A Note on Magnesium Alloy for Castings*

The Properties and Practical Processes in the Production of Magnesium Alloy Castings with Special Reference to Elektron

By E. Player

In recent years several interesting and excellent papers have been read before various Societies, dealing with magnesium and its alloys.

So far as the author is aware, however, none of these papers has dealt with the practical side of the manufacture of magnesium alloy castings in any detail.

It is in the belief that a description of the practical processes involved in the manufacture of such castings will be at least as interesting as a purely metallurgical thesis, that this paper is presented.

There still exists an impression that magnesium alloys, interesting though they are, yet remain in the experimental stage, and that their commercial production and application is some distance ahead.

It is hoped that this paper will show to engineers and metallurgists that this idea is erroneous.

It will be seen from the data to be given and the examples quoted that the production of magnesium alloys in all forms is now on a strictly commercial scale of quantity, technical excellence, and cost, thus offering the engineer a new material possessing many desirable qualities.

It is proposed to confine this paper mainly to the manufacture, properties and applications of magnesium alloy castings, as obviously any attempt to deal with forgings, sheet, extrusions and the like demands too great a time and space.

It should be stated that all the data quoted refer to the alloys known under the trade name of "Elektron," magnesium being the base of these alloys, and this name will be used for the sake of convenience.

The author is indebted to the I. G. Farbenindustrie Aktiengesellschaft, Frankfurt A. Main, and to Sterling Metals, Ltd., Coventry, for permission to publish much of the information given, and it may here be mentioned that the first-named concern has not only pioneered the production of magnesium on a large scale, but has also developed the special technique which has made the manufacture of sound elektron castings a commercial success.

History

Magnesium was first isolated by Sir Humphrey Davy in 1808, and in the long period which has since elapsed, it may be said that no appreciable progress toward commercial production and application was made till well on in the present century.

Outside the laboratory, magnesium chiefly existed as photographer's flash powder and ribbon, and this fact has unfortunately created the general impression that magnesium is dangerous to use as an engineering material on account of its inflammability. The conception is, of course, entirely a mistaken one.

About 1907, the then Griesheim Elektron (now part of I.G.F.A.-G.) began seriously to attempt the commercial production of magnesium metal, using as a raw material $Mg\ Cl_2$, which was largely a waste by-product arising from the extraction of potassium salts from the Stassfurt beds in Germany. The process which was eventually successfully developed is briefly outlined below, and brings this short historical note up to the present day.

Production of Magnesium

Magnesium is largely produced by the electrolysis of $Mg\ Cl_2$, the complete electrolyte consisting of this compound mixed with K Cl or Na Cl.

The mineral carnallite, found in the Stassfurt beds, has been the chief source of supply hitherto.

This is a double chloride of Mg. and K with the formula $Mg\ Cl_2\ KCl\ 6\ H_2O$.

Before charging into the cells, the carnallite must be dehydrated, after which the finely powdered mineral is put into an iron pot, which forms the cathode. Carbon anodes are usually employed.

Electro-Chemical Series of Metals

1. Cæsium.	17. Nickel.
2. Rubidium.	18. Tin.
3. Potassium.	19. Lead.
4. Sodium.	20. (Hydrogen).
5. Lithium.	21. Antimony.
6. Barium.	22. Bismuth.
7. Strontium.	23. Arsenic.
8. Calcium.	24. Copper.
9. Magnesium.	25. Mercury.
10. Aluminium.	26. Silver.
11. Chromium.	27. Palladium.
12. Manganese.	28. Platinum.
13. Zinc.	29. Gold.
14. Cadmium.	30. Iridium.
15. Iron.	31. Rhodium.
16. Cobalt.	32. Osmium.

The mixture of chlorides is fused and simultaneously electrolysed by the current passed through it, chlorine being developed at the anode and magnesium discharged at the cathode. The necessity of disposing of the liberated chlorine harmlessly, and the cost of dehydrating the carnallite have led to the development of a process using the oxide or carbonate as a base, these minerals being widely distributed.

Where the carbonate is employed, it is first calcined to reduce to the oxide.

This is then mixed with powdered fluorides, such as Ca F, which on being fused by the current in the cell dissolve the Mg O, and thus form a fluid electrolyte.

An iron pot forms both container and cathode, and a carbon anode is used.

Oxygen is liberated at the anode, and burns to form CO_2 at the surface of the bath. Magnesium is deposited at the cathode, and is removed from time to time in a manner similar to that employed in the aluminium reduction cell.

The metal thus produced may be contaminated by up to 10 per cent. of electrolyte, which is removed by remelting under a suitable flux. The oxide process has the following advantages :—

(1) The minerals used, $Mg\ CO_3$ and Mg O are widely distributed in workable quantities and are cheap.

(2) No dangerous gases are evolved at the anode.

(3) The process is continuous.

The resultant metal is of a high degree of purity, generally well over 99 per cent. pure.

Chemical Properties

The outstanding characteristic of magnesium is its strong affinity at high temperatures for oxygen, and this one fact is responsible for most of the difficulties encountered in the reduction of the metal from its compounds, in manipulating its alloys in the furnace, forge and foundry mould, and in using the alloys for any wide range of engineering purposes.

The means whereby these difficulties have been overcome constitute, in the author's opinion, the most interesting part of this paper.

Magnesium combines with atmospheric oxygen when raised to a temperature of 650° C. As this reaction is productive of great heat, the temperature of the burning metal is raised sufficiently to cause the formation of nitrides through the combination of magnesium with atmospheric nitrogen. This latter reaction occurs at anything above 670° C. approximately. Magnesium, in contrast to aluminium, is attacked by most acids, with the curious exception of hydrofluoric acid. On the other hand, it is practically unaffected by alkalies, not excluding powerful reagents like sodium and potassium hydrates, whether in the form of dilute or concentrated solutions. Magnesium and its alloys are attacked by saline solutions, such as sea water, to a greater extent than aluminium, and this fact has led to the development of special alloys and methods of coating which have greatly improved resistance to salt-water corrosion.

On exposure to ordinary atmospheric conditions, magnesium alloys become quickly coated with an oxide film, which then acts as a protection against further attack.

This characteristic is similar to that displayed by aluminium.

At sufficiently high temperatures magnesium will attack silica and form Mg_2Si. It will be at once seen that this constituted an early problem which had to be solved before satisfactory sand castings could be produced. As magnesium also decomposes water rapidly at temperatures at or above its melting point (651° C.), it will be appreciated that means had to be devised whereby, in pouring sand-moulded castings, reaction could be inhibited between the molten magnesium and the free

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moisture and/or the water of hydration in the clay bond of the moulding sand.

Magnesium is unaffected by petrol, paraffin, or lubricating oils provided they are free from water and acids. The metal does not combine with sulphur either in the fused or solid condition, in this respect having an advantage over many other metals in common use.

It is now generally recognised that the corrosion of alloys is very frequently caused wholly or partly by electrolysis set up under suitable conditions between two of the metal constituents of the alloy, and this is confirmed by the undoubted fact that a chemically pure metal will nearly always exhibit a far greater resistance to a corrosive reagent than any of its alloys.

If this is admitted, it will be obvious that, in seeking a magnesium alloy which will possess the greatest possible resistance to corrosion, a first step will be to select, as alloying constituents, those metals which stand nearest magnesium in the electro-chemical series, provided always that such selected metals produce alloys with good working qualities and physical properties.

It will be seen from the table showing the relative positions of the various metals in the electro-chemical series that magnesium is electro-positive to all the metals commonly employed in engineering practice. Thus any metals which can be used to improve the physical properties of pure magnesium will be electro-negative to the matrix metal.

For reasons so obvious that they need not be detailed, the choice is really confined in practice to the following :—

Aluminium.	Nickel.
Manganese.	Tin.
Zinc.	Lead.
Iron.	Copper.

With the addition of the non-metal silicon.

Of these eight metals, iron does not alloy with Mg, and the alloys of nickel, tin, and lead have so far shown no very useful properties, whilst the copper alloys have serious disadvantages. Thus the selection narrows down to aluminium, manganese, zinc, and silicon.

Magnesium forms alloys with zinc, aluminium and copper which have excellent casting qualities and physical properties.

As might be expected from its relative position in the electro-chemical series, however, copper forms alloys which are very subject to corrosion under certain conditions commonly met with, such as exposure to damp atmosphere, this arising from the galvanic action set up between the magnesium and the copper. For this reason, copper does not form a principal constituent of any of the elektron alloys. Aluminium and zinc, however, as will be appreciated from what has been said, form binary and ternary alloys with magnesium which not only have good physical properties but are, in addition, satisfactorily resistant to corrosion under all ordinary working conditions.

Manganese, whilst not exercising any noteworthy influence in improving the physical properties of the alloys, has a pronounced effect in improving resistance to corrosion, and for this reason, a small amount, generally about 0·3 per cent. forms an essential part of all elektron alloys. Higher percentages do not make observable improvement.

Alloy AS.82, composition of which is given in Table 1, contains 2 per cent. silicon, and

TABLE I

Symbol Application	Zn	Al	Si	Cu	Mn	Melting Point
						deg. C.
AZF Sand castings ..	3·0	4·0	0·3	0·3	0·35	635
AZG " " ..	3·0	6·0	0·3	0·3	0·35	635
V1 Die castings and forgings	0·6	10·0	0·3	0·3	0·35	635
AZ31 Forgings ..	1·0	3·0	0·3	0·3	0·35	
AS.82 " ..	0·5	8·0	2·0	0·3	0·35	
AZM Forgings and sheets	1·0	6·3	0·2	—	0·35	

is susceptible to hardening when subjected to a suitable heat treatment.

Composition of Elektron Alloys

The adjoining Table I gives details of the composition of the various elektron alloys which are used in the production of castings, forgings, etc.

The alloy AZG is now chiefly used for sand castings, having a somewhat higher yield point than the older alloy AZF, whilst still giving a somewhat higher elongation than aluminium alloy L.5. V1 is specially suitable for die castings, being less subject to hot shortness than the zinc bearing alloys. It is also useful in the sand foundry where castings of greater hardness and rigidity are required than can be obtained from AZG alloy, with lower elongation.

All the alloys classed as for forgings are used for the production of stampings and extruded sections, having various physical properties to suit a variety of requirements.

Physical Properties of Elektron Castings

Strength

The characteristic of elektron alloys which is of most interest to the engineer is undoubtedly the low specific gravity combined with good mechanical strength.

The specific gravity of elektron averages 1·82 as against those of the usual aluminium alloys 2·83 to 3·0. Table II gives the approximate specific gravities of the metals and alloys commonly employed in engineering construction.

TABLE II.—*Specific Gravities*

Metal	Specific Gravity	Density Factor
Elektron	1·82	1·0
Aluminium L.5	2·95	1·62
Aluminium L.11	2·85	1·56
Aluminium 11 per cent. Si	2·66	1·46
Steel	7·8	4·25
Cast iron	7·2	3·94
Cast brass	8·6	4·7
Extruded brass	8·6	4·7

This low specific gravity would, of course, be of little service to the engineer unless accompanied by reasonably good strength values. In this respect, elektron has much the same characteristics as the usual aluminium alloys, and Table III indicates the relative strength of various engineering alloys, including elektron.

TABLE III.—*Mechanical Properties of Sand Castings Tons/Sq. In.*

Material	Yield Point	Ultimate Stress	Elongation Per cent.	Brinell Hardness	Specific Gravity	Mass-Strength Ratio $\frac{\text{Ultimate Stress}}{\text{Specific Gravity}}$
Elektron A.Z.G. ..	6–7	9–11	4	50–60	1·82	5·5
Aluminium L.5 ..	6–7	9–11	3	50–60	2·95	3·4
Aluminium L.11 ..	7·2	9–10	2	60	2·85	3·33
Aluminium Sil (Mod.)		12	8		2·66	4·5
" Y " alloy as cast ..	10	11·9	1·5	89	2·80	4·2
" Y " alloy heat-treated	13·9	14·7·	1	100	2·80	5·25
70/30 brass	6·5	13·15	30–40	50	8·6	1·7
Cast steel ..	17–19	28·32	10–12	150	7·8	3·35
Cast iron ..		11·15	Nil		7·2	1·8
Malleable cast iron	13–17	20–24	6	150	7·2	3·1

The mass-strength ratio is calculated by dividing the mean of the figures given for each metal in the ultimate strength column, by the specific gravity of the metal.

It will be at once seen that this ratio is a valuable guide in selecting the most suitable metal for any particular duty, and, aside from such considerations as cost, chemical properties, etc., it will be found that, generally speaking, metal is most suitable which offers the lowest total weight whilst possessing a given standard of mechanical properties.

The figures quoted in the tables are necessarily approximate, but may be accepted as results usually to be looked for in general engineering practice.

In the Table referring to sand castings, the results are those usually to be obtained from sand cast test bars, correctly poured.

Chill cast bars will always show results from 25 per cent. to 50 per cent. higher in ultimate stress and elongation, both on magnesium and aluminium alloys.

The tables showing the strength figures for the various metals used in engineering are largely self explanatory.

It will be noticed that the elektron alloy AZG has, in the sand condition, physical characteristics very similar to those of Aluminium L5 alloy, though it is, of course, approximately 40 per cent. lighter.

It is interesting to observe that only one casting alloy shows a mass-strength ratio approaching that of Elektron AZG, this being " Y " alloy in the heat-treated condition. There are, however, as is well known, many serious difficulties in producing large " Y " alloy sand castings that are thoroughly sound and free from cracks, draws and pin holing. These difficulties do not exist to anything like the same extent in the case of elektron and, furthermore, expensive and difficult heat treatment is necessary to obtain the relatively high figures instanced for " Y " alloy.

TABLE IV.—*Mechanical Properties of Wrought Alloys Tons/Sq. In.*

Material	Yield Point	Ultimate Stress	Elongation Per cent.	Brinell Hardness	Specific Gravity	Mass-Strength Ratio $\frac{\text{Ultimate Stress}}{\text{Specific Gravity}}$
Elektron VI. w. quenched	15–17	22–24	8–10	70	1·82	12·6
Elektron VI. h. aged ..	16–18	22–26	2–3	85–90	1·82	13·2
Elektron AZM as forged ..	15–17	20–24	10–12	65–70	1·82	12·1
Elektron or rolled ..	15–17	18–20	8–10	60–65	1·82	10·4
Elektron SZ	8·10	14–16	10–15	44	1·82	8·2
Duralumin, aged ..	18–20	24–27	10–15	100	2·80	9·1
Duralumin, annealed	12–14	20–24	15–20	60–80	2·80	7·9
" Y " alloy heat treated ..	15	20–25	10–20	100	2·80	8·05
60/40 brass	16	25	20	120	8·6	2·9
Manganese bronze ..	18–20	35	25	130	8·6	4·05
Mild steel ..	22	38	33	149	7·8	4·85

The Elektron alloy VI (10 per cent. Al. 90 Mg.) has stress figures very similar to those of aluminium alloy 2L11.

Shock resistance is at least equal to that of the aluminium alloys, and liability to deformation under stress is less than is the case with the aluminium silicon alloys.

Rigidity is good, though not, of course, equal to that of cast iron.

Machine Shop Practice

All the magnesium alloys possess excellent machining qualities, in this respect comparing favourably with aluminium. The latter metal is rather difficult to handle where fine threads and specially smooth finish are required.

Magnesium alloys can be machined at considerably higher speeds than nearly all other metals, and fine and accurate finish obtained without the necessity of costly finishing operations.

These properties are of considerable value in modern manufacturing operations, where speed of operation usually means lower costs.

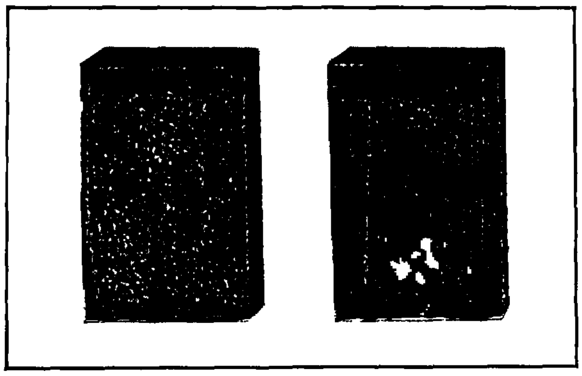

FIG. 1.—*Cleansing effect of fluxing treatment on Elektron*

No lubricants should be used in machining, and all trimmings and swarf should be frequently removed from machines and stored in closed metal bins to prevent deterioration through oxidation, and also to avoid any risk of fire from carelessly thrown matches, etc.

In the event of swarf or turnings becoming ignited, water should not be used as an extinguisher. The combustion can be smothered by liberally covering the burning swarf with dry sand.

Foundry Practice

Melting. As has previously been mentioned, molten magnesium on exposure to the atmosphere rapidly forms oxides and nitrides, which having almost the same specific gravity as the metal itself, become disseminated through the bath and contaminate the metal.

Little real progress in the production of sound castings could be made until this initial difficulty was overcome.

Various methods were tried, such as melting in vacuo, under inert gas and so on.

Either for technical or practical reasons, none of these attempts succeeded.

Magnesium chloride suggests itself as a possible flux, being, in the fused condition, a solvent for the oxides and nitrides of magnesium.

Unfortunately the use of this material alone in ordinary foundry practice is almost impossible, as, when used alone, it is too fluid in the fused condition and may enter the mould with the metal in pouring.

Working on this basis, however, a compound flux known as Elrasal has been evolved, which very satisfactorily solves the melting problem of magnesium alloys. The basis of Elrasal is magnesium chloride, with the addition of other salts which on fusing form a viscous flux which does not readily dissociate at high temperatures. The molten surface is kept covered with a skin of the flux till the whole charge is melted, when the temperature is raised to ensure the complete fusion of the flux. The bath is then stirred thoroughly to bring all the metal in contact with the viscous flux, which dissolves all entrained oxides and nitrides during the stirring process, and sinks to the bottom of the crucible. The surface of the metal is then completely covered with an additional amount of Elrasal, which fuses and forms a tenuous covering which protects from surface oxidation.

In pouring the casting, this surface skin is held back by a skimmer, and, owing to its inherent tenacity, does not flow or break away and so enter the mould with the metal.

The accompanying photograph (Fig. 1) shows very well the cleansing effect of this treatment on contaminated Elektron. Ingot A, the fracture of which clearly shows the presence of a considerable amount of oxide and brown nitride, is poured from a batch of Elektron melted without the use of any flux whatever.

Ingot B, the fracture of which is quite clean, is from the same batch of contaminated metal as Ingot A, remelted under Elrasal.

Where the melting process described is carried out carefully, the metal losses during the melting process should not exceed 1 to 1½ per cent.

The author has proved, over a number of years of routine foundry experience, dealing with castings, large and small, that this process ensures absolutely clean metal being delivered to the moulds, provided the furnaceman knows his job and exercises reasonable care.

The subjoined drawing (Fig. 2) illustrates the relative position of the metal and the fused Elrasal in a pot of molten elektron ready for pouring.

Wrought iron or mild steel crucibles are used for melting, as magnesium does not, like aluminium, readily alloy with iron, and the crucible is never attacked by the molten metal. Plumbago crucibles are unsuitable, as the molten metal will attack the silicon compounds employed in the manufacture of graphite crucibles. Cast-iron crucibles can be used for small sizes, but weight limits their use in larger capacities. For very large melting units, where cranes are available, cast steel pots are suitable.

Failure of iron crucibles always occurs through scaling in the furnace, and it is therefore necessary, as far as possible, to employ a reducing atmosphere in the furnace.

Calorised and chromium plated crucibles give a considerably longer life, but the author has found, up to the present, that the increased cost more than outweighs the increased life.

The pouring temperature of magnesium alloys may range between 680 deg. C. for thick section castings to 780 deg. C. for thin work.

A notable property of Elektron alloys is that castings thoroughly sound and free from cracks and draws can be poured over this wide range of temperature, which certainly is not the case with most aluminium alloys, in which cracking due to hot pouring is a great source of trouble in the foundry, especially on thin sections.

This feature is largely due to the ideal cleansing conditions of the melting process, and also to the inherent characteristics of the alloys of magnesium, which are less liable to the trouble known to the founder as "hot shortness" than are the usual aluminium alloys.

Another interesting feature of the magnesium alloys, when melted under the conditions outlined, is that resultant castings are entirely free from that defect which causes so much trouble in the aluminium foundry known, for want of a better name, as "pin-holing" or "specky metal."

These desirable properties largely offset the extra care required in the melting and moulding processes.

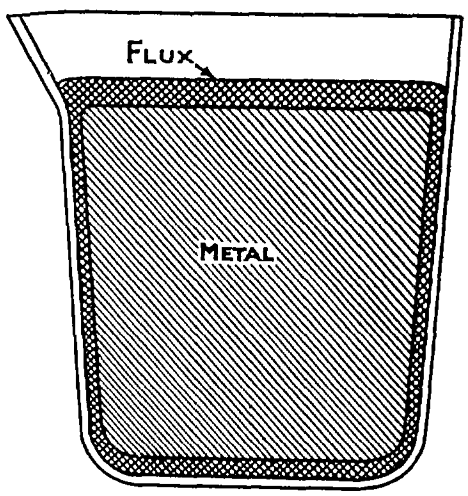

FIG. 2.—*Relative position of metal and fused Elrasal in a pot of molten Elektron*

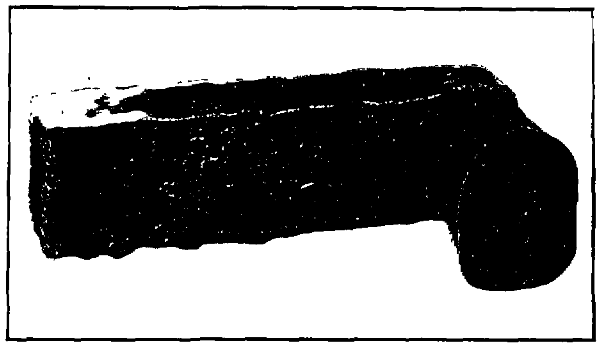

FIG. 3.—*Elektron casting poured in a thoroughly dried mould of ordinary moulding sand*

Where maximum strength is required in the casting, it is always advisable to pour at the lowest temperature that will ensure a sound and completely run casting.

Moulding and Coremaking

From the readiness with which molten magnesium decomposes water, it will be appreciated that, in the early stages of development, the problem of producing sound, clean castings in sand moulds appeared almost insoluble.

Magnesium poured into an ordinary greensand mould will be ejected with a force almost amounting to an explosion, due to the great volume of hydrogen liberated from the moisture in the mould.

The use of perfectly dried moulds appeared the natural solution, and for some years this method was followed, with, however, indifferent results.

Prolonged drying at relatively high temperature, say, 400 deg. C., will drive out the free moisture in the sand, but even so, castings made in this manner show patches of surface oxidation and are dirty and blown when broken. This is due partly to reaction with the water of hydration in the clay which forms a small but necessary proportion of all moulding sands, and partly to reaction with air borne moisture which inevitably fills all the pores of the mould when the latter is allowed to cool to safe pouring temperatures.

If the mould drying temperature is raised sufficiently to drive off the water of hydration in the clay bond, the bond of the sand is destroyed, and the mould will crumble. Apart from these serious technical defects, the method is slow and costly.

Fig. 3 illustrates a casting poured in a thoroughly dried mould of ordinary moulding sand.

It will be seen that the surface oxidation takes place, and some of the oxide is washed into the body of the casting.

The wastage of metal due to oxidation by this process is an additional serious financial loss.

Attempts were made to cast after filling the mould with a gas more or less inert to magnesium, for instance, CO_2.

This also proved a failure, as the method did not prevent the mould stream from coming in contact with the metal. Further disadvantages were the obvious difficulty of applying the process in ordinary foundry practice, and the cost of the operation.

From the failure of this experiment the opinion was formed that it would be necessary to surround each grain of moulding sand in the neighbourhood of the metal with a complete pellicle of some substance, itself inert to molten magnesium, preferably with a strong affinity for oxygen, and of such a nature that, whilst freely penetrating all the pores of the mould, it would not readily escape and so leave the sand layers surface unprotected.

To be brief, the desired substance was found in sulphur, which is mixed, in small proportions together with a less quantity of boric acid, with ordinary moulding sand.

This process is patented, and in several years' continuous experience the author has proved it uniformly successful in producing thoroughly sound and clean castings in every way, provided ordinary care and intelligence are used.

The molten metal entering the mould instantly vaporises the powdered sulphur in the surface layer of sand, forming a protective layer between the metal and the moisture in the sand. A small proportion of the vapour probably combines with the free air in the mould to form SO_2.

The vapour evolved is sufficiently fluid to penetrate the mould pores and surround each grain of sand but, being heavy, does not escape readily, and further is constantly replenished by the gradual vaporisation of sulphur deeper in the sand as the heat penetrates the mould.

As the casting freezes and cools off, most of the sulphur vapour condenses in the sand again, so that there is little loss of this medium.

The moulds are cast green by this process, though it is advisable to skin dry large and important moulds, as is the case with aluminium, to avoid risk of seaming and surface blow holes.

Fig. 4 illustrates a casting made in a greensand mould by this process, the sand being partly cut away to show the manner in which the sulphur has been vaporised away during the process of pouring and freezing of the metal.

From time to time the small amount of sulphur and boric acid which is driven off from the surface of the mould requires replacing, the necessary amounts being added when the sand is passed through sand mixing machines of the usual type.

Alternatively, sulphur and boric acid may be added only to new sand used for coremaking, the old cores after use being added to the mould sand and thus replenishing the protective reagents.

The special moulding sand preparation described, together with the melting process employing Elrasal as a protective and solvent flux, form the basis of successful production of Elektron alloy castings as the author knows it.

In other respects, practice follows very much on aluminium foundry lines.

Cores are made in sand similar to that used for moulds, dried at a temperature not exceeding 200 deg. F., to avoid vapourising the sulphur. Cores should be permeable and not too hard, as for aluminium. A smaller percentage of sulphur is needed in core sand, as most of the sand moisture is removed in drying the cores.

Core sand does not require so large a percentage of sulphur addition as mould sand, as owing to the drying process to which cores are submitted, there is much less moisture to be counteracted.

Chills are required on heavy bosses and increased sections where direct feeding is not practicable, and these may be either in brass, aluminium with 5 per cent. iron, copper or magnesium, or in cast iron.

It is specially important to give chills a surface dressing of such a nature to prevent moisture condensing on them, otherwise blow-holes and oxide inclusions will be formed when the metal comes into contact with a moist chill.

Experience has shown that a mixture of fine graphite in methylated spirits give good results. The graphite should contain not less than 85 per cent. carbon, and the mixture should be sprayed on to the chills.

If brushed on, the surface pores and irregularities of the chills are not filled up, but only coated with the mixture, and blowing may take place.

Wherever possible, Elektron castings should be poured from the bottom, tranquil filling of the mould being most important.

Both aluminium and magnesium have a highly tenacious oxide skin when in the molten state, and air bubbles entrapped through undue agitation of the metal when pouring are frequently unable to break through the film of oxide surrounding them and remain in the metal.

For the same reason, the crucible should be held as near as possible to the runner bush when pouring, and the latter kept full until the pouring is finished, to avoid air being sucked into the mould with the metal.

When this is done, the metal actually flows through a stationary, though flexible, tube of oxide skin, so that the Elektron enters the mould in complete isolation from the atmosphere, and consequently free from oxidation.

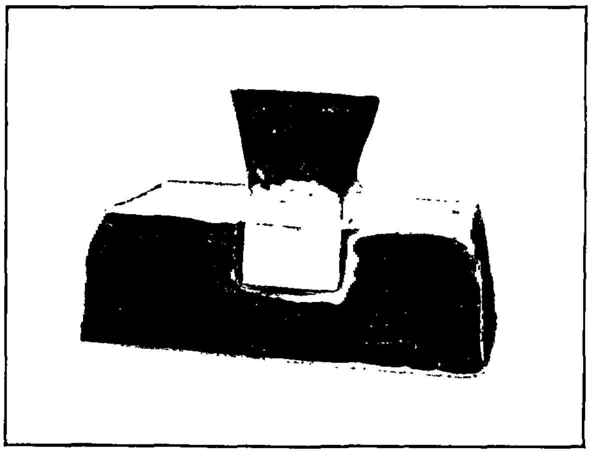

FIG. 4.—*Casting in sectioned mould, showing variation in sulphur content in surface layers*

Heavy sections require adequate feeders, and, when unusually massive in relation to the adjacent parts of the casting, require well chilling in addition.

Trimming

In trimming or fettling Elektron castings, the practice usual in aluminium foundries is followed, with the exception that it is not advisable to use emery wheels for grinding purposes, as the fine metallic dust given off by these may ignite if lights are carelessly handled in the immediate vicinity.

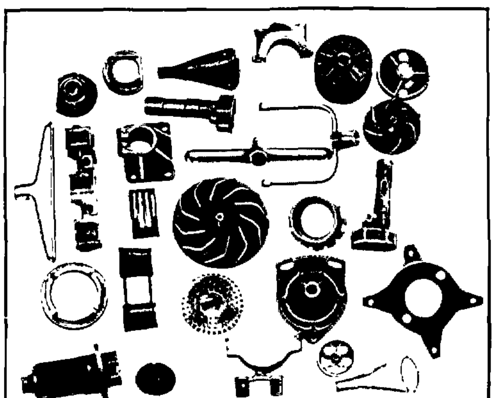

FIG. 5.—*Pressure die castings*

Bandsaws are used for removing the runners and risers, the finishing being carried out by pneumatic or hand chisels, and files.

Protection against Corrosion

Very considerable protection against corrosion is secured by subjecting the castings to a dipping process in a bath of dilute nitric acid with a proportion of potassium bichromate in solution. This has the effect of removing the film of iron and iron oxide, which the skin of the casting acquires from contact with the moulding sand, and replaces it with a golden coloured skin, which is very resistant to all usual corrosive influences, such as damp atmospheres, &c.

If further protection is desired, the Elektron casting can be coated, when ready for assembly in the structure of which it forms a part, with any good enamel, those with a cellulose base having been found particularly good both in adhesive qualities and indifference to external chemical influence.

Die Castings

Elektron alloys are now employed in the production of die castings, and also, to a lesser degree, of permanent mould castings.

Where aluminium is used for this purpose, there is always the difficulty caused by the erosive effect of the aluminium on the steel of the die, due to the tendency to form an alloy of iron and aluminium, which tendency is aggravated by the high speed and pressure at which the metal enters the die. This action necessitates frequent renewal of die parts to maintain the die in working order, and retain the original accuracy of the castings.

Elektron alloys are peculiarly suitable for use in the manufacture of pressure die castings, owing to the fact that magnesium does not alloy to any appreciable degree with iron. It is thus possible to produce castings of great accuracy in large numbers from one die, and where large quantities of one design are required, considerable economies can be made, as it is usually possible to eliminate entirely many machining operations which would otherwise be required.

Fig. 5 shows a variety of castings made by this process, including vacuum cleaner parts, bearing caps for petrol motor crankshafts, binocular casings, &c.

An unusually high pressure is used in the special machines designed for Elektron pressure casting, making it possible to produce relatively difficult and thin casting sections; down to 1 mm. thick being possible on suitable designs.

The production of gravity die castings is as yet in its infancy, as there are several technical difficulties still to be overcome.

It is obviously impossible to employ in a metal mould the same protection against oxidation as is obtained by the sand moulding process already described, and thus, up to the present, permanent mould castings are frequently defective owing to oxide skin inclusions formed as the metal enters the mould, especially where thin sections occur. Progress is being made, however, and it is quite probable that Elektron castings made in permanent moulds will be obtainable as readily as aluminium die castings are to-day, and equally as sound.

The Safety Glass Industry

The Splintex Safety Glass Company entertained at their works on Monday, June 24, a large company of guests to witness the opening by Earl Howe of their new factory at Wimbledon, at which they are preparing to service the Aircraft Industry on a large scale. We propose to deal in more detail with this, and to discuss some matters connected with the safety glass industry, in an early issue.

The New "Argosies"

Besides the interesting servo aileron-control described elsewhere in this issue the new Armstrong-Whitworth "Argosy" aeroplanes built for Imperial Airways, Ltd., have another novelty in the fitting of "Townend" rings to the three Armstrong-Siddeley "Jaguar" engines. This is the first time these rings, to which reference is made in the Annual Report of the N.P.L. reviewed in our last issue and whose effect is described in the account of a visit to the N.P.L. on the opposite page, have been fitted to a commercial aeroplane.