar characteristic of increasing strength under strain. This means that as the stresses rise in the material, as in pipe, under the action of frost or water hammer, so does the strength. Similarly cold working of the metal increases its strength. Tellurium lead is particularly suitable for use as water-pipe in places subject to vibration, such as in certain factories and particularly in ships.

Leadburning

Leadburning is a variety of welding. As a process it has been known for centuries, but only since the invention of the gas welding flame have its possibilities been fully exploited. Two kinds of equipment are used, an oxy-coal gas flame and an oxy-acetylene flame. Both technique and results vary according to the type of flame, but in general the joints are similar to those in the welding of other metals and consist either in adding metal from a filler rod or melting down the edges of the two pieces to be joined after they have been turned up together for this purpose.

The process is a rapid one, so rapid that little heat is lost by conduction. Indeed, lead laid on wood can be joined by leadburning without charring the wood. Leadburning on cast leadwork does not cause any change in the structure of the material, but in milled lead the process changes a rolled structure into one that is cast and therefore of lower tensile strength. Hence it is customary to use a filler rod when burning milled lead to give added thickness to make up for the loss of strength.

Leadburning has one great advantage over the use of solder for jointing. Solder, owing to its tin content, has a different coefficient of expansion from lead and therefore, under the influence of successive expansions and contractions, soldered joints are liable to crack. On the other hand, in leadburning, the variation in expansion between the weld metal and body metal (which are the same) is negligible. Consequently, leadburning is particularly suitable for the jointing and repair of sheet leadwork.

Recently a leadburning outfit has been developed which is light enough to be carried up a ladder by one man. This renders very satisfactory repair of roofs and gutters easy and cheap. It also gives an alternative process to bossing against awkward shapes that is economical of time and labour, and a new technique of "tailoring" lead by bending up flat sheets and burning the joints may well take the place of the traditional raising or "bossing" from the sheet. Such work is, of course, of equal thickness throughout and so may be used for a wide variety of new technical purposes.

Leadburning is being used increasingly for jointing pipes. Indeed in chemical works it is essential because soldered joints are liable to attack. While it has certain limitations in everyday plumbing practice, under favourable conditions the cost of burned joints both in sheet and pipe is about half that of soldered or wiped joints. The characteristic appearance of a lead-burned joint is a series of intersecting circles (see illustration on previous page). These are really solidified pools of lead that have been melted.

PEWTER

The early forms of pewter were lead-tin alloys and were of course widely used in the form of plates and drinking vessels. Later other metals were introduced in increasing proportions, often replacing a large part of the lead as in the material known as "plate pewter." In England pewter has lost much of its popularity in the last few decades and its use for bar fittings is now relatively rare. In Sweden, however, it has recently become very popular for decorative work, largely because of the skill shown in the finishing of the metal. Actually, contrary to popular belief, the alloy used is identical with that common in England, the difference depending entirely upon the methods of surface finish employed.

ZINC

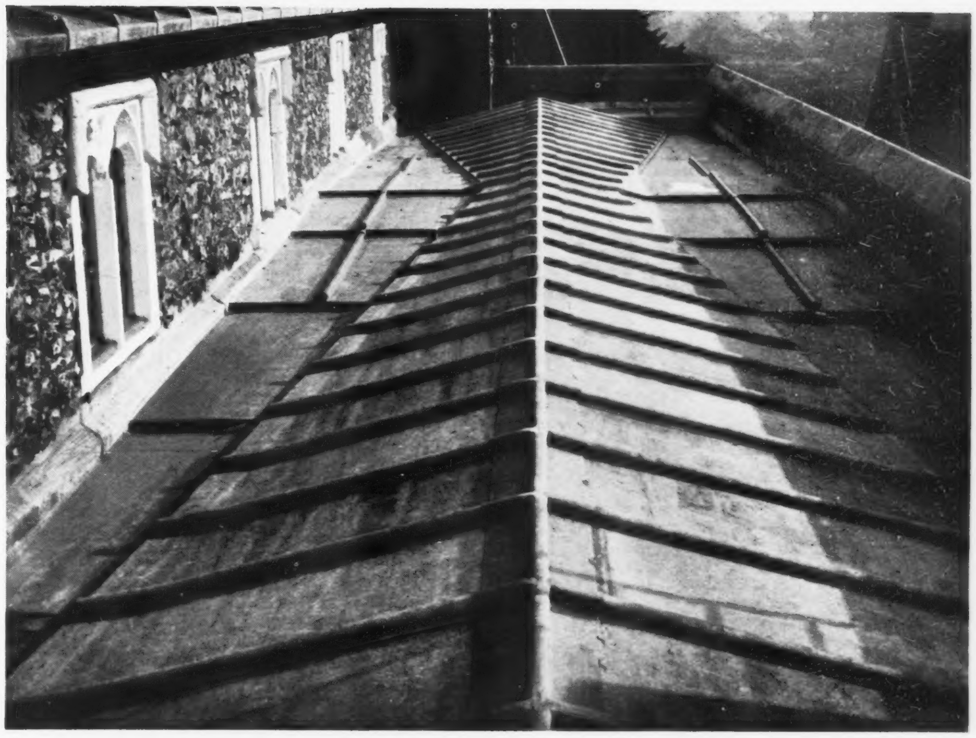
By J. W. Knight

Zinc is the Cinderella of the architectural metals in this country, for its very real merits have been almost completely overlooked at least by the present generation. The architect mainly accepts it as a poor substitute for lead or copper in roofing, and as the cheaper metal in the manufacture of brass and bronze alloys. The position, however, is very much the reverse on the Continent, where it has no such unhappy reputation. This difference in popularity might very well be investigated, since, generally speaking, there is little variation in the building materials used throughout the world, except in isolated places where transport is lacking. Curiously enough, there is practically no mention of zinc in the usual English text-books, and references are rarely made in the building trade training courses.

To some extent, the bad reputation of zinc is due to differences in roof design in this country where the metal has been mainly used for flats—particularly the "back additions" of cheap weekly property built about fifty years ago, where metal of insufficient thickness has been used.

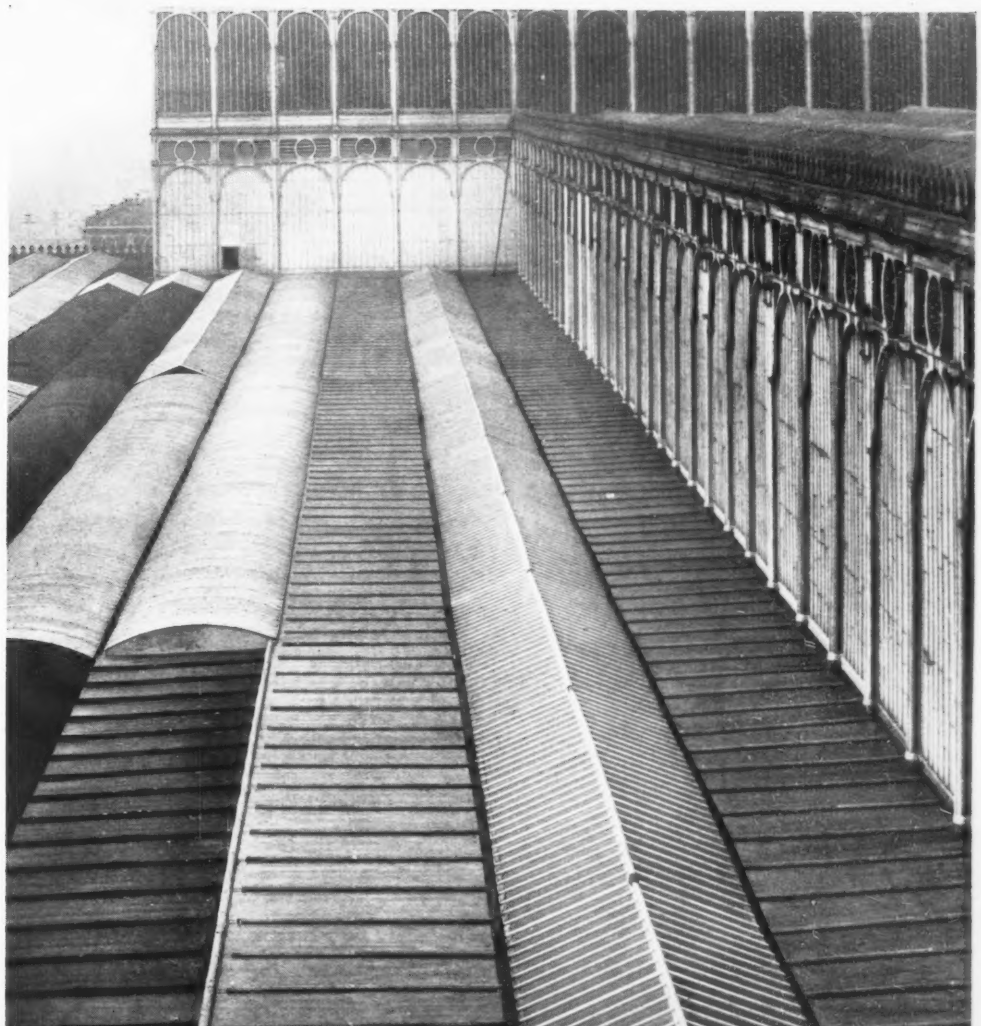
In France, its chief use has been for mansard coverings, and in Germany for low-pitched roofs. In both cases, any soot or dirt deposit is rapidly washed away, whereas a flat roof lies wet and is never really clean. The material is recognized as one of the best roofings in Paris, and is dealt with fully in all the standard text-books. Its popularity may be gauged by the fact that, in looking over Paris from the Courtyard of the Sacré-Coeur, there are only four buildings on which it is possible to distinguish any other roofing material, and even on these a good deal is used for flashings and gutters. As a result of this wide use, zinc workers are an established and well organized trade. The subject is fully dealt with in the training centres and apprenticeship schemes are still universal.

In England, however, there is no specialist course in any one of the building trade training schools, and entry to the trade is in no way



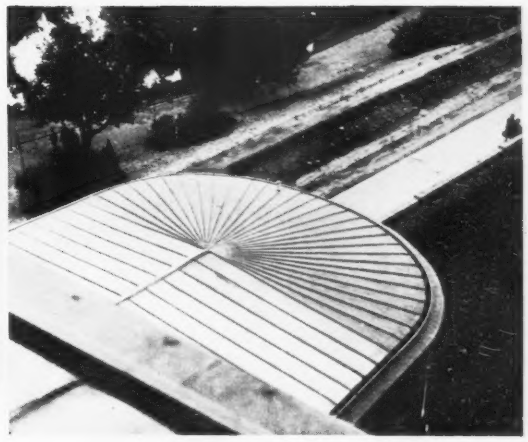
L E A D

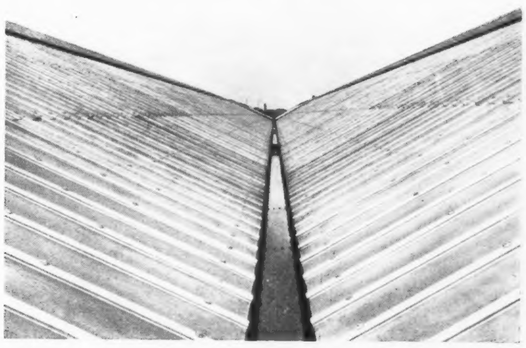
The traditional use of lead, plumbing apart, is for flat or low-pitch roofs. This photograph shows the aisle roof of Cobham Church, Kent. The interesting geometrical shape derives from the gutter falling in either direction from its highest point in the middle distance.



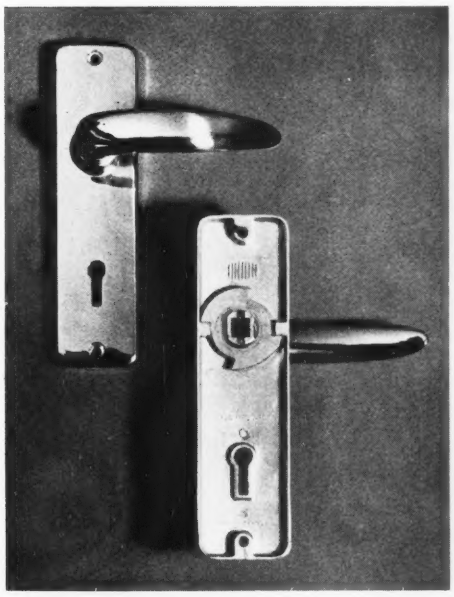
Z I N C

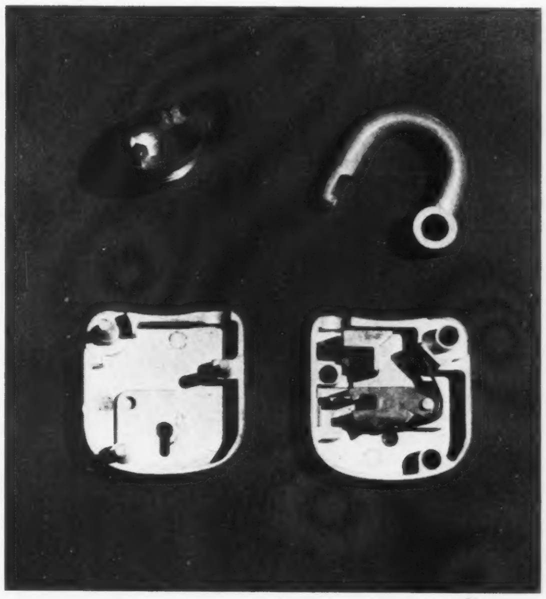
Zinc is shown here as an alternative roofing material. The photograph of the Crystal Palace, as it was re-erected on Sydenham Hill, shows the flat stretches of zinc roofing between the the areas of glass.





Zinc for roofing: top row, German examples laid on the standing seam system. A steep pitched domestic roof and a low-pitched roof to the apsidal wing of a school. Continuous strip has been used, making it possible to omit cross joints. The triangular sheets for the conical roof are cut in pairs so that there is none of the waste which would occur had it been cut from short sheets. Bottom row, English examples: (left) on the Surrey Commercial Docks and (right), a flat roof laid on the traditional cap and roll system.





Zinc base die castings. Three examples showing the accuracy with which detail can be reproduced. Die-casting has been used in engineering for many years, but has not been used to any great extent for hardware. The use of zinc alloys for this purpose is new. The technical advantages are considerable and it is probable that their introduction will increase the use of die-castings for hardware to a considerable extent and may make as great a change as the introduction of hot pressed metal in lieu of sand casting has in the production of plumbers' brasswork.

organized. In addition, a fair proportion of the laying is done by firms unqualified for the work, who, by under-cutting prices and employing unskilled labour, still further impair the reputation of the metal. That the technical objections to the metal have been over-stressed to the exclusion of its advantages, is obvious when the life of work executed with reasonable weight sheet is considered. For example, the roof of Snow Hill Station in Birmingham is still sound after some fifty years, despite exceptionally polluted atmospheres inside and out. A life of twenty-five years for flats is the minimum likely to be obtained in industrial districts, and considerably longer lives are known.

In England, most roofs are laid on the cap and roll system. In Germany, the standing-seam or double welt is quite common, probably because it is more generally laid to a pitch rather than on flats. Within the last few months, however, the Germans have developed an autogenous welding process. This was intended to reduce the consumption of tin in solder, which is wholly imported; but should the welding process prove technically sound, it may be assumed that it will ultimately effect a revolution in laying technique. Due allowance will always have to be made for expansion and contraction, but this can be more economically done without the double fold of the welt, or the complication of the cap and roll.

Throughout the Continent, zinc rain-water goods are largely used. They require, however, to be supported at frequent intervals, as the front edge of the gutter tends to get out of line and to look untidy. The real advantage of zinc for such purposes lies, however, in its complete immunity from damage by frost, and the ease with which the back of the gutter can be dressed up under the bottom edge of the roof covering, so as to form a really water-tight joint. In England, zinc down-pipes have, quite needlessly, only been looked upon as a substitute for lead or iron, and cases are known where a good deal of ingenuity has been expended in trying to imitate the characteristic ears and joints of the other metals.

Another use which is common on the Continent, but rarely seen here, is for sheathing the top of window-cills and parapets and, particularly in France and Germany, for the complete covering of chimneys. Great ingenuity is shown in the fixing methods, and there is no doubt that such a metallic cloak gives excellent protection against the entry of water. How far this custom is likely to grow in England, is not clear, but there is at least as great a need for it in our damp climate as on the Continent.

An interesting comment on the value of pure scientific research has recently arisen in connection with the protection and repair of old and partly perished zinc work. It was known that the phenol content of coal tars under favourable conditions has a serious corrosive action on zinc. For this reason, in Germany great stress is laid on the need for "tar-free" waterproof felts on which the zinc is laid, and for "tar-free" mastic repair compounds. Recently, however, it has been found that some of the products of decomposition of bitumen compounds can, in the presence of sunlight, produce rapid corrosion. This provided the explanation for a series of otherwise wholly inexplicable failures. Unfortunately, the knowledge of both causes of corrosion has never spread far in England, and it is still remarkably common to find a coat of tar being applied to zinc flats to increase their life.

Zinc is sold in this country mainly in sheets from 7–10 ft. in length, but it is becoming common on the Continent to use continuous wide strip, which is not only easier to handle, but greatly reduces the waste. Stock section gutter and roll caps are also available, as are seamed round pipes, all bent up from sheet.

The gauge under which zinc is sold is an interesting survival from the nineteenth century, for not only is it not standardized, but the ratio of number to thickness runs exactly opposite to that for any other metal, sheet or wire. It is not surprising therefore that architects are confused, and that light gauges are often substituted for the correct weight of sheet for roofing work.

Perhaps the most interesting recent development in the trade is that of zinc-based die-castings (see illustrations on the previous page). These seem likely to play an important part in the hardware trade in the near future.

As has been said, the real value of zinc has been largely overlooked in this country, but there seems reason to believe that only small changes in the methods of marketing and slight technical improvements in the method of laying will be found enough to enable the old market position of the metal to be regained.

GOLD LEAF

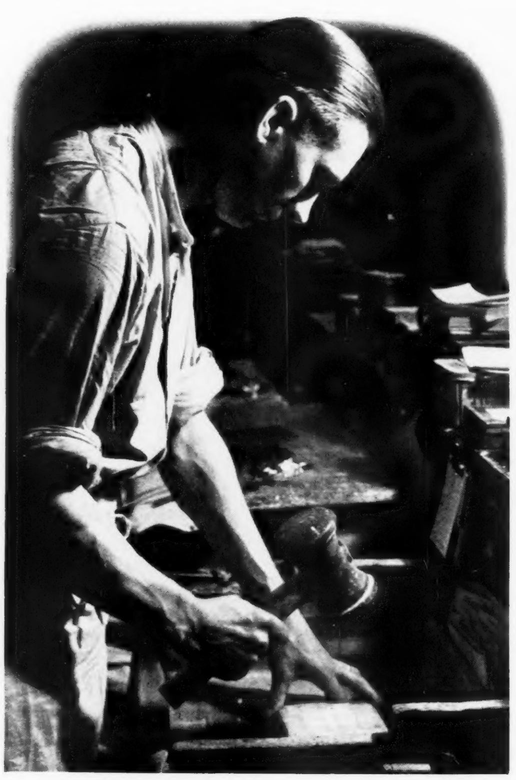
By M. Seifert

GOLD leaf, in spite of modern commercial research, is still produced by hand, in the same way that it has been for countless centuries, certainly for four thousand years and very possibly more. The quality and colour of the leaf depends upon the addition of minute quantities of copper and silver to pure fine gold. This is melted and cast in 6 in. by 1 in. by ⅛ in. moulds.

The resulting ingot is then passed between highly burnished steel rollers. During this process the pressure is steadily increased and annealing frequent. This produces a ribbon 1¼ in. wide and 1/1000 in. thick. Pieces of this ribbon 1 in. square are then placed between the leaves of a "cutch," which is made up of 200 sheets of fine vellum and is 4 ins. square. The cutch is bound with parchment bands and then beaten with a 20 lb. hammer for about thirty minutes, until the gold squares have spread to the edges of the cutch.

The gold leaves are taken from the cutch and quartered, each quarter being placed between the skins of a "shoder," which has 800 skins 4½ in. square. The shoder is carefully beaten for about two hours with a 12 lb. hammer, until the gold leaves have reached the size of the shoder skins. After they have been removed from the shoder, they are quartered again with a sharpened reed.

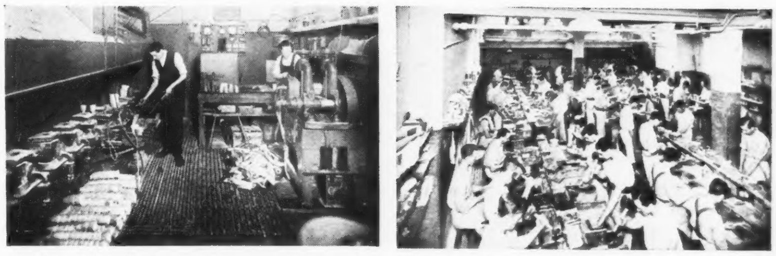
When the gold leaves are ready for the final beating, they are placed between the skins of a "mould" which consists of 1,000 5¼ in. square sheets of gold-beaters' skin. Incidentally this mould is less than 1 in. thick, weighs but a few ounces and costs almost its weight in pure gold. It is during the five hours of beating with an 8 lb. hammer that the quality of the leaf is determined, and it is here that the greatest skill of the beater is required to



One of the few industries not yet mechanized. Gold beating by hand exactly as it has been done for at least 4,000 years.

GOLD LEAF

A traditional example of the use of gold leaf is the ball of flames which crowns the Monument, commemorating the Fire of London. It has been re-gilded this spring. The Monument was designed by Sir Christopher Wren in 1673, in collaboration with the City Surveyor, Robert Hooke.



Gold leaf. Left, melting, casting and rolling the strips. Right, beating in progress.

keep the leaf free from stains, holes or cracks. The succeeding stages are performed by women and it takes many years of apprenticeship to make an efficient worker. Each leaf of gold, after being removed from the skin, is individually cut to size and then placed in a book containing 25 leaves.

The usual quality of leaf—known as " best English," assays at over 23 carat, but for exterior work " Pure Fine Gold " is generally used which assays at the full 24 carat. Varying colours from white to almost red can also be obtained by suitable alloying.

During the whole process, the gold is handled with boxwood pincers about 12 ins. long, and never touched by hand. The amazing malleability of gold is a property that is seldom realized. Beaten to its thinnest form, a quarter of a millionth of an inch thick, one ounce of gold in leaves would cover an area of about 250 square feet. Goldbeating is one of the few remaining industries where the art has been handed down from father to son. In some cases the actual blocks of marble on which the gold is beaten are centuries old, and this is evidenced by the deep holes that have been worn in the blocks by the light pressure of the beater's thumb as he holds down the mould. Many of the hammers have been acquired in the same way, and it is the continual wielding of the hammer that explains the exaggerated development of the gold beater's right arm.

THE UNFAMILIAR METALS

ALSO USED IN ARCHITECTURE

In this article it is proposed to deal very briefly with a few instances in which some of the more unfamiliar metals are introduced in modern buildings. In order to get some idea of the relationship between the lesser known and the more common metals, a table showing all the known metals is given on the next page. The table is based on Mendeléeff's famous periodic classification of the chemical elements and will be well known to any student of chemistry. The arrangement of the elements in this table follows, according to modern theories, the internal structure of the atoms; thus, reading from " lithium " in the top left-hand corner to " uranium " in the bottom right-hand corner, the atom of each successive element has one more electron than in the preceding one, while the elements in any vertical group show a similarity in the arrangement of their electrons. It is, therefore, not very surprising that in this table we can see a definite order of the properties of the metals. Thus, the lighter metals are found in the top left-hand corner, while the denser metals are towards the bottom or to the right of the table. The elements are divided into eight vertical groups, and there are distinct similarities between the metals in each group.

It is now proposed to deal in a very brief manner with each group in turn, omitting any mention of the well-known metals whose architectural values are dealt with in the preceding articles of this issue. It will probably be noticed that each group of metals is subdivided into two vertical lines, and that, apart from purely chemical considerations, there is but little similarity between them.

In Group I, the first division consists of the "alkali" metals—these are extremely reactive, and will burn or decompose water with, in some cases, almost explosive violence. Their use as metals is, therefore, extremely limited, as, for instance, the employment of lithium and sodium in the casting of copper alloys to remove oxygen which, if present, would tend to make the metals brittle. Rubidium and caesium are used for photo-electric cells. Such cells are sometimes used nowadays to control lighting, or automatic doors, as on London's Underground, where a train entering certain stations cuts off a small beam of light focused on a photo-cell, and thus switches on a set of lamps at the edge of the platform. Again, in shops or stores, a person about to enter a door may put into operation a similar device, which automatically opens the door. In this group come also silver and gold. Silver plating is still used as a decorative finish for interior fittings, and " oxidized " silver finishes are still much used, though probably not to the same extent as formerly. Gilding is dealt with elsewhere.

Group II of the Table is divided into the " alkaline-earth " metals and the zinc series. The former, like the alkali metals, are rather too reactive to have many uses, though, of course, the " compounds " of calcium play a tremendous part in the construction of buildings, the use of cement being based on the chemical reactions taking place when certain calcium silicates and aluminates are mixed with water. Calcium is used as a deoxidizer for copper, and .03 per cent.—.04 per cent. of this metal improves the quality of lead for electric cable sheathing. Other metals added to lead to improve its strength include silver (a .01 per cent. addition), which raises its " creep " strength, and cadmium, which, together with either antimony or tin, is recommended to prevent intercrystalline cracking of lead pipes subject to " fatigue " by vibration. The zinc metals show an increasing order of stability to atmospheric corrosion as we read down the column from beryllium to mercury; such gradations of properties can be seen throughout the classification. Thus, while zinc is used for coating water cisterns, etc., cadmium, which is much more expensive, is used for covering nuts, bolts and locks where they may meet more severe atmospheric corrosion conditions, such as are found near the sea.

As well as the similarities of the metals in the same group, those which are found horizontally, side by side, in the table, often resemble one another in their behaviour. Thus, the three metals beryllium, magnesium and aluminium show very similar properties. All three are very light, beryllium and magnesium being about half as light again as aluminium. The use of magnesium alloys for aircraft is already very common, but the use of beryllium for such alloys has not yet met with success. This interesting metal is as strong as steel and has a fairly good corrosion-resistance but, unfortunately, lacks ductility. At the present time it is a good deal more expensive than silver, but the latest surveys indicate that sources of beryllium in South Africa may be really substantial. The use of this metal for alloying to copper is already well established—small amounts are used as a deoxidizer for bronze, while an addition of 2¼ per cent. to copper makes excellent springs for electric contacts—these are specially useful where repeated flexures are needed in such devices as flashing signs. Architecturally, aluminium alloys containing 2 per cent.—9 per cent. of magnesium (e.g., "Birmabright") are of great value owing to their excellent resistance to corrosion.

The third group includes, beside aluminium, the metals thallium and cerium. Thallium is nowadays produced in the United States on a moderately large scale; its price is approximately that of silver; silver-thallium alloys do not tarnish in the air. Cerium is the only one of the " rare earth " metals used commercially; its alloy with iron is the

" flint " which is used in cigarette and gas-lighters.

In the first division of Group IV come carbon and silicon, two non-metals (with which we may also class phosphorus—Group V.). These are of great importance in metallurgy, as they dissolve and form alloys with the metallic elements. Thus, the alloy of iron with carbon is the basis of every type of steel, while a great number of the aluminium alloys contain silicon, many of which, like the 5 per cent. silicon alloy, have very good corrosion-resistance, especially near the sea. Titanium, which also comes in this division, has only recently been much used in the metallurgical field. It is by no means a rare metal; indeed it occurs very abundantly. Lead and tin are found in the second division of this group. Tin, though not usually connected with building construction, actually plays quite an important part : for example, it is used as a lining for lead water pipes, in solders for plumbing, and as an alloying addition to copper to form bronze.

The use of columbium (Group V.) has a rather interesting history. Quite recently it was discovered that very successful welding of stainless steel was possible if the welding rods used contained columbium. It was then calculated that the amount of columbium at that time available would be insufficient to supply the amount of welding rod needed, and a search for new sources of columbium was made. After surveying in U.S.A. and Canada, an abundant source of ore was finally found in Africa, and now today there is sufficient metal available to meet all the requirements. The second set of metals in Group V. are used almost entirely as additions for " hardening " the softer metals. Arsenic is added in very small quantities to some grades of copper, while antimony is added to tin to form pewter, which is of late being used again to some extent for ornamental fixtures, such as lamps and candelabra. (A nice gradation is found in the cost of the elements of this group—ranging from free nitrogen and the almost valueless arsenic to antimony and bismuth at 9d. and 4s. a pound, respectively—about which fact the writer is at a loss for a purely chemical explanation.)

In the next group are three metals, the main applications of which are found in steel. Chromium is used in stainless steels while molybdenum and tungsten (also vanadium—Group V.) are used in structural steels. Tungsten is also used for the filament wires for electric lamps.

Of the two metals of Group VII., manganese is used in large quantities for strengthening steel, brass, bronze and aluminium-alloys, while rhenium, the most recently discovered element on our list, already has one commercial application (for thermo-couples) and is being considered as a non-tarnishing plated coating.

The final group includes both the cheapest and the most expensive metals that the architect is likely to meet; namely iron and rhodium. It will be notice that this group, which is arranged rather differently from all the former ones, contains the three magnetic elements—iron, nickel and cobalt, and the six " platinum " metals. Nickel is chiefly associated with the modern non-tarnishing metals, and enters into the composition of stainless steel, nickel-silver, Monel metal, and the nickel-bronzes; while a deposit of nickel is nearly always used as an undercoating for chromium plating. Here we might also mention the nickel alloys which are used for the " elements " of electric fires and radiators. The most usual alloy for these is one containing 80 per cent. of nickel and 20 per cent. of chromium; though newer alloys are now coming into use (*e.g.* one containing 65 per cent. nickel, 15 per cent. chromium and 20 per cent. of iron—which is somewhat cheaper to produce). The platinum metals are characterized by their non-tarnishing properties. The least expensive of these is palladium; this can be beaten out into leaf like gold, and has been used in this form for covering picture frames. Platinum is used in the " catalytic " type of gas-lighter. This consists of a wad of asbestos wool impregnated with platinum powder, which automatically ignites the gas. Palladium, platinum and rhodium can also be used for electro-plated coatings, and give very beautiful effects. In spite of the differences in the prices of these metals, the cost of plating is very similar for all three. Palladium plating has to be rather thicker than platinum, and platinum rather heavier than rhodium, to produce good coatings. Rhodium plating, which produces the most perfect non-tarnishing " finish " of the three, has in recent years become quite a commercial practice. These coatings, which are only a few millionths of an inch in thickness, are frequently used to render silverware untarnishable, and in spite of the high cost of rhodium (some £17 an ounce), the extreme thinness of coating needed makes it not an altogether unreasonable proposition to rhodium-plate architectural fittings, where the highest quality of workmanship is required.

M.A.

CLASSIFICATION OF THE METALS (after Mendeléeff)

GROUP I	GROUP II	GROUP III	GROUP IV	GROUP V	GROUP VI	GROUP VII	GROUP VIII		
Lithium	Beryllium	★	[Carbon]	★	★	★			
Sodium	Magnesium	ALUMINIUM	[Silicon]	[Phosphorus]	★	★			
Potassium COPPER	Calcium ZINC	Scandium Gallium	Titanium Germanium	Vanadium Arsenic	CHROMIUM ★	MANGANESE ★	IRON	NICKEL	Cobalt
Rubidium SILVER	Strontium CADMIUM	Vitrium Indium	Zirconium TIN	Columbium ANTIMONY	Molybdenum Tellurium	★	Ruthenium	Rhodium	Palladium
Caesium GOLD	Barium MERCURY	Cerium and 14 other Rare Earth metals Thallium	Hafnium LEAD	Tantalum BISMUTH	Tungsten	Rhenium	Osmium	Iridium	PLATINUM
	Radium		Thorium		Uranium				

The " familiar " metals are in capitals. Elements in brackets are non-metallic elements. The positions of other non-metals are indicated by asterisks. The metals which have regular commercial use today are underlined.

A BIBLIOGRAPHY, CLASSIFIED TO CORRESPOND WITH THE PRECEDING ARTICLES, IS GIVEN ON PAGE 300.

MATERIAL: TECHNIQUE: DESIGN

For this page and the following one a series of chairs has been collected with a view to demonstrating how intimately design is bound up with the qualities of the material and the characteristics of the process used to work the material. In no materials is this relationship so apparent as in the metals, as the wide divergence of shapes employed in these chairs shows, the functional demands being, of course, the same in each case. The first photograph shows a pair of the split-strip aluminium chairs designed by Marcel Breuer in 1933. The lightness of the metal is taken advantage of, as well as its high tensile strength to give a certain amount of spring. It was also Marcel Breuer, it will be remembered, who designed the first tubular steel chair. The chairs in this photograph are the only aluminium examples in this series, but see also the illustrations of three representative chair frames, including an old-fashioned and a modern casting, on page 268 in the article on aluminium. The second photograph shows the familiar London park chair with wooden slatted seat and back fixed to a wrought iron frame, of rods and flat bars riveted together. They are typical of the greater rigidity of mild steel. Alongside are examples of a heavy steel chair designed for the out-door terrace of the Shakespeare Memorial Theatre at Stratford-on-Avon by the architects, Scott, Chesterton & Shepherd. Advantage has been taken here of the

flexibility of flat steel strips to give a natural spring seat. The first photograph on this page is a good example of the fashionable tubular steel chair, in which spring is again attained by means of the tensile nature of the material; but in this case (as distinct from the previous one) the stability of the whole chair also depends on the strength of the tubular section. Alongside is a typical (though less modern) use of cast iron—the most rigid of all—for a bench characteristic of its location, a seaside esplanade. The large photograph below shows the charming light iron chair of French origin, built up of rods and thin strips, the flexibility of the latter again giving a springy seat and back.

DESIGN: MATERIAL: TECHNIQUE

THE FINISHING OF METALS

By S. Wernick

The finishing of metals is one of those borderline subjects, highly specialized in itself, which the architect cannot avoid encountering from time to time. The writer, who has had the privilege of lecturing to architectural societies both in London and the provinces at which metal finishing problems have been discussed, does not wish to imply that the average architect finds the subject distasteful, but his experience suggests that the complexities of the subject probably prompt the architect, already burdened with technical data of the most diverse kind, to leave its technicalities to the metal finisher.

Occasionally one meets an architect who, possibly because he has made use of metal finishes in some special manner, is keenly interested in the technical aspect, but he is the exception rather than the rule. The more usual attitude towards metal finishes is that, as a result of the modern trend of development in design and materials they appear to be a necessary evil, but that to achieve a really effective and durable " job " needs a considerable amount of luck rather than judgment!

There appears to be a prevalent feeling that a metal finish is by nature ephemeral, that it has not the substantial merit of a material which is solid right through, and that therefore one cannot expect too much from what after all amounts to no more than a superficial effect. In other words, there is fairly widely current a rather contemptuous view of the real value of plated or painted products.

The writer feels that he can do no better service to architects than to dispel this view. In the first place, in the nature of things one must continue to employ metal finishes, since they are the means of producing decorative effects which can be produced in no other way. That they lack " solidity " does not imply that they must necessarily be non-durable; on the contrary metal finishes are pre-eminently valuable as combatants of corrosion.

The editor of this Journal, in inviting the author to write this article, made the suggestion that " plating is not a method of giving an improved appearance to a necessarily shoddy core; in fact it is as legitimate a method of finishing as veneering in the cabinet trade." This in the writer's view states the case for metal finishes very modestly. If veneering in the case of wood is an accepted and an approved practice, then plating and kindred methods of finishing in the case of metals should be given a pre-eminent place. The fact is that plating, when produced under scientifically controlled conditions, possesses important properties, such as that of protecting the metal, which veneering cannot claim in the case of wood.

Lest it be thought that the object of this article is a hymn of praise to metal finishes, it should be clearly understood that the quality of the latter entirely determines its value to the architect, engineer, or other user. Here we come to the crux of the matter. It is a fact that the quality of plating can, and does, vary to a very considerable extent, depending very largely on the source of supply. The following extract from a lecture by the author to the Architectural Association some two years ago summarizes the position, and unfortunately still holds good:

" It is a very unfortunate fact that superficially it is not always easy to distinguish between a good and a shoddy finish. In the case of electro deposits, for example, copper, nickel, chromium or cadmium plating, even the expert has difficulty if he is not allowed to submit the deposit to tests. How much more readily is the engineer or architect deceived? There are unscrupulous metal finishers, although their number is rapidly dwindling, who are prone to take advantage of this fact, and unfortunately they are encouraged by a certain type of buyer who is ruled exclusively by the cheapness of the finish he purchases. . . . . Meantime, a bad impression is created which reacts adversely both on the metal finishing industry and the manufacturers of the product treated."

Having said that, both the cause of present dissatisfaction with metal finishes in general and with plating in particular, and also its remedy, become apparent. If metal finishes are ordered on the understanding that they are produced to a rigorous specification, containing certain minimum requirements, failure to comply with which will mean rejection of the article, then the supply of a satisfactory " job " will be assured.

The inherent difficulty of the architect lies in the fact that he usually does not know what to specify and is therefore in the hands of the metal finisher. If he is fortunate enough to find a reliable firm, he will thankfully delegate all the specifying to them and hope for the best. If he finds himself continually in trouble on finishes then his only remedy is to specify his requirements technically. To do this he must either acquire the necessary technical information on the subject himself, or in the absence of officially recognized specifications, seek the advice of an expert to guide him. It is a curious fact that while most architects are usually very glad to take expert opinion on any specialized work connected with the construction of a new building, the idea of consulting a metal finishing expert to look after this part of the undertaking is seldom adopted.

THE PROPERTIES OF PLATING

The life of a metal finish, or indeed any type of finish, and its general serviceability depend on the process which has been employed and the care which has been taken in its production. If this has been carried out efficiently, then the finish is imbued with a number of essential properties, of which the most important are enumerated below.

Adhesion

For example, the degree of adhesion between plating and the basis metal on which it is deposited is amazingly high. A good nickel deposit on steel would require a force of the order of 20 to 25 tons per sq. in. to part it from the basis metal, so well is it " anchored."

Reference has already been made to the extraordinary degree of adhesion which may be attained by electrodeposits. This is the case if they are properly produced. The degree of adhesion, which greatly affects the resistance of the coating to sudden knocks or stresses, and indeed to wear generally, may vary from the virtually non-detachable to the complete absence of adhesion.

The metal finisher has to guard against any intervening foreign body between the finish and the basis metal, the presence of which prevents the " inter-atomic " type of locking between the two already referred to. The surface of the metal must be perfectly clean before the deposit is applied. Cleanliness such as is commonly understood by the layman is not sufficient. Even when the surface has been freed from every trace of grease, an oxide film may still be attached to it which must be removed and the virgin metal exposed, upon which the new coating is deposited. This chemical cleanliness of the surface is achieved by very rigorous methods in the plating shop, which may involve an organic solvent vapour de-greaser, an alkaline detergent degreaser, and an acid electrolytic etch, with numerous washes in clean running water between each step.

Thickness

Perhaps no single property of the deposit is as fundamentally important as the thickness, which in turn determines that important property, the corrosion resistance of the finish. If the architect does nothing else, he will have solved his metal finishing problem to the extent of some 75 per cent. if he sees that he gets a deposit of a given minimum thickness. The exact figure depends on the nature of the deposited metal and also the degree to which the basis metal requires to be protected. Thus, it is obvious that steel and ferrous structures generally will require to be protected to a greater degree than brass, bronze, copper, and non-ferrous metals in general.

Taking the non-ferrous metals first, those mentioned above which have a considerable quantity of copper in their composition will require something of the order of 0.0004—0.0005 inch in thickness of nickel for their protection against both external and internal atmospheres.

It is well known that while nickel plating is not very much in evidence today as a visible finish, it nevertheless figures very largely as a finish which is not seen, because it is now very commonly covered with a thin layer of chromium. Practically all the chromium plating at present produced is applied over an undercoating of nickel. It is the quality of the latter which largely determines the corrosion resistance and general performance of the chromium finish. However, whether nickel is applied as a finish by itself or as an undercoating, the thickness requirement is practically unaffected.

Zinc Base Alloys

A non-ferrous basis material which is very much to the fore at present is the zinc base alloy. While alloys of this type, the preponderating constituent of which is zinc, are finding increasing use in the manufacture of the smaller kind of article, its use for door handles and other internal architecture fitments suggests that this is a material which may enter the building trade increasingly in the future.

When polished, zinc base alloys look attractive, particularly as when die-cast they faithfully reproduce the design of the mould with admirable sharpness. Zinc, however, is a relatively easily corrodible material, and exposure to the atmosphere may result in comparatively rapid deterioration. It should therefore be protected and chromium plating again has been found to produce satisfactory effects. As an undercoating both copper and nickel plating, and usually both, consecutively in the order named, are applied.

In view of the corrodible nature of the base metal, as compared say with brass or bronze, a somewhat thicker deposit than that specified above would be required to attain the same degree of protection. Certainly in the case of outdoor fitments the thickness of nickel should be not less than 0.00075 in.

Zinc base alloys, in common with other base metals are now also being finished with organic materials, e.g. cellulose acetate products.

Ferrous Material

If steel is the basis metal then the thickness must be increased. It is now generally recognized that a minimum thickness of nickel of

1/1000th of an inch (0.001 in.) is necessary to protect iron and steel, and that for special conditions, e.g. continuous exposure to the atmosphere or marine or tropical locations, a thickness in excess of this must be specified. The precise thickness may vary from 1.5 to 2/1000th of an inch, depending on the severity of the conditions.

Electro-Chemical Protection

While this thickness is necessary for nickel deposits (and about the same thickness would apply were the coating copper instead of nickel) thinner deposits of certain other protective metals are effective. These protective metals do not act purely as mechanical envelopes of the basis metal, shielding it from corrosive influences, but also as electro-chemical protectives. Zinc and cadmium in particular exercise this valuable function and are now commonly employed by engineers, and to a lesser extent by architects (who do not perhaps like the decorative value of these metals so much) for the purpose.

The electro-chemical action arises through the fact that both zinc and cadium are actually more corrodible than practically every type of ferrous metal. Hence when a piece of steel coated with either of these metals happens to be damaged, resulting in the exposure of the steel, the electro-chemical effect occurs as a result of a battery which is set up between the basis metal, the coating, and any moisture (e.g. that in the atmosphere) in their neighbourhood. Under these conditions the zinc or cadium coating corrodes "sacrificially" and the steel is unaffected until all, or nearly all, of the coating in its neighbourhood has disappeared. This of course is the principle of the durability of galvanized iron, which will remain uncorroded until the zinc coating has been almost completely dissolved.

A thickness of about 0.0003–0.0004 in. in the case of cadmium and zinc plating may accordingly be specified depending on the service conditions which it is anticipated will be encountered.

Porosity

The porosity of the deposit is an obviously important factor in that however thick the deposit may be, if its condition resembles that of a sieve then the protection which the basis metal derives will be purely localized to the non-porous parts of the surface. Fortunately the porosity of a deposit is linked up with the thickness to a very large extent, i.e. as the deposit is progressively thickened so is the porosity correspondingly reduced. In general, deposits of the order of 1/1000 of an inch, certainly in the case of nickel, are pore-free.

Uniformity

The question of uniformity of a metal coating is particularly pertinent in the case of an electro-deposit in view of the fact that plating processes inherently produce coatings which are more or less non-uniform. The process is popularly imagined to be a kind of "dip" in a chemical solution, which results in all parts of the article plated being covered uniformly with metal—in a rather similar manner to that which applies in painting or lacquering. Nothing is further from the facts. Plating arises through highly complex electro chemical phenomena. The electric current, for example, taking the path of least resistance, will tend to focus on those parts of the article being plated which are nearest the walls of the plating vats which are lined with anodes. As a result more metal will deposit on such "high-lights" of the immersed job than on the flat or recessed portions. In a word, the metal distribution of the coating may vary to a considerable extent.

Since the weakest link in a chain determines its strength, so will the thinnest portion of the plating on the surface determine its useful life. This fact is an extremely important one, since it affects the architect directly on the question of design. This is dealt with further below. The main properties of the deposit having now been outlined, it is interesting to examine some of the newer finishes and to see, *inter alia*, how they apply in these cases.

CHROMIUM PLATING

Although chromium plating has now been employed for some ten to twelve years, there is no falling off in its popularity as a finish. Perhaps its greatest demerit as an architectural finish is the fact that it is so ubiquitous, while the cost of its production has been so reduced that it can be, and is, applied on the cheapest of articles. There are some who decry the blue cast in the colour of the metal, while one architect known to the author has referred to its "superficial tawdriness." In recent years the colour of the finish has been improved, but one cannot, of course, gainsay the permanent metallic brilliance which in fact is the *raison d'être* of chromium as a finish!

The quality of chromium plating has undoubtedly been improved of late, although it will always be possible to obtain cheap chromium plating (which is in fact applied to the cheaper articles of an ephemeral type, the lasting qualities of which do not matter). The architect who is influenced by the price at which he can get his chromium plating done is always in a doubtful position. The price of *specified* chromium plating does not greatly vary among reputable platers.

Despite the drawbacks of chromium plating, there is no sign that it is less widely used for architectural purposes. Some architects occasionally specify stainless steel on the logical grounds that a solid material must be superior to a superficial one. Stainless steel is, however, too expensive for most purposes for which chromium plating will do, while it can hardly be considered superior from the decorative viewpoint.

Good quality chromium plating will give years of satisfactory service. It devolves on the quality of the nickel undercoating as already discussed and, what is perhaps little appreciated, its maintenance and up-keep. The current impression that chromium plating is a stainless finish which requires no attention on the part of the user is a fallacy which still requires to be exploded. Actually, chromium plating which is left untended deteriorates fairly rapidly. The deterioration is a superficial one, a brown corrosion product forming in the atmosphere in due course especially if this is damp. If, on the other hand, the chromium is washed periodically, it will retain its original appearance unimpaired. When neglected chromium has been cleaned free from the brown surface incrustation, it may appear satisfactory at first, but if the neglect has been a lengthy one, lasting damage will have been caused and early failure of the finish may result.

It should be remembered, too, that the "throwing power" of the chromium plating solution—or its ability to provide a uniform deposit of chromium—is not of a high order. Hence in designing any article which is to receive a chromium finish it is as well to employ simple shapes. Acute or right-angle bends should be avoided; wherever possible angles should be rounded off. Similarly, recesses and re-entrant parts of the surface are not likely to help the finish. Co-operation of this kind with the metal finisher, even if the architect loses something in the process, will make for a better and more lasting effect in the long run.

ANODIC OXIDATION

This is a very broad term in chemistry, covering a considerable number of widely different processes. The architect however has become acquainted with it recently in connection with the finishing treatment of aluminium and its alloys.

Aluminium belongs to that class of metals which owe their comparative immunity from corrosion to a natural thin layer of oxide on the surface. The process of anodic oxidation of aluminium is, so to speak, an improvement on nature, in that this layer is artificially very considerably thickened by making the aluminium an anode in a suitable electrolytic circuit.

The first successful anodic process was the result of the work of two British chemists, Bengough and Stuart, who in 1923 published the results of work carried out with a weak chromic acid electrolyte. Since then other processes using such electrolytes as sulphuric acid and oxalic acid have been developed, in which uniform voltage conditions are employed and shorter times required for producing the requisite oxide film.

Properties of the Anodic Coat

The anodic coat possesses remarkable properties apart from its unique protective qualities. Thus it is extremely hard, as one might expect the oxide of aluminium to be, and therefore highly resistant to wear and abrasion.

The coating is also an electrical insulator and has been found to resist comparatively high voltages of the order of 1,000 volts under special conditions. Hence an anodized piece of aluminium provides an excellent conducting core covered with a well insulated layer of oxide.

The heat radiating properties of the oxide represent a marked improvement on the original surface. Its light reflecting properties are also useful in that the blue cast of aluminium is replaced by the whiter oxide, while the even etching of the surface resulting from the electrolytic action in anodizing provides a surface resulting in a high degree of diffusion of the reflected light. An even, uniform reflection is achieved which has been utilized successfully for such special applications as searchlight reflectors and floodlight equipment. The anodic finish thus provides good reflectivity allied to quite excellent corrosion resistance of the reflecting surface to out-door conditions.

Its most interesting quality is its mordanting property, as a result of which it readily absorbs dyes. This property has been developed so that it is now possible to obtain aluminium which is not merely highly protected but attractively coloured in almost any desired shade. Special colours have been developed which very successfully resist the effects of practically any specified service conditions. Coloured finishes of aluminium can now be obtained which will resist atmospheric conditions, sunlight, heat, rain, various chemicals, etc.

The oxide layer, which is highly absorbent when first produced, may be impregnated with greases to render it still more resistant.

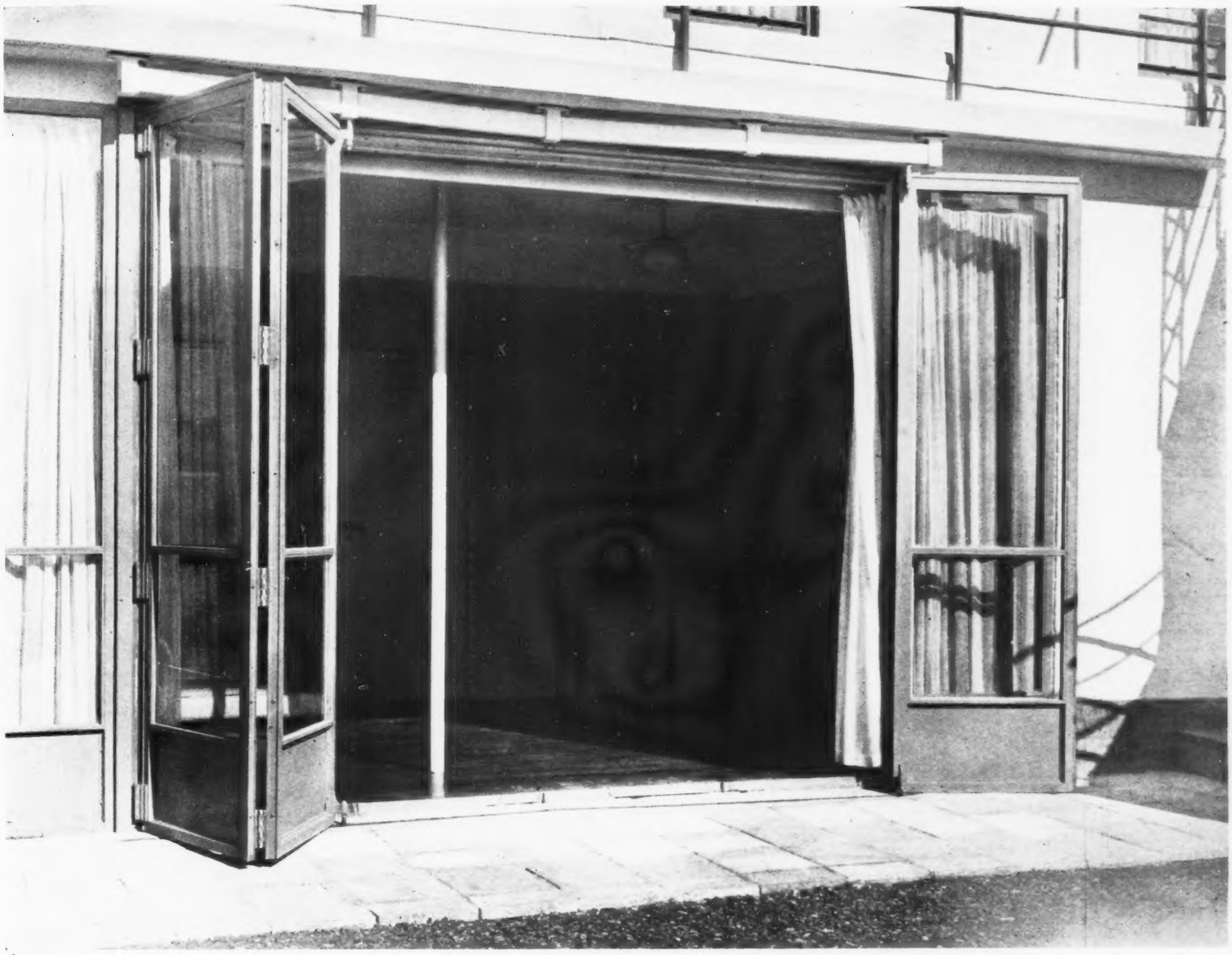
Applications of Anodized Aluminium

Anodized aluminium is being used in increasing quantity, the applications being extraordinarily diverse owing to the fact that there is a considerable and growing demand for light metals which possess high corrosion resistance allied to decorative value.

Perhaps the most important applications of anodized aluminium today are aircraft and architectural fitments, which are exposed to severe corroding conditions. Instances of its use in architecture include shop fronts, balustrading, hand-rails, door furniture, grilles, mouldings, canopies, shelving, laylights, bath fittings, table and counter tops, panelling, reflectors, lift fittings, tiles, bar fittings, tubular furniture, lettering, signs, and ornamental metalwork of every description. Coloured anodized aluminium with a backing of plywood is a new material used for panelling, table and counter tops, etc.

In ordering such material, which is difficult to specify in the manner of plated finishes, the architect is best advised to ask for a guarantee of performance, particularly should he require a coloured anodized finish to withstand external atmospheres.

W I N D O W S



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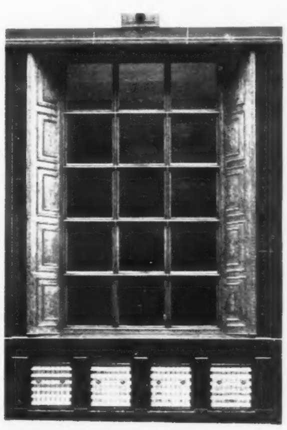

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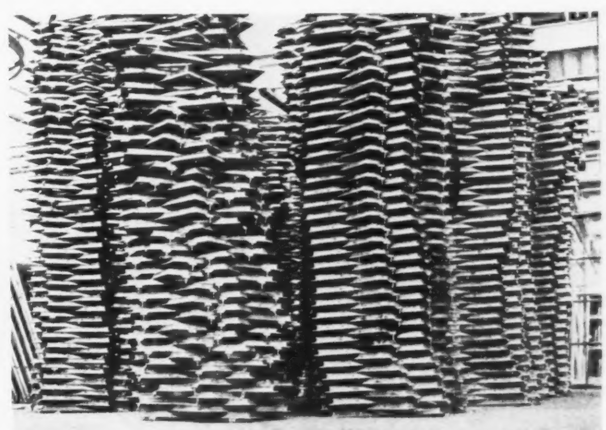

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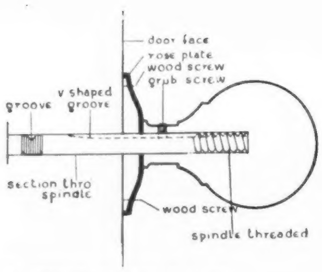
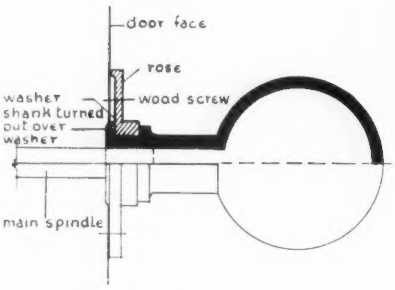
The earliest form of metal window, in which a flat wrought-iron section was used with welded corners and leaded lights, is shown on page 259. This page illustrates the more recent developments of metal windows. 2, the typical post-war window for domestic work, a standardized and widely-used form based on Georgian proportions both for pane and casement size. It follows very closely the dimensions found in traditional Cotswold work, where the width of the casement was determined more by the maximum convenient length of the transom stone than the qualities of the metal. This width in turn limited the height because of the traditional classical proportions. Later, following a fashionable demand, the vertical bars were omitted (as in 5) but the general overall dimensions remained the same. Recently the proportions have tended to change and the limiting factor becomes the strength of the metal. 1, indicating modern possibilities: a logical use of rolled sections for windows. This new type of window, giving larger glass areas and capable of being opened to a greater extent, is made possible only by new rolling methods, coupled with an appreciation of the opportunities the new form of the metal offers. 3, a window and spandrel in aluminium requiring no painting for maintenance: in the new Gerrard Street Post Office. 4, an example of another method of reducing maintenance costs by the use of bronze sections. The two jamb linings are also in cast bronze. From a bank in Cornhill: architects, E. Stanley Hall and Easton & Robertson. 5, a recent development combining a rolled-steel section window with a pressed steel frame. 6, the basis of the metal window trade has always been mass production, and the window was, after the brick, the first building unit to be standardized in design and dimension. How far this standardization based on tradition will hamper developments made possible by improved materials and increased realization of the essential qualities of those materials is yet to be seen.

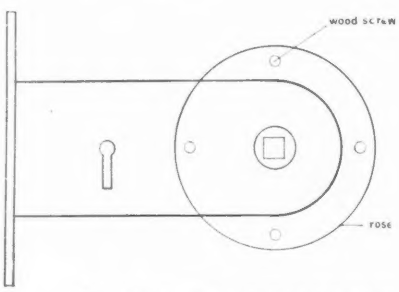
D O O R



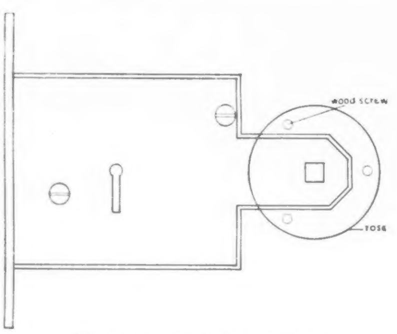
A SPINDLE FIXING WITH GRUB SCREW



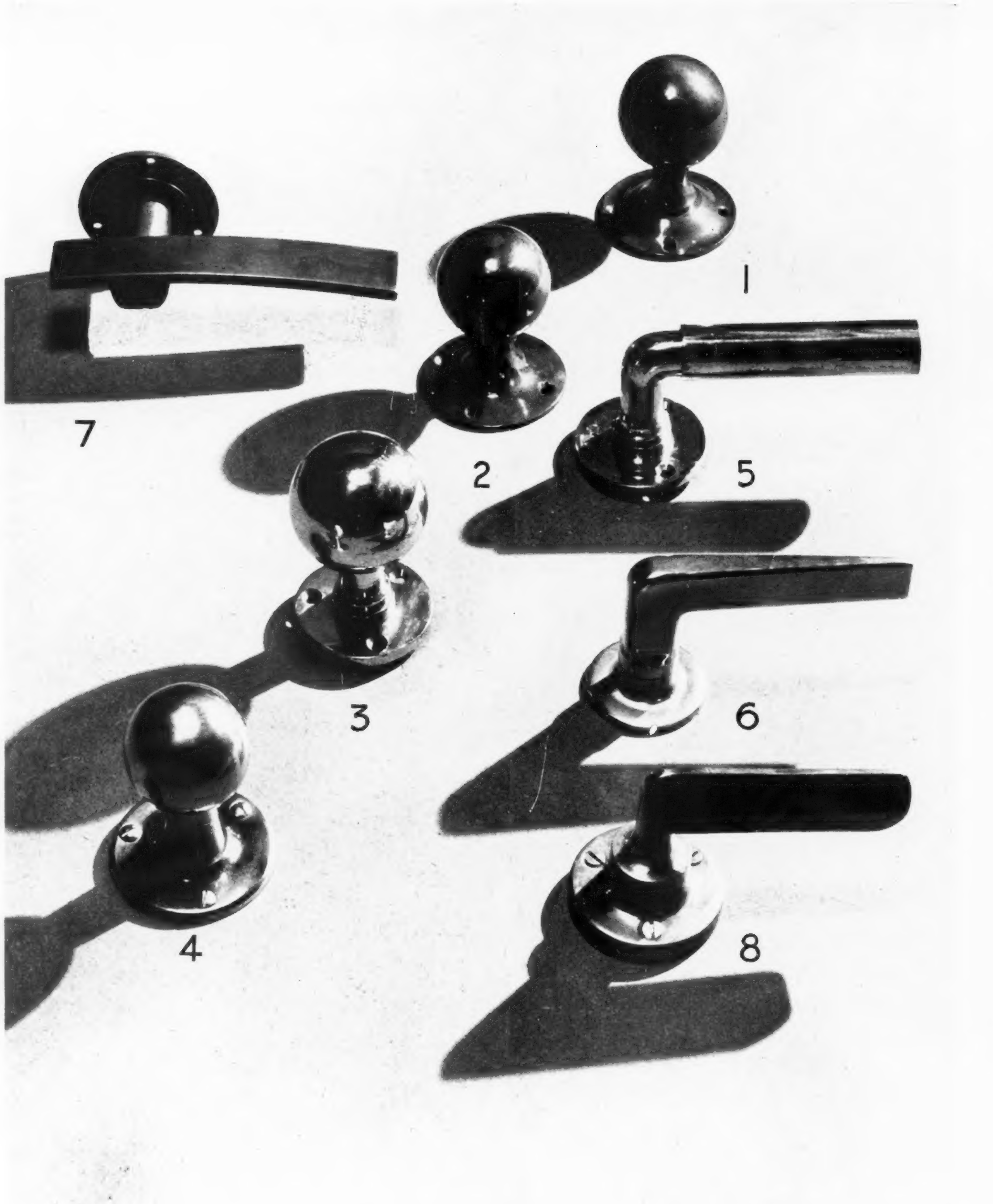
B PITT'S ROSE



C LOCK WITH LARGE BACK PLATE

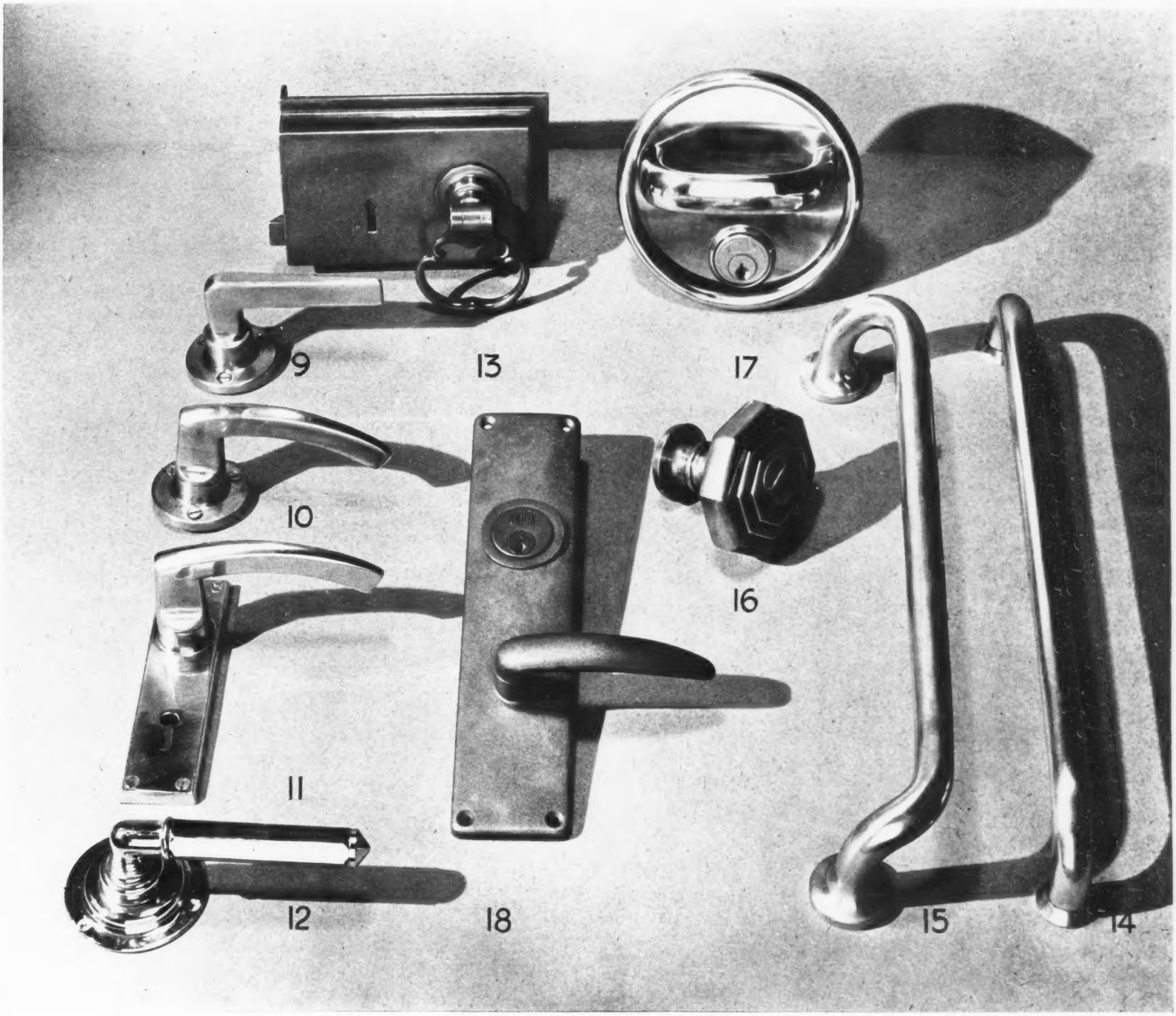


D SHAPED MORTICE LOCK



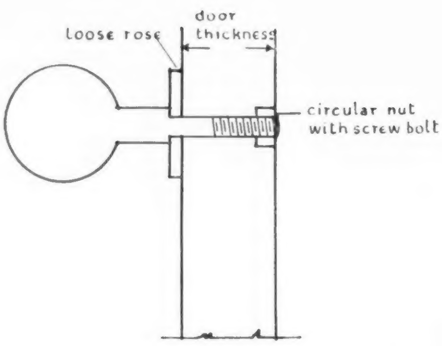
Metal door furniture is, theoretically, easy enough to design: the functional problem is not complicated and the material, whether cast or pressed, offers few serious limitations. But the resolute individuality of the ironmongery trade, the wide difference in taste among architects and their clients, and the speculative builders' search for "selling points" combine to hinder the evolution of the simple standardized inexpensive types which modern conditions would appear to demand. In what may be called the architectural market of cast sets selling at 6s. and upwards, a number of good designs are available some of which are, in fact, suitable for mass-production by other processes. In the cheap end of the trade, dominated by the speculative builder who spends perhaps 1s. or 1s. 6d. per set, very little that is not intolerably ugly can be obtained. For housing work, at rather higher price levels, there is plenty of plain and sturdy but rather insensitively designed stuff. As architects generally include comparatively high p.c. sums for door furniture, even for very cheap doors (the cost of the lock plus fixing and the furniture plus fixing may very easily, and often does, exceed the cost of the door itself on architect-controlled work), they are rarely concerned with the scarcity of good types in the lower-price classes, but the housing authorities, whose orders in the aggregate must form a large proportion of the total market, are in an influential position and might well, if they wished, simplify, standardize and appreciably cheapen, existing practice. The present enormous range of patterns in many different finishes to suit every taste is a luxury; the cost of carrying obsolete and wasted stock; the cost of producing seasonal new designs; the cost, in a curiously intricate trade, of marketing, may under present circumstances be inevitable; but these represent, from any rational point of view, unnecessary costs and unnecessary complications in practice. The typical English arrangement for domestic work, until in recent years it was partially ousted by the lever, is the horizontal mortice lock with ball-knob furniture, originally fixed to the spindle but now more generally fixed to the rose, with a floating spindle. A common spindle-fixing method is illustrated (sketch A): known as Mace's it consists of a threaded and grooved spindle, secured by a grub screw: the firmness of the handle depending on the bite of the grub screw in the groove, which cannot be relied upon indefinitely. Many improvements on this method are available but all, compared with Pitt's (sketch B) are comparatively expensive to produce and to fix. Pitt's, both more efficient and neater in appearance, has the shank of the handle permanently fixed to the rose but free to rotate. The pull is taken by screws into the door: in thin doors with mortice locks there may be insufficient

F U R N I T U R E

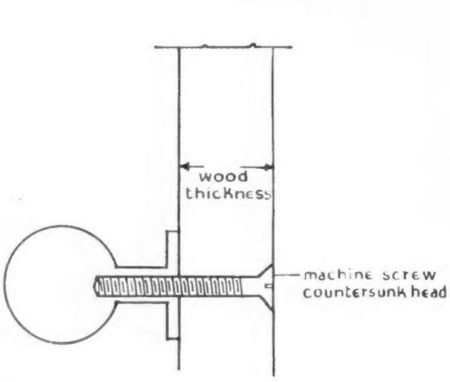


thickness for secure screwing—a difficulty which may be overcome by larger backplates (sketch C) or by specially shaped locks (sketch D). A selection of some of the better designs available in metal door furniture is shown in the photographs. 1 and 2 are good examples of a type which, with many minor variations, is listed by most manufacturers. 3 and 4, with straight shanks and simple roses, look, without being in fact more efficient, more functional; and are possibly more appropriate to flush doors than the types with moulded shanks and roses. Although there are some circumstances in which levers are for practical reasons preferable to knobs, their present popularity among architects is mainly due to continental influence, and it is perhaps for this reason that most of the good designs available in this country are closely based on current German practice; 5 is a direct simple design: the tubular grip is, if anything, more comfortable to use than the more general flat bar types, of which 6 is an exceptionally good example. The common defect of levers is drooping—a difficulty recognized in the past either by the use of wavy line shapes or, as in shop-door handles, by setting the grip deliberately at an angle. For the Shakespeare Memorial Theatre the architects, Scott, Chesterton and Shepherd, designed a bow handle, 7, which looks well on or off the horizontal. Most manufacturers now list levers with coil springing behind the rose so that the handle is sprung independently of the lock. With this a slightly clumsier rose cannot be avoided, 8, 9 and 10. As with knob sets thin doors may make a long back plate necessary in order to get screwing area outside the lock; 11 combines the long plate with a sprung lever. 12 is interesting as an example of furniture assembled mainly from cold pressings (other designs illustrated are castings) and well designed from all points of view: production, use, appearance. Rim lock sets are generally, in architects' houses, relegated to the servants' quarters: few speculative builders employ them: only in housing work are they common practice. However, for work where low cost is essential they are the logical furniture. The saving in cost of fixing compared with mortice locks is appreciable, and with the thin light doors necessarily used for this class of work rim locks avoid several minor difficulties which cannot always be cheaply and satisfactorily solved where mortice locks are used. Patterns available are either in cheap japanned pressed-steel cases or clumsy and roughly-finished cast-iron: neat and reasonably well-finished cases, with something of the quality at present only obtainable in expensive brass locks, 13, must be produced before the use of the rim lock can be extended as widely as its

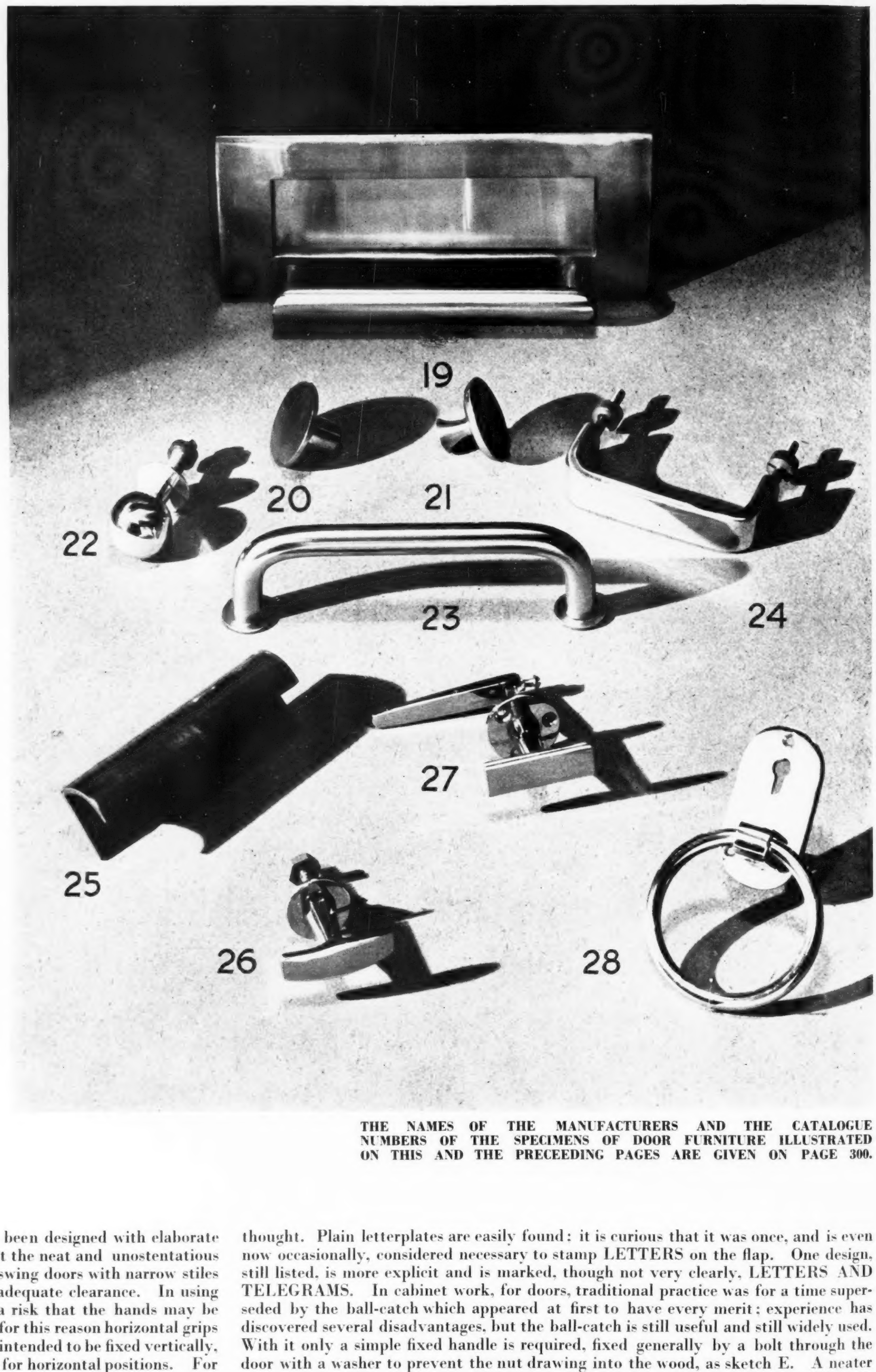
D O O R   F U R N I T U R E



E BOLT AND NUT FIXING FOR KNOBS



F MACHINE SCREW FIXING FOR KNOBS



THE NAMES OF THE MANUFACTURERS AND THE CATALOGUE NUMBERS OF THE SPECIMENS OF DOOR FURNITURE ILLUSTRATED ON THIS AND THE PRECEEDING PAGES ARE GIVEN ON PAGE 300.

intrinsic advantages suggest. Grip handles have often been designed with elaborate swellings and shapings on a vaguely functional basis, but the neat and unostentatious bent rod, 14, is sufficient for most purposes. On double-swing doors with narrow stiles it may be necessary to use cranked types, 15, to obtain adequate clearance. In using double-swing service doors with vertical grips there is a risk that the hands may be caught in the handle and bent very painfully backwards: for this reason horizontal grips are often preferable. Although grip handles are generally intended to be fixed vertically, nearly all the simpler designs can be used as satisfactorily for horizontal positions. For front doors the common arrangement for many years has been cylinder locks with separate fixed knobs, and some degree of ostentation has usually been considered appropriate in the design of the knob, 16. The separate lock, knob and letter-plate, however, tend to be spotty, and a design that combines lock and handle, 17, is an improvement. Still better, but apparently unobtainable, would be a combined lock, handle and letterplate. The normal night latch cylinder lock, unless snibbed back, locks automatically as the door is closed. This is not always a convenient arrangement, and the cylinder mortice types, 18, with a latch bolt operated by lever handles or key, and the dead bolt by key from outside and turn from inside, are probably more satisfactory in use and again combine neatly the handle and the lock. Many catalogues show examples of combined letter plates and grip handles; 19 is neater than most but the plate hardly recognizes, in shape, the existence of the grip; the handle is an afterthought. Plain letterplates are easily found: it is curious that it was once, and is even now occasionally, considered necessary to stamp LETTERS on the flap. One design, still listed, is more explicit and is marked, though not very clearly, LETTERS AND TELEGRAMS. In cabinet work, for doors, traditional practice was for a time superseded by the ball-catch which appeared at first to have every merit; experience has discovered several disadvantages, but the ball-catch is still useful and still widely used. With it only a simple fixed handle is required, fixed generally by a bolt through the door with a washer to prevent the nut drawing into the wood, as sketch E. A neater method uses a threaded shank and a machine screw from the back, sketch F. Between knobs and bar handles there is nothing to choose in point of efficiency; 20, 21 and 22 are good examples of the former: 23, 24 and 25 of the latter. The old-fashioned cupboard turn is still in several respects superior to the ball-catch, but the small ball knobs with which it is often used do not as a rule afford a sufficiently comfortable grip for turning, and tee handles are preferable. Of the few patterns available 26 and 27 are exceptionally good. For large doors, where wardrobe locks are often useful, the small dimension between the spindle and the keyhole practically enforces the use of drop handles. As with cupboard turns, modern designers tend to ignore wardrobe locks and only reproduction patterns are listed. 28 shows that the problem can be treated in a suitable contemporary way.

DAVID BOOTH.

R A I L I N G S

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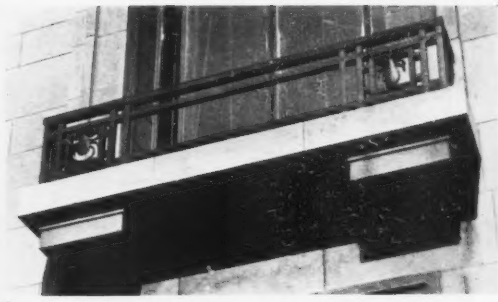

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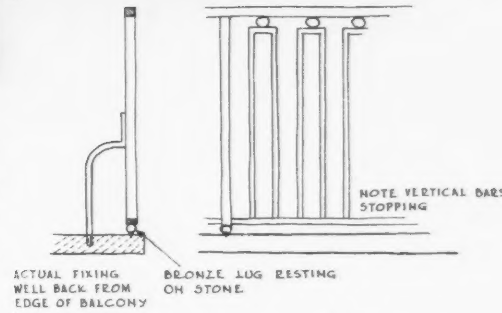

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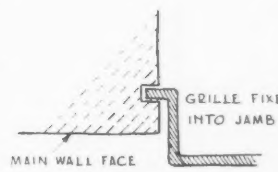

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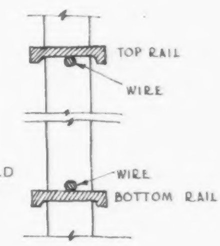

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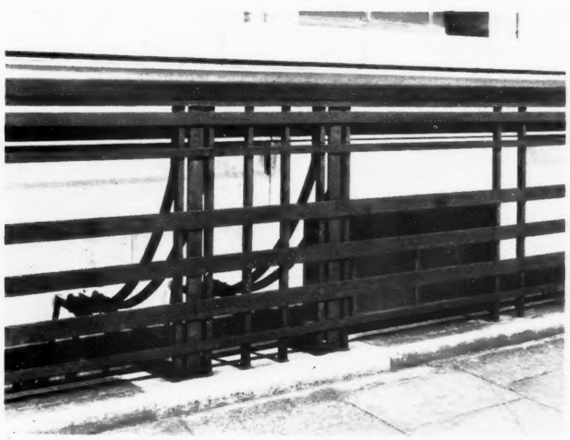

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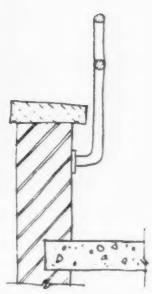

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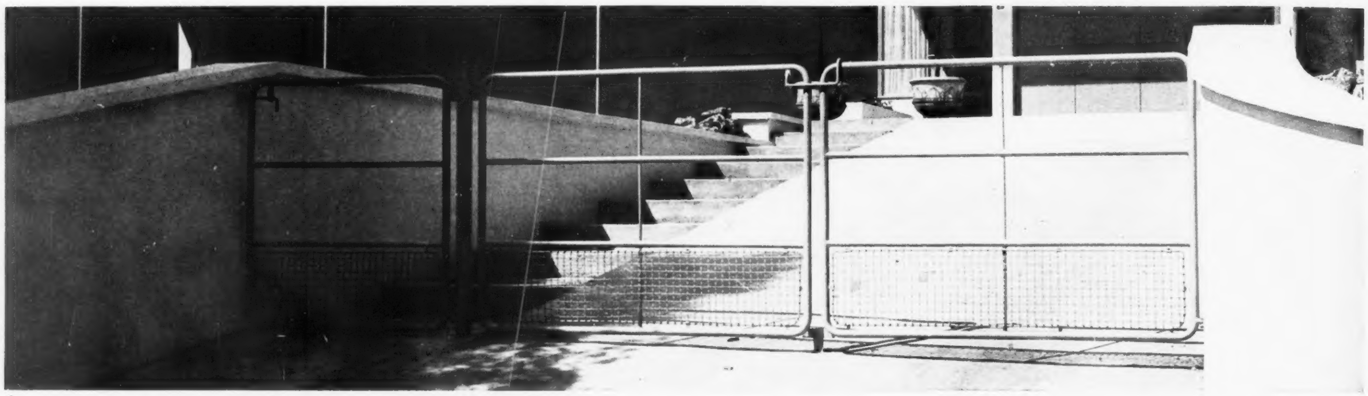
Ironwork unfortunately, is one of the things usually covered by a provisional sum in the specification and is consequently apt to suffer, like many other so-called "specialist" items, from lack of time, being left wholly in the hands of the sub-contractor. It is possible, however, that even this is better than an ill-considered design worked out in great detail without any reference to the requirements of the craftsman. Apart from the obvious fact that the finished article must be pleasing in appearance there appear to be three main things to consider in designing ironwork: (1) the design should be sensible from the manufacturing point of view; (2) the finished article should be properly fixed to the building; (3) the problem of upkeep and weathering should be kept in mind during all stages of the design. With regard to the first point one of the greatest difficulties the craftsman has to encounter is the ignorance of some designers of the characteristics of the material in which they are working. So often a design is shown with, say, twisted upright bars and classically moulded caps; the one being essentially a wrought-iron job, the other a cast-iron. The average architect can hardly expect to be fully equipped with the necessary detailed knowledge and much trouble would be saved if he would admit this and seek the advice of an expert at an early stage in the design, then carry on with small scale drawings or, better still, dimensioned perspective sketches which should be handed over to the specialist for full size detailing. On the other hand when it comes to common-sense questions of fixing or the ease of maintenance the architect should be able to hold his own. Existing specimens of ironwork both old and new, some examples of which are illustrated above, show many faults which could be avoided. Take for instance the ordinary railing consisting mainly of vertical bars. 1. shows an example of such a railing where every vertical bar has been fixed at the bottom into stonework. The result is that a very large number of the bars are badly rusted, as the "wind and water" position at the junction is always the first place to suffer. It would have been perfectly possible to stop most of the vertical bars on a flat horizontal one a few inches above the stone and to fix at intervals of three or four feet instead of every six inches. 2. shows a small iron balustrade to a balcony. In such cases, where the ironwork is fixed into the stone near the edge of the balcony, rusting is likely to occur with the accompanying expansion and bursting of the stone. This problem has been carefully thought out at the new London University building where the balcony railings, sketch 3, are dealt with in an extremely sensible manner. The vertical members near the edge of the balcony are not fixed into the stonework at all, but have small bronze lugs at their feet which merely rest in hollows in the stone. The actual fixing is done by struts carried back well away from the face of the stone, thereby minimizing the danger of spalling. Incidentally this railing adopts the method of stopping most of the vertical members on a horizontal cross-bar a few inches above the balcony level. Similar trouble of fixing iron into stone occurs wherever parapet railings have to be provided, though here there is a simple way out since it is an easy matter to fix the railing to the vertical wall instead of directly on top, sketch 7. In any kind of fixing of metal to stone the danger of rust stains must always be faced. On projecting balconies this is not so serious but where ironwork is fixed to a vertical face it is an important consideration. Window grilles or other wall fittings for instance might just as well be designed with fixing bars to slope down and away from the wall so that the water is at least encouraged to drip clear rather than to run down the face of the stonework. A useful old method of fixing wrought-iron window grilles was to fix to the window reveals instead of to the main wall face, as in sketch 4. This was good both because it tended to hide any staining and also because it ensured a safe fixing of the grille even if the leading-in of the ironwork was poorly done or subsequently became loose. Staining from painted iron ventilator gratings is so common that it should be accepted as essential to use a non-staining metal in any building faced with a light coloured material. Rusting of external ironwork raises another point, that of the possibility of adequate painting. Assuming, as one must, that painting will be attempted at regular intervals, will the design permit of this being done efficiently? A good design should reduce the areas of contact of cross-members to the minimum. 6 shows a railing which is weak in this respect. An old example at Hampstead, sketch 5, deals with this problem in an ingenious manner by making it possible to remove all the vertical members for painting. The vertical bars are drilled and then held in position by a wire and can be withdrawn for repainting.

C. C. HANDISYDE

GRILLES AND HANDRAILS



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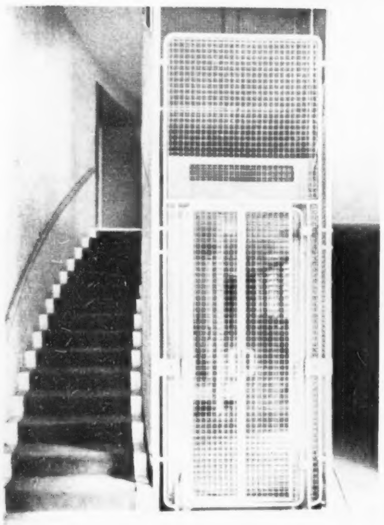

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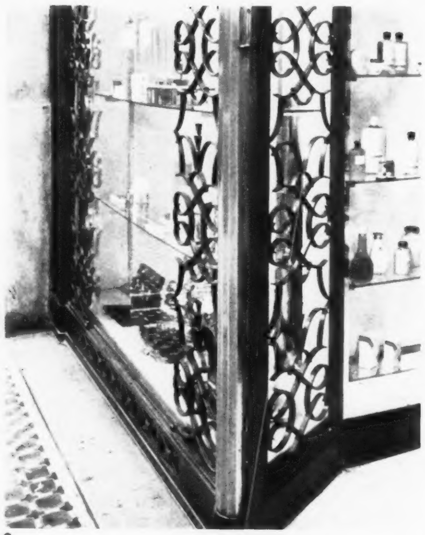

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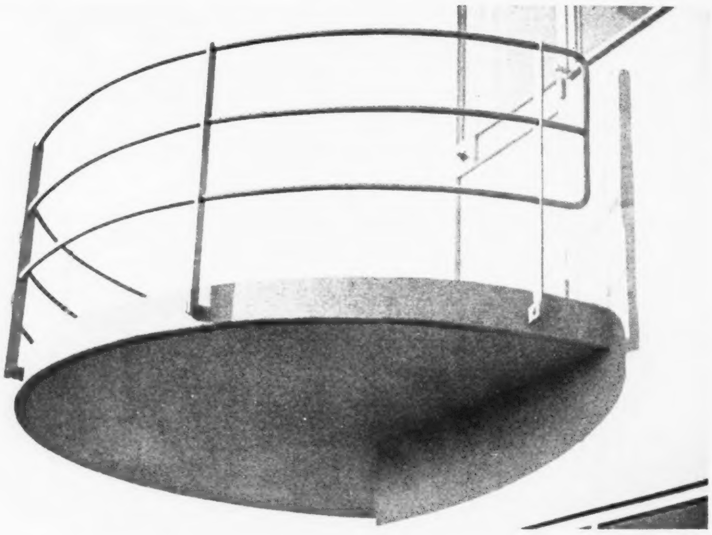

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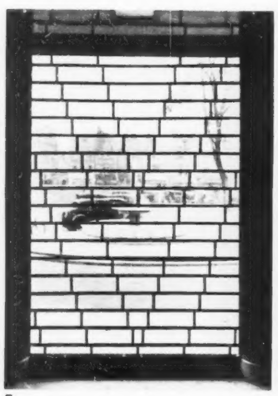

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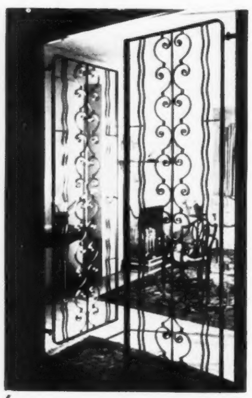

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The photographs above serve to illustrate a number of points in the article on railings on the last page, as well as being typical examples of contemporary uses of metal for grilles, gates, handrails, etc. The photographs on the facing page show typical contemporary uses on exteriors, for shop fronts and entrances. 1, welded steel tubular gates to a house in Hampstead: architect, E. Maxwell Fry. The usual difficulty of preventing corrosion at the intersection of the bar is overcome. The tube presents the smallest possible external area of any section of equal rigidity, and is easy and economical to paint. 2, a somewhat similar use of tube for lift enclosures at Highpoint: architects, Lubetkin and Tecton. 3, a bronze shopfront grille, backed by plate-glass. In this case the usual difficulty of cleaning the glass behind the metalwork is overcome by hanging the grille so that it may open—a point that designers sometimes overlook. 4, a balcony railing to a house at Rugby (architect, Serge Chermayeff) in steel tube and flats. The tube joint at each end is welded, and the whole galvanized and painted. The method of fixing to the vertical face of the balcony overcomes many of the difficulties of the usual fixing to the horizontal. 5, an example of the use of bronze sections to form a lifting and collapsing grille at Hornsey Town Hall: architect, R. H. Uren. 6, a recent example of decorative wrought ironwork: designer, Gordon Russell. 7, a handrail in a hostel at Nottingham, in "Birmabright" alloy, illustrating an unusual method of obtaining rigidity to the lower end of the handrail. The

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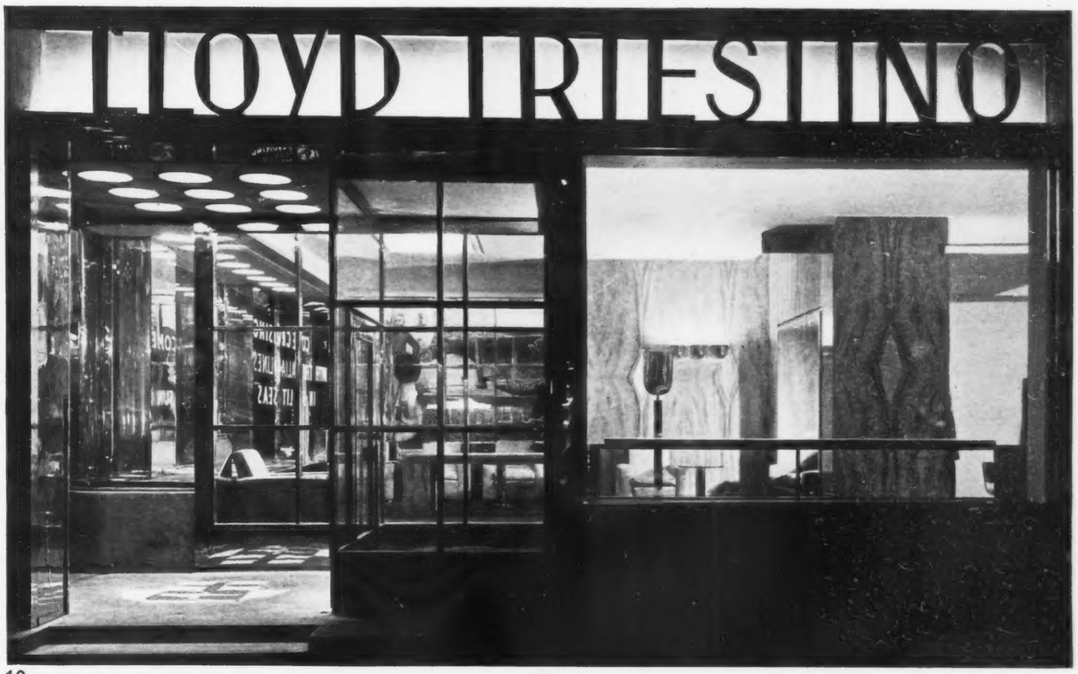

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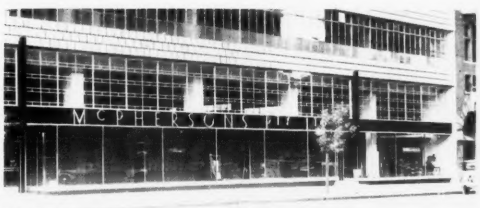

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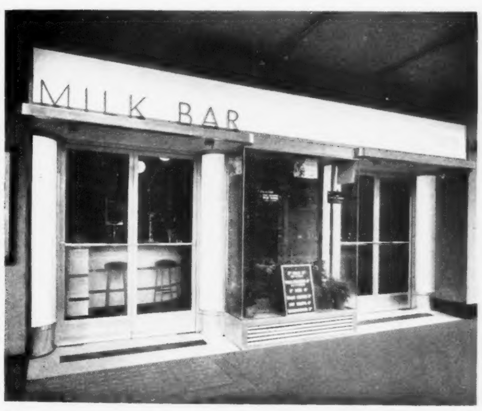

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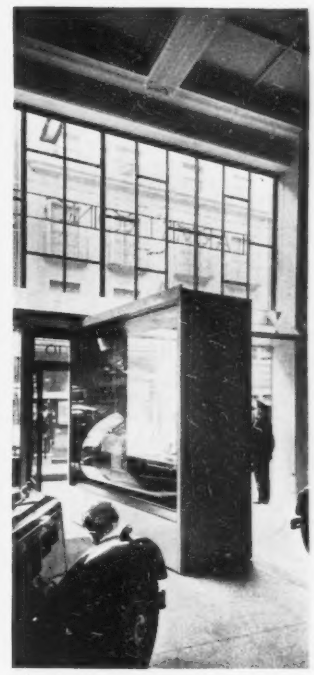

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traditional form of handrail gives strength where there is most sideways pull. Many modern designers overlook this with the result that the handrail is easily loosened in the fixing: architects, Bromley, Cartwright and Waumsley. 8, a nickel-silver handrail set on a dwarf marble-faced balustrade wall. The amount of bending which is possible with even an unusually heavy section is well illustrated. 9, an entrance grille, in copper alloy rods of two different colours, at the Ideal Radiator Building, off Regent Street. The Royal Arms above are in enamel on bronze, an interesting minor use of metal in shopfitting: architect, Gordon Jeeves. 10, an example of the use of stainless steel in shopfront work, the same metal being also used for a good deal of interior work: The Italian Travel Bureau, Lower Regent Street: architects, Rachlis & associates. 11, showing the extreme thinness possible with metal fronts: an aluminium alloy ("Birmabright") front in Melbourne, Australia: architects, Reid & Pearson, and Stuart P. Calder. 12, anodized aluminium in London: below the Paramount Cinema, Tottenham Court Road. The greater part of the metal is a silver grey in colour while the fascia letters are anodized and dyed green: architects, Frank S. Verity and S. Beverley. 13, anodized aluminium, dyed pink. The vertical lines on the window are in stainless steel: architect, Gerald Lacoste. 14, metal makes possible a non-reflecting window that is also movable. The whole is mounted in a bronze frame and arranged to open: architect, W. A. Forsyth.

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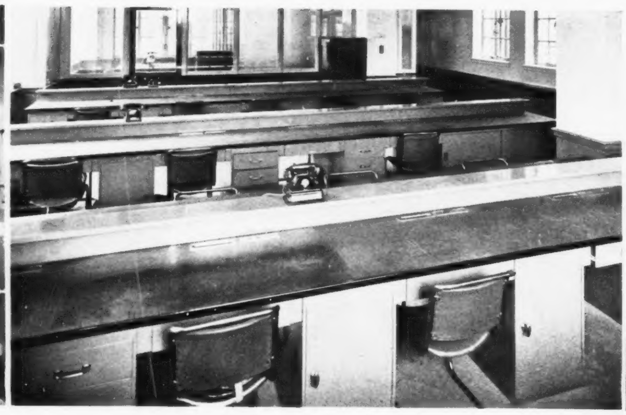

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The use of metal in furniture is a comparatively recent development, and one of the few examples of historic interest are the light iron chairs of which a modern derivative is included on page 278. Metal may be used in several forms for the purpose, the form necessarily controlling the type of design even more than the nature of the building material must control the design of a building. The cast-iron park-seat is wholly different in conception from the contemporary tubular chair. 1, aluminium sheet veneered to plywood for table tops, forming flat sheets requiring no supporting frame: a continuous metal surface smooth on both sides and the edges. The stools as well as the tables are supported by mild steel tubes, screwed to cast-iron flanges fixed to the floor. Where movable seats are not required such supports interfere least with sweeping. From the Miners' Welfare Committee's Pithead Baths at Parsonage Colliery: architects, J. H. Forshaw and C. G. Kemp. 2, a range of steel lockers, also for the Miners' Welfare Committee. Rigidity is partly obtained by bending and flanging, and partly by the use of mild steel

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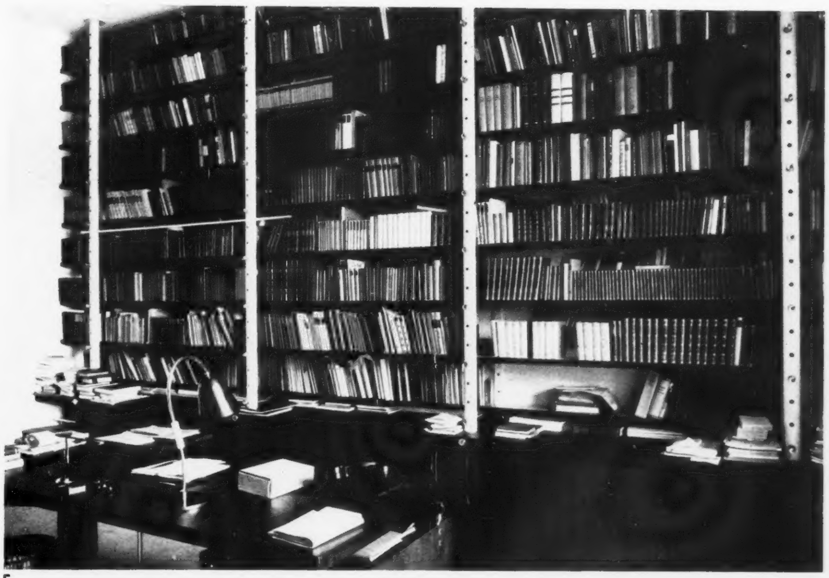

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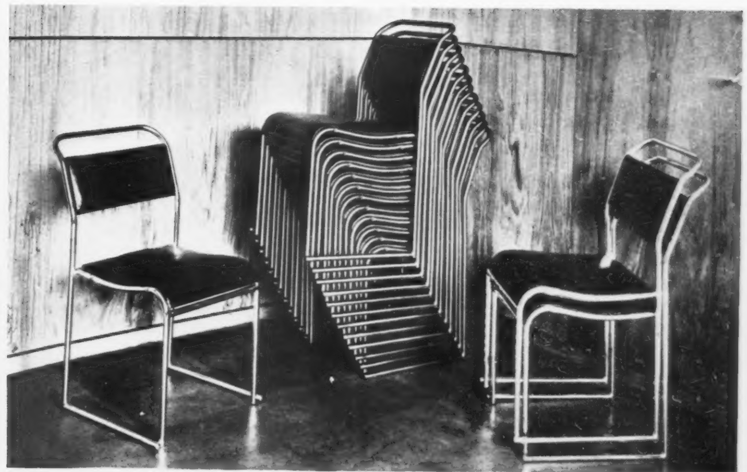

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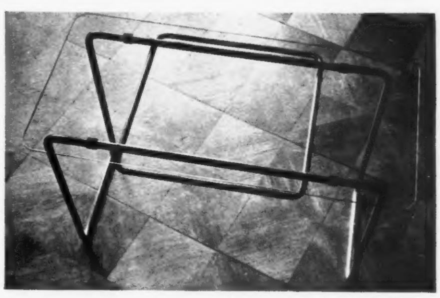

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angle and strip. A tubular handrail is provided at eye-level to simplify access to the upper tier. 3, a typical example of sheet-metal office furniture, where most of the rigidity is derived from flanging and bending. The tubular chairs make full use of the tensile strength of solid drawn-steel tube. 4, typical strong-room fittings in which advantage is taken of the fireproof characteristics of sheet steel. The rolling shutters show another typical use of drawn light-range sections. 5, a combination of sheet-steel shelves with heavy steel tubular uprights for library shelving where considerable stack heights are required: an American example. 6, an aluminium sheet wastepaper basket designed by Walter Gropius. 7 and 8, examples of the contemporary use of steel tube for furniture. A table by Marcel Breuer showing the use of metal in combination with glass. Very few joints, necessarily relatively expensive to make, are required. Also a series of light nesting chairs illustrating the possibilities of mass-production. 9, a range of furniture from aluminium tube and strip, also by Marcel Breuer.

MISCELLANEOUS BUILDING USES

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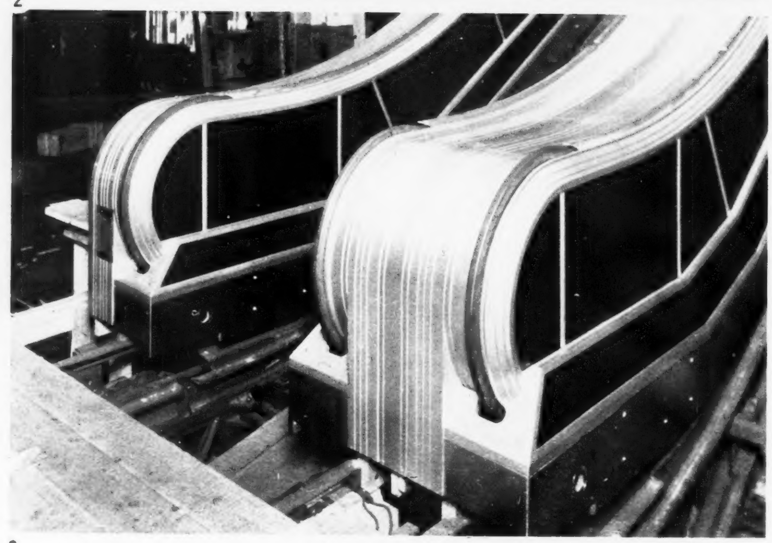

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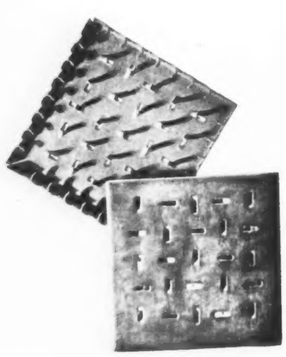

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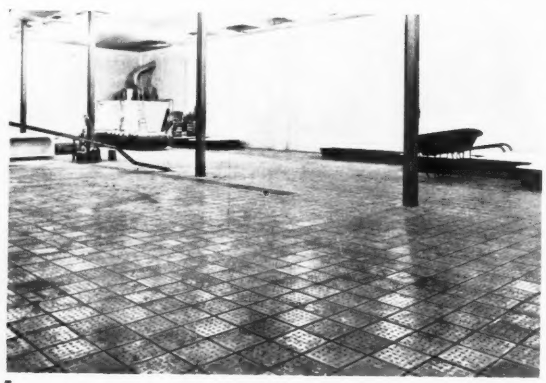

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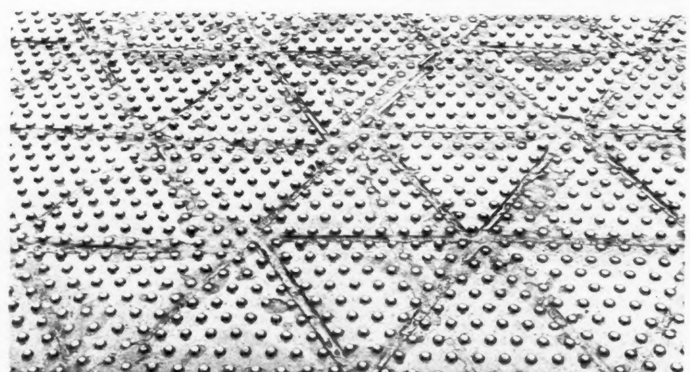

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This issue deals only with the non-structural uses of metal, but as technique and development expand it is increasingly difficult to say where structure ends and fittings begin. 1, an American prefabricated house, in which the finishings to windows and walls are incorporated with and become part of the structure. 2, sheet-metal stairs, in a sense structural, but nevertheless capable of being made in the shop, brought on to the job and screwed in position as easily as one could erect a Victorian wardrobe or bedstead. The structure incorporates the finishing mouldings to the stairs. 3, aluminium with an anodized finish forming both the casing and the decorative finish to an escalator in a department store in Toronto, Canada. 4 and 5, punched steel floorplates for industrial use and, 6, cast-iron paving setts for heavy (exterior) road work. Both examples of the use of metal in new and logical forms for purposes undreamed of in the last generation.

Up to this point this issue has dealt with traditional metal-working techniques; with metals, that is to say, as they have been worked for a long time past—cast, wrought or drawn—the fundamental method having remained the same notwithstanding improvements in manufacturing processes and changes in habits of design. In these concluding pages we look more towards the future, first with an article on pressed metal, an entirely modern technique that, though extensively used today, is still only in its infancy, and afterwards with an article on metal research describing how the scientist of today is working on behalf of the architect of tomorrow.

A TECHNIQUE OF THE FUTURE

PRESSED METAL

By Philip Scholberg

Some years ago quite a distinguished architect built a school in which there were some octagonal reinforced concrete columns, perfectly plain, and growing straight out of a flat slab floor in the way which anyone would expect. This, however, was thought to look too bare, so a nicely moulded base was made in two halves (hollow of course) wrapped round the column like an Eton collar, and welded in two seams.

Here we have at once the strength and the weakness of pressed metal as a substance for design. Pressed metal may be made to imitate, with an all too perfect fidelity, almost any conceivable material from uncoursed rubble to blistered mahogany, and, as a result, is hardly ever allowed to look like itself. This is only partly the fault of the designers, for many of the manufacturers seem to be ashamed of their materials, or at any rate think it easier to find a market for their goods if they make exactly what everybody else makes, and disguise, as far as possible, the fact that the material is different: the same course, in fact, as that pursued by the less intelligent part of the plastics industry.

According to one's outlook, there is plenty of excuse either for tears or laughter, but the present uncertainty in design can be no more than a passing phase, for the manufacturers know perfectly well that simplicity is not only far cheaper but also, more often than not, produces a far more satisfactory job. The current view of design happens to coincide, here, with efficiency from every point of view, and it may therefore be assumed that pressed metal goods will become cheaper and better as time goes on.

That a free use of pressings ultimately leads to cheapness can be shown fairly clearly by a glance at current practice in the motor industry. For a decade or so after the war the standard method of coachbuilding was sheet metal panels fixed to an elaborate wooden frame, panels, too, which always had to be hand-beaten if the curves were in more than one plane. The result was heavy, and became noisy in a few years as the panels worked loose and as play developed in the joints. The flexible-framed leathercloth-covered body was the next step, but the popularity of this type began to wane as soon as the manufacturers of cheaper cars began to use leathercloth as a finish over the normal rigid type of body construction and the snob-appeal of purpose-made bodies was lost. The pressed steel body of today, produced with a minimum of welded units, came originally from America, where large outputs and an almost universal desire for one particular body type made the high cost of the dies worth while.

The products thus marketed were, admittedly, far stronger and lighter than the old types. From the production point of view they had numerous advantages which have been steadily developed until now a typical mass-produced body is made entirely of steel save for the upholstery and cloth linings. And made from a very few pieces of steel too, for the body shell may be welded up from three or four pressings, and these pressings will embody all the necessary door and window rebates so that finishing times are cut down to a minimum.

Pressed steel bodywork, owing to the high cost of cutting the necessary dies, only becomes possible when output is measured in tens of thousands per annum, yet in spite of this many people imagine that it is quite simple to produce a very cheap mass-produced house which anybody can buy off the peg. Efforts to do so have so far been unsuccessful, largely because the two jobs are by no means parallel. Cars are bought as cheap transport, and carry anything from two people upwards in a strictly limited space which, incidentally, probably costs something like ten to fifteen shillings a cubic foot. In houses produced on these lines the family will have to adapt itself to what is available, just as it now squeezes itself, with dogs and picnic baskets, into a car far too small for it. Deviations from the standard design will only be available at a prohibitive increase in cost, and it would seem, therefore, that the true prefabricated house, delivered all ready on the site by a large truck, will only be accepted by the buying public if the price is so low that cost and nothing else will make up for the almost inevitable inconveniences. As a secondary consideration the various experts concerned have not yet decided what a normal dwelling should be.

American manufacturers and designers, thinking at some length along these lines, have more or less decided that as nobody knows quite what to build or how to build it, and that as hardly anybody would buy it if they did, it is better to concentrate on standardized units which can be incorporated in contemporary house designs and do two or more jobs where they did only one before.

Here would seem to be the most profitable opening for the use of pressed metals of all kinds, for the multiplicity of parts in the average small house is nothing less than horrifying. The *Architectural Forum* of America, in a recent survey of the whole question says: "It takes more than 30,000 parts to build a typical house, counting only items which must be ordered as such—not counting things like nails and screws, separate pieces of assembled parts like hardware, pieces cut in two on the job, loose or plastic materials etc." Reductions in this number may be made either by employing larger units or by making each unit perform several duties, e.g. by making a metal door-frame support its partition, or by making a sink or basin with an integral turn up to form its own splash-back.

A process such as this involves a good many changes not only in the technique of building but in the craftsmen to be employed on the job, plumbers, plasterers and joiners giving way to the mechanic type, capable of doing a larger range of work. It seems almost possible in fact, that the only trades employed on a job, after the preliminary levelling of the site, may be welders, painters, floor layers and drain layers, with perhaps a few labourers to apply the necessary insulation to walls and roofs. This final state is still a long way off, but a visit to any large job in this country will show that there is a large amount of pressed metal used in one form or another, replacing not only the work of the joiner, but of the bricklayer, plasterer and concretor.

Staircases for example: strings can be pressed in channel form, treads and risers bolted or welded to them, and the whole assembly goes up easily at the same speed as the steel frame, so that safe and easy vertical circulations are immediately available, handrails and balusters are easy to fix, and the final finishings can easily be left until the job is nearly completed.

Doors and door frames in pressed steel are widely used if the job is large enough to allow of a reasonable amount of repetition, and several manufacturers are standardizing flush doors in various sizes with a standardized frame section suitable for any size of door. Most of these are in simple designs with no unnecessary mouldings and the frames give a fair amount of support to the thin lightweight partitions that are now common practice. The early types of door with wood graining photographed on (particularly prevalent in America) have now been virtually abandoned in this country.

Skirtings, picture rails and corner beads are also widely used, and have many virtues, particularly for housing work where vermin are troublesome, but there are still some difficulties at external and internal angles, where radiused junction pieces are applied, either with a joggled joint to give a flush finish, or with the joint lapped, leaving an unnecessary ridge. Cut and welded junctions do not seem to be popular, and certainly they offer considerable difficulties on the job, though the result is a good deal better.

The all steel partition is also produced in a variety of forms, frequently as a narrow unit with the top half glazed, the joints being hidden by a cover channel sprung over flanges at each edge. So far there seems to be no all-metal partition suitable for housing work, nor is a great deal of effort made to ensure proper sound insulation, a factor which is not of paramount importance in office planning, but which must be carefully considered anywhere else. Probably a core of cork or some other material will prove to be the ultimate solution. Separate skirtings, picture rails and corner beads will, of course, be unnecessary with this type of partition.

Pressed steel furniture is now appearing in larger quantities and here too there are encouraging signs that manufacturers are growing out of their first imitation-wood ideas. Filing cabinets, desks, chairs, tables and shelving are all made in a variety of shapes, and the shapes are essentially *pressed* shapes. Some objection is frequently taken to steel or any other metal as a furniture material on the grounds that it is cold to the touch; to a certain extent this is true, but at least it is no colder than the current fashion for glass, and the objection is much reduced where central heating is employed.

The general heading of equipment covers a multitude of products ranging from cookers and refrigerators to sinks and flushing cisterns. Here there would seem to be opportunities for an immense number of fittings which are at present made from an almost infinite number of traditional materials. If the most is to be made of these possibilities it is essential that pressed metal equipment must not only work, but work in a much better way than the articles it replaces. The buying public is supremely uninterested in pressed metal *qua* pressed metal—price will be about the same, or at best a very little less (often more)—and the deciding factor will be efficiency, with a possible extra pull through general appearance and finish. Manufacturers, therefore, must rigidly eschew the policy of imitating existing shapes, and stop to analyse the purposes for which their products will be used, having the courage, if necessary, to produce something better, even if it looks like nothing ever before used for the job.

At this point it is worth stopping for a moment to consider one product in which this policy has been properly worked out, and where the result has been remarkably successful. For endless years the ordinary domestic sink remained exactly the same: broader, longer, shallower or narrower, the variations were small and the result was always recognizably a sink. Monel metal and stainless steel, with their corrosion-resisting properties were ideal materials for the purpose, yet, before they rushed into the market with a slavish copy of the old fireclay types, the manufacturers had the sense to stop and decide exactly what a sink was for.

The result of their forethought is familiar enough to everyone nowadays: a two-compartment sink with proper arrangements for straining dirty water—large radius corners for easy cleaning—a proper draining board in one piece with the sink—proper water channels in the draining board—a rolled front edge and a back edge upturned so that the wall finish can be neatly stopped off—a product designed essentially *as a pressing*, but a product which is also much better *as a sink*.

For such things as baths and lavatory basins pressed steel is far more widely used in America than in this country, but there are signs that further developments are not far off. The Steel Sheet Market Development Committee, for example, are building a block of four experimental flats just north of King's Cross station, and here they are experimenting with different types of pressed steel doors and frames, baths, lavatory basins, picture rails, skirtings, window frames, ceilings, not to mention light built-up floor trusses and plastered dovetail sheeting for partitions. The flats are not yet completed, so that they still lack the test of actual use, but it is intended that the job shall form a small experimental station where the faults and the merits of different equipment designs and constructional methods can be tried out.

Most of the pressed baths and lavatory basins on this job are American designed and made, and fittings such as these are now taken more or less for granted by the American public. There are signs, however, that further developments are to be expected in America, for the Phelps Dodge Research Laboratories have been experimenting with a prefabricated bathroom unit designed by Buckminster Fuller (see page 294). Made entirely from pressings, this bathroom measures only 5ft. square on plan and contains a W.C. and a lavatory basin as well as a bath: save for the door opening, height all round is 3 ft. and the wall finish, tiles or plaster, is carried upwards from this line. Weight is about one quarter that of the conventional tiled bathroom and fittings. So far the price is not fixed.

This is an example of what may be expected from pressed metal in the not too distant future; the units, instead of remaining as we know them now, bath, refrigerator or wardrobe, will increase in size to bathroom, kitchen, or one wall of a bedroom. With the choice of a suitable measurement unit for the design there is no reason why the resultant units should all look the same, for they will be produced in separate sections, welded together, and there will be plenty of opportunity for varying overall dimensions, though the cupboards, shelves, or whatever else the units may consist of, will remain the same size, and there is every reason why they should do so if they have been properly designed in the first place.

That there is nothing outrageous in this idea is shown by the *Architectural Forum's* design for a "power plant," a prefabricated unit in which pressings would be very largely used, and which would include all the necessary bathroom and kitchen fixtures, heating, hot water and ventilating equipment, needing only soil pipe, water, gas and electrical connections to be ready for use. The unit is designed (see page 294) so that the kitchen and bathroom share a common wall, and its use is therefore limited to a single storey house or flat. For a two storey house there seems no reason why much the same thing should not be done with the bathroom over the kitchen instead of beside it, and the whole idea behind this unit is both possible and reasonable, not necessarily as something which must be produced in large quantities at once, but as a serious suggestion that this sort of thing is what prefabrication means, and, moreover, it embodies no units which are not in existence already.

So much for the possibilities. A building technique such as this is bound to be developed sooner or later, for building at the moment is a slow and laborious process, and it costs too much. And here one may perhaps quote Dr. J. O. Downey, an economist attached to the General Motors Corporation of New York: he quotes figures showing that the average number of small houses produced per building trade worker per year is about ·6 to ·7, while in the automobile industry each factory worker has an output of about 10 cars a year, and he says: "if automobiles were built by methods similar to those employed in building houses, the present $600 car probably would be priced at more than $5,000."

Within limits, the same state of affairs would apply also to the building and the automobile industries in this country, and although it is not suggested that the building industry is ever likely to reach the output or the standardization of the automobile industry, it is none the less certain that the building industry might well more nearly approach it. And it is more than probable that sheet metals will have a good deal to do with this progress.

RESEARCH

In considering the value of research to those who have to design and work with metals it is well to realize how highly organized industrial research work has become. In this country it has developed almost entirely in the post-war years. Towards the end of the Great War the British Government began an experiment that resulted in the establishment of over twenty Research Associations in which a very large number of industrial concerns co-operate with the Department of Scientific and Industrial Research (D.S.I.R.) to carry out research and development for the benefit of industry.

The work of two of these associations—namely the British Non-Ferrous Metals Research Association (B.N.F.) and the Iron and Steel Industrial Research Council—should be of direct interest to the architectural user of metals. These associations are controlled and supported by a number of industrial concerns including the primary producers of metals and the manufacturers and users of many classes of finished and semi-finished products. Next come the research organizations run by those concerned in forwarding the interests of some particular metal. These may be co-operative organizations controlled by the interests of groups of primary producers, as for example the International Tin Research Council, or they may be the research departments of the large industrial concerns such as the producers of stainless steel or nickel.

In recent years there have grown up a number of "Development" Organizations; the work of these is a very useful and necessary supplement to that of the research organizations. Their purpose is to provide the ultimate consumer of metals with information as up-to-date and as accurate as possible on the properties and applications of metals and their alloys affecting every field of their use.

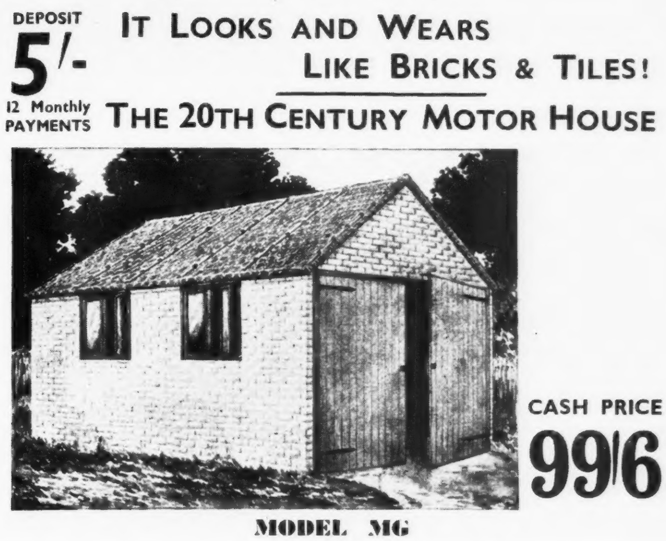
Side by side with these research organizations there exist a very large number of scientific and technical Societies or Institutes, which though of much earlier origin, play quite an important part in present-day industrial research. These societies are composed of an evenly balanced number of individual members engaged in research and industry; they may be concerned with general metallurgy like the Institute of Metals or the Iron and Steel Institute, or they may concentrate on some particular aspect like the Institute of Welding or the Electrodepositor's Technical Society. These societies taken together publish a large volume of papers giving details of experimental research and modern metal-working practice. Their virtue is that they are completely independent bodies where individuals engaged in research and industry meet and discuss their technical problems together. A great deal of the research of the organized associations and individual firms is published and read at meetings of these societies, by those who have carried out the experimental work themselves. The results are then freely discussed by the other members who can criticize and appraise them in the light of their own scientific or industrial experience. The discussions, which are often published with the research papers, serve as useful guides to the value of the proceedings.

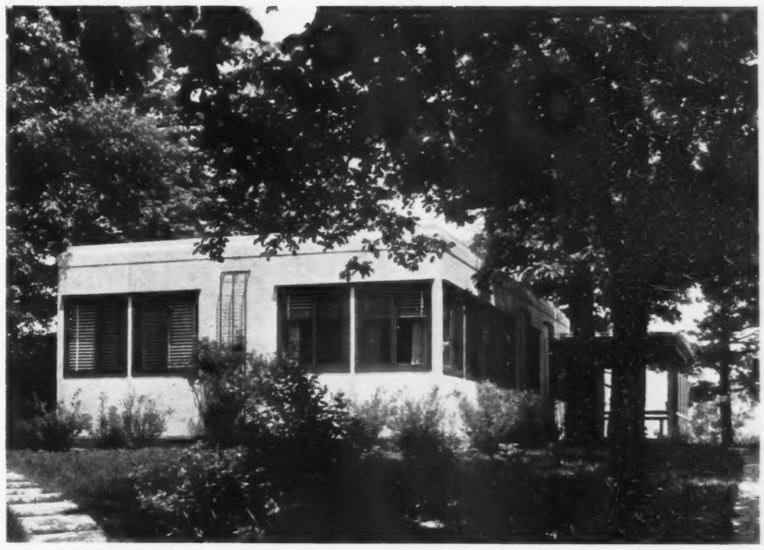
Let us now consider some of the more important recent developments where research has resulted in new advances in architectural metalwork. Many present-day decorative effects are largely due to the use of new metals and to production methods which were not available say twenty-five years ago. For example the use of stainless steel and anodized aluminium or of extruded sections of bronze, monel metal and aluminium alloys for shop fronts are advances of quite recent years. In such decorative work architectural designers seem to show a marked preference for the solid untarnishable or relatively untarnishable metals such as stainless steels or the white nickel-silvers and this in spite of their rather high cost. At the present stage of development this is probably quite natural, but preferably the ideal should be to use a relatively cheap basis metal embodying all the necessary structural requirements and then to give this a coating of a second metal that will both satisfy the design requirements and stand up against whatever corrosive influences are known to exist. Ultimately research will show how this can be done.

For the moment let us consider the solid metals and leave the coatings to a later stage of this article. Stainless steel as well as being used for exterior decorations is also very popular for interior fittings, where we find it in such varied forms as door handles and water taps, fireplaces and ornamental grilles. The development of the stainless steels is largely due to the research carried out in Firth-Vickers' laboratories. The first stainless steel, which contained 13 per cent. of chromium, was invented twenty-six years ago. It was first used for cutlery and its great resistance to corrosion was only secured when in a fully hardened condition and well polished. These drawbacks naturally led to a considerable amount of research. As a result a much superior steel containing 18 per cent. of chromium and 8 per cent. of nickel was developed. By modifying the composition somewhat a steel containing about 12½ per cent. of both nickel and chromium was obtained; this is still more workable and allows drawing over a hard-wood core.

Nickel-silver, owing to its pleasing appearance, is also very widely used; its applications range from complete doors and balustrading to plumbing and door fittings. In general the corrosion-resistance of nickel-silvers, which are alloys of copper, zinc and nickel (they are occasionally called white bronzes), increases with increasing nickel content; it has been reported that the fittings in the U.S. Senate offices, which were made from alloys containing 20 per cent. Nickel and have been in use now for twenty-five years, are still in a substantially new condition. The technique of casting nickel-silver is still felt to require improvement and research on this is included in the present programme of work by the B.N.F.

Apart from stainless steel, most of the metals used for exterior work are now available in the form of extruded sections. The process of extrusion is essentially the forcing of a billet of metal while it is in a plastic state through a die which is shaped to produce the section required. Though this process is now some fifty years old, it is only in the last few years that it has been applied to metals of relatively high melting point and its range of metals now includes, besides the earlier used copper alloys, also aluminium and its alloys, brasses (including the harder nickel brasses) and numerous bronzes. The





" Pressed metal may be made to imitate, with an all too perfect fidelity, almost any conceivable material from uncoursed rubble to blistered mahogany." Two examples of design in pressed metal, using much the same material for much the same purpose, by different designers, one thinking in terms of the material in use, the other thinking only in terms of imitation. The latter practice can only serve to damage the reputation of a new and growing industry. The left-hand illustration explains itself; the right-hand one, unfortunately not from this country but from America, shows an intelligent use of the material for prefabricated domestic design.

PRESSED METAL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Typical examples of contemporary pressed metal. 1, the mass-production of steel doorframes. 2, the same door-frames built in and finished. 3, a range of lavatory doors and frames in which full advantage is taken of the special properties of pressed metal. 4, an example of stock units which can be assembled much as "Meccano" to form almost any size or type of partition or wall lining. The units mostly clip together, and the wallboard panelling sheets are held in place by cover moulds sprung over legs so that no fixings show. The units may be taken down and re-erected as desired. 5, a glazed partition in Unity House, Liverpool, (Ormrod and Banister, architects) built up from pressed steel units and illustrating the rigidity and light appearance obtainable with carefully designed sections.


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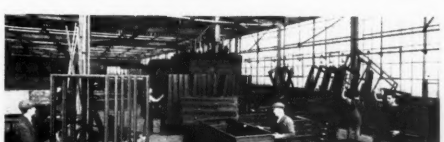
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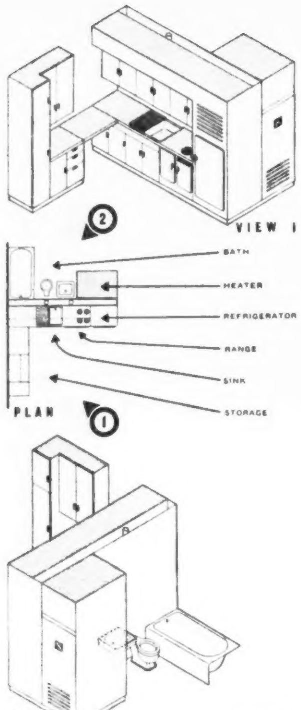

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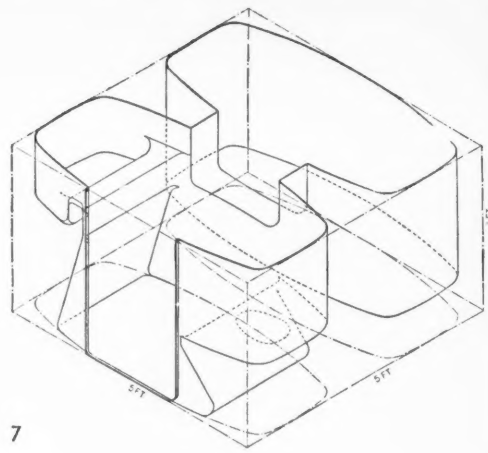

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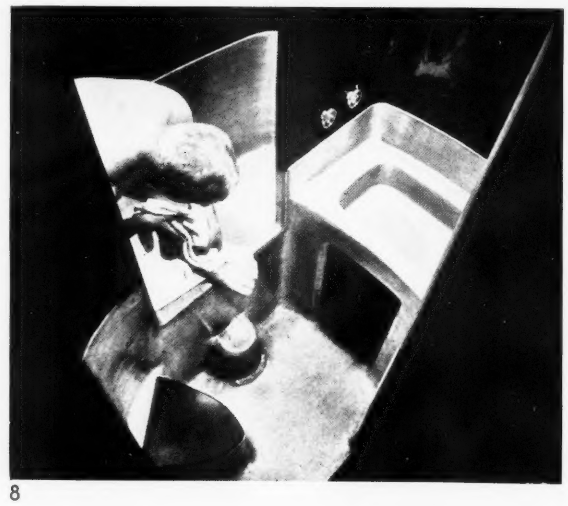

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The trend of development. The completely standardized house appears as yet to be an impossibility, but standard units which may be fitted into a house of almost any normal plan form a logical and immediately practical starting point made possible only by the technique of pressed metal. 6, The "integrated power plant," by courtesy of the *Architectural Forum*, combining all the sanitary and cooking equipment of the normal house. 7 and 8, bathroom combining the normal fittings in one sheet metal unit. 9, sheet metal bank and office shelving in which the stiffness is obtained by turning the edges of the metal. 10, monel metal and, 11, stainless steel sinks, both products designed essentially as pressings, but also more satisfactory as sinks compared with traditional designs. 12, a pressed metal radiator; clean, light, and surprisingly resistant to damage by frost.

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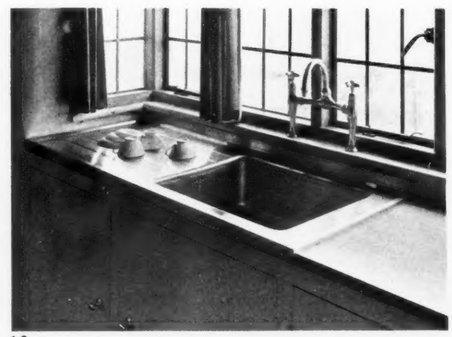

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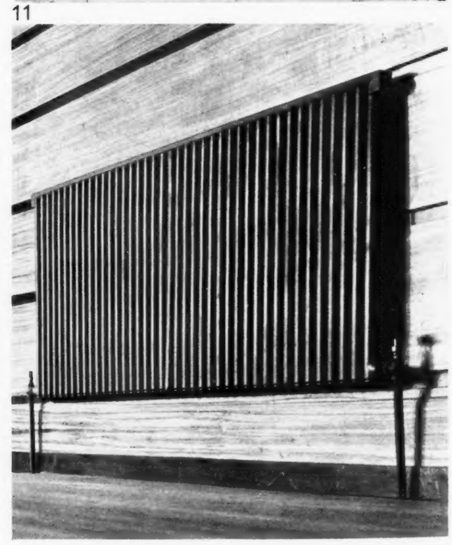

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widening of this field has been greatly helped by knowledge gained from laboratory work on the behaviour of metals at high temperatures. The development of new high strength engineering steels, which can make the presses sufficiently robust to allow the harder metals to be extruded, was also essential. The strains involved, when the metals with a very short plastic range have to be extruded, at high speeds, so that they may not cool below their critical temperature, are of course enormous. It has been reported that extruded sections have now been produced experimentally from nickel-copper alloys (including monel metal), nickel-silver and nickel-chromium alloys. The nickel-copper alloys are already commercially available in the extruded form as tubes. Other workers are investigating the fundamentals concerning the forces involved in the plastic working of metals, in the belief that a knowledge of these factors will lead to further improvement and it is felt by many that it will not be long before steel itself will be extruded.

To continue our considerations of exterior uses, the question of the corrosion resistance of the metals is of the utmost importance. Without doubt more research has been expended on corrosion problems than in any other field of investigation. A tremendous amount of work has been done in "tabulating" the corrosion resistance of innumerable metals and alloys to a variety of specific conditions. These tests may be of the "accelerated corrosion" type or perhaps actual exposure under varying atmospheric conditions. It is perhaps an unfortunate fact that the accelerated tests do not provide corrosion resistance figures which give a perfect key to the behaviour of metals exposed to the atmosphere. A large number of instances could be quoted where the relative resistance to corrosion of two alloys or coatings as tested by laboratory methods is found to be reversed under certain atmospheric conditions. Generally, such anomalies are only found when the metals have approximately the same order of resistance and it must be admitted that laboratory tests which can be performed in a few hours or days serve a very useful purpose, especially in the early stages of development, when atmospheric tests, which may need to be of a few years' duration, are not available. Apart from specific tests many fundamental investigations into the factors involved in corrosion are proceeding —e.g. the work of Dr. U. R. Evans of Cambridge.

The modern view of metallic corrosion indicates that metals, with the exception of the precious metals such as gold and platinum, become coated on exposure to air by films of oxides (or other basic materials) and that their resistance depends thereafter on how far these films will protect the underlying metal from further attack. These oxide films vary from the almost infinitely thin layers which form on stainless steel or chromium to the thick loose rust on iron or mild steel. With stainless steel the chromium oxide film is "self-healing"—i.e. when it is broken in any place, say perhaps by scratching, a new film immediately forms—and thus perfect protection is provided. Conversely the rust which forms on iron is loose and porous and allows the corrosion of the underlying metal to continue freely; it may in some cases even accelerate this by forming a "sponge" which will hold the moisture (laden with acids from industrial atmospheres) to the surface of the iron. Ultimately a cheap anti-corrosion treatment for iron, applicable to all the normal purposes for which the metal is used, will be found.

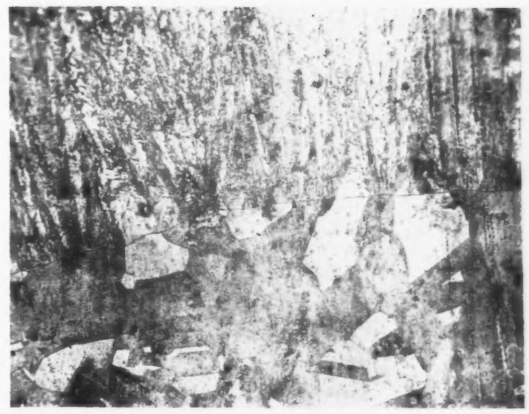
From an architectural point of view the types of oxide layers which form on metals are of much importance. Thus the brown shades assumed by bronze or the green patina formed on copper are considered quite pleasing as well as giving protection of quite high merit. The patina on copper, though normally protective, can in some atmospheres become only loosely adherent and then will fail to stop corrosive attack. Artificial methods of producing patina are now available and the electrolytic methods are said to produce coatings of good quality which will withstand further "weathering" extremely well.

Bronze—which is essentially copper alloyed with up to 30 per cent. of tin—is nowadays frequently modified in composition by additions of other metals such as zinc, lead and nickel. Lead is added to improve machining qualities, but except in very small amounts is detrimental where oxidized "finishes" are to be used; while zinc is said to prevent the formation of a good patina. Nickel has proved to be extremely useful and its addition gives a wide range of bronzes of varying colours and physical properties. The alloys containing up to 10 per cent. of tin and 40 per cent. of nickel can be made workable by a homogenizing heat treatment, while maximum hardness is obtained by equal additions of tin and nickel. As a typical example of a modified bronze one may take the 8 per cent. tin, 2 per cent. nickel, 2 per cent. zinc alloy, which has excellent fluidity and is useful for thin castings, such as door plaques and signs, or the 2 per cent. tin, 2 per cent. nickel, 8 per cent. zinc alloy which suffers practically no contraction on solidification and can be used to give very sharp ornamental castings.

In a more utilitarian field the corrosion resistance of copper alloys proves of great value; monel metal, a nickel-copper alloy, is a good example. A notable case of its use is the roof of the Pennsylvania Railroad Terminal in New York where the corrosive conditions of an industrial atmosphere laden with soot are very trying. Examination of metal taken from this roof some fifteen years after erection has led to the belief that the monel metal is capable of giving service there for another hundred years.

Coming back to oxide films, those which form on exposure of lead and aluminium are of the "self-healing" type, though by no means as perfect as those on stainless steel. Lead, in spite of its extreme softness and lack of mechanical strength, finds many

Micro - photograph showing porosity test of thin nickel plating. The visible spots are rust patches which develop around microscopic holes through the nickel.



Nickel plating showing continuation of the crystal structure of base metal. In the micro photograph the division between the annealed base metal and the electrodeposited coating occurs approximately half way.

Duplicate coating of nickel showing continuation of structure in top coating plated on first coating after suitable etching. The divisions are clearly marked: at the bottom the steel base, and on it the first and second nickel deposits.

uses, and aluminium is still finding an increasingly large number of applications. Pure aluminium lacks sufficient strength to be used in a great many fields and for numerous purposes it is alloyed with small amounts of other metals, such as copper, magnesium and silicon. Some of the alloys are age-hardening and like duralumin (aluminium plus copper) require heat treatment before they can be formed to shape. Though duralumin has great strength its corrosion resistance is not as good as that of pure aluminium. Of recent development are alloys containing 2-9 per cent. of magnesium with or without small amounts of manganese (e.g. Birmabright and M.G.7). These have good strength and their corrosion-resistance is of the highest order yet obtained with any light alloy and they are being used increasingly for decorative work.

Anodizing is an electrolytic process which produces an oxide coating quite thick by comparison with the air-formed films, which improves the corrosion resistance of aluminium. The process of anodic treatment of aluminium in chromic acid solutions was first introduced in 1924 by Bengough and Stuart in the direct course of their work for the D.S.I.R. These workers also reported that the anodic films were capable of absorbing coloured dyestuffs. For decorative purposes the process has now been modified and uses new electrolytes which produce white or colourless coatings; but where the corrosion-resistance is the main necessity the chromic acid treatment, which gives a greyish colour, still holds its own. The processes are also applicable to a number of, though not all, the alloys of aluminium. By dyeing these coatings very beautiful effects (or ugly ones according to the choice of the producers) may be obtained.

Rapid developments are taking place in the production of interior fittings, pressure cast in zinc-base alloy such as door furniture, bathroom fixtures and parts for electric fires. (See the illustrations of these new uses in the article on zinc, page 273).

The process of pressure casting zinc-base alloy is the forcing of the alloy under great pressure into a steel mould. This method of manufacture can produce complicated castings with great accuracy of detail at very low cost. Because the metal is cast under pressure, detail and design can be brought up very sharply.

The rapid development in the use of zinc-base die castings is due primarily to the very considerable research which has been carried out in the investigation of suitable alloys. It has been found that only zinc of over 99.99 per cent. purity produces alloys which are free from intergranular corrosion and such high purity metal is now available in this country.

The usual plated finishes can be applied to zinc-base die castings—copper, nickel and chromium—also lacquered finishes.

During the last few years developments have been taking place in the production of articles which are a combination of zinc-base die castings and plastics, the combination being particularly useful for door furniture.

Let us now consider a rather different application of metals in buildings, namely the use of lead for gas and water pipes and for sheathing electric cables. A great deal of research is at present being carried out to improve the qualities of lead for these uses. The two most important properties to be considered are the strength and the resistance to corrosion. With most structural metals the normal method of estimating the tensile strength by finding what force is required to break a standard-sized specimen is a very good test. But with a soft material like lead (whose tensile strength is usually quoted as 1 ton per sq. in.) it is more important to know something about its creep strength, that is how far much smaller loads will tend to fracture it if they are applied over a prolonged period of time. Again one must consider the fatigue strength, that is how far the material will stand up to the alternating stresses produced by vibration. Innumerable reports could be quoted from sources as widely apart as U.S.A. in the West and Japan in the East, of failures of lead pipe and cable. As examples fatigue failures have been experienced near railway bridges and street trams, and corrosion failures where cables were laid in fresh concrete or next to unsuitable timber or again in pipes carrying unusually soft water supplies. Fatigue failures result in intercrystalline cracking and occur more often in pure lead when it has a large crystal structure than with alloyed leads which have a finer crystal structure.

At the present time many alloying metals have been suggested and used to improve lead; for example, .01 per cent. silver improves the resistance to creep, while .05 per cent. tellurium improves the fatigue strength. Of particular note are the recommendations of the B.N.F. for alloys to prevent intercrystalline cracking. They are as follows :—

	Tensile strength.	Haigh fatigue limit.	Brinell hardness.
Lead + ·5% antimony + ·25% cadmium ...	1·68 tons	·74 ton	6·5.
Lead + 1·5% tin + ·25% cadmium	1·69 tons	·57 ton	5·7.
Pure lead ...	1·05 tons	·18 ton	3·2.

Finally something should be said about electroplating. Since the industrial advent of chromium some ten years ago, electroplated "finishes" are finding a very wide scope. Chromium plating was not the result of industrial research but was evolved in Professor Bancroft's physical-chemistry laboratory in the U.S. At the present day the process used is not essentially different from that first described. It may be of interest to note that when a paper on the subject was first read by Sargent (one of Professor Bancroft's investigators) in 1920 not a single representative of the electroplating industry took part in the discussion and consequently it was a few years before the process began to be used commercially. The growth of chromium plating has also led to great improvements in the quality of nickel plating; for chromium coatings are of little practical value unless they are deposited on a good undercoating of nickel. A very recent development is bronze plating; (the deposition of copper-tin alloys, not to be confused with the colouring of copper known as "bronzing"). This has been applied successfully as an undercoat for chromium and might also be of value as a decorative finish.

In pre-war years there was practically no organized research on electroplating. Advances in this field were left to individual firms who developed new plating solutions and improved working methods with but little co-operation; while the fundamentals underlying the processes were mostly discovered by academic investigators working in the field of pure science. During the war the government started applied research in electroplating for munition manufacture and in post-war years this work was continued by the D.S.I.R. and at the moment is in the hands of the B.N.F. This work, largely undertaken at the Research Department, Woolwich, has led to much improvement in the quality of electrodeposited coatings. An interesting example is the investigation of Hothersall and his co-workers on the adhesion of electrodeposits —he has shown that by suitable etching during cleaning operations prior to plating, perfect adhesion to the base metal can be obtained and has proved that in a number of cases the crystal structure of the plated coating will continue the structure of the base metal and will thus produce a uniform product with no line of weakness between the two.

For architectural metalwork it would be of great advantage if electroplated coatings were made to conform with a set of standard specifications. In order to get such standards it is necessary to know what qualities will ensure long life and freedom from corrosion and to have simple methods of testing for these qualities. It has been found in general that the corrosion of say nickel-plated steel takes place by the attack of the base metal starting at "pores," which are microscopic holes in the nickel, at the bottom of which the steel is exposed. Many good methods of testing for porosity are available. The illustration (page 295) shows a thin coating of nickel tested by the Macnaughtan "hot water test" where the porosity is revealed in a few hours by visible rust spots which develop around each microscopic pore. Again it is known that the thicker the plating the smaller is the porosity and, therefore, minimum thicknesses, above which there is good corrosion resistance, can be specified. A greatly needed test for rapidly estimating the thickness of nickel coatings has been published in the last few months by the B.N.F., but a good rapid test for adhesion has still to be found.

W.B.

Film detached from anodized aluminium, and the method of detaching the film: the aluminium is dissolved in mercuric chloride solution after exposing it by wetting the edges. (From "Anodic Oxidation of Aluminium": a paper prepared by Dr. S. Wernick for the Electrodepositors' Technical Society).

TWO NEW BRIDGES OVER THE RIVER TIGRIS
for the Iraq Government, at BAGHDAD

THE ABOVE IS AN ARTIST'S IMPRESSION OF THE NEW KING FEISAL BRIDGE AS IT WILL BE WHEN COMPLETED
(The other Bridge—the North Bridge—is of similar construction, but with five spans.)

Engineers: Messrs. Coode, Wilson, Mitchell & Vaughan Lee.

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A Persian Triumph

The Mosque of Sheikh Lutfullah is Persian in the fabulous sense: the Omar Khayam brigade, to whom rational form is as much anathema as rational action, can wallow in it to their hearts' content. For while the dome-chamber is form only, has no colour, and obliterates its ornaments by the intentness of its construction, the Mosque of Sheikh Lutfullah hides any symptom of construction or dynamic form beneath a mirage of shallow curved surfaces, the multitudinous offspring of the original squinch. Form there is and must be; but how it is created, and what supports it, are questions of which the casual eye is unconscious, as it is meant to be, lest its attention should wander from the pageant of colour and pattern. Colour and pattern are a commonplace in Persian architecture. But here they have a quality which must astonish the European, not because they infringe what he thought was his own monopoly, but because he can previously have had no idea that abstract pattern was capable of so profound a splendour.

As though to annouce their principles as soon as possible, the outside of the mosque is careless of symmetry to a grotesque degree. Only the dome and portal are seen from the front. But owing to the discrepancy between the axis of the mosque and that of the Ali Gapu opposite, the portal, instead of being immediately under the dome, is set slightly to one side of it. Yet such is the character of the dome, so unlike is it to any other dome in Persia or elsewhere, that this deformity is hardly noticeable. Round a flattened hemisphere made of tiny bricks and covered with prawn-coloured wash runs a bold branching rose-tree inlaid in black and white. Seen from close to, the design has a hint of William Morris, particularly in its thorns; but as a whole it is more formal than pre-Raphaelite, more comparable to the design of a Genoese brocade immensely magnified. Here and there, at the junction of the branches or in the depths of the foliage, ornaments of ochre and dark blue mitigate the harshness of the black and white tracery, and bring it into harmony with the soft golden pink of the background: a process which is continued by a pervading under-foliage of faint light blue. But the genius of the effect is in the play of surfaces. The inlay is glazed. The stucco wash is not. Thus the sun strikes the dome with a *broken* highlight whose intermittent flash, moving with the time of day, adds a third texture to the pattern, mobile and unforeseen.

If the outside is lyric, the inside is Augustan. Here a still shallower dome, about 70 ft. in diameter, swims above a ring of sixteen windows. From the floor to the base of the windows rise eight main arches, four enclosing right-angles, four flat wall-space, so that the boundaries of the floor form a square. The space between the tops of the arches is occupied by eight pendentives divided into planes like a bat's wing. . . .

Each part of the design, each plane, each repetition, each separate branch or blossom has its own sombre beauty. But the beauty of the whole comes as you move. Again the highlights are broken by the play of glazed and unglazed surfaces; so that with every step they rearrange themselves in countless shining patterns; while even the pattern of light through the thick window traceries is inconstant owing to outer traceries which are several feet away and double the variety of each varying silhouette.

I have never encountered splendour of this kind before. Other interiors came into my mind as I stood there, to compare it with: Versailles, or the porcelain rooms at Schönbrunn, or the Doge's Palace, or St. Peter's. All are rich; but none so rich. Their richness is three-dimensional; it is attended by all the effort of shadow. In the Mosque of Sheikh Lutfullah, it is a richness of light and surface, of pattern and colour only. The architectural form is unimportant. It is not smothered, as in rococo; it is simply the instrument of a spectacle, as earth is the instrument of a garden. And then I suddenly thought of that unfortunate species, modern interior decorators, who imagine they can make a restaurant, or a cinema, or a plutocrat's drawing-room look rich if given money enough for gold leaf and looking-glass. They little know what amateurs they are. Nor, alas, do their clients.

ROBERT BYRON ("The Road to Oxiana:" Macmillan)

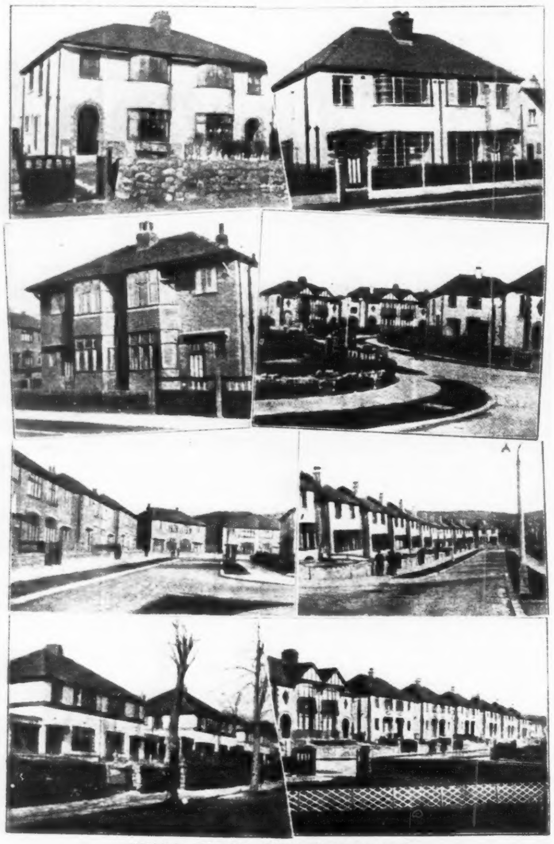
Elizabeth Denby and Kensal House

The editor regrets that the name of Miss Elizabeth Denby, Housing Consultant, was inadvertently omitted from the list of the members of the architectural advisory committee responsible for the design of the Kensal House flats, Ladbroke Grove, London, when the flats were illustrated in the May issue of THE ARCHITECTURAL REVIEW.

Semaine de Gala

Now all the fun is over it may not be unprofitable to pause for a brief survey of the various loyal displays with which the streets of the metropolis have recently been enlivened. For weeks beforehand we had been told that this time a real effort was to be made to co-ordinate all the various schemes; happily this gallant effort was once more crowned with failure and rugged individualism scored another triumph. The most rugged, if not the most individual, was undoubtedly Messrs. Selfridge's vast pageant of Empire which almost literally put all its neighbours in the shade. However not even those towering silver allegories could detract from Messrs. Swears & Wells unique if incomprehensible historical display. What exactly was the significance of this staggering *mélange* which included Queen Victoria and a clever combination of the central figure of Botticellis Primavera with the background of the same artist's Birth of Venus, is still open to varying interpretations, but anyhow we have the satisfaction of knowing that *every inch was handpainted.* Of the other great shops Messrs. Derry & Toms gigantic Britannia (or was it Boadicea?) careering across that modernistic facade in a four-horse chariot was one of the most surprising, and Messrs. Peter Jones's long red streamers one of the simplest and most effective, albeit in conjunction with the architecture slightly reminiscent of Berlin on the Fuehrer's birthday. Of the clubs the United Services with its freshly gilded capitals and its wreaths of gold laurel leaves was both highly effective and properly traditional; the Athenæum opposite was characteristic and restrained and, considering Sir Reginald's well-known

A Few Illustrations Of Modern Houses in Barrow



SNAPPED BY OUR OWN PHOTOGRAPHER

In this picture, reproduced from the *North Western Daily Mail*, one is hard put to it to decide which are the more worthy of admiration, the buildings depicted, or the typographical skill and fine lay-out work with which they are presented.

antipathy to the Regency and all its works, the shade of Decimus Burton could consider himself lucky. The municipal endeavours, with the exception of Bond Street, which looked like some Brobdignagian suburb on washing day, were better than we had any reason to expect: the glorified maypoles in St. James' Street, Oxford Street, and Trafalgar Square, were singularly gay and free from the taint of municipal art. But when, oh when, will the Westminster Council stifle their all too fervent local patriotism and abandon that fearful blue and orange combination? In general one is forced to the conclusion that as long as people confine themselves to flags and streamers all is well; it is when they start draping the facades that trouble begins.

May 12th

Occasionally it is a pleasure to have one's prognostications falsified by events; the coronation was such an occasion. The decorations, the newspaper clamour, past experience of official pageantry, had all combined to fill one with the gloomiest forebodings, but the truth was that neither manufactured enthusiasm, nor tawdry bunting could in any way spoil, the central *clou* of that long procession. The effect created by the appearance of the great coach, heralded by the scarlet lines of the yeomen of the guard and the King's Watermen, a great splash of pure concentrated colour separating the central figures of the whole procession from the variegated colours of the other participants, was something quite staggering, akin to the greatest achievements of art. Whatever views one might hold about the rest of the procession—some like military displays, some do not—no one could deny that the grave hieratic figures of their Majesties in their golden setting and surrounded by their immediate attendants was an expression of the whole English tradition at its very finest. Moreover it is pleasing to reflect that, although there were troops in plenty, the Sovereign himself was immediately preceded by a party of bearded old gentlemen whom even in the sixteenth century cannot have been regarded as a very formidable military body, and a handful of plump and eminently peaceful bargemasters. Few other monarchs and certainly no dictators would be so unsuitably, according to foreign notions, attended on their progresses.

You have been warned

The fact, recently stressed in this paper by Mr. Byron, that the demolition of our monuments is apt to be decided on and straightway carried out, almost overnight with never a word of warning, should put those interested in the preservation of our architectural heritage on their guard. All the more interest attaches, therefore, to the recent newspaper agitation in favour of the widening of Decimus Burton's noble screen at Hyde Park Corner. The burden of the complaint is that the three gates are quite inadequate to deal with the motor traffic entering and leaving the park and that the arch is therefore another clog on the wheels of progress. Actually of course all that this means is that the taxi-cabs and limousines at certain hours of the day are forced to waste, at the most, three to five minutes, waiting their turn at the exits. As the park is closed, and rightly closed, to all commercial and passenger traffic, the loss of the time is one that the community as a whole can well afford. In defence of their monstrous proposal the motoring community, surely the most arrogant section of the whole nation, assert that the entrances could be widened thirty feet without in any way damaging the proportions of the screen itself. How this miracle is to be accomplished we are not informed. Anyhow that is a tale which has been told too often; was it not stated that Lansdowne house would be re-erected just as it was and the beauty of the facade thus preserved for all time? However, as it would be far too optimistic to suppose that the most powerful vested interest in the country will not get their way in the end, let it be urged, here and now, if their wrongs cry to heaven and must be redressed, that instead of tampering with Decimus Burton's handiwork, a new carriageway be made through the smal- strip of garden, which is cerl tainly one car's width and now serves no useful purpose alongside Apsley House. It is Crown property and the dissappearance of the few square yards of depressed evergreens can hardly affect the amenities of the ducal tenant.

Bedroom for the Titian Girl

For the woman with Titian hair I have chosen a Bedroom with a background of pale green walls and curtains, and with carpet and bed coverings the shade of Parma violets.

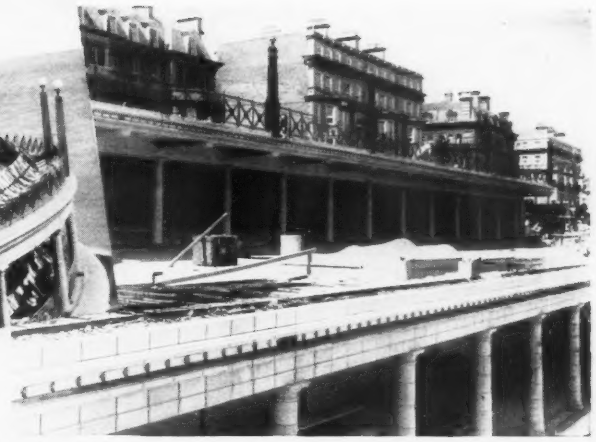
The furniture is sycamore, the pale colour to harmonize with the creamy texture of her skin. Silver metallic cloth is used for the upholstered and buttoned bedhead, and also for the piping of the easy chair and dressing stool.

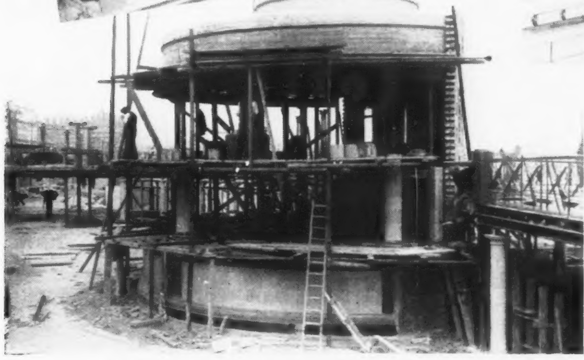
A wallpaper with mauve and silver spots provides an attractive panel behind the bed, and is also used effectively to cover a plywood pelmet.

AN ARTICLE ENTITLED "BACKGROUNDS FOR BEAUTY" IN THE CATALOGUE OF THE RECENT IDEAL HOMES EXHIBITION.

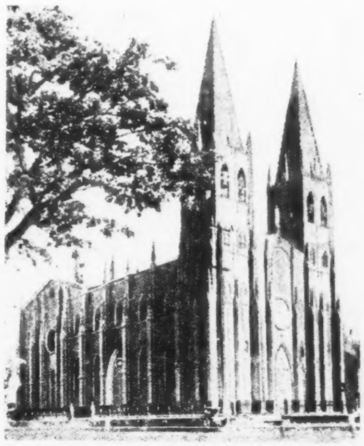
Architects Awake!

Each year as May comes round the public is shocked and horrified once more to find that yet again there has been some dirty work at Burlington House. No exhibition of the Royal Academy ever seems to open





MODERN TREASURY—IX.



The occasion of a special Metals issue makes this photograph of the Church of San Sebastian in Manilla of topical interest. Built in 1891 it is, believe it or not, constructed entirely in iron.

without the announcement that someone or other has been asked to withdraw their contribution, either because it has been discovered that the artist has been such a cad as to paint over a photograph or because his annual problem picture is open to too dubious an interpretation or some such scandalous reason. On the other hand, to balance the horror which such an event evokes in every decent breast, there is always the gratifying discovery that one or more pictures are the work of a paralysed postman from Tulse Hill or a five-year old orphan who has only taken to art as a result of a present of a sixpenny paintbox at Christmas. But alas all these excitements, both pleasant and deplorable, are exclusively provided by the painters. Why is the architecture always so barren of similar surprises? Will no one send a design for a cottage hospital that is subsequently discovered to be a plaster-cast of a model of the Parthenon? Can no architect provide a problem building that might be taken by some to be a combination of Fort Belverdere and the Brown House, or some equally significant work of dubious taste? Moreover can no window-cleaner in the Isle of Man or deaf and dumb five-year-old be prevailed upon to try his hand at architecture? The sooner that something of the sort happens the better, for there is a very definite feeling abroad that the architects are not pulling their weight in the maintenance of these age-old traditions of Burlington House.

The New Stamps

The new stamps are undoubtedly an enormous improvement, not only on the stamps of the last reign, but also on all stamps since the earliest Victorian issues. Minor criticisms there are bound to be; the way that the circle enclosing the figures overlaps the base of the neck of the medallion strikes one as a not altogether happy arrangement, but on the whole, as far as the ordinary issues are concerned, both the designers (Messrs. Gill and Dulac) and the Post Office deserve general congratulation.

The Coronation issue is not perhaps on quite the same high level, but then few special issues are ever very satisfactory; the shape for one thing is awkward. But perhaps the happiest aspect of the whole matter lies in the proof it provides that at least one Government Department is not impervious to intelligent criticism. Alas, numismatists must now be filled with righteous envy for their more fortunate philatelic brethren; the Mint remains firmly unmoved by any outcry.

A P.E.P. Centenary

That energetic research body, Political and Economic Planning, usually known simply as "P.E.P.," can congratulate itself on reaching this month a remarkable land-mark in its career. Its "broadsheet," *Planning*, actually a neat pamphlet of a dozen or more pages, which it publishes periodically, reaches its hundredth issue. The title of P.E.P. explains itself; its personnel, though remaining anonymous, possesses authority as well as enthusiasm—also versatility, as the index of titles to the Broadsheets indicates. The titles have included such various subjects as "Britain and World Trade," "Housing Survey," "Planning in America," "Transport Problems," "A New Employment Policy," "Marketing Acts," "The Use of Statistics," "The Fuel Problem," "How New Industries Grow," "The Hospital System," "Inquest on Ottawa," and "The Problem of South Wales."

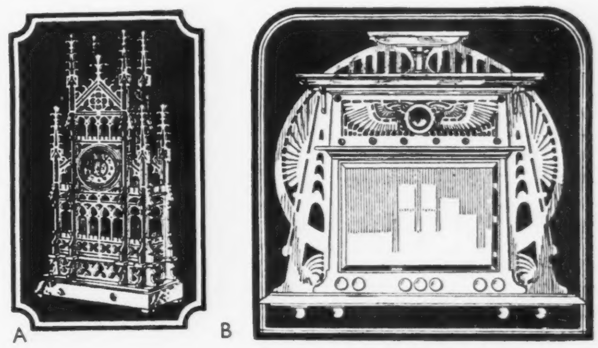
Photographs in this Issue

The editor is indebted to the following, who have been kind enough to lend photographs for this issue, to give facilities for taking them, or to provide necessary information:—

The Director of the British Museum; the Victoria and Albert Museum; the Copper Development Association; the Lead Industries Development Council; the British Constructional Steelwork Association; Messrs. Alfol Insulation, Ltd.; the Aluminium Union, Ltd.; the British Aluminium Co., Ltd.; Firth-Vickers Stainless Steels, Ltd.; J. & E. Hall, Ltd.; Messrs. Harvey; Messrs. Haskins, Ltd.; Messrs. Henry Hope, Ltd.; London Zinc Mills, Ltd.; H. H. Martyn & Co., Ltd.; the Mond Nickel Co., Ltd.; the Northern Aluminium Co., Ltd.; Messrs. E. Pollard & Co., Ltd.; Messrs. Gordon Russell, Ltd.; Messrs. Roneo, Ltd.; Messrs. Joseph Sankey, Ltd.; Messrs. Sankey-Sheldon, Ltd.; J. Starkie Gardner & Co., Ltd.; Messrs. Stelcon, Ltd.; Messrs. Venesta, Ltd.; George M. Whiley, Ltd.; Messrs. Henry Wiggin & Co., Ltd. Thanks are also due to Mr. Alfred Cracknell, photographer, for trouble taken with a number of special photographs.

Correction

The name of the architects of the factory at Worcester, illustrated in the May issue, given as Sir John Brown and Hanson, should of course have been spelt "Sir John Brown and Henson."



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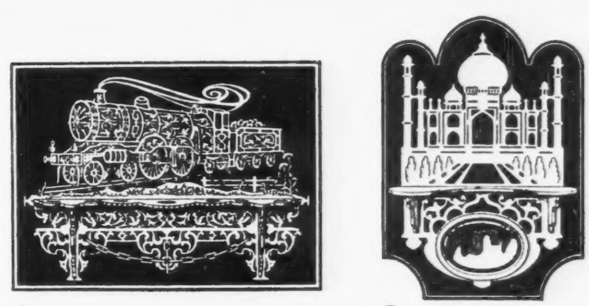

C D

Some of us may have been under the misapprehension that fretwork was a dying art. The above examples, selected from Messrs. Hobbies catalogue of designs, should dispel this foolish illusion, and prove that fretwork is not only in a flourishing condition, but has wisely refused to break with the age-old traditions of the art. A. Gothic clock. B. Egyptian overmantel. C. Express pipe rack. D. Taj Mahal mirror frame.

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The following is a selected list of books which relate to the subjects covered by this special metals issue of The Architectural Review, *for the information of readers who wish to pursue the subject further. The books are classified to correspond with the articles in the issue.*

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Metal Castings. By Harry L. Campbell, M.S. New York, 1936.

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Journal of the Electro-Depositors Technical Society.

Journal of the Institute of Welding.

The Metal Industry—London.

Door Furniture

The following is a list of the manufacturers and craftsmen for the examples of door furniture illustrated on pages 281–283.

No. 1. N. F. Ramsey & Co., Ltd., design 108.
No. 2. N. F. Ramsey & Co., Ltd., design 107.
No. 3. Gordon Russell, Ltd., design 1024.
No. 4. Dryad Metal Works Ltd., design K30.
No. 5. Gordon Russell, Ltd., design 1023.
No. 6. Dryad Metal Works Ltd., design K18R.
No. 7. James Gibbons, Ltd., design B4227, but without patera and long bush rose.
No. 8. Dryad Metal Works, Ltd., design K17SR.
No. 9. Dryad Metal Works, Ltd., design K18SR.
No. 10. Dryad Metal Works, Ltd., design K19SR.
No. 11. Dryad Metal Works, Ltd., design K19.
No. 12. General Stampers (Welwyn), Ltd., Base A, fluted section handle cover and domed stop.
No. 13. Henry Hope & Sons, Ltd., design 878.
No. 14. Dryad Metal Works, Ltd., design H96, 15in.
No. 15. Dryad Metal Works, Ltd., design H93, 12in.
No. 16. Henry Hope & Sons, Ltd., 2068 centre slow knob.
No. 17. British Ogro, Ltd., handle with lock.
No. 18. Josiah Parkes & Sons, Ltd., "Union" upright cylinder mortice lock No. 2272.
No. 19. Dryad Metal Works, Ltd., design L4.
No. 20. Dryad Metal Works, Ltd., design H88.
No. 21. Dryad Metal Works, Ltd., design H89.
No. 22. Gordon Russell, Ltd., design 26a.
No. 23. Dryad Metal Works, Ltd., design H77.
No. 24. Gordon Russell, Ltd., design X1495.
No. 25. Dryad Metal Works, Ltd., design H76.
No. 26. Gordon Russell, Ltd., design 21.
No. 27. Elsa Booth, design No. 280/2.
No. 28. Elsa Booth, design No. 280/1.

the wolf should have known better – for they were

Marston Bespres Flettons

made by
Marston Valley
Brick Company Ltd

Standard types of Flettons:

Plain
Slotted
Webcel
Bark Rustic Facings

Immediate Delivery – Whatever size the order

Marston Valley Brick Co Ltd. Sales Office: 30 Gordon St., London, W.C.1. Euston: 2861-5

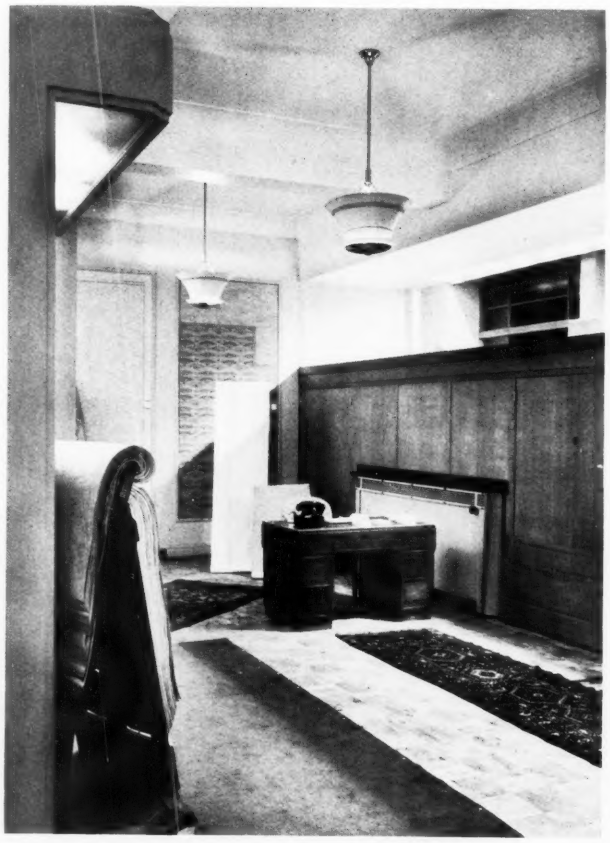
Trade News and Reviews

By BRIAN GRANT

"Oceana" Moulded Plywood Panels

When I first heard mention of the name "Oceana" I visualized a new super-gigantic transatlantic liner, a prospective competitor to the "Queen Mary" and the "Normandie" in their grim battle for the much cherished blue-riband. "Oceana," however, is the name given to a new type of moulded plywood panelling of, I believe, French origin, and being marketed in this country by James Latham, Ltd.

The panels are manufactured in a range of seven standard designs in three thicknesses ($\frac{1}{4}$ in., $\frac{3}{8}$ in. and $\frac{1}{2}$ in.) and there are fifteen different standard veneer facings to be selected from, including butt walnut and French walnut, rosewood, teak, plain and figured oak and a group of four mahoganies. The prices (not including fixing) range from 9d. to 3/3d. per sq. ft. delivered according to the thickness required and the veneer finish chosen. The maximum size of the panels is 92 in. × 41 in. Any number of the designs may be used in combination and the panels can be fixed either vertically or horizontally, thus, taking into consideration the variety of facings available, a very large number of different decorative panelling effects can be obtained. The method of application is identical to that of ordinary flush panelling and the finished effect, it is claimed, is in no way inferior: in cost however, it is considerably lower and a saving of 25 per cent. per ft. is in some cases possible.



A corner of one of the wall paper showrooms at John Line and Sons recently completed Newcastle office. Architect: Charles S. Errington.

Oak desk designed by Henry G. Dowling. The side panels are constructed in "Oceana" moulded plywood panels.

John Line and Sons new Newcastle premises

Henry G. Dowling has used "Oceana" for some of the furniture and panelling at his Company's new offices and showrooms in Newcastle which were officially opened a few months back. The building of these premises is part of an extensive building programme which John Line & Son have undertaken in order to cope with greatly increased business and to provide better facilities and services for their many customers in the north of England. Their new Manchester building is nearing completion and will probably be opened towards the end of June.

Charles S. Errington was architect for the Newcastle premises and Messrs. Cruikshank & Seward are responsible for the new Manchester branch office. Special furniture and the interior decoration of both offices has been designed by Henry G. Dowling.

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Silent sliding doors

I was present recently at a demonstration given by a company calling itself Silent Gliding Doors Ltd. The Company is a comparatively new one and has been

CREATION WITH CRAFTSMANSHIP

THE GRAFTON HOTEL (Associated London Properties Ltd.) Architects: T. P. BENNETT & SON

IN an article: "Signs of our Time," published in *The Architects' Journal*, of 15 June, 1927, Mr. G. Grey Wornum, F.R.I.B.A., wrote:

> *A marquise can be an extremely useful adjunct to the design of a façade, and is by no means to be despised from an architect's point of view. Built of glass and metal it can give as much sense of frivolity to a building as the designer wishes . . . .*

Behind that moderate statement, written almost precisely ten years ago, may have lurked a prophecy. But, while anticipating its popularity, Mr. Wornum can hardly have foreseen the remarkable extent to which architects would, in the short space of a decade, discover the utility and beauty of the marquise, or, as we more often describe it today, the canopy.

Over the entrances to hotels, clubs, restaurants, theatres, cinemas, and public buildings, and along the full frontages of large stores and groups of shops, canopies are now installed, not only to give a "sense of frivolity and lightness," but also to provide protection for patrons, and to add dignity to the buildings.

Here is one of the latest examples of C.P. craftsmanship applied to canopy construction. Coloured green and cream, with projecting fillets and letters faced stainless steel, this canopy is illuminated from coved recesses, lighting boxes and low-tension tubes.

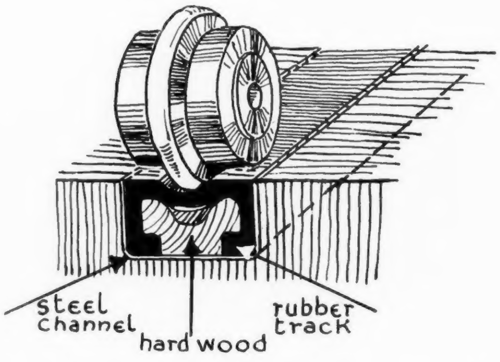
COURTNEY POPE LTD

AMHURST PARK WORKS TOTTENHAM N15 · TEL: STAMFORD HILL 4266 formed to market a new type of sliding door gear invented, I believe, by a major of the Royal Air Force who found certain "snags" in the ordinary type of sliding door used for aerodrome hangars and set out to overcome their disadvantages. Two types of gear were demonstrated: 1. Gear for heavy doors, such as folding partitions, folding and "round the corner" garage doors and doors for factories, hangars and commercial buildings generally. 2. Gear for the ordinary domestic door (normally a swinging door) for use in private houses, offices, hotels and the like.

The company tell me that their first objective was to get rid of the open floor channel which has always been an essential part of sliding door construction: their objections to this open channel or track being that the track when employed in open places, factories or garages is constantly getting clogged with dirt and small stones and is, in any case, always far from being noiseless. For any type of interior door, either sliding or folding, a flush floor runner giving silence in operation is certainly something to be grateful for.

For the lighter type of door, to replace the ordinary hinged door, a design is employed whereby the door is suspended from a type of runner consisting of one tube sliding in another and is guided at the bottom by means of fibre blocks running along an invisible guide track. The track in this case does not carry the weight. This type of door can be installed in existing buildings. In the case of new buildings these small sliding doors are invariably housed in the cavity walls and this can be simply and effectively achieved within any standard thickness of wall from a 3 in. partition breeze upwards.

With the heavier type of doors there is no overhead suspension track, merely a complementary guiding track, the weight is carried on the specially designed runners which travel silently along the flexible rubber track. The accompanying illustration shows how the flexible rubber track, which is carried on a hard wood former in a steel channel, is let into a wooden, concrete or granolithic flooring so as to form a retentive guide for the special runner carrying the weight of the doors.



Detail showing roller and flush rubber track. The rollers carry the weights of and are concealed in the base of the door. The rubber track is depressed as the rollers travel along it.

Both types have been tested in use under a wide variety of difficult conditions for the last five years and the many actual contracts carried out by them during the past three years have, I am informed, proved entirely satisfactory. The Company will be pleased to provide architects with illustrated literature and the names of factories, colleges and other buildings where the doors may be inspected in actual operation. Enquiries should be addressed to Messrs. Silent Gliding Doors Ltd., 53 Archer Street, London, N.W.1.

• • •

Concerning flush doors

I do not know how many different types of flush doors and how many different forms of core construction are today being employed by manufacturers—

The *only* sanitary ware...

THAT REMAINS TRULY SANITARY

VITREOUS CHINA is absolutely non-porous throughout. The body is as hard as the glaze to which it is amalgamated . . . a glaze that cannot crack or craze.

With all other materials it is the glaze only that is non-porous. Once this glaze crazes, as it will in time, moisture will penetrate into the absorbent body, fouling it and making it insanitary.

Specify "Standard" Vitreous China when planning new buildings or modernization schemes. The public are learning of its advantages and will be asking for it.

Write for illustrated leaflet S.18.

"Standard"

VITREOUS CHINA—W.C. SUITES · LAVATORY BASINS · BIDETS

IDEAL BOILERS & RADIATORS LTD., IDEAL WORKS, HULL. Showrooms: LONDON, Gt. Marlborough St., W.1. BIRMINGHAM & HULL certainly there are very many and the cost of them vary to a quite extraordinary degree. I would say beware of the very low-priced flush door; in fact, whatever the price, it is a wise and necessary precaution to pay greater attention to the manufacturer's method of construction than to the apparent smartness and finish of the door. A brand new flush door almost always looks trim, solid and attractive, but it is the workmanship hidden beneath the veneer that counts for most. Many an architect has discovered this to his cost.

A small but instructive brochure on the evolution and construction of the flush door has recently been issued by F. Hills & Sons Limited, of Trafford Park, Manchester, the manufacturers of "Aristocrat," "Trafford" and "Clymax" flush doors. The "Aristocrat" is a costly door, made up to a standard rather than down to a price. Its core consists of nine separate laminations of wood bonded together with Bakelite glue under hundreds of tons of pressure. The "Trafford" is of semi-solid construction whilst the "Clymax" is built upon a hollow frame. All three are described in the brochure but (unnecessary omission !) no prices at all are given. It is, we know, impossible for manufacturers to quote firm prices in a brochure that may be in circulation for a number of years but it is not difficult for them to give an approximate indication and every architect knows that prices must fluctuate according to current prices of raw materials and to the size of the order being placed.

An electric cooker for the 20th century kitchen. Manufacturers : Moffats Ltd.

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An elegant utilitarian

These notes last month contained a brief description of the new Moffat electric cooker which I had seen for the first time at the Ideal Home Exhibition at Olympia—having since secured a photograph, I reproduce it here. The cooker is of cast iron and steel construction throughout finished in grey and white porcelain enamel or special finishes in either two tone ivory, green and ivory, ivory and crimson or ivory and black. Standard equipment includes thermostatic oven heat control, minute-minder, condiment set and hob floodlight. The boiling plates on the hob have stainless steel covers and the baking oven is fitted with a smokeless top grill ; it has also an independently heated warming drawer and a roomy utility drawer which will hold the pots, pans, baking dishes and other cooking utensils. In appearance it is decidedly a thoroughbred and, from the specification, an eminently sturdy and workmanlike piece of equipment. The manufacturers are Moffats Limited of Blackburn, Lancashire.

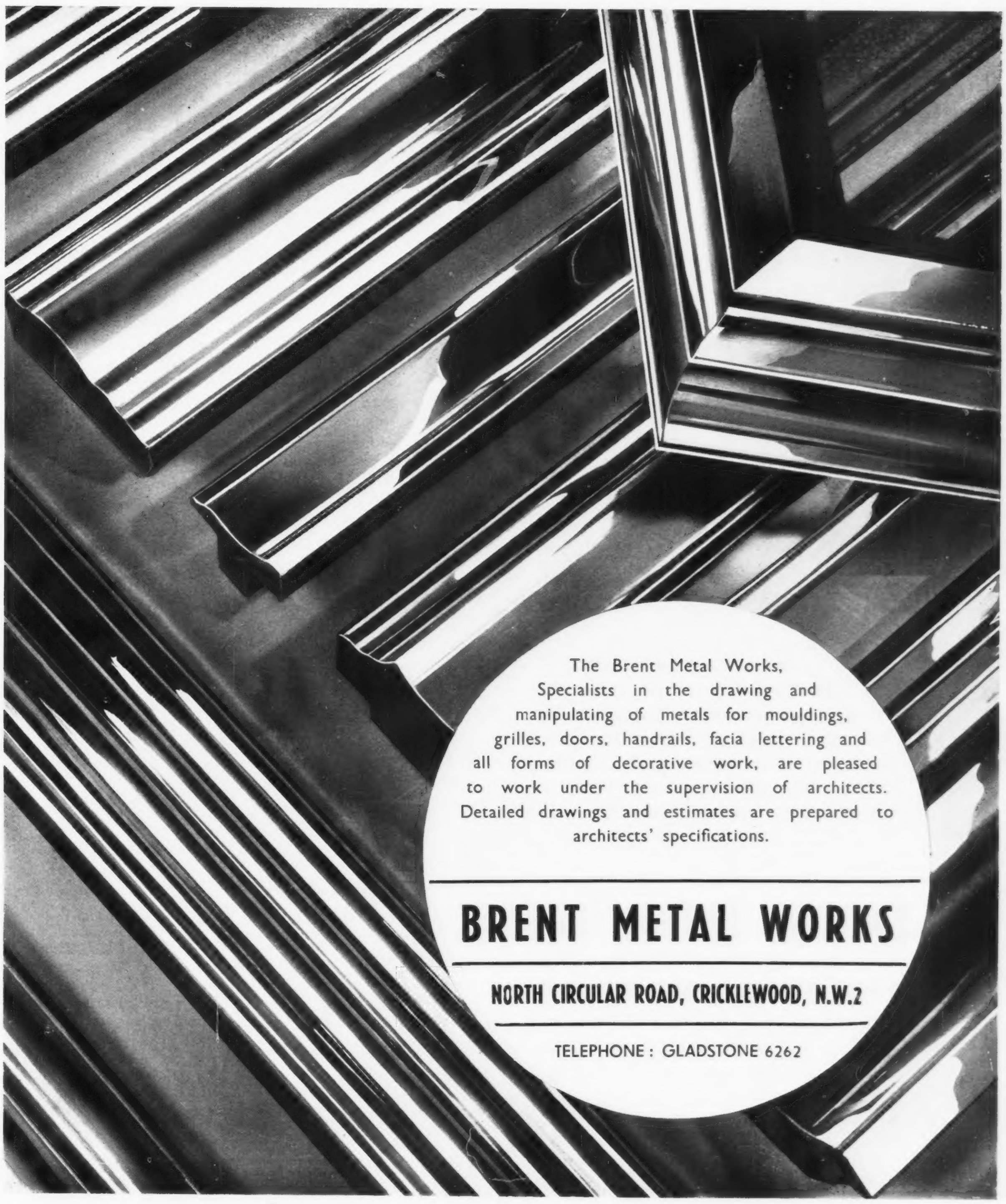
• • •

A Catalogue of Electrical Accessories

A comprehensive catalogue of electrical accessories has just been issued by C. H. Parsons, Ltd., of Birmingham. In a brief and pleasantly composed foreword it is

ARCHITECTURAL METALWORK

IN STAINLESS STEEL BRONZE AND ANODISED ALUMINIUM



pointed out that the company's first catalogue, issued in 1924, consisted of two pages. This 1937 edition contains over 300 pages and, be it noted, there is not a single page of unnecessary "padding" or extraneous advertising. The company's products include almost every type of small electrical accessory —adaptors, switches, switch units and switch boxes, bell pushes, ceiling plates, etc. The fittings are made in a variety of metals and bakelite. A colour chart shows the 13 standard bakelite colours available. All essential information and price particulars are given in concise tabulated form. It is, in brief, an honest to goodness catalogue—well indexed, conveniently sectionized, satisfactorily illustrated and very well printed.

Copies may be obtained from C. H. Parsons, Ltd., Britannia Works, Tyseley, Birmingham.

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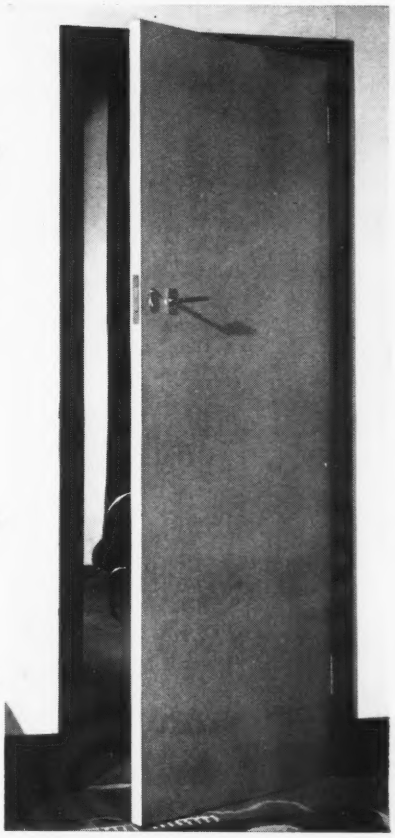
"Portcullis" Grilles

Messrs. Haskins most recent catalogue dealing solely with the various types and designs of metal grilles will be of interest mainly to those architects concerned with the construction of stores and shops, though rolling and collapsible grilles are used quite extensively in commercial buildings of a general character. The grille curtains are constructed of internal horizontal tubes (in mild steel, bronze, aluminium or other metals) connected by malleable vertical links and separated by external tubular distance pieces. The bottoms of the curtains are fitted with angle or tee iron bottom bars. The catalogue contains complete specification details, line drawings and half-tones showing the various "curtain" designs available, and working details giving methods of installation and the different available systems of mechanical operation. Application for copies should be

Collapsible Portcullis grille at the entrance doors to the Hornsey Municipal building. Architect, R. H. Uren. Photograph reproduced from Messrs. Haskins catalogue.

The ACE Flush Door



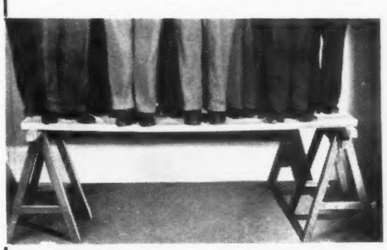
AMAZINGLY STRONG

CANNOT WARP

SOUND INSULATING

FIRE RESISTING

The famous 'Ace' Flush Door, made on a patent laminated principle, is now available with facings of birch ply or Lloyd Hardboard. Either can be used in its natural state, requiring only wax polishing, or can be painted without knotting. Being dead flat, special veneers can be applied with complete success.



The untouched photograph above shows nine men supported on an 'Ace' Flush Door—about ninety stone supported with scarcely a bend.

AVAILABLE IN SIX SIZES

6ft. 8in. × 2ft. 8in.
6ft. 6in. × 2ft. 6in.
6ft. 6in. × 2ft. 4in.
6ft. 4in. × 2ft. 4in.
6ft. 6in. × 2ft. 0in.
6ft. 0in. × 2ft. 0in.

All sizes are available immediately from stock and prices will be quoted on request

THE ACE LAMINATED PRODUCTS CO.

3 WARWICK LANE, E.C.4 'PHONE: CITY 2705

A Setting of the 'Panella' Gas Fire Architects: Mewes and Davis, F.R.I.B.A.

The 'Panella' Gas Fire is the fine product of the makers' fifty years' experience. The original flush-fitting Gas Fire, requiring neither trivet nor hearth, it is in perfect conformity with modern decorative tendencies. Equally, it carries technical and hygienic efficiency to a high level, embodying as it does the Radiation silent burner and 'Beam' (trade mark) radiants, which are extremely durable and emit a 'softer' warmth, with a sensation of greater comfort.

Panella

GAS FIRES

First of their type

Full details and illustrations of the various models and finishes will be sent free on application to the Davis Gas Stove Co., Ltd., 7 Stratford Place London, W.1.

Radiation

(Opposite Bond Street Underground)

addressed to the company's offices at Blackhorse Lane, Walthamstow, E.17.

● ● ●

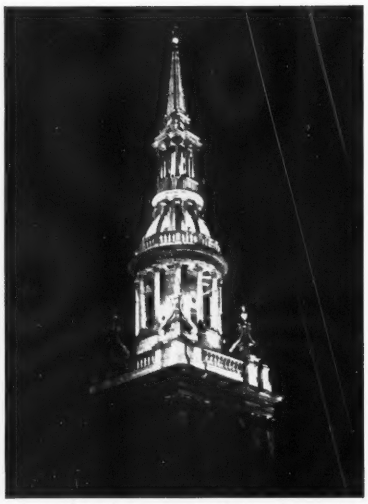
Decorations of Today

"Tribute in Colour" is the title given by Nobel Chemical Finishes, Ltd., to the fourth of their series of booklets dealing with the various aspects of colour in architecture. It is a small, gay brochure amusingly illustrated by a number of specially prepared colour sketches by Gordon Cullen and some ingenious photographs depicting London thoroughfares in their Coronation garb. It criticizes the haphazard methods usually employed for the decoration of streets and buildings at times of national festivity, and suggests, quite reasonably, that a touch of permanent colourfulness might with benefit be given to many of our austere and rather drab edifices and highways.

● ● ●

Floodlighting and Church Lighting

Two brochures reach me from the General Electric Company. The first deals comprehensively with the subject of modern floodlighting and is well filled with practical and informative data. It describes and illustrates the various types of lamps, reflectors and general equipment used in floodlighting schemes, surveys briefly the principal recent developments, discusses beam control, colour control and light distribution and outlines the systems adopted in a number of typical installations. The second brochure is mainly pictorial and shows in a series of half tone plates the many different types of interior illumination and floodlighting as carried out by the General Electric Company in cathedrals, abbeys and churches of all denominations. Divided into four sections it deals with (i) Concealed lighting; (ii) Lighting by visible fittings; (iii) Exterior illumination and church floodlighting; (iv) G.E.C. Standard church lighting units. Valuable companion brochures for the architect and illuminating engineer.



A night photograph of St. Mary-le-Bow, Cheapside, reproduced from the G.E.C. church lighting brochure.

● ● ●

The use of Asphalte for Mastic Roofing

Architects and building contractors will find a large amount of useful information compiled for their especial benefit in a 30 page report on the above subject, which has just been issued by the Building Research Station.

Published in booklet form the report comprises—

I. A survey of the general problems which arise in connection with the use of asphalte mastics to form an impermeable jointless roof covering.

II. A description of the nature of the materials used and the detailed procedure for the manufacture of reliable mastics.

III. Recommended practices for the construction and laying of mastic roofs.

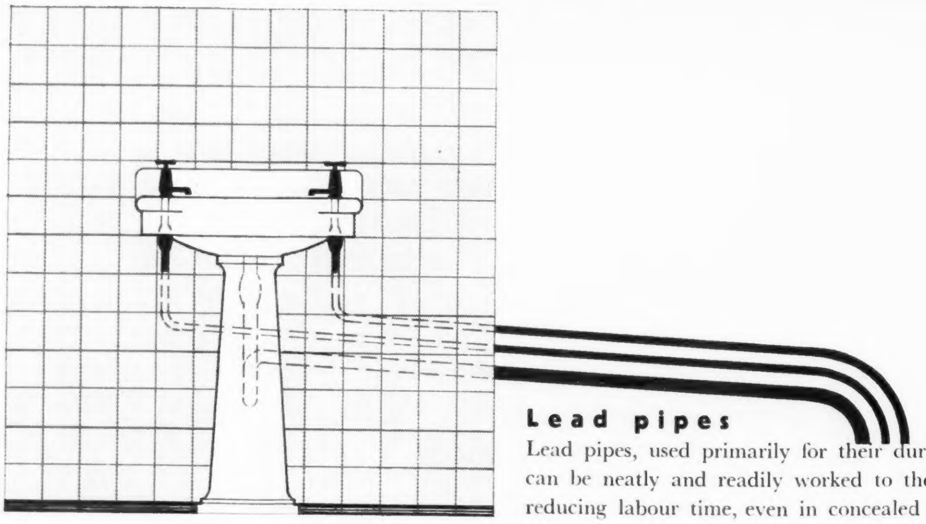
IV. Recommendations for alteration and repair work.

V. Weathering factors, thermal effects and the action of light.

It concludes with an appendix of notes on the methods of testing employed at the Research Station at Garston.

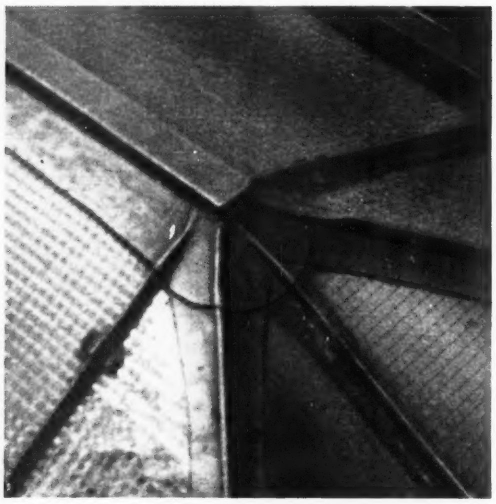
I understand that copies of this report may be obtained from the National Asphalte Mine Owners' and Manufacturers Council, whose offices are at Thermal House, Grosvenor Gardens, Victoria, S.W.1.

The Flexibility of Lead



Lead pipes

Lead pipes, used primarily for their durability, are preferred by plumbers since they can be neatly and readily worked to the right bends and to good even falls, while reducing labour time, even in concealed work.



Close fitting flashings

Patent glazing with small metal sections is purely a product of the present day and calls for a flashing material which can be worked to quite a fine degree over the metal bars, particularly at the inter-sections. Such flashings are invariably in lead.

h

Ancient Symbol for LEAD

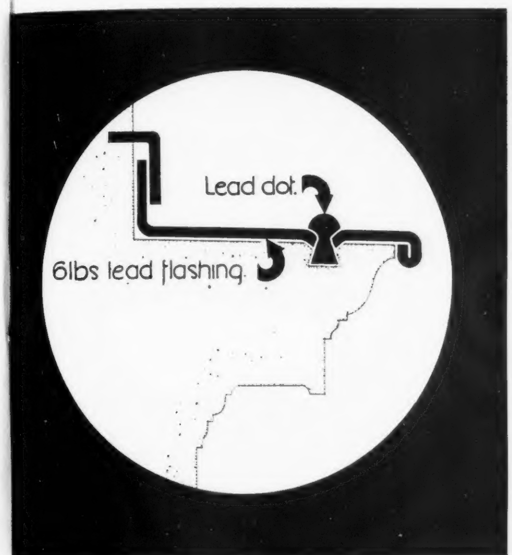
Roof flashings

Flexible and close-fitting, no other material can serve this purpose so completely as does lead.

Enquiries

In regard to the properties and uses of Lead and Lead alloys should be addressed to the Technical Information Bureau of the Lead Industries Development Council, 19, Hobart Place, Eaton Square, S.W.1.

It is a misuse of good material to leave a stone cornice unprotected from the weather and particularly from frost action.



Lead covered Cornice.

Lead weatherings protect good stonework.

A lead weathering protects the stonework of the cornice, waterproofs the vital joint at the back where it meets the wall face and forms a drip along the edge which prevents water-staining and streaking.

h

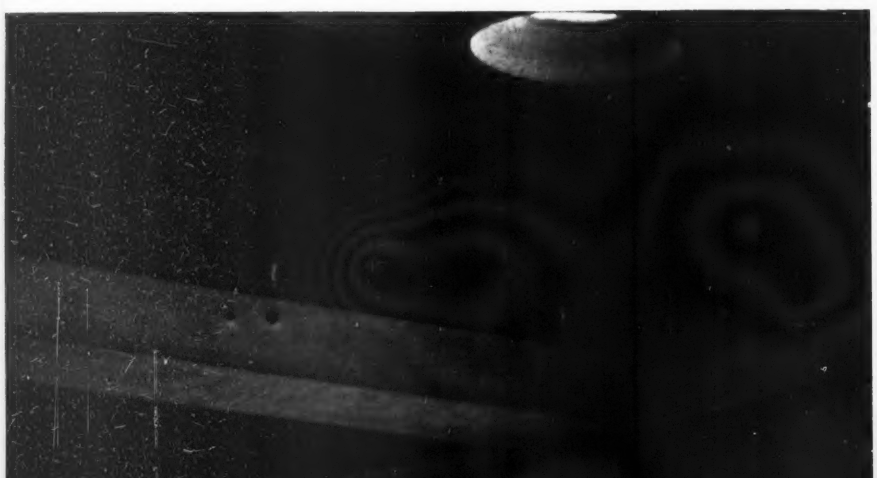
Ancient Symbol for LEAD

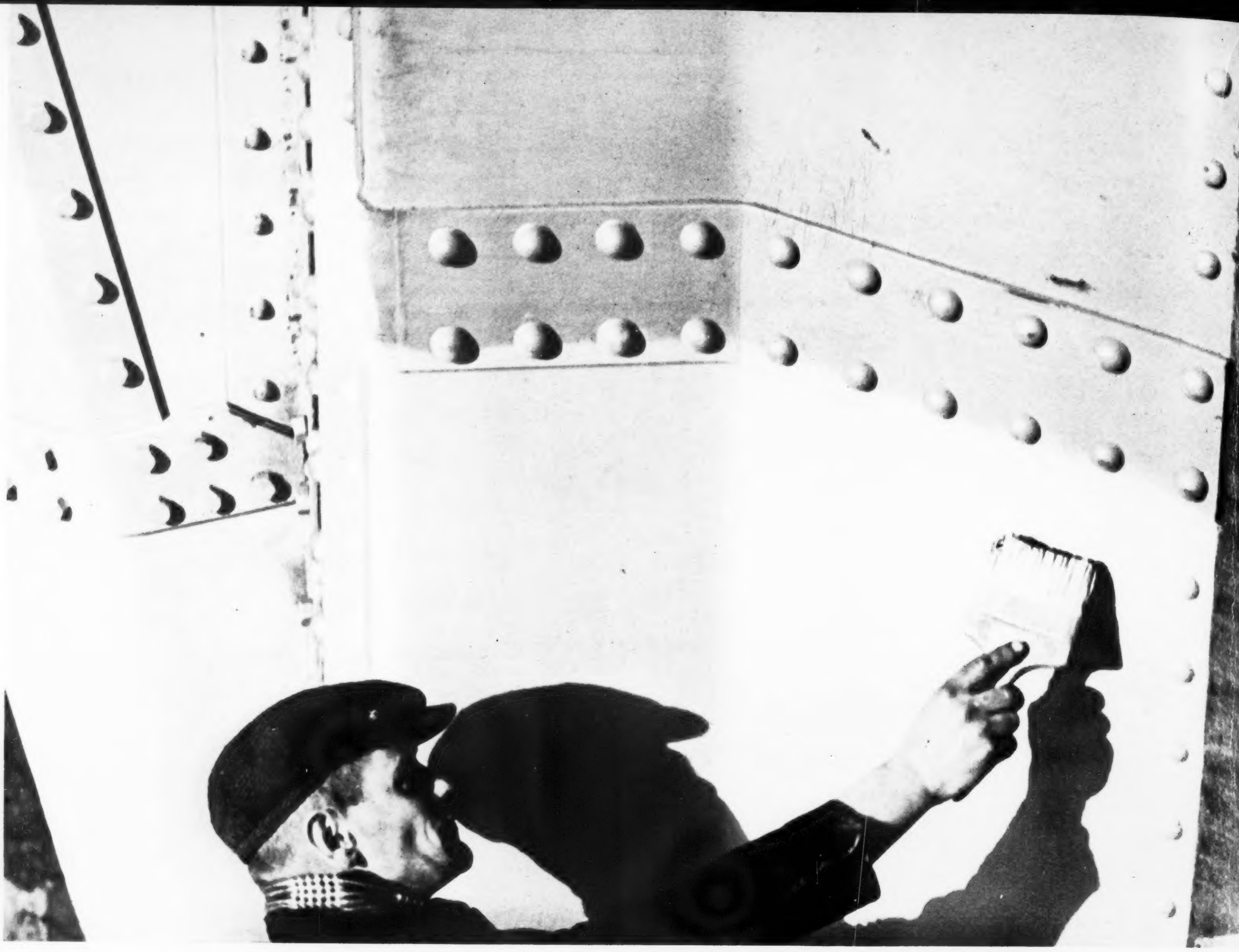
Enquiries:
in regard to the properties and uses of Lead and Lead alloys should be addressed to the Technical Information Bureau of the Lead Industries Development Council, 19, Hobart Place, Eaton Square, S.W.1.

The entrance to the Burlington Arcade has a cast lead decorative fascia with gilt lead lettering. The soffites and sides of the beams have been all cased in lead sheet to give a decorative and permanent finish. The whole of the lead work was plugged direct to the concrete after the concrete had been coated with bitumen.

h
Ancient Symbol for LEAD

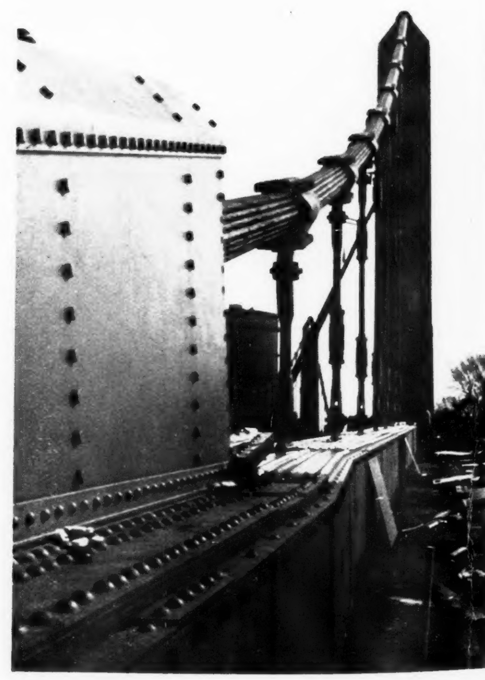
Architects: E. Bates & W. G. Sinning. Craftsmen: G. Jackson & Sons.





Chelsea Bridge. Contractors: Holloway Bros. (London) Ltd.

It is a true economy to use Red Lead for priming all exposed steelwork



In maintaining exposed steelwork structures, labour costs for painting in relation to the cost of material must necessarily be exceptionally high. The "saving" of a few pence on paint is lost many times over by the reduction in the time during which cheap paint gives efficient protection against corrosion. For priming there is nothing to equal well brushed-on red lead and if all factors are taken into consideration there is nothing cheaper.

LEAD PAINTS PROTECT

Enquiries relating to Red Lead painting should be addressed to the Technical Information Bureau of the Lead Industries Development Council, 19, Hobart Place, Eaton Square, S.W.1.

f

ALUMINIUM

The illustrations on this and the opposite page have been chosen to illustrate in some measure the versatility of aluminium as a decorative medium. Whether used as castings or extruded bars, whether for sternly utilitarian purposes or decoration, the various forms of aluminium are eminently applicable. The process of anodising, with or without dyeing, adds further scope and provides aluminium with an exclusive finish impossible of imitation.

FOR DECORATION

3

1 R.M.S. "Queen Mary" observation lounge and cocktail bar on the Promenade Deck, showing the counter, balustrading and columns with extensive metalwork in "Birmabright" aluminium alloy.

Architects: Messrs. Mèwes and Davis, A.R.A., FF.R.I.B.A., and Benjamin W. Morris, Esq., F.I.A.A.

Art Metalwork: The Crompton Forge Limited.

2 Edinburgh Royal Infirmary: Lift enclosure and balustrade of aluminium.

Architect: Thomas W. Turnbull, Esq., F.I.A.A., M.I. Struct.E.

Metalwork: Mr. Charles Henshaw.

3 Anodised aluminium stair and side rails at the Havana Cinema, Romford; anodised aluminium also used for the door and auditorium grilles.

Architects: Messrs. Leslie H. Kemp & Tasker, A.R.I.B.A., F.I.A.A.

Metalwork: Messrs. Garton & Thorne Ltd.

4 The Brasserie at Lyons' Corner House, Coventry Street, in which an Oriental effect has been achieved by the use of brilliantly coloured anodised aluminium tiles.

Architect-Designer: Oliver P. Bernard, Esq., L.R.I.B.A.

Aluminium Metalwork Contractors: Evenlite Limited.

Anodising: Aluminite Limited.

Fabrication: Blunt & Wray, Limited.

4

We produce aluminium and its alloys in all commercial forms and we are always glad to advise architects and designers on the possibilities of aluminium.

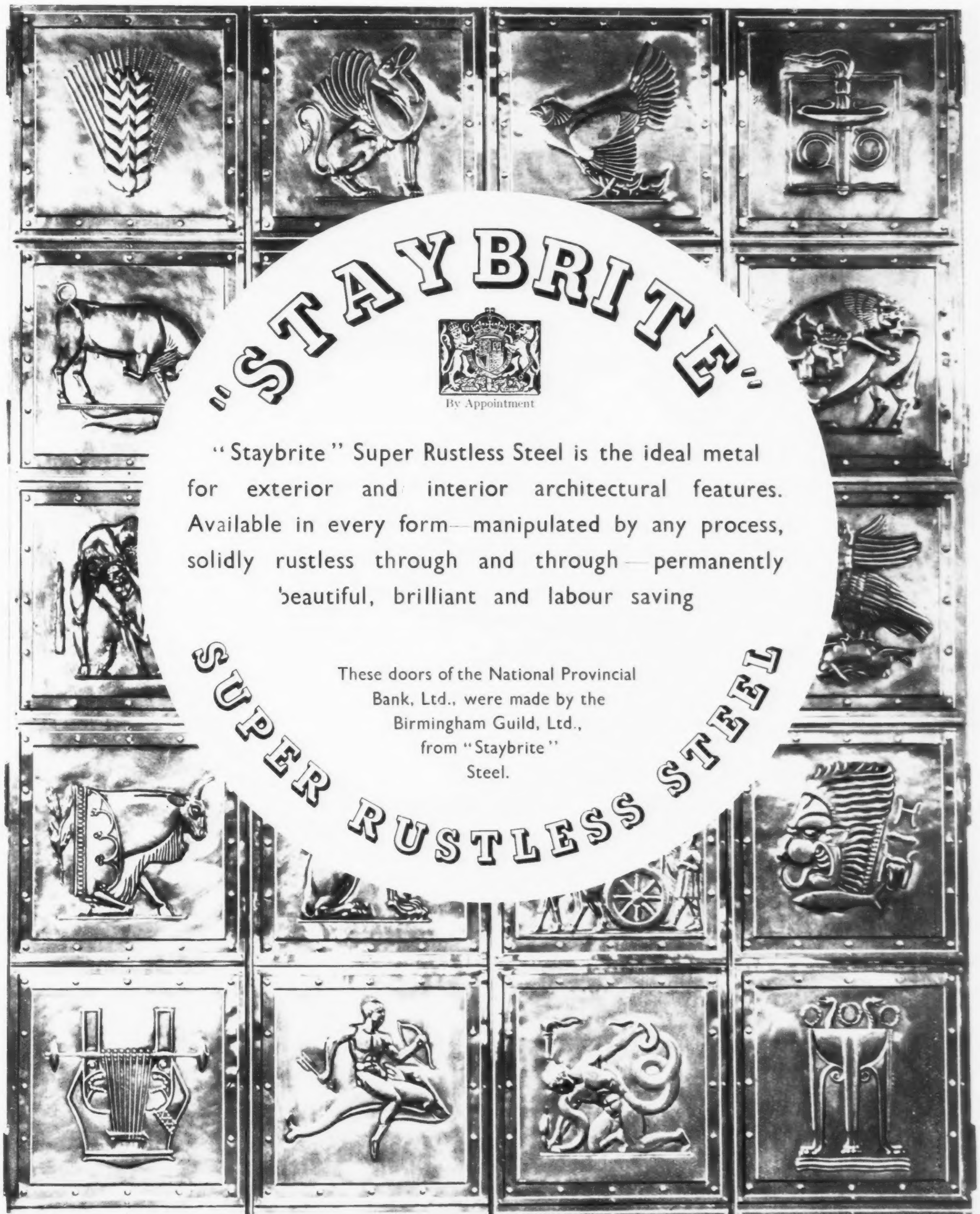
THE British Aluminium CO. LTD

HEAD OFFICE: ADELAIDE HOUSE, LONDON, E.C.4.

Telephone: Mansion House 5561 (6 lines).

Telegrams: Cryolite, London.

AR6 37

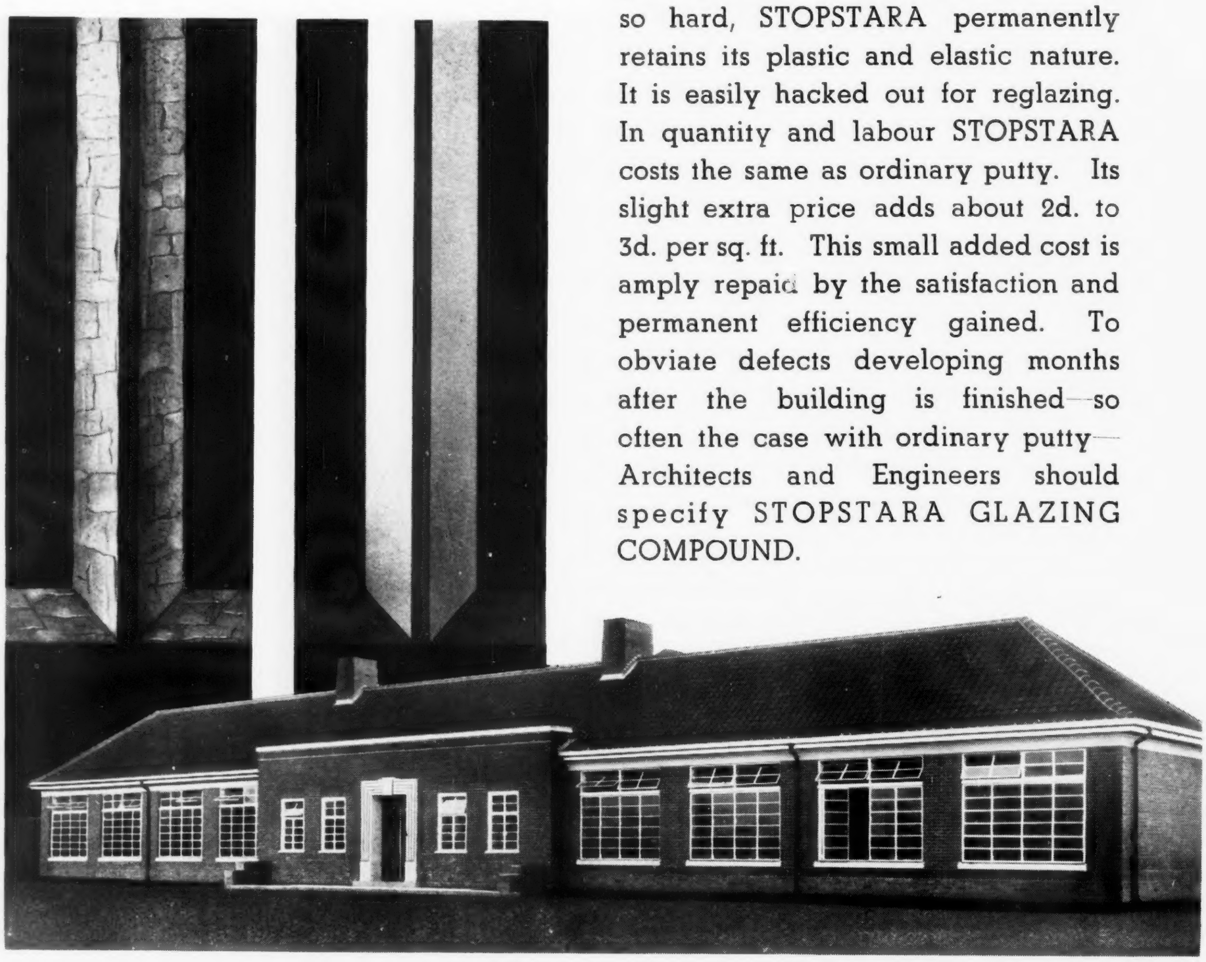

"STAYBRITE"
By Appointment
"Staybrite" Super Rustless Steel is the ideal metal for exterior and interior architectural features. Available in every form—manipulated by any process, solidly rustless through and through—permanently beautiful, brilliant and labour saving
SUPER RUSTLESS STEEL
These doors of the National Provincial Bank, Ltd., were made by the Birmingham Guild, Ltd., from "Staybrite" Steel.
FIRTH—VICKERS STAINLESS STEELS LTD
STAYBRITE WORKS, SHEFFIELD, 9.

STOPSTARA

The New Glazing Compound

STOPSTARA GLAZING COMPOUND is not subject to the defects of ordinary putties. This fact is proved by the way it has stood up to the searching tests of time and exposure. Putty is a highly important structural material. It should be specified with the same care as stone, brick and tiles. Ordinary putties remain soft indefinitely, fingermark, exude oil, bladder, crack, run and ruin the paint. STOPSTARA is subject to none of these faults. It works easily, trims neatly, and remains exactly as finished without shrinking, cracking or wrinkling. *It hardens quickly.* This enables STOPSTARA to be painted within 48 hours. Thus scaffolding can remain up until painting is finished, cheapening the job considerably.

For internal screens and partitions STOPSTARA is the ONLY satisfactory glazing material. Although apparently so hard, STOPSTARA permanently retains its plastic and elastic nature. It is easily hacked out for reglazing. In quantity and labour STOPSTARA costs the same as ordinary putty. Its slight extra price adds about 2d. to 3d. per sq. ft. This small added cost is amply repaid by the satisfaction and permanent efficiency gained. To obviate defects developing months after the building is finished—so often the case with ordinary putty—Architects and Engineers should specify STOPSTARA GLAZING COMPOUND.

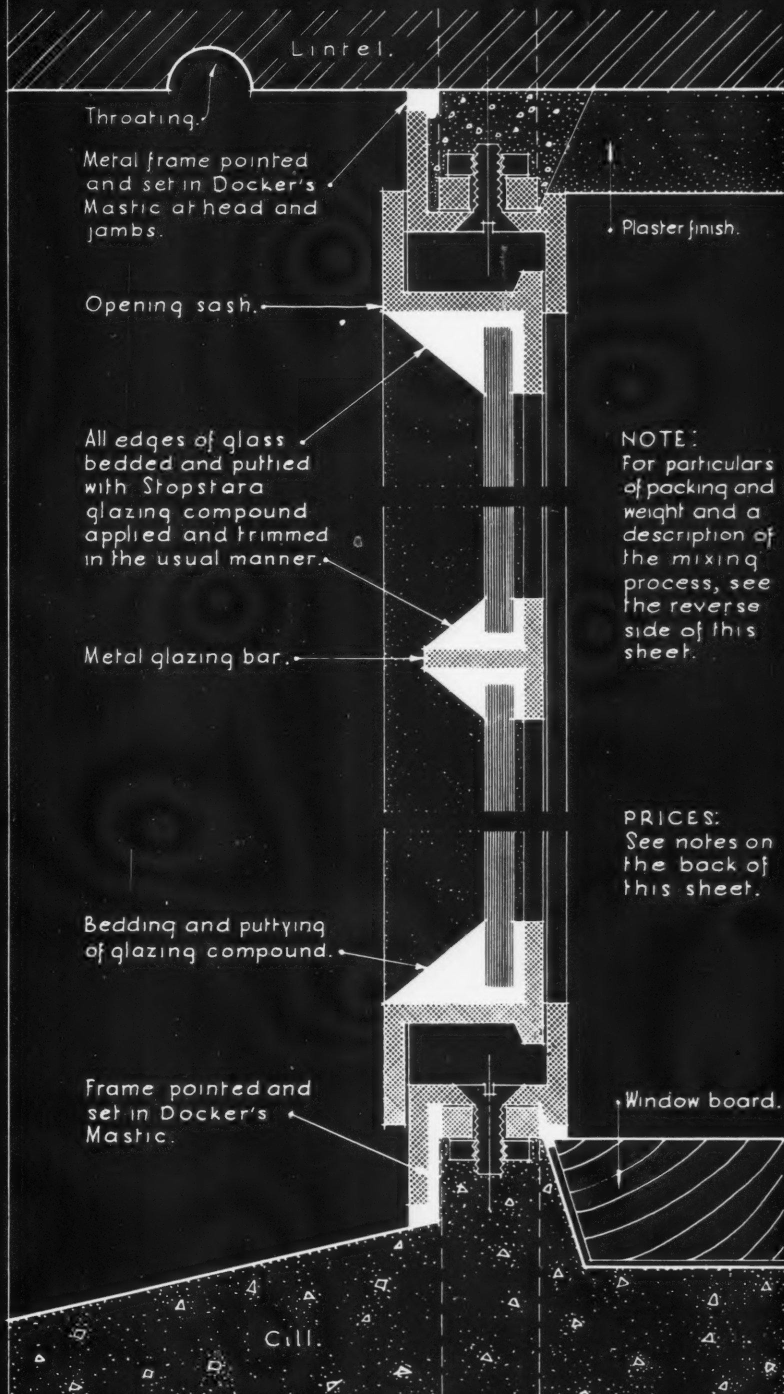


STOPSTARA used throughout the new Framlingham School, illustrated above. Photo by courtesy of E. J. Symcox, Esq., A.R.I.B.A., County Architect, Ipswich.

★ The working drawing on the opposite page is reproduced from "The Architects' Journal" Library of Planned Information edited by Sir John Burnet, Tait and Lorne.

STOPSTARA GLAZING COMPOUND: (for steel, wooden & metal windows, casements & lights.)

FULL SIZE DETAIL SHOWING THE APPLICATION OF THE COMPOUND TO A TYPICAL OPENING WINDOW IN MASONRY OR WOODWORK.



NOTE: For particulars of packing and weight and a description of the mixing process, see the reverse side of this sheet.

PRICES: See notes on the back of this sheet.

DESCRIPTION. Stopstara is a glazing compound of special composition for application to metal surfaces, and is suitable for internal or external use. It may be used on wood if desired.

PROPERTIES. The material is permanently plastic and waterproof, and is readily worked and trimmed.

It commences to harden immediately after mixing, and this combined chemical and mechanical action occurs right through the substance without shrinkage, cracking or wrinkling.

It is easily hacked out if reglazing becomes necessary.

PREPARATION. The putty is prepared on the site by the hand mixing of glazing paste with a hardening paste in the proportion of 10 to 1 by weight, in amounts sufficient for one time.

USES. Stopstara may be satisfactorily used on all forms of metal and wooden windows & lights, as well as for the puttying of internal screens, partitions, pressed steel door glazing, decorative facing glass, etc.

DECORATING. As the putty hardens rapidly, scaffolding already erected may remain until painting is finished.

Under normal drying conditions, painting may be started about forty-eight hours after application.

Information from Docker Brothers

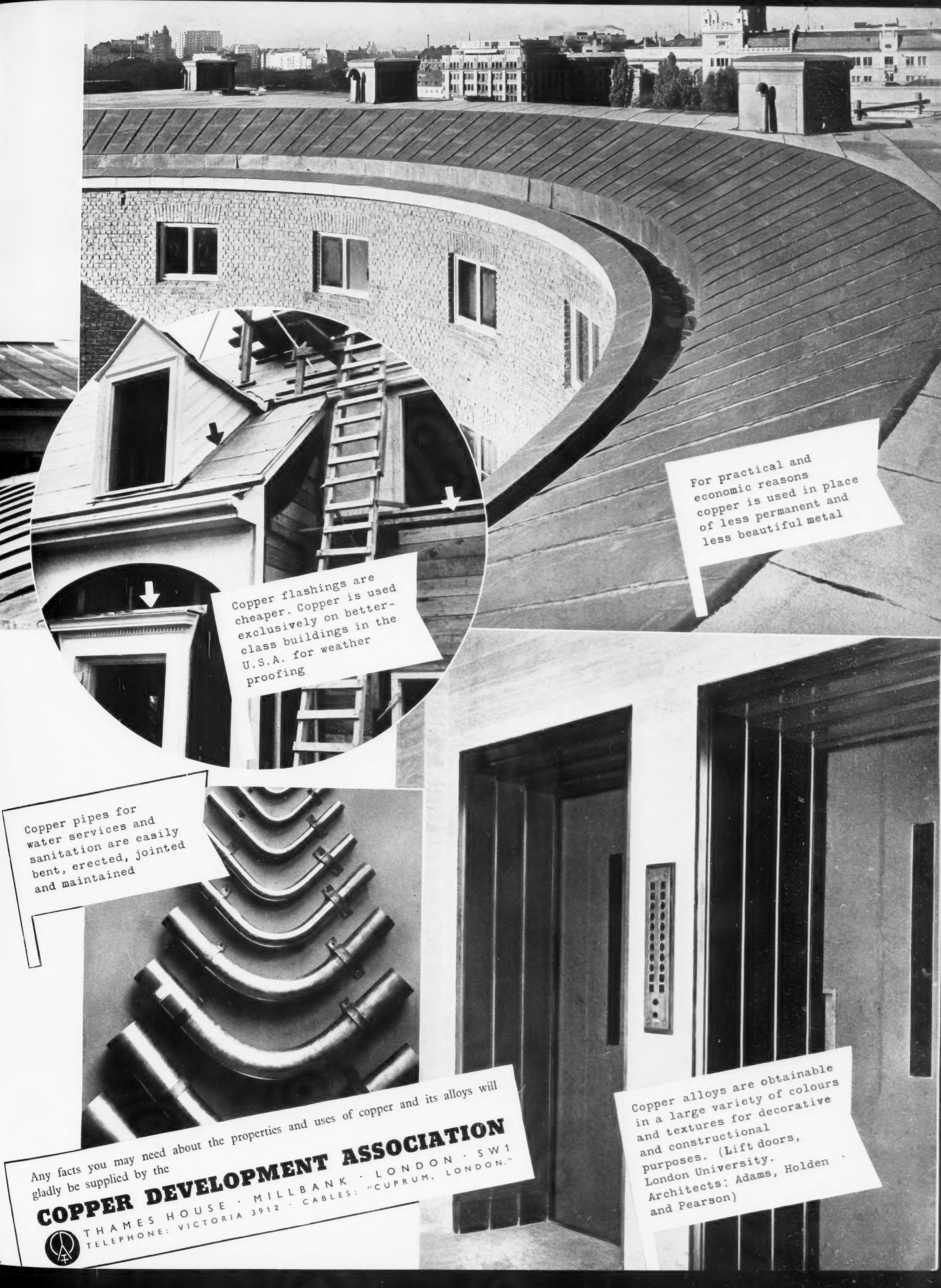
INFORMATION SHEET: METAL GLAZING COMPOUND

Copper does not creep on steep slopes or vertical surfaces

Copper is lighter, requires no maintenance, and weathers beautifully. (Slough Town Hall. Architects : C. H. James & S. Rowland Pierce)

Copper gutters and down-pipes used exclusively on better-class buildings in Scandinavia and the U.S.A. Lighter. Neater. Need no painting

Copper can be easily worked and manipulated


For practical and economic reasons copper is used in place of less permanent and less beautiful metal
Copper flashings are cheaper. Copper is used exclusively on better-class buildings in the U.S.A. for weather proofing
Copper pipes for water services and sanitation are easily bent, erected, jointed and maintained
Copper alloys are obtainable in a large variety of colours and textures for decorative and constructional purposes. (Lift doors, London University. Architects: Adams, Holden and Pearson)
Any facts you may need about the properties and uses of copper and its alloys will gladly be supplied by the
COPPER DEVELOPMENT ASSOCIATION
THAMES HOUSE · MILLBANK · LONDON · SW1
TELEPHONE: VICTORIA 3912 · CABLES: "CUPRUM, LONDON."

—its advantages.

It is—

absolutely weatherproof for a great number of years.
one of the lightest forms of PERMANENT roofing.
one of the least expensive forms of PERMANENT roofing.
equally suitable for flat, pitched, or curved roofs, and can be used for vertical cover.
easily and quickly laid—no melting, tarring, or dirty operation necessary at all.
easy to repair if damaged by accident.
proof against fires from flying sparks etc.
dust-proof and odourless.
impregnable to vermin and insects.
not poisonous to rain-water.
non-staining to stone or paintwork.

It forms—

its own protection against corrosion and needs no painting.

It has—

an attractive colour.
a high scrap value if the building is demolished or altered.

It can—

be obtained easily and quickly all over the country.
be easily earthed to form protection against lightning.

It does not—

crack under the action of frost.
crack if the foundations of the building settle.

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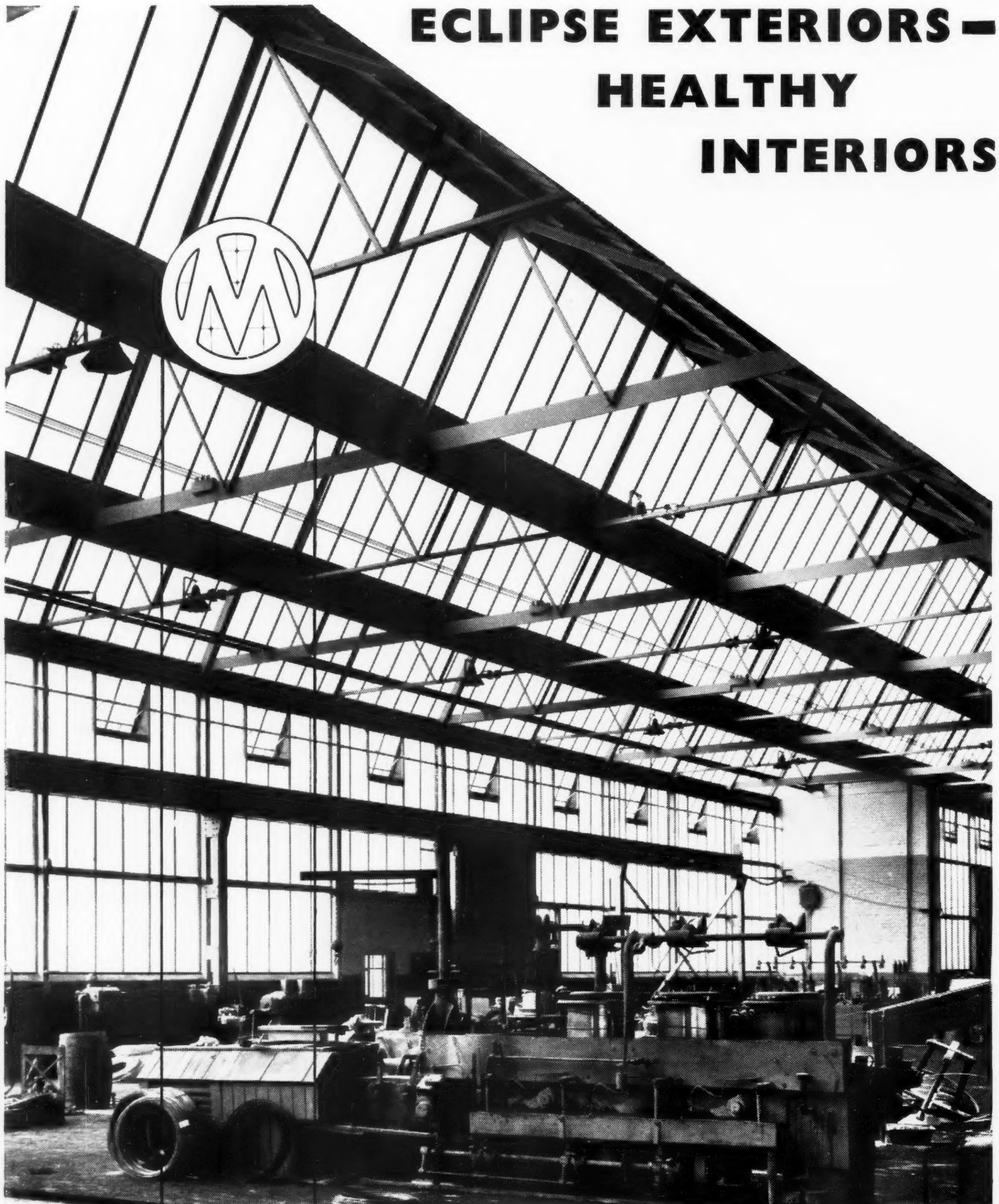
3. Enamelled shower-stall linings.
4. Enamelled linings of larders and food cupboards.
5. Coverings of window-cills.
6. Coverings to projecting courses, copings, parapets, etc.
7. Name-plates.
8. Chute linings.
9. Zinc tubing for electrical wiring.
10. Zinc Slating and Sheathing Nails.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HEALTHY
INTERIORS

THINK

AND

PLAN

IN

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H. N. Martyn & Co., Ltd.

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Branch Offices : Banbury, Birmingham, Bristol, Coventry, Glasgow, Manchester, Sheffield.

AR.14

Craftsmanship in Lead

Top & Bottom : Cast lead rainwater heads for Ripon Hall, Oxford and the Jockey Club, Newmarket. *Architects : Messrs. Richardson & Gill, FF.R.I.B.A.*

Centre : Cast lead flower boxes for the London Passenger Transport Board, 55 Broadway, S.W.1., which included the making and fixing of a 427 ft. run of boxes, each box measuring 5 ft. long, 10½ ins. deep, and 11 ins. wide, with three loose containers in duplicate to provide for easy changing of plants as required. Under the direction of Charles Holden, Esq., F.R.I.B.A.

Other recent and current contracts include :

Eltham Hall, Eltham and King's School, Canterbury.
Architects : The Hon. John Seely, F.R.I.B.A., and Paul Paget, A.I.A.A.

New London University Buildings.
Architects : Adams, Holden and Pearson, FFF.R.I.B.A.

New Civic Centre at Dagenham. *Architect : E. Berry Webber, A.R.I.B.A.*

Reigate, Eltham and Gerrard Telephone Exchanges.
For His Majesty's Office of Works.

Epsom Fire Station. *Architects : Pite, Son and Fairweather, FF.R.I.B.A.*

Officers' Mess and Quarters, St. Lucia's Barracks, Borden, and Royal Engineers Officers' Mess and Quarters, Longmore Camp.
Architect : W. A. Ross, F.R.I.B.A.

Girls' School at Twickenham for the Middlesex County Council.
Architect : W. T. Curtis, F.R.I.B.A.

Private Residence, 67 Avenue Road, St. John's Wood.
Architects : Wimperis, Simpson and Guthrie, FFF.R.I.B.A.

House at Haslemere *Architects : W. S. Grice and Denis Poulton, FF.R.I.B.A.*

House at Cobham. *Architect : Hubert Lidbetter, F.R.I.B.A.*

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ALUMILITE

The PATENTED protective and decorative process for aluminium and its alloys, the qualities of which have been PROVED by the test of TIME and EXPOSURE.

These beautiful, lustrous, coloured and Natural finishes were admired from their very inception and the acceptance of the process for application to many productions in aluminium was quickly secured.

Before this process was offered to the public, our research work, which culminated in over thirty patents, was tested out on a commercial scale, and there has been less delay than we anticipated in the acceptance of ALUMILITE for application to really important and costly art metal-work manufactured from aluminium and its alloys.

In Europe this process is now operated by over 150 manufacturing licensees and consequently there are many examples which have been subjected to severe exposure which can be inspected.

Woolwich Electrical Showrooms
"Alumilited aluminium staircase manufactured by the Morris Singer Company, London."

It is important to note that the ALUMILITE finishes are distinctive in regard to the sunfastness of the colours and the tones of Natural finishes.

All these have a very high resistance to abrasion, give exceptional protection against atmospheric corrosion and staining, and require no polishing.

Amongst the examples of our work referred to below there is ample evidence of the very necessary continuity of colour tone over a large number of units.

It is important to note that we obtain these results with the same exactitude on sand and die-castings in aluminium alloys as in the case of the wrought metal.

There are important and patented features in the ALUMILITE process which give these distinctive results and these patents are supported by our own and our licensees' extensive commercial experience of this class of work.

ALUMILITE should not be confused with any other process, secret or otherwise.

ALZAK

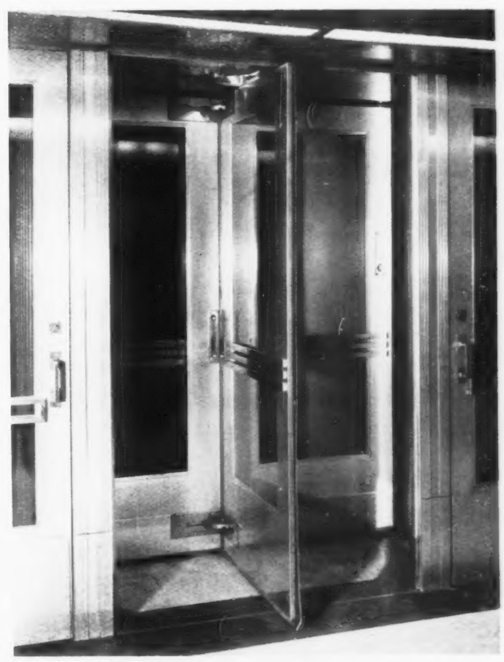
the new aluminium alloy which after electrolytic treatment produces an untarnishable, mirror-like reflectivity of high efficiency in either specular or diffuse finishes.

Many examples of this product are now in use and giving great satisfaction with marked economy in current consumption.

The services of our technical staff are available to assist in the selection of suitable aluminium alloys and in dealing with the details of construction entirely free of charge.

By appointment we shall be pleased to give inspection to our Works and the ALUMILITE process.

All enquiries for samples, detailed information or quotations will receive our very prompt and careful attention.



Revolving doors in 'Alumilite'.

At the Thames Factory, Rainville Road, Hammersmith, we maintain a very large equipment and amongst the many important jobs which we have Alumilited and are easily available for inspection in London are the following :—

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(Manufacturer—Morris Singer Company)

The Strand Palace Hotel Cocktail Bar
(Manufacturer—Evenlite Ltd.)

Lyons Corner House, Coventry Street, (Argentine Brasserie Coin Bronze and Gold Room, etc.)
(Manufacturer—Evenlite Ltd.)

The Gas Light & Coke Company Ltd., Oxford St.
(Manufacturer—H. N. Barnes Ltd.)

Italian State Railways, C.I.T., Regent Street
(Manufacturer—H. N. Barnes Ltd.)

The Knightsbridge Hotel (Interior lighting fittings)
(Manufacturer—Troughton & Young Ltd.)

Kay-Ef-Em, 186 Shaftesbury Avenue, W.C.
(Manufacturer—H. N. Barnes Ltd.)

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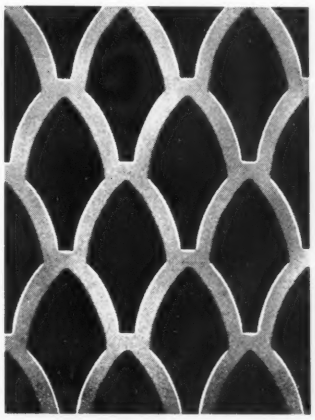

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Produced from the solid sheet in a wide variety of patterns in Steel, Brass, Copper, Bronze, Stainless Steel and many other metals, "HARCO" Perforated Metal Radiator Covers, Ventilator Panels and Grilles combine artistic effect with strength and durability.

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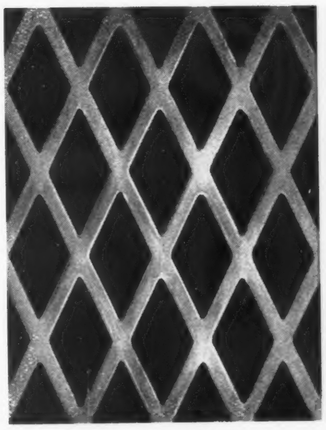
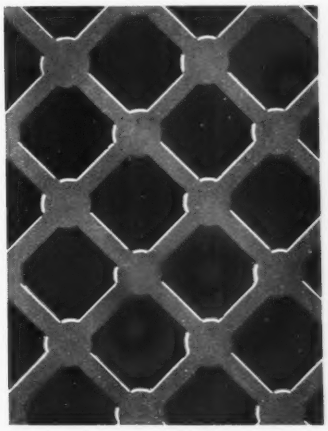


Pattern No. 1026.

These three Patterns are shown three-quarters actual size.



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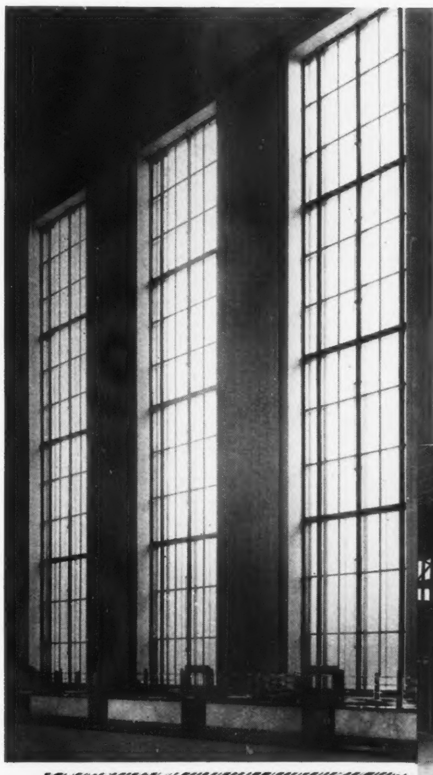
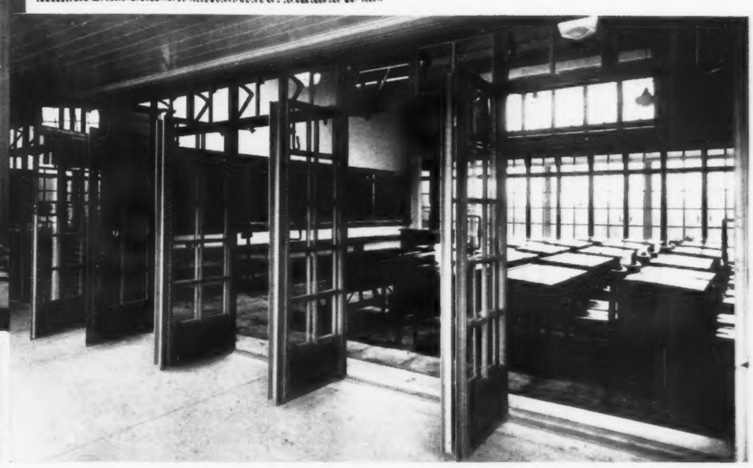


" Fitness for purpose " is perhaps the best description that can be given to these modern metal windows.

They are architecturally pleasing . . . draught and waterproof . . . open easily and shut tightly . . . do not warp, shrink or swell.



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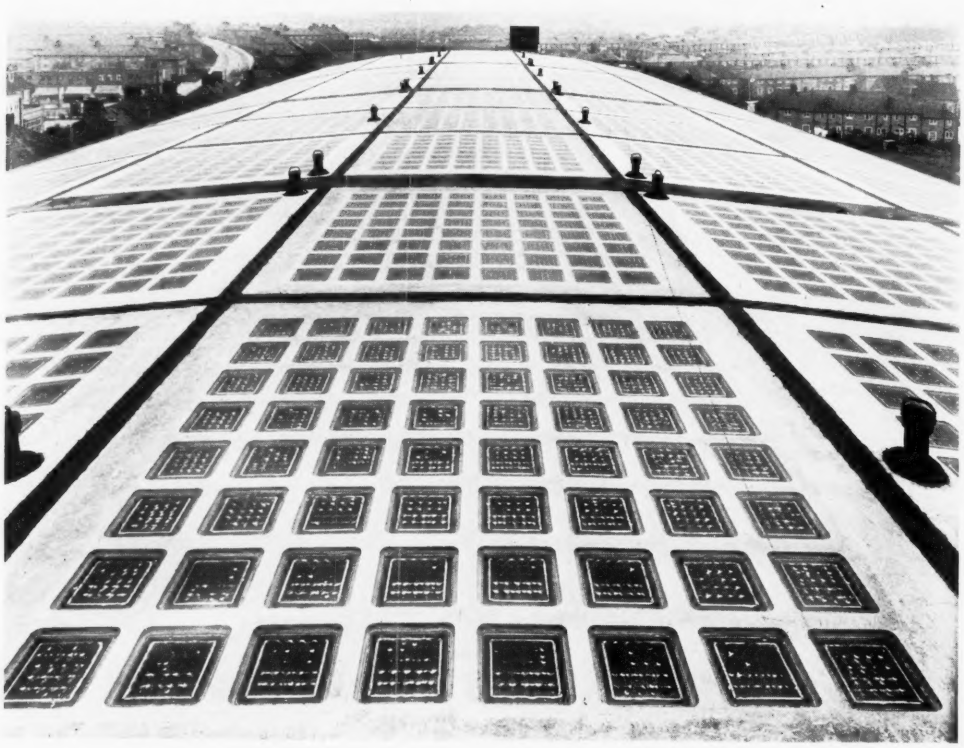

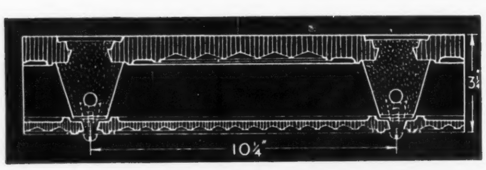

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