Vol. VI. APRIL, 1910. No. II.

PROCEEDINGS—AUSTRALASIAN INSTITUTE OF MINING ENGINEERS.

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MOUNT MORGAN PRACTICE IN RECORDING AND ESTIMATING ORE TONNAGES AND VALUES.

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THE irregularity of the Mount Morgan ore body presents problems other than those of mining only. For irregularity of outline is coupled with irregularity of grade, and the ore varies so rapidly from profitable to non-profitable, and from highly siliceous to highly pyritic, that the task of estimating quantities and values of ore reserves is manifestly rendered a difficult one, while the actual disposal of the broken ore demands constant supervision.

Four classes of ore are handled. The oxidized ore, cheaply mined and cheaply treated, is obtained by quarrying from the top of the mountain. Below the 315-ft. mine level (measured from the original summit) sulphide ore comes in, and this is divided into siliceous sulphide ore (too siliceous for economic smelting), sulphide ore suitable for smelting, and ore too poor either to be smelted or to be treated by wet process with the siliceous ore. It is with these three latter descriptions of ore that this paper principally deals.

Although the output from most stopes in the mine may usually be presumed beforehand to be either smelting or wet-treatment ore,

yet it is never safe to take this for granted, and constant assaying is necessary. At the same time the ore merges from one class into another in such a way as to give no clear dividing line, and unremitting attention is required to see that unpayable ore is not sent for treatment, and that payable ore is sent to the works best adapted for it. In consequence there has grown up an elaborate system designed to enable the selection of ore to be made, to record the division as made, and to obtain and preserve the data whereon to base estimates of various classes of ore reserves, either of payable ore suitable for the wet-treatment or smelting plants, or of unpayable suitable for a possible milling and concentrating plant.

In dealing with this subject it seemed to the authors that an outline description, giving the practice in a condensed form, would not be so easy to write as one giving more fully detailed particulars and at much greater length, while the latter would probably prove easier to follow. It will therefore be found that this paper includes much detail, all of which, however, goes to make up the system as a complete whole.

Another thing should be noted here. Specimen forms are shown, and these in some cases appear not to work in with one another. As these various forms, however, were not all designed at one time, but came into use gradually, certain anomalies inevitably made their appearance. One in particular might be mentioned. The whole of the company's statistical system is now based on the monthly period. Until recently a four-weekly period was in use, although the calendar month had to be used as well to a certain extent. To obtain uniformity, the four-weekly period was given up (pays, formerly fortnightly, being made bi-monthly), and the whole system was brought into line. It will be seen that traces of this four-weekly period show still in several of the forms.

The method of mining at Mount Morgan is not a subject with which it is intended this paper should deal; yet brief reference to it is necessary, so far as it enters into the system of underground nomenclature and affects those records of sampling, mining, and filling that do come within the scope of the article.

Stoping by square set, which is now in general use throughout the underground workings of the mine, was introduced in the old "Hopper" level, 198 ft. below the original summit, in ground now completely removed by open cutting. On this level a small stope six floors high was taken out, and the topmost of these became No. 1 floor. Counting downwards, and allowing the necessary space for future intermediate floors, stopes opened out on the main levels below were so numbered that the floor numbers have run through consecutively from 1 to 102, at present the highest number and the lowest stope floor.

But while floor numbers have run through without break, the stopes themselves have not. Dykes and bands of lean ore have separated the bodies of pay ore, and stoping has been carried on in these bodies by disconnected blocks of square sets. Each set in each such block is numbered, being further identified by its floor number, and by the abbreviated designation of the stope itself. If, for example the first set were taken out in the south-east "A" stope in the floor immediately above No. 59 floor, the set would be described as 58 S.E. A – 1; while 100 N.E. – 371 would indicate that the three hundred and seventy-first set had been taken out on the 100 floor in the north-east stope.

It is evident that such a method of mining lends itself readily to a simple system of underground records.

It is by set that ground is sampled and assayed, the assay result for "101 N.E. – 371" representing a general sample of the block of ore removed and replaced by a square set. By set also the underground records of ground stoped and of stopes filled with waste are kept, while, incidentally, it is also by set that most of the contract stoping is let, contractors preferring the set to the ton as a basis of payment.

Simple though the system may be, there are yet details about it which are perhaps of some interest.

The original record of ground mined is kept by the shift bosses in a book of convenient size for carrying through the stopes. For many years strongly-bound books 15 in. x 18 in. were used, but latterly these have been made books of second entry, and, as

more convenient in size for use in the stopes, small exercise books ruled into squares were adopted. These will be replaced shortly, by a loose-leaf binder, taking leaves 9·5 in. x 7·5 in., which, instead of being ruled square, are divided into rectangles 0·3 in. x 0·25 in., or 6 ft. x 5 ft. on the standard mine plan scale of 20 ft. to an inch. (See specimen leaf, fig. 1, pl. I.).

Cards were tried, but proved unsuitable. Bound books are inconvenient, not so much because it is impossible to keep stopes in their proper consecutive order as because such books do not last, mine dust wearing out covers and mine dirt and water soiling paper, requiring periodical renewals, when many pages unstained and still clean have to be copied into the new book with those that have become illegible. Such conditions evidently call for a loose-leaf book.

The sampling and plotting of stopes is usually done on the night shift. The shift boss on his rounds notes in his book the squares which represent sets being taken out. On his return to his office he marks in the consecutive numbers for these sets. A wall card, ruled into as many columns as there are stope floors working on the levels under his charge, shows the last set numbers, and on this the figures just used are entered to show they have been appropriated. At the same time a small piece of cardboard has the stope, floor, and set numbers marked on it, and is put aside as a sample ticket. The name of the machine-man is added if two machines are boring simultaneously on the one floor.

In keeping this stope book, a set bored but not fired out is indicated by a small cross, while "½" indicates that a full set has not been taken out. If the half-set is sampled, however, it carries its number. Sill sets (paid for at a higher rate in contract work) are marked by a red stroke beneath the number.

Towards the end of the night shift a boy takes the tickets and goes through the stopes to the working places indicated, where with a scraper he gets a sample from the drill-holes. The collected samples are then taken up to the assay office to be ready for the sample crushers to start on at the beginning of the day shift. If during the other two shifts the shift boss notices that a set being

bored will be fired before the sample is taken, he himself takes it and records the set, leaving the sample to be taken up by the boy on night shift.

In driving and sinking the sampling practice is different. The shift boss, who in his rounds sees that preparations have been made to rig up for another cut, makes out a sample ticket, showing the floor, drive, or winze number and total distance or depth, the latter being obtained by adding 5 ft. (or such other distance as he considers correct) to the "last distance," obtained from a wall card similar to the "last set" card. This method of obtaining total measurements by adding a fixed distance is corrected when tape measurements are taken, and a cut slightly longer or shorter is shown to adjust the assay measurements. The shift boss himself takes the sample as soon as sufficient boring has been done in the top holes to give it.

For some time past the shift bosses have been required to make up each week a return of sets erected and sets filled (to which reference is made later). To obtain the information required, it is now the practice to show in the stope book the plan of a floor of a working stope on one page, and opposite it a skeleton plan of the same floor with a small cross showing sets erected, and at each weekly count the sets counted are lined off. The bosses of the lowest levels keep an additional book into which they mark filling week by week, but for the floors, from the 750-ft. level and upwards, filling is marked directly by the bosses into the underground filling book—a square-ruled book, 15 in. x 18 in. Into this book also the underground clerk enters the filling below the 850-ft. level, filled sets being shown by lining them round with red, and the outlined block should then be (but is not always) shaded in with pencil.

The principal underground record of the stopes is kept by the shift bosses and the underground clerk in another square-ruled 15-in. x 18-in. book. Sets are marked as in the small stope book, but instead of containing only working floors each floor in every stope is shown. Until recently it showed all filling, but the filling book is now taking its place for this. For each pay the shift boss counts up and marks off each contractor's sets on these floor plans, so that

it also shows the progress of the various contracts. Steps are being taken to replace this book also with a large loose-leaf binder taking leaves ruled similarly to the small ones already described. (See specimen leaf, fig. 2, pl. I.).

Once a month all sets mined and filled are marked up into a solidly bound 24-in. x 20-in. book (square-ruled), which is sent out of the mine down to the mine survey draughtsmen to allow them to bring the survey office floor plans up to date. The one book, however, cannot conveniently contain both gold and copper stopes, and the latter at present go into a supplementary book (one of the 15 in. x 18 in. size). Although, no doubt, a loose-leaf book would be exceedingly convenient in this case, it is unfortunate that when a new book was last obtained it was made to stand rough use, and in consequence is still too good to be replaced.

Still another book is kept underground. As a check on the shift bosses' count of sets mined each month by the contractors, the mine manager has a monthly contract book into which he draws the block of fresh stopes shown in the underground stope book. These he lines round and counts, and his total must agree with that of the two half-monthly periods counted up by the bosses. Any sets overlooked and uncounted by the latter are noticed at once when the floor plan is copied into a book where nothing is shown but the outline of the stope and the lines of previous payments. This book has always been ruled with small squares, and a new one having become necessary recently the opportunity was taken to introduce the loose-leaf binder with rectangularly-ruled leaves, although in its simplest form. The binder measures 11 in. x 22 in. and takes a sheet ruled to represent sets on the scale of 40 ft. to the inch (that being the scale in use for the smaller mine plans). These sheets are ruled on one side only. On this scale a single page represents 800 ft. x 400 ft., and will take without difficulty the largest blocks of stopes. (See specimen leaf, fig. 3, pl. I.).

The rectangular ruling has been adopted in this case in order to allow more than one block of stopes to go on each sheet if necessary. Where (as in the copper chambers) several blocks having practically the same bearing can be put on to the one sheet, it was

considered an advantage to show them to scale, to have their relative positions to one another shown, and at the same time to have them so placed that if two blocks come to join up the sets will close up exactly as they do in the stope. For the books in which set numbers are shown on the floor places, the rectangular ruling has another advantage. The plan of a newly opened floor is not necessarily entered in his book by the shift boss with any particular point of the compass to the top of the page. If any rule is followed it is to have the drive entering the stope to the bottom, although this is not the universal practice by any means. Consequently it has happened that a small floor plan showing an even number of sets on each side has had these sets plotted in their correct position, but with the numbers away, so that, more sets having been added in their relative position to the original set numbers, the whole plan has been twisted. While rectangular ruling cannot entirely obviate the risk of this being done, it clearly lessens the possibility very considerably.

Before passing from this subject, a description should be given of the system of keeping a record of stoping in the copper chambers with the flat-back method of mining formerly in use, but discarded recently for the square-set method.

This special system was adapted from that followed in the square sets, as it would be the more easily worked underground.

Each cut was counted and numbered as a floor. Long rolls were prepared by taking prints on "Helio" (ferro-gallic) mounted paper of a tracing showing squares 0·5 in. x 0·5 in., wide enough to show two chambers and long enough to take in the full length of the ground to be opened out.

Before the plan of a floor was taken into the mine it had marked on it the winzes from the level above, and also the main chamber drives, if it happened to be a sill floor plan. Each of the faintly printed squares on the plan represented the block of ground it was assumed one round of holes would break, and which was taken to be the set. When the floor was started, the shift boss located the position on the plan of the first ground broken by the winzes, using a measuring tape if necessary. The squares covering the position

on the plan so determined were numbered as sets, and, as the stope extended, adjoining squares were numbered to indicate this extension. When the flat-back stope was being carried forward at its full width, and row after row of sets was being numbered in on the plans, the position of face was occasionally checked with the tape from some winze. If the plan showed too much ground out, a few blocks were stoped without recording them on the plan. If the error was the other way, the sets were marked in on the plan to bring the face up to its true position. Each set was assayed, the sample being usually taken in the manner already described, but for sets added to the plan, which did not actually represent the boring of a round of holes, a grab sample of the broken ore underfoot was taken approximately from the spot where the set would have fallen.

These plan-rolls were kept in duplicate, one set of rolls being in the underground offices on the copper levels, and the other in the top office on the 450-ft. level. The latter was taken out when the assay plans were entered up, no survey plans being kept of these stopes except for the main levels, and the assay plans were made up directly from the underground record (as will be described later).

While the tonnage of ore treated each month was less than it now is, by reason of extensions to the copper-smelting plant, it was possible for the assay results of the morning samples to be returned at mid-day. But lately, since a much greater number of samples are sent up, all of which must now be done for gold, copper, and silica, this is not always possible. The number of samples varies from day to day very considerably, one day being about 40 and another 120. If, then, the results of any set or face are wanted as early as possible, it is the practice to label the sample with a special coloured label, and the crushers in preparing the samples for the assayers pick out these first to let them go through with the first batches of assays. This makes it possible to telephone down shortly after noon the results of the specials, and the regular "slip," showing both special and ordinary assays, is sent down in the course of the afternoon.

When stoping commenced in the auriferous copper ore body it was expected that it would be possible to keep the copper stopes and the gold stopes quite separate. It might almost be said that they were looked on as two distinct mines, divided by the andesite dyke Copper was known to exist through the gold ore, but rarely to such an extent as to warrant the ore being sent to the smelters, while only when the copper ore was unusually siliceous was it ever sent to the gold treatment works. This idea has gradually been modified. First it became necessary to look on the ground lying just outside the andesite dyke as an "intermediate zone," where it was not possible to say definitely that any ore mined would be either gold ore or copper ore. Another dyke which goes by the name of the "stope dyke" was looked on as the eastern boundary of this zone. Then drives north of the existing gold stopes proved the existence of good copper ore, low in gold contents, to the eastward again of this "stope dyke;" and at the same time through the copper body, but more particularly at the north-westerly end, it is being found that large quantities of auriferous ore exist sufficiently low in copper and high in silica to be classed as gold ore. In consequence the old idea that one class of ore will come from one stope and another from another is practically abandoned. All samples are assayed for gold, copper, and silica, and the disposal of the ore is regulated entirely by the assay.

The daily assay slip is carbon-copied in triplicate—one copy going to the mine records office, another to the mine clerk's office, and a third to the underground office. On this last copy the mine manager marks the disposal of the ore, "H" (hopper) representing gold ore, "P" (pocket) copper ore, and an encircling line mullock. The term "hopper" and "pocket" are survivals from the time when the main shaft pulled copper ore only from the underground pockets, and all gold ore was hoisted directly by the 27 shaft (vertical) to outside hoppers in the trucks which came from the stopes.

The daily slip is entered underground into a loose-leaf assay book. This has been in use for some time, and has proved very satisfactory.

Small note-books were formerly used, and as the working places were entered in them in no particular order—the assays running on

without any break at the end of months or years, and spreading through one book until it was finished and another could be started—it was no easy matter to refer to back assays. Instead of this, the entries are now arranged in the consecutive downward sequence of floors, the stopes, drives, and winzes on each floor following in a fixed order. The ruling is in no way remarkable, merely giving columns for the date, mark (*i.e.*, number or distance), gold, copper, and silica of each sample. (See specimen leaf, fig. 4, pl. II.). A transfer binder is kept, into which sheets are transferred when it is probable that the assays entered on them will not be required except for very occasional reference.

A record of all mine assays is kept in the assay office and also in the mine records office. The former of these is entered direct from the assayer's working note-book, while the latter is written up from the underground slips, as these show the ore disposal and also any correction the shift bosses may have found it necessary to make, as the mine dirt often renders the labels more or less illegible, and misdescription of assays may result.

Both these books are entered by the month. When a month ends a fresh set of pages are headed and commenced, so that all the assays of each month are kept together. At the month end the assays are averaged up in the mine records book stope by stope and drive by drive, the assays marked as mullock being omitted and the remainder divided between gold ore and copper ore according to the markings "H" or "P" (which have been copied into the book at the same time as the assays). At the foot of each column of assays there is marked in red ink the average for gold and that for copper, the number of assays and the totals from which the average was obtained being also noted, to make it easier to get the total average of a drive or a block of stopes from assays running over several months. (See specimen leaf, fig. 5, pl. II.). These figures are then all written down in a list, from which the averages of all underground ore—gold and copper—are worked out. This monthly average sheet is then used in making up the tonnage from the various workings, and is referred to again.

The permanent record of these averages is kept in a special book, having two sets of columns on each page. A page is given up to a drive or stope, and each line shows its averages for one month, the ore sent to the mundic works going in the first set of columns, and the ore to the smelters in the second. Together with the averages, the number of assays and totals are shown, a column being provided for each, to enable the average of the whole stope to be worked out without referring back to the assay book. (See specimen leaf, fig. 6, pl. II.).

The mine assay plans are kept in duplicate, one set in a room off the underground office and another in the mines records office. The assays are plotted up monthly or oftener. The plans are on the scale of 20 ft. to an inch, and each assay is plotted on the particular block of ore which the original sample represents for its full width and length ("assay inches" being unknown in the Mount Morgan mine). Gold assays are always marked in black, copper in red, and silica in blue. The older stopes and drives usually show gold assays only, but it has been possible in places to show assays for copper and silica along drives and on the edges of old stopes by chipping wall samples and plotting the assays opposite the point from which the sample was obtained. The assays of all horizontal diamond drill bores are also shown, each assay being written in on the plans against the length of bore it represents. (See specimen sheet, fig. 7, pl. IV.).

The copper chamber plans, however, have not kept to the 20-ft. scale. For one thing, as no survey plans were kept except for the main floors (and these without any set numbers) each set had to show its number as well as assay, a detail unnecessary on the square-set plans, as any set on the assay plan can be found on the survey plan with its number marked on it when reference to the numbers is desirable. This meant that the space into which the figures were to be entered should be larger if these figures were required to be of reasonable legibility. And for another thing the underground rolls from which the sets were plotted were kept in a scale of 10 ft. to the inch, as also were the working survey plans on which the surveyors plotted the first copper stope floor opened up.

A scale of 10 ft. to the inch was therefore adopted for these plans, and has been adhered to in spite of the change to square sets. (See specimen sheet, fig. 8, pl. V.).

No diamond drill prospecting has been done for several years, but while this work was in progress all assays from the drills were kept in a special bore book. This book shows the gold, copper, and silica assays for every 4 ft. 6 in. since the core was sent up to the assay office in these lengths in a lidded box made with a series of slots into which the core was placed in the order it came out of the bore. Before sending the box away in the morning the assistant mine manager inspected the cores, measuring and taking notes—particularly of any dykes passed through—and keeping a sample of dyke material. At the assay office the dyke was picked out and all the remaining core was crushed, sampled down, and assayed. When the assays were entered up the notes about dyke, country, &c., were inserted in their proper position among the assays. In this book also the various winzes put down in the copper chambers were entered up from the assay books with notes on the dykes intersected, as recorded by the shift bosses in the log book at the time of sinking.

The samples of dykes from the cores have been carefully labelled and are kept in a specimen cabinet, which has frequently proved of great use when the copper chamber dykes have come under consideration.

While all horizontal bores are shown on the assay plans the vertical bores can only be shown at the point they cut the various main floors. For the working copper chambers, however, it was considered advisable to have these vertical bores plotted, and sections were prepared along the centre lines of the chambers. These showed the assays of the vertical bores through the chamber and of the chamber winzes from level to level. It was also possible by joining up their points of intersection in the bores and winzes to show the various cross chamber dykes, the representation of which very considerably enhanced the value of these sections for purposes of reference.

With the increasing output of copper ore from the mine there are at present nearly one thousand sets added to the plans each month, and all but a few hundred of these go on the chamber assay plans. The result has been that these plans show such a mass of figures that their import can only be grasped with difficulty, and some means of "massing" the figures had to be devised. In the mine manager's scheme for working these chambers stoping sections 30 ft. long and of the full chamber width have been adopted. On the plans showing the scheme before it was adopted ideal blocks of these stoping sections were represented (from which the actual stoping has not deviated to any considerable extent). To carry out this massing of figures directions were given that plans of the main floors should be prepared, with the chambers divided into 30-ft. sections to include those shown on the scheme-of-working plan, extending them to cover the whole of the copper body west of the andesite dyke. The chambers are numbered outwards from the central main south dyke, which divides the copper body longitudinally, odd numbers running in a N.E. and even numbers in a S.W. direction. The sections were lettered from the andesite dyke, so that each working block can be described—K3 representing section K in No. 3 chamber, and W6 W section in that part of the mine which will be No. 6 chamber.

These section lines were marked on the assay plans, and all the assays were averaged floor by floor in each chamber section. These averages were then tabulated on the prepared plan with the floors in their proper order, each table being on its particular section block. At the bottom of the columns the block average was noted, so that the whole plan is a very condensed assay plan, on which a block of ore 100 ft. x 60 ft. x 30 ft. is represented by one assay instead of by any number up to 780. (See specimen sheet, fig. 9, pl. IV.).

Assays expressed in percentages and pennyweights alone, however, cannot give so clear a concept of the value of ore as do the same assays converted to shillings per ton. The calculation to obtain this value is simple enough, and can be done with no

trouble when but few assays are concerned, but to avoid calculation when a great number of assays are being dealt with (as at Mount Morgan) a table of values has proved a very effective substitute. Taking copper at £60 per ton and gold at 4s. 2d. per dwt., a table has been computed for each 0·1 dwt. of gold and 0·1 per cent. of copper, showing the value in shillings and decimals of a shilling. The preparation of this table was exceedingly simple, as a Brunsviga calculating machine was used, the work being reduced to giving the handle of the instrument one turn and then writing down the result on the table.

This table has been in use now for some time, and its only disadvantage has been found to lie in its size. As made out it covers a sheet of paper 26 in. x 40 in., while if printed it would not be reduced to such extent as to be convenient for constant reference. With a view to having something more suitable, a "slide rule" has been devised, which has proved very satisfactory. The one first used was constructed of cedar, on which drawing paper had been glued to give a surface on which to mark the figures, but (being informed that no Australian instrument makers had appliances for constructing machine-divided scales) accurately made rules were ordered from Europe to take the place of this one. This rule has on it three scales, the central one of which is constructed to slide. The first or right hand scale represents dwts. and tenths of a dwt. on a scale of 3 dwts. to the inch, graduated up to 47 dwts. The second or sliding scale is placed so as to move up and down in contact with the gold scale, and represents per cents. and tenths of a per cent. of copper, and is so graduated that one division is equal to 2·88 divisions of the gold scale. Zero on the gold scale is at the top of the rule, and on the copper scale about the centre of the sliding piece, the scale reading upwards and in the opposite direction to the gold scale. The copper graduations run up to 10 per cent. Zero on the copper scale is extended across the sliding piece into the point of the arrow indicating values, which is done on the third scale, representing ten shillings and shillings. The last scale is divided so that 12 divisions (or shillings) equal 1 main division (or 1 per cent.) on the copper scale. The

graduations run for the full length of the scale up to 200s., with the zero at the top exactly opposite zero on the gold scale.

To use the scale and find the value per ton of ore with a given gold assay and copper assay, bring the point representing the copper assay on the copper scale up to the point on the gold scale representing the gold assay. The value arrow then marks the value per ton in shillings on the shillings scale.

For smelting ore, however, the gross value per ton as computed from the gold and copper contents does not give all the information which is required before it can be decided whether ore will pay to smelt or not. When the silica contents vary only slightly a fixed figure will serve as the treatment cost, which has to be taken into consideration, but with a wide range of variation no fixed figure is possible. At Mount Morgan the silica may constitute anything between 20 and 80 per cent. of the ore, and it is evident that no single treatment cost figure will cover this range. As daily costs have always been kept in the smelters it was possible to get the cost per ton of treatment with varying amounts of silica on the charge, and, under instructions, from this data a treatment cost table was prepared to show this cost per ton with all silica percentages from 1 to 99 %, and for copper percentages up to 6·5 %. The copper has to be taken into consideration, since converting and realization costs are included in the figures shown. Slag and dust losses are not included; to allow for them a small fixed percentage has to be deducted from the copper contents. To find the "obtained" percentage of copper in the ore another table has been prepared, on which the obtained percentage is shown against the actual percentage for amounts up to 10·0 %. There is no deduction to be made from the gold contents, as the smelter extraction practically agrees with assay extraction.

In order that block average plan should represent the values of the ore blocks as truly as possible, the figures showing gross and net value have been added. Beneath the average copper percentage is shown the obtained percentage, in vermilion. To one side of it the gross value (taken on the obtained copper) is shown in orange, and on the other side the treatment cost in green. For

mining cost a fixed figure has been taken, based on the stoping cost for some years back. The treatment cost and the mining cost are deducted from the gross value, giving the net value (written in violet), which shows as a minus quantity if the costs are greater than the gross value.

Graphic representations of these particulars were made on another set of plans prepared for the purpose. Taking a base line approximately in the centre of each chamber, points were plotted midway in each block section to indicate net value, on a scale of 40s. to an inch. Where these values were negative (*i.e.*, represented a loss per ton), they were plotted below the base line. A second series of points were then plotted to show gross value, making treatment and mining cost plus net value equal to this gross value. In other words, the space between the two points represented the cost even when the one point was plotted negatively. The two series of points were joined up, and the spaces between the base line and the curves tinted with wash—blue violet for net value (gain), red violet for net value (loss), and yellow for the strip representing cost. Tinting was necessary, as the curves, with several parallel base lines, only 4 in. or less apart, are superimposed in places. With this graphic method it is possible to show the varying values of a whole floor in such a way that the eye takes in the information at a glance. The chief drawback is that the plans once made cannot be changed, and represent conditions as known to exist at a particular stage of development and working. The same objection would apply also to the block average plans, but by only pencilling in those figures which will be altered the plans can be brought up by adding on the averages of newly opened or stoped ground every two or three months, and this is done.

The sampling practice which has been described is that of the underground levels only. Entirely different methods of working render it unsuitable for the open cut quarry. No assay plans are kept up for this part of the mine, although a complete one of the open cut was made in June, 1908, under instructions, for the purpose of investigating makes and patches of ore of payable grade

and providing the management with information on this matter at that date. To prepare this plan, pot-holes about 2 ft. deep were dug over all the surface of the mills and benches, from 10 ft. to 20 ft. apart. The ore dug out was crushed and sampled down before sending away to the assay office, and a survey was made to pick up the position of the holes. When plotted up the plan was a satisfactory one, although it could not be entered up to date month by month like the underground plans. As a substitute for such plans an elaborate system of naming and numbering the various parts of the mill holes and benches is in use, and assays taken can be described and recorded by this system. In the past it was the practice of the open cut overseer to check the assay results by panning, and it is claimed that good results were so obtained while the ore values remained reasonably high. The quarrying of this open cut oxidized ore has now practically come to an end, and very brief reference to the assaying practice is necessary. Each day a certain number of "special" samples were taken, now in one part of the quarry, now in another, as the foremen required information about newly exposed faces.

These daily "specials" were, however, no guide to the grade of ore being sent to the west (or oxidized ore) works. To indicate this, a box, bucket, or other receptacle was placed near each spot where men were filling trucks either from the bench floors or from passes. Into this the men threw a small handful of ore off the top of each truck as they filled it. This ore would afterwards be divided down to give a sample of a few pounds, which would be sent to the assay office, carrying the name of the pass or filling place whence it came.

Such a method of sampling ore sent to the works is satisfactory enough when the conditions are considered. It allows for the mullock picked out, and can be taken to actually represent what has gone to the works on a particular day. It is considered that taking samples from the jumper holes or from the ore face would not be nearly as reliable as this, which takes them from the broken ore. The works, of course, do not depend on this sampling for their daily assays of ore crushed. For these "crusher" samples are taken as the ore is drawn out of the works hoppers.

As the open cut has been deepened, and more sulphide ore exposed, the quantities of such ore obtained from the open cut has gradually increased. Except that rock drills take the place of jumpers and nitro-compounds are used instead of blasting powder in breaking this ore, the mining practice is the same as that adopted in the bench-mining of the oxidized ore. The sampling practice is consequently the same also, and samples are taken from each truck. At the end of each day the men give to the foreman the tally of trucks filled, and this is entered in a note-book. When the open cut assay slip is received next day, the day's assay is entered opposite the tally of trucks—

27 Floor, No. 5.

Date.	Copper.	Silica.	Gold.	Trucks.
Jan. 17th ..	1·06 ..	65·2 ..	11·25 ..	22
„ 18th ..	0·47 ..	57·6 ..	23·97 ..	15
„ 20th ..	0·91 ..	61·2 ..	8·81 ..	31

Assays of *all* sulphide ore are done for gold, copper, and silica, as has been mentioned. Only oxidized ore is assayed for gold alone. Consequently this open cut sulphide, though usually low in copper, shows the full assay. The tallies of all trucks filled from each pass and filling place are kept, but it is only for the sulphide ore that the record is kept in this manner. At the end of each month the note-book is sent down to the mine records office, and a fresh note-book started. The filled note-book is used to compute the average assay of this open cut sulphide from the 21 and 27 floors, the average being obtained by multiplying each assay by its number of trucks and totalling the products, then dividing the total by the truck total. This is done very rapidly on a calculating machine such as the "Brunsviga," on which, by leaving the result of each multiplication on the "result" spaces, these products are added up as the work is carried forward, giving the sum total in the position on the machine in which it is required to be to perform the final operation of dividing

As has already been mentioned, contract stoping is carried out either by the ton or the set. The latter method was the one originally adopted, and is one for which many contractors still have a preference.

Payment by tonnage was introduced when contracts for stoping in the copper chambers were first let, and has been retained in most of those square-set stopes where it is possible to send the ore mined over the weighbridges. Such a method of payment acts as an incentive to the contractors to get the broken ore away as soon as possible to the ore passes rather than allow it to lie in the stopes, and also makes them careful not to lose any ore when stoping above sets into which filling is being run. All the ore which goes across the bridges may not be paid for by the ton, as some stopes, even on the weighbridge floors, are let by the set, but all ore is weighed. Weighbridges are at present installed on the 750 and 850-ft. mine levels, and there will be another on the 650-ft. level in the near future. On these levels the greater part of the ore haulage is carried out by electric motors, which travel with trains of side-tipping trucks between the ore passes in the stopes and the pockets of the main shaft. The weighbridges are placed alongside these pockets, and, as the motorman runs his full train up to be tipped, he slows down to cross the bridge, at the same time handing the tally clerk a slip on which he has noted the numbers of the trucks in his rake, together with the name of the contractor from whose passes the ore was drawn, or, instead of the contractor's name, the name of the working place for stopes or development work which are not being paid for by tonnage.

These slips (See specimen leaf, fig. 10, pl. I.) were originally designed to allow a "mixed" rake, made up of trucks of ore from several places, to be shown on one slip, but the tally clerks prefer a separate slip for each lot of ore, for convenience in checking over their tonnages. As the trucks pass over the bridge and are weighed one by one, the clerk marks the weights down on the slip, from which he enters up his tonnage books. On each bridge there are three clerks (one per shift), of whom one is a head man, responsible for all the bridge

figures. He checks the other men's slips and books, and keeps the book into which all tonnages for the 24 hours are entered, from which he prepares for each pay a return showing the tonnages for which each contractor is to be paid, this information going to the outside mine office, where the pay vouchers are prepared. At the end of the month a more complete return is prepared by this head tally-clerk, showing in detail for each stope and working place the tonnages and destination of all ore weighed over the bridge for the period. This return is sent to the mine records office.

At the end of each month the tonnages of the various classes of ore sent to the works (as weighed in the three works weighbridges) are sent down to the outside mine office. To the same place is sent the monthly truck record of open cut mullock. Throughout the mine it is the practice to compute mullock quantities from truck tallies. From this information a card is written up, on which all tonnages of ore and mullock are shown, but in no detail. From the time books the number of men employed is obtained, and is shown on the reverse of the card, together with certain other figures. (See specimen card, fig. 11, pl. II.). The tonnages of ore actually sent to the smelters and mundic works are noted on this card. The tonnages of underground ore sent to the 750 and 850-ft. level pockets of the main shaft are obtained from the underground weighbridge returns; but the balance of the underground ore which has come from the 450, 574, 650, or 950-ft. level pockets cannot be determined by weight. But, as a substitute for weighbridge returns, a record is kept of the hoisting carried on at the main shaft, by which all underground ore is now sent to the surface.

The main shaft driver tallies on a slate the skips of ore he draws from each pocket during the course of his shift, and, at the end of his eight hours, transfers the totals to a specially ruled note-book, prefixing the letters C, M, or W to the number of skips according as copper, mundic (*i.e.*, gold ore), or waste has been pulled. At the time he notes any delays that may have occurred for any reason during his time on duty. When a page (which gives the record of one week) is full a carbon copy that has been taken

of it is torn out and sent down to the mine records office (See specimen leaf, fig. 12, pl. III.), where the totals of the skips of each class of ore hauled are taken from this shift record and noted on a "main shaft hoisting card." Spaces are provided on this card for six weeks, or parts of a week, since the beginning of one month and the end of another may be shown on one slip, and the week's "pull" of ore must then be divided between two cards. The figures entered week by week are totalled at the end of the month, when, as the total ore sent to the works is known and the ore on hand in the headgear and surface pockets between the works weighbridges and the shaft itself has been estimated, it is possible to compute the quantity of ore that has been actually hoisted during the month. By assuming that the tonnage per skip is uniform the amount of ore taken up the main shaft from each level is obtained. Although the results are not absolutely accurate, they yet serve as a guide to the quantities of ore from those levels where there are no weighbridges to give more exact figures, and form a check on these tonnages as computed by other methods. At one side of the card the figures taken to work out the tonnage per skip are shown, and immediately beneath this is placed the "copper balance," by which the tonnages of copper ore drawn from each level (as obtained by weighbridge weight or by computation), plus the ore on hand at the end of last period are checked against the ore sent over the works weighbridge plus the ore on hand at the end of the period under consideration. (See specimen card, fig. 13, pl. II.).

The method by which the shift bosses keep a record of the numbering of the square sets has already been described. If, however, it becomes necessary to go back to a last number used months, or perhaps years, back in a floor on which stoping has been re-started, the wall card will be no guide. For such a case as this—not altogether an uncommon one—each month a list is made out of the latest numbers of all floors in all stopes through the mine. This list was written out for years in a rough book, into which the shift boss also entered certain particulars about tonnages, sets erected, and trucks of rejected waste obtained from various parts of the

mine during the month. This information about waste became necessary when the practice was adopted of analyzing the tonnages of mullock handled, just as are the ore tonnages. A printed form was therefore introduced on which both the last sets and the other details can be shown, and a copy of this is taken and sent down to the mine records office at the end of the month. (See specimen form, fig. 14, pl. III.).

It has also been mentioned that each week the shift bosses prepare a return showing the sets erected and the sets filled, the weekly count being made on Wednesday night. A carbon copy of this return is sent down to the office each Thursday to supply information required at the week end by the general manager. The number of sets filled and erected for the month is obtained from these returns, the figures for the first and last weeks being divided in the ratio of 1 to 5, 2 to 4, &c., according to the number of days of each month in that particular week. (See specimen form, fig. 15, pl. II.).

There is still another return sent down to the office each month from underground. On the last night of a month the shift bosses in their rounds estimate the tonnages of ore broken and lying on the stope floors, in the ore passes and pockets, and in the headgear, and these tonnages they note down on an ore-on-hand form. (See specimen form, fig. 16, pl. III.). Such a method of arriving at the amount of broken ore carried over from one month to the next cannot claim to be other than a rough approximation, although by estimating stope by stope, and pass by pass, the possibility of compensating errors comes in. Yet it is sufficiently accurate for the purpose for which it is required, since the error of one month always cuts out in the next, and the error in the six months will practically be only the error of the last month of the period.

The mine-records office then has its data for the month end, comprised in the reports and returns which have just been described. From this information must be prepared a detailed statement to show how the tonnage and gold contents of ore sent to the mundic works have been made up, a similar return to show the detailed tonnages of the copper ore with the average assay of each working

place, and also the necessary figures for the mine manager's monthly report of progress. The detailed tonnages of both gold and copper ore are required by the mine cost office in order that each scheduled working place may be credited with the tonnages shown in these statements, the same office also requiring the numbers of assays made for each place, to allow the assay office charges to be split up accordingly.

In the dissection of ore tonnage and gold contents of "mundic ore" the following method is adopted :—The ore estimated to be on hand at the beginning of the month, and its gold contents in ozs., are taken from the previous month's statement. The tonnage of ore quarried in the open cut having been weighed separately from the other ore on its way to the works, is obtained from the "Linda Card" and its average assay from the "open cut sulphide assays" note-book. The tonnage of ore actually mined is obtained by subtracting these amounts from the total of the ore sent to the works and of the ore estimated to be on hand at the month end. The gold content of the ore on hand is estimated by taking the average of the last few sets of ore broken in a stope and left lying on the floors or sent to a chute or a pocket, as the case may be, to be the assay of each lot of the stone on hand. The underground weighbridge returns show part of the tonnage mined, both from stopes and from development. Reference to the list of monthly averages shows which working places are not included in these weighbridge lists, and for these the tonnages must be computed. For development—drives and winzes—the averages list shows how many cuts of ore have been taken out, and the cubic contents of these cuts gives the tonnage. The balance represents ore stoped and unweighed, and the average list shows how many sets go to make up this ore. This remaining tonnage is therefore divided between the unweighed stopes in proportion to the numbers of sets in each stope. To find the gold contents of this ore is easy, since the average assay of the ore from each stope is known. The gold contents of the ore sent to the works can then be calculated, and from this the mine average assay is obtained. This assay has always been found to compare quite closely with the

works average assay, obtained by averaging the daily assays of samples taken mechanically in the treatment works. Occasionally, when the amounts of ore on hand are large, the error may rise as high as 1 dwt., but usually it is much under this, and at times even drops to under 0·10 dwt. This information, together with some particulars to show how the estimated amounts have been arrived at, is embodied in a type-written return entitled the "Mine Statement," which is filed for reference. The tonnages and gold contents given in this statement are properly set out on a monthly card, on which the stope tonnages are further subdivided, floor by floor, with the average gold assay shown for the tonnage from each stope floor. It is this card which summarizes for the general manager information about stoping progress in its relation to grades of ore for the month. (See specimen card, fig. 17, pl. II.).

With the ore sent to the smelters a simpler practice is followed. The tonnage obtained from the various working places is detailed in a list, not necessarily floor by floor, and the assay of each stope, drive, or winze is shown opposite this tonnage. No printed form is found necessary for such a return. The analysis of tonnage is simple :—The amounts of ore on hand at the beginning and end of the month being known, and the greater part of the ore having been weighed on the underground bridges, the balance is divided according to the numbers of sets in the unweighed stopes. The tonnages hoisted from each level, as determined by the main shaft hoisting returns, serve as a check on the division of both gold and copper ore by this method, and if the discrepancy is greater than the variations in skip-weight could account for, the tonnage from a level must be increased or decreased accordingly, being then subdivided between stopes independently of the tonnage divided up on other levels.

The tonnage analysis of copper ore is shown in a type-written list, the average assay for gold, copper, and silica being showu against the tonnage from each chamber, stope, drive, or winze, as the case may be. The average assay of all ore sent to the copper works each month is obtained by totalling the assay of all sets, each cut in a drive being given the value of two sets, to which it is

almost equal. The works average assay is computed by multiplying the bin tonnages (weighbridge weights) by the assays of samples quartered down from a slice cut out of the ore as it falls into the bins out of the hopper trucks. The multiplication is performed on the Brunsviga calculating machine, and is far from being a formidable task, though there are well over one hundred bins each month. An appreciable discrepancy is not uncommon between these two averages each month, due no doubt (as far as the gold and copper are concerned) to the fact that the valuable constituents of the ore on hand at the beginning and end of the month have been assumed to be uniform, since the discrepancy is largely eliminated over a period. The mine silica assay is, however, uniformly low, being rarely under 2 % less than the works assay. The reason to which this is usually attributed is that the samples are taken from rock drill holes, in which the drill has a tendency to pulverize quartz to fine dust in dry holes and to slime in wet holes, leaving a larger proportion of pyrites in the dust or mud than should be there. The error so introduced seems to be too small to affect the gold or copper assays, but does show itself in the silica determinations. The way in which machine-men (naturally enough) avoid bands of siliceous ore showing in the face, preferring to bore in more pyritic stone, must also affect the silica averages in some small measure. An appendix to this paper shows a table comparing these works assay averages with mine averages over some years.

The tonnage of filling material passed into the different stopes each month is also required by the cost department. The total quantity of filling is known, having been obtained by taking the truck tallies of waste sent to the mullock passes. To ascertain how much of this actually went into the stopes, an estimate should be made of the filling on hand at the month end in these various passes; but to make this estimate in addition to the estimates of ore would entail such work on the shift bosses at the month end that it is assumed that the filling on hand remains constant, and the mullock in the stopes is made to agree exactly with that sent to the passes. The numbers of sets filled in each stope are obtained

from the weekly returns, and the filling waste is distributed between the stopes accordingly. The cubic contents of a square set, less the timber, is 218·44 c. ft., and over a period of nine months the tonnage per set has been found to average 10·58 tons, which allows 20·64 c. ft. filling material to the ton. The monthly variation of the tonnage per set from this average is inconsiderable, perhaps tending to go a little higher. The figures available do not go as far back as could be desired.

In addition to these particulars as to the work of a month just completed, the management also requires some information with regard to the probable progress in the month entered upon. At the beginning of each month the mine office makes an estimate of the ore tonnage it is expected that each working place will supply, basing such figures on the known output per machine from each stope or drive in previous months. The greater part of the tonnage is from the copper chambers, and the working places are carefully described by the block-titles—K–5, 2/50, 3/5 N–1, RS–2, &c. This return is sent to the general offices, and one copy is delivered to the mine records office, where an estimate is prepared of the values of this ore, each stope, drive, or winze being considered in detail. The block average plans give the assays, floor by floor, of the ore previously taken from a stope, and comparison of these figures with the average assay for the month just ended show how closely the ore extracted since the block plans were last entered up is comparing with the block averages. The estimated metallic contents of a stope is based on these block average figures, but varied to a certain extent, according to the way in which the last month's assays indicate that the ore being mined is differing from the previously determined averages. For the ore from a drive or winze, previous assays, adjacent bores, and such knowledge as is possessed of the trend of "values," serve when block averages are not available. For the copper ore all these estimated tonnages and assays are entered on an "estimated values" form. Following the assays the "obtained copper" is shown, this being the percentage of copper in the ore which will eventually reach the blister bars. The figure is determined by deducting a fixed percentage from the

estimated ore assay. For the purposes of this return the gross value is taken on the gold contents and the obtained copper contents, and the treatment cost on the obtained copper and the estimated silica contents plus 2 %. The silica percentage of the ore has been determined on mine assays, and the treatment cost on bin assays. When this estimating was commenced 2 % was taken as the figure at which the variation could be placed, and although it now seems that a higher figure is desirable, the estimating practice has adjusted itself to this variation, and made a change unnecessary. The mining cost is taken from the previous month's costs, and by deducting the treatment and mining costs from the gross value the estimated profit or loss is determined.

This estimating practice is as yet comparatively new, but for the time during which it has been followed it has been found that the average ore sent to the works can be estimated in this way with reasonable accuracy, the copper and silica usually comparing closely although it is not possible always to get very close to the actual gold average assay since the gold contents of one block of ore cannot be determined so accurately from the assay of adjacent blocks as can the silica and copper.

To enable an estimate of the cupriferous ore reserves to be made, exploratory diamond drilling was commenced in July, 1903. In all 19,084 ft. of boring was carried out, horizontally, vertically, and dipping. By November, 1904, sufficient work had been done to block out large areas of ore reserves, and an estimate was made of the ore so developed. In this estimate a distinction was drawn between "ore blocked out" and "ore partly blocked out." The former included all the ore developed on six sides, the latter that developed on five sides only or less. The ordinary "four sides," "three sides," and "two sides" classifications in use for ore deposits of lode formation cannot be applied to the Mount Morgan bodies. All ore between the vertical bores and bounded horizontally by bores and drives was termed "ore blocked out," and in the other class was placed ore between angles and outside these vertical bores. The ore was also divided into high grade and low grade, the former being estimated to average 3·5 % copper and

8·0 dwts. gold, and the latter 3·0 % copper and 2·5 dwts. gold. In May, 1908, a comparison was made between this estimated average and that of the ore actually smelted to date. It was found that the latter worked out at 3·30 % copper and 8·62 dwts. of gold per ton.

Further exploratory work developed yet more ore, and another estimate was made in May, 1905, when the same classification of the ore reserves was adopted. No more drilling was carried out after this 1905 estimate, but development work for the mining and transport of ore showed the ore body to extend in various directions outside the area then included in the ore reserves, and in May, 1908, a fresh estimate was made. In this no distinction was made between ore partly and wholly blocked out. Such a division seemed scarcely necessary since the probability of partly blocked out ore with five sides developed fell very little short of that of ore with six sides. If any risk was run of over-estimating the reserves in this way it was more than compensated for by the fact that certain bores show ore which (being of one dimension only) cannot yet be added to the reserves, although it was considered that the proved existence of this ore allowed an ample margin of safety in estimating the reserves at the amount based on calculation of the blocked out areas. Since then ore estimates have been made in May, 1909, and November, 1909, the latter being of ore only west of the main fault, in what is known as the north-west body. Development since these estimates were made has shown that these boundaries were too conservative.

The method adopted is as follows :—The main floor assay plans are taken, and the points in the horizontal bores and in the drives at which the two grades of ore run out are marked. Tracings are taken, on which these points are joined up, and the assays along the drives and bores are examined to make certain that the ore inside these lines does not include any patches of poor stone, or if so to allow for them. The vertical bores are marked on the tracings, with a note alongside each one to indicate what grades of ore it passes through and between what levels and the outlines of the ore blocks are altered to include or exclude these bores if necessary.

The result of these markings on the tracings is to give two irregular blocks, one inside the other, of ore of two different grades. When all these tracings have been prepared the area of each block of ore is measured up. It is customary to use the planimeter and check by dividing the block into triangles. Having obtained the areas, the tracing of one floor is superimposed on that of the one below it, and, from a comparison of the two, the mid-area is scaled off and determined. The prismoidal formula is then applied to obtain the amount of ore between the two levels, and the same calculation is made for the ore lying between each other pair of levels. Dykes are measured on the plans, and the cubic contents determined and deducted from the contents of the blocks. Vertical bores show that two horizontal dykes intersect the ore body between levels, and, to allow for each of these, its thickness is deducted from the height used to compute the cubic contents. The detailed records give the quantity of ore already mined in the blocked out areas, and this quantity must be deducted from the estimated tonnage within the ore body to give the actual ore reserves.

These estimates refer only to the so-called copper body, but it has become necessary lately to determine the quantities of ore remaining around the gold stopes in that part of the mine lying east of the andesite dyke and the copper body. It was required to divide the estimated ore into grades equivalent to ore of 20s., 25s., 30s., 35s., and 40s. value per ton, and to do so with ore that possesses nothing like the continuity of values of the copper ore. So irregular are the makes of ore that any system of determining areas of a certain grade and computing volumes therefrom was impossible. The only method that appeared to be workable was to subdivide the whole of the block under consideration into small sections, and deal with each in detail.

The existing assay plans show the 100 ft. co-ordinate lines, and as no divisions like the chamber sections of the copper body are in use east of the andesite dyke it was evidently on these co-ordinate lines that the subdivisions should be based. The 100-ft. squares were accordingly divided into 25-ft. squares or blocks, and the main floor assays of drives, bores, and stopes were averaged block

by block. In the stopes the intermediate floors were also averaged, but (to save time) only on the outer edges of the larger stopes. All this block averaging was entered on special plans (See specimen plan, fig. 18, pl. IV.), showing the floor averages, with the number of sets on each floor taken into the block, together with the total of the sets and the block average. Bore and drive averages were kept separate, and to distinguish one from the other, bore averages are enclosed in a green and drive averages in a yellow circle. On a rough tracing of this plan was marked the assay value in shillings of each block—in one colour for the values based on bore assays, another for those on drive assays, and yet another for those determined from the stope averages. In this way two or three values might be entered on one block. Figures were then marked in showing the approximate value (to the nearest 5s. between 20s. and 40s.) at which each block was taken. When this was completed strings of blocks over the sheet had their values shown, while intermediate patches were blank. From a consideration of the adjacent marked blocks and of the probable directions of the known makes of ore these intermediate blocks were marked with estimated values. (See specimen plan, fig. 19, pl. III.) It was further necessary to prepare east and west sections, one to each 100-ft. strip, on which the main levels were represented, at right angles to which lines were drawn at distances equal to 25 ft. from top to bottom of the plan. Every fourth line represented a north and south co-ordinate line, and was marked accordingly, and the sixteen blocks or columns in each 100-ft. square were represented by the four intervening strips, the westerly four in the first space and the others in the following ones. On these sections the main dykes were also shown, with such other geological formations as would affect the extent of the possible ore. Along the main level lines the estimated values as marked on the tracings were written in, each value in the space representing its block. (See specimen plan, fig. 20, pl. IV.). On this data it was intended to work out the estimate, applying two facts which influenced the choice of this particular method. Firstly, if the irregular patches of ore east of the andesite tend to have any continuity it is vertical rather than horizontal. Secondly, between

those levels and in that part of the mine under consideration ore values improve upwards as a general rule. With the section and the block value plan it was then possible to commence to deal with blocks in detail. On a form (See specimen form, fig. 21, pl. III.) spaces are shown to take the estimated details of the sixteen blocks (lettered "a" to "p") of a 100-ft. square. From the block value plan the number of sets stoped out of a block is obtained, and with a scale or (after a little practice) by eye the floor area of driving and development in any block is also determined, a uniform fixed height being taken to give cubic footage mined. The amount of ore so removed is converted by the use of tables to its equivalent in a column of 25-ft. x 25-ft. base, the height of which is recorded on the form in its proper space. The cubic contents of dyke included in each block is rapidly scaled from the cross section, and is in a similar manner expressed in terms of its height in a 25-ft. x 25-ft. column. (If, from consideration of the section, a column appears composed wholly or in part of stone containing under 20s. per ton value, such length of the column as is determined by scaling is marked as "waste.") Such lengths then as may be left are divided between the various classes of ore. If the top and bottom values of any column (taken from level to level) are the same, all the remaining length is put down to that value; if different, however, the length is divided up between the values and intervening values in such proportion as appears most probable. The remaining work is merely a matter of totalling up these column lengths and converting to cubic contents and tonnage. Such a method of estimating ore is undoubtedly laborious, and cannot claim a high degree of accuracy. It has the disadvantage also that the personal equation enters too much into account. But it is practically certain that compensating errors must be introduced, and by preventing optimistic views from influencing the division of the ore columns such errors as must be made in this way (on a 25-ft. square pillar) will probably not affect too greatly the final ore totals expressed in millions of tons.

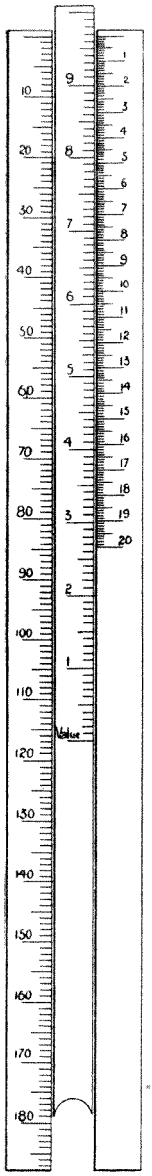
Tonnage of filling material required to fill a set with 218·44 c. ft. of available space, as determined by dividing total material used each month by the number of sets filled:—

Period 15th April to 25th May, 1909	..	10·53 tons per set.
,, ,, to 6th July, 1909	..	10·70 ,,
,, ,, to 3rd August, 1909	..	9·90 ,,
,, ,, to 31st August, 1909	..	9·80 ,,
Month of September, 1909	.. ..	12·00 ,,
,, October, 1909	.. ..	10·86 ,,
,, November, 1909	.. ..	11·07 ,,
,, December, 1909	(Figures incomplete owing to broken time.)	
Month of January, 1910	.. ..	9·58 tons per set
,, February, 1910	.. ..	10·83 ,,
		10·58 ,,

= 20·64 cubic feet to the ton.

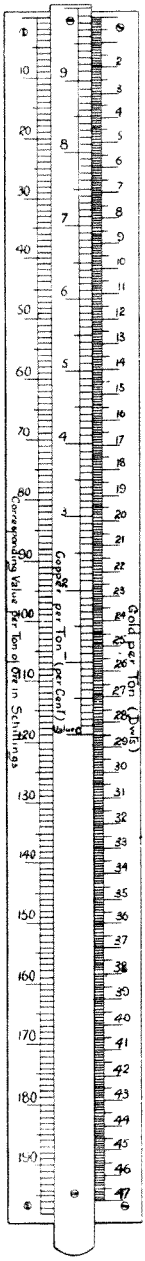
TABLE COMPARING SIX-MONTHLY AVERAGES OF STOPE ASSAYS WITH SMELTER (BIN) ASSAYS.

PERIOD ENDING	STOPE ASSAYS.			SMELTER ASSAYS.			INCREASE OF SMELTER OVER STOPE.			DECREASE OF SMELTER OVER STOPE.		
	Au.	Cu.	SiO_2.	Au.	Cu.	SiO_2.	Au.	Cu.	SiO_2.	Au.	Cu.	SiO_2.
26/11/07 ..	5·87	3·43	40·6	7·83	3·71	42·7	1·96	0·28	2·10	—	—	—
26/5/08 ..	7·29	3·64	41·5	7·31	3·58	43·5	0·02	—	2·00	—	0·06	—
24/11/08 ..	8·51	3·52	43·7	8·49	3·53	46·8	—	0·01	3·10	0·02	—	—
25/5/09 ..	7·06	3·25	44·4	6·36	3·10	47·7	—	—	3·30	0·70	0·15	—
30/11/09 ..	9·30	3·77	44·7	8·53	3·49	48·6	—	—	3·90	0·77	0·28	—
28/2/10 ..	11·73	3·63	43·8	10·99	3·57	47·2	—	—	3·40	0·74	0·06	—
Average of all assays from 9th July, 1907, to 28th Feb., 1910	7·98	3·53	43·1	8·00	3·49	45·9	0·02	—	2·80	—	0·04	—



SLIDE RULE FOR COMPUTING GROSS VALUE OF COPPER ORE.

ORIGINAL MODEL.



SLIDE RULE FOR COMPUTING GROSS VALUE OF COPPER ORE.

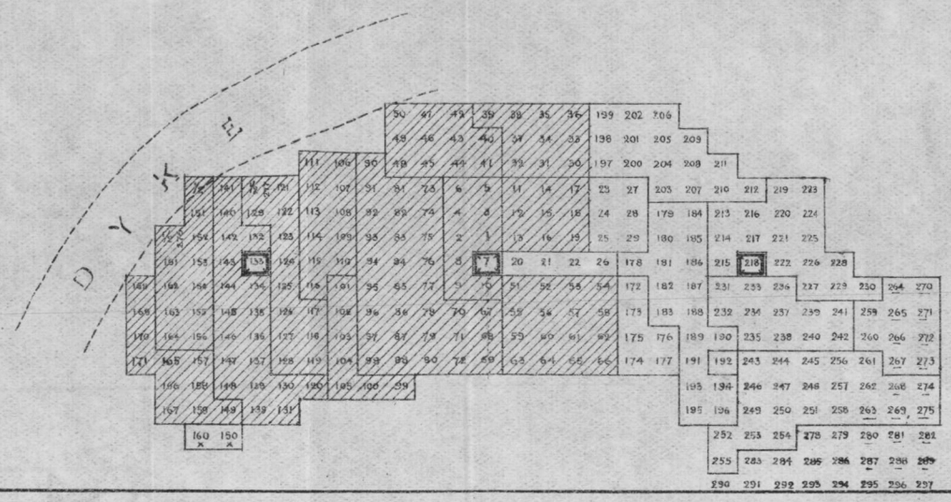
FIG. 1.

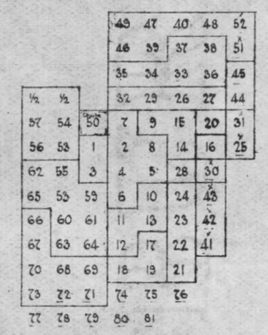
(SEE PAGE 166.)

(2)

(1)

(3)

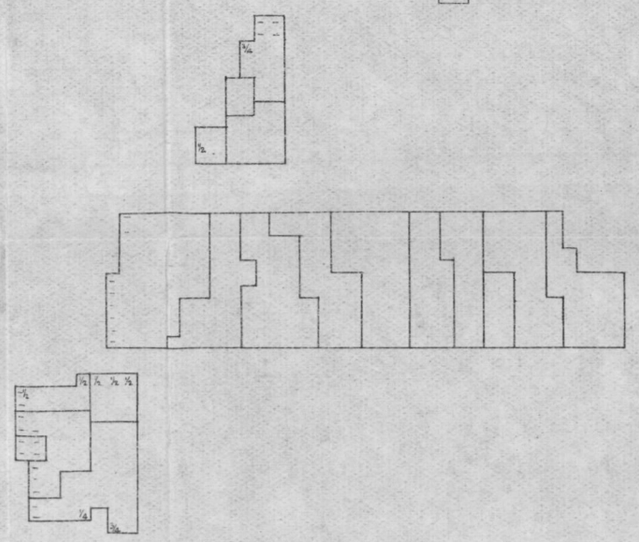




This plan is usually in pencil, not ink.

83 East

Truck Numbers.	Contractors.	Weights — Tons.	Cwts.	Qrs.	lbs.
(10.)					
	Total				



Floor No. 67

Patterson and Thomas
On Recording and Estimating.
Plate II.

(6) 49 East — 151

GOLD ORE. COPPER ORE.

Period Ending	Au. No. Assays	Au. Sum.	Au. Average	Cu. No. Assays	Cu. Sum.	Cu. Average	SiO_2 No. Assays	SiO_2 Sum.	SiO_2 Average	Au. No. Assays	Au. Sum.	Au. Average	Cu. No. Assays	Cu. Sum.	Cu. Average	SiO_2 No. Assays	SiO_2 Sum.	SiO_2 Average
6.7.09	14	211.82	15.13	14	13.30	0.95	14	887.6	63.4	5	36.20	7.24	5	17.85	3.57	5	236.0	47.6
3.8.09	9	108.81	12.09	9	7.83	0.87	9	550.8	61.2	7	48.50	6.94	7	25.76	3.68	7	316.4	45.2
31.8.09	7	52.68	10.24	7	8.12	1.16	7	504.0	72.0	12	104.76	8.73	12	38.28	3.19	12	559.2	46.6
30.9.09	3	35.85	11.95	3	5.15	1.71	3	197.1	65.7	16	124.00	7.75	16	56.16	3.51	16	753.6	47.1
31.10.09	4	25.36	6.34	4	5.28	1.32	4	268.8	67.2	15	96.15	6.41	15	51.60	3.44	15	687.0	45.8
30.11.09	15	214.65	14.31	15														
31.12.09	12	114.48	9.54	12														
31.1.10	7	67.76	9.68	7														

(5) 296

To 31.1.10.

	49 North East. Au	Cu	SiO_2	51F:17 Drive Au	Cu	SiO_2	51F:56 Winze Au	Cu	SiO_2
M. 1	086	12.1	81.4	P 21.	463	3.87	61.3	H 18	1499	0.46	76.3
. 2	026	10.6	82.4	. 28							
. 3	065	13.2	81.0	M 30							
P. 4	489	2.91	47.6	. 5							
5	7.18	3.01	44.4	P 40							
6	7.34	2.75	47.0	H 5							
H 7	7.50	1.10	62.2	M. 50							
. 8	10.76	1.26	58.6	P 6							
. 7	8.16	1.31	60.4	H 60							
P 10	0.48	3.56	47.0	M 5							
M. 1	6.53	1.34	77.4	P 70							
. 2	7.18	1.34	75.6	H 5							
P. 3	11.43	3.75	48.0	P 80							
. 4	9.13	3.64	45.3	. 6							
. 5	6.53	3.06	42.1	. 92							
. 6	6.05	3.91	47.4	H 3							
. 7	7.50	3.86	46.3	Average							
M 8	1.28	0.74	88.4	P 8							
H. 9	14.07	1.11	68.2	Average							
. 20	13.88	1.39	64.8								
H 7	67.78	8.86	472.2								
Average	9.68	1.26	67.4								
P 9	61.33	30.45	41.54								
Average	6.81	3.38	46.2								

(15) Week ending March 9th 1910

Sets Erected. Place	Sets	(For Office Use Only.)	Sets Filled. Place	Sets	(For Office Use Only.)	Round Sets. Place	Sets
54 SE'H	6		45N	3		No 30 Drive 450	6
59 E	4		46N	10		No 12 " 650	4
60 E	17		51 SE'H	4		No 14 " 650	2
61 NW	6		52 SE'H	5		No 20 " 250	
62 NW	3		54 SW	2			
60 SW	8		55 SW	4			
	5		56 SW	10			
	14						

(4) 100 South West Stopes.

FROM 5 Jan 1910.

DATE. 1910	MARK.	GOLD.	COPPER.	SILICA.	DATE. 1910	MARK.	GOLD.	COPPER.	SILICA.
Jan. 5	1	3.58	1.76	56.2	Jan 12	36	4.07	1.97	55.2
	2	2.28	2.30	54.0		7	3.58	2.00	54.2
	3	2.11	1.79	59.2		8	5.86	1.36	56.3
	4	3.26	1.60	46.0		9	5.54	2.10	57.6
	5	3.56	2.46	51.0		40	5.37	2.00	51.2
	6	2.60	2.49	49.3	13	1	4.56	1.53	47.6
	7	5.21	1.96	58.0		2	1.30	1.60	60.0
6	8	3.91	2.00	56.4		3	4.89	1.30	51.0
	9	2.93	2.26	60.0		4	5.54	2.00	60.0
	10	4.23	2.30	54.0		5	10.44	1.40	51.2
7	1	3.48	2.50	55.1		1	4.23	1.81	46.5
	2	2.77	2.60	60.0		7	4.28	1.86	50.6
	3	3.58	2.16	57.3	14	8	2.93	1.71	49.9
	4	2.60	2.49	56.0		9	6.85	1.50	46.3
	5	4.07	1.97	49.0		50	4.23	1.68	50.1
	6	2.93	2.50	50.0		1	5.21	1.35	49.4
	7	2.77	2.50	56.0		2	3.58	2.20	47.3
8	8	3.91	1.79	46.9		3	3.61	2.40	51.4
	9	4.10	1.97	62.0		4	8.16	1.60	60.0
	20	3.10	2.26	49.2	15	5	7.83	1.79	54.5
	1	3.58	2.30	50.3		6	6.40	1.60	55.6
	2	2.60	2.46	49.0		7	4.51	1.97	50.0
	3	4.23	1.97	59.9		8	1.63	1.00	37.6
10	4	3.69	1.80	46.3		9	2.93	1.30	54.3
	5	2.77	0.88	48.7		60	5.54	1.75	57.3
	6	2.61	2.59	61.2		1	4.89	1.80	47.5
	7	4.32	1.86	46.6		2	2.28	2.50	49.7
	8	6.85	1.60	49.2	17	3	3.91	2.46	46.0
11	9	1.30	Trace	61.0		4	4.89	2.00	50.9
	30	1.63	Trace	69.9		5	0.97	0.90	36.4
	1	6.53	2.00	50.4		1	4.89	1.00	41.6
	2	5.86	2.60	56.2		7	4.89	1.30	61.0
	3	3.21	2.00	60.0		8	5.86	1.50	66.3
	4	6.53	1.75	59.3		9	6.53	1.79	56.3
	5	4.68	1.97	54.6		70	4.56	1.50	54.6

(11) LINDA RETURN FOR ~~FOUR WEEKS~~ Month ENDING 31st October 1909

	TONS.	West.	Mundic.	Copper	Acid.	Total	Mullock Tip.	Mullock Stopes	Mullock Total.
Open Cut.									
Oxide Ore: Mills Benches									
(W. Leasehold 3986 W. Freehold 667 E. Freehold 1749)		6404				6404			
Mullock: Mills Benches Sulphide Bench							9	11977	11986
Sulphide Ore: Grasstree 4123 27 Floor Linda Pocket			4123			4123			
Acid Shed Ore 64 Converter Silica 265				265	64	329			
Main Tunnel Fireclay				5		5			
Total Open Cut		6404	4123	266	64	10663	9	11977	11986
Underground									
Main Shaft Ore (Total Mundic pulled 6520)			6520	18965		25485			
Mullock: Development								381	381
Stopes								617	617
Copper Chambers								726	726
Total Underground			6520	18965		25485		2324	2324
Total Mine		6404	10643	19231	64	36342	9	14301	14310
Fireclay									
To Brickyard 239 To Copper				239		239			
Acid Shed Ore to Mundic Works						64			
Total Treated in Works	6468		6520	19470	64	36645	9	14301	14310

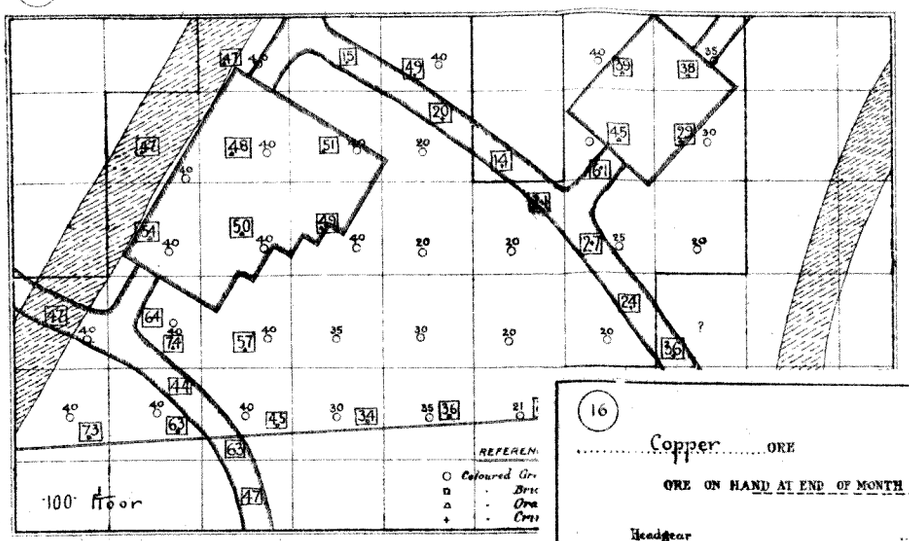
(17) MINE AVERAGE VALUES OF STOPES FOR January 1910

FLOOR	N. STOPES TONS	N. STOPES AVERAGE WIDTH	N.E. STOPES TONS	N.E. STOPES AVERAGE WIDTH	S. STOPES TONS	S. STOPES AVERAGE WIDTH	S.E. STOPES TONS	S.E. STOPES AVERAGE WIDTH	S.W. STOPES TONS	S.W. STOPES AVERAGE WIDTH	W. STOPES TONS	W. STOPES AVERAGE WIDTH	ALL STOPES TONS	ALL STOPES AVERAGE W. DRIFT	OZS GOLD CONTAINED
54			225	6.48									225	8.48	95
55			450	17.63									450	17.63	396
56			113	5.21			765	9.06					878	8.56	376
57							405	8.35					405	8.35	169
61									180	11.31			180	11.31	102
62									67	14.52			67	14.52	48
63			765	14.52					67	7.29			832	13.93	579
64			225	7.95					113	6.11			338	7.32	124
71	196	5.02			263	2.40							459	3.71	203
72	302	7.12			31	5.1							433	8.20	178
73	26	12.12			26	14.0							187	11.33	76

(13) MAIN SHAFT HOISTING FOR MONTH OF October 1909

SKIPS OF —	Linda. Pocket.	574. Pocket.	650. Pockets	750, 1. Pocket.	750, 2 Pocket.	850. 1. Pocket.	850, 2 Pocket.	950, 1. Pocket.	950, 2 Pocket.	Totals.	Skip Weights.	
Copper. 1st Week			162		262		127			551	Copper: Headway this period	335
2			223	178	434		267			1105	Weighbridge	18963
3			236	131	445		360			1172		19298
4			361		572		228			1161	Headgear last period	680
5			190		279		219			688	Total Copper Ore pull-d	19118
6											Giving as tonnage per skip	498
Total Skips			1172	310	1992		1201			4675	Gold: Headgear this period	200
Gold. 1st Week				262		39		52	403		Weighbridge	6520
2				159		117		58	334			6720
3				223		141		71	435		Headgear last period	175
4				281		110		101	492		Total Gold Ore pulled	6545
5				156		111		78	345		Giving as tonnage per skip	525
6											COPPER BALANCE	
Total Skips				1071		578			360	2008	In Headgear last period	680
Mullock 1st Week											In Pockets	210
2											750 (Pocket)	65
3											850 (Weighbridge)	5335
4											750 "	6895
5											650 (Pocket)	6388
6											Total Copper	20168
Total Skips												
Copper Ore, Tons			4733	1258	8165		4912			19118	Weighbridge Copper	18963
Gold				3488		1063			1173	5666	Total in Pockets	270
Mullock											Total in Headgear	435
In Pockets											Total Copper	20168

(18)



Specimen of Block Average Value Tracing (for Eg

(19)

Last Numbers of Sets and Output of Mine for Month end: May 9

Su.	No.	Su.	No.	Su.	No.	Su.	No.	Su.	No.	Su.	No.	
3611	153	3654	573	3647	169	3715	484	3761	4	559	31	Total Number of Square Sets erected in Stopes.
35	172	33	215	39	185	35	512	36	4	40	27	Mundic —— Copper —— Total ——
	196	40	319	40	228	40	319	37	4	41	28	Open Cut Mullock into Stopes (Trucks at 5 cwts.) Mundic 1468 T. Copper 3617 T. Total 6278
			373	40	271	41	331	36	4	41	29	Shafts worked by Truckers filling Stopes

dic 2446 Copper 213 Total 559

om Drives up Supply Shaft (Trucks at cwts.)

Nil

from Drives into Stopes (Trucks at cwts.)

450	559	4
450	860	5
574	878	6
574	378	5
		35
		23
		58

Sets erected in Drives

460	3	
574	2	
460	4	
460	5	
574	6	
460	6	
460	7	
574	5	
450	7	
	57	

Ore to Works 8439 Tons

Ore to Works 1589

(16)

Gold ORE

ORE ON HAND AT END OF MONTH OF February 1910

Headgear	150 tons
Linda Pocket	
574 "	
650 No. Pocket	
750 No. 1 "	100
850 No. 2 "	50
950 No. 1 "	40
Dry Chute	70
64 N.W.	30
90 N	100
93 W	70
TOTAL Gold ore in hand	650

(16)

Copper ORE

ORE ON HAND AT END OF MONTH OF Fe

Headgear	
Linda Pocket	
574	
650 No. 1 Pocket	
750 No. 2 "	
850 No. 1 "	

(21)

BLOCK 9J LEVEL 650-750

SQUARE	STOPED	40	35	30	25	20	DYKE	WASTE
A					75		25	
B						66	25	9
C						25	12	63
D						16		84
E			27	27	21		25	
F					9	66	25	
G						46	12	42
H	4					25		71
I			28	29		18	25	
J			36	37	2		25	
K	12					73	10	5
L	15		21	32		11	21	
M			31	32		12	25	
N			37	38			25	
O	14		10	22	22	22	10	
P	12		21	21	20	20		6
TOTAL	57		211	238	149	400	265	280

(9a)

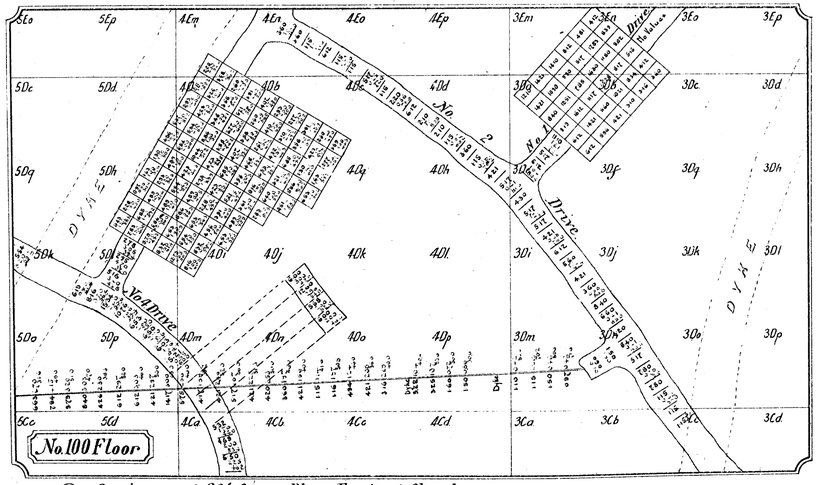
Floor No. 65 No. 2 Chamber.

Section.	Totals.						Averages.		
	No.	Au.	No.	Cu.	No.	SiO2	Au.	Cu.	SiO2
A									
B									
C									
D									
E									
F									
G	28	8932	28	5128	28	10477	319		
H	59	50917	55	23010	53	20414	863		
I	60	62100	60	26100	60	22140	1035		
J	61	69930	61	25864	61	22326	1150		
K	60	56280	60	24000	60	23640	938		
L	55	28455	55	8960	55	15960	813		
M									
N									
O									
P									
Q									
R									
S									
T									
U									
V									
W									
X									
Y									
Z									

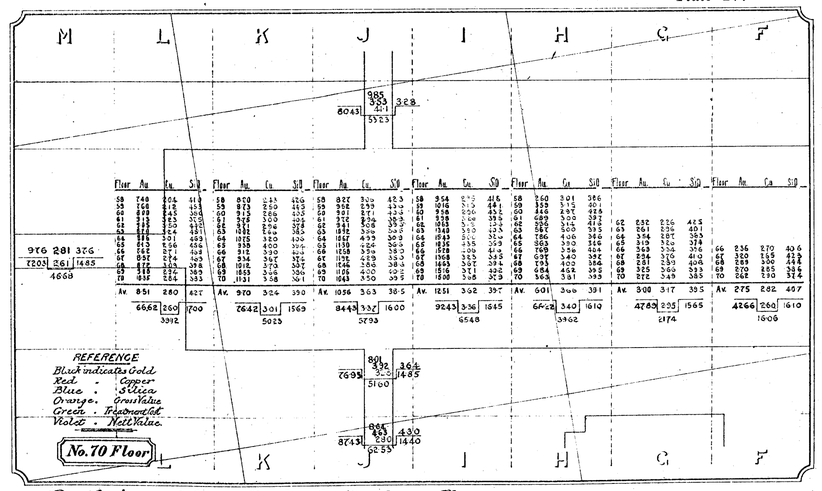
(12)

Main Shaft Hoisting for Week commencing Wednesday 29 September 1909 96

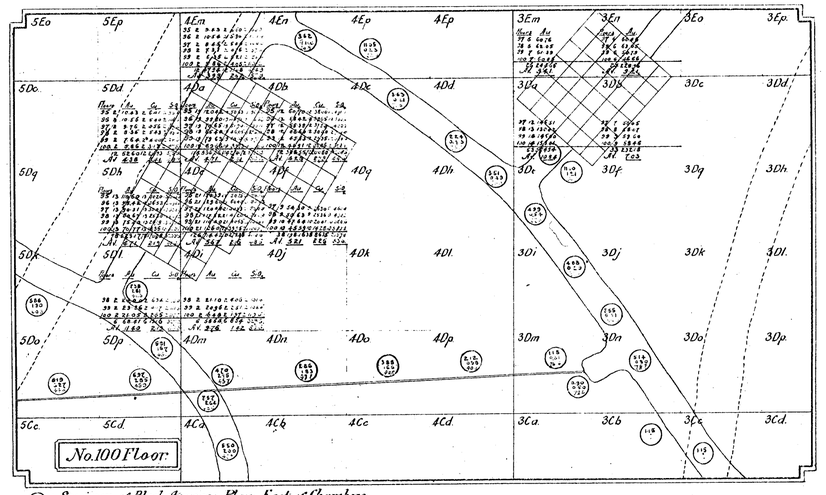
Day and Shift.	SKIPS. (Put C for Copper, M for Mundic, W for Waste (Mullock), in front of number of skips pulled.) LINDA. Pocket.	54. Pocket.	650. Pocket.	1 Pocket. 750.	2 Pocket. 750.	1 Pocket. 850.	2 Pocket. 850.	1 Pocket. 950.	2 Pocket. 950.	HOURS LOST Bailing.	Current Off.	Au. Off.	(Remarks.) Pocket, Repairs, and other time lost.
Tu. N			M 30	C 25		C 26							
Wd. D			M 30	C 18		C 23		M 23					
Wd. A		C 21		C 44		C 30							Repairs to Capstan 1 hr.
Wd. N		C 25		C 21		C 24							
Th. D		C 46	M 27	C 24									Putting glass in Cap Skip 1 hr
Th. A	Men acted	C 29	M 6	C 16	M 18	C 35							Delay with broken Chain
Th. N			M 30	C 44	M 8								
Fr. D		C 5	M 30	C 14	M 21					2½ hrs			
Fr. A		C 56	M 26	C 24	M 4	C 18							
Fr. N			M 30	C 29	M 10	C 30							
St. D													
St. A													
St. N													
Su. D			M 30	C 27	M 18					2½			
Su. A													Putting in rails 3 hrs 6
Su. N		C 25		C 10		C 30							
Mo. D				C 27		C 3		M 18		5½ hrs			
Mo. A			M 24	C 18	M 21			M 31					
Mo. N		C 23	M 32	C 18		C 27							
Tu. D		C 17	M 30	C 25		C 30							Changing Cond. Skip 1 hour
Tu. A		C 32	M 32	C 32				M 28					Pockets cut full 1 hour
		C 162	M 252	C 252	M 99	C 137		M 92					



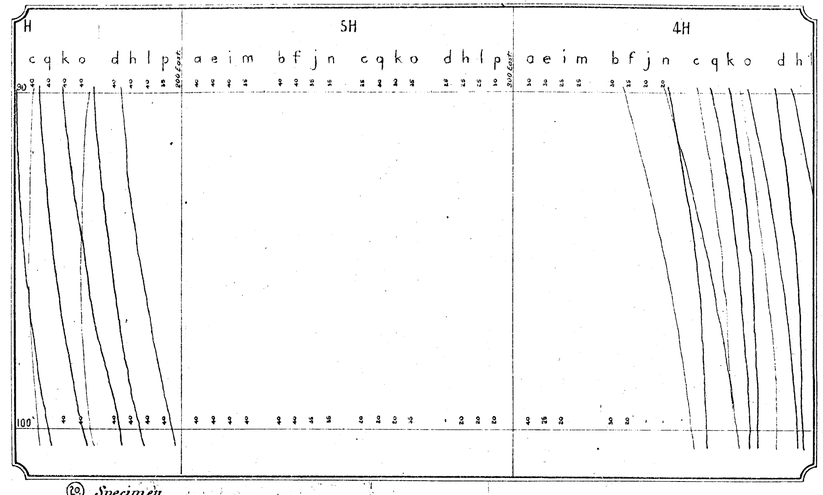
⑦ *Specimen of 20' Assay Plan East of Chambers.*



⑨ *Specimen of Copper Chamber Section Average Plan.*

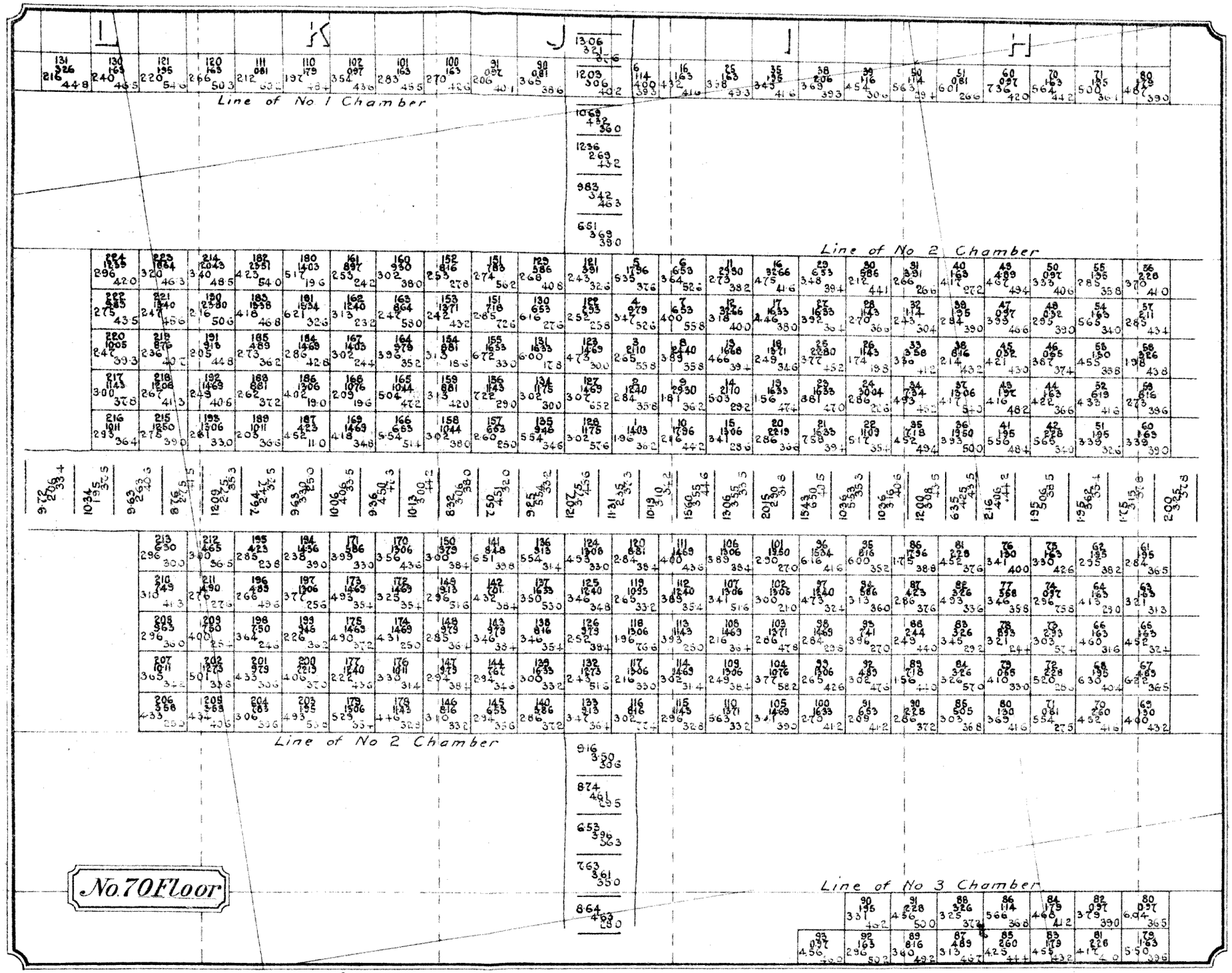


⑱ *Specimen of Block Averages Plan, East of Chambers.*



⑳ *Specimen*

(ASSAYS AND VALUES SHOWN ARE IMAGINARY.)



(8.) *Specimen of 10' Assay Plan, Copper Chambers*

(ASSAYS AND VALUES SHOWN ARE IMAGINARY.)