"That each constituent society should, in sending out its notices and agendas of ordinary general monthly meetings, inform its members that they are welcome to attend any of the ordinary general monthly meetings of other constituent societies. A copy of such notices to be exhibited on the notice board in the entrance hall to the Scientific and Technical Club."

The Chairman then called upon Mr. J. T. Becklake (Visitor) to read his paper entitled "The Minting of Gold and Silver Coins at the Royal Mint, Pretoria," which was illustrated by lantern slides and by diagrams.

"THE MINTING OF GOLD AND SILVER COINS AT THE ROYAL MINT, PRETORIA."

PAPER BY J. T. BECKLAKE (VISITOR.)

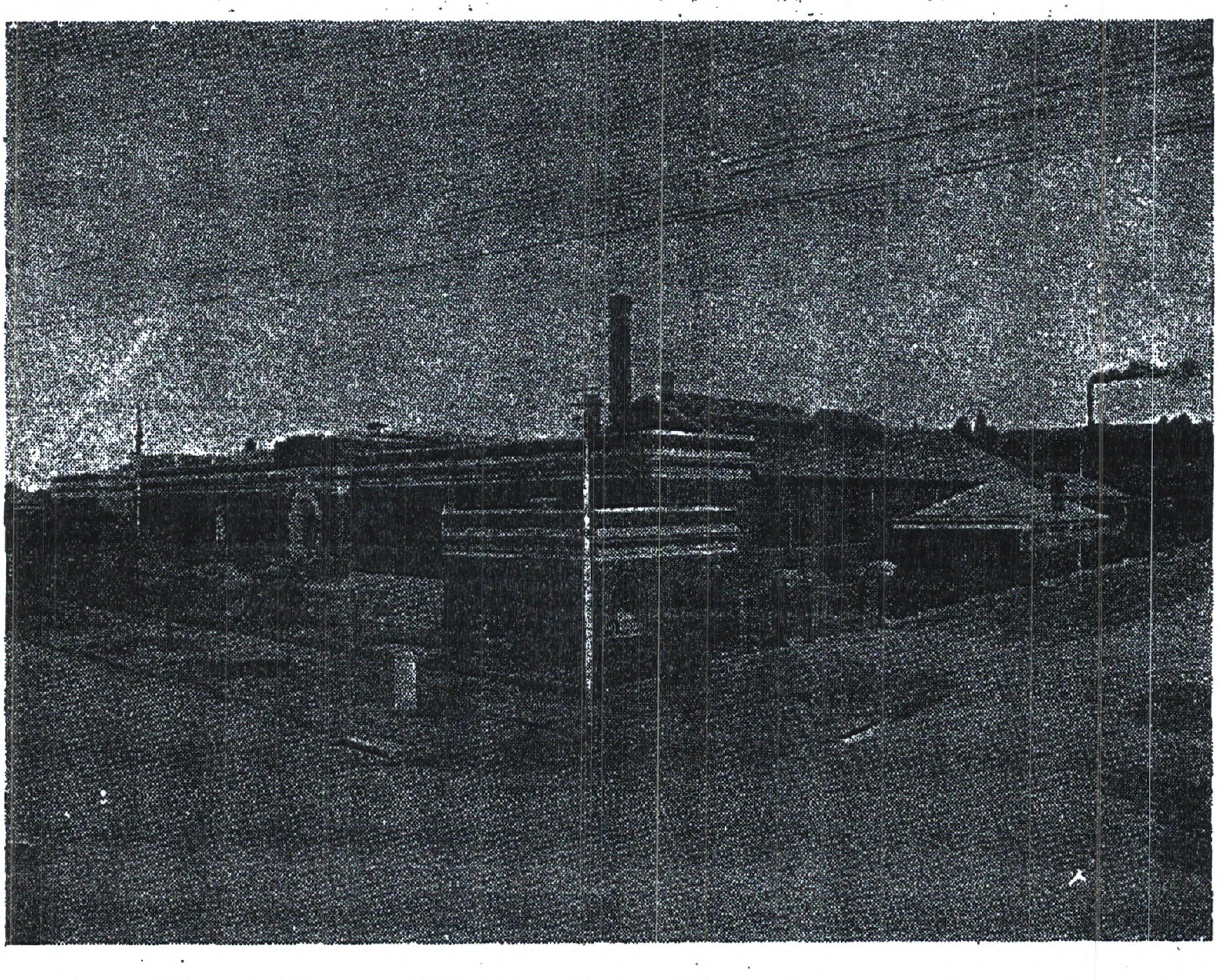
GENERAL.

The branch of the Royal Mint at Pretoria was completed in December, 1922, and coinage operations were commenced early in 1923. The total outlay on buildings, machinery and plant has been as follows:—

	£
Land	9,000
Buildings	160,867
Machinery	90,171
Miscellaneous Plant ...	5,809
Total	£265,847

The department is capable of undertaking the coinage into sovereigns of the full output of the Rand gold mines (approximately £40,000,000 per annum) and of producing the silver and bronze coins needed for circulation in the Union of South Africa.

Subject to a minimum quantity of 50 ounces, the right to deposit gold in the Mint for coinage is open to all. In practice, however, the South African Reserve Bank is the sole depositor, as that institution now purchases, by agreement, all gold not otherwise disposed of by the Transvaal Chamber of Mines. The standard gold coin minted is the British sovereign, which weighs 123·27447 grains, and consists of 22 parts of pure gold plus two parts of copper.



GENERAL VIEW OF ROYAL MINT, PRETORIA.

Silver coins are produced in accordance with the demands for silver currency experienced by the banks, and are sold by the Mint at face value. The Union's silver coins are 800 fine, *i.e.*, they contain 800 parts of pure silver and 200 parts of copper. The seigniorage on these coins is the Mint's main source of profit. Since the commencement of minting in 1923, to the end of June, 1928, the revenue accruing to the Union Government has exceeded the capital and running expenses by over £234,000.

Outline of Minting Processes.

Fine bullion, with the necessary alloy, is melted and cast into bars or strips of the required shape and size for each denomination of coin to be produced. These bars are then cold rolled to the correct thickness for each type of coin and, in the case of gold, are put through a drag-bench. From the "fillets" thus formed, blank discs are punched. The "blanks" so obtained are next passed through a "marking" machine, in which they are edge rolled and thus given a protecting rim. In addition, they are all brought to a standard diameter by this procedure.

All blanks, after "marking," are cleaned and then annealed in coke-fired ovens. By this means clean and soft blanks are prepared in readiness for the striking (or stamping) process which follows. In the "striking" operation, both sides of the blank are given their correct impression between hardened steel dies. A splined collar surrounds the die necks at the moment of impact, and produces the milled edges which serve as a protection against filing and "clipping." Finally, the coins are weighed individually on automatic weighing machines, and those not within the legal limits (or remedy) for weight are eliminated. Assay tests are taken of the cast bars and of the finished coins to ensure that no issues to the public of pieces outside the legal limits of fineness are made.

I propose to discuss some of the details of the chief processes involved, in the hope that they may be of interest to those engaged on analagous operations, and that they may lead to a useful discussion.

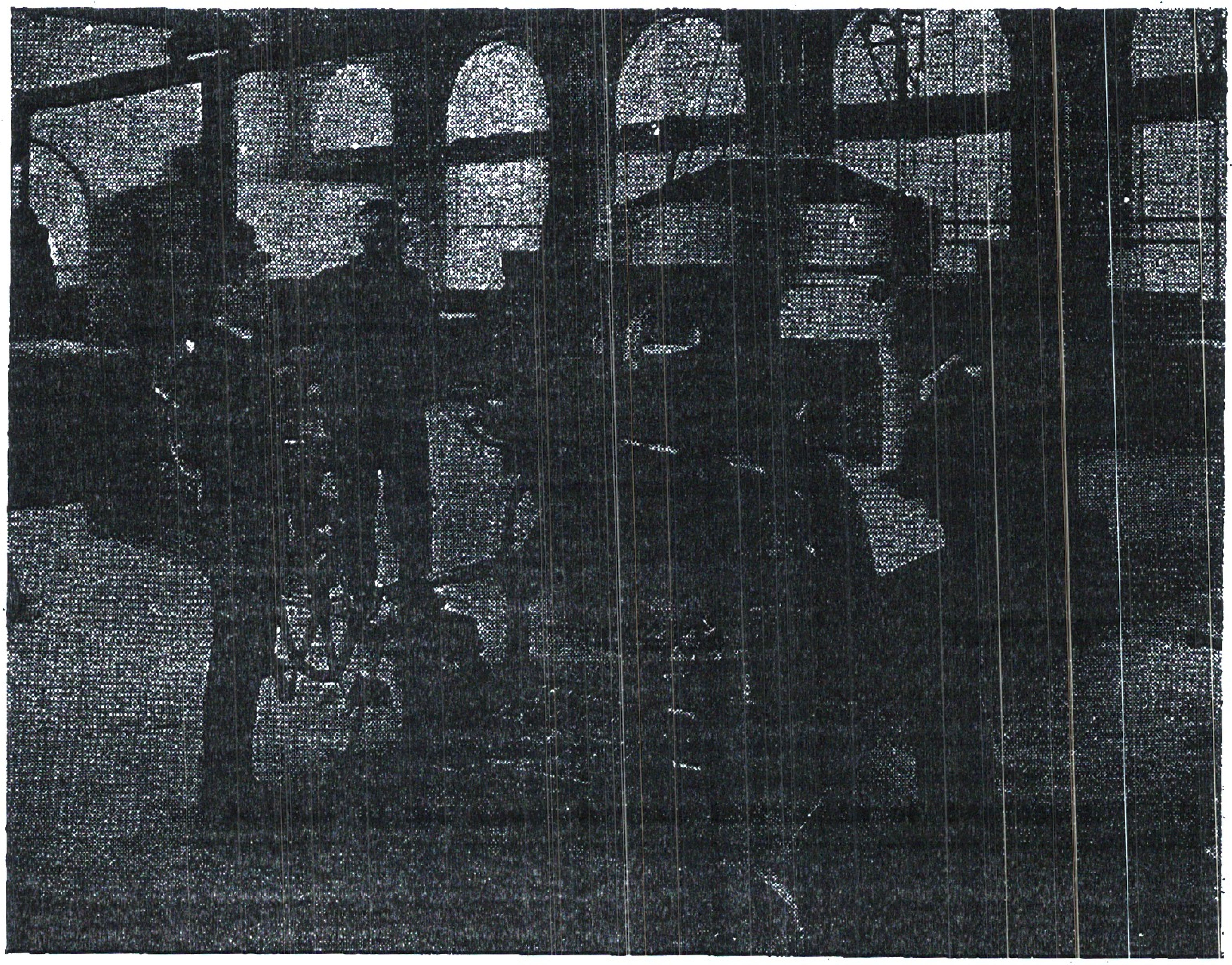
Melting.

The metals are "charged" into crucibles or "pots," and brought to a molten state in coke-heated furnaces. As each pot is withdrawn from the furnace, it is well stirred and an assay "dip" taken. The contents are then poured into cast-iron moulds of such dimensions as to form suitably-shaped bars for the rolling process which follows. The assayer's report on the assay "dip" being satisfactory, the bars are passed to the rolling department. Should the assayer "stop" any particular "pot," it is remelted after a recalculation and adjustment of the proportions of fine bullion and alloy.

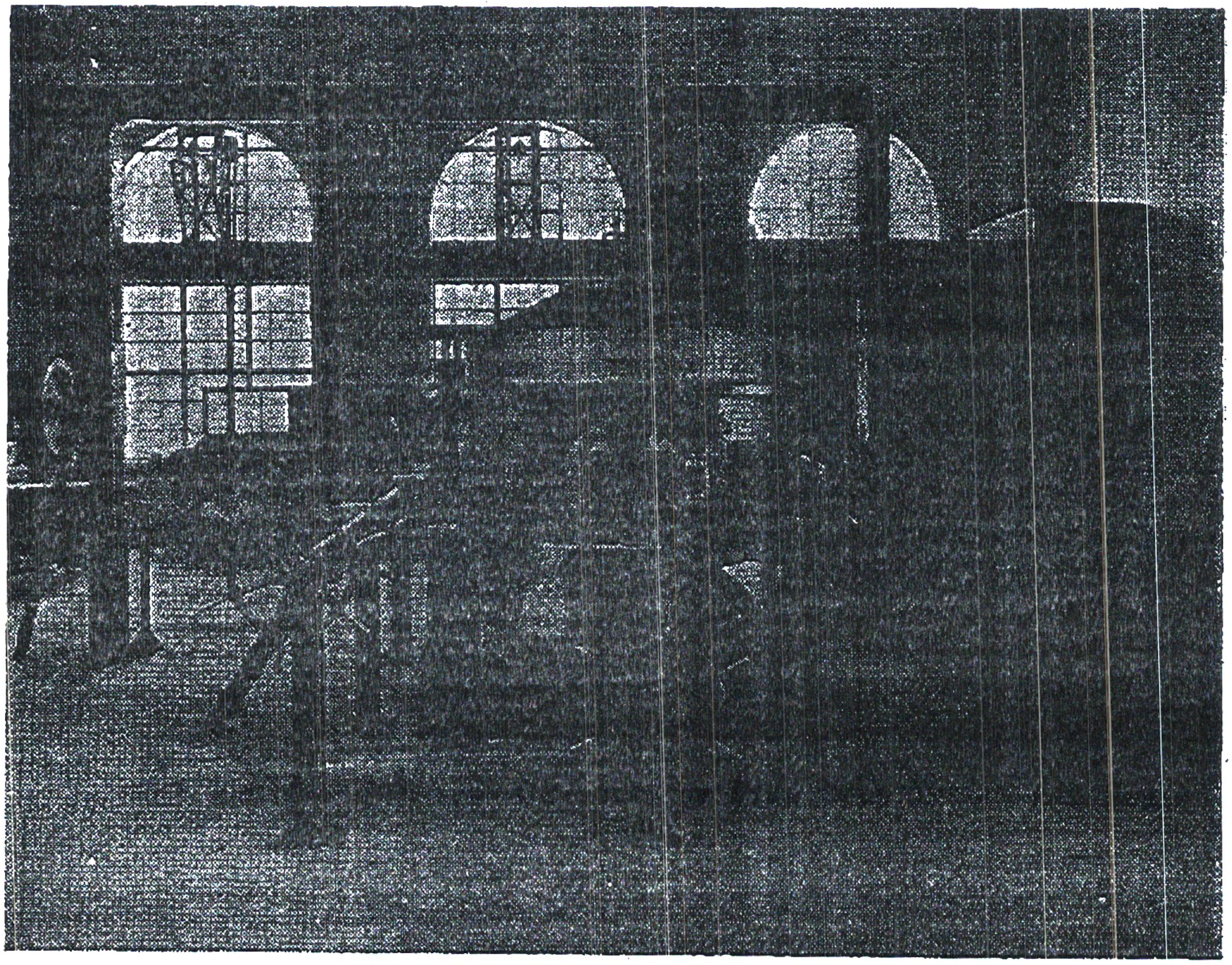
The above-mentioned pit type coke furnaces (14 in number) are fired under natural draught. The furnace gases are led to the main flue (16 sq. ft. area) and past baffles to a stack 75 feet high (area at base 12·5 sq. ft.) through a condensing chamber, which is periodically cleaned, and the small proportion of gold and silver volatilised during melting recovered from the walls. The furnaces themselves are the "Carr" crucible type (square), and consist of a solid piece fire brick, of the required shape, with frame and fire bars. As these solid piece linings become burnt, Boksburg fire bricks have been used for rebuilding with good results. Circular furnaces have been tried, but are not so efficient—the extra fire space at each corner in a square furnace appears to give more effective and rapid combustion of the coke fuel, and the furnace output is higher in consequence.

During 1927, approximately 7,500,000 ounces of gold were melted. The average melting loss for this period was 0·132 ounces per 1,000 ounces melted. Against this must be set certain recoveries from the ashes, crucibles and flue sweepings, which approximately amounted to 0·05 ounces per 1,000 ounces melted. The net melting loss, therefore, works out at 0·082 ounces per 1,000 ounces—equivalent to less than 1/100th of one per cent. of gold melted. The average output per furnace, per day of 8½ hours, is 4,500 ounces (308 lbs.) and the quantity of coke used 100 lbs.

In addition to the above furnaces, a 50 k.w. electric melting furnace was installed in 1927 especially for use in gold melting.



Electric Melting Furnace—Charging of Fine Gold Ingots and Scrap Gold.



Electric Melting Furnace, Showing Transformer Chamber and Switch Room.

This furnace is of the resistance radiation type, and is supplied with single-phase L.T. current, through a three- to one-phase transformer, from the Pretoria municipal mains at 6,600 volts. The furnace body tilts and has a lip axis pour. Electrodes at opposite sides lead the current to and from a circular trough—half the main current passing through each arm of the trough which is filled with granulated carbon. The hearth is of special refractory material, which is moulded and tamped into the required shape in the furnace body. The quantity of gold melted, per charge, is from 22 to 29 thousand ounces, and two charges can be dealt with in the working day of 8½ hours. Insufficient experience has been gained to give definite figures as to cost of melting, etc., but so far it has been demonstrated that the gold can be more economically melted than with coke furnaces, and that no difficulty has been experienced in obtaining satisfactory mixing of the copper alloy with the gold. In melting such large quantities in one charge, it was anticipated that the stirring might present a certain amount of trouble. In the early stages of the electric furnace melting, however, considerable difficulties were encountered with the quality of the bars produced. These were generally less homogeneous and ductile than those from coke-fired furnaces, and gave a higher percentage of spoilt work in manufacture. It was not easy to locate the cause of the trouble.

In crucible melting, in order, it is generally considered, to prevent oxidation of the copper alloy during melting, and to reduce volatilisation losses to a minimum, charcoal is added in sufficient quantities to cover the metal when molten. With this excess of carbon, the oxygen of the air which finds its way into the crucible combines with the carbon, forming carbon monoxide which ignites when the lid is removed, combining with another atom of atmosphere oxygen to form carbon-dioxide. As the electric furnace was entirely closed in, except for such time as the door is opened for charging, no charcoal was deemed necessary. It seems certain, however, in view of our experience, that chemical action was taking place, and this unexpected factor has made it necessary to protect the molten gold with a layer of charcoal. Since this has been done sound bars have been produced. A rather longer time is required for heating, owing to the layer of charcoal coming between the source of heat and the metal. It is not clear, as yet, what was the exact nature of the chemical action referred to. The actual atmosphere of this type of closed-in furnace probably consists of CO_2 and CO—the latter largely predominating. The presence of carbon electrodes and resistor material makes this possible. It is conceivable, however, that at the temperature of such a furnace (viz., anything from 1,100—1,400°C.) the CO_2 may become dissociated into $CO - O$, and that this released oxygen and the copper alloy are free to re-act on one another to form cuprous oxide. In the neighbourhood of the furnace door, small quantities of air, no doubt, enter through the pouring lip (although that is normally plugged) and the crevices of the bottom joints. In this way more oxygen constantly finds its way into the furnace, and further oxides of carbon and/or copper may be formed (in the absence of excess of carbon in the latter case). The presence of a small carbon monoxide flame at the top of the furnace door during melting indicates that carbon monoxide, at least, is being produced continuously. When no charcoal is added as a cover to the melt, it is practically certain that some action between the furnace atmosphere and the melt is taking place. When charcoal is added (giving an excess of carbon), the latter action appears to be eliminated, and only the former action takes place. These suggestions are put forward tentatively—no time has been available for fuller investigations. The true position is rendered more uncertain in that recent experiments tend to throw doubt on the idea that oxidation of the copper alloy in standard gold, when melting, is detrimental to the ductility and good rolling qualities of the cast strips.

A further point of importance in either system of melting is the temperature of pouring. Within limits this may vary, but beyond such limits unsound bars are produced. Better results are obtained if the temperature of pouring is slightly above, rather than below these limits. Long experience and occasional checking by pyrometers enables the melters to judge satisfactorily the temperatures when using the coke furnaces. With the electric furnace it appears to be more necessary, however, that an effective method of temperature measurement, taken from a point as near the metal as possible, be adopted. In the type of electric furnace in question, experiments are being made to ascertain the best and most convenient position for taking temperatures. Doubtless, every type of new furnace presents its own problems in this connection.

When molten, and at the correct pouring temperature, the metal is poured into accurately-machined cast-iron moulds. In the coke-melting system the crucibles, when withdrawn from the fires, are placed on a stand and protected from draughts by a heat insulating frame of metal. Whilst in this position the metal is well stirred and an assay "dip" taken, after which the crucibles are placed in a pouring cradle with the heat insulating frame surrounding them, and a bottom slide added, and poured without delay. It is considered important by some that the stirring operation should take place immediately before pouring, and away from the heat of the furnace. Our experience on gold with the electric furnace does not show the former point to be vital. In the electric furnace stirring is carried out just before pouring starts in the furnace itself, and again halfway through the pouring of a full charge of, at times, nearly 30,000 ounces. As the gold from the electric furnace is poured first into heated crucibles (used as ladles) in quantities of about 2,500 ounces, and each ladle poured before another is filled, it will be seen that the contents of six ladles (or crucibles) are poured without any stirring beyond the first stirring, which takes place prior to the metal entering the first ladle. No difference in regularity of assay can be detected in coin produced from bars produced in this way, as compared with that from bars produced in the coke furnaces. The actual pouring in both cases consists of tilting the ladles (or crucibles) by hand, and allowing the metal to flow in a small stream into the moulds.

Experiments were made to endeavour to obtain a satisfactory bottom pouring ladle or crucible for gold from the electric furnace, but it was found that the holes became clogged by the "freezing" of metal on the sides, and the resultant stream altered its line of descent during a pour and thus caused the gold to strike the sides of the moulds and even spill over the top. An added difficulty is that, by the cleaning up after each pour, the holes become enlarged and very soon too big to keep the rate of pouring at a satisfactory pace. As our coinage bar moulds are comparatively small in cross section (varying from $2\frac{1}{4}$ in. x $\frac{1}{2}$ in. [2s. 6d.] to $1\frac{5}{8}$ in. x $\frac{7}{16}$ in. [3d.]), it is essential that the downward stream be particularly straight and regular. Bottom pouring ladles, with specially designed plungers whose tapered bottom ends fitted into similarly tapered holes in the ladle bottoms, have been tested for brass melting, but I have no information as to how they stand up to the work. The use of tundishes and dozzles has been considered, but these both introduce complications which involve delay, and do not appear to offer sufficient promise of improvement to justify their adoption.

The moulds used are of grey cast-iron. Certain authorities state that the type of grey cast-iron generally used in moulds has the peculiarity of evolving gases when heated, and this causes "blowing." "Blowing" connotes the occlusion of air or gases in the structure of the cast bars, and results in slight cavities being formed. These produce defects in the form of blisters on the metal after rolling, and are a source of difficulty in producing sound blanks of good surface for coining. Further, if the stream of metal in pouring touches the sides of the moulds, local heating and splashing takes place, and, in consequence, local "blowing" occurs in greater or lesser degree, depending on circumstances. Experiments have been made with tilted moulds to reduce the tendency for the stream of metal to strike the sides and to facilitate the escape of gases, but it is difficult to lay down any definite rule for producing the best results. Much depends on the apparatus used in pouring and on those carrying out this operation. In the Pretoria Mint our present practice is to give the moulds a slight tilt (approximately 5° from the vertical). Some Mints definitely prefer a vertical mould, whilst others use moulds with considerably more tilt than our 5°. In the case of coinage bar moulds with a length of two feet, the pouring process requires considerable skill and constant care if sound bars are to be produced, especially when hand pouring is practised. In fact it might be claimed that casting of strip ingots is not so much an exactly defined engineering process, but rather an art needing a special temperament and facility of operation for its success. Our experience of gold and silver melting certainly confirms all that I have just stated in regard to "blowing." I am not in a position to be able to offer any light on the question of whether certain grey cast-iron moulds evolve gases when heated. The question naturally arises as to what gases can be first absorbed and later given out.

The type of mould dressing is a very important factor also, as well as the treatment of a mould before use. In our case each mould is well "baked" before any metal is poured into it. In this way a hard oxide skin is formed; without such treatment the surfaces would become scored and pitted (at the mouth particularly) very quickly. The bottoms of all the moulds are formed of replaceable cast-iron blocks. In the choice of dressing, a compromise must be effected between a number of considerations. A heavy oil dressing will flame heavily and particles of solid graphite become embedded in the bars. A non-flaming dressing, on the other hand, necessitates the use of a flame protection of the molten stream of metal to prevent oxidation. This can be provided quite easily, but non-flaming dressings in the case of coinage bar moulds, such as soot or china clay, are not readily applied and would cause the loss of much time. They could be relied on for two or three pours probably, and would then need renewing. This would involve removal from the mould carriage for examination and re-treatment, and thus retard output very seriously. Alternatively, an oil dressing can be readily and quickly applied before each pour without removing the moulds, and reasonably regular results obtained. Too light an oil dressing must be avoided, or the mould surface would not be sufficiently protected. The dressing appears to act as an insulator, and tends to assist the formation of a smooth surface on the cast bar before solidification. Also, it retards the rise of temperature of the mould, which otherwise would be too rapid, and thus prevents the bar and mould adhering to one another. The latter effect is fatal to the life of a mould, as the surface becomes broken and pitted. The Mint bar mould carriages contain 50 sovereign bar moulds, and are heated to approximately 75°C. before use in an electric oven. This removes all traces of moisture and prevents excessive chilling as the pouring takes place. After a round of bars has been cast, the temperature rises to about 160°C., and, before further use, this temperature is reduced to 90°C. by means of fans. As regular a temperature as is practicable is maintained. Uniform heating and cooling of the individual moulds is essential, also, to avoid internal stresses in the moulds themselves. The dressing used for the moulds for melting all coinage metals in the Mint is lard oil. Many other oils and mixtures have been tried, but for generally satisfactory results lard oil has been found best. It is applied immediately before pouring by a pad on a suitable holder which can be used very rapidly, and which gives a very even film of dressing within the moulds. An added advantage of a medium grade of oil dressing, such as lard oil, is that a light flame is formed at the mould mouth which protects the stream of metal from oxidation during a pour, particularly if this flame is protected from draughts and thus burns, at the mould mouth, vertically. In the Pretoria Mint the gas protecting flame (usually used in other Mints) has been discontinued, as the flame produced by the mould dressing appears to be equally effective and is certainly more economical.

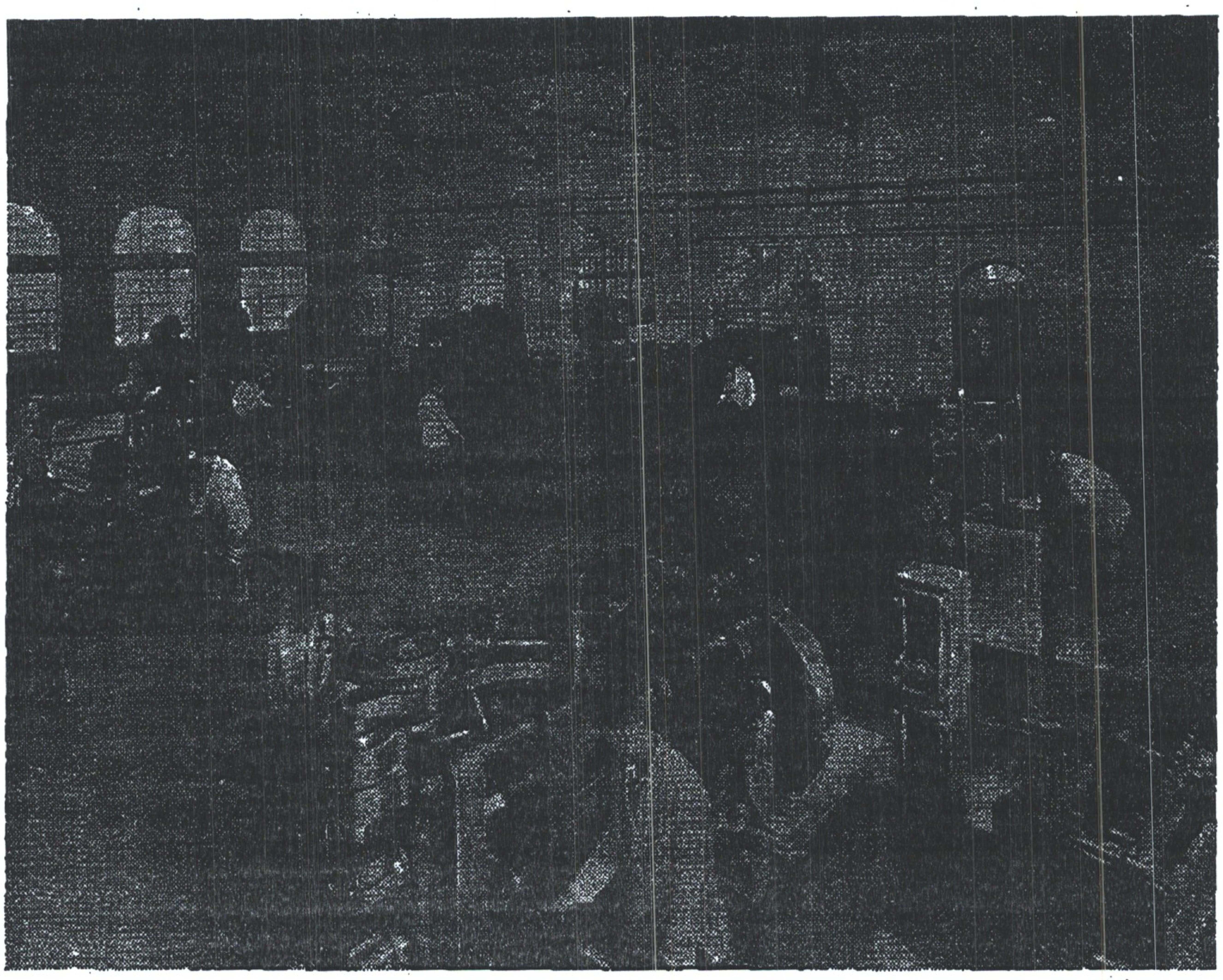
The last word has not yet been spoken, however, in regard to casting such metals as coinage metals into bars. The question of water-cooled moulds is being considered. Good results appear to have been obtained in Europe and America by the use of water-cooled moulds when casting such metals as brass. It is claimed that in such moulds the rate of cooling may be adjusted to give the most favourable conditions for the prevention of blow-holes and pipes, and liquation, or segregation, may be practically eliminated. Also that, as there is no local overheating, the mould dressing does not cake on the surface and the moulds are readily kept clean and smooth. Again, it is not improbable that moulds made of some metal other than grey cast-iron may be found to give freedom from the defects of cast-iron, *e.g.*, malleable cast-iron, steel, nickel, chrome, etc. So far, however, from the small amount of information available, experiments in this direction have resulted in the discovery of difficulties in other directions. In the London Mint, gas-fired furnaces have replaced coke-fired furnaces, and the then superintendent, in 1917, placed a very complete record of the results before the Institute of Metals. It was shown that the output of each furnace on gold and silver was approximately doubled, and that the cost of melting was reduced by 27½ per cent. As gas is not available in Pretoria, the only alternatives to coke-firing are oil and electricity. The chief Mint precautions for the production of sound bars are briefly summarised below:—

1. Pour within the narrowest practicable limits of temperature and heat insulate the crucible or ladle during the pouring. For std. gold ladle or crucible (2,200 ounces) pours, the most satisfactory range is from 1,090 to 1,120°C., and for silver (800 fine) the corresponding figures are 1,050 to 1,100°C. In the electric furnace melts, the average pouring temperature for gold has been a little below the range stated. During a gold pour of 2,200 ounces, the temperature drops about 15°C. in the two minutes which such a pour takes. This is not sufficient to impair the mechanical properties of the strips.
2. Maintain the lip of crucible or ladle during pouring as close to top of mould as practicable, to avoid splashing the sides of moulds and to minimise the risk of oxidation of the metal. Maintain an even rate of pour—too fast a pour tends to the occlusion of gases, whilst too slow a pour tends to cause local crystallisation and, therefore, erratic solidification of the strips. Protect the stream from draughts during a pour.
3. Dress the moulds lightly and evenly for the reasons given above.
4. Maintain moulds at as constant a temperature as is practicable by preliminary heating and effective cooling between pours.
5. Regularly inspect moulds for correctness of size and development of defects on surfaces. Accuracy of dimensions is essential to production of a high percentage of good coins from each bar, as the rolling which follows will not remove entirely initial variations in thickness and width. Any differences of over 3/1,000ths in the mould dimensions which may develop are rectified immediately.

After removal from the moulds, the bars are quenched (to soften and clean them) in a dilute acid bath and rinsed in water. Finally, they are wire brushed, dried, edge filed and stamped with their identification marks.

Rolling and Blank Cutting.

In the rolling process, gold bars are passed some 35 times through a series of rolls—the largest being 14 in. in diameter and the smallest 10 in. in diameter. A gold bar, $\frac{7}{16}$ in. thick by 1·19/32 in. wide and 23 in. long, becomes, in this way, lengthened into a "fillet" of the thickness of a sovereign, and approximately 16 feet long. Silver bars vary in width, according to denomination, from 1·$\frac{3}{16}$ in. to 2·$\frac{7}{16}$ in. by ½ in. and ⅜ in. in thickness, and are 23 in. long. They are passed through the mills from 20 to 22 times, and become elongated to from 15 ft. to 20 ft. In all cases the lateral spread is comparatively small. A sovereign bar spreads in rolling 5/32 in. and silver bars ¼ in. to ⅜ in. The spread is greater if the first few pinches are heavy, and *vice versa*. Further, small diameter rolls cause less lateral spreading than large diameter rolls. The smaller periphery of small rolls means that a smaller area of the strip is being subjected to deformation at any particular instant. Incidentally, also, small diameter rolls consume less power than large diameter rolls in effecting a given reduction of thickness, but the greater transverse strength of the latter outweighs this advantage in most instances—certainly so in minting at present. The relation of equality of roll diameter to roll face, which has been adopted in the Pretoria Mint, gives a high degree of rigidity, and at the same time a reasonably wide working face. Each roll face is mapped out into "journeys," *i.e.*, bars are rolled on definite areas which do not overlap one another. Thus, when one "journey" has become worn or defective, rolling is started on the next, and so on until the whole face is worn and regrinding is necessary. Rigidity in a Mint rolling mill is a vital necessity, as the high specific gravity of gold renders it essential that the "fillets" be rolled to within very narrow limits of thickness. A difference in thickness of a finished "fillet" of 1/1,000 in. means a difference in weight which are adjustable to 1/10,000 of an inch. In the dragbench the fillets are dragged between rigidly-fixed steel cylinders and inequalities of thickness are thus reduced. A dragbench will flatten out difference of thickness from end to end, and from side to centre, of nearly 1/5,000 in., but the differences that remain are still too great to allow of all fillets being put through blank cutting-out presses with punches of one fixed diameter.



Rolling and Cutting Room.

of the blank sovereign disc punched from it of 2½ grains. As the remedy allowance (or tolerance) on the weight of the finished coin (sovereign) is ± 0·20 grains from standard weight, it will be seen how important it is that the rolling be accurate. In practice it is possible, generally, to get the "fillets" rolled to within 1/5,000 in. of one another. Variations of thickness also occur along the length of individual "fillets" and from side to side of individual fillets, and are a source of difficulty in obtaining blank pieces of the correct weight. The centre or "middle" of a fillet is always thicker than the sides. These differences are partially taken out by the dragbenches, A range of cutting-out presses is employed, in which five pairs of punches (one pair in each machine) are used, each pair being of slightly different diameters. Thus, fillets of maximum thickness are cut out in the press with minimum diameter punches, and *vice versa*. This selection of cutting press for each fillet ensures that the blanks punched out are within reasonable limits of weight. The selection is made by means of a test blank, the weight of which is an indication of the thickness of the fillet. It is impossible at present to measure the differences of thickness of the fillets by direct measurements, as the variations to be ascertained are of the order of less than 1/10,000 in. An instrument capable of measuring such small differences would be of value in a Mint, if it were strong and simple in design and capable of rapid operation.

From the above it will be apparent that the rolling and cutting process is vitally important from the point of view of obtaining a high percentage of good coins from bars. The department's experience of the types of roll used has been instructive. Hitherto, most Mints have used chilled cast-iron rolls, and rolls of this type were installed in 1922 in Pretoria.

The rolls then purchased were longer on the face than the diameters by 2 in. The three ranges were 14 in. diameter x 16 in. face, 12 in. diameter x 14 in. face and 10 in. diameter x 12 in. face. With these

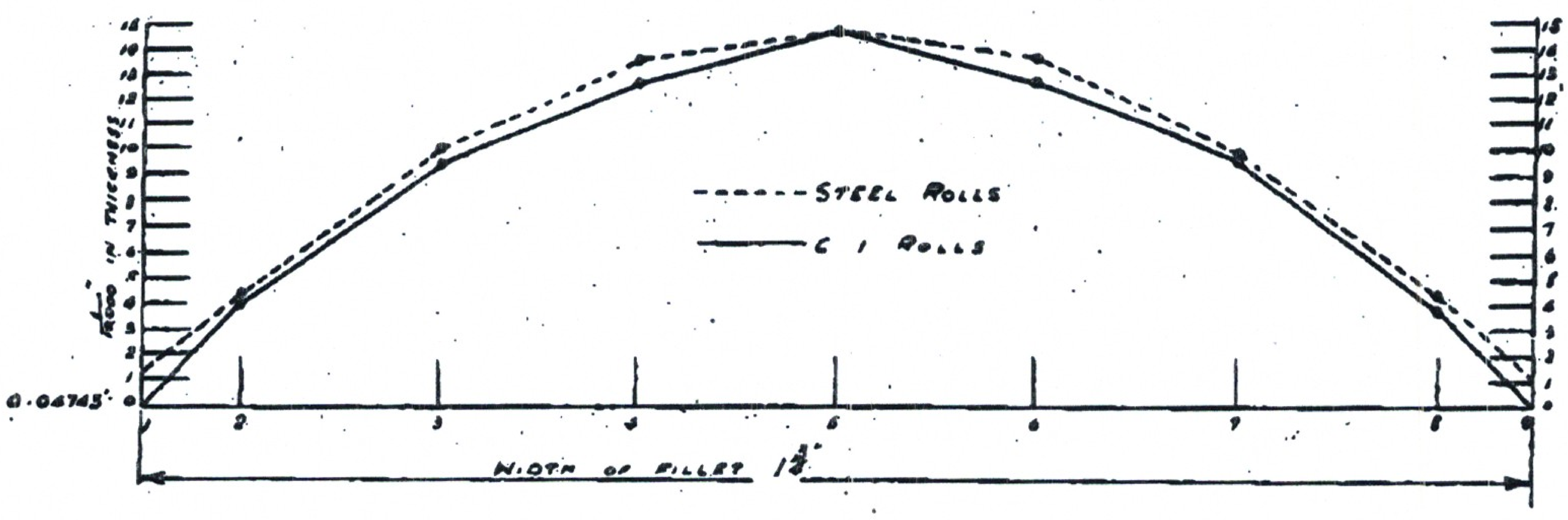
1926—Weight of good coin obtained from weight of bars rolled, 47·32% (cast-iron rolls only used).

1927—Weight of good coin obtained from weight of bars rolled, 55·00% (steel rolls [three mills] and cast-iron [one mill] rolls used).

It is not suggested, however, that it is impossible to obtain perfectly satisfactory chilled cast-iron rolls. Satisfactory rolls of this type are in use in most Mints, but are, I believe, generally of pre-war manufacture.

In Pretoria we have secured better rolling results when the series of rolling

FIGURE I



rolls it was found that, owing to their being unevenly hard on the face and not as hard at their hardest points as is usually the case with cast-iron rolls, the effects on the fillets being rolled were unsatisfactory. In addition, there was a tendency to spring, owing to their length. Constant regrindings became necessary, and delays in production were serious. A well-cast roll of this type should have a Shore Scleroscope hardness on its face of 75-80 (Universal Hammer), but the rolls in question range from 60 to 65 (Universal Hammer) only. It was, therefore, decided to adopt hardened chrome steel rolls, and with a width of face equal to the diameter and a hardness of 90 (Universal Hammer) on the Scleroscope. These steel rolls are water-cooled through their centres. The effect on the quality of the rolling, and consequently on the percentage of good coin produced from bars in the case of gold coinages, is indicated in the following figures:—

mills used have all been fitted with steel rolls. To roll fillets alternately on steel and cast-iron rolls is undesirable in the heavier duty rolls, as the fillets assume slightly different cross sectional shapes according to which type of roll is used. Thus, a fillet rolled between cast-iron rolls is rather more sharply convex than a fillet rolled between steel rolls.

The sketch above shows the difference in shape of two gold fillets—one rolled between steel rolls and the other between cast-iron rolls, all of 12 in. diameter, the same per cent. reduction being made in each case.

This difference is due to the cast-iron rolls being softer, both on the surface and in the core, than the steel rolls, and the "journeys" in the former undergoing more local deflection under the heavy stresses of rolling than those of the latter. The convexity increases with the amount of reduction per pass.

With cast-iron rolls, periodical regrinding of the face is more frequently necessary than with steel rolls. The "journeys" of cast-iron rolls become worn and sometimes distorted by wear within a comparatively short time—with steel rolls such regrindings need be less frequent. The following figures are those obtained in the Pretoria Mint, but I am unable to compare them with any other Mint results, and cannot say whether more extended experience will substantiate them:—

	Average number of gold pots rolled before re-grinding became necessary.
14 in. cast-iron rolls ...	1,000
12 in. cast-iron rolls ...	1,000
10 in. cast-iron rolls ...	750

	Pots rolled to 30/6/28.	
14 in. steel rolls	5,700	No regrinding as yet necessary and no individual "journey" condemned.
12 in. steel rolls	5,600	
10 in. steel rolls	5,800	

NOTE.—The average weight of a "pot" is 2,200 ounces.

In using hollow chrome steel rolls, care must be taken to maintain their temperature at not less than 60°F., and this necessitates special arrangements being made during non-working hours—particularly in the winter months.

The surface speeds and power of the rolling mills in use at Pretoria are:—

14 in. dia. rolls, 117 ft. p.m., 50 h.p. motor drive.

12 in. dia. rolls, 142 ft. p.m., 30 h.p. motor drive.

10 in. dia. rolls, 152 ft. p.m., 10 h.p. motor drive.

In the cold rolling of gold, probably nearly 90 per cent. of the power used is needed to overcome roll neck friction, so that it will be seen that the design and lubrication of the bearings is an important factor. Phosphor bronze bearings are used in all the Mint rolls—of the plain type with suitably-placed oil channels. Sight feed lubricators maintain a regular oil supply. For the heavy duty rolls, castor oil is found most effective, but as it has a tendency to congeal in the channels during non-working hours when the mills are standing, a lighter oil is run through before closing down at night and when starting up each morning. Michell anti-friction bearings are being tested in the London Mint for rolling mill work, but no information is available as to whether these are more satisfactory, taking all things into consideration, than the plain type. Roller bearings, sufficiently strong to withstand the heavy pressure of rolling, would need to be of large dimensions. This, in turn, introduces difficulties in the housing design, where compactness and rigidity are essential features. Mr. W. H. A. Robertson, in 1919, expressed the opinion that "none of the methods of lubrication in vogue is efficient," and the same statement could be made to-day with considerable truth. On balance, there is much to be said for a solid, plain type bearing, which is keyed into position in such a manner as to prevent the bearing "closing in" on the journal should it become hotter than usual. A water or air cooling duct in such a bearing would be advantageous, in all probability, but I have not seen any such arrangement tried.

In certain steel works in America, a small diameter roll is used with a large idler buffer roll in roller bearings, which acts as a support to the working roll. This would seem, possibly, to be attractive from the point of view of decreased power consumption and rigidity, but whether such an arrangement would give the high degree of accuracy necessary for Mint rolling is problematical.

The effect of cold rolling on standard gold and silver appears to resemble that observed on certain other metals and their alloys. It is generally agreed that the elastic limit, yield point, hardness and tensile strength are raised, and the specific gravity is lowered. In the graphs representing the relation between the percentage reduction in cold rolling and some of the mechanical properties just noted above, certain points of inversion appear to occur with marked persistence.

The following graphs show the relation between per cent. reduction and hardness, and per cent. reduction and power absorbed in reduction (Fig. II). I regret I have not had opportunities for taking more extended observations, but hope it may be possible to do so at a later date. In taking readings for these curves, no special apparatus was available, but every

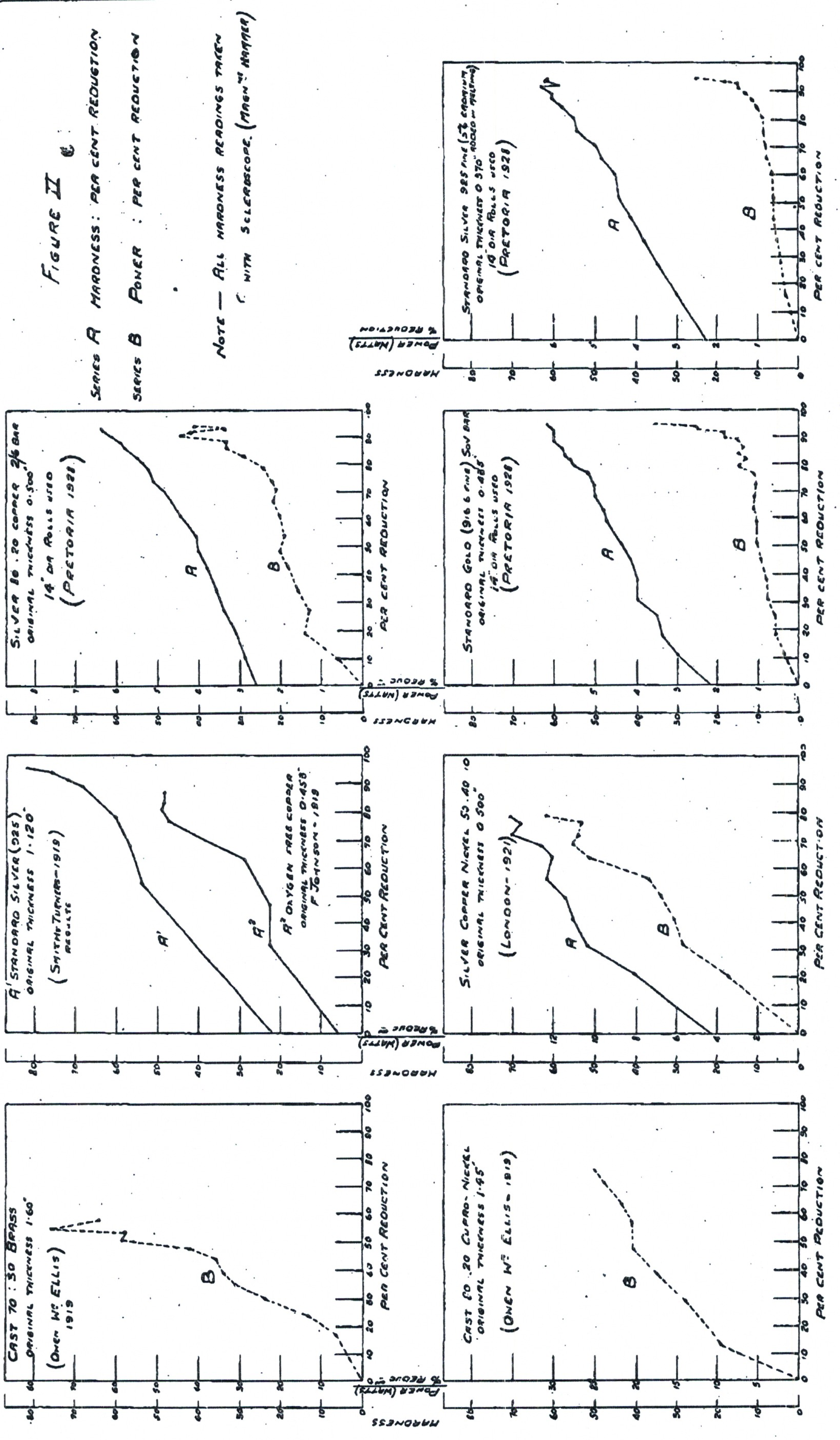


FIGURE II
SERIES A HARDNESS : PER CENT REDUCTION
SERIES B POWER : PER CENT REDUCTION
NOTE — ALL HARDNESS READINGS TAKEN WITH SCLEROSCOPE (MAGN.ᴰ HAMMER)
STANDARD SILVER 925 FINE (5% CADMIUM) ORIGINAL THICKNESS 0.370" 14" DIA ROLLS USED (PRETORIA 1928)
SILVER 80 : 20 COPPER 2½ BAR ORIGINAL THICKNESS 0.500" 14" DIA ROLLS USED (PRETORIA 1928)
STANDARD GOLD (916.6 FINE) SOV BAR ORIGINAL THICKNESS 0.485" 14" DIA ROLLS USED (PRETORIA 1928)
A¹ STANDARD SILVER (925) ORIGINAL THICKNESS 1.120" (SMITH-TURNER-1919 RESULTS)
A² OXYGEN FREE COPPER ORIGINAL THICKNESS 0.458" F JOHNSON - 1919
SILVER COPPER NICKEL 50.40.10 ORIGINAL THICKNESS 0.500" (LONDON - 1921)
CAST 70 : 30 BRASS ORIGINAL THICKNESS 1.60" (OWEN WM. ELLIS) 1919
CAST 80 : 20 CUPRO-NICKEL ORIGINAL THICKNESS 1.45" (OWEN WM. ELLIS - 1919)
HARDNESS
POWER (WATTS)
% REDUCTION
PER CENT REDUCTION
A
B
A¹
A²

effort was made to eliminate all avoidable sources of error, and the results are given with these reservations.

Similar graphs by Owen Wm. Ellis on cast brass and cupro nickel in 1919 (Proceedings Institute Metals) and F. Johnson (in connection with Smith and Turners' paper on Sterling Silver) in the same year (Proceedings Institute Metals) for standard silver are given also for comparison. These show that, at more or less defined stages, the characteristics of the metal undergo a change. These stages have been termed the "critical ranges of deformation." In taking the recent scleroscope reading for figures on portions of the strips below 0·050 in. in thickness, a second piece of similar strip was placed below the piece being tested, both being held tightly by the clamping lever. From a number of tests, I have found this to give what appear to be the most trustworthy results. For ranges of reduction of over 90 per cent., the difficulties of obtaining reliable readings are considerable, and this section of these results I do not look upon as really trustworthy. For example, it is difficult not to doubt that the somewhat remarkable decreases of hardness shown actually take place—on the other hand, the hardness given does appear to remain practically stationary over certain ranges of deformation, and this is confirmed by the power-reduction curves at these critical ranges. The consideration of what these inversions indicate, and the theory of cold rolling generally, are subjects on which it is most difficult to form conclusions. F. Johnson, in 1920, before the Institute of Metals, endeavoured to apply the amorphous phase theory to the phenomenon of the critical range. He suggested that "the critical range of deformation is due to 'smooth' slipping along preferential planes of slip, whilst increase in hardness and tenacity are due to simultaneous slipping along planes of 'forward' and lateral slip on which the amorphous phase is generated."

Annealing.

The rolling and cutting processes leave gold and silver blanks in a state of hardness which must be corrected before the stamping of the impression takes place. Annealing is necessary, and is effected in coke-fired furnaces consisting of three or four horizontally placed mild steel tubes with the fire grate below, and the flue opening above them.

In addition to blank annealing, it has been found advisable to anneal the silver fillets or strips after about two-thirds of the rolling operation. This reduces wear and tear on the rolls themselves, and also on the punches and cutters used in punching out the blank discs. Gold fillets can be readily rolled to the correct thickness without annealing.

A strip casting standard gold has an average scleroscope hardness (magnifier hammer) of 22. After rolling to the final gauge, its hardness has increased to 60. A strip casting of 800 standard silver has an average hardness of 26, and, after partial rolling, this increases to nearly 58. It is then annealed and softens to 33. Further rolling brings the figure up to 61.

The hardness of gold and silver blanks before annealing are 60 and 61 respectively. After annealing, these hardnesses are reduced to 24 and 30.

These results are summarised for convenience of comparison, as follows:—

Hardness of cast strip.	Hardness of partly rolled strip at stage when annealing is carried out.	Softened by annealing to.	Hardness after final rolling and cutting out of blank disc.	Blanks softened by annealing to.	Approximate hardness of coins after stamping.		Approximate maximum hardness obtainable. (Sir T. K. Rose's results in 1914.)
					Relief.	Base.	
Gold (916·6 fine), 22	—	—	60	24	£1—37	52	76
Silver (800 fine), 26	58	33	61	30	2/6—26	40	75
					2/-—32	41	
					1/-—30	38	
					6d.— -	50	

Before annealing, all blanks are cleaned by means of a hot soda solution to remove oil and dirt which they have accumulated during the operations of rolling and cutting out. This is done in specially designed p.b. drums, which are revolved in the necessary baths, after which the blanks are dried in a centrifugal dryer.

As the following processes differ for gold and silver, it will be better to note each separately. *Gold:* Gold blanks are annealed in wrought iron tubes under a charcoal seal at a furnace temperature of 750°C. for 20 minutes. They are next quenched and rinsed in hot distilled water and finally dried. *Silver:* Silver blanks 'e annealed in open grooved cast-iron trays, on which they are laid in rouleaux, at a furnace temperature of 800°C. for 25 minutes, and in an atmosphere of steam. The latter prevents too deep an oxidation of the surfaces. Following this they are tipped into a stout wire mesh tray and quenched. At this stage they are coated with a layer of copper oxide, and are dark brown in colour. To remove this oxide, the blanks are rotated in drums in a 10 per cent. sulphuric acid bath, from which they emerge in a "blanched" condition. The surface of the blanks now is pure silver and white in colour. After rinsing in hot water and drying they are ready for stamping, being soft and clean.

The coke-fired furnaces used in the above annealings are as satisfactory as can be expected with the type of fuel employed. For good annealing, however, a constant temperature is required, and this cannot be assured unless a regular and adjustable source of heat is available. It is hoped that it will be possible to instal a more modern system in the near future. Standard gold (916·6 fine) will anneal very slowly if raised to from 300°C. to 400°C., and extremely slowly at much lower temperatures, but for rapid annealing it must be heated to not less than 600°C. The 800 fine silver used for the Union's coins anneals slowly at the same temperatures as given above for standard gold, but for rapid annealing it requires to be heated to not less than 700°C. Sir T. K. Rose, in 1912, investigated the annealing of coinage alloys, and concluded that metals and alloys when hardened by rolling are in an unstable condition at ordinary temperatures, and undergo a gradual change to the soft state. As the temperature rises, this change is hastened until, at temperatures considerably below their melting points, metals and alloys revert from the hard to the soft states almost instantaneously.

It is interesting to note that standard silver (925 fine), according to Dr. Norbury (Institute of Metals, March, 1928), when in a quenched condition, is 30 per cent. softer, and from 20 to 30 per cent. more ductile than it is when in an ordinarily annealed condition. It is on this account that the cast bars of gold and silver and annealed fillets and blanks are quenched immediately after casting, and after heating for annealing, respectively.

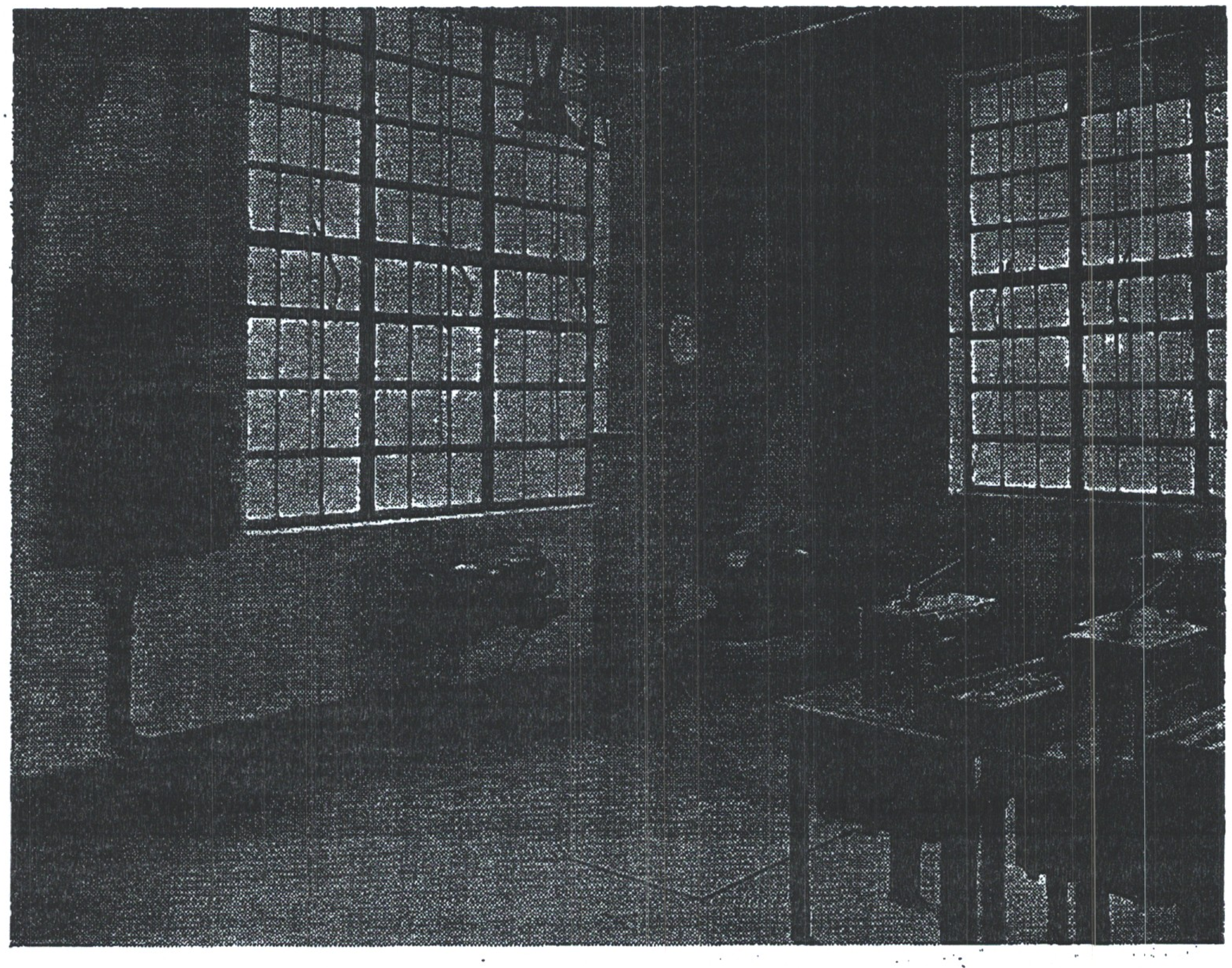
Coining.

The coining presses in use are belt driven at a speed of 80—100 r.p.m., according to the size and thickness of the coins to be struck. A heavy flywheel is employed to take the sharp impact at the moment of striking. It has been ascertained by experiment (Bourke and Nicoll, Bombay Mint) that the blow requisite in a screw type press to strike a dollar is 160 tons and that for a rupee 137·5 tons. In the Pretoria Mint, with the type of press used and the size of coins made, the actual blow probably varies between 30 and 50 tons.

Blanks are fed by hand into a shoot, and reciprocating steel fingers at every revolution place one blank in position between the top and bottom dies, and remove the piece struck on the previous revolution. The top die block is actuated by a system of knuckles, which, in turn, are driven from the main shaft through a crank and sway lever. A collar surrounds the blank at the moment of striking. The milled edges, where these are necessary, are produced by making the collars splined. In other cases they are made plain, and the coin struck is plain on its edge.

The dies are of cast steel, hardened and tempered, and usually are capable of striking from 50—100 thousand pieces before failure. In some instances, however, dies have struck as many as 500,000 pieces satisfactorily.

All sovereign dies for Pretoria, and for all other branches of the Royal Mint, are made from a "master" punch in the



AUTOMATIC COIN WEIGHING MACHINES, WITH SPECIAL SPEED CONTROL MOTOR DRIVE.

COINING PRESS ROOM.

The Chairman, W. S. Carr (Vice-President), said members were indebted to Mr. Becklake for a most excellent paper, and the very fine slides by which it had been illustrated had but whetted their appetites for a more intimate view of the mechanisms and appliances used in the plant at the Mint. Most of those present were concerned, to a greater or lesser degree, in the winning of gold, and it had been highly instructive to them to listen to a description of the processes employed in transforming gold into what was, to the majority of humans, its most attractive form. Mr. Becklake had made use of certain terms which were not included in their every-day parlance. It was a prerogative of the ancient monarchs to claim a certain percentage of the gold and silver sent to their Mints for coinage, but to-day one would interpret seigniorage to mean "profit made in issuing coinage at a higher rate than its intrinsic value." He would like the author to define the words "tundishes" and "dozzles." It was pleasing to note that local firebrick had been found suitable for the renewal of the solid piece linings of the furnaces when the original linings were burnt out. The net loss of less than one hundredth of one per cent. of gold melted was remarkably small, and one was surprised to note the effect of a layer of charcoal on the homogeneity and ductility of the bar. Every time one was brought into contact with processes for the melting of metals, one was impressed with the necessity for care in temperatures. Some months ago Mr. A. K. Gold, in a paper upon Non-Ferrous Alloys, read before this Institution, emphasised that white metals should not be melted too slowly, lest the hardening elements separate out and collect at the top of the molten mass, and so necessitate a higher temperature to melt the whole than is desirable. Mr. Becklake had to-night indicated that, when melting gold for the pour, if deviation from the required degree of heat is unavoidable, a higher rather than a lower temperature is preferable. It might be assumed, too, that the experience and skill of the operator were very deciding factors in the successful pouring of bars into the moulds. Some of the devices were very ingenious. For instance, the stamping machine seemed almost uncanny, with its reciprocating steel fingers controlling the coins or blanks. When told that the weight tolerance permitted was only 0·2 of a grain, one realised why the British sovereign is the staple coin for comparisons throughout the world. The ringer, shut off in his sound-proof compartment, must have a very delicately attuned ear to be able to detect defective coins when ringing at the rate of 200 pieces per minute.

A hearty vote of thanks was accorded the author, after which the paper was declared open for discussion.

A Thompson (Member) inquired about the composition of the silver coin.

W. G. C. Nixon (Past President) asked why gold blanks were annealed in sealed wrought-iron tubes, while silver blanks were annealed in open grooved cast-iron trays, necessitating subsequent treatment with acid.

J. T. Becklake (Visitor) said that this interpretation of seigniorage was correct. That was the term the Mint now used. Of course, the Crown did not receive any portion of the profits which accrued from the Mint. The Union Government found the funds to carry on the Mint, and naturally it received all the profits. For purposes of administration and supervision, the Royal Mint in London was the head. The Master of the Mint in London had control of the Mint at Pretoria, for the reason that the Mint was mainly required to coin sovereigns, and coinage of sovereigns was allowed only under the direct control of the London Mint. The sovereign was universally accepted, as the Chairman had pointed out, and this was because trust and confidence were displayed in it. That trust and confidence had only been built up by a long and steady interest in the maintenance of its integrity. The tundish was a dish with holes in the bottom, into which the metal would be poured from a crucible, and then a number of holes allowed vertical streams of metal to go down into the mould. A series of four, five or more moulds could be filled at once. That was the idea of the tundish, and the dozzle was devised for just closing in the top of the mould with a little flume in order to allow a bigger head to be built up which could be later cut off so that the pipe of the cast bar would not interfere with the main bar. The composition of the Union silver was 800 parts pure silver and 200 parts copper. The composition of the Imperial coins before the war was 925. Since 1920 it had been reduced to 500 fine. The standard of 925 fine had been practically maintained in Great Britain for hundreds of years, and it seemed, from a sentimental point of view, a very great pity that this long line of regular quality in the silver coinage of England had now been debased to 50 per cent. silver. When the Union token coins were decided on, the Union Government decided to make its standard 800, as it was felt in 1921 and 1922 that there was a possibility of the price of silver rising again, although not to the extent of the very high post war prices. From the point of view of profitableness, 800 fine silver gave a good-looking piece, and was more profitable to make than a 925, though not so profitable as the 500 fine coin. The question had been asked: Why did the Mint deal with silver in open trays and gold in tubes. The gold was annealed in tubes because they did not want it to oxidise. The oxidation of the silver was a mild and innocent deception practised on the public. By allowing a silver blank to oxidise, and then taking off the copper oxide on the surface, a pure silver surface was formed. They covered up 200 parts per 1,000 copper underneath, and consequently it looked a better piece. In London, where the Mint made coins with a much lower silver content, they allowed them to oxidise much more deeply than the Mint did at Pretoria. In this way a deeper layer of pure silver is left on the surfaces, and the coins are able to stand more wear before the "coppery" tints of the interior are exposed.

This concluded the business, and the meeting terminated.

Union Patents Column.

This column, which was inaugurated in No. 7, Vol. II., of the Institution's Proceedings, contains all applications made for the grant of patents since January 1st, 1903.

The applicant advertises the fact that a complete specification has been lodged, in the "Government Gazette," and within two months of the date of the last advertisement (or some eleven weeks of the acceptance of the complete specification, which date is given in the following list) any person may lodge a written objection to the grant of the patent.

In the list (P.) *means Provisional Application;* (C.) *means Complete Specification. The date signifies when filed.*

Thanks are due to Messrs. D. M. Kisch & Co., Johannesburg, F.M., Chart. Inst. Patent Agents (Lond.), *who have supplied information for this column.*

(C.) 542/28. Dunlop Rubber Co., Ltd. Improvements in or relating to the circulation of liquids and the like and apparatus therefor. 3/5/28.

(C.) 543/28. George Raw. Improvements in and relating to the separation of solid materials of different specific gravities. 3/5/28.

(P.) 544/28. Rolfes Becker & Co., Ltd. Paper tube manufacturing machine. 5/5/28.

(P.) 545/28. Rolfes Becker & Co., Ltd. Method and means for filling tubes. 5/5/28.

(P.) 546/28. Edwin Livingstone-Jackson. A deodorizing tube. 5/5/28.

(P.) 547/28. Thomas William Keet and Anton Friederick Heinrich Schiel. Flying-motioned water-wheel. 5/5/28.

(P.) 548/28. William de Klerk Bosch. Valve-seat tool. 7/5/28.

(P.) 549/28. Wyville Albert Russel Botha. Improvements in plunger pumps. 7/5/28.

(P.) 550/28. David Laird. Improvements in deep water fishing apparatus. 7/5/28.

(P.) 551/28. Clovis Leopold Seccombe. Improvements in covers for the bowls of tobacco pipes. 7/5/28.

(P.) 552/28. John Elkington Montgomerie. Improvements relating to the baling or pressing of wool, forage, cotton and the like. 8/5/28.

(P.) 553/28. John Bassett Holman. Rock drill piston hammer and bolt. 8/5/28.

(P.) 554/28. Percy Tyler Woodland. A machine for harvesting maize and the like crops. 8/5/28.

(C.) 555/28. Louis Hendler. Improvements relating to measuring spoons. 8/5/28.

(P.) 556/28. James Easterbrook Thomas. Improvements in linings for tube mills and the like. 8/5/28.

(P.) 557/28. Wilfred Austin Darmuch, of African Explosives & Industries, Ltd. Improvements in apparatus for distributing gases, vapours and the like. 8/5/28.

(C.) 558/28. Mangham's Automatic Needle Changer, Ltd. Automatic needle supplying and changing attachments to gramophones and the like machines. 9/5/28.

(C.) 559/28. James Henry Ed. Francis and Richard Congdon Coath. Improvements in and relating to the manufacture of containers, and tubes from sheet material. 9/5/28.

(C.) 560/28. Lionel Canard. Improvements in electric heat radiators. 9/5/28.

(C.) 561/28. Archibald William Blair. Improved means of coupling rolling stock. 9/5/28.

(C.) 562/28. Suddeutsche Telefon-Apparate, Kabel und Draktwerke, A.G. Improvements in and relating to long distance cable installations. 9/5/28.