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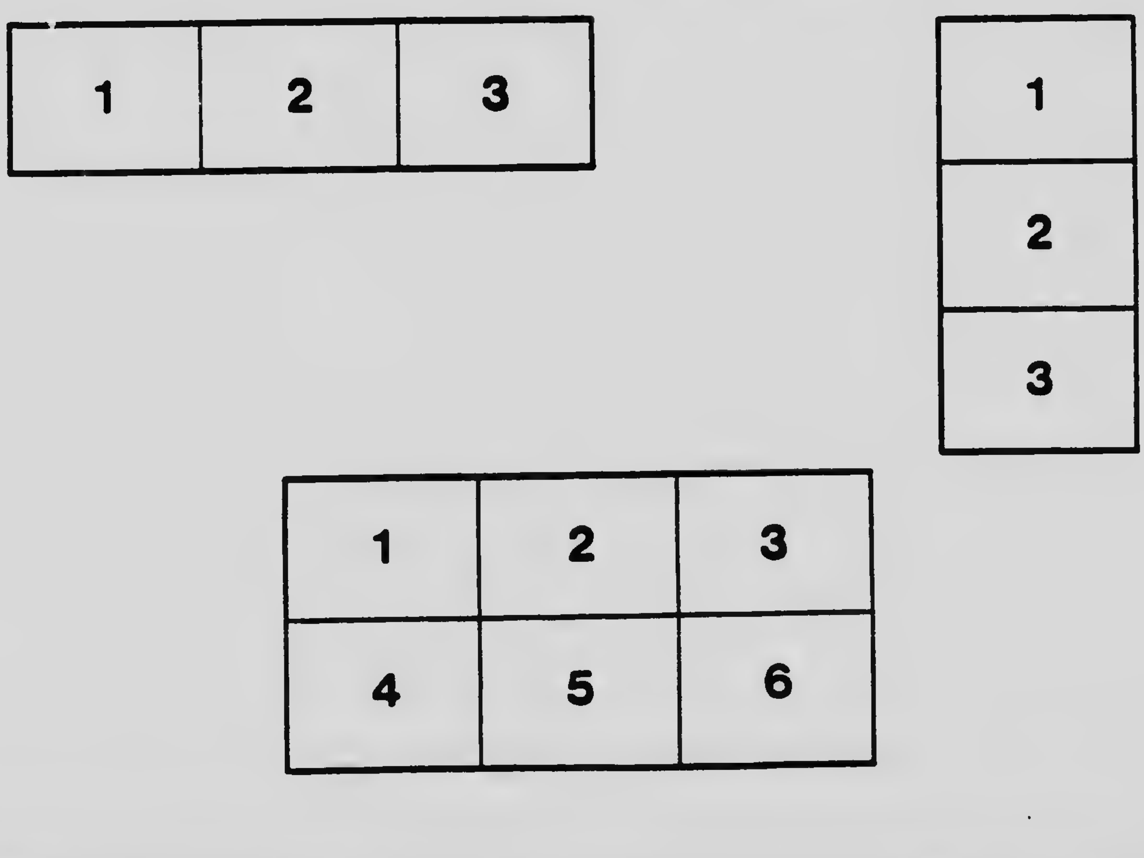

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THE EDUCATION

OF

MINING ENGINEERS

BY

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THE EDUCATION OF MINING AND METALLURGICAL ENGINEERS.

By John Bonsall Porter, D.Sc., M.Inst. C.E.
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Until a comparatively recent day Engineers as a body showed little interest in what may be broadly termed Engineering Education, and left it to the Universities and Technical Schools to formulate and carry out such schemes for training young men as they saw fit. There were of course notable exceptions and many Engineers of the highest rank gave invaluable advice, assistance and sympathy; but in general the feeling of practicing engineers and particularly of Mining Engineers to teachers of Engineering was indifferent and occasionally even unfriendly.

Under these conditions the natural tendency of professors to become pedantic was not sufficiently neutralized, and although the public demand for advanced education led first to the foundation of professorships in engineering in each of the great Universities, and later to the development of special faculties and schools of Engineering with elaborately differentiated departments covering the several branches of the subject; yet, in general the methods of teaching remained to say the least somewhat academic.

It has been a very few years since it was possible, and even quite a matter of course, for young men to be granted University degrees in Mining Engineering without even having seen a mine, and in other branches of Engineering the situation was no less absurd.

The so called Summer School established twenty odd years ago by Columbia University, and adopted (usually as an optional course) by several other Mining Schools, was the first and most important movement in the right direction. The equipment of Engineering Laboratories, and later of special laboratories of ore dressing and metallurgy, was almost equally useful; and now every school of importance is provided with laboratories, and

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offers its students so called practical and experimental courses in many branches of engineering.

These changes, and the introduction of manual and technical training in both elementary schools and colleges, have met with approval from practical engineers, and during the last few years the technical journals and the Transactions of Societies have contained a great number of papers on Engineering Education. Further, practising engineers and works managers have displayed interest in the education of young men, and have shown a far greater willingness than heretofore to admit students to their establishments and to offer employment to engineering graduates.

This general interest in technical education is most gratifying to those professionally engaged in engineering teaching and is bound to result in great good, but it is not without its danger.

The practising engineer, no matter how thorough his own education has been, usually finds little or no direct use in his practice for higher mathematics and for the pure sciences, and he fails to realize the immense part played in his own intellectual development by the study of these subjects. On the other hand he is constantly concerned with technical detail and naturally looks with approval on any school which turns out men ready with facts and figures for immediate use. His influence is therefore almost always in favor of technical as compared with scientific education.

For somewhat similar reasons the majority of engineering students—at least in North America—are very keen to work at studies which have direct and obvious bearings on their future profession, and are grudging of time given to pure science. They fail to see why in a mining course, for example, mining itself should be assigned fewer hours of study than certain other subjects, and why all professional subjects together should occupy but one quarter of their course.

Similarly, many managers and even thoroughly educated engineers, in judging the comparative merits of young men seeking employment, naturally prefer those who have a maximum of technical knowledge and can at once be made useful, to men whose knowledge is more general.

Under these influences the engineering courses are being somewhat rapidly modified even in the more conservative schools.

As a whole the changes are for the better, but, at the moment, it is probable that in this country at least, too great weight is being given to the technical side of education. Certainly there is great confusion in the minds of many laymen and some teachers between Science and Technology. How to do a thing is taught rather than why to do it, and, in the stress and rush of filling students with facts, the infinitely more important business of teaching them to think is almost forgotten.

This utilitarian tendency is shewn most fully in the Correspondence Schools which have sprung up within the last few years and now number their students by hundreds of thousands. These schools have largely taken over the work once attempted by night schools, mechanics classes, etc. and as a whole do it admirably, but they are unfair to their patrons in that they often ignore or make light of difficulties and give their students a somewhat exaggerated idea of the completeness of their own knowledge. The young men who take these courses are rarely able to spare the time and money necessary for a University education, and what they do learn is therefore all to the good, but it is unfortunate that these schools so often fail to make it clear to the students that purely technical knowledge is after all only half knowledge, and that the highest achievements in engineering are only possible for men who are thoroughly familiar with the principles of the pure sciences underlying all engineering practice.

Technical schools and similar institutions usually occupy a position in advance of the Correspondence Schools, but as a rule their standards of admission and of class work are comparatively low, and it is left to the more conservative Universities and to certain exceptionally thorough technical schools to provide the highest type of engineering teaching.

This teaching should be in general very similar for all branches of engineering. The preparatory work should include good elementary training in the usual school subjects, in elementary mathematics and in at least one modern language. Latin is also desirable, and last, but far from least, the students should be able to write English accurately and clearly.

Assuming this preparation to be of the standard of the best Canadian and American schools, the engineering course should then take four years, two of which can be devoted with advantage to advanced mathematics, and to physics, chemistry, geology, etc. With these pure science subjects there may be a certain amount of elementary shop work and foundry practice. Time must also be found for mechanical drawing and some sketching.

The long vacations should also be utilized in part for further shop experience in real works, or, in the case of mining students, for labourer's work underground, and for field classes in surveying.

The two final years may then be given with safety to more technical studies. Pure mathematics being now sufficiently in hand, its engineering applications to structures and machines are considered under the heads of applied mechanics and machine design. The elements of electrical and mechanical engineering are also essential to all engineers, and miners need also elementary metallurgy and mineralogy. The studies in chemistry and geology must also be extended, and laboratory work must be done in one and field experience gained in the other.

The main part of the work last outlined can be done in the third year of the course, and a portion of this year and almost the whole of the fourth can be given to what may be called "professional work," that is to say to special studies in the branch of engineering chosen by the student. In the case of Mining and Metallurgical students the various branches of mining and ore dressing and of advanced work in metallurgy may be included.

It is obvious that no very elaborate detail can be taught in technical courses which have to be carried through in a single year or at best in a year and a half, but elaborate work is not needed in engineering classes. The essential thing is to get students in the way of thinking as engineers, and to familiarize them with the general principles and fundamental problems of their profession. It would be impossible in one year or indeed in ten, to teach a student the detailed technology of the whole of his selected branch of engineering, and it is obviously rarely possible to select the particular part which he will afterward practice. It is however quite possible to give an intelligent young man a general view of the subject, and then to teach him the technology of a limited number of carefully selected typical processes, and if he knows these thoroughly he will have no difficulty later in learning whatever special processes he is called upon to use. In other words if a man is taught to think as an engineer and to work as an engineer in any one branch of mining or metallurgy, he can, whenever necessary, qualify himself quickly for any other branch when the circumstances make it necessary.

In what has been said above, practical work, summer schools, and laboratory experiments have been mentioned, but it remains to discuss them at some length. The student of engineering should, at an early period in his course have some training in shop work on the ordinary materials of construction. He will not be able to spare time enough to become a skilled workman or even a half skilled apprentice, and he must be made to understand this clearly; but he can and should work long enough to know something of the use of tools, and to understand the qualities of the materials of construction which he is about to study theoretically. This elementary shop work is often carried out in work shops connected with the schools and universities themselves, and frequently can be done in the afternoons of days, the mornings of which are given to more academic studies. This method is economical of time and there are many advantages in having the teaching and shop work under the same direction, but unless a boy is to get thorough practical training later, it is better for him to go to an ordinary shop where he should be required to work full time each day under ordinary shop discipline. In no other way can he be made to realize what work really is; the intimate acquaintance with workmen is also very useful.

The shop work if done outside of the school can usually be arranged for the long vacation, which should be long enough to give time for it, and for a reasonable holiday. Two periods of two or three months each in two successive vacations should suffice for an ordinary boy, especially as practical technical training is also required at a later period in his course.

This latter technical work is even more important than the shop experience. It should, if possible, follow the general science teaching, and precede the specialisation. The students should first be taken into the mines in a body, and be given an opportunity to visit and study works under the guidance of a staff of competent instructors. After a month or two of this field work, each student should obtain bona-fide employment in some works in his chosen speciality, but the exact nature of the work is of no very great moment, so long as it is good engineering, done by good workmen intelligently directed. The important thing again is to get the student in touch with real work and real wage-earners, and to give him an idea of scale. The elementary shop work may be done at convenient times in a school shop, as recommended above, but this technical work must be real in every respect. The student should, for the time being, become a plain workman on wages, responsible to his foreman for certain duties, and liable to penalty or discharge for cause.

The time to be given to this work must depend on circumstances. Three months under the right sort of foreman, in a small but interesting mine or mill, will teach as much as a year of ill-directed drudgery. Furthermore, students differ greatly in the readiness with which they take to practical work. Some are the better scholars for having had many years of hard apprenticeship; but very frequently the man who has spent even one year in practice finds it difficult to return to his classes. He is earning money at work, and can often ill-afford to give it up, and again become dependent on his people. Study also often proves irksome, and sometimes very difficult after a man has been actively employed. As a result, many men fail to return to their final studies, and thus lose what should be the most useful part of their education.

If a definite time for practical experience must be set in advance, it is probable that two periods of about four months each in different establishments, or one period of a year would be about right; but in this, as in all other matters of technical education, it is far better to make the regulations somewhat elastic in respect of field work and advanced study. Much time can be saved the students, and their training made more effective, if each case is separately considered by the responsible head of their school.

This last and most important period of practical training should follow the elementary engineering studies, and if possible come between the third and the fourth year in a four years' course. From it the student comes back to his school with fresh enthusiasm yet without having got out of touch with academic methods as he would have done had he spent a longer period at work. He now enters on his advanced study and the teaching may be highly specialized and quite technical, but care must be taken to keep fundamental principles in sight, and the detailed technical work should be carefully laid out to cover only certain important typical operations. The academic work can be made much more interesting and effective by the free use of technical laboratories, in which engineering machinery (and in our case ore-dressing and metallurgical apparatus) can be used; but here, as in the lecture room care must be taken to teach principles, not processes. Certain processes must of course be used, and a good deal of careful detailed work done; but the primary purpose must always be to teach general principles, and mere technology must be kept in a secondary place.

The best function of laboratories, aside from the limited use necessary to illustrate fundamental principles, is to develop the initiative of the students. Each man should be given certain carefully selected pieces of independent study, and should be encouraged to attack his task in his own way. One or two comparatively heavy investigations are more useful than many short experiments, and the instructor in charge can often do his men far more good by showing interest, and yet letting them work out their own salvation whenever possible, than by being too ready to set up apparatus and smooth over difficulties. This advanced individual work can utilize to the full the resources of even the most magnificently equipped laboratories; but care should always be taken especially in schools which are very rich in practical apparatus, to see that the students should do a few things thoughtfully, and with a clear apprehension of their bearing, rather than that they should get shallower experience of many processes and machines.

In connection with this advanced study the men should be taught to write up their results, and to apply the knowledge gained in works, laboratories and lecture rooms, to some practical problems in engineering. In these, questions of estimates and costs should be considered, for the men are now about to go out into the world where costs form an essential element in every enterprise. Estimates made even by advanced students are likely to be far from right, but their preparation gives the men extremely valuable experience, and a competent instructor can do excellent work by discussing economic matters with his men in this stage of their training.

This should end the school course in engineering, for no amount of mere teaching will turn a boy into an engineer, still less into a mining engineer. If, however, he is given a good grounding in science and the principles of engineering, is then put in touch with practical engineering work, and is finally taught the elements of the technology of his subject, he will be prepared as well as any school can prepare a man to go out into the world and learn to become a good engineer.

Such a course of study as has been outlined above is very different from the old-fashioned course in Mining, and in fact is different in some respects from any course in Mining offered at present, although many schools approach it, and each year sees changes made which bring our science courses closer to this ideal. In this connection the author takes the liberty of briefly outlining the course in Mining and Metallurgy offered by his own University, not because he believes it to be by any means perfect, but because it illustrates very well the modern practice in engineering teaching.*

At McGill University students are required when entering to show a good knowledge of mathematics, of one modern and if possible one ancient language, and of the usual English and general subjects of the higher schools. They then devote their time for two years to advanced mathematics, physics, chemistry, elementary mechanics and surveying. They also give a great deal of time to drawing and to shop work. In addition to their studies in the University they are required to do one month each year of extra mural-work in surveying.

Up to the end of the second year, all engineering students take the same course; after that differentiation begins, mining and civil engineers giving more time to surveying and surveying field work, while electrical and mechanical engineers spend additional time in the drafting rooms and machine shops.

In the third year in the Mining and Metallurgical courses, lectures are given on the elements of mining, metallurgy and ore dressing, and final work is done in the more general engineering subjects.

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*The illustrations accompanying this paper need no description beyond that printed on the plates. They are chosen with a view to illustrating the character of the Ore Dressing and Metallurgical laboratories alone and do not by any means cover the whole equipment of the department, much less of the school as a whole.

At the end of this year the class is taken to the field and five weeks are spent in studying mines and metallurgical plants under the personal direction of the staff of the department. The district visited is carefully chosen with a view to offering the students the best possible opportunities for observation, and the method in general is to first spend ten days or a fortnight in one particular mine or works, thus familiarizing the students with the plant and making them quite at home in it. The remainder of the period is then spent in visiting other works, one or two days being given to each, and the differences in method, etc. noted and studied.

During these excursions, which are ordinarily carried out in a private car chartered for the purpose, students and staff live together, and informal lectures and discussions are held whenever practicable, in order to call the attention of the men to salient points of interest.

While this class work is going on arrangements are made with the managers of the plants visited to take on individual students for the remainder of the summer as workmen. In this way it has always proved possible to provide employment for all men who have not already secured engagements for the summer, and at the end of the field school the class disbands, not to play for three months, but to go to remunerative individual work.

On the return to the University in the autumn the detailed technical and laboratory work already referred to is seriously begun.* Certain typical operations are performed by the whole class, such as a stamp mill run, the concentration of a lead or copper ore, and a short campaign with a copper or lead blast furnace. The main work of the succeeding six months is however individual and each man is encouraged to take up same investigation which is especially interesting to him, such as the concentration of the ore from some mine in which he hopes to obtain employment, or the smelting of a particular material, etc. This individual study is under the eye of competent instructors, and assistance is given when needed; at the same time, and, when possible, in the same connection, he is required to design

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*In the appendix will be found a copy of the instructions given to students at the beginning of their elementary work in ore dressing. The more special advanced work is similarly covered wherever possible by instruction papers which need not be repeated here.

work as and to prepare approximate specifications and estimates as already outlined.

In a recent paper by Dr Stansfield* the method of laboratory teaching in Metallurgy is admirably set forth in detail. The method employed in the Mining and Ore Dressing Laboratories is so similar that it need not be more fully described here.

The University course thus closes with a year of work as practical as possible, yet so laid out and directed as to be theoretical as well, and at its end the student is sent out to begin the practice of his profession. His education is however but half over, and if he wishes to achieve high success in the end, he must content himself with a subordinate post for many years, and work hard and patiently to master the details of his special business, to learn to command men and to know himself.

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*Can Min. Inst. Vol. IX, 1906

APPENDIX.

LABORATORY NOTES ON TRIAL RUNS IN ORE DRESSING.

DEPARTMENT OF MINING ENGINEERING, McGILL UNIVERSITY.

With some ores it is so simple a matter to separate the constituents, that a competent engineer needs only to examine the material and have it assayed in order to determine upon a fairly satisfactory scheme for concentration.

With the majority of ores the case is, however, very different, and the engineer can by mere inspection do little more than decide upon the general features of schemes that will probably be effective. In such cases it is very desirable that these schemes be tested and developed by means of experiments on a small scale, before any extensive tests are made, and still more before actual plants are designed and built.

These small scale tests can sometimes be carried out with very simple tools, such as the hand sieve and the miners' pan; but usually it is best to use more elaborate apparatus, and to attempt the actual work of concentration on a laboratory scale.

Such experiments, if properly carried out, are frequently of the greatest value, not only in testing the proposed scheme, but also in bringing out the individual characteristics of the ore under examination, and in determining many details of treatment.

It is, of course, unreasonable to expect such tests or laboratory tests on any scale, to determine every part of a complex scheme for commercial treatment, and many adjustments, and even important changes will have to be made after the final plant is built and in operation; but in the meanwhile, the test is invaluable as an aid to the designer and engineer.

In the following pages a somewhat comprehensive scheme for testing is set forth, but persons using it must remember that any general method, no matter how carefully drawn up, will apply imperfectly to any special case. Students will, therefore, be expected to use their own judgment and to follow the spirit rather than the letter of the instructions.

SAMPLE.

The Purpose of the test is, first, to determine the method to be used, and, second, to approximately determine the details of the apparatus required, and the probable results of operations on a large scale.

Sample. Secure a representative lot of the ore to be tested. If at the mine, this should be taken from the working places in a systematic and impartial manner, to represent the average output of the mine under working conditions.

Sometimes it is desirable to test some part of the mine, or some p as for example the low grade ore left after the removal of special ore which is sent direct to market. In such cases the sample sho fairly chosen with a clear understanding of the end in view.

The sample should, when possible, weigh at least a ton, and often times this amount should be taken. In this connection it is not to consider only the amount required for the proposed tests. As a g rule ores containing high grade mineral are more irregular than low material, and therefore larger quantities are needed to secure a fair a lot, even if only part of the lot is afterwards needed for the test prope

If it is impractible to sample the mine as above, every effort sho made to secure a representative lot of the ore, a d in this connection it be remembered that it is almost as bad to have the sample too low in as too high.

Care should also be taken to get the ore in about the condition in it would normally come from the mine. There should not be an proportion of fine or coarse ore, and there should be as much gangue wall rock as would be likely to get in in ordinary mining.

PRELIMINARY EXAMINATION.

A small average sample of the main sample should be taken and fully examined to determine the constituents minerals and their rela to one another. Note especially the siz and shape of the individual g of the valuable minerals and decide upon some size above which reason clean separation is obviously impossible.

Then crush a portion of the sample to this dimension and size it nest of sieves. Examine the coarsest size, then the next finer, etc., one is found in which the majority of the grains are free

The proper size is one that will free a good proportion of the grains yet will not crush them more than is necessary. It is better to leav moderate number of inclusions along with the freed grains, than to c a large amount of free material too small. The inclusions can usually separated as a middle product and specially crushed and treated again, less loss than follows the undue sliming of the whole lot. Not infrequen an ore will be found in which none of the coarse particles are sufficien free from valuable mineral to be wasted, while some are so high in gr that further crushing is undesirable. In this case the coarser sizes sho be jigged for coarse high grade heads, and both the middles and tails tained should be recrushed separately or together and treated again.

In the above instructions it has been assumed that the mineral gra are all comparatively small and disseminated through barren or low gra rock. This is true of concentrating ores proper, but often the original samp will contain some comparatively large pieces of pure or high grade materi When these are over an inch or so in diameter, it is expedient to subje both the preliminary and the main samples to hand sorting.

Hand sorting is rarely practised out of the laboratory on material th will pass through a sieve with one inch openings, and ordinarily the lin is two inches or over.

All stuff finer than this is ordinarily crushed and concentrated, but the coarse stuff should be examined for the following grades of material.

(1) Pure mineral and mineral so rich that it is already fit for the smelter or market, should be picked out and set aside.

(2) Rich concentrating ore, or ore with special constituents which require special treatment, should be similarly set aside and separately tested.

(3) Barren material or ore of very low grade should also be set aside.

(4) Average concentrating material which remains should be added to the fines.

The lots thus specially selected should be weighed and then sampled, and the results noted.

Note.—In laboratory tests hand sorting is often done on stuff down to ½-inch or even smaller, when there are difficulties in the way of jigging small lots of material of this size.

Crushing and Sizing of the Main Sample.

After the preliminary work is finished, the main sample should be carefully mixed and quartered, and a portion of sufficient size for the final test taken. The amount required varies with the circumstances, but may be taken roughly at from 5 to 25 lbs. for a field test with sieve and pan, and from 100 to 300 lbs. for a laboratory test with small jigs and tables. In any case it is expedient to have an ample quantity.

This portion should be weighed and roughly sized for hand sorting as per the instructions given above, and then should be crushed to a size a trifle larger than that decided upon in the preliminary work as giving a fair separation. If this crushing is to a small size it should be done in stages with intermediate screenings.

Any available crusher may be used, even a spalling hammer, but it is best to use a machine of the type that would be used in practice.

The crushed rock should then be screened into as many sizes as are likely to be necessary: (the scale of reduction depending on the specific gravities of the minerals to be separated).

The portion under 1 m.m. or better ½ m.m. need not be sized as it will have to be classified. In fact in mills the minimum is usually over 1 m.m.

The weight of each size should be taken and with it a note made of the appearance of the material. Then each size should be jigged.

Classifying.

Classification in rising currents may be used for comparatively coarse material, but is usually desirable only for the stuff under 1m.m. A small portion of this material should be tested in a small tube classifier, and current velocities determined that will divide it into, say, four nearly equal classes. The whole portion of fines may then be treated in a larger Richards or Munroe Classifier set successively for these several velocities.

The best method is to set for the minimum velocity first, and catch the fines in the overflow. The coarser sorts can then be readily separated by successive treatments with increased velocities without further diluting the slimes.

The several products of classification should be kept separate, and subsequently treated; the coarser by jigging, and the finer by vanning; but each should first be sampled, and if convenient dried and weighed.

Note.—Trouble is frequently caused by the tendency of fine dry stuff to float when first put in water. It is therefore expedient to wet the whole lot before attempting to classify it. To do this, place the fine material in a sieve or sack and stand it in water deep enough to almost cover it. The lower part will at once become wet, and capillary action will soon carry moisture to the topmost grains.

Jigging.

Jigging may be done with either a small hand sieve or with more elaborate apparatus such as the Vezin laboratory jig, or the larger two compartment jigs recently built. The former demands considerable skill on the part of the operator, and at best usually gives less exact results than a power jig but it has the great advantage of being always available even in the field.

Hand Jigging should be performed on sized stuff, each size being treated by itself. The mesh of the sieve should be smaller than the smallest grains treated on it, except in special cases where it should pass the finest but hold the coarsest part of the material.

The sieve should be filled about two-thirds full of the coarsest sized stuff and jigged under water for several minutes. The stroke should be slow on the rise and quick on the descent, and great care should be exercised to avoid any side throw. In some cases the jig may be raised enough to partly emerge from the water. This increases the suction and tends to draw the smallest grains to the bottom. The operation is, however, difficult to perform, and is only useful in special cases. For coarse stuff, the stroke may be long and slow. For fine it should be quick and short.

After jigging for some time the surface of the sand will show clean tails. These tails may then be skimmed and new ore added and jigged. This operation must be repeated until a sufficient quantity of heads and middles have accumulated in the sieve, or until the whole of the portion of the ore has been used. The sieve must be carefully skimmed at the end, and the portion too rich for tails and too poor for heads set aside as middles. Each of the three products may require rejigging or panning by itself to make it sufficiently clean.

Each size of the test sample should be similarly jigged and the products kept separate.

Usually some fine stuff remains in each size and passes through the jig sieve, some fines are also formed during the operation; these fines, if rich enough, should be added to the heads or middles, but if too poor for that, they must be added to the next size finer, and treated again with it.

Machine Jigging is performed in much the same way as hand jigging, but the mechanical devices make it possible to do more accurate work. Laboratory jigs are rarely provided with quick return mechanisms, but it is usually possible to adjust the water supply in such a way as to give the effect of either quick or slow return.

The coarsest stuff should be jigged first, with [illegible] slow strokes, and ample water in the piston compartment (pulsion). The bed of material on the sieve should be about three inches thick, and [illegible] it has been jigged until the surface shows clean tails, fresh material sho[illegible] be fed slowly and uniformily. The surplus tails overflow automatic[illegible] into a tank, and at the end any remaining tails are skimmed and added to them. The middles are then skimmed, and next the heads and each saved. If the middles fill the sieve and begin to come over before the end, the jig should be stopped, and part of the accumulated heads and middles removed.

At the end each product may have to be run again by itself to get it clean.

The fines which pass through the sieve in [illegible] the bottom box should be flushed out at the end and either added to the product already made or re-treated with a finer size

Each size should be jigged as descr[illegible] e, with the difference that the finer sizes require shallower beds [illegible] and fast[illegible] strokes. Less underwater is needed also, and for very [illegible] very heavy [illegible] action may be obtained if necessary by feeding water [illegible] ore and per[illegible] a constant escape of water from below the s[illegible]

This last device in combination w[illegible] of the stay bo[illegible] makes it possible to jig very fine stuff such as the [illegible] from the cl[illegible]ication of the material too fine to sieve.

Jigging through the bed is sometimes [illegible] even with hand sieves and coarse sizes, although the methods already described are better adapted to most ores. With fine stuff and mach[illegible] jigs [illegible] desirable, and in test work with very fine stuff it is almost [illegible] expedient to use this method.

The sieve must be selected for each size and [illegible] pass the greater part while it retains, say, one third or one [illegible] The stroke should be short and quick and the water adjusted to g[illegible] strong [illegible]

After a good bed of concentrates has accum[illegible] the sieve, work should be stopped and the bottom [illegible] cleaned [illegible] its contents mixed with the stuff remaining to be fed.

On resuming work the throughs should [illegible] or nothing but pure heads, and work can be continued until [illegible] coarse concentrates come over with the tails.

By using a stay box or a two compart[illegible] jig [illegible] middles can be saved without frequent skimming.

Occasionally it is practicable to get really [illegible] work, by using a sieve of such size that everything can go through. In th[illegible] case a bed of coarse mineral is secured (usually from the next size larger) and put on the sieve before starting, and if necessary additional miner[illegible] is fed from time to time.

This method is too complicated for most tests, but is occasionally useful as a means of securing a large and uniform output from a small jig.

Vanning.

The finest class of slimes from the classifier, and often one or more of the classes next coarser than this, are too fine to be jigged and must be concentrated by vanning. This may be done with considerable accuracy in the pan or batea, but when practicable it is expedient to use a laboratory slime-table.

Vanning with the Plaque is done on comparatively small portions of material. The plaque is held firmly with both hands and partly filled with water. It is given a slow downward and forward motion of half or three quarters of an inch, followed immediately by a quick upward and backward jerk; the plaque being meanwhile held slightly inclined. This drives the heads up the inclined surface of the plaque, and by repeating this operation they may be separated from the other material. The plaque is then given a slow gyrating motion which lifts the tails while disturbing the heads but little. This sweeps some of the tails over the edge of the plaque.

By alternating these motions the tails can all be cleared from the plaque, but it is best to van them again and add their heads to those first obtained.

The material must be kept wet to avoid float, and must be kept in motion to prevent packing.

By repeating the operations and weighing and assaying the products, it is possible to get surprisingly accurate results.

Another method of using the plaque is to hold it in one hand, as one uses the horn spoon, and strike it on the edge with the other hand, thus getting a bumping motion. This is less effective than the method first described, but is easier to learn.

The Pan may be used for larger quantities up to say 10 lbs. per charge. It is scarcely as accurate as the plaque or batea except on very heavy minerals.

The pan is filled, immersed in water, and the contents gently but thoroughly mixed. The pan is then raised and gently shaken to level and settle the contents, none of which may yet be permitted to waste.

The shaking should be gyratory, with occasional short, sharp, forward, backward, and side shakes, and should continue until the contents are well settled. The pan may then be inclined four to eight degrees, held with two-thirds of the rim under water and given a horizontal elleptical movement, the forward motion being slow and the return more rapid. Water flows in on the forward stroke and escapes on the return carrying sand with it.

This motion may be repeated five or six times, and then must be followed by settling as above after which a little more sand may be washed off. By alternating these operations the heavy pulp can be kept settled while the tails are being removed. If the work is carefully done, a very clean concentrate can be made. The tails often carry too much mineral and must be repanned.

Vanning on Tables.

Small slime tables seldom do as perfect work as tables of full size, and whenever the quantity of pulp is sufficient it is best to treat it on standard

Wilfley, Bartlett or Frue machines. Small quantities of pulp cannot however be successfully treated on these large tables, and a number of special tables have been designed, modelled upon the larger ones, but differing in minor details. The best of these small tables have riffled surfaces and are in general similar to Wilfley or Bartlett tables.

The following general rules should be observed in using these tables. If more detailed instructions is needed in any case it should be sought in the notes on the special device to be used, such as the Wilfley, or Bartlett table, the Frue Vanner, etc.

(1) The mechanisms should first be adjusted to give a short stroke, with slight but unmistakable quick return or bump. The speed should be moderate, say 300, and care should be taken to prevent any lifting of the table, which should work smoothly on its bearings.

(2) The table should then be given a moderate slope and the wash water and feed water turned on and adjusted to give an even flow.

(3) Provision should then be made for catching the products of the table without any loss.

(4) Pulp may then be fed slowly and evenly, and its course carefully observed. In all probability some separation will be at once evident, but it will be far from satisfactory, and it will be necessary to change one or more adjustments, with a view to effecting a clean separation and to sending the several products to their proper places.

(5) These adjustments are as follows:

- Change of slope of table.
- Change of quantity and distribution of wash water.
- Change of quantity of feed water.
- Change of quantity of pulp fed.
- Change of speed.
- Change of length and character of stroke.

These changes should be made one at a time, and their effect observed until a fairly satisfactory result is obtained. The several products should then be critically examined on the vanning plaque and final adjustments made.

(6) Note should be kept of these adjustments, and of the conditions of water, slope, speed, etc., finally adopted.

(7) The products of the table during its adjustment should then be collected, mixed, the surplus water run off, and the pulp returned to the feed and treated again. The products of this run must be kept separate, weighed and assayed.

(8) Sometimes it is impossible to make clean products in one operation on small tables. In such cases, the best work possible should be done, and then each product needing it should be treated again alone. This is quite legitimate, as the distance travelled by pulp on a full sized table is from three to ten times that on a small machine.

(9) After one product from the classifiers has been treated, the next should be attempted, and it will usually be found necessary to change the adjustments before good work can be done. These changes should be carefully studied with reference to the difference in size of the particle treated.

Special Work.

The operations above outlined (sorting, crushing, sizing, classifying, jigging, and vanning), comprise the ordinary work of ore dressing, but there are many cases where additional or special work is required. It is unnecessary even to give a list of the various special cases which may arise, but a few of the most important may be named as follows:—Amalgamation as applied to ores of gold and silver, Magnetic separation as applied to a great number of substances, Oil Concentration, Pneumatic Concentration, Heating followed by some operation not previously effective, etc., etc.

Samples, Assays and Records.

In order to make full use of the work done in tests of the kind outlined above, it is necessary to keep records of every detail of the operation, and every product, intermediate and final, must be weighed, sampled, and if necessary assayed.

In many cases, certain of the products may be sufficiently examined under a lense or microscope others and sometimes all can be approximately tested by fine grinding and vanning on a plaque, but in all work of importance it is essential to assay all the chief products, and sometimes every sample should be carefully assayed.

FIG. 1. Macdonald Chemistry and Mining Building, McGill University.

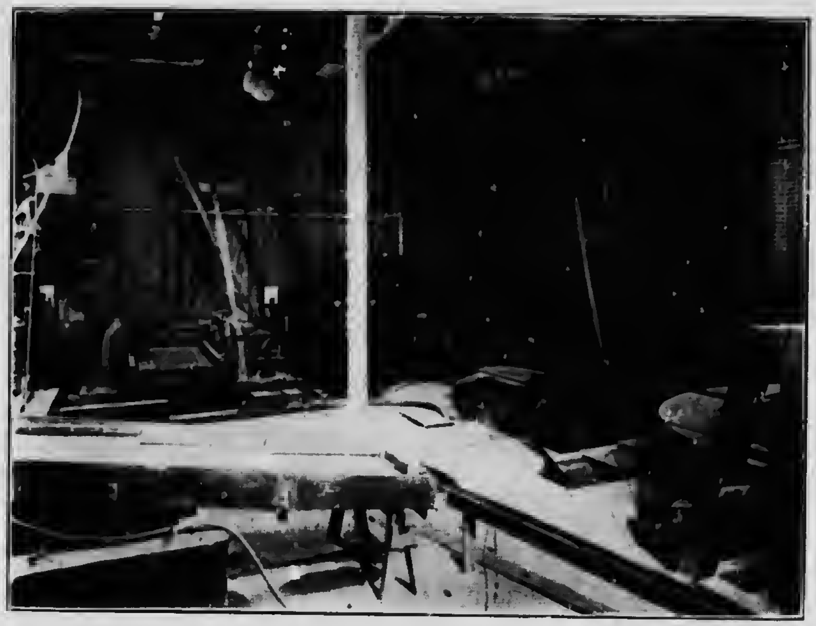


Fig. 2a.—Plates, Tables, Amalgam Pans, etc. Nos. 37a, 31, 40, 41, 43, 48.

Fig. 2b.—Sampling Floor, Crushers, Rolls, Elevators, and Jigs, Nos. 1, 2, 3, 12, 20.

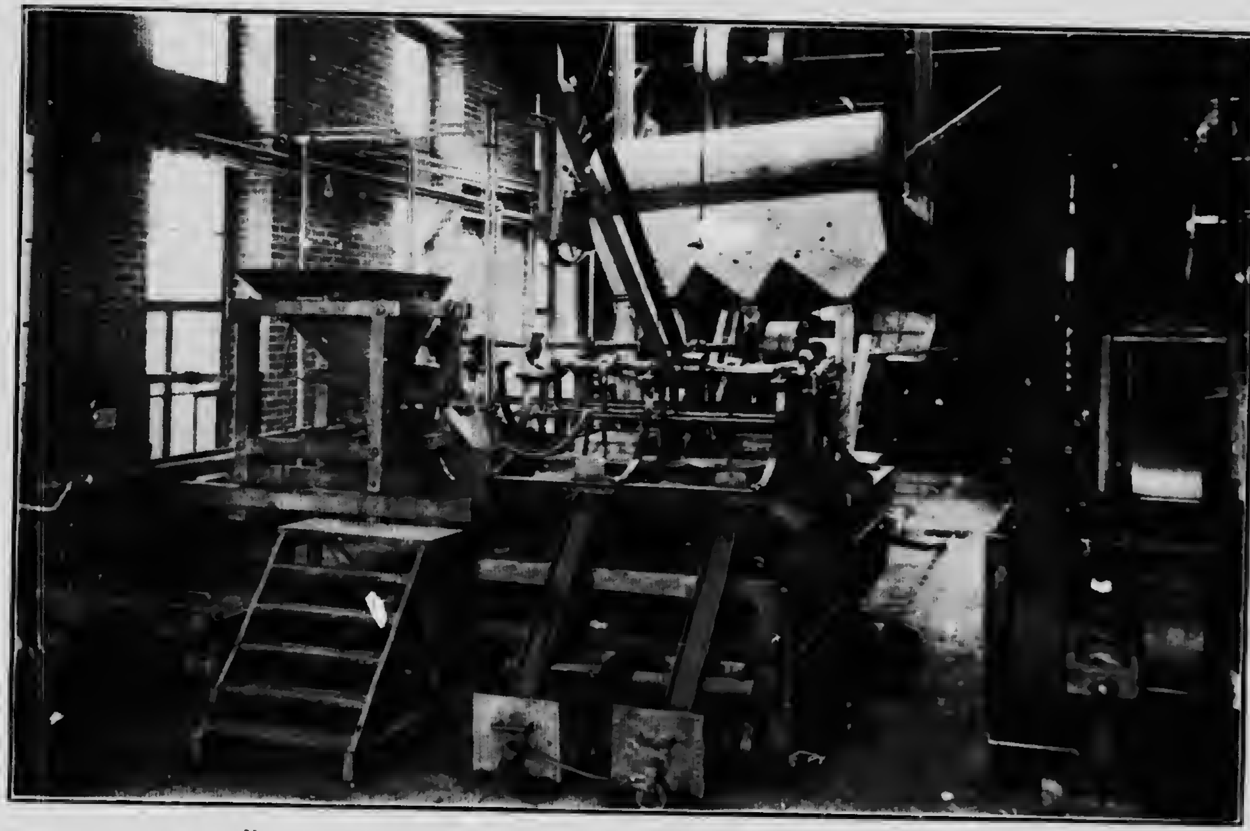


FIG. 3.—Jigs and Feeder, Trommel and Drying Table, Nos. 20, 15, 19, 47.

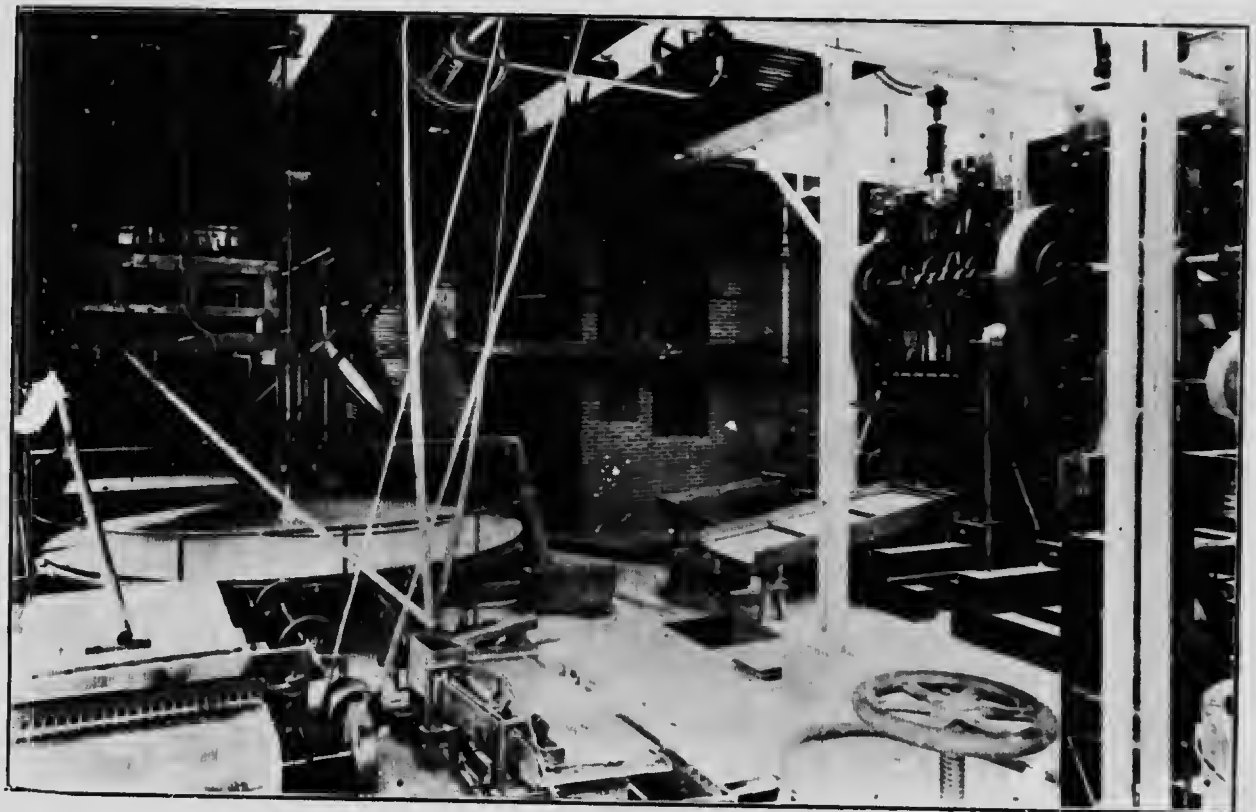


FIG. 4.—Batteries, Classifiers, and Tables, Nos. 8, 11, 37a, 25, 31, 36, 37.

FIG. 5a.—Bartlett Table and Slimer, Jigs and Classifiers, Nos. 32, 33, 21, 22, 26

FIG. 5b.—Stamp Batteries, Steam Stamp, Jigs and Rittinger Table, Nos. 8, 9, 10, 21.

FIG. 6a.—Small Amalgam Pans and Vezin Jigs, Nos. 42, 23.

FIG. 6b.—Amalgam Pan, and Settler and Drying Table, Nos. 40, 41 and 48.

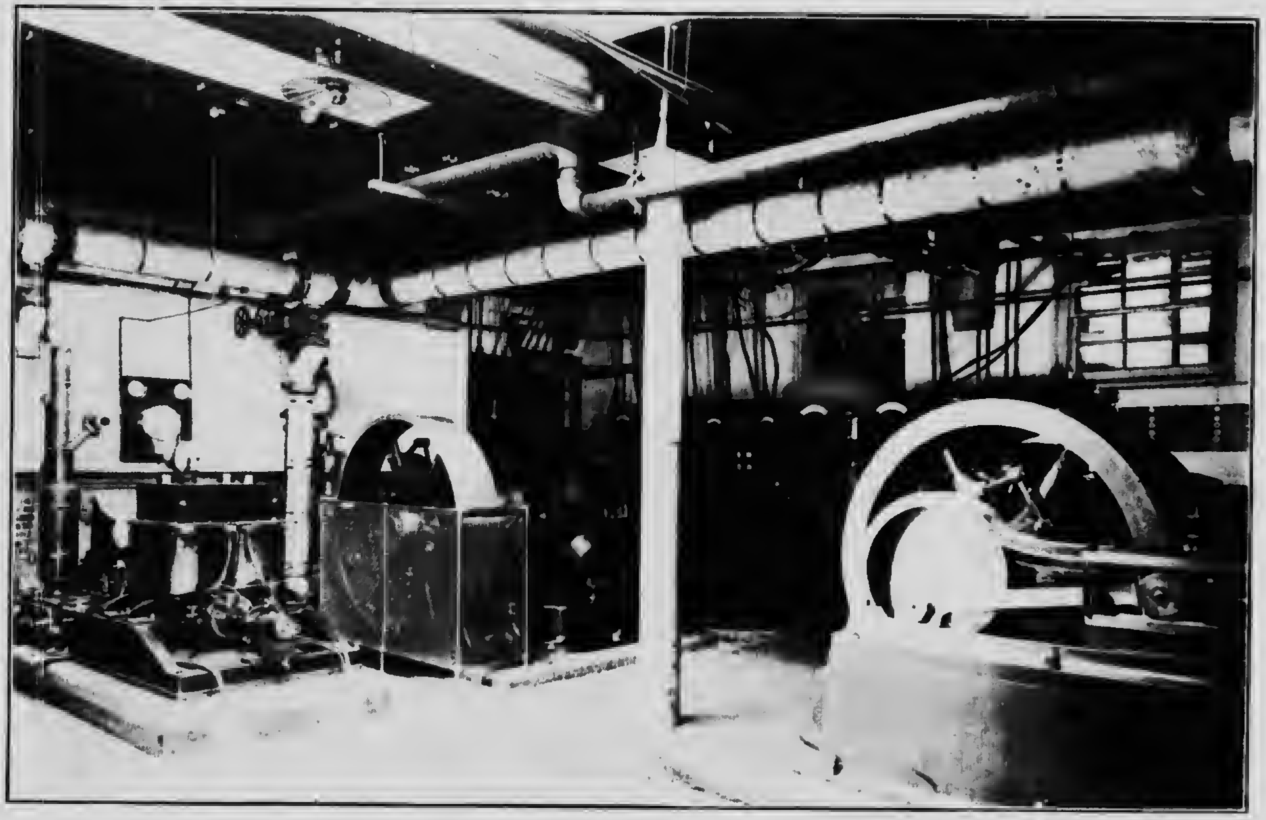


FIG. 7.—Electric Light and Power Station, Engineering Department.

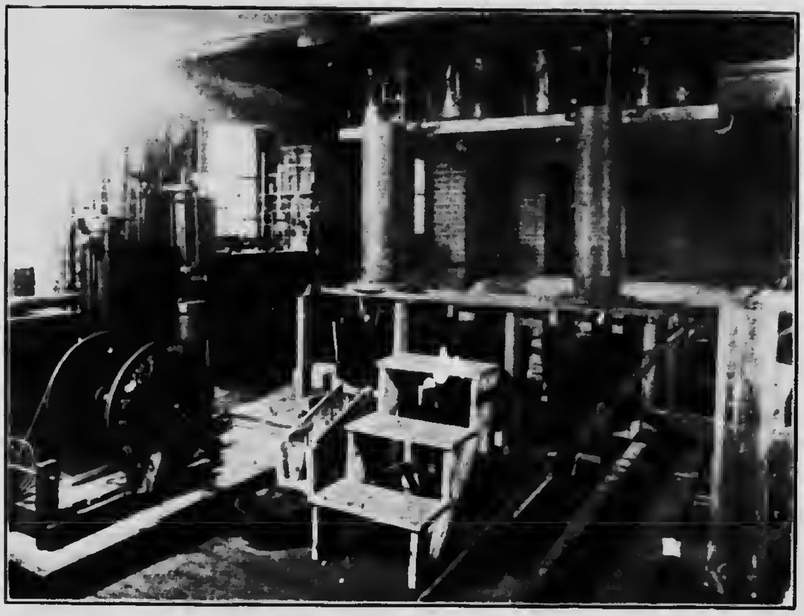


Fig. 8a.—Cyanide Plant, No 49.

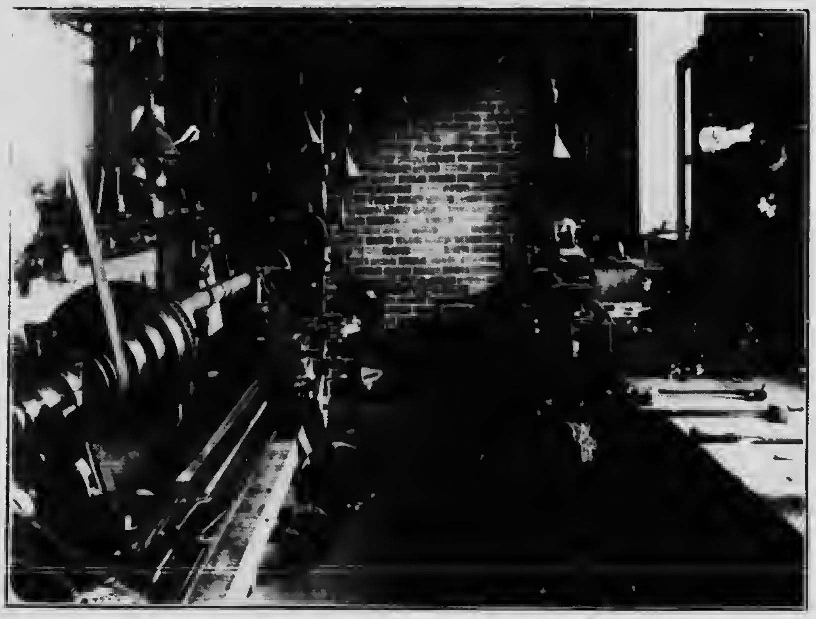


Fig. 8b.—Machine Shop, Mining Department.

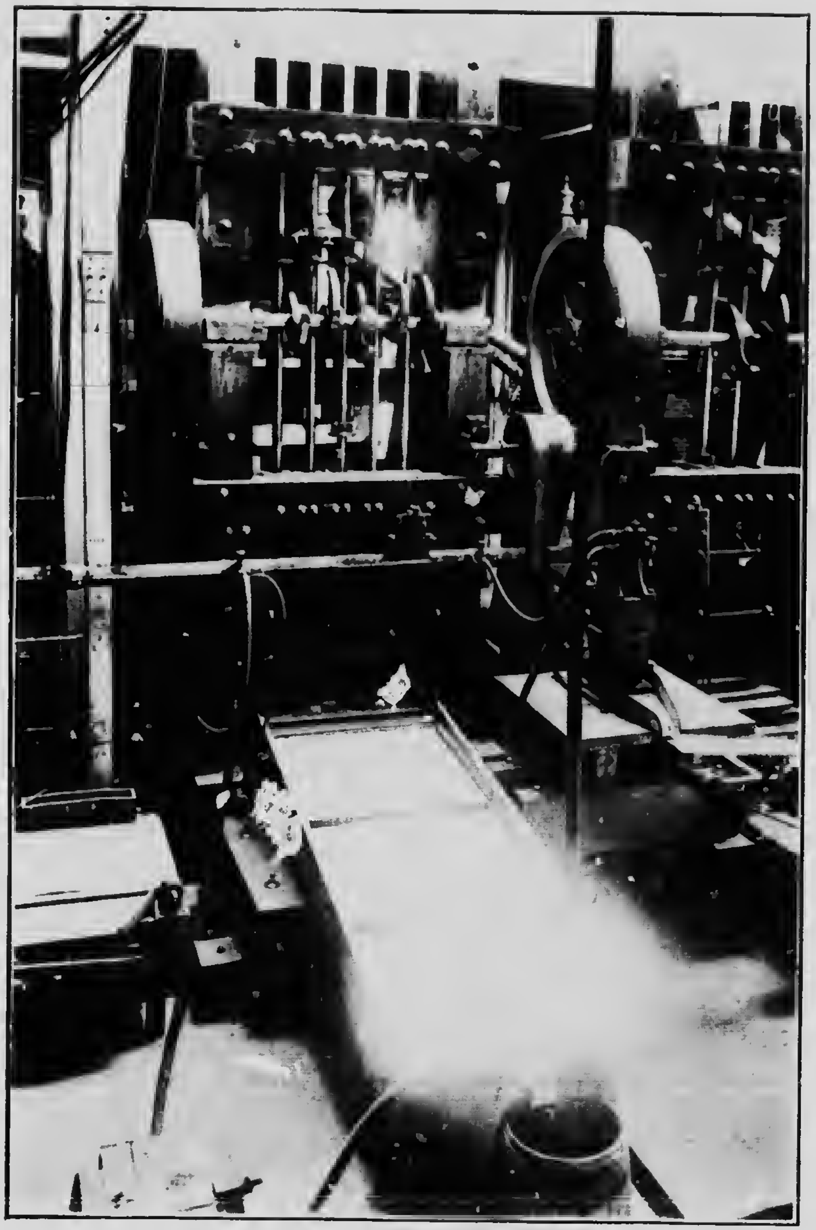


FIG. 9.—Stamp Batteries and Plates, Nos. 8, 9, 10, 37a.

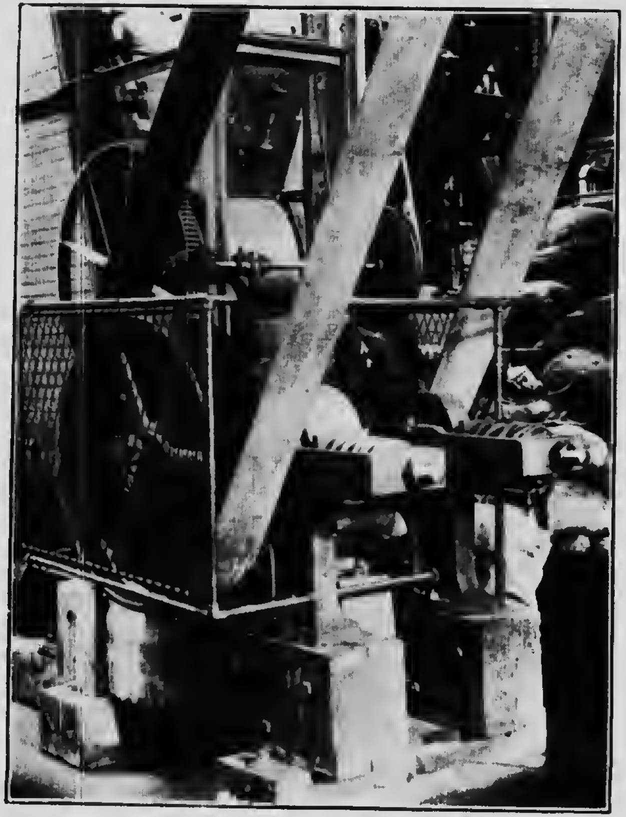


FIG. 10a.—Crushing Rolls, No. 12.

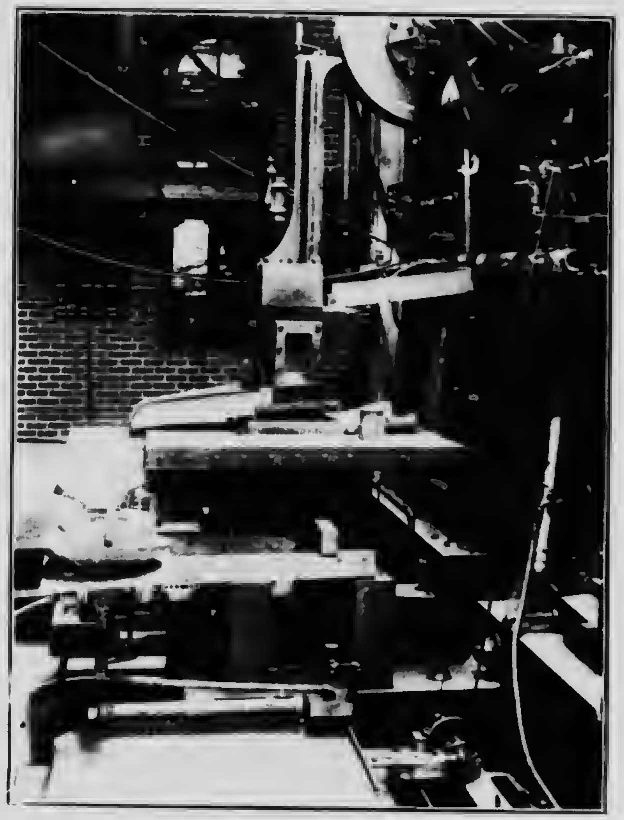


FIG. 10b. Steam Stamp and Table, Nos. 10, 39, 27, 35.

FIG. 11a.—Classifier arranged as Washer for Fine Coal, No. 26.

FIG. 11b.—Wetherill Magnetic Separator, No. 43.

KEY TO FLOOR PLAN OF McGILL MINING LABORATORIES.

ORE DRESSING DEPT.

1. Comet Crusher.
2. Dodge Crusher.
3. Ball Mill.
4. Sample Grinder.
5. Roller Jaw Crusher.
6. Hydraulic Lift.
7. Bridgman Sampler.
8. Five Stamp Battery, 600 lbs.
9. Two Stamp Battery, 1,000 lbs.
10. Steam Stamp.
11. Huntington Mill.
12. Crushing Rolls.
13. Suspended Challenge Feeder.
14. Challenge Feeder, Portable.
15. Tulloch Feeder, Portable.
16. Blake Crusher.
17. Shaking Screens.
18. Shaking Screens.
19. Trommel, with 3 fields.
20. Large Jig, 2 comp.
21. Large Jig, 4 comp.
22. Three small Jigs, 2 comp.
23. Three Vezin Jigs, 1 comp.
24. Spitzkasten, 4 comp.
25. Brown Sizer, 3 comp.
26. Three Large Cone Classifiers.
27. Three Small Cone Classifiers.
28. Pointed Box Settler.
29. Three Brass Tube Classifiers.
30. Seven Glass Tube Classifiers.
31. Wilfley Table.
32. Bartlett Table.
33. Bartlett Slime Table.
34. Small Riffled Table.
35. Small Riffled Table.
36. Evans Buddle.
37. Frue Vanner.
37a Battery Plates, Large.
38. Battery Plates, medium.
39. Battery Plates, small.
40. Amalgamation Pan, large.
41. Settler.
42. Six Amalgamation Pans, small.
43. Wetherill Magnetic Separator.
44. Heberli Magnetic Separator.
45. Centrifugal Separator.
46. Pneumatic Jig.
47. Steam Jacketed Drying Table.
48. Steam Jacketed Drying Table.
49. Cyanide Plant.
50. Elmore Plant.

METALLURGICAL DEPT.

60. Brueckner Roaster.
61. Hand Roaster.
62. Blast Furnace, water jacketed.
63. Fore-Hearth.
64. Cupellation Furnace.
65. Wind Furnace.
66. Forge.
67. Gas Muffle.
68. Gas Furnace Table.
69. Electric Furnace Table.
70. Chlorination Barrel.
71. Power Saw.
72. Grindstone.
73. Drop Test.
74. Electrolytic Table.
75. Power Lift.
76. Iron Table.
77. Polishing Apparatus.
78. Small Blower.
79. Experimental Open Hearth Furnace.
80. Recording Pyrometer.
81. Soft Coal Muffle.
82. Six Wind Furnaces.
83. Six Muffle Furnaces.
84. Three Gas Muffle Furnaces.
85. Draft Cupboard.
86 Seven Working Benches.
87. Bucking Board.
88. Bullion Rolls.
89. Root Blower.
90. Hydraulic Press.

POWER, ETC.

100. 15-H.P. Motor.
101. 15-H.P. Motor.
102. 15-H.P. Motor.
103. 10-H.P. Motor.
104. 2-H.P. Motor.
105. 2-H.P. Motor.
106. 2-H.P. Motor.
107. 2-H.P. Motor
108. 1-H.P. Motor
109. 2-H.P. Motor.
110. Ventilation Fan.

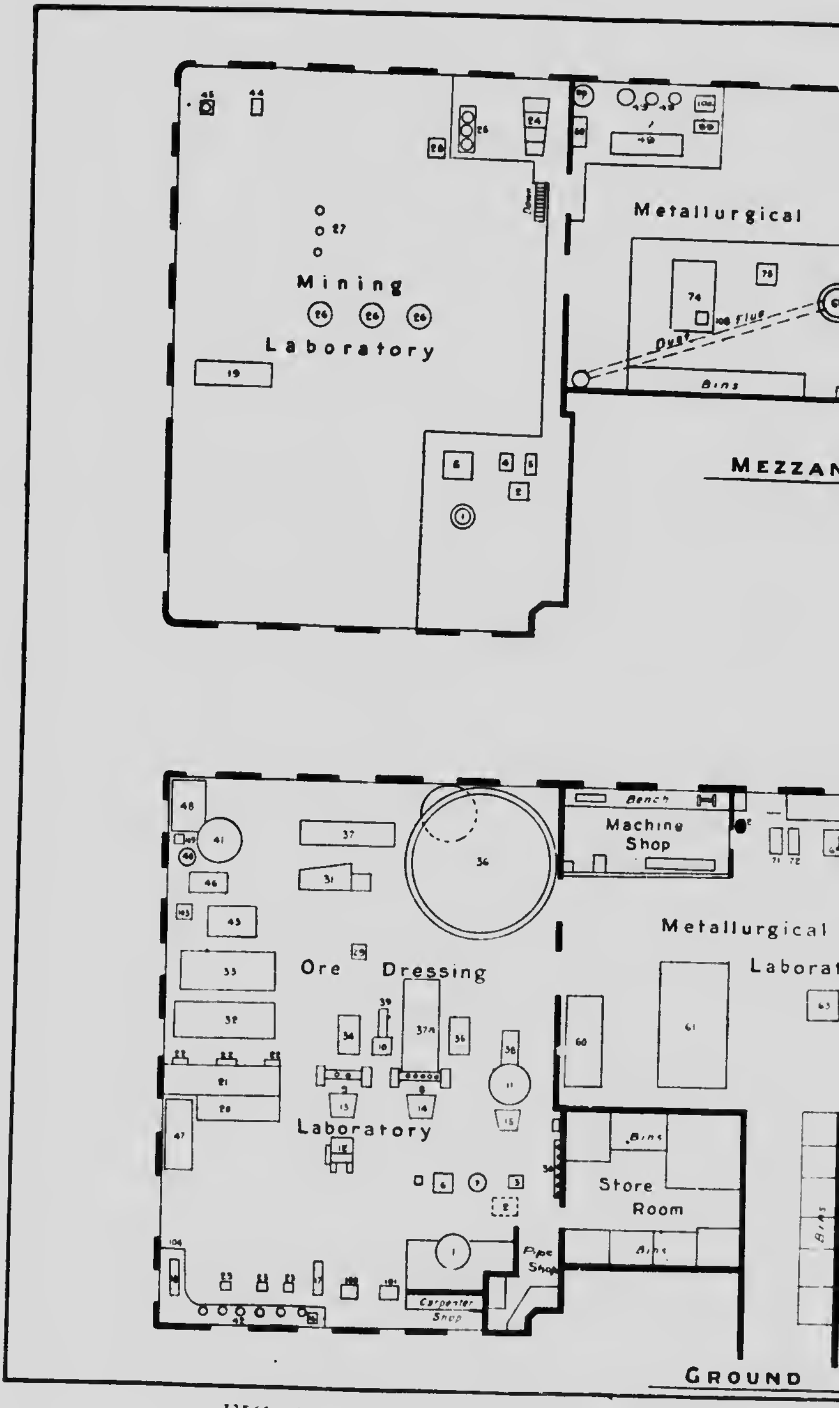
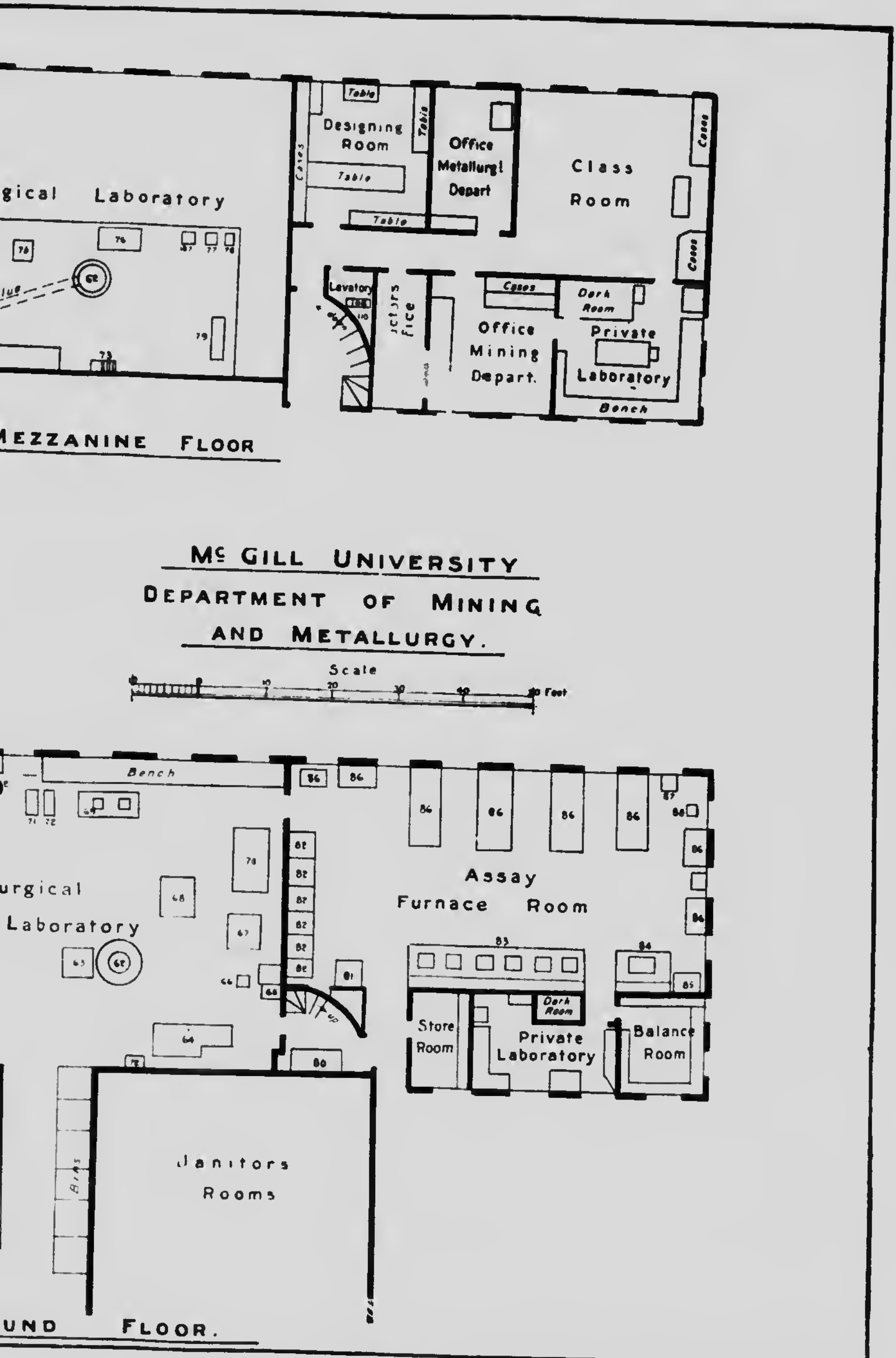


FIG 12.—FLOOR PLANS OF DEPARTMENT OF MIN



OF MINING AND METALLURGY, MCGILL UNIVERSITY.