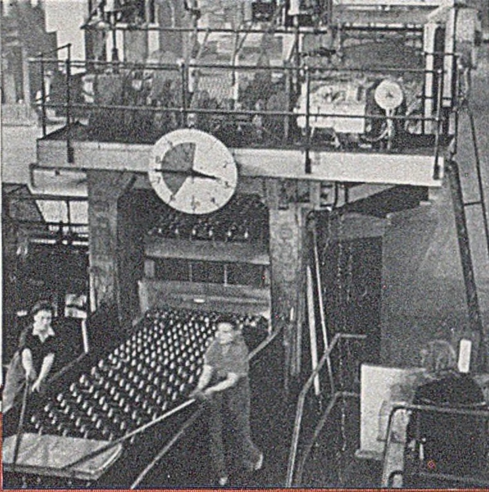
WELDING TECHNIQUES—AN INTRODUCTION

LIGHT METALS

FEBRUARY
1948

2/-

ALUMINIUM
AND STRONG LIGHT ALLOYS



Rolling slab in hot mill

NOTCHED BARS
& SECONDARY INGOTS

ROLLING SLABS

HOT ROLLED PLATES

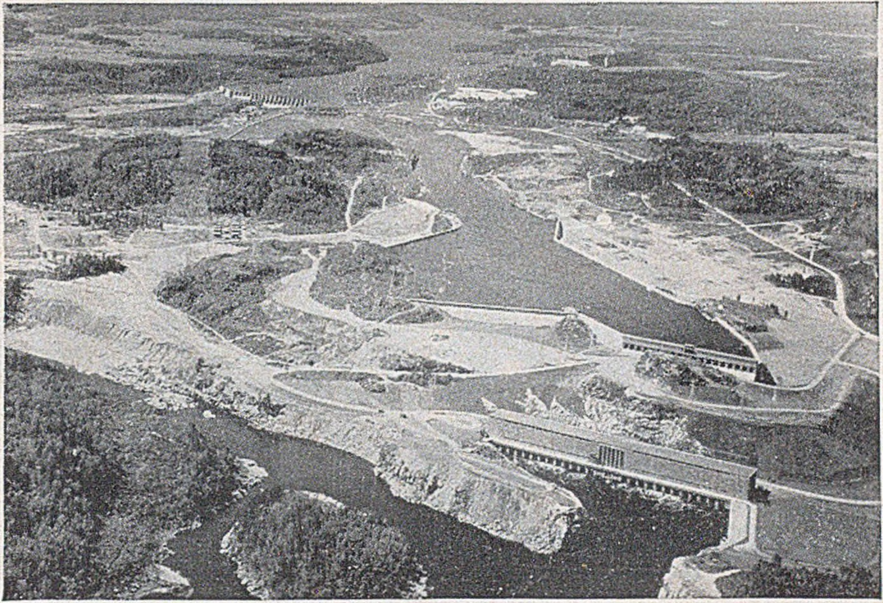
COLD-ROLLED SHEETS

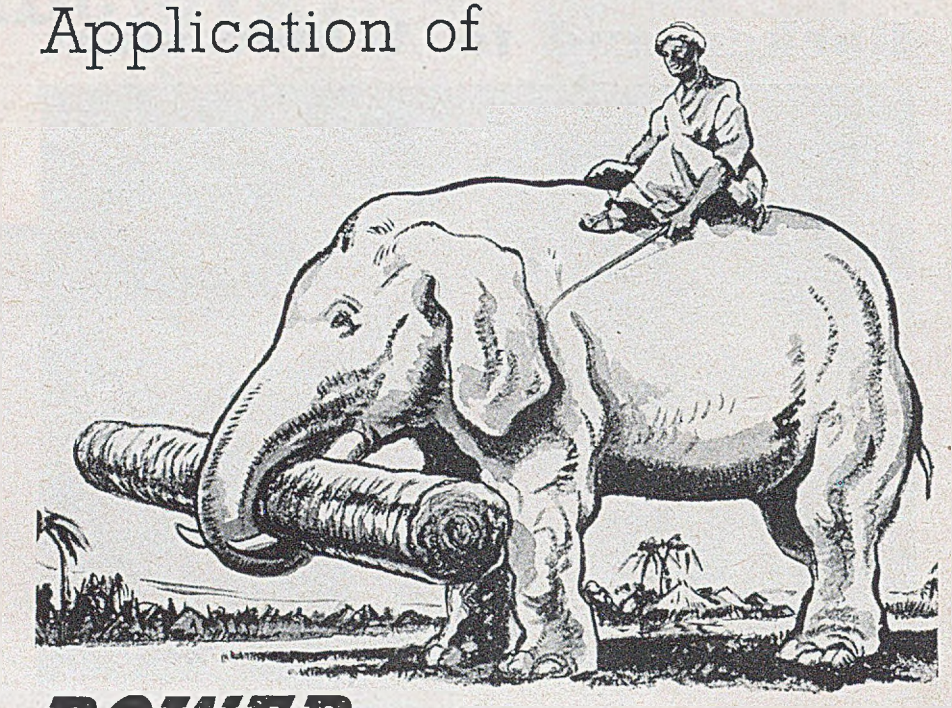
CIRCLES

If you have a problem, or if you contemplate using these metals for the first time, write or telephone us and we will place all our experience at your disposal and, if necessary, our technical representative will call and discuss your difficulty.

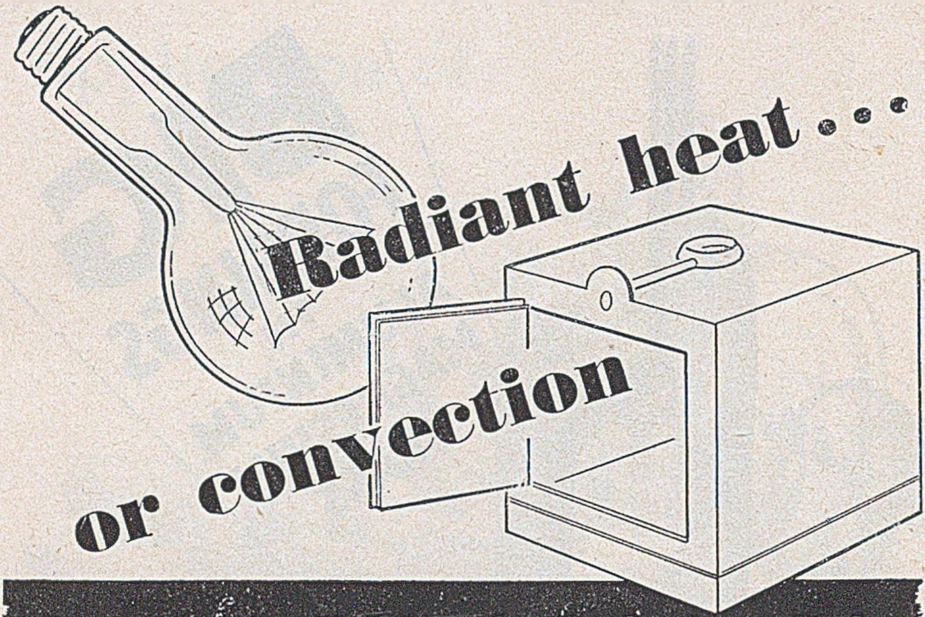
Richard Thomas
& Baldwins Ltd.

WERN WORKS,
BRITON FERRY,
NEATH, GLAMORGAN,
SOUTH WALES.
Telephone: Briton Ferry 3211



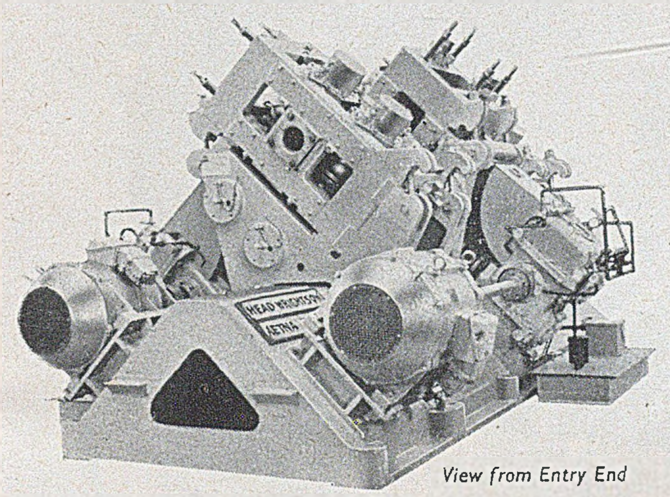


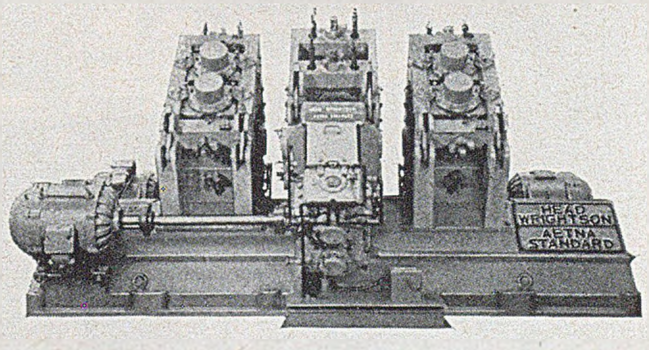

BIG
FORGINGS
IN
ALUMINIUM
MAGNESIUM
BRASS


Radiant heat . . .
or convection


CERRIC
CELLULOSE LACQUERS
CERRUX
SYNTHETIC FINISHES
CELLON LIMI
KINGSTON-ON-T
CERRUX
Stoving Finishes


Infra-Red
LAMP HEATING
by G.E.C.


HEAD WRIGHTSON
AETNA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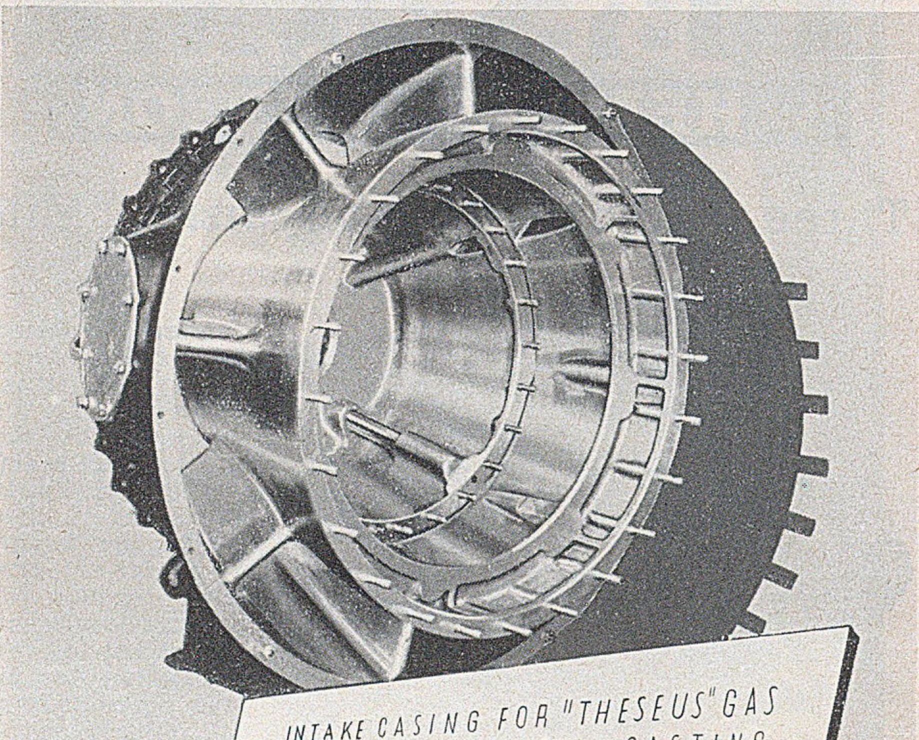
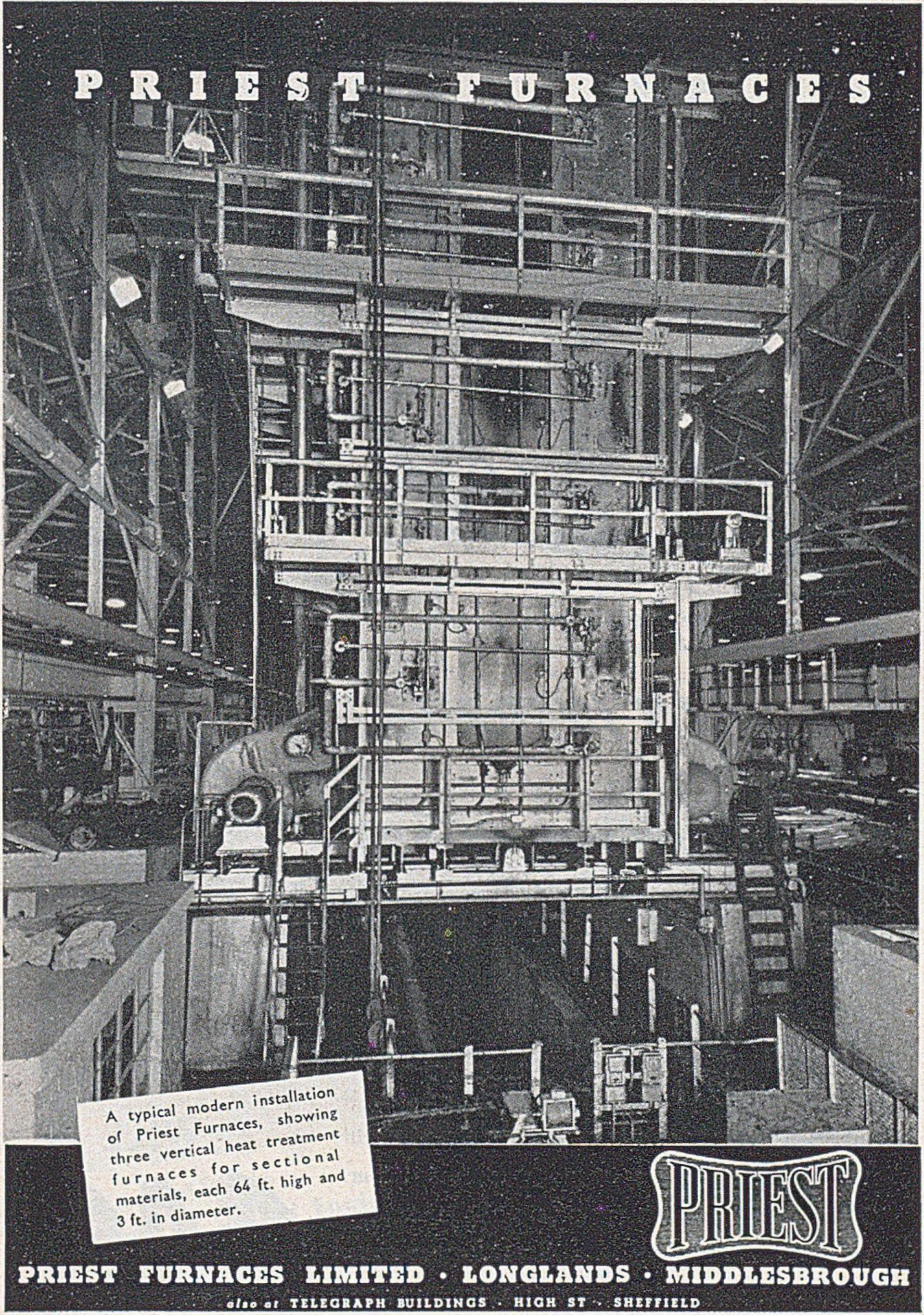
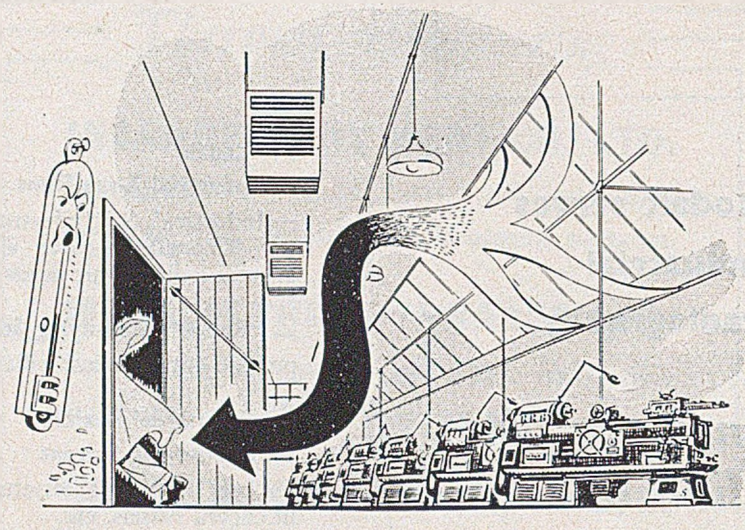

INTAKE CASING FOR "THESEUS" GAS TURBINE AIR-SCREW. CASTING IN D.T.D. 133.C ALUMINIUM ALLOY.
BY COURTESY OF BRISTOL AEROPLANE CO. LTD.
WHERE CASTINGS ARE IN QUESTION THERE IS A FIELD FOR ALUMINIUM ALLOYS





The warmth that went to dinner !

Scene—a machine shop of a light engineering works in the Midlands. The whistle blows for dinner—down tools—up jackets—doors are flung open and the rush to the canteen is on.

Back in the shop, doors are left open —temperature is dropping down—down—down. Warm—cheerless—COLD. In the stokehold extra firing strives to counteract the drop. Precious fuel goes to fight a battle that need never have been fought.

Action from the Works' live-wire Joint Fuel Efficiency Committee. All external doors to be fitted with air locks—light inner structures with sprung swing doors to be provided. Result: extra firing no longer necessary and the heat in the machine shop stays in to dinner!

This is a true story. Is there a lesson in it for *you?* Are your factory doors self-closing? Are broken windows patched up, if only temporarily, until proper repairs can be made? *Are cracks and crevices in the building's structure tightly sealed?*

Are you keeping warmth IN by keeping draughts OUT!

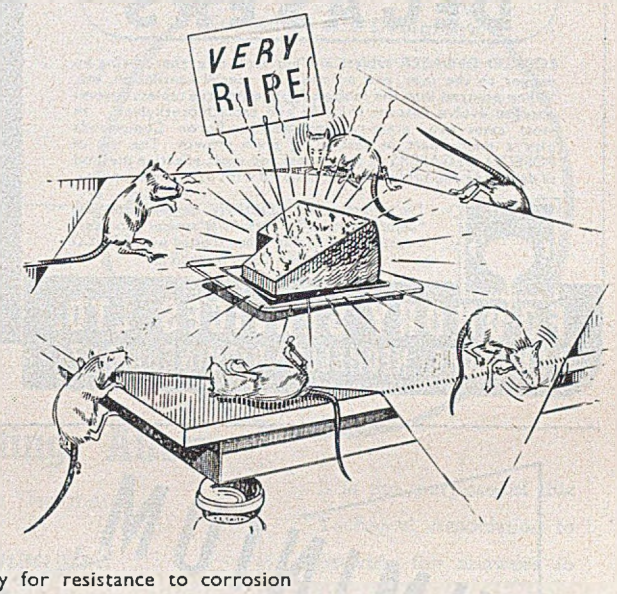
YOUR REGIONAL FUEL OFFICE

REGION	ADDRESS	TELEPHONE
Northern	Government Buildings, Ponteland Road, Newcastle-on-Tyne, 5	Newcastle 28131
North-Eastern	Century House, South Parade, Leeds, 1	Leeds 30611
North-Midland	Castle Gate House, Castle Gate, Nottingham	Nottingham 46215
Eastern	Shaftesbury Road, Brooklands Avenue, Cambridge	Cambridge 56268
London	Mill House, 87/89, Shaftesbury Avenue, W.1	Gerrard 9700
South-Eastern	95, High Street, Rochester	Chatham 3487
Southern	Whiteknights, Earley, Reading	Reading 61491
Wales	27, Newport Road, Cardiff	Cardiff 9234
South-Western	12/14, Apsley Road, Clifton, Bristol, 8	Bristol 38223
Midland	Temporary Office Buildings, Hagley Road West, Birmingham, 17	Bearwood 3071
North-Western	Burton Road, West Didsbury, Manchester, 20	Didsbury 5180-4
Scotland	145, St. Vincent Street, Glasgow, C.2	Glasgow City 7635
Scotland	51, Cockburn Street, Edinburgh, 1	Edinburgh 34881
Scotland	1, Overgate, Dundee	Dundee 2179

ISSUED BY THE MINISTRY OF FUEL AND POWER

TRADE TERMS TRAVESTIED · NUMBER NINE

Corrosion Resistance . .

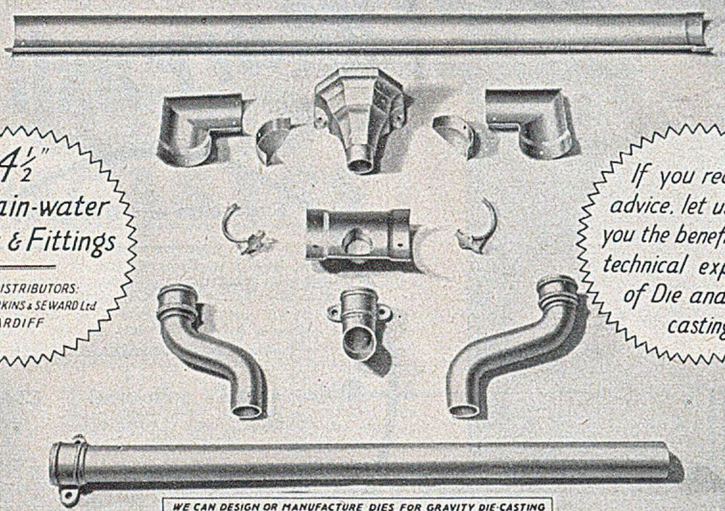


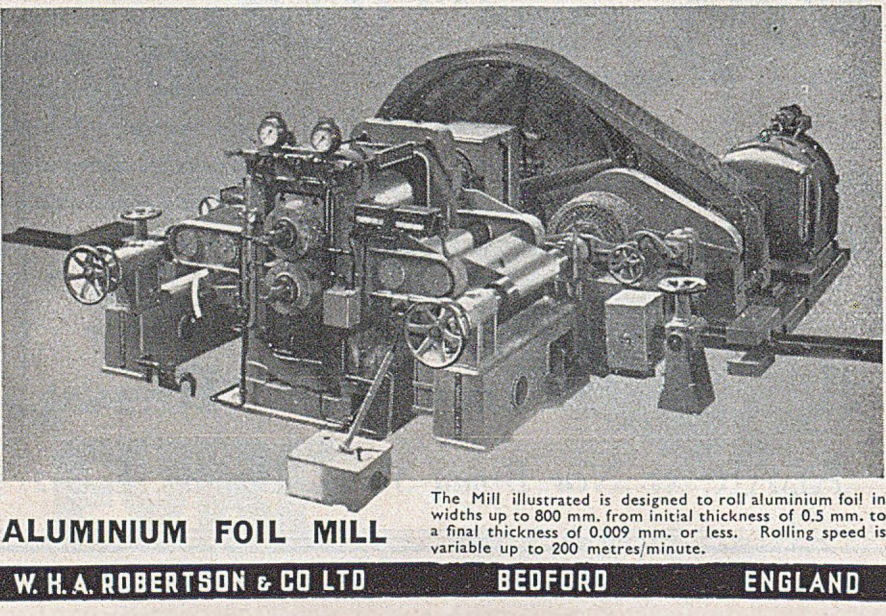
DON'T get the idea that PRIESTMAN products are over-ripe. That little failing is confined to the stories we tell in off-duty time. In our sterner moments, when we make a claim for some special virtue in any one of the range of TJP aluminium alloys, we stick strictly to the truth and nothing but the truth. Take this business of corrosion resistance, for example. We have some excellent specifications, in which the capacity for resistance to corrosion by sea-water or oils and fatty acids, is an outstanding feature. If their employment is your problem, then park your headache with our experts, who can either suggest the right TJP standard specification for the job, or co-operate in the production of a specially made individual alloy. Each consignment, from the first to the last, will be consistent to the original specification. Very particular people in our chemical and physical laboratories will see to that by frequent and exacting tests at every stage of manufacture.

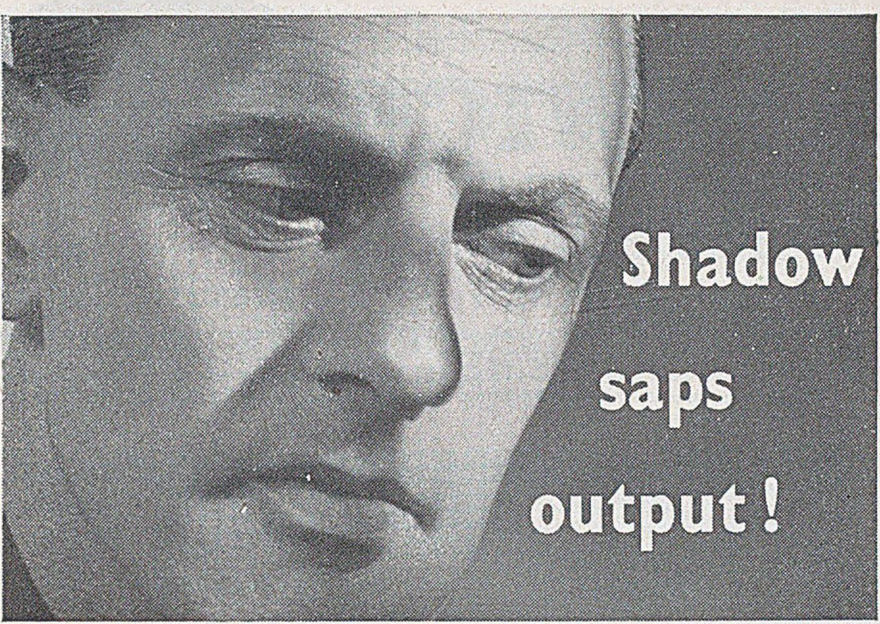
T. J. Priestman LIMITED

ALUMINIUM ALLOYS · BIRMINGHAM · 12 · Vic: 2581-5

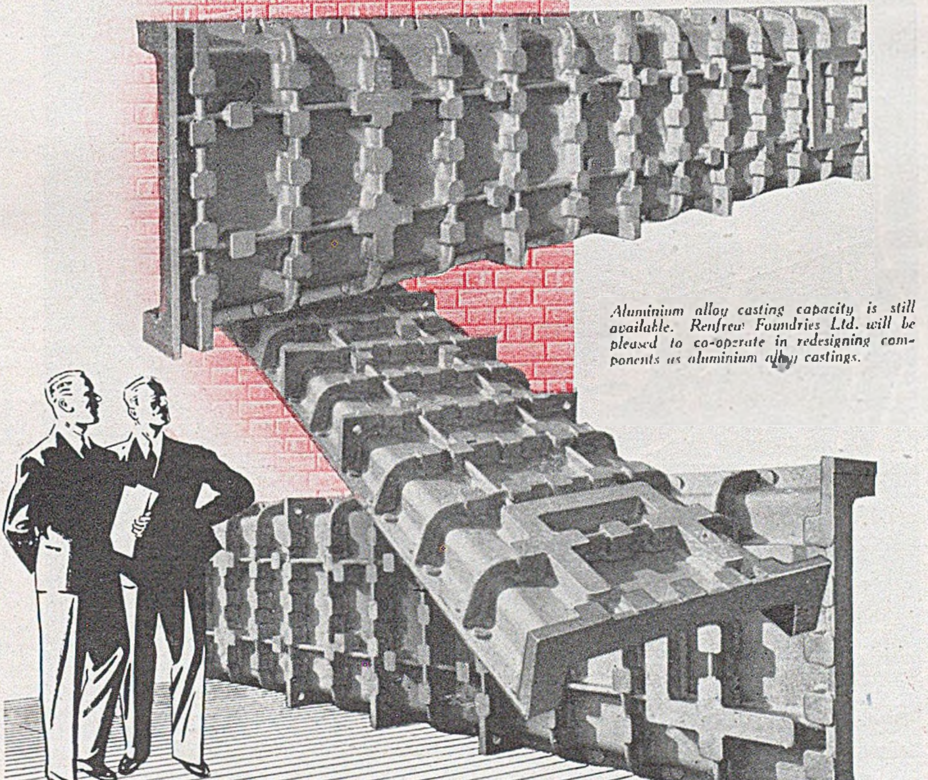
ALUMINIUM TPJ BRAND ALLOYS

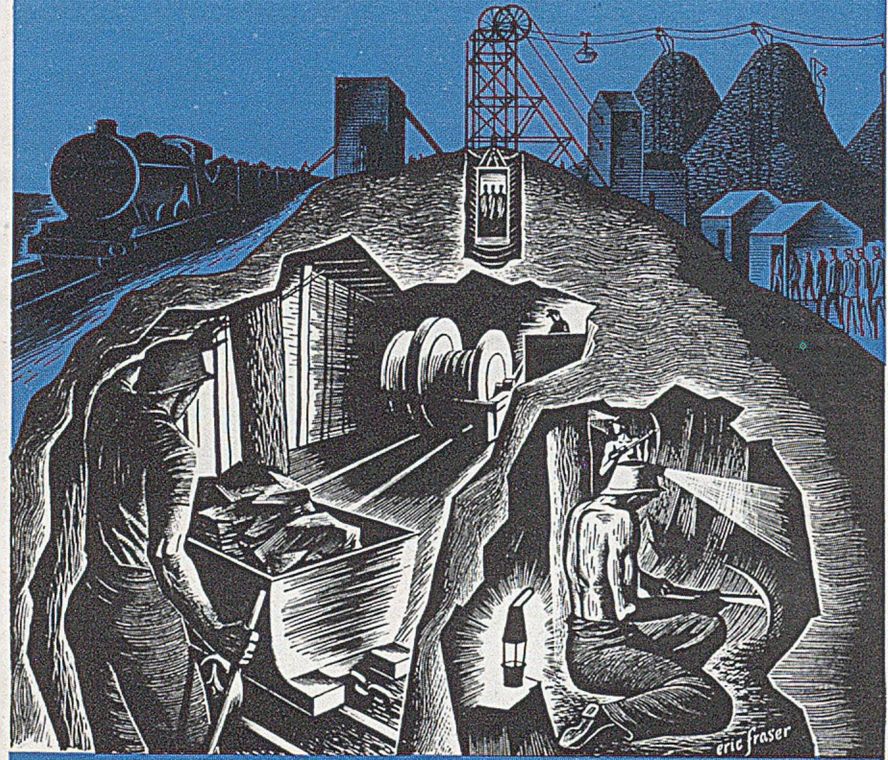






Shadow
saps
output!




eric fraser

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LIGHT
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with the Production, Uses
and Potentialities of
Light Metals and
their Alloys

Editor:
E. J. GROOM, M.Inst.MET.

Branch Offices at
BIRMINGHAM,
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and
GLASGOW

EDITORIAL OPINION

"Skin Game"

"The sabres especially, the blades of which emitted a dazzling radiance, fixed, more than all the rest, the caliph's attention; . . ." (*Beckford, "Vathek."*)

THE art of imparting finishes of all sorts, ornamental or utilitarian, to metallic surfaces, developed, in all probability, almost simultaneously with that of the use of metals themselves. Neglect or forgetfulness, it must soon have been realized, could play havoc with tools of the housewife, husbandman and soldier and, notwithstanding the excellent (even if accidental) formulation of early bronzes and the superb rust-resisting quality of primitive irons, the tarnish bogy soon made its presence known even in those far-off prehistoric days. Then, it must have been, that a growing insight into the nature of the superficial reactions of metal when subjected to treatment in various ways with fire, "chemicals" and abrasives, offered the pioneer craftsman novel possibilities of fortifying his work against greedy time, the elements and careless handling. A bright polish, besides being decorative and possessing greater eye appeal was, he no doubt quickly observed, less susceptible to deterioration than a cruder finish. The lasting sheen of fine oriental sword steels was, for centuries, proverbial.

Attack by various media and agents (including weather) upon metals produces typical visible effects which have formed an object of study from the remotest ages. The pathology of corrosion, however, as we understand it to-day, is a recently matured branch of learning, suffused, still, with much of that fanatical enthusiasm which characterizes most original work in science. Thus it is not surprising that, in the pursuit of knowledge, we find up and down the country metals in various stages of dress and undress, martyred on factory roofs by exposure to rank industrial fogs; spat on by brackish mists in the laboratory; stifled by smoke in railway tunnels (yours and mine now); alternately soused by the tides and dried by the winds whilst nailed to posts in some maritime dock; racked, indeed, till they crack up under the ordeal, or until the grand inquisitor is satisfied with the squiggles and hieroglyphics he derives from all this jolly business.

And what about the rest of the world? While a numerical minority is doing its level best to knock spots off its hardware, the larger number is employed no less assiduously in the application of elbow grease directed to the very opposite end. We see the chemist building up deposits of rust or verdigris, striving to lose metal, in fact, in order to garner material for some learned thesis, whilst the lifeguardsman busily burnishes his breastplate and the daily help wields a fistful of wirewool on behalf of the aluminium saucepans, all with the object of producing a really good shine and, in the process, saving metal.

Now the results of the chemist's handiwork have been studied from A to Z by every possible means. It is safe to say that not only do we know all about that layer of rust but, furthermore, we can, at any given moment, say exactly what is happening to the metal surface beneath it, though it be temporarily hidden by a deposit of reaction products. The same confidence in our knowledge is not justified in the case of the very valuable work done in keeping our household metalwork bright.

What happens to a metallic surface which is "conditioned" by constant cleaning, rubbing and polishing, maybe for some half a century? In what way does it alter with time as the treatment progresses? Are the factors we must look to merely of a physical nature, or have we to reckon with obscure chemical changes? Do we put "something" on, or take "something else" off?

In a few special instances some attention has been given to this facet of metallurgical science. Cylinder-bore wear, a physico-chemical phenomenon still not fully understood, has been gone into most minutely; bearing surfaces subjected to rotary rubbing and backwards-and-forwards sliding actions respectively, react physically in typically different ways; silver, polished with rouge, acquires a warm gloss, the nature of which may be largely explained on purely chemical grounds. The behaviour of the cut-throat razor, stropped daily, year in year out, presents a pretty problem in chemistry, physics and mechanics.

Let's go into the kitchen now! Aluminium ware, used every day, "washed up" in soapy water, polished with steel wool, occasionally boiled dry and burned and subsequently restored by more vigorous treatment with some abrasive cleaning powder, gains in character; what is the nature of the conditioning process which occurs here? For it is quite certain that, with regular cleaning when first put into service, light-metal pans become disciplined to use and, as time goes on, tend, with much less expenditure of energy on the part of those whose duty it is to care for them, to get brighter and to keep their shine for a longer period. We have observed this singular behaviour especially marked in the case of cast-aluminium-alloy sinks.

Many theories have been advanced in explanation of this amenability to the educative influence of the "daily round," the dish cloth and the pot scourer. Some insist that there occurs at the working surface selective removal of less "noble" (i.e., more highly reactive) constituents, a process which results gradually in the formation of an unbroken homogeneous skin of metal naturally resistant to attack. Others, as a variant of this theme, suggest that these surface changes in the metal are conducive to the promotion of a continuous, uniform and perhaps slightly thickened oxide film. Another school postulates the formation of adsorbed films of grease or metallic soaps, these being either wholly responsible for the effects we have noted, or reinforcing the favourable changes supposed by others, as we have said, to take place in the body of the surface metal itself. Their production, although pre-eminently exemplified by aluminium and magnesium, is not confined to these metals; it is likewise apparent in the case of some of the brasses and bronzes, but, in its more useful forms, less noticeable in the case of unalloyed copper or the higher aluminium-coppers. Preferential diffusion phenomena can, it is thought, play only a very minor role in the conditioning reaction at normal temperatures.

In emphasizing this credit side of the corrosion problem (we will call it that for want of a kinder term), we are not entirely unmindful of the accomplishments of, and the difficulties facing, the supplier and user of applied finishes such as paints, lacquers and even sprayed-metal and electro-deposits. There is reason to believe, indeed, that the value of these depends, in many cases, almost as much on their ability to prevent alteration or "ageing" of an undesirable nature at the metallic surfaces, as upon their intrinsic sealing qualities; conversely, the adhesion and efficacy of enamels, let us say, may frequently be promoted by the artificial conditioning of the surface they must ultimately cover.

It has been amply demonstrated, we believe, that every reason exists for the initiation of a coherent research project undertaken with the object of clearing up many of the points to which attention has been drawn. This investigation, complete in itself, must, at the same time, not be divorced entirely from that devoted to conventional corrosion study, for the two aspects are obviously intimately linked.

Indirectly, the phenomenon of conditioning possesses a certain element of sales value which, at times, might be turned to good account in connection with the marketing of light-metal products for domestic purposes and the food industries. It is suggested, for instance, that, where final cost warrants such a step, the normal finishing process be supplemented by a further operation designed specifically to expedite surface "stabilization," or, at least, to simulate its effects until use and time have enabled the normal sequelæ of superficial "ageing" to manifest themselves.

Sporadically, lamentation arises concerning the untoward behaviour of certain articles of kitchenware when first put into service; surface-darkening may occur, or, at times, for example in the case of light-metal washing-up bowls, accusations are levelled against the material on the grounds that it causes blackening of crockery; again, water allowed to stand in aluminium vessels for any length of time may exhibit, when poured out into a glass, a slight flocculent suspension. These effects, we know, are quite benign and are, in general, of a temporary nature. To the uninitiated, however, they may constitute cause for mild perturbation. Pre-conditioning of the surface of such ware before it be released to the public would, most conclusively, greatly diminish the incidence of these complaints and might be achieved by a subsidiary barrelling or tumbling operation, the polishing charge carrying with it a medium selected on the basis of previous experiment and known to have some influence on the conditioning cycle. In the case of apparatus designed for some industrial uses, bread-making, for example, it might be diplomatic to include, as a final touch, the actual running of a dough-mix.

A more speculative proposition is the possibility of surface-treating certain articles with metallic soaps before release for sale. This, incidentally, might apply not only to aluminium but even more so to magnesium. These substances, well rubbed in to start with, and then scrubbed off with clean rags, give an ideal, pre-greased, non-stick, non-wetting working face.

This line of thought can be pursued far beyond the kitchen wall. Decorative work in aluminium, both for interior and exterior work, may be seasoned by judicious treatment with one or another popular brand of floor polish, petroleum jelly, or a metallic soap, say aluminium naphthenate; such compounds, applied to an unbroken as-cast skin, would seem to be especially efficacious in preventing unwanted changes in surface appearance. Casual experiment indicates that doctoring in this way controls, very desirably, the weathering which takes place on exposure of the metal to the atmosphere. Even hot water or low-pressure steam can be turned to good account, so can that tried medicine for heresy and porosity—boiling oil.

Contents

SPECIAL FEATURES

REGULAR FEATURES

"LIGHT METALS" is published in London, England, on the first Wednesday of each month.
Annual Subscription Rate : 26/- post free. Shorter periods pro rata.

NEWS

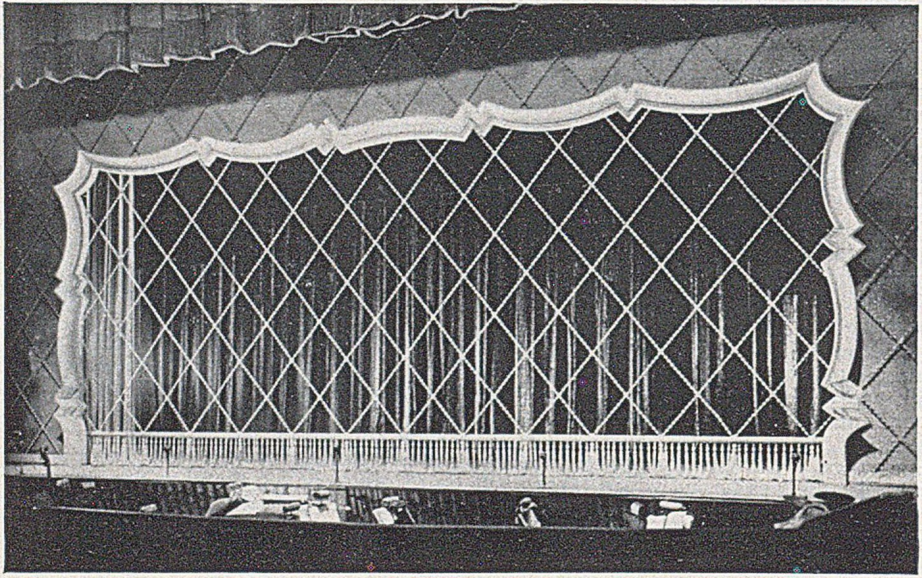
General, Technical and Commercial

Oil Pipe Lines

A REPORT from America indicates that as a result of the shortage of steel the Reynolds Metal Company is co-operating with some of the oil companies in the U.S. to develop an aluminium pipe for the transportation of oil, natural gas and gasolene. One project, apparently, is for a 10-in. pipeline in Argentina, 1,000 miles long. Also under consideration are pipelines in the Far East.

Milk Bottles

ANOTHER new development attributed to the Reynolds Metal Company of America is an aluminium milk bottle. This is intended as an improvement on the wax-paper type of container and, like it, will be used only once. No details regarding design or metal-substance are given, but a simple fold-over-type foil "can" is visualized as the most likely form.



A.D.A. Welding Research

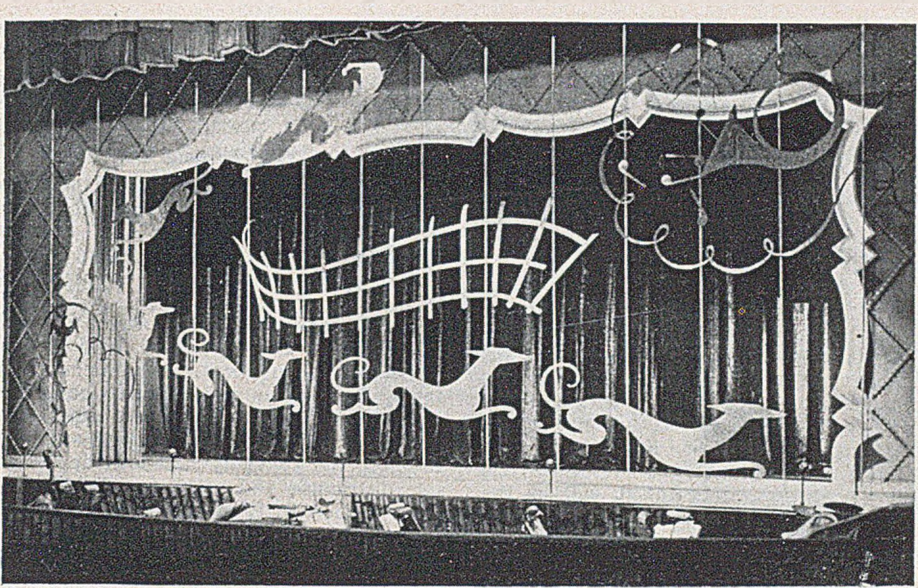
RESEARCH work on aluminium, which has been in progress at Birmingham University for 2½ years, has now been presented in summarized form in Research Report No. 1, published by the Aluminium Development Association.

This publication refers to the work of the welding research team, originated by the Wrought Light Alloys Association and now sponsored by A.D.A. The work was commenced under the supervision of Professor D. Hanson with Dr. A. R. E. Singer as the first leader of the team, and is now proceeding under the supervision of Professor L. Aitchison. Dr. Singer has been succeeded by W. I. Pumphrey, M.Sc.

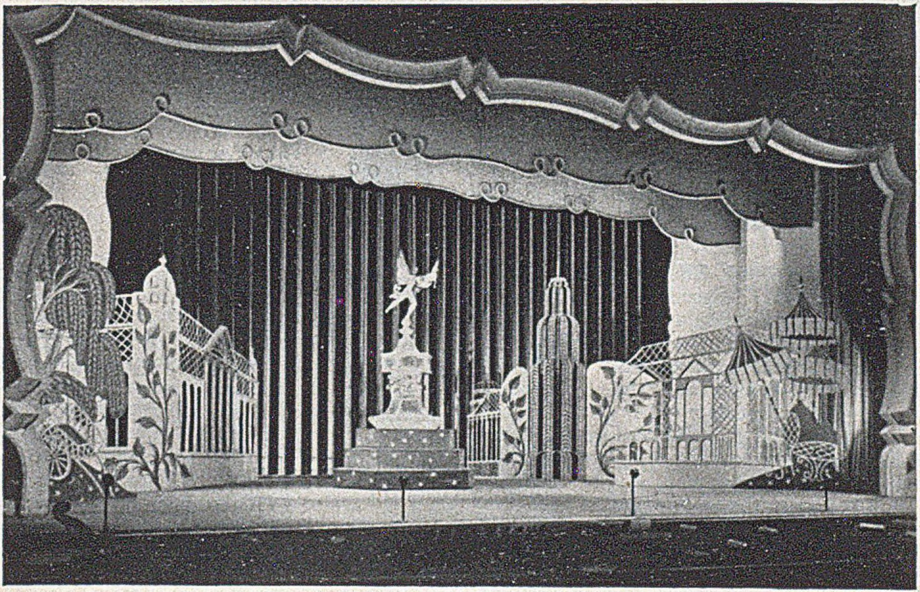
Ten separate and individual reports are summarized and cover, in general, the properties of various aluminium alloys at elevated temperatures and correlate the various researches, indicating their importance in the general plan of research in this field. Some of the work referred to has appeared earlier in Technical Memoranda, Welding Research Reports, and has also appeared in the Journal of the Institute of Metals under the following titles:—

(1) Properties of the Aluminium-Silicon Alloys at Temperatures in the Region of Solidus. (A. R. E. Singer and S. A. Cottrell.)

(2) Hot-Shortness of the Aluminium-Silicon Alloys of Commercial Purity. (A. R. E. Singer and P. H. Jennings.)



THE presentation of "Piccadilly Hayride" at the Prince of Wales Theatre, London, was notable for the extensive use made of aluminium in the decor by Alec Shanks and executed by J. Starkie Gardner, Ltd., London. Pictured above is the "Hunting Curtain," constructed in light metal, with vertical members consisting of ¾-in. diameter 14-gauge natural finish tube. Applied cut-outs are in ⅛-in. thick aluminium, spray coloured in copper and gold. Below is a production number—"The Piccadilly Scene." Aluminium is used throughout; the back cloth is built up with reversible louvres formed out of 18-gauge sheet, fixed to vertical supporting tubes 1-in. diameter 16-gauge; the scenery is constructed in aluminium sheet, pierced, and reinforced where necessary, the scenic effects comprise table, sun-shade, trees, cart, lamp-posts and "Eros" on pedestal. The illustration on the preceding page shows the all-aluminium proscenium arch and proscenium curtain. The lattice grille filling is in 1-in. by ⅛-in. twisted aluminium with 2-in. diamond rosettes at interception.



(3) Hot-Shortness of Some Aluminium-Iron-Silicon Alloys of High Purity. (A. R. E. Singer and P. H. Jennings.)

An appendix is devoted to a subject of considerable importance and interest. Some confusion has arisen in the past—as was indicated during the discussion of the three papers mentioned at a meeting of The Institute of Metals, on the use of such terms as "hot-shortness." Three terms used in the text of the present report, namely, hot-shortness, hot-short composition range and hot-short temperature range, are defined in the appendix to avoid any further misunderstanding.

The report itself is very well produced and presents factual matter in a concise form. The graphs and diagrams are reproduced sufficiently large to permit detailed investigation and thorough understanding of the facts presented. This, it is hoped, will be the forerunner of a series of publications, presenting concisely, for the benefit of the industrialist, the results of current research.

"Little Black Book" Revised

THE booklet, "Specifications for Aluminium and Aluminium Alloy Products," published by the Northern Aluminium Co., Ltd., first appeared in October, 1940, and became well known as "the little black book." Since that date it has been reissued several times and by 1945 was out of print. It has now reappeared, completely revised and brought up to date.

In addition to the usual index of specifications (BS/STA7 Schedule, British Standard and D.T.D.) pages are devoted to proprietary names with an idex thereto, and suppliers. The main part of the book contains detailed specifications.

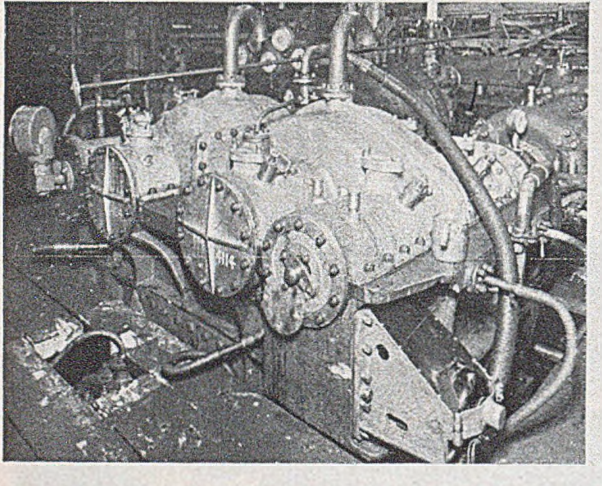
Copies are available on application to Northern Aluminium Co., Ltd., Banbury, Oxon.

Indian Wild-Barfield Co., Ltd.

FOR many years, the interests of the above company in India have been in the hands of Alfred Herbert (India), Ltd., and, the formation of the Indian Wild-Barfield Co., Ltd., supplements rather than supplants the long co-operation.

The company has been formed to cover sales and service of standard Wild-Barfield furnaces and equipment in the dominions of India and Pakistan and adjoining countries, and to carry out assembly and other constructional work as occasions demand. In addition, the company has been appointed sole distributor and agent for the productions of G.W.B. Electric Furnaces, Ltd.

The local management is under the control of R. A. P. Misra, who has recently returned to India after a prolonged stay in England, during which he gained a thorough knowledge of the design, construction and practical uses of Wild-Barfield furnaces. The address of the company is Fort Chambers, 6-10, Dean Lane, Hammam Street, Fort, Bombay.



MASSIVE aluminium-alloy cover for a double reduction marine engine gearbox for a French liner under construction by John I. Thornycroft and Co., Ltd. at Woolston, Southampton. The cover is cast in D.T.D. 424 in Thornycroft's own foundry.

Magnesium News—Chairs

RECENTLY placed in service on the Chicago, Milwaukee, St. Paul and Pacific Railroad's streamlined trains were several hundred new dining-car chairs constructed from the lightest structural metal—magnesium. Developed in co-operation with The Dow Chemical Company, these chairs are of welded tubular construction and have a baked enamel bronze finish.

They are so light that four of them weigh approximately the same as one traditional dining-car chair. A comparison between the difference in weights of various types of chair frame is: wood or steel, 13 lb.; magnesium, 3 lb.

Reasons for adopting magnesium dining car chairs, in addition to weight saving, included a reasonable production cost and, on estimate, cheaper maintenance. Although they have been in use a comparatively short time, the chairs have proved extremely satisfactory, and are expected to give good service here and in other trains.

THE passenger coach and the dining car on the U.S.A. railways maintain a friendly family atmosphere, surprisingly absent from their English counterparts. The introduction of modern materials and designs in no wise disturbs this effect ; we welcome, therefore, the appearance of these welded tubular ultra-light alloy chairs—forerunners, we hope, of a long and successful line of magnesium furniture.

Materials Handling Show

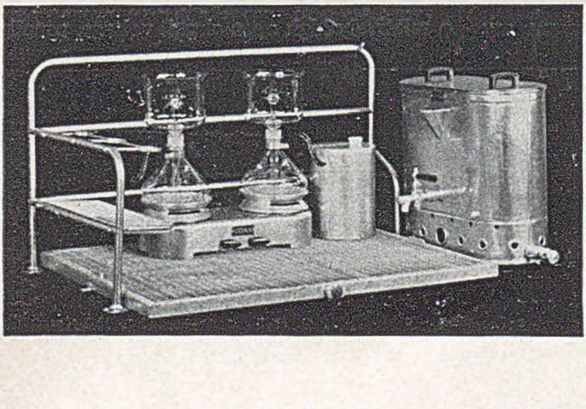
MODELS demonstrating the advantages of magnesium over steel as a structural metal for materials handling equipment were displayed at the annual Materials Handling Show held at the Civic Auditorium, Cleveland, from January 12 to January 16.

Light in weight, strong and rigid, magnesium is a metal with many future possibilities, as was indicated by models of experimental as well as tested products exhibited by Magline, Incorporated, of Pinconning, Michigan, and the Magnesium Company of America, of Chicago, Illinois.

Hand trucks of sturdy construction, capable of accommodating heavy loads but in themselves light weight, permit increased pay-loads, whilst magnesium dockboards weigh only a fraction as much as corresponding sizes in steel, yet can be moved and placed with less labour and increased safety to worker. Both the Magnesium Co. of America and Magline Inc. showed models.

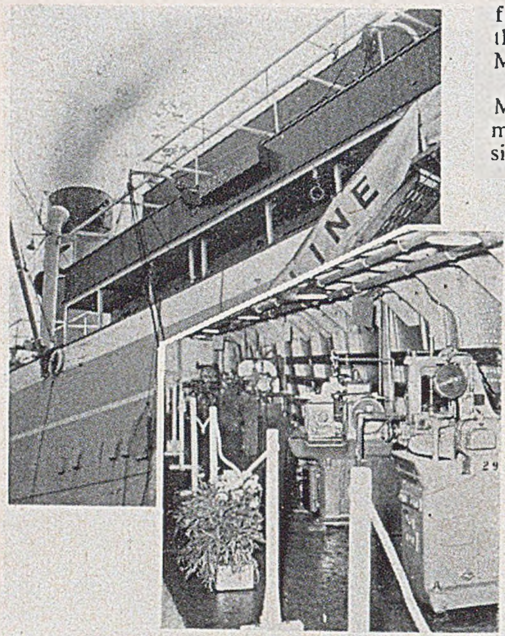
Also shown by the Magnesium Co. was a new range of barrel skids and several models of grain shovels, where the light weight and rigidity of magnesium was an outstanding feature in both applications.

The flexible design characteristics of magnesium were ably illustrated by a barrel truck of welded tubular construction exhibited by Magline Inc., who also had on view a can fork constructed of extruded magnesium tubing.



AT the left is the "Conabar" coffee percolater exhibited at the Hotel, Restaurant and Catering Exhibition. The machine is gas operated and the stands upon which the glass vessels rest are of cast aluminium.

(Courtesy British Gas Council.)



At the left: the M.V. St. Merriel just returned from South America after her successful exhibition tour. Inset, a view of the exhibition.

St. Merriel Returns

On September 10, 1947, the M.V. St. Merriel sailed for ports in South America with an exhibition on board organized conjointly by E. H. Jones (Machine Tools), Ltd., and the South America Saint Line. She has now returned to this country after a highly successful journey.

A dinner was held on board the ship on January 8, 1948, to celebrate the return. G. C. Hibbert, general manager and director of E. H. Jones, whilst speaking about the results of the exhibition, said:

" This exhibition has proved that we could be firm business friends with our South American visitors—were it not for politicians! "

He went on to say that a constant cry from Argentine business men at the time of the visit was " when will the British Trade Mission arrive? "

The St. Merriel had shown the British Mercantile Flag, it had shown British machine tools, and both caused great enthusiasm. Amidst applause, he added:

> " I was never more proud to be a Britisher —the Lion still has a kick in his trade legs."

The St. Merriel has returned to London, having sold practically her complete exhibition of machines. In addition a heavy volume of enquiries have been received from the three countries visited, Argentina, Brazil and Uruguay, whilst the reputation of British machine tool and instrument craftsmanship has become firmly established in industrial South America.

She was visited by some 500 invited business men and officials at each of her ports of call.

Calcium Metal

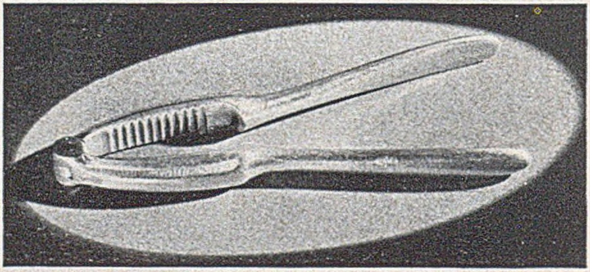
According to a recent announcement, New Metals and Chemicals, Ltd., 16, Northumberland Avenue, London, W.C.2, have been appointed sole distributors for the United Kingdom for calcium metal produced by Dominion Magnesium, Ltd.

Safety Device for A.C. Welding Equipment

An important safety device to protect operators during the changing of electrodes on A.C. transformer-type electric arc-welding machines has been developed by Murex Welding Processes, Ltd.

This type of machine which operates on a relatively high open-circuit voltage, usually

There is a moral in the illustration presented here at the right. Unbelievers have ventured to remark that the light-alloy nutcrackers pictured on page 17 of our January issue were nothing more than an interesting experiment; the particular specimen we now reproduce, however, is in duralumin, was made in Germany in 1928, and has been in constant use ever since.



These attractively coloured milk-bottle caps of aluminium foil were featured at the Dairy Show, Olympia, by Empire Aluminium Co. Ltd., of Glasgow. The art effects are produced by the use of opaque or translucent lacquers.

HENRY FORD DIDN'T LIKE g Henry Ford was the first man to make a light-weight motor-car. He didn't see the use in pushing a lot of unnecessary weight around. He realised that if he could reduce the power of gravity (g for short) he'd be on to a good thing. To-day, if only manufacturers would realise it, we have forged a fine weapon against the power of g—we have a range of light alloys developed by H.D.A. that make for extreme lightness without loss of strength. Next time you have a production problem . . .

. . . make light work of it with **HIGH DUTY ALLOYS**

HIGH DUTY ALLOYS LIMITED, SLOUGH, BUCKS

INGOTS, BILLETS, FORGINGS AND CASTINGS IN 'HIDUMINIUM' ALUMINIUM ALLOYS
(Regd. trade mark)

in the region of 80 to 100 volts, can be dangerous to operators who do not observe the necessity for switching off before changing electrodes. The new device, which is known as the Murex Safety Device for A.C. welding equipment, provides a means whereby the voltage across the electrodes is reduced to a safe figure whilst the machine is not in actual operation without interfering with the operation of the machine.

By means of a timed relay device, within a fraction of a second of the termination of a welding run the voltage is automatically reduced to approximately 30 volts. To commence welding again the electrode is touched to the work in the normal manner, causing an auxiliary circuit to close the relay, restoring full welding voltage and current. The unit is introduced into the secondary circuit of the transformer and is compact and robust. It does not entail separate leads or controls on the machine.

Production of this component has already commenced. It is anticipated by the makers that it will be in demand particularly where work is carried out in the open or on structural work. It is especially useful in confined spaces and can be considered essential where native labour is employed abroad.

Vive l'Export

CHRISTMAS has come and gone and now energies are directed towards ensuring, in the New Year, that prosperity which was so heartily wished from all quarters.

Reminiscent of these good wishes at the turn of the year is the publication "Birlecomedy 1947," received from Birlec, Ltd. This unusual approach to the usual season's greetings is a humorous treatment of the practical advantages of an export trade.

We understand that Birlec, Ltd., wish to send their greetings to anyone who is interested.

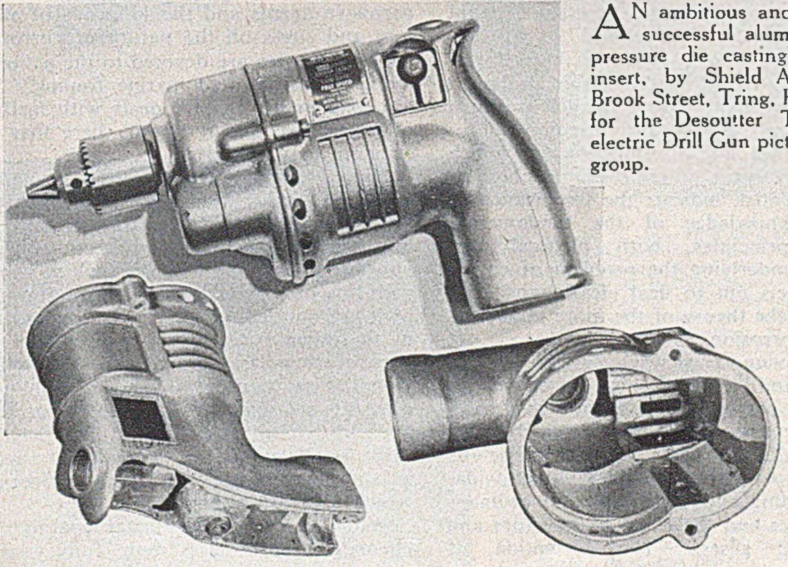
Surface Finishing

WE have received from the Aluminium Development Association their Information Bulletin No. 13, entitled "Surface Finishing of Aluminium and its Alloys." The publication pays due attention to such subjects as cleaning and degreasing processes, emphasizing their importance in any finishing process. The finishing processes proper are divided into four groups—mechanical, chemical, electro-plating and paint finishes. A selected bibliography is given and also two lists of relevant specifications.

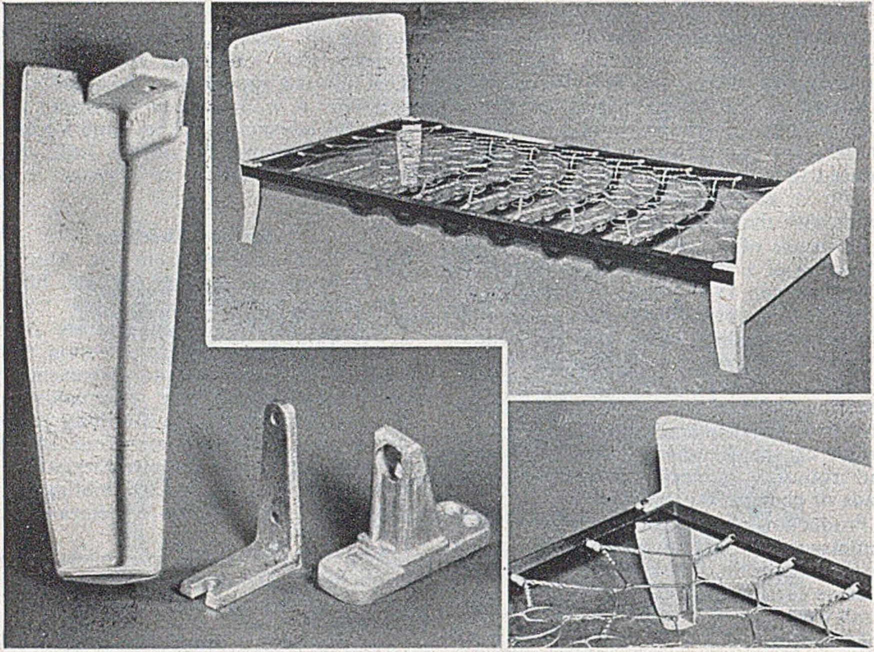
Copies are available on application to the Aluminium Development Association, 33, Grosvenor Street, London, W.1.

"Diamond" Brand Hot-plate Ware

REFERRING to the illustration on page 22 of the January issue of "Light Metals" the London Aluminium Company, Ltd., has pointed out that the "Diamond" brand hot-plate ware was wrongly described as being spun aluminium, whereas it is in fact deep-drawn press work.



AN ambitious and eminently successful aluminium alloy pressure die casting with steel insert, by Shield Alloys Ltd., Brook Street, Tring, Herts. It is for the Desoutter Type "B" electric Drill Gun pictured in the group.



PICTURED in the above group is a bedstead manufactured by Horatio Myer and Co., Ltd., Vauxhall Walk, London, S.E.11, with legs and supporting brackets cast in aluminium alloy by Shield Alloys, Ltd., Brook Street, Tring, Herts. An interesting feature is the curved surface to the foot of the leg; this is designed to protect carpets.

"El Problema de la Corrosion Metalica."
By Emilio Jimeno. Pp. 237. Madrid. Ministerio de Marino. Instito Espanol de Oceanographia. 1947.

THE reader who is aware of the unfortunate dearth of authoritative technical books in the Spanish language will welcome Prof. Jimeno's treatise on corrosion.

The preface and introduction, in which the author shows himself philosopher as well as scientist, indicate the importance of a sound knowledge of the fundamental scientific principles, both physical and chemical, underlying the problem of corrosion and sets out to deal clearly and concisely with the theory of the more important types of corrosion.

After giving a general survey of the problem and a brief history of earlier theories of corrosion, the author goes carefully into chemical and electro-chemical attack, dwelling at some length on bimetalic corrosion. Attention is given to direct oxidation, including action at high and ordinary temperatures and the effect of moisture and atmospheric gases. The formation of natural and inhibitor-produced films is covered and the author goes on to treat corrosive agents and the influence of structure and stress on the nature of corrosion.

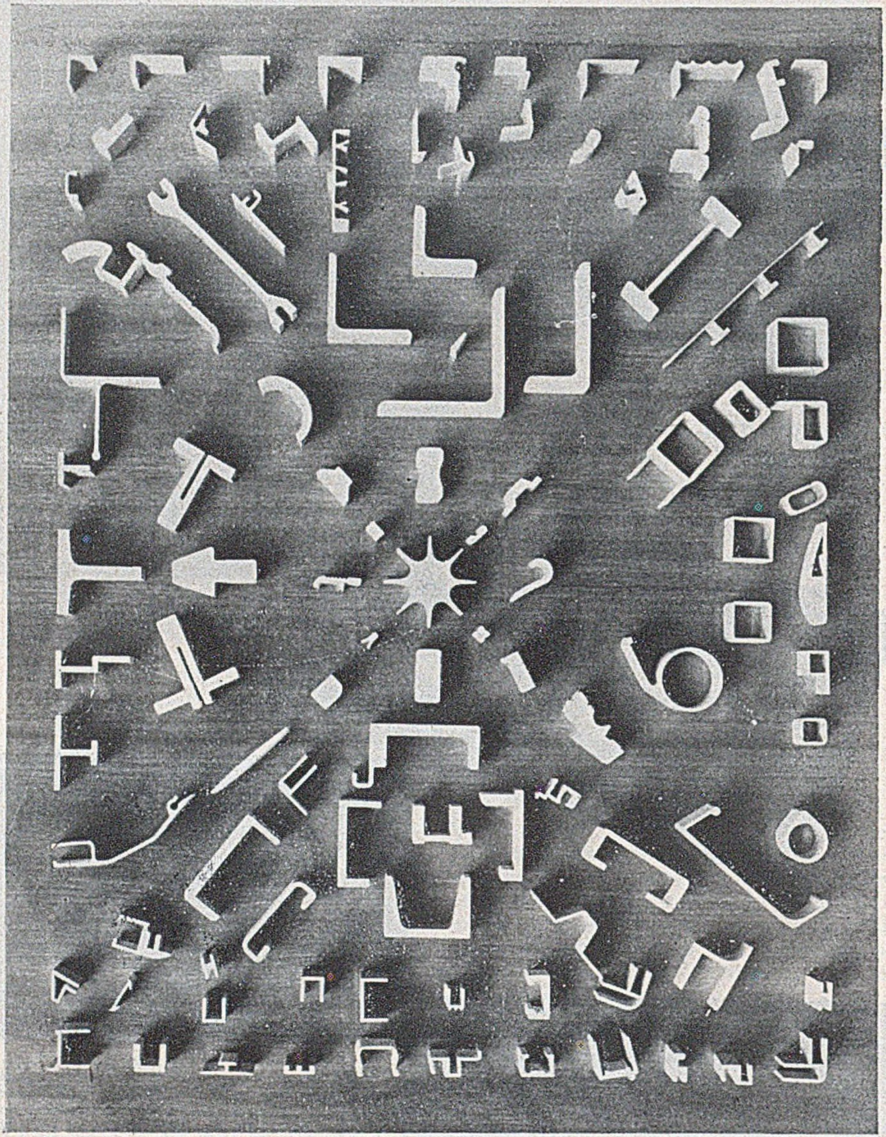
Several pages are devoted to the action of living organisms and marine fouling. The last and largest chapter deals with methods of protection, and it is only here that any criticism may be raised.

Only three pages are devoted to protection by paints, and it seems unfortunate that so little space is conceded to the cheapest and most widely used form of protection. Probably because the author has dealt so shortly with this subject, wide and important aspects of it are omitted, and the over-condensation of the other material will undoubtedly give rise to misunderstanding. For example, it is not wise to class together as inhibitory pigments red lead, zinc chromate, zinc oxide and lead chromate without reference to their specific properties in relation to appropriate binders and the metal surfaces to which they are applied.

While protection by metal coatings and chemical treatments is more fully covered.

Overseas Press visits Redditch

ON January 14 some 40 of the leading industrial correspondents of the Overseas Press, visiting a number of companies in the Hawker-Siddeley group, made a tour of the Redditch factory of High Duty Alloys, Ltd. Pictured on this page are some of those who participated in this event. Left to right : (1) D. C. Embley, publicity officer, H.D.A. ; H. G. Herrington, managing director, H.D.A. ; Lucjan Blit, "Robotnik," Warsaw. (2) C. A. G. Hicks, Hawker-Siddeley Sales Co-ordination Department ; H. G. Herrington ; Miss Robertson and L. W. Robertson, Sir W. G. Armstrong Whitworth Aircraft Ltd. (3) J. A. May, "Christian Science Monitor" ; Mrs. C. B. Hallstroem, "Svenska Morgonbladet," Stockholm ; Mrs. W. MacGowan, "New York Sun" ; Miss G. F. Szabo, "Uj Magyaroszag," Budapest ; Miss C. J. Aubrey, H.D.A. (4) D. C. Embley ; G. A. Hunt, commercial manager, H.D.A. ; Mrs. W. MacGowan, "New York Sun." (5) S. Cotton, press officer, M.O.S. ; W. Savage, B.O.T. ; M. Scanlon, H.D.A. ; I. H. Buchi, "Hindustan Times."



ARRANGED and executed by J. Starkie Gardner, Ltd. the display panel shown here demonstrates the range of extruded magnesium-base alloy sections manufactured as production lines by The White Metal Rolling and Stamping Corporation Brooklyn, New York. Section thicknesses range from $\frac{3}{64}$ in. to $\frac{1}{2}$ in. and section dimensions up to an equivalent containing circle of 5 ins. diameter. It will be noticed that the range of shapes in no way falls short of that representative for aluminium-alloy extrusions, and that, equally, for complexity of form and variety of section, there is nothing to choose between the possibilities offered by either material. Contrary to certain difficulties experienced in sheet-rolling practice for the ultra-light alloys, most magnesium-base alloys extrude very readily.

the author has tried to embrace too many types of process rather than stress the better and more frequently used ones. It is disappointing to find only a few pages devoted to light metals, and in view of the considerable work done recently on the electroplating of aluminium, one is surprised to find reference to one rather obscure electrolyte containing zinc sulphate and β-naphthol.

The book is well documented with 152 references and contains a short bibliography. There is a fairly full and accurate index.

Foundryman's Compendium

A NEW publication of great interest to all foundrymen is being offered for sale by Foundry Services, Ltd., of Long Acre, Nechells, Birmingham. This "Foseco Foundryman's Compendium" contains a wealth of tabulated data of great value to those engaged in the foundry trade. Produced in a useful size (6¼ ins. by 4¼ ins.), it is recommended as a valuable pocket reference, and is available in two finishes: leather bound, price 7s. 6d., or with board cover, price 5s.

Recent Intelligence

THE following announcements have been received:—

British Aluminium Co., Ltd., The Midland Warehouse at 17-18, Providence Street, Cradley Heath, Staffs, is now in full operation. (Tel., Cradley Heath 6881.) The Midland branch office remains at Lansdowne House, 41, Water Street, Birmingham, 3. (Tel., Central 3053; Telegrams: "Britalumin, Birmingham.")

The publicity and sales research department of the British Aluminium Co., Ltd., has been reorganized on the retirement of H. Cousins, publicity manager. He retired at the end of January, 1948, at his own request, after completing 40 years' service with the Company.

As a consequence, the publicity department has been combined with the present sales research and statistical section under C. G. McAuliffe, as manager. The new department is known as Publicity and Sales Research Department and commenced operation on January 1, 1948. E. G. Fielding, responsible for the publicity work of the department, has the title of publicity officer.

ATTRACTIVE double pedestal aluminium desk, with stove-enamelled ripple finish in olive green or black. The top is specially treated to provide a smooth and durable surface. (Courtesy Nu-Bilt Typewriters Ltd., 25-27, Southampton Row, London, W.C.1.)

Aluminium for Export

WE wish to make a correction with regard to an item in our January issue under the above heading, in which it was stated that Messrs. Calum Grant and Partners, Ltd., Macmerry, had received a contract of £160,000 worth of light-alloy equipment for postal and railway services in South Africa. It has been drawn to our attention by Alloy Developments (Lothians), Ltd., that they hold this contract direct from the Union of South Africa and that Messrs. Calum Grant and Partners, Ltd., are engaged as sub-contractors fabricating part of this contract.

Aero Research, Ltd.

WE are informed that Aero Research, Ltd., Duxford, Cambridge, which has for some years held the rights of manufacture from Ciba, Ltd., of melamine-formaldehyde resins for adhesives and the like, has now concluded arrangements with Ciba, Ltd., covering a number of novel plastics, including melamine-formaldehyde resins for textiles, wet strength paper and other applications, as well as the new metal-to-metal adhesive and casting resin known as "Araldite" (see "Light Metals," 1946/9/356). An advantage of Araldite lies in the fact that, in application it does not demand the use of pressure for effecting an adequate join. It is thus admirably suited for large-area sheet work and for jointing "on the site."

Light Alloys in
THE INTERNAL-COMBUSTION ENGINE

Continued from "Light Metals," 1948/11/56, this Section of the Account Considers the Application of Light Alloys to Crankcases and Sumps for all Types of Engine and Introduces a Discussion on Light Alloy Bearings

WITH all engines the inevitable bulk of the crankcase makes the application of light alloys to this component of considerable importance from the point of view of reduction of dead weight. In actual fact, light alloy crankcases have been used in enormous numbers of internal-combustion engines, although they are not now so popular in the automobile engine as they were. Let us, therefore, deal with the case of the automobile engine first. Originally such engines employed a one-piece iron casting for crankcase and cylinder block, but, in the interests of reduced weight, a two-piece construction was later employed consisting of an iron block and a light alloy crankcase. Such a construction was employed in the engine of the Rolls-Royce Phantom III, where the crankcase was cast in RR 50 and weighed 130 lb. when machined and in the 3½-litre and 4.3-litre Alvis engines, where the crankcases were in L.5. The difficulties associated with the use of studs in light alloy construction were by-passed by the employment of through bolts. The Alvis engines, e.g., employed through bolts of alloy steel, which passed through the crankcase from the main bearing caps up to the top surface. Collars on the bolts fitted recesses in this surface, and an upward prolongation was used to pass through the cylinder block flange and to carry an holding-down nut. The success of the plan was first established by the famous Alvis Speed Twenty power unit, and caused it to be used for the more recent 3½-litre and 4.3-litre engines. The 12-cylinder Hispano-Suiza engine, which was a V-type unit developing 220 b.h.p. from a total cylinder capacity of 9.4 litres, employed an aluminium alloy crankcase in conjunction with a light metal cylinder block fitted with wet iron liners.

Naturally the use of an aluminium crankcase, carrying an iron block with integral bores, is more costly than the one-piece iron casting so widely used, but there are numerous advantages and the true difference in price is probably much less than is often supposed. Apart from a valuable reduction in weight, the aluminium crankcase is kinder to the bearings, because it permits a readier conduction and dissipation of heat. Consequently it is widely used in sports cars, where good performance and the ability to withstand hard driving are essential. In small cars the most famous example is, of course, the Austin Seven.

In considering the cost of aluminium construction, in addition to the high cost of light alloy per lb. in comparison with cast iron, one must also bear in mind the smaller quantity of light alloy required in view of its lower density and economies due to its ease of machining and handling. In illustration of this we quote an example taken from a booklet published by the British Aluminium Co. in 1938 and which, therefore, refers to economic conditions ruling a year or two before that.

Some years ago Mr. L. H. Pomeroy designed two well-known engines in which an aluminium crankcase was used in conjunction with a single iron casting comprising a cylinder block with integral head. As compared with previous engines of equivalent size and type, the cost involved by this change worked out as follows:—

Iron crankcase: Weight, 90 lb.; cost of casting (at 4d. per lb.), £1 10s.; machining cost, including 200 per cent. overheads, £2 5s.; total cost, £3 15s.

Aluminium crankcase: Weight, 45 lb.; cost of casting (at 1s. 4d. per lb.), £3; machining cost, including 200 per cent. overheads, £1 2s. 6d.; total cost, £4 2s. 6d.

This interesting example shows how a ratio in basic cost per lb. of 4 to 1 is reduced, in the final prices of the two articles, to a ratio of about 1.1 to 1. This is not a big sacrifice to make for a saving in weight of about 50 per cent. It must be added that to obtain the full advantage of the machinability of aluminium necessitates a suitable plant capable of providing speeds and feeds suited to this material. To bring the above figures into line with present-day conditions, one must increase the price of cast iron and multiply the machining costs in both cases by a factor of around 1.4; the cost of casting the aluminium alloy will show a smaller pro rata increase. The effect of these adjustments is to make the increased cost of this particular aluminium crankcase over the iron component smaller than ever, probably even a negative quantity.

However, this method of construction has been found to possess certain disadvantages, notably a lack of stiffness due not to the use of light metal, but solely to the two-piece construction. The tendency has been, therefore, to develop the one-piece combined crankcase and cylinder block and, in the case of the automobile engine, monobloc construction in cast iron has largely displaced the aluminium crankcase.

Diesel Engine Crankcases

In the case of Diesel engines, however, the quest for that efficiency which follows in the wake of light construction has proceeded with greater vigour and more audacity, and the result has been monobloc construction not in cast iron but in aluminium alloy. A number of large cast aluminium crankcase-cylinder block units are illustrated. Naturally the foundry problems involved are not simple, but there are available several aluminium-base alloys which are quite capable of rising to the occasion.

Perhaps the major requirement of a crankcase is stiffness, but in practice the design of a light-alloy Diesel crankcase is really settled in the foundry, since castings of this nature which will run comfortably and soundly into the inevitably extensive and varying mould sections will probably be stiff enough in practically any good alloy. For this reason there is seldom any necessity to employ special high-tensile material, and a " general purpose " alloy will probably do the job and cost less.

Where a combined engine casting is concerned, the casting also does duty as a water jacket, and the upper parts are brought into the region of fairly high temperature changes.

The liners are pressed into the casting and are usually of the wet type. In some instances a light-alloy cylinder sleeve is used in conjunction with a wet or dry liner in cast iron or steel. Apart from reduction in weight, more efficient cooling is obtained, and the composite assembly is said to overcome difficulties due to differential expansion of the iron and the light-alloy piston.

Nevertheless, monobloc construction in Diesel engines is by no means universal and crankcases which are also bedplates carrying the bearings and having a separate cylinder block bolted to them have been produced as light-alloy castings of considerable size. Edwards, Frary and Jeffries in their classic volumes on "The Aluminium Industry" refer to a cast aluminium bedplate weighing 3,800 lb. This must have been produced prior to 1930. Some manufacturers of large engines have given the welded-steel crankcase and cylinder block considerable thought as a means of reducing weight and, in some cases, have either built a few of these engines or built them in production. When very small production is considered, this type of construction sometimes appears most economical, but a satisfactory welded-steel crankcase requires considerable research work, and this same crankcase and cylinder block can be made lighter by using an aluminium casting. Cast-iron crankcases will, no doubt, always be cheaper than aluminium for these parts, but, where lightweight is of importance, the saving in weight made possible by the use of aluminium usually pays very satisfactory dividends.

In redesigning iron crankcases for casting in light alloy, service conditions must be closely analysed and the foundry characteristics of the light alloy to be employed should also be considered. Jackson, in a paper presented at the summer meeting of the Society of Automotive Engineers, June 1-6, 1941, and entitled "Aluminium-alloy Applications for Major Diesel-engine Parts," has examined this aspect in some detail, double horizontal ribs result in better stress distribution, whilst box-sections confer increased rigidity and serve both as manifolds for the lubricant and as engine-supporting flanges.

The Gardner 4LK engine employed a magnesium alloy crankcase and sump in conjunction with aluminium alloy cylinder block and cylinder heads.

It is only natural that considerable interest should have been taken in the possibilities of light alloy crankcases in oil engines designed for aircraft and lighter-than-air craft.

Both Germany and America have developed compression-ignition engines of high power/weight ratio suitable for aircraft. It was, in all probability, the disaster of the R.101 in 1930 which influenced the Zeppelin Aircraft Constructional Works towards the exclusive use of compression-ignition engine propulsion in their commercial dirigibles.

The modern version of the unit is the Mercedes-Benz D.B.602, developing a continuous output of 800-900 b.h.p. with a maximum of 1,200 b.h.p. Light alloys are used extensively in this engine, a special light alloy being employed for the pistons. The crankcase is in silumin gamma cast in one piece, the design incorporating rib stiffeners and transverse partitions. Details of the latest design of this unit have not been fully revealed, but the performance of the airship "Hindenburg" in multiple crossings of both the North and South

Atlantic evidenced that it was a commercially successful proposition.

The Guiberson compression-ignition engine model A-1020 is an outstanding achievement designed for use in aircraft. It is a conventional nine-cylinder, air-cooled radial motor of the four-cycle, two-valve type. Bore and stroke are 5.125 and 5.500 ins. respectively, the capacity being 1,021 cubic ins. Operating at a compression ratio of 15 to 1, the rated power is 320 h.p. at 2,200 r.p.m., with 340 h.p. at 2,250 r.p.m. available for take-off. The specific fuel consumption at full-rated power is 0.38 lb. per h.p. hr. The overall diameter of the engine is 47 ins., the weight being 620 lb. The weight per h.p. ratio is, therefore, 1.96 lb. per rated h.p.

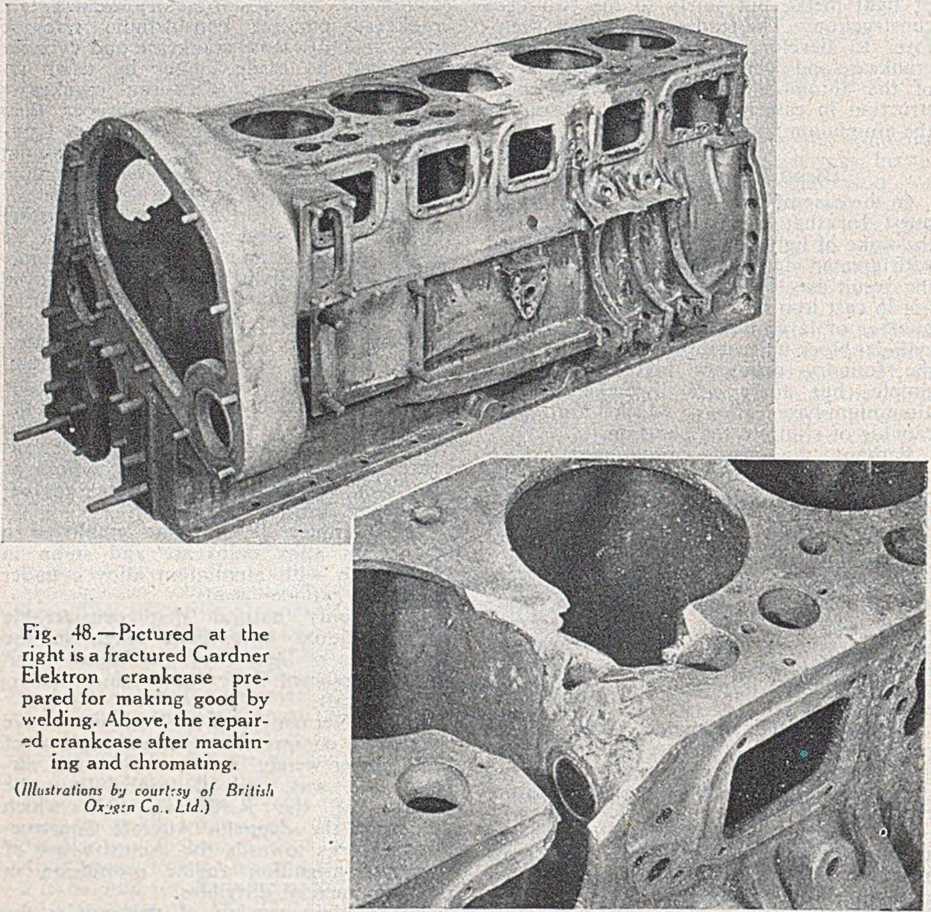


Fig. 48.—Pictured at the right is a fractured Gardner Elektron crankcase prepared for making good by welding. Above, the repaired crankcase after machining and chromating.

(*Illustrations by courtesy of British Oxygen Co., Ltd.*)

The crankcase, in two parts bolted together on a centre line, is of aluminium alloy. It supports the crankshaft in roller bearings of large diameter, with a ball-thrust bearing to take the airscrew loads. The rear of the crankcase contains the valve-tappet guides and the fuel-injection pumps, the latter being located so that they connect with a fuel duct bored in the rear part of the crankcase.

Aluminium crankcases are popular in motorcycle engines and in the engines of motorized bicycles. Good heat conductivity is a desirable attribute, and this component has sometimes been made with a ribbed profile to assist in dissipating heat to the atmosphere. Magnesium alloys have also been used for crankcases and sumps, both as castings and as pressings from sheet metal, and present the advantage of a still greater reduction in weight.

In certain cases, the crankcase has been made further to participate in the cooling system by conducting the heat from the cylinders and cylinder head down to the crankcase by direct contact surfaces at the joints. So far, this interesting example of heat transfer via aluminium surfaces of high heat conductivity has necessitated some accurate machining at the joints, an operation which might possibly be avoided by the use of gaskets of pure aluminium, the softness of which would enable a good seal to be obtained.

As regards the light alloy most suited to the production of crankcases, much depends on the type of engine to which the component is to be fitted. The smaller types demand alloys that flow well in the molten condition to produce sound castings of intricate design and variable section. In larger types of crankcase, the emphasis shifts in the direction of strength and rigidity. Where monobloc construction is employed, the metal is exposed to greatly increased temperature variations around the cylinder bores and to the qualifications of ease of casting and rigidity must be added the possession of an adequate resistance to thermal shock.

For automobile work the stock alloy used to be L5, but this was already becoming obsolescent before the war, and the war has hastened the process. The reasons were, first, the development of something better through research, and, secondly, the need for absorbing masses of duralumin scrap arising through the manufacture and subsequent destruction of an enormous output of 'planes and other munitions of war. Soon after the outbreak of hostilities there came into extensive use the alloy designated D.T.D.424, designed to mop up duralumin scrap and so to release the maximum amount of virgin material for aircraft. This alloy is made up of 75 per cent. duralumin scrap, 20 per cent. virgin aluminium and 5 per cent. silicon, and it seems destined to take the place of many of the older casting alloys of the cheaper class for general purposes in the coming years, even in the unlikely event of the sources of suitable scrap drying up. By former standards it is notably easy to cast either in sand or permanent moulds, has adequate strength for a wide range of uses, and will certainly be cheap. It appears to possess a stability in service not shared by the older alloy L.5.

Stronger alloys, in roughly increasing order of cost, are Birmasil Special (D.T.D. 264) U.T.S. 12 tons per sq. in., 0.1 per cent. proof stress 4.5 tons per sq. in., elongation 2 per cent.; Alpax Beta (D.T.D. 240) U.T.S. 11 tons per sq. in., 0.1 per cent. proof stress 6 tons per sq. in., elongation 1.5 per cent.; RR50 (D.T.D. 133B) and Ceralumin B (D.T.D. 287) U.T.S. 11 tons per sq. in., 0.1 per cent. proof stress 7.5 tons per sq. in., elongation 2.5 per cent. Of these alloys, the first two are used without heat treatment, whilst the last two require a low temperature heat treatment but no quench. Any idea of quenching such a large and complicated component as a crankcase is, of course, quite out of the question.

Two magnesium-base alloys are suitable for this application, D.T.D. 59A and D.T.D. 289, the first alloy being in the as-cast condition, whilst the second specification covers the same alloy in the heat-treated condition; again quenching is not required. The mechanical properties of two typical alloys to these specifications are: Elektron A.8 (D.T.D. 59A) U.T.S. 9 tons per sq. in., 0.1 per cent. proof stress 4 tons per sq. in., elongation 2 per cent.; Magnuminium 181 (D.T.D. 289) U.T.S. 13 tons per sq. in., 0.1 per cent. proof stress 4.5 tons per sq. in., elongation 6 per cent. (Mechanical properties quoted here were current at the time of writing; figures should be confirmed by reference to the latest specifications.)

Sumps

In many types of vehicle the attainment of continuous high speeds leads to the problem of how to dissipate heat rapidly from the hard-worked bearings. The use of an aluminium crankcase is a help, as already mentioned, but the provision of an efficient oil-cooling unit is equally important. This has been widely recognized and many makers now fit aluminium sumps of large capacity with external fans to assist in heat conduction. The Rolls-Royce and Bentley units and the 2½- and 3½-litre SS engines are good examples in which these large, finned. aluminium sumps are fitted. Even Diesel engine sumps often incorporate thin external fins to assist in cooling the lubricating oil. Ordinarily they are not called upon to withstand great stress except where the sump is specially designed to take part of the crankcase stresses. Nevertheless, they can account for a lot of weight and they are quite commonly made of aluminium, or even magnesium alloy, not only for greater cooling effects but also for lightness, ease of handling, and appearance.

Alloy requirements for these are not usually critical. Where the sections are very thin or where deep, fine finning is called for, the aluminium-silicon range of alloys are most suitable. In other cases, D.T.D. 424 or another of the general-purpose light alloys will be found quite suitable. Where sea-water spray may be encountered, D.T.D. 165 (Birmabright: 3.0 – 6.0 per cent. Mg, 0.25 – 0.75 per cent. Mn, remainder Al) cannot be bettered and where the minimum weight is required, magnesium-base alloys are ideal (D.T.D. 59A or 289). Where the sump is designed to take part of the crankcase stresses, one of the alloys recommended for the casting of crankcases (Birmasil Special, Alpax Beta, R.R.50 or Ceralumin B) should be employed.

In marine engines, light alloy sumps require protection from the effects of bilge water. The question is an important one, but it is not limited to the use of light alloys and applies equally to cast iron. The latter is usually painted; bitumastic paints are preferred, and a good bitumastic paint will go a long way towards protecting an aluminium-alloy sump. Sumps of the dimensions required for marine diesels are generally cast in aluminium-silicon alloy, which is fairly resistant to corrosion; alloys from the aluminium-magnesium series (Birmabright) are even less affected by sea-water and are satisfactory for the purpose in other characteristics. In the extreme cases, the light alloy sump should be anodized and then painted with bitumastic paint, this combination affording complete protection.

Bearings

Whilst a few matters relating to the employment of light alloy bearings still remain to be settled, sufficient evidence is now available to show that certain aluminium alloys can give reliable and highly satisfactory performance as bearing metals. They have high loading capacity, are relatively insensitive to load variations, and are readily run in (if necessary). They have high heat conductivity, are light in weight, are readily machined, show good wear-resistance properties, and are not affected by heat developed in running. In the Cross engine previously described, the rotary valve, which is made of nitralloy steel, runs directly in a split housing of aluminium (" Y " alloy). A novel device is fitted to control the maximum load and bearing pressure.

Messrs. Laystall have achieved considerable success in racing engines using light alloy connecting rods running directly on a nitrided steel crankpin. The 12-cylinder Lagonda engine already described uses the same plan, and, so far as is known, has proved completely satisfactory. Moreover, satisfactory results have been obtained for some time with case-hardened steel gudgeon pins running in aluminium piston boxes, and it seems that the only prerequisite for satisfactory service is that the steel must be extremely hard. The principle of casting the crankshaft in an alloy iron, as pioneered by Henry Ford, is likely to be more widely adopted and gives ample opportunity for the development of a hard surface by chilling, or, better still, by nitriding.

Special aluminium alloys containing tin have actually been used as bearing metals for some time. The 25 h.p. Rolls-Royce and the Bentley engines have made considerable use of an alloy containing 90 per cent. aluminium, remainder tin, antimony, manganese and silicon. They operate against an Ni/Cr steel crankshaft heat-treated to a Brinell hardness of 302. In a test of coefficient of friction these bearings showed a marked advantage over white metal and lead-bronze; the tests were taken up to a speed of 2,800 r.p.m. and a pressure of 2,400 lb. per sq. in.

Before proceeding further with the subject of aluminium-base bearings, it is helpful to consider briefly the requirements and functions of a satisfactory bearing metal. There are, fundamentally, two distinct types of bearings. In one type the bearings are always lightly loaded, or of low temperature or low speed of operation, or simple rotary motion is transmitted, i.e., there is no reciprocation or inertia loading, or combinations of these. In such cases, conditions are not severe and bushes are inserted for ease of replacement when wear has occurred. In the other type high loads, high speeds, reciprocation, temperature, and corrosion effects come into play either singly or together and the requirements of a suitable bearing metal become much more stringent.

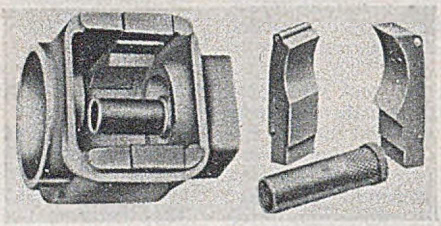


Fig. 49.—Magneto body produced by pressure-die casting in aluminium alloy, with the laminated steel pole-pieces and the bronze bush cast in to ensure permanent rigidity and alignment.

One of the most important characteristics of a successful bearing metal is its ability to carry over metal-to-metal contacts. Actually, in a well-designed bearing operating under conditions of ample lubrication, metal-to-metal contact is largely replaced by a state of full fluid lubrication so long as the shaft is running at a steady and sufficiently high speed, since rotation produces a wedging action of the oil, which causes the shaft to rotate eccentrically; regions of varying oil pressure are set up. This can be beautifully illustrated by a simple experiment,[16] to be described in the next section of this account, which will appear in the April issue of " Light Metals."

(To be continued)

ARC WELDING of Aluminium and its Alloys

by A. Schärer,
Dipl.-Ing.-Chem. E.T.H.

Doctorate Thesis based on experimental work carried out between 1942-1944 in the Research Laboratories of The Aluminium Industrie-A.G. Neuhausen (Switzerland) under the guidance of Prof. Dr. A. von Zeerleder. Werkzeug-Maschinenfabrik Buhrle & Co. (Abteilung Elektrodenfabrik) gave valuable assistance.

THE oldest welding process for steel and aluminium is forge welding, which is still being used as a commercial process. Parts to be joined are bevelled near the welding point and heated in a forge almost to the melting point of the metal; subsequently, they are united on an anvil by hammer blows (either by hand or power hammers). This system is, however, not always very practical, as the weld area must be accessible from both sides. In addition, unavoidable oxide inclusions in the welding seam are detrimental to the quality of the joint and its use is rather limited.

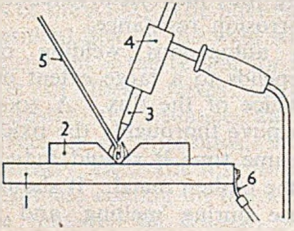
The production of pure oxygen by electrolysis more than 50 years ago and the manufacture of oxygen by fractional distillation of liquid air caused the rapid development of autogenous welding. Initially oxy-coal gas was used, but this was gradually superseded by oxy-acetylene.

Bernardos obtained a German patent in 1885 for an electrical welding process using a carbon arc for generating the heat required for welding, while additional metal was added in the form of a bare wire (Fig. 1). This process was superseded by metallic arc welding introduced by Slavianoff, who took out a patent in 1892; in this case the electrode itself supplies the weld metal (Fig. 2). An arc is struck between electrode and work piece. Generation of heat by the arc and melting of the electrode are inter-dependent.

Gas-electric welding (Arcatom process) has been in use for light metals since 1926 and its use is steadily increasing. Resistance welding of steel started at the beginning of this century; resistance welding of aluminium, however, made progress only in the past 10 or 15 years; developments in this field were pushed ahead during the war by industries using light metals. The different types of resistance welding are the following:—Butt welding, spot welding, seam welding and the so-called Weibel process.

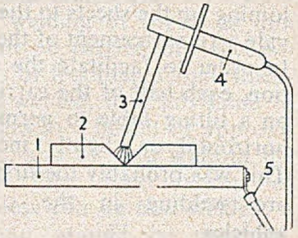
Autogenous welding of steel was

Fig. 1.—The Bernardos Process (1885). An electrical process with heat generated by a carbon arc and metal added from a bare wire.



1. Work table.
2. Workpiece.
3. Carbon electrode.
4. Electrode holder.
5. Filler rod.
6. Connector.

Fig. 2.—The Slavianoff Process (1892). Weld metal is supplied by the electrode itself. An arc is struck between the electrode and workpiece.



1. Work table.
2. Workpiece.
3. Bare wire electrode.
4. Electrode holder.
5. Connector.

already widely used in competition with riveting when electric arc welding was introduced as a fabrication method just prior to the 1914-1918 War. Gas welding of aluminium was taken up roughly at the same time. Its success was due to the invention of oxide-removing fluxes.

M. U. Schoop and P. Odam[1] are connected with the invention of these fluxes. The first patent was taken out in Switzerland by Schoop in 1907 (Swiss Patent No. 41457), and this date marks the beginning of aluminium welding, a method which gradually replaced riveting as a manufacturing technique.

Attempts to weld aluminium electrically by means of a bare wire were not successful in spite of painting the weld area with oxide-removing fluxes. According to Gröbler[8] arc welding of aluminium was first attempted in 1928 with coated electrodes. The Atelier de Machines d'Helemmes des Chemins de Fer du Nord used arc welding of aluminium in 1934 for the fabrication of the chassis of a three-part suburban train. The whole carriage, except the bogie and the supporting struts, which were made from special steel, was constructed from Al-Mg 7 alloy. The Al-Mg 7 used had the following mechanical properties:—

Yield point :	18 kg/mm^2
Tensile strength :	36 kg/mm^2
Elongation :	18-22%

Special backing bars were used for joining up the sheets to the girders to provide a reinforcement of the welding seam. In order to facilitate the welding operation, each half of the carriage was placed on a tilting table to permit welding in a horizontal or slightly inclined position. This was probably the first application of arc welding in the construction of vehicles.

Arc welding of aluminium and its alloys has gained in importance in the past few years and several brands of electrodes are nowadays available commercially.

Arc welding is finding increasing uses, particularly in the construction of vessels for the chemical and allied industries; the repair of castings can very often be carried out only by means of the electric arc.

Gas Welding

(Autogenous welding.) (See Fig. 3.)

The gas-welding process, sometimes also called autogenous welding, is still the most important jointing process for aluminium and its alloys apart from riveting and it is obvious that any other welding process, for instance electric-arc welding, will necessarily be compared to gas welding, to ascertain mechanical properties, speed of welding, temperature, etc. It seems, therefore, appropriate to discuss in detail the gas welding of aluminium.

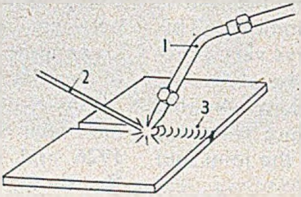


Fig. 3.—The gas welding process. (Autogenous welding.)

1. Torch ; 2. Filler rod ; 3. Workpiece.

The autogenous welding process yields joints which are sound and free from porosity or cracks; this applies not only to aluminium but also to its alloys (cast and wrought). The chemical and physical properties of aluminium are distinctly different from those of steel and this explains the need for modifications in the welding methods used. Fluxes are required, which, in the course of welding, melt and remove the oxide skin from the surface of the metal. Furthermore, they prevent reoxidation of the surface of the molten metal. Filler rods used should be of the same material or, at least, of the same type of alloy as the elements being joined; use of dissimilar welding rods may yield junctions of inferior corrosion resistance.

Success in autogenous welding of aluminium depends to a large extent on the proper choice of the flux. A good flux should remove thoroughly the oxide skin; at the same time it should induce easy flow of the molten metal. It should not decompose during melting, and it should not leave an unmolten residue which would prevent proper flow of the metal. The specific gravity of the flux should be lower than that of molten aluminium to enable the flux to rise to the surface and to prevent flux inclusions in the weld. A further condition for a successful flux is that its melting point should be approximately 50 to 80 degrees C. lower than that of molten aluminium or its respective alloy to be welded. In general, pure aluminium is comparatively easy to weld, whilst magnesium-containing alloys require considerably more skill.

All fluxes for aluminium welding contain chlorides and fluorides of alkalies and alkaline earths and most of them are, therefore, hygroscopic. They are sold in tins which must be kept stoppered to prevent access of air. Any residual flux left on the weld will attract moisture from the atmosphere with the result that the weld becomes corroded. It is, therefore, essential that even traces of flux should be removed once the work piece is sufficiently cold by holding it under a tap or by immersing it in a solution of 10 per cent nitric acid, followed by rinsing in water.

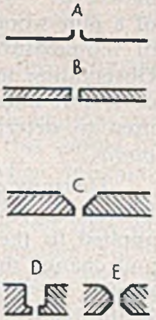


Fig. 4.—Various methods for preparing weld edges. (See column 3 of Table I.)

Due to the position or shape of the welding seam, removal of residual flux is often difficult and sometimes even impossible. In such cases it is recommended to use an insoluble non-hygroscopic flux such as, for instance, Luniweld N of the AIAG. The possibility of leaving residual flux on the weld without causing corrosion is the reason for the increasing use of these fluxes in the electrical industry, for instance, and in the construction of apparatus, in the building industry, etc. The flux forms a glass-like insoluble coating on the weld which may be removed (if desired) by mechanical means, such as hammering, milling or filing. These non-hygroscopic fluxes, however, require more skill of the welder, especially in the case of alloys of the Al-Mg type.

The flux powder should be intimately mixed with distilled water in a glass bottle until it is of the right consistency. It is then painted on the filler rods and the clean edges of the work piece by means of a brush. Oxy-acetylene is used most commonly as the welding gas because of its intense flame (approximately 3,200 degrees C.). The less intense oxy-hydrogen flame (2,400 degrees C.) is seldom used.

The high heat conductivity of aluminium explains why a fair amount of preheating is required; the heat input is the same as for a steel weld of a similar size, assuming equal size of blowpipe. The size of the blowpipe depends not only on the thickness of the material, but also on the size of the object to be welded. It is advisable to select a blowpipe of a slightly larger size than specified to make certain that the welder will not be faced with difficulties.

Table 1.—Data for Gas Welding Aluminium Alloys (see Fig. 4).

Sheet thickness mm.	Dia. of filler rod mm.	Preparation of weld edges	Nozzle dia. of blowpipe mm.
Up to 1 mm.	No. filler rod used	A	0.8
1	2	B	0.8
2	3		1.0
3	3.5		1.2-1.3
3-5 6-12	5 8	C	1.4-1.6 1.8 2.2
Over 12	8	D and E	2.2-2.6

Autogenous welding of sheets as thin as 0.5 mm. can be carried out successfully. If sheets of less than 1 mm. thickness are to be welded, it is advisable to turn up the edges to a height of approximately 2-3 mm. and to weld without the addition of a filler rod. Sheets of 1-3 mm. thickness can be butt-welded; a gap of 1-2 mm. should be provided,

Table 2.—Gas Welding.

Sheet thickness mm.	Welding time in minutes	Acetylene litres	Oxygen litres	Filler rods 800 mm. long	Flux powder in gm.
0.5	4.5	4	3	—	5
1	5	6	5	3–4	7.5
2	6	10	8	3	10
3	8	20	16	2–3	13
4	11	40	35	2–3	15
5	15	70	60	2–3	17
6	20	100	90	2–3	18
8	32	250	200	3–4	21
10	45–50	350	330	4–5	22
15	100	1,000	1,000	9–10	25

Table 3.—Pre-heating and Flame Adjustment for Various Alloys.

Type of alloy	Pre-heating temperature	Flame adjustment
Pure aluminium	400–450° C.	Normal
Aluman (Am)	400–450° C	Normal
Anticorodal (Ac)	400° C.	Normal
Avional (Av)	400° C.	Normal
Peraluman–1, –3,	300–350° C.	Strong flame
–5, –7 (Pe)	—	Steep-angle local heating of weld area

depending on the sheet thickness. For the welding of objects varying in thickness from 3-12 mm. the edges should be bevelled under approximately 30 degrees and a gap of approximately 2 mm. allowed to facilitate penetration.

Aluminium and aluminium alloys should always be welded with a reducing flame, i.e., using an excess of acetylene. Adjustment of the flame can be effected by reducing the oxygen supply until the feather reaches approximately four times the length of the inner bluish cone of the flame. The requirements for welding a seam of 1-metre length are given in Table 2.

Prior to welding, the weld area should be suitably preheated. The same blowpipe used for welding may be employed for this purpose; in the case of heavy-gauge sheets, the use of a multi-flame nozzle and preheating from the back of the sheets is recommended. The blowpipe is moved slowly over the weld area and with a circular motion. It is essential to control the temperature during preheating, as too high a temperature results in sagging-through of the molten material during welding, whilst too low a temperature retards the formation of a molten pool and results in insufficient penetration. The above list of preheating temperatures may serve as a guide for some of the more important alloys.

Temperature Control

The temperature of preheated aluminium sheets can be measured by means of a pointed pine-wood stick, a match, or "Thermindex" colours. Use of a pine-wood stick permits observation of temperatures as given in Table 4. Observation in this way, of the charring of a soft-wood splint, was once widely used to determine light-alloy annealing points.

"Thermindex" colours permit a much better temperature control. They can be applied to the hot surface of the metal and change their colour within a second once a certain temperature is reached. If the colour change takes more than a second, it can be assumed that the tem-

Table 4.—Temperature Measurement using a Pinewood Stick.

Approx. 350° C.	Slow rubbing under considerable pressure ; light brown streaks.
Approx. 400° C.	Rubbing under slight pressure ; brown streaks stay on.
Approx. 450° C.	Slow rubbing ; dark brown streaks. Quick rubbing ; light brown streaks.
Approx. 500° C.	Quick rubbing leaves a black streak which disappears after ½ minute.
Approx. 550° C.	Quick rubbing leaves a black streak which disappears after a few seconds.
Exceeding 550°C.	Quick rubbing leaves a black streak, which disappears almost immediately; stick catches fire.

Table 5.—Temperature Measurement using "Thermindex" Colours.

Temperature °C.	Colour change	
	From	To
75	White	Light Blue
100	Pink	Blue
150	Light Green	Lilac
200	Bluish Green	Black
300	Green	Olive Colour
350	Light Brown	Reddish Brown
450	Pink	Black
510	Light Yellow	Dark Yellow
600	Blue	White

Table 6.—Tensile Strength of Gas-welded Butt-seams (4 mm. sheets)

Parent material	Mechanical properties of parent material			Filler rod	Tensile strength of weld kg./mm.^{2}	Strength of weld in % of the strength of parent material	Fracture occurred
	Proof stress 0.2%	Tensile strength kg./mm.^{2}	Elongation $= 11.3\sqrt{F}$				
Pure aluminium 99.5%, soft	2.5–4.5	7–9	30–40	Al	8–9	100	3–7 cm. away from weld
Peraluman–3, soft ..	10–14	22–26	18–26	Pe–3	20–24	95–100	In the weld
Peraluman–5, soft ..	12–18	27–32	18–28	Pe–5	23–27	90–100	In the weld
Anticorodal B, heat-treated	27–38	32–42	10–14	4 Si (weld not heat-treated)	15–17	45–50	In the weld
Anticorodal B, heat-treated	27–38	32–42	10–14	Ac (weld heat-treated)	25–30	90–95	Next to the weld
Avional M, heat-treated ..	28–34	43–50	16–20	Av (weld not heat-treated)	29–32	60-65	In the weld
Avional M, heat-treated ..	28–34	43–50	16–20	Av (weld heat-treated)	35–44	90–100	In the weld

perature indicated on the label of the pencil is not yet reached and if it takes place instantaneously, it may be regarded as an indication that this temperature has already been exceeded. (See Table 5.)

The structure of the welded seam itself has the same characteristics as a chill casting and the structure of the weld is therefore different from the wrought structure of the sheet material or stamping. It will have lower elongation and lower tensile strength and this should be taken into consideration when designing fabricated parts by placing the welded seam in a position which is less stressed.

In the case of heat-treatable alloys (Anticorodal, Avional, Alufont, etc.) it is possible to counteract softening in the zone adjacent to the weld by subsequent heat treatment and to obtain the same strength in the welded seam as in the parent material.

For those alloys which cannot be heat treated (Aluman, Peraluman, etc.) the strength of the welded seam equals that of the parent material in its soft condition. Where work-hardened materials are used, a softened zone is found adjacent to the weld and runs parallel to it; its width varies according to the speed of welding from 6 to 8 cm.

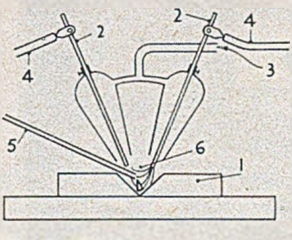


Fig. 5 —The Arcatom process. (Langmuir, 1926.)

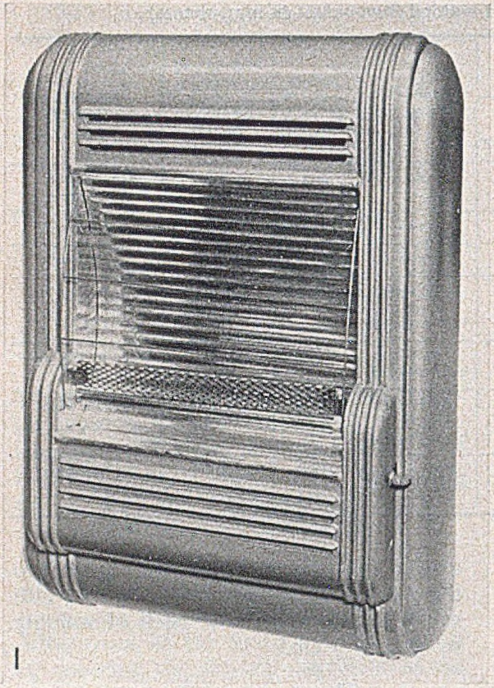
1, workpiece ; 2, tungsten electrodes ; 3, hydrogen supply ; 4, welding cable ; 5, filler rod ; 6, electric arc.

The Arcatom Process

(This process, invented by Langmuir in 1926, is known in this country and in America under the name of atomic hydrogen process; for the arrangement of electrodes, etc., see Fig. 5.)

The atomic hydrogen process is a combination of electric arc and gas welding. An A.C. arc is struck between two tungsten electrodes. The electrode holders are made in the form of annular dies through which molecular hydrogen is fed into the arc. By action of the arc the hydrogen is reduced to its atomic state, a process which consumes heat which is taken away from the arc. At the fringe of the arc, these hydrogen atoms recombine to molecules and a considerable amount of heat is set free, with the result that the temperature at the fringe is increased to approximately 4,000 degrees C.

(To be Continued)



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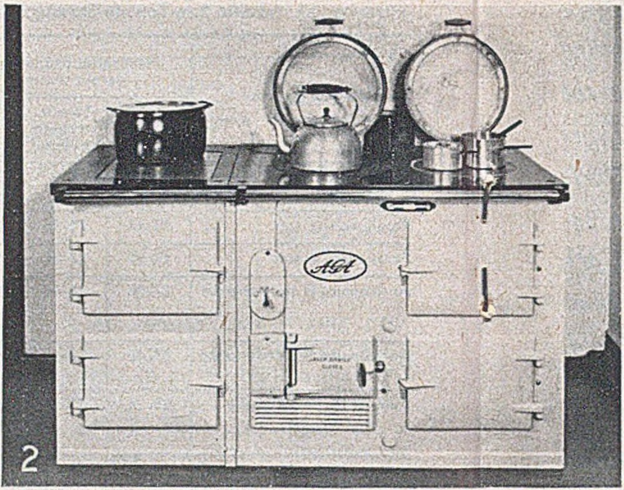

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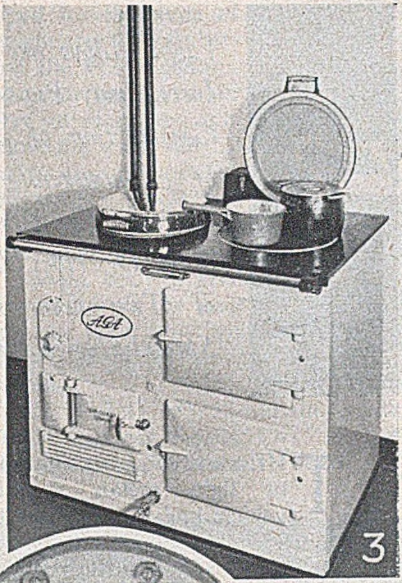

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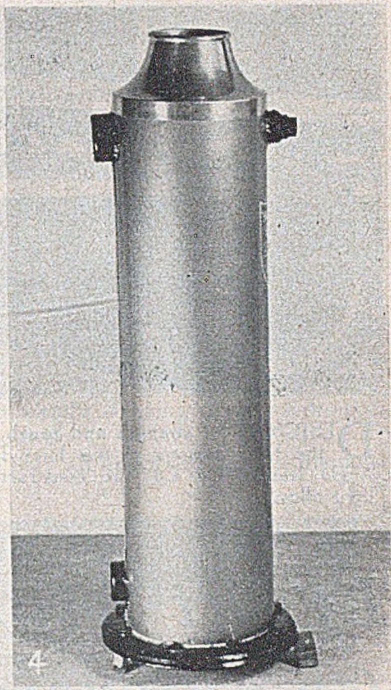

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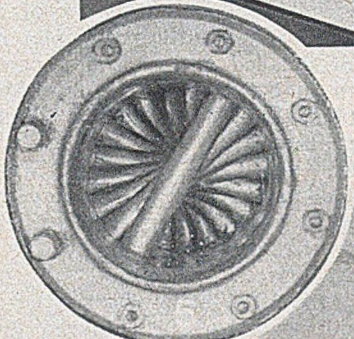
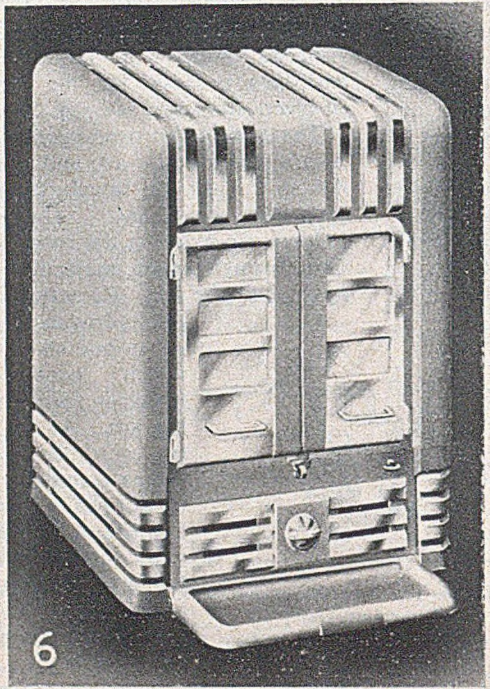
Heating in the Home





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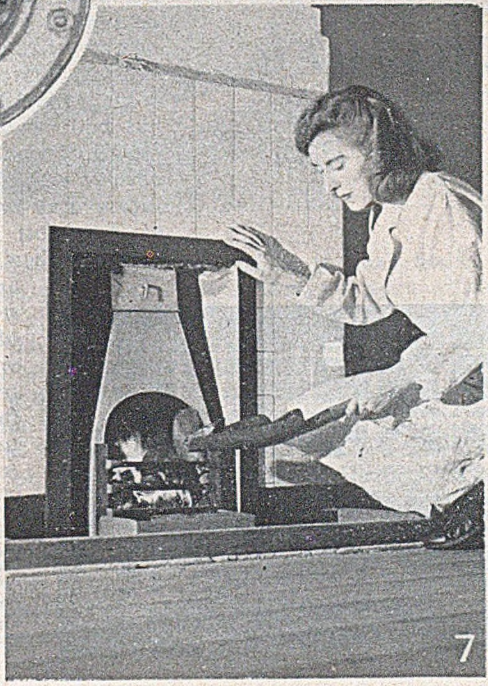
FAMILIAR though we are with the applications of aluminium in electrical apparatus for the home, the extension of its use to gas heated appliances and coal-fired equipment is more recent. Some of the latest developments are pictured on this page.

1.—This panel fire recently introduced at the Building Trades Exhibition is made almost entirely from light alloys. The reflector is polished sheet and the body consists of two castings. (Courtesy, Cowper Penfold and Co., Ltd.) 2 and 3.—These Aga cookers have side and back plates of aluminium. The utensils for use with them are also largely of aluminium. (Courtesy, Aga Heat Ltd.) 4.—A domestic water heater of novel design which has an aluminium casing anodized and coloured in an attractive range of shades. The interior design is illustrated by an end-on view (5). (Courtesy, Halliday Boilers, Ltd.) 6.—The "Alimin" stove has been designed to ensure maximum heating efficiency. The exterior casing is entirely of cast aluminium alloy. (Courtesy, London Warming Co., Ltd.) 7.—The outcome of work by the British Coal Utilisation Research Association, this experimental grate is made of aluminium and reduces coal consumption per hour from 2.5 lb. to 1.4 lb.



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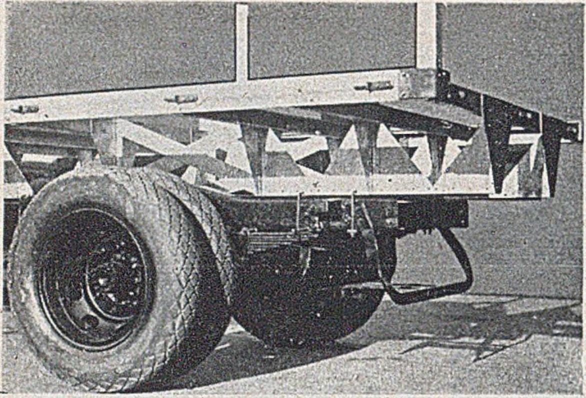


DESIGNED for strength and rough usage, the body bearers of this lorry for the Anglo Iranian Oil Co. are constructed in light alloy.

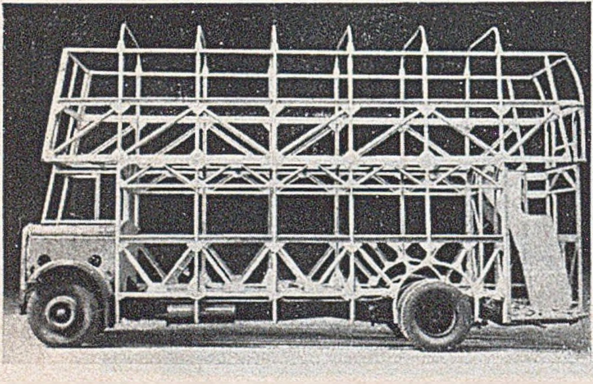
Light Alloys are Becoming Increasingly Popular in the Construction of all Types of Commercial Vehicle Bodies. The Present Account Describes the Work of Two Concerns Now Specializing in This Field.

Light Alloy Commercial Coachwork

by L. Graham Davies

THE steadily increasing employment of light metals in commercial vehicle bodybuilding has been mentioned in several recent issues of this journal, and two further examples now call for detailed notice. An important concern in South Wales, Welsh Metal Industries, Ltd., is producing double-decker buses, from prefabricated components, whilst in London, Messrs. Bonallack and Sons, Ltd., very old-established coachbuilders, are making a number of rather special alloy bodies for overseas service.

In the Welsh Metal Industries job the bus body skeleton is constructed from partial assemblies of standard form and covered with alloy sheet. The body conforms in all respects with latest Ministry of Transport regulations and all structural members are in alloy of the same approximate strength as of steel. With the exception of the pillars, the cant rail and floor rail, all pressings required for these prefabricated components are made in the Welsh Metal Industries factory, which is



SKELETON of the prefabricated body for a double-decker bus produced in aluminium alloy by Welsh Metal Industries, Ltd.

well equipped for this type of product.

Twenty-eight standard frames make up the sides of the bus skeleton. Starting from the bottom there are six ordinary frames, three on each side, and two arch frames, below the waist rail. Above the lower windows are ten more frames, each with double struts. These join up with the lower deck top rail, and above them are 10 more single-strut panels, five on each side. Main body bearers in the buses now coming off the assembly line are in steel, but light alloy will be used when suitable sections become more freely available.

The pillars, in D.T.D. 683, 35-ton alloy, are supplied by James Booth, Ltd., of Birmingham, but extruded section will be used here, when delivery of such material can be obtained. Panel frame members are in top-hat section pressings of D.T.D. 390 alloy, while the waist rail, of deep channel section, is a pressing from 16-gauge sheet of the same metal. Floor bearers are of laminated channel formed into H section and fixed to the standing pillars by box-type gussets.

The body is carried on eight large rubber mountings and Bostic tape sound insulation is introduced between the framework and both outer and inner sheet panelling. Outer panelling is of 18-gauge alloy and the inner of 22 gauge, while 12-gauge sheet is used for the floors. The rear staircase is constructed throughout from heavy-gauge light alloy with ample loading capacity.

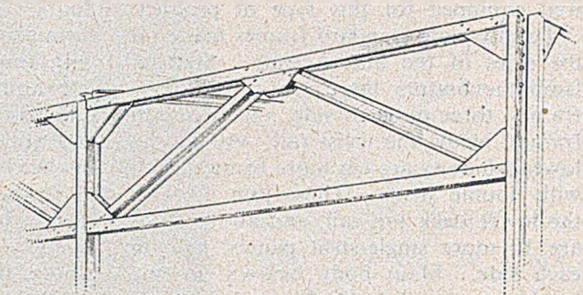
Examining these bus bodies in detail, one was impressed by their great strength and stiffness. All joints are reinforced by heavy-gauge alloy angle plates, and all frame connections subjected to special stress are secured by bolts rather than rivets. When visiting the Caerphilly works, John Cowland, managing director of Welsh Metal Industries, admitted to us that the design might appear to be slightly over-emphasized in this direction, but it is a good fault and further reduction in weight is being made as production goes on.

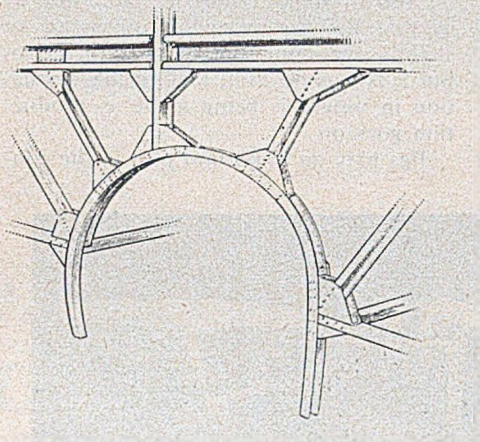
COACHBUILT tractor cabs covered with aluminium sheet at the works of Bonallack and Sons, Ltd. These have now been superseded by an all light alloy model.

Jigs play an important part in the construction of these bodies and a jig has been designed upon which an entire side for one of these double-decker bus body skeletons can be erected before mounting. All light metal parts are anodized against corrosion, and one coat of primer is applied before assembly and painting. High-tension steel bolts are used in mounting the body on its bearers and for all frame connections where riveting is not employed.

As with other systems of bodybuilding from partial assemblies, this method not only expedites delivery of new bodies but should prove of great value in maintenance. Components being interchange-

DETAILS of the Welsh Metal Industries' bodywork for double-decker buses. (Right) Lower-deck top rail. (Below) Wheel-arch panel frame.



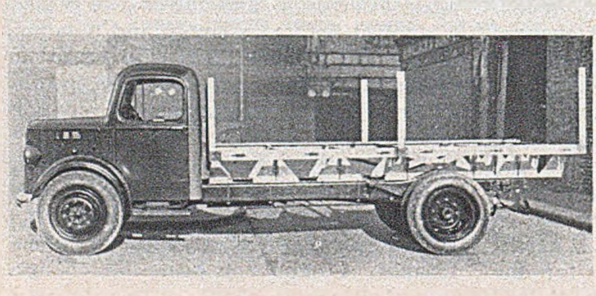


able, they can be replaced with a minimum expenditure of time and labour. With a commercial body of normal construction, a relatively slight accident may cause the vehicle to be laid up for weeks, or, in a more serious instance, for months. Meanwhile the operator is losing money every day that his vehicle is out of service. With the Welsh Metal Industries' system, on the contrary, an entirely new side can, when necessary, be put on to a body in a very short time, thus minimizing such waste.

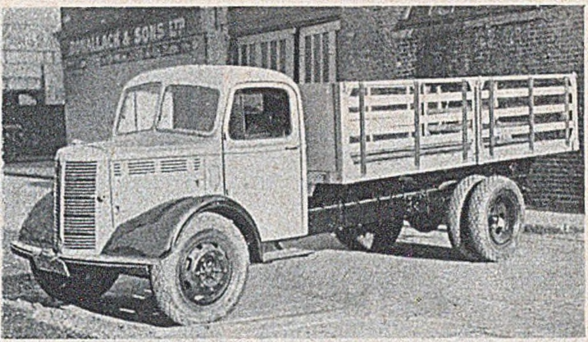
The Caerphilly factory started work on these double-decker buses last July. Two of them are already in regular service in the city of Swansea, and on a recent visit to the works we saw a number of bodies under construction on the assembly line. An all-alloy single-decker bus, built on the same system, will be put into production in the near future.

The comparative weights for the standard model are interesting. Original steel construction gave a total bodyweight of 3-3½ tons: in light alloy this is reduced to 2 ton 6 cwt., a saving of at least 14 cwt., or over 20 per cent.

Turning now to the work of Bonallack and Sons, Cable Street, London, E.7. This company has been building a number of special cabs for the Shell concern. They have been mounted on very large A.E.C. tractors, for work on the Haifa pipe line and all the earlier examples were straightforward coachbuilt jobs in wood, covered with aluminium sheet. Bonallacks are, however, turning over steadily from wood construction to light alloys. When we visited their works recently, the first part of this tractor cab contract was approaching completion ,and work had already started on a second batch of cabs con-



FLOOR frame and bearers of the lorry body. Bonallack T-form extrusions with slotted central flange enter largely into this construction.



COMPLETE slatted lorry body for the Anglo-Iranian Oil Company built by Bonallack and Sons, Ltd. Both side and back panels hinge downwards for ease in loading.

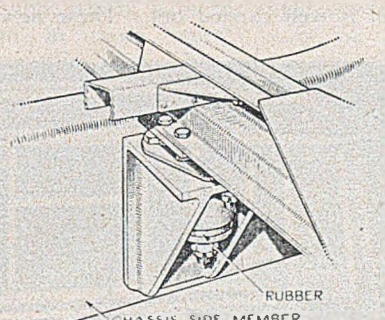
structed entirely in light alloys to the same general design.

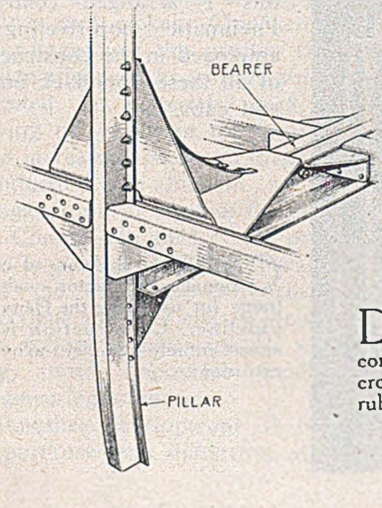
Because of the extremely rough terrain over which Haifa pipe-line vehicles are frequently obliged to operate, A.E.C. engineers advised Bonallack and Sons to allow a large measure of flexibility in the mounting and design of these cabs. For this reason the cab body is articulated at the rear and anchored forward at the most rigid point in the tractor chassis; that is to say, where the frame cross-bracing is exceptionally strong.

At the back of the body a channel section bridge is built up from the tractor frame, and the cab body is flexibly mounted at this point. A large, solid rubber block is fitted on top of the bridge, and the rear bearer of the cab frame, running the whole width of the cab body, rests on this. The arrangement is completed by two spring-loaded bolts, with coil springs, mounted above the cab bearer. The entire rear end of the body thus hinges upon this point.

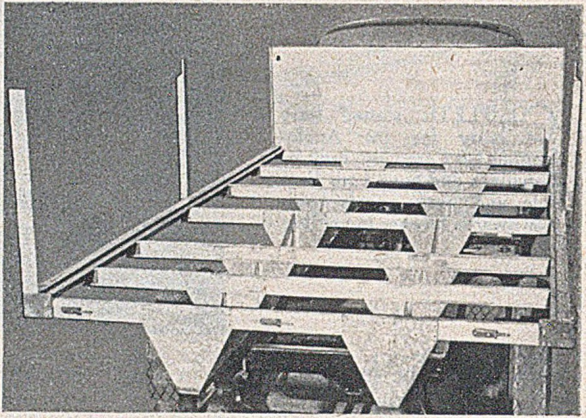
The cab, which occupies the full width of the tractor chassis, accommodates a crew of three, and the driver is provided with a most comfortable armchair seat, which is adjustable. Doors do not fit tightly and have substantial rubber strip padding all round the edges. The frame skeleton is built from robust extruded sections—channel, top-hat, angle and T forms, the front end and windscreen being entirely in channel.

Roof construction is interesting. The curved ends of the roof ribs are in extruded angle, the ribs themselves being





DETAILS of the double-deck bus body built by Welsh Metal Industries, Ltd. Left: construction of joint between side pillar and cross-member. Above: location of one of the rubber pads used in the mounting of the body.



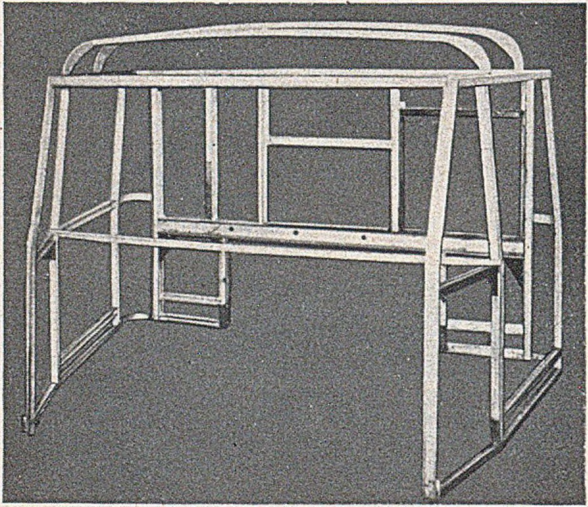
ANOTHER view of the body bearers on a Bonallack general purpose lorry for the Anglo Iranian Oil Co.

made from 14-gauge alloy strip. Gussets, in 10-gauge alloy plate, are attached to the angle used at the rib ends, and these are anchored neatly to the top of the cab frame. For this purpose, a special T-form extrusion, with a split central flange, is employed. Short pieces of this extrusion are mounted transversely on the cantrail and the gusset drops into the slot, where it is riveted. As these vehicles are destined for work in a climate liable to extreme sun temperatures, Isoflex insulation is arranged between the outer and inner roof panelling.

Incidentally, on all these cabs, the inner skin of the roof, in alloy sheet, is mounted directly, without panel beating, a job which calls for considerable skill, but is well carried out. These new all-alloy cabs have exactly the same dimensions as the coachbuilt models, and the flexible mounting already described, is retained.

We were also shown a number of all-alloy bodies under construction for the Anglo-Iranian Oil Co., at Basra. These are open lorries with slatted sides, the sides having let-down panels for ease in loading. They are mounted on Bedford chassis. Intended for general-purpose work in rough country, the body frames, built up largely from extruded section channel, are of exceptional strength.

The special T-form extrusion, with slotted central flange, enters largely into frame construction. Gussets for the body bearers have this T arranged centrally. Pneumatic pop-riveting is employed in the construction of all these Bonallack bodies and cabs.

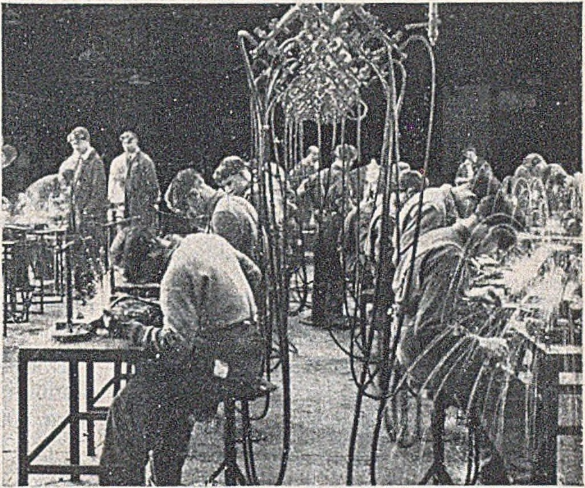


COMPLETE skeleton of a Bonallack tractor cab frame for use along the Haifa pipeline. Construction is almost entirely from light-alloy extrusions.

WELDING THE LIGHT ALLOYS

Part I

Presenting the First of a Series of Four Articles. Here, the Importance of Adequate Training is Stressed and an Outline Given of the Techniques to be Presented in Later Sections of the Series



CRAFTSMEN of the future being trained in the British Oxygen Co.'s welding school, North Circular Road, Cricklewood, London, N.

THE advantages of welding over other methods of jointing have long been recognized by those concerned with design and construction in the ferrous metals and the heavier non-ferrous metals, such as copper, brass, bronze and nickel. Chief among these advantages are the greater freedom of design afforded, the considerable economy effected in materials used, resultant saving of weight in the finished article, and increased speed and lowered costs in production. In fact, it would be no exaggeration to say that the discovery by Le Chatelier in 1895 of the properties of the oxy-acetylene flame, heralding as it did the rapid development of oxy-acetylene and later electric welding during the following half-century, was one of the most important landmarks in engineering science.

Another development of far-reaching importance was occurring at the same time as Le Chatelier's discovery, namely, the commercial applications of aluminium, which, with the rapid development in more recent years of the magnesium alloys, has been responsible for revolutionary changes in nearly all forms of industrial design. During the past ten years the use of these alloys has developed particularly rapidly, and the development of welding has been commensurate with this growth. And yet, although these two industries have grown up and expanded side by side, and although welding is widely used in the fabrication of all types of articles from aircraft to buckets in magnesium or aluminium, the full possibilities offered by welding to all engineers concerned with design or fabrication in light-alloy sheet, tube or plate are still by no means fully recognized.

For many years the welding industry has devoted much time and research to the question of the weldability of aluminium and its alloys, and in more recent years the problems concerned with the welding of magnesium have been investigated with the same energy. As a result of these inquiries methods have been developed, and have been in use constantly for many years, whereby with the use of materials specially designed for the purpose these light metals may be as readily welded as steel. But in spite of this fact there is still a widespread belief in certain circles that aluminium cannot be welded, and this presumption has not unnaturally been extended to magnesium.

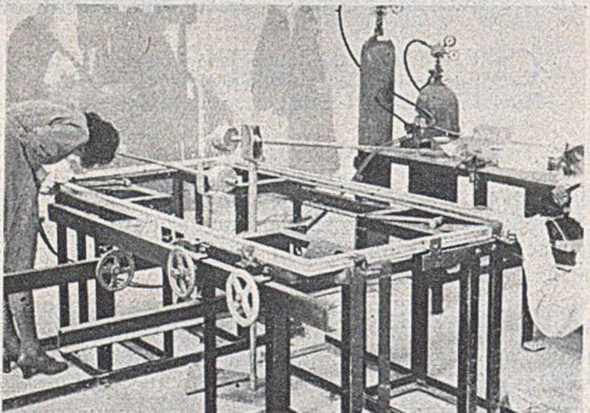
The reasons for this misapprehension are, perhaps, not far to seek. In the first place the light metals have entirely different characteristics from those of steel and the heavier non-ferrous metals and consequently attempts to apply the same technique to the welding of these metals as is required for the welding of steel cannot hope to be successful. In the second place, the light metals do not, at present, always lend themselves satisfactorily to metallic arc welding, and therefore the welding processes as a whole are sometimes dismissed as unsatisfactory in ignorance of the fact that oxy-acetylene welding, and certain other methods to be described later, are, in fact, ideally suited to the purpose.

But if the operator be properly trained, knows the characteristics of the metal with which he is dealing and uses the correct equipment, faultless results will be obtained.

The Welding Characteristics of Aluminium and Magnesium

To the beginner, aluminium and magnesium alloys are not so easy to join by oxy-acetylene welding as mild steel, and the reasons for this are clear when one examines the properties of these metals, the main characteristics of which are:—

1. Low melting points (659 degrees C. aluminium, 651 degrees C. magnesium), some 800 degrees C. less than steel.
2. High conductivity of heat.
3. They give no indication of temperature by change of colour when approaching the melting point; i.e., they do not get red-hot like steel.
4. Lower strength. When cold their strength may be only a quarter that of steel; this strength diminishes rapidly with rise in temperature until, when nearing the melting point, they are liable to sag or collapse altogether without warning.



FLAME brazing of aluminium window frames in a special jig at the works of Gardiner Sons and Co., Ltd., Bristol.

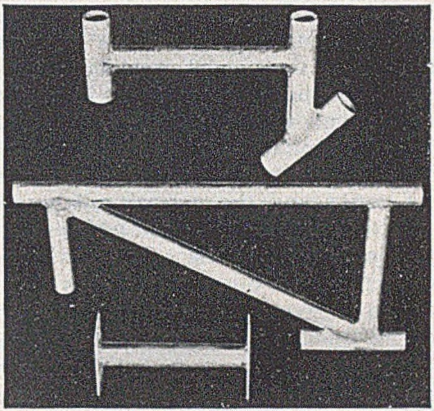
Thus, the welder has not the latitude of control at his disposal which he has when welding steel, and although these difficulties are overcome with practice they are, nevertheless, a source of trouble to the inexperienced operator or to the welder who does not fully understand the basic metallurgical principles of his work.

Furthermore, when welding aluminium another difficulty is encountered which is not met with in the case of other metals. The corrosion resistance of aluminium is derived from an oxide which forms rapidly on all surfaces of the metal. The melting point of this oxide is much higher than that of aluminium (2,000 degrees C.), and in the molten state the oxide forms a heavy skin on the surface of the metal. In order to make a sound weld this skin must be removed, and because the oxide has a higher melting point than the metal, this can obviously not be achieved by the blowpipe alone. To overcome this difficulty a flux has been developed which combines chemically with the aluminium oxide to form a fusible slag, which floats to the top of the weld pool during welding and is thus removed. The presence of this oxide will be a source of some difficulty to the inadequately trained operator, and unless the proper flux is used oxy-acetylene welding of aluminium cannot successfully be carried out.

These difficulties do not imply, however, that light alloys cannot easily be welded by oxy-acetylene or other methods, but they do mean that proper training (including a sound elementary knowledge of metallurgical principles involved, and of the right rods and fluxes to be used for each alloy) and plenty of practice are required before the necessary skill can be achieved. For the oxy-acetylene welder is a craftsman, and this is particularly true of the operator who specializes in the welding of light metals.

The Training of Welders

In the circumstances the training of welders, technicians and supervisors is a factor of the greatest importance if the full advantages are to be derived from the possibilities of welding in the light-metals industry. In order that the most comprehensive instruction may be available to industry, The British Oxygen Co., Ltd., runs a modern and well-equipped welding school at its Sales Technical Service Department, Cricklewood, London, and at branches throughout the country, where tuition is available under the supervision of experts. As pioneers in the field of oxy-acetylene welding, and possessing as they do extensive research and metallurgical laboratories, they are well qualified to give instruction in all subjects related to welding. In addition to the course of tuition available, the staff are available to give demonstrations in the welding of all metals and technical advice on all welding problems.

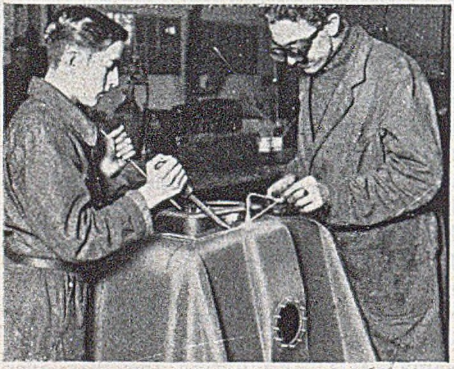


TO demonstrate their ability in the argon-arc welding of magnesium, students in the welding school are required to assemble the structures illustrated here ; these are in form, official A.I.D. test specimens.

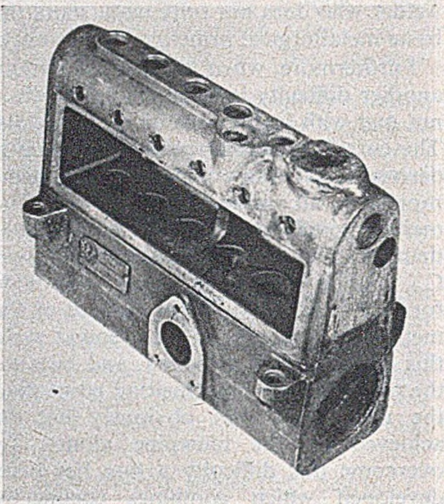
The London school, which has a maximum capacity for some 60 students, has been granted authority to undertake testing for Air Registration Board requirements, and arrangements have also been made with the Association of Heating, Ventilating and Domestic Engineering Employers to train and test men according to the proposed pipe-welding code for the industry. This school has been in existence now for some years, and during the war over 5,000 welders were trained for the British and Allied Forces.

The instructors at this school stress that a few days' training will not produce a proficient welder, and employers and students are advised to arrange for as long a period of training as possible in their own interests. Bearing this in mind, certain special refresher training courses have been arranged of a minimum length of two weeks. Instruction includes lectures, film shows and practical work, and is designed to give the operator enough ability to undertake simple production work with confidence. First-class welding is a question of experience and continual practice, and these he will be in a position to obtain upon his return.

Two principal courses are run, designed to teach oxy-acetylene welding from the most elementary stages. The first of these is a sheet-metal welding course, which has been arranged to meet the requirements of the aircraft, automobile and sheet-metal industries in general. The minimum period for this course is two weeks and the normal syllabus is restricted to mild steel, upon which metal all beginners receive their primary instruction. It normally requires from four to six weeks for a beginner to reach A.R.B. standard on steel, and where instruction on magnesium and aluminium is required an additional two weeks or more is necessary. The second course is a general and maintenance welding course, which has been designed to cover the field of fabrication, repair and maintenance work. The complete course, covering the welding of steel plate and pipe, the reclamation of worn surfaces, the welding of castings (including aluminium and magnesium) and the welding of non-ferrous metals, including the light alloys, has a syllabus of eight weeks, but a short course of four weeks is also arranged for those who do not require to cover the whole syllabus.



OXY-ACETYLENE welding in the workshop of Essex Aero, Ltd., Gravesend, Kent, of a 47-gallon petrol tank for a Spitfire aircraft.



AN aluminium-alloy casting after repair by oxy-acetylene welding and before the dressing of the weld.

In addition, special courses of a fortnight or longer may be arranged for experienced welders who simply require tuition in the welding of certain particular metals.

The courses so far mentioned cover the field of oxy-acetylene welding. A further course of a fortnight or more is also available on the Argonarc welding process, which has been developed in this country by The British Oxygen Co., Ltd., for the welding of magnesium and aluminium alloys and stainless steel, and which will be described in a later article.

Thus, comprehensive instruction is available in three methods of jointing aluminium and magnesium, namely, oxy-acetylene fusion welding, for magnesium and aluminium; oxy-acetylene flame brazing, for aluminium only; Argonarc welding, for magnesium and aluminium.

Oxy-acetylene Fusion Welding of Aluminium and Magnesium

Oxy-acetylene fusion welding is undoubtedly at present the form of welding most widely used for the jointing of light metals. It is employed in sheet-metal fabrication and for the repair or rebuilding of aluminium and magnesium castings.

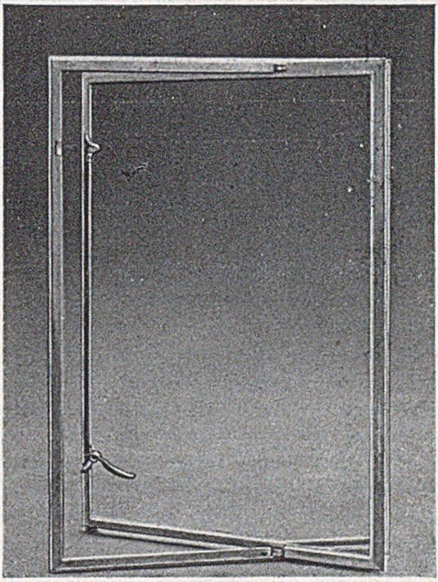
Fusion welding involves the heating of the two edges of metal to be joined to such a temperature that, either with or without the addition of a filler rod, they coalesce and so form a homogeneous joint. Such welded joints are strong, have the same characteristics as the parent metal and are of smooth and even contour. This latter point is of particular importance in the case of aluminium, which is extensively used for chemical, brewery and dairy plant, in which the slightest unevenness would provide opportunity for the trapping of small substances liable to set up chemical attack.

In fusion welding the light alloys it is of the utmost importance to use the right filler rod for each type of alloy. Special welding rods have been developed for the various types of aluminium and magnesium sheet and cast alloys, and if these are used correctly the resulting weld will be stronger than the parent metal itself. If the wrong rod is used, however, a satisfactory weld will not be obtained.

Correct preparation of the metal to be welded is also a matter of importance, and this, together with the employment of the correct welding technique for each type of job, will be discussed in a later article.

It has been mentioned already that it is necessary to use a flux for the welding of aluminium; it is also necessary to use a specially prepared flux when welding magnesium in order to protect the metal from oxidation, to which it is very prone. Unfortunately, both in the case of aluminium and magnesium, the most effective fluxes from the weld-manipulation point of view are also highly corrosive, and must therefore be thoroughly removed after completion of the weld. This may be done in several ways; washing in warm water, followed by vigorous brushing with a wire brush, is one reliable method of removal, but wherever possible the welded article should be dipped in a warm 5 per cent. solution of nitric acid and immediately thereafter washed in warm water. It is sometimes advisable to wash a second time after a few days in order to make certain that the last trace of flux has been removed.

If minute particles of flux are left in the weld zone after work they will, in time, cause severe corrosion in the metal, and it is therefore important when designing for welding in the light alloys to avoid such joints as might cause surplus flux to



FLAME-BRAZED aluminium window frame. (Courtesy Gardiner, Sons and Co., Ltd., Bristol.) This is assembled from extruded sections, with mitred joints.

ALUMINIUM kettles the spouts of which have been flame-brazed into the bodies. The use of the process for this purpose demonstrates very admirably the resistance of the joint to any possible preferential attack.

be entrapped, and butt joints should be employed wherever possible. When tube assemblies are welded it is advisable to drill holes to enable the flux to be completely removed.

In order to avoid the additional operations inherent in flux removal, two further welding processes have been recently developed, namely, flame brazing and Argonarc welding.

Flame Brazing of Aluminium

When fusion welding light-gauge aluminium difficulty is sometimes experienced when joints have to be made near edges, such as narrow-fillet or close-corner joints; such joints call for the highest degree of skill on the part of the welder. Again, although butt joints are recommended for the fusion welding of aluminium, in order to avoid the danger of entrapped flux, there are occasions when some form of fillet or lap joint cannot be avoided, or where to employ butt joints instead would cause additional operations and so increase the cost of production.

In order to overcome such difficulties the flame brazing process has been developed, and though originally restricted to thin-gauge material, this method has been found to be highly successful on aluminium of up to ½ in. in thickness. Not only does it avoid the melting back of edges on thin-gauge material and all danger of flux entrapment, but it has the advantage of being considerably quicker and more economical in gas consumption than fusion welding.

The essential feature of the aluminium brazing process is the use of a filler rod containing between 10-12 per cent. silicon. This rod has a melting point some 73 degrees C. below that of pure aluminium and when molten percolates round and into the joint by capillary attraction and the force of the flame, thus driving out flux which would otherwise become entrapped. Furthermore, as the whole operation is carried out below the melting point of aluminium there is no danger of melting back edges or projections. A special aluminium brazing flux has also been developed to remove the aluminium oxide; this flux is so constituted that it flows rapidly and cleanly ahead of the molten filler metal, thus materially assisting the operator. It wets and cleans both joints and filler metal, thus ensuring complete penetration. This flux, however, is also corrosive and must be completely removed after brazing.

The use of this process is expanding rapidly at the present time and it is being employed in such a variety of ways as the fabrication of tubular aluminium furniture, the manufacture of milk churns, aluminium kettles, vacuum cleaners, window frames, bus-bars and a great number of other articles. It has recently been approved by the Air Registration Board for various classes of work. It should not, however, be regarded as the solution to all the problems concerned with the welding of aluminium. In the first place, some types of fabrication, particularly in connection with long seams, do not readily lend themselves to the brazing operation and, secondly, with the materials at present available it cannot be used on aluminium-magnesium alloys containing more than 3 per cent. magnesium. Nevertheless, the variety of applications already mentioned and now in commercial use, indicates that this method offers a satisfactory solution to the jointing problems of many potential light-alloy assemblies and may be expected to become increasingly popular.

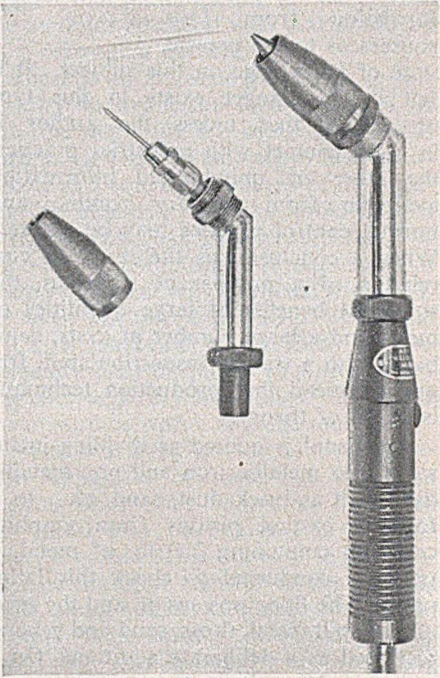
Argonarc Welding

The magnesium alloys have been successfully welded with oxy-acetylene equipment since the early days of their development, but as already stated, it is essential to use a flux to protect the metal from rapid oxidation when in a molten state and to remove the oxide which forms in the vicinity of the weld. The most successful fluxes for this purpose are also highly corrosive and so must be thoroughly removed after welding, and this operation is a comparatively lengthy item in production. So with the greatly increased use of these alloys in the past few years it became evident that there was a need for a welding process which would overcome this difficulty.

The Argonarc process was originally developed for the welding of these alloys without the use of a flux, and it also has the advantage of being considerably faster than oxy-acetylene welding. To-day the process is finding a greatly extended field of application in the welding of other metals, particularly aluminium and stainless steel.

Argonarc welding is an electric arc process employing a tungsten electrode as the heat source. The arc operates in an atmosphere of the inert gas argon, which is fed into the weld zone from the welding torch; the argon fully shrouds the molten metal during welding and thus prevents the chemical change of any elements in the parent metal, which would normally combine at fusion temperature with either oxygen or nitrogen. The arc from the tungsten electrode provides heat only, and for all but the thinnest sections a separate filler rod is used, as in oxy-acetylene welding.

Argonarc welding is not regarded as a process which is displacing the older welding methods, but rather as an additional tool at the welder's disposal. In fact, the three processes above described, which will be dealt with in detail in future articles, are none of them mutually exclusive. On the contrary, they are complementary one to another and represent, between them, a considerable part of the contribution which the welding industry has made to the commercial development of the light alloys.



WELDING torch designed for Argonarc welding of aluminium and magnesium. The electrode is of tungsten, whilst argon is admitted to form a concentrated shroud around and over the molten metal.

There is no doubt that the future will see the much wider adoption of welding by the light-metal industry, and it cannot be too strongly emphasized that sound knowledge and thorough training are the basis of all successful welding.

INCLUSIONS—A Critical Study

By H. G. Warrington, F.I.M.*

Bardot's Conclusions, Based on Hypotheses, are Refuted by Experimental Evidence

A REVIEW of published information on hard-spot inclusions in light alloys, by Bardot,[1] presents information from four sources as to the present state of knowledge on this subject. It is felt that a danger exists in this type of article, that unless the author is in close contact with industrial practice, the store of unpublished information available from foundry routine and normal control practice may be ignored. When a conclusion is the result of correlation of a number of variables, the statistical benefits of large quantities of metal and a large number of casts, combined with a trained inspection staff, frequently mean that production technique is ahead of theory.

Anderson[1] is quoted as dividing inclusions into metallic iron and non-metallic dirt, such as brick dust, sand, etc. In a foundry casting pistons from graphite crucibles containing 200 lb. of metal, a test was conducted to check this latter point. The floor was swept, and the mixture of spilt metal, dross, sand and general dirt used as a deliberate addition. On a series of 10 melts, alternate casts were treated by adding a spadeful of the sweepings, stirring and skimming. All melts were treated with a proprietary flux and reskimmed before casting. The runners were kept separate until after the experiment, so that the number of pistons represent the bare recovery.

Metal treated correctly: 263 pistons; total scrap, 12; scrap for inclusions, 5 or 1.9 per cent.

Metal contaminated by dirt: 258 pistons; total scrap, 15; scrap for inclusions, 6 or 2.3 per cent.

In view of the severity of treatment, the difference is not significant, the only feature of note being the slight amount of metal lost in skimming causing a lower yield.

The deterioration of the surface of worn graphite crucibles is attributed to Girot[1] as one cause of inclusions. Production returns do not show this to be a serious cause of hard spots as a direct factor. When the glaze is broken internally, by stirring hardener alloys or by the wedging of large ingots, flakes of graphite and some clay become detached, but are normally fluxed off and do not affect the incidence of scrap. When the external glaze is broken, the graphite shows preferential oxidation, the crucible rapidly becomes thinner locally, and severe temperature gradients are set up. There is some evidence that formation of the hardest type of inclusion—corundum—is favoured by this condition, although it is difficult to separate this factor from others, such as flux absorption above the metal line, and reaction of the metal with siliceous materials, which operate in parallel. Certainly in the case of low-frequency electric furnaces with a silicon containing lining in the slot, there is a gradual replacement of SiO_2 by Al_2O_3 accompanied by solution of silica in the metal. Metal from these furnaces, however, is consistently cleaner, with fewer inclusions than metal from oil- or gas-fired crucible furnaces. Some silicon-carbide crucibles, on the other hand, are extremely friable below the glaze, and appear to be a direct cause of some types of inclusion.

Röhrig[1] divides inclusions into the relatively soft Al_2O_3 and the hard corundum which transforms above 950 degrees C. No one will quarrel with this identification of those inclusions attributable to

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* Chief Metallurgist Almin Limited.

aluminium oxide. Analysis of some hundreds of inclusions has identified this compound as the major constituent present in nearly every case, and X-ray spectrograms of selected examples has identified corundum as the harder or tool-breaking type. The soft alpha alumina may be recognized under the microscope as fine, spidery skeins, frequently carrying entrained bubbles of air or other gas.

M. Tournaire[1] claims that corundum formation is more likely in magnesium-free alloys from alumino-thermic reactions, whereas alloys containing magnesium are more likely to form spinels. Investigation, however, shows that inclusions generally increase with increasing magnesium content, as shown by Sachs, Dana and Ebert.[2]

This increase in inclusions occurs at a lower magnesium content than that at which spinels can be identified. It is considered by some that magnesium may act in a way analogous to a catalyst, as the rate of loss of aluminium by oxidation in melts held for long periods at relatively high temperatures is invariably found to be higher than the rate of loss of magnesium, for magnesium contents up to 2 per cent. This suggests a reaction:—

$$2\ Mg + O_2 \longrightarrow 2\ MgO$$
$$3\ MgO + 2\ Al \longrightarrow Al_2O_3 + 3\ Mg$$

To check this point, a bracket pattern was poured with a gate producing a certain amount of turbulence, the castings being made in an alloy corresponding basically to the composition of D.T.D. 133.C. Successive batches were cast with metal containing Mg 0.02 per cent., 0.05, 0.10, 0.5 and 1.5 per cent. Radiography showed conclusively a marked increase in porosity and dross, which was first evident at 0.1 per cent. Mg and increased rapidly with increasing magnesium content.

None of the authorities quoted by Bardot mentions carbides or nitrides, an aspect covered by von Ludwig,[3] nor do any consider chlorides a possible source of inclusions. It is true that such contaminants are probably not the cause of "hard" spots in the same category as corundum, but none the less cause rejections just as freely on components subject to much machining, although the delays caused by tool breakage are not so marked. A rejection report is insufficient evidence, however, on which to identify an inclusion as a hard spot. A comparatively soft inclusion will frequently cause a slight tool-jump, leaving a "tail" from the inclusion identical with that produced by a corundum particle.

There is an increasing tendency in this country to avoid the inconveniences of chlorine degassing by using compounds such as carbon tetrachloride or hexachlorethane as a convenient means of introducing this element. For the liquid CCl_4 a carrier such as absorbent brick or asbestos is used, and for simultaneous grain refinement may be mixed with $TiCl_4$ or even carbon and TiO_2. The solid C_2Cl_6 is marketed in the form of conveniently sized briquettes as a proprietary degasser and may be plunged below the metal surface with a suitable tool.

Tests with Pfeiffer's vacuum solidification apparatus at successive stages in melting show that no matter how well the metal may be degassed in the furnace, a considerable increase in gas content occurs after transfer to the pouring ladle, and if subject to a second treatment at this stage, some further gas pick-up may be demonstrated by remelting metal taken from the mould. The briquetted degassing medium appeared a convenient way to clean the metal at later stages than in the melting furnace, and in the case of billets cast into thin-walled metal moulds where the metal is totally liquid for an appreciable period before progressive water chilling, it is possible to degas in the actual mould in which the metal solidifies. A number of test melts cast in this manner gave satisfactorily pore-free billets, although remelted samples did not show any marked decrease in apparent gas content over those from metal degassed in the furnace. An inspection report on machined components, however, recorded a definite increase in rejections for inclusions. Fracture tests on a number of billets confirmed this feature, and the defects appeared to be relatively soft, some grey in colour and others black and grey. Exposure to a moist atmosphere increased their apparent size and closer examination revealed that the included material was hygroscopic in nature. Analyses showed the presence of carbon and chlorides, and it is probable that the compounds present were aluminium chloride with a little carbide. Either the time before solidification was insufficient for all the products of the reaction to escape, or under these conditions aluminium chloride has some solubility in molten aluminium, and is rejected on solidification. Tests using aluminium chloride in place of C_2Cl_6 at varying temperatures suggest that the latter cause is the true one, as a billet degassed at 850 degrees C. and then rapidly chilled still showed less inclusions than one treated at 660 degrees C. and allowed to stand for some time before solidification.

The analysis of inclusions is tedious, and correlation of their presence with the factors involved in melting and casting implies knowledge of the virgin metal production, the hardener alloys and the history of any scrap or remelted metal that may be used. Unsupported statements in literature, as distinct from the results of careful experimental work, may be very misleading, as they frequently prove to be impressions gained from casual observations.

REFERENCES

(1) *M. Bardot, "The Present State of Knowledge of Hard Spots in Light Alloys," "Fonderie,"* 1947/18/684. (2) *Sachs Dana and Ebert, "A.F.A." Preprint No.* 47-26/1947. (3) *D. von Ludwig. "Carbides, Nitrides and Porosity in Aluminium," "Iron Age,"* 1947 *(Nov.* 20) *p.* 73.

POROSITY—Another Approach

By F. A. Allen, A.I.M.

Discussion on the Work of von Ludwig Concerning the Influence of Carbide and Nitride Impurities

IT is somewhat surprising, on reflection, that olfactory evidence has not hitherto excited aluminium metallurgists to investigate the peculiar smell associated with freshly fractured aluminium. This odour, as everyone knows, is that popularly ascribed to acetylene.

The sense of smell is extraordinarily sensitive. The vapour of certain mercaptans, even when diluted so that 50 c.c. of air contain no more than 1/460,000,000th part of one milligram, can still be detected by the nose. Although this is a special case, it is true, in general terms, that the amount of a substance capable of exciting smell reactions is almost unbelievably small. So that what is perceived as "acetylene" emanating from aluminium may be the result of a minute amount of that gas or other odorous compound.

The writer recalls dimly that many years ago, in his first energetic enthusiasm for light-alloy production metallurgy, he tracked down a reference in "Comptes Rendus," dated for an early year in the industrial life of aluminium, in which the presence of a carbide of manganese in aluminium was suggested or demonstrated. One apologizes for the paucity of detail of the reference, but the fact that the presence of a carbide was a possibility is distinctly remembered as affording some relief to the problem—whence comes the smell?

Further study in chemistry, however,


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taught that pure acetylene had no smell and that the characteristic unpleasant odour was due to sulphuretted hydrogen, phosphine and silicon hydride formed from impurities in the calcium carbide normally used as the reactant with water in preparing the gas.

The question may therefore be asked if any theory dependent upon the smell of "acetylene," apparent when aluminium alloys are fractured, is based upon a sound foundation, especially when it is admitted that the trace-gas of extremely small proportion is notoriously difficult to detect chemically and probably impossible to determine quantitatively.

Davidlee von Ludwig, in a paper in the American "Iron Age" for November 20, 1947, discusses the effect of non-metallic impurities in relation to porosity in aluminium alloys, and as the impurities he treats are carbides and nitrides this question of the smell, reminiscent of acetylene, associated with freshly fractured aluminium, is again posed.

Von Ludwig does not agree that the major cause of porosity in aluminium alloys is hydrogen. If it were completely true that the absorption of hydrogen in molten alloys and its precipitation on solidification were the only factors involved in characteristic porosity, there would be no problem, for, as he observes, methods of control of hydrogen in this respect have long been understood. It is pointed out that many defects, porosity among them, occur under conditions such that they cannot readily be explained on the hydrogen-absorption theory.

The haphazard nature of the incidence of porosity is well known to all who have to produce sound metal and, indeed, its mysterious comings and goings have been remarked upon in many discussions, both on Institute of Metals papers and in these pages. Whilst hydrogen may be the major contaminant in gaseous form, the significance of non-metallic impurities in aluminium must be thoroughly studied and understood.

Active solid impurities are carbides and nitrides chiefly, and scant attention has hitherto been paid to them, although it is known that carbon monoxide and carbon dioxide react with molten aluminium to form Al_4C_3 and Al_2O_3, especially when it is held at high temperature under CO_2. Nitride formation may be suspected when dry nitrogen gas is used as a flux for aluminium. It has been suggested that no immediate bad effects result from the presence of nitrides because they do not decompose in the freezing range.

Carbides and nitrides are not stable in the presence of water at temperatures below 1,250 degrees F. (675 degrees C. approximately). Above this temperature, water tends to react with aluminium to evolve hydrogen and to form oxides. Below this temperature, water does not tend to break down readily, but is active preferentially with carbides or nitrides liberating hydrocarbon gases or ammonia. These reactions can take place only at the surface of molten, or hot, solid metal, and no detriment is incurred by these reactions while the metal is liquid or pasty prior to casting.

The water reaction may in fact be used to remove these active impurities. As carbides and nitrides cannot liberate gases except in contact with water molecules, they are superficially considered to be stable non-metallic inclusions. As the combined total of carbides and nitrides in aluminium alloys rarely exceeds 0.5 per cent. even in metal processed in very inefficient melting equipment, they are ignored in considering fractures in subsequent production stages.

The possibility of carbide and nitride formation with alloying elements and impurity elements must not be lost sight of. This, considers von Ludwig, is particularly true of copper, calcium, and lithium. Simple confirmation of the presence of carbides and nitrides is provided by the well-known smell of freshly fractured aluminium, as noted above. Unfortunately, conventional methods of gas analysis are not applicable.

Gwyer has reported that varying proportions of simple or compound gases are evolved when aluminium alloy samples are melted in vacuo dependent upon previous metallurgical history and alloying materials and methods. It is significant that at least one sample revealed 25 per cent. of acetylene.

It is not clear as to how carbides are formed. Tullis has observed that they are most common in remelt aluminium derived from oily or greasy scrap or which has been melted in reverberatory furnaces. Erikson more or less confirms this observation. Hiram Brown has discriminated between melting methods and fuels in relation to their effects on aluminium alloys and has concluded that oil-fueled reverberatory furnaces produce metal that suffers from profound porosity defects. As a matter of observed fact, the defects from melting in contact with oil flames relate more to the formation of carbides and nitrides than to the solution of evolved hydrogen.

Von Ludwig maintains that in most melting furnaces conditions are not favourable for the solution of hydrogen within the melt, due to the fact that little or no free hydrogen is present in the flue gases in contact with the melt. He states further that the reaction of superheated water vapour with the metal is also unimportant, except at extremely high temperatures. Nevertheless, whilst poor melting conditions cannot be allowed, it is a fact that aluminium alloys melted in reverberatories fired by coke, and in which therefore little or no hydrogen gas can be present, do suffer from severe porosity. In such cases, porosity can be due only to the formation of carbides by reaction of high concentrations of CO_2 with perhaps CO.

It is difficult to determine carbides, and in any case, few specifications contain a limiting clause on the aluminium content of an alloy, usually estimated "by difference," of course. Of the small amount of published information, that due to Bobalek and Shrader ("Indust. and Eng. Chem.," Vol. 17, September, 1945), is probably the most important. Their work was performed on magnesium alloys, and it is significant, von Ludwig thinks, that they showed far more carbon to be present in alloys containing aluminium than in pure magnesium. Von Ludwig infers that this work can be interpreted to substantiate the presence and effects of the carbide constituent as formed in the aluminium component. Incidentally, grain refinement by superheating of magnesium alloys by nucleation by particles of aluminium carbide is also substantiated.

Methods of combustion analysis would mask the mode in which carbon is present; no differentiation could be made between carbon present as carbide, or present as dissolved gases such CO_2, CO. C_2H_2, or CH_4. Similarly the role of nitrogen would be uncertain.

Von Ludwig goes on with further discussions. Eastwood considers that the source of atomic hydrogen may be represented by the reaction: "Metal plus water yields metal oxide plus atomic hydrogen," atomic hydrogen dissolving in the molten metal to be precipitated on freezing with the production of characteristic pinholing. But, Eastwood says, this porosity is most pronounced in silicon-aluminium alloys containing calcium or lithium. The next stage in von Ludwig's argument may be quoted: "The known affinity of both lithium and calcium for carbon, plus the excessive activity of the resultant carbides when reacted with water, promotes the thought that it is not an increase in the affinity of the metal for hydrogen, due to some inexplicable effect of calcium or lithium on the characteristics of the metal in this regard, which causes the increase in pinhole porosity, but the quite logical increase in concentration of active carbides in the metal, which (in reacting with mould moisture) liberates increasing quantities of hydrocarbon gases, primarily acetylene, within the metal."

Von Ludwig describes the mechanism of hydrogen formation and absorption in a mould: assuming hydrogen-free metal enters the mould, the temperature must be raised to at least 1,250 degrees F. (680 degrees C.) before the molten metal can react with mould moist gases or mould moisture, releasing atomic hydrogen, as indicated by Eastwood. At the same time, however, the metal is rapidly chilling and a tough oxide film is being formed at the surface. As it is well known that the oxide film hinders the escape of chlorine or nitrogen used in degassing processes, von Ludwig considers that it is improbable that hydrogen is absorbed by means of the mechanism described, and that the formation of gas defects in aluminium through reactions of carbides and water is chemically and physically simpler and far more logical.

As metal containing carbides and nitrides is poured into the mould, reactions are instantaneous and gaseous products are formed progressively as new surfaces are thrown up by turbulence during pouring. The active constituents are contained within the metal, and as gas evolution takes place some escapes through metal face and oxide film, part may be trapped and expand within the solidifying metal. The hotter the metal and the higher the concentration of carbides or nitrides, the larger and more numerous are the defects. Von Ludwig maintains that this mechanism is borne out in all references to carbide-active constituents of calcium or lithium, and in general is more likely than the involved method of atomic hydrogen pinhole formation.

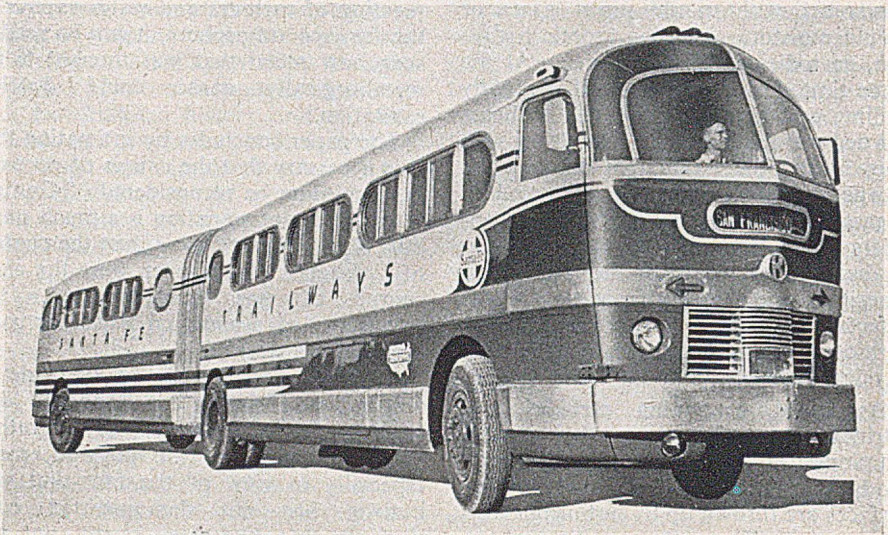
A statement, due to Erikson, is reported to the effect that 98 per cent. of the porosity encountered in (pressure) die-castings is due to trapped mould gases; this report is inconclusive, as the author asserts that the trapped gases are invisible to normal X-ray or metallographic examination. Yet such castings are subject to blistering when subjected to normal solution treatment temperatures, and this fact is presented as proof of the existence of trapped gas. The difficulty of reconciling apparent absence of gas cavitation and the emergence of blisters may be resolved, von Ludwig suggests, if the facts are viewed in the light of carbide reactions, for if the blisters, formed during heat treatment, were the result of reaction of carbides and water vapour in the furnace atmosphere, it can be readily seen how metal that was thought to be metallurgically dense could develop cavitation.

The paper concludes by intimating that it is necessary that the causes of porosity in aluminium be reconsidered. "Control of carbide contamination is a much more difficult problem to solve than the control of hydrogen. If hydrogen were the chief source of gas contamination, the metallurgy of aluminium would actually be relatively simple."

It would be possible to find metallurgists and foundrymen prone to disagree somewhat strongly with this rather poetic statement of the position, more especially in view of the fact that von Ludwig has not demonstrated conclusively that hydrogen is still not the main source of trouble. It has long been assumed that this is the case and, for this reason, study of the problem has tended to take a hydrogen bias.

It is conceivable, however, that, whether or not von Ludwig's conclusions are in their entirety correct, they may lead to the adoption of a new approach, resulting, possibly, in a simplification of our views on the mechanism of hydrogen absorption and on the somewhat sinister role the gas may play in conjunction with such straightforward shrinkage as occurs on solidification of the metal. One development would certainly simplify the foundryman's task, that is, the discovery of some means whereby the retention of hydrogen could be assured, for we must recognize that the trouble starts only when the gas attempts to escape.

There can be little doubt that all foundry metallurgists who have attempted to control cavitation, whatever is the correct view of the mode of formation, will be ready to join issue with the American author at some points, or at the very least be eager to offer comments on his thesis. They will be prepared to agree that the problem is not a simple one; it may be hoped therefore that correspondence on the subject will be forthcoming.



Santa Fe Trail — New Style

STRIKING as the accompanying illustration may be, the new articulated Kaiser coach will hardly be regarded as a model upon which our future passenger transport vehicles will be built. It is of interest, however, because aluminium and magnesium are basic features of the design, and comparison may be drawn with analogous British and French projects previously reported in "Light Metals."*

The coach, described as a highway luxury liner, has been built by The Permanente Metals Corporation, Oakland, California, for the Santa Fe Trail Transportation Co. Measuring 60 ft. in length, it is more than twice as long as the average British double-decker, and incorporates many luxury features including foam rubber swivel seats, spacious baggage accommodation, ample head- and leg-room, air conditioning, lavatories and "Torsilastic" spring suspension.

Magnesium and aluminium are used exclusively in the manufacture of the coach body. It is of true monocoque construction with all parts built into the main structure and designed to share the stresses on the combined structure. Exterior panels are flush-mounted and flush-riveted to reduce wind resistance and improve appearance, and the interior panels, in walnut and light oak, are bound with polished aluminium moulding. The

COMPARED here with the normal American four-wheeler is the articulated Kaiser coach. Overtaking is rendered a simple matter due to the exceptionally high power Cummins engine.

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*Cut Operating Costs and Increase Payload 1947.10.97
Prefabricated Parts for Coachbuilders 1947.10.346
Prefabricated Light-Metal Coachwork in France 1947.10.551
Simplifying Bodywork Construction and Assembly 1947.10.629

floors are magnesium plates covered with deep-blue wear-resisting plastic material.

Although complete air conditioning is fitted, the windows can be opened. They are of laminated safety glass set in polished aluminium frames. In the event of damage, the glass in any window can be replaced in five minutes. A flexible corrugated aluminium shade can be adjusted by the passenger to cover any part of the window.

Exceptional performance is given by a Cummins 275 b.h.p. six-cylindered supercharged oil engine located under the floor midway between the front and centre axles. The lower crankcase is of aluminium, this material also being used for the water-cooled exhaust manifold. The location of the engine and also the air conditioning plant and baggage compartment under the floor gives the vehicle a very low centre of gravity. Also contributing towards this is the use of so much light alloy and particularly magnesium in the bodywork.

The contrast with British buses is striking. A typical 56-seater in use in this country weighs 7 tons 12 cwt. unladen and occupies less than half the road space required by the Kaiser. The unladen weight per passenger of the British double-decker is about 2.7 cwt. and of the Kaiser approximately 3.8 cwt. despite the wide use of lightweight materials.

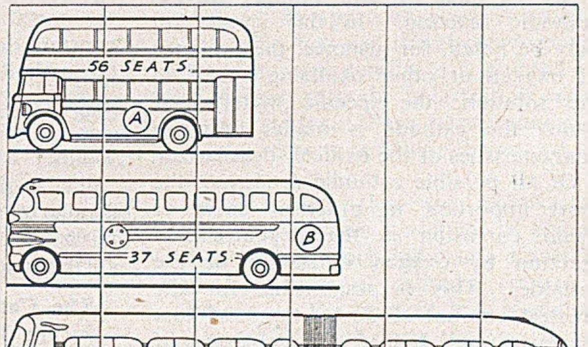
On the other hand, comparison with a typical American coach shows that a considerable saving has been achieved by the incorporation of these lightweight materials. A normal 37-seater in America has an unladen weight of 10 tons, so that the new Kaiser coach represents a 70 per cent. increase in payload with a gain of only 27 per cent. in unladen weight.

When considering the higher unladen weight per passenger of this coach compared with the normal British double-decker, it must be remembered that great attention has been paid to passenger comfort. Not only are there provided two lavatories and ample luggage accommodation, but also a space of 2 ft. 11 ins. is allowed between seats with headroom of 6 ft. 8 ins.

The four-wheeled " tractor " portion of the vehicle has a wheelbase of 21 ft. 6 ins. and the rear part a wheelbase of 23 ft. 6 ins. The two sections have a flexible connection similar to that of a railway corridor coach. Single tyres are mounted on the front and rear wheels and twins on the centre wheels. By means of a patented steering system, the front and rear wheels are linked, and an articulated joint causes the rear wheels to follow the track of the centre axle.

Whether or not such a vehicle could ever become an economic unit in the United Kingdom is questionable.

THE average British double-decker (A) compared with the normal American large-capacity single-decker (B) and the Kaiser articulated six-wheeler (C). In spite of the fact that the Kaiser coach is claimed to turn in a radius of only 38ft., so far as this country is concerned the increase in road space is not considered to be justified by the increased accommodation.



CORROSION OF METALS WITH OXYGEN DEPOLARIZATION

Continuing from "Light Metals," 1948/11/14, this Section of Tomashoff's Work Concludes the Synopsis of the Theoretical Background and Describes the Experimental Technique

Analytical Investigation of Cathodic Processes in the Corrosion of Metals

FROM what has been stated previously, the significance of studying the cathodic processes and their fundamental influence on the overall nature and velocity of corrosion may be readily appreciated. Cathodic depolarization consists of the assimilation at the cathode surface of excess (metal) electrons released by anodic dissolution, i.e., the transfer of metallic ions into a solution. In its most generalized form this reaction may be expressed by: $D + \theta \longrightarrow (D\theta)$, where D denotes a depolarizer (a neutral molecule or ion) capable of assimilating the electron, that is, of being reduced at the local cathode under the given conditions of corrosion.

It is obvious, therefore, how important it is to know the influence of any factors likely to bear on the velocity of the cathodic reaction. In this connection may be noted, for instance, the presence of oxygen or other oxidizing agents in the solution; the specific material of which the cathode is made; diffusion characteristics of the oxidizer-depolarizer.

Of all possible cathodic processes, the most important in practical cases of metal corrosion is the depolarization reaction by oxygen ionization at the cathode. This is responsible for the greatest amount of destruction and loss by corrosion. Indeed, the corrosion of most structural metals (with the exception, perhaps, of magnesium and magnesium-base alloys), in neutral electrolytes, and under the atmospheric conditions, proceeds chiefly because of this process. The same explanation commonly holds good for the dissolution of metals in weak acid solutions in the presence of oxygen. Ionization progresses with varying ease on different metals, which may be arranged as a series in order of increasing ionization over-voltage of oxygen.

A mathematical treatment of the cathodic processes with oxygen depolarization is given by Tomashoff on the basis of analysis of the following cases:—

The cathodic process is controlled by the rate of the cathodic reaction. For this case the ionization over-voltage of oxygen is determined by an expression similar to Tafel's equation for hydrogen over-voltage:—

$$\vartheta = a + b\log_e I_r, \qquad (16)$$

where a is a constant (experimentally determined), depending on the nature of the metal and the depolarizer; b is a constant determined by the mechanism of the cathodic reaction, equal in the given case to $\frac{2RT}{nF}$, in which R is a gas constant, T—the absolute temperature, n—the valency of the depolarizer in a given depolarization reaction, F—one Faraday = 96,500 Coulombs; I_r is the cathode current density.

The Cathodic Process is Controlled by the Rate of Oxygen Transfer to the Cathode

The mechanism of conveying atmospheric oxygen to the cathode surface is of a complex character, which, in a general case, may be divided into the following principal stages: (a) Passage of oxygen through the boundary line: air—electrolyte; (b) its transference through the body of the electrolyte by thermal or mechanical convection: (c) diffusion of oxygen through a static layer, or a layer with laminar flow, of liquid directly adjacent to the cathodic surface (diffusion layer).

In this event the polarization of the cathode is determined by a purely diffusion mechanism and is expressed by Nernst's equation for concentration polarization:—

$$\Delta\phi = \frac{RT}{nF} \log_e (1 - \frac{i_d}{I_d}), \qquad (17)$$

in which $\Delta\phi$ is the variation of cathode potential due to difference between the concentration of the depolarizer (oxygen) in the body of the electrolyte and that at the cathode surface (gram—mol. 0_2/cm.^{3}); i_d—current density at the cathode. I_d—limiting diffusion current for given conditions of experiment; the remaining notation is the same as above.

This expression determines the shift of the cathodic potential owing to the concentration polarization by the ratio of current densities $\frac{i_d}{I_d}$, one of which (i_d) is controlled by a given diffusion rate of oxygen, and the other (I_d)—the maximum possible diffusion velocity for a given corrosion case.

Mixed Control

If the maximum diffusion rate of the depolarizer and maximum velocity of the cathodic process be commensurable, then the overall velocity of the cathodic reaction will depend on both these factors (i.e., mixed control). In such a case, which occurs most frequently in practice, the polarizability of the cathode is determined by:—

$$\vartheta_d = a + b \log_e i - b \log_e (1 - \frac{i}{I_d}), \quad (18)$$

where ϑ_d denotes the total ionization overvoltage of oxygen, that is, the shift of the cathode potential for a polarizing current density i. The other symbols are identical to those as indicated before.

Complex Process of Oxygen-hydrogen Depolarization

When upon the process with oxygen depolarization is simultaneously superimposed a second depolarization process with hydrogen evolution, these two reactions proceed parallel with, and independent of, one another.

Although the relationship between the cathode potential and the density of the polarizing current can also be deduced analytically, the mathematical expression is of a rather complicated form, and its solution is laborious and difficult: however, it may easily be obtained graphically, by which method the overvoltage plotted as a function of the current density (i.e., the value for the shift of potential) is determined with an adequate degree of approximation.

Graphical Methods for Computing Rate of Corrosion Processes

The application of polarization curves is widely used for studying the kinetics of electrode processes. Accordingly, Tomashoff gives a detailed graphical interpretation of the principal relationships which hold good for all possible cathodic processes in the corrosion of metals by plotting polarization curves on the basis of the analytical expressions deduced.

As such an approach presents an ideal relationship between the electrode potential and current density, it is pointed out that the real cathodic polarization curves may deviate from those derived theoretically; the reasons for these deviations are examined.

Analysis of the theoretical polarization curve demonstrates a number of characteristic points which indicate a transition from one form of cathodic control to another. In the light of this revelation, the possibilities of using the polarization curves for computing the rate and characteristics of the cathodic processes are extensively discussed.

For example, if the curves of the

cathodic and anodic polarization (they may be obtained experimentally for a number of typical corrosion processes) and the ratio of the cathodic and anodic areas be known, we can, for a given instance of corrosion, determine the value of the local current and corrosion rate. Computation is simplified when the resistance of the local couples is so small that the ohmic drop of potential may be neglected. In this case the maximum local current is directly given by the intersection of the curves for the cathodic and anodic polarization.

If the equations for the relationship between effective potential and local current density be represented graphically, by platting of current densities as abscissæ and effective potentials as ordinates, we obtain a very convenient form of corrosion diagram.

Tomashoff's Diagram for Corrosion Processes

Of the various graphical methods for the computation and interpretation of corrosion phenomena, Tomashoff's original diagram is of special interest. By its aid. the mechanism of various types of attack can be readily analysed in such a way as not only to illustrate all the elementary stages of a complex sequence, but to show, also, the role played by each of them and the mutual interrelations of the individual stages and their influence on the overall velocity of a given corrosion process.

The initial stages of corrosion (diffusion of oxygen, the oxygen reduction, discharge of hydrogen ions, ionization of metal, etc.) are expressed by one general value $\frac{\Delta V}{I}$, i.e., the potential drop for a given strength of the corrosion current. For the flow of electrons within metal, or that of ions through the solution, this value is equivalent to the ohmic resistance of the metal or to that of the electrolyte. For the reaction of oxygen reduction, or for the discharge of hydrogen ions, the value $\frac{\Delta V}{I}$ indicates the shift of the electrode potential (its polarizability) owing to interference in the progress of the cathodic reaction. Consequently, this shift of potential will characterize the ionization overvoltage of oxygen, or, similarly, hydrogen overvoltage.

For the diffusion of oxygen or hydrogen ions, this value determines a change of electrode potential at a given general rate, due to inhibition of the process by the transport of oxygen or diffusion of hydrogen ions; i.e., it obviously corresponds to a concentration polarization of the electrode. All the remaining stages of the corrosion process can, in a similar manner, be represented by a more or less pronounced drop in potential for a given strength of corrosion current, or, what amounts to the same thing, by some resistance to the continuation of attack at some given stage of the process.

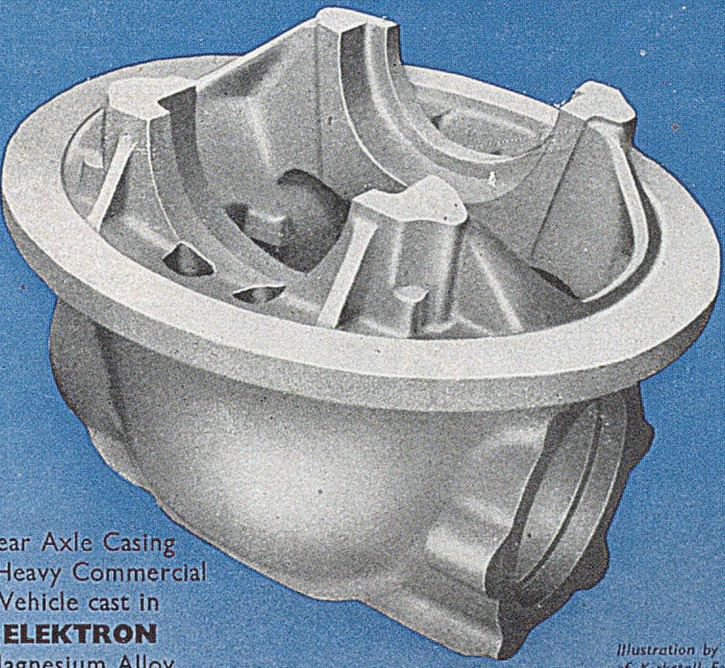
In Fig. 20 (Fig. 6 in the Russian text) each discrete stage of the corrosion process is depicted as a certain resistance to the progress of a specific stage, the width of each field being in inverse ratio to the assumed resistance of a given stage of the process. The individual stages of the corrosion cycle are so interconnected as to reproduce the sequence, in which (according to existing views) they proceed in actual instances of electrochemical destruction of metals.

Just as in an ordinary electric circuit with branching conductors, the overall velocity of the corrosion process (total strength of current) for a series-connected sequence will be mainly determined by those stages with the lowest velocity (i.e., with the greatest resistance). For a parallel-connected sequence, the overall velocity of the process will be governed by that stage having the maximum velocity (i.e., the minimum resistance).

In Fig. 20 are shown resistance values, or, what is the same thing, potential drops, at a definite strength of the corrosion current for the following elementary stages of the corrosion process:—

(1) The passage of metallic ions into the solution and their hydration

$$\theta \longleftarrow (\theta\ Me^{+}) \longrightarrow Me^{+}\ .\ n\ H_2O\ ;$$



(2) The diffusion of metallic ions through the film on the metal surface into the solution, and that of anions of the electrolyte in the opposite direction.

(3) Diffusion of metallic ions from the anode into the body of the electrolyte, and that of anions in the reverse direction.

(4) Migration of anions and cations in the solution under the action of electric current.

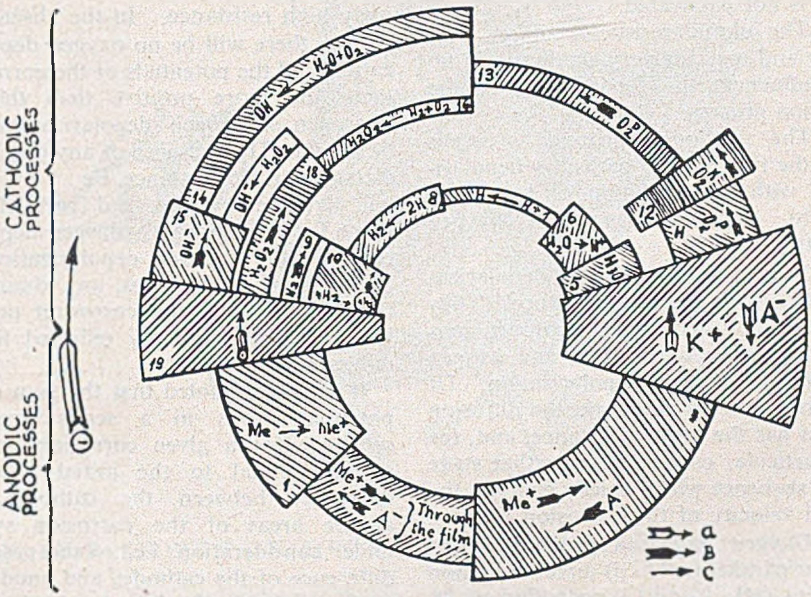


Fig. 20.—Corrosion diagram of Tomashoff: A, direction of motion of electrons or ions under the action of an electric field; B, direction of motion of particles under the influence of diffusion or convection; C, direction of the reaction (Fig. 6 in Russian text).

(5) Diffusion of the hydrated ions of hydrogen H_3O towards the cathode and that of hydroxyl ions in the opposite direction.

(6) Dehydration of the hydrated hydrogen ions.

(7) Discharge of hydrogen ions (which, in turn, may be regarded as a resultant of several elementary stages), $H^+ + \theta \longrightarrow H$;

(8) Combination of hydrogen atoms to form molecules.

(9) Diffusion of hydrogen molecules from the cathode.

(10) Formation and detachment of hydrogen bubbles from the cathode surface.

(11) Passage of oxygen through the boundary surface: air—solution (O_2^F).

(12) Transmission of oxygen by convection through the main body of solution (O_2^D).

(13) Diffusion of oxygen through the static (diffusion) layer of electrolyte adjacent to the cathode (O_2^K).

(14) Oxygen reduction at the cathode surface with the formation of ions OH^- ; $O_2 + 4\,\theta + 2\,H_2O \longrightarrow 4\,OH^-$.

(15) Diffusion from the cathode of the OH^- ions formed in the process of oxygen depolarization.

(16) Reduction of oxygen to hydrogen peroxide (which process, in its turn, consists of several stages):

$$O_2 + 2\theta + 2H_2O \longrightarrow H_2O_2 + 2OH^-.$$

(17) Further reduction of hydrogen peroxide to OH^- : $H_2O_2 + 2\theta \longrightarrow 2OH^-$.

(18) Diffusion from the cathode of any hydrogen peroxide not reduced to OH^-.

(19) Process of electron flow within the metal (this is characterized by the electrical resistance of the metal).

Such diagrams, constructed according to approximate data available on corrosion, may give an adequate semi-quantitative picture of the nature of the corrosion process under consideration.

From inspection of Fig. 20 we can, for example, make the following deductions as to the character of the corresponding corrosion process:—

(a) Corrosion proceeds without any noticeable slowing-down of the anodic processes (No. 1 and No. 2); i.e., the metal is not passivated.

(b) The ohmic resistance of an electrolyte and metal is very small and in no way influences the general rate of the corrosion process.

(c) The cathodic process proceeds along the two parallel paths: by depolarization with the evolution of hydrogen, and by depolarization with oxygen ionization.

(d) Processes of cathodic depolarization exhibit the greatest resistance. They comprise the discharge of hydrogen ions in hydrogen depolarization, and oxygen diffusion in oxygen depolarization. Of these two parallel reactions, the diffusion process has the lower resistance, and, for any particular case, represents that stage of the sequence which chiefly controls the overall velocity of the corrosion process.

(e) Oxygen reduction proceeds along the two parallel paths: (i) direct reduction of O_2 to OH^-, and (ii) reduction of O_2 to H_2O_2, with the further partial reduction of H_2O_2 to OH^-.

(f) Although the resistance of the oxygen ionization stage is smaller than that of oxygen diffusion, it has, however, a commensurable value and exerts, also, a marked effect on the overall velocity of the process.

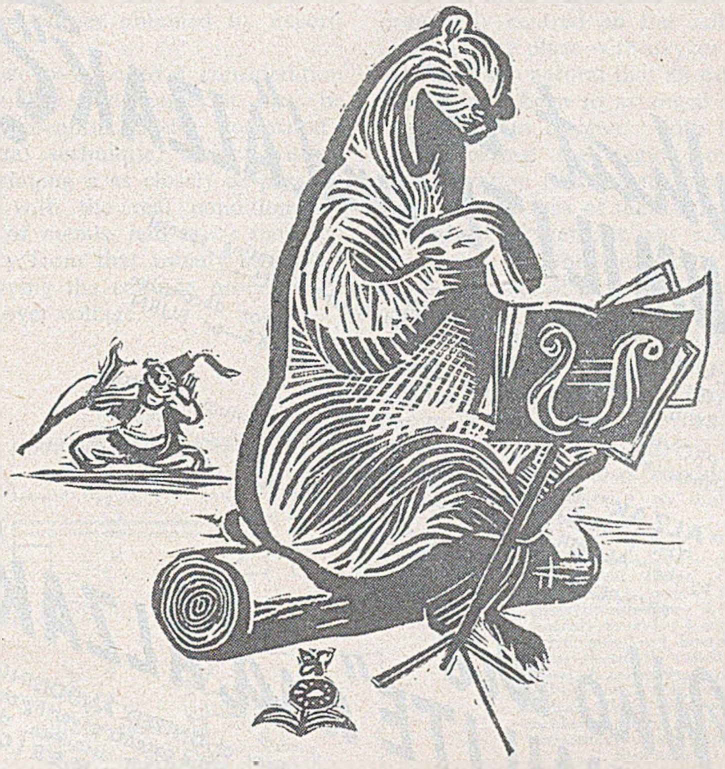
(g) The passage of oxygen through the boundary zone, electrolyte—air, the transference (by convection) of oxygen to the cathode, and the diffusion of the OH^- ions from the cathode and Me^+ from the anode; these stages in the sequence have a low resistance and consequently exert little influence on the corrosion process.

Naturally, if conditions in the system change, the relationship between the resistances of the elementary stages in the sequence will also be altered. Thus, for example, if corrosive conditions involve marked passivation, great resistance will be offered to the transmission of metal ions through the surface film (i.e., field No. 2 in Fig. 20 would then have a small cross-section). In the case of corrosion in media of low conductance, stage No. 4 in the sequence will exhibit a correspondingly high resistance. In the absence of oxygen there will be no oxygen depolarization. If the potentials of the corroding metal be more positive than that of hydrogen, hydrogen depolarization will be absent. The presence of any other oxidizing agent (for instance, Fe^{+++} ions) will give rise to a new field (parallel with those for oxygen and hydrogen depolarizations)—the cathode depolarization by this oxidizer, etc. Thus, any change in the conditions of the corrosion process will be correspondingly reflected in the diagram.

It should be noted that the sum of all potential drops in a series-connected sequence for a given corrosion process will be equal to the initial potential difference between the cathodic and anodic areas of the corrosion system under consideration: i.e., to the potential difference of the cathodes and anodes on open circuit (e.m.f. of the local cell). The sum of the potential drops due to ohmic resistance of the local couple in the external and internal circuit (i.e., fields No. 4 and No. 19 in Fig. 20) gives the effective actual potential difference of the cathodic and anodic areas under the given corrosion conditions. The sum of the potential drops at the individual areas (except those due to ohmic resistance) will correspond to variation of the initial potential difference by reason of the polarization processes.

Experimental Study of the Efficiency of Various Cathode Materials.—Methods

The individual characteristics of the performance of different cathode materials in the process of oxygen depolarization can be most completely



evaluated on the basis of analysis of polarization curves obtained by experiment.

Before we pass on to a consideration of their utility and scope, it may be helpful to mention briefly Tomashoff's experimental technique, which, with a view to bringing it as closely as possible into line with the real conditions of corrosion of metals, had to be modified appreciably from that usually employed when studying the cathode processes of hydrogen over-voltage.

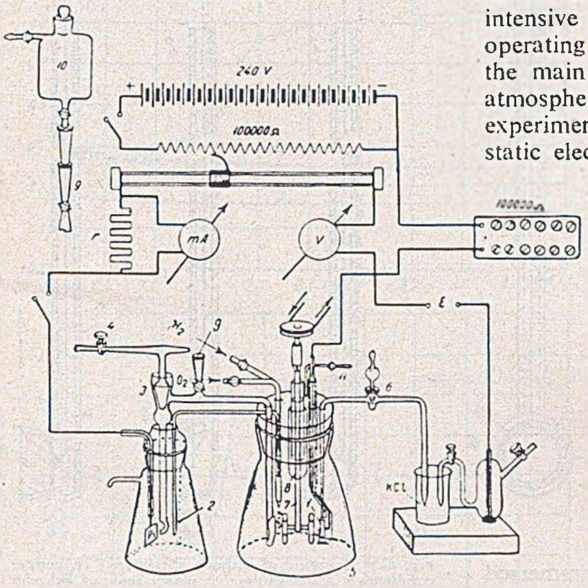


Fig. 21.—Apparatus for determining experimental curves of cathodic polarization in oxygen: 1, electrode under investigation; 2, vessel for auxiliary electrode; 3, cock for electrolytic switch; 4, branch tube for filling electrolytic switch; 5, main vessel; 6, connecting cock for calomel electrode; 7, stirrer; 8, bell of hydraulic lock; 9, connection for auxiliary vessel; 10, 11, air-communicating tubes. (Figure 10 in Russian text.)

As an electrolyte, 0.5N aqueous NaCl was employed, as in the process of cathode polarization, an initially neutral solution becomes alkaline in the proximity of the cathode, and because this variable pH at the cathode is highly undesirable from the viewpoint of a satisfactory reproducibility of the experiments, it was decided to use electrolytes weakly buffered with sodium carbonate or bicarbonate reckoned to give in solution 0.005M Na_2CO_3 and 0.005M $NaHCO_3$, having a pH value of about 9.2. Measurement showed that this figure did not markedly vary in the course of cathodic polarization.

As in these researches attention was principally centred on the cathode processes taking place with oxygen depolarization, it was natural that all experiments should have been so arranged as to give free access to oxygen. With the object of increasing the region of oxygen depolarization (that is, to bring about a more distinct area of the ionization over-voltage of oxygen), it was necessary to accelerate to the maximum possible degree the rate of oxygen diffusion to the cathode; for this purpose the electrolyte in the cathode space was subjected to intensive agitation by means of a stirrer operating at 2,000 r.p.m. Parallel with the main experiments performed in an atmosphere of oxygen, comparative experiments were also conducted in a static electrolyte in air, as well as in a non-buffered 0.5N solution of NaCl and several other electrolytes. To diminish the influence of variations of concentration, the quantity of solution employed was fairly large—usually about 500 cm.^{3} for each experiment. The experimental installation used for obtaining the polarization curves in an oxygen atmosphere, and circuit connections, are shown in Fig. 21.

The electrode material under investigation, I, is in the form of a cylinder or disc 16 mm. in diameter, sealed into a glass tube in such a way that the working cathode surface is constituted by a circular face with an area equal to 2 cm.^{2} The mounting arrangement for the various types of the cathode material is indicated in Fig. 22. Section A shows the cathode fixture. The cathode itself, in the form of a cylinder 4 to 8 mm. in height, may be turned to shape and is welded to a copper lead. One or two layers of phenolic-resin-impregnated tissue paper are then wound round the cylindrical surface of cathode, which is then inserted tightly into a specially shaped glass tube. After drying, first at room temperature and then at 60 degrees C., the resin varnish is cured by heating for several hours at 120 degrees C.; the resulting plastic seal ensures a strong, impermeable bond between the metal specimen and glass. If the electrode material be in sheet form, its mounting is effected as shown in Fig. 22, section B; in this case the specimen, in the form of a metal disc, is first joined by means of a synthetic-resin adhesive to a "Textolite" washer, and then mounted in the same way as for the cylinder. Specimens were mounted direct on to the glass tube (Fig. 22, C) when the cathode was required to undergo preliminary treatment in alkaline media, or in certain experiments designed to check up the absence of any influence of the phenolic-resin seal upon the electrode process. The platinum electrode serves as an auxiliary electrode for polarization; it is placed in a separate vessel, 2 (Fig. 21), and immersed in the same electrolyte.

The cathodic and anodic spaces are connected by means of an electrolytic switch with a tap, 3, which was kept in the "off" position in all the polarization experiments, with the object of avoiding the transport of oxygen or ozone, and of platinum ions (if any) formed at the anode, to the cathode under test. The electrolytic switch is provided with a branch, 4, for drawing off the electrolyte from the main vessel, 5, and the auxiliary vessel, 2.

As the electrolytic switch with the tap, 3, closed has a high electrical resistance (about 20,000 ohms), it is necessary, to induce polarization, to employ a battery of accumulators giving a potential difference up to 240 volts. The electrical circuit arrangement permits the strength of current in the cathode circuit to be raised from zero up to approximately 10 mA without disconnecting the electrode. The current strength is measured by means of a micro-galvanometer (sensitivity 1.4×10^{-8} A.; complete period of oscillation, 0.2 sec.). Depending on the necessary limit of sensitivity, the galvanometer may be shunted for the following resistance range: 100, 10, 1, 0.1 or 0.01 ohms. The voltmeter V is used for the control of voltage supplied to the system under investigation.

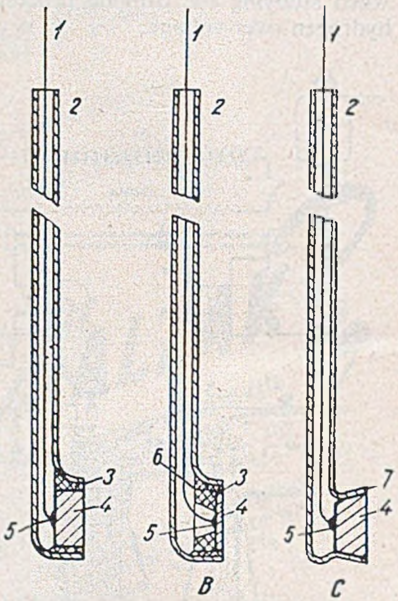


Fig. 22.—Mounting of cathode specimens: 1, copper conductor; 2, glass tube; 3, plastic seal; 4, cylinder or disc of cathode metal; 5 welded joint between copper lead and cathode; 6, plastic washer (Textolite); 7, mounting of specimen direct to ground glass tube. (Figure 11 in Russian text.)

The potential of the polarized electrode (ϵ) is measured by means of Raps potentiometer in relation to a normal calomel electrode, connection for this being effected through the electrolytic switch 6. One end of the connecting switch, together with the nose of the calomel electrode, is dipped into normal

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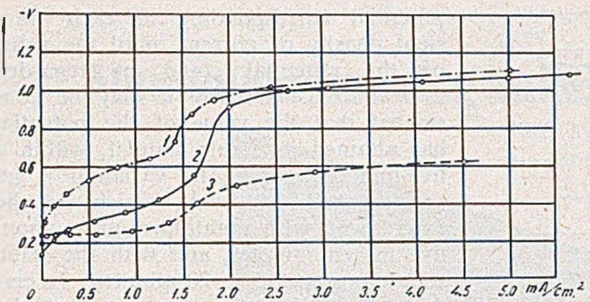

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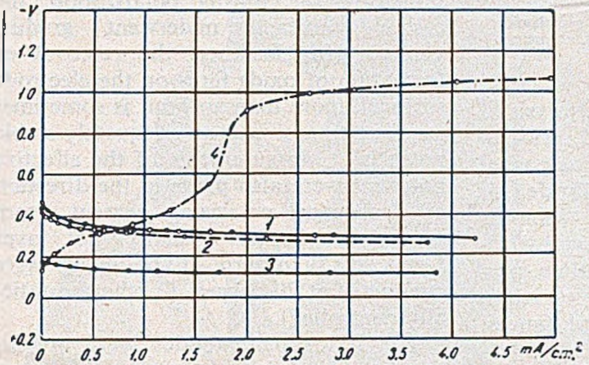

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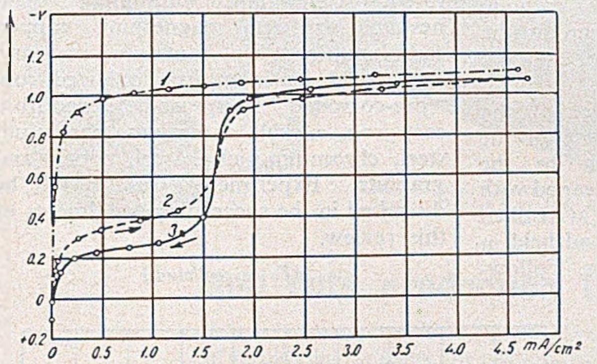

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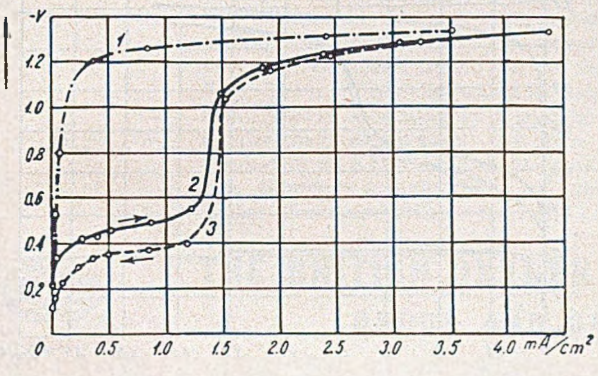


Fig. 23.—Cathodic polarization of iron in 0.5N NaCl at various pH values:

1 0.5N NaCl + 0.01N NaOH;
2. 0.5N NaCl + 0.005N Na_2CO_3 + 0.005N $NaHCO_3$;
3. 0.5N NaCl + 0.01N HCl.

(Figure 23 in Russian text). Fig. 24.—Anodic polarization of iron: 1, with agitation in hydrogen atmosphere (black circles on curve indicate reverse course); 2, static electrolyte in hydrogen atmosphere; 3, with agitation in oxygen atmosphere; 4, cathodic polarization of iron. (Figure 24 in Russian text). Fig. 25.—Cathodic polarization of nickel: 1, static electrolyte; 2, direct course; 3, reverse course. (Figure 25 in Russian text). Fig. 26.—Cathodic polarization of chromium: 1, static electrolyte; 2, direct course; 3, reverse course. (Figure 26 in Russian text).

KCl, the other being joined to the capillary, the end of which is located in the immediate proximity of the cathode surface. The cock of the electrolytic switch 6 was also kept closed throughout the experiment.

To ensure maximum aeration of the electrode, the blades of the stirrer Z are situated at a distance of 5 to 6 mm. from the cathode surface, at the same level with the cathode. The shaft of the stirrer is fitted with a glass bell 8, filled with the same electrolyte as that in the vessel 5, for effecting the hydraulic locking.

The tube II, in the top part of the main vessel, serves as a channel for communicating with the atmosphere, a necessary condition for filling the vessel with the electrolyte, in order to complete displacement of air from the system, may be effected at the beginning of the experiment. Excess electrolyte from the main vessel, 5, is then transferred by the oxygen pressure into the vessel 2. Before commencing the experiment, and throughout the run, oxygen was passed through the elec-

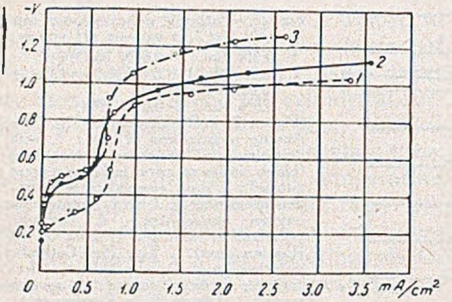


Fig. 27.—Comparative curves for cathodic polarization in air:—1, iron; 2, chromium steel; 3, chromium. (Figure 27 in Russian text.)

trolyte. It was obtained by electrolysis of sodium hydroxide solution, and, prior to admission into the apparatus, was passed successively through calcium chloride (for drying), through palladinized asbestos at 300 degrees C., to remove hydrogen, and, finally, through alkaline permanganate to oxidize possible inclusions of SO_2 and organic substances. If required, it is possible to pass hydrogen or air through the apparatus for cathode polarization. This installation can also be utilized for the studying of anodic polarization.

Immediately before the start of the experiment, the working surface of the electrode, prepared according to the scheme shown in Fig. 22, was cleaned with the finest emery paper, washed in distilled water, dried with filter paper and held in a desiccator, for about one hour. Following measurement of the initial electrode potential prior to impressing the external voltage, the electrode was then polarized by the application of steadily increasing current, with periodic measurements (within one, three, five, ten minutes, etc.) of the potential corresponding to each transient density of current, until the value of the potential could be regarded as stabilized. Usually it may be considered that the value of the potential has attained its stable state if, within a five-minute interval, its variation is no greater than 0.01 volt, which, in the experiments with agitation, requires about five to ten minutes, and with the static solutions some 15 to 20 minutes. In certain cases, if, during polarization, the cathode surface underwent gradual changes (for instance, the removal or formation of oxide films on the electrode surface), more than an hour is sometimes required to arrive at an adequately stable potential. Measurements of the effective potential were also made in the direction of decreasing polarizing current, from maximum density (usually not over 5 mA./cm.^{2}) to zero. Experiments were conducted at 20 degrees C. (thermostatically controlled).

The following cathodes were investigated:—Aluminium, duralumin, magnesium, oxidized magnesium, copper, cadmium, lead, tin, tantalum, mercury, silver, gold, platinum, iron, oxidized iron, " pre-corroded " iron, case-hardened iron, cast iron, nickel, chromium, chromium steel, chromium-nickel steel, cobalt and graphite. Experimental results will be discussed in the succeeding instalments of this review.

(To be continued.)

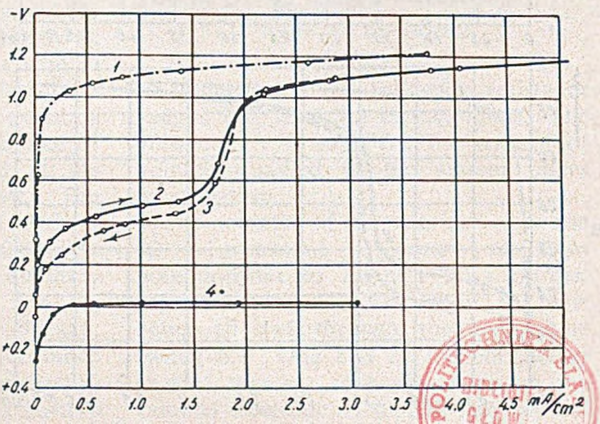
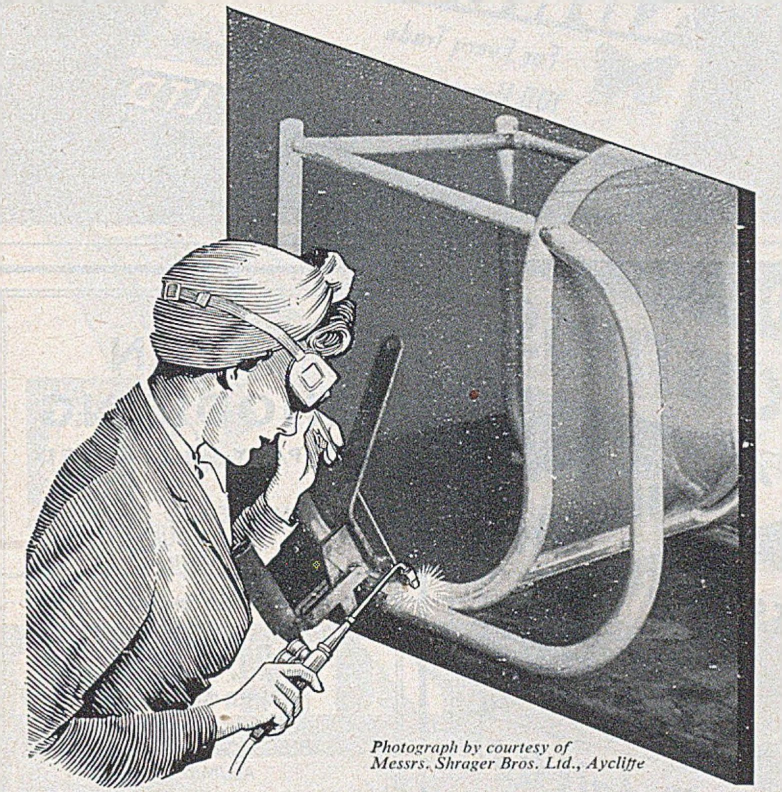
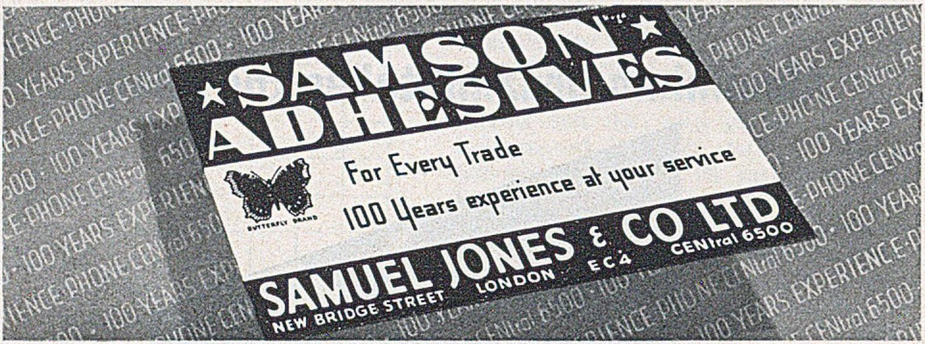


Fig. 28.—Cathodic polarization of 8/18 nickel-chromium steel:— 1, static electrolyte; 2, direct course; 3, reverse course; 4, with additions to electrolyte of 0.1N $FeC2_3$. (Figure 28 in Russian text.)





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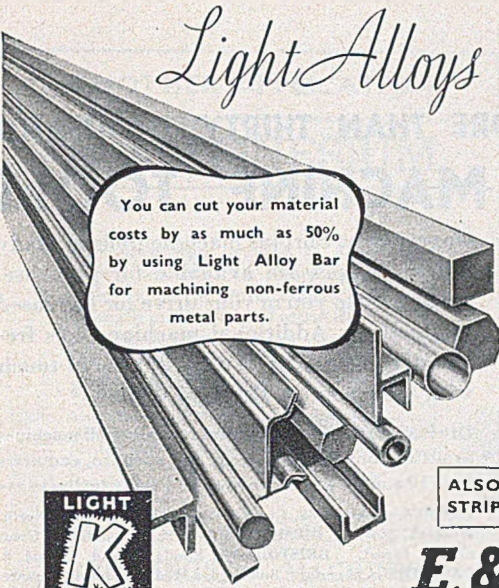


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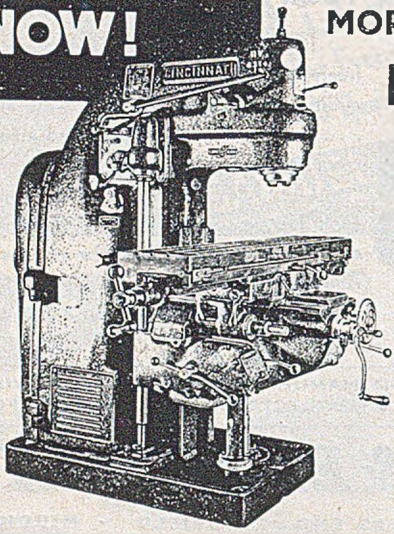

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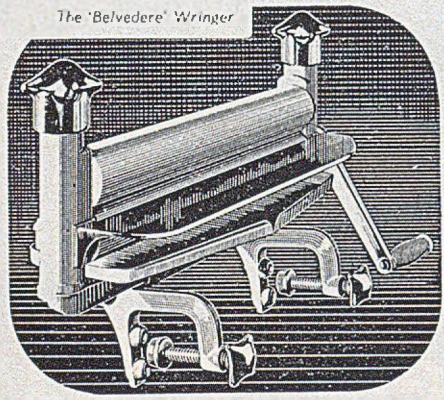

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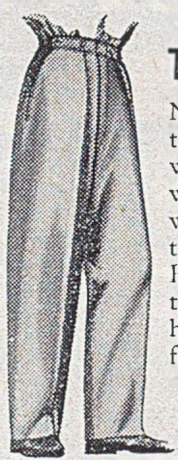

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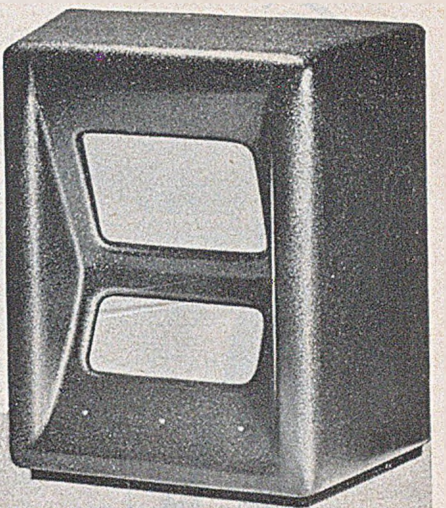

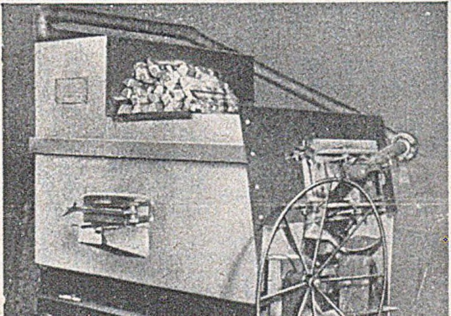

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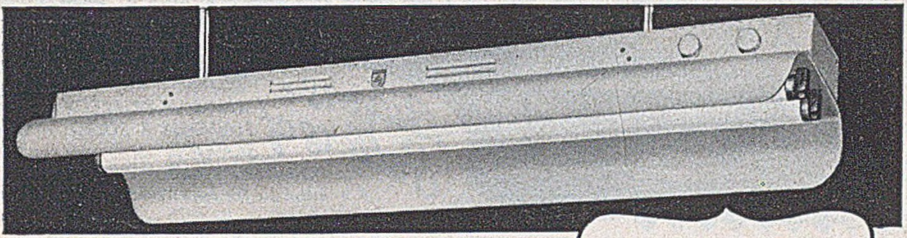

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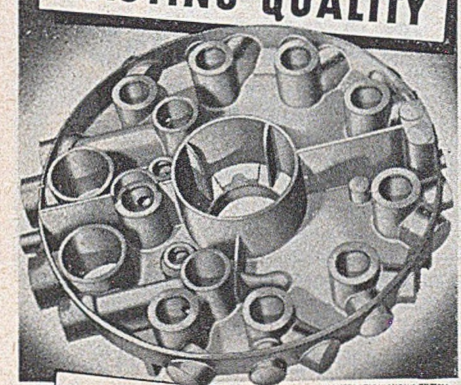

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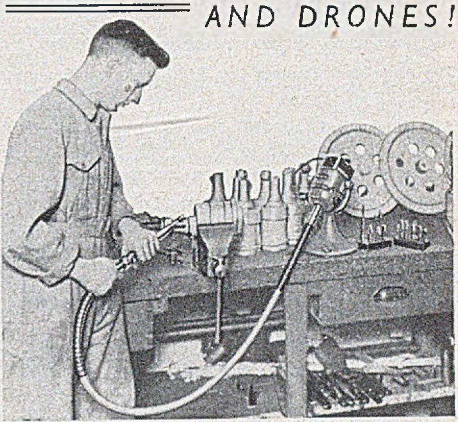

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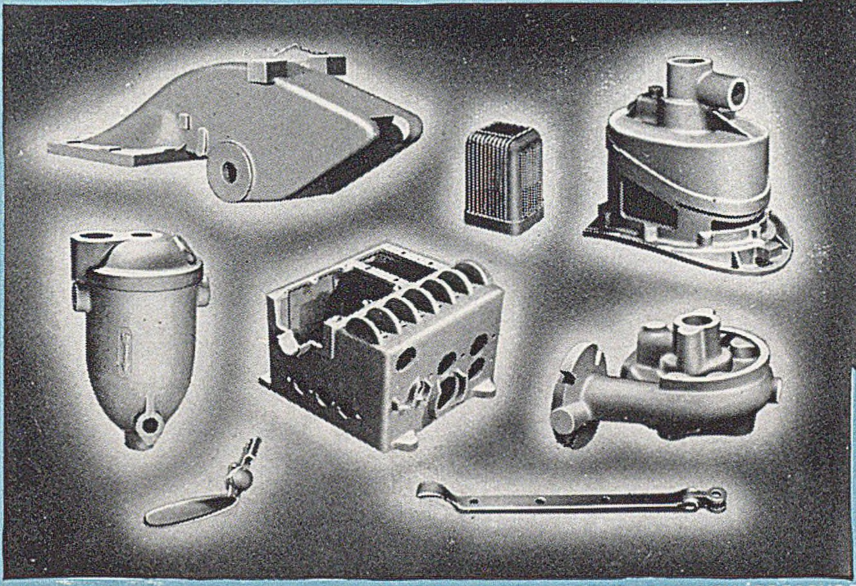

Vol. XI. No. 121 LIGHT METALS FEBRUARY, 1948

A perfect Casting . . .

At breakfast everything was wrong. First the coffee. Then the new maid. (Anyway she left the same morning!) Now everything is wrong with the news! Yes, Father (LESLIE BANKS) is hard to please . . . like all men who insist on perfection in an imperfect world. A close-up from "LIFE WITH FATHER". The play ran on Broadway for 8 years! Now it's a big hit in London's Savoy Theatre — due to a perfect casting by Firth Shephard.

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