

UC-NRLF

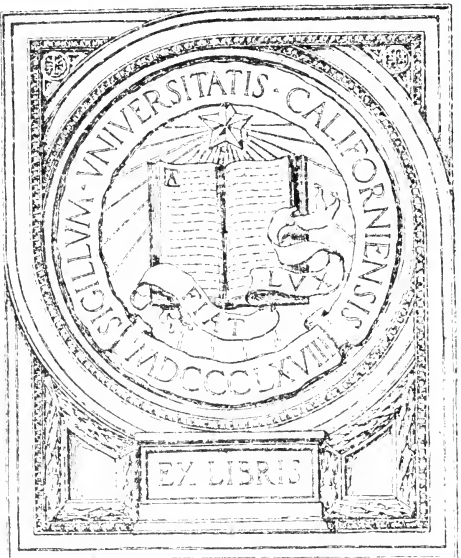


\$B 76 417

MODERN MINE VALUATION

M. HOWARD BURNHAM, B.Sc.

GRIFFIN'S MINING SERIES



EX LIBRIS

Mining Dept.

MODERN MINE VALUATION.

NET BOOK.—This book is supplied to the Trade on terms which will not allow of Discount to the Public.

CHARLES GRIFFIN & CO., LTD.

GRIFFIN'S MINING AND GEOLOGICAL WORKS.

- ORE AND STONE MINING.** By Sir C. LE NEVE FOSTER, D.Sc., F.R.S. SEVENTH EDITION, Revised by Prof. S. H. COX, A.R.S.M. 28s. net.
- THE ELEMENTS OF MINING AND QUARRYING.** By Sir C. LE NEVE FOSTER, D.Sc. Revised by Prof. S. H. COX. SECOND EDITION. 7s. 6d. net.
- METHODS OF AIR ANALYSIS.** By J. S. HALDANE, M.D., LL.D. In Crown Svo. 5s. net.
- THE AIR OF MINES.** By Prof. J. CADMAN and J. S. HALDANE, M.D., LL.D.
- A TEXT-BOOK OF COAL-MINING.** By H. W. HUGHES, F.G.S. FIFTH EDITION, Revised and Enlarged. With 4 Plates and 670 Illustrations. 24s. net.
- PRACTICAL COAL-MINING.** By GEORGE L. KERR, M.E. FIFTH EDITION, Rewritten.
- ELEMENTARY COAL-MINING.** By GEORGE L. KERR, M.E. With 200 Illustrations. THIRD EDITION, Revised. 3s. 6d.
- ELECTRIC SIGNALING IN MINES.** By GERALD H. HOOGHINKEL, M.Inst.E.E., M.I.Min.E. Cloth. Illustrated.
- MINE SURVEYING.** For the Use of Managers of Mines and Collieries, &c. By BENNETT H. BROUGH, F.G.S. FOURTEENTH EDITION, Revised by Prof. S. WARREN PRICE.
- THEODOLITE SURVEYING AND LEVELLING.** By Prof. JAMES PARK, F.G.S. In Crown Svo. Cloth. Illustrated. SECOND EDITION. 7s. 6d. net.
- THE EFFECTS OF ERRORS IN SURVEYING.** By HY. BRIGGS. 5s. net.
- MINING GEOLOGY.** A Text-Book for Mining Students and Miners. By JAMES PARK, F.G.S., M.Inst.M.M. THIRD EDITION. 6s. net.
- PROSPECTING FOR MINERALS.** By Prof. S. HERBERT COX. SIXTH EDITION, Revised. 5s.
- MINING LAW OF THE BRITISH EMPIRE.** By CHARLES J. ALFORD, F.G.S. Cloth. 8s. 6d. net.
- MINE ACCOUNTS AND MINING BOOK-KEEPING.** By J. G. LAWN, Assoc.R.S.M. SEVENTH EDITION. 10s. 6d.
- THE MINING ENGINEER'S REPORT BOOK AND DIRECTORS' AND SHARE-HOLDERS' GUIDE.** By EDWIN R. FIELD. THIRD EDITION. Pocket Size. Leather. 3s. 6d.
- ELECTRICAL PRACTICE IN COLLIERIES.** By Prof. D. BURNS, M.E., M.Inst.M.E. THIRD EDITION, Revised. 7s. 6d. net.
- SHAFT SINKING IN DIFFICULT CASES.** By J. RIEMER and J. W. BROUGH. 10s. 6d. net.
- BLASTING: And the Use of Explosives.** By O. GUTTMANN. SECOND EDITION. 10s. 6d.
- TESTING EXPLOSIVES.** By C. E. BICHEL and AXEL LARSEN. With many Plates. 6s. net.
- SPANISH AND SPANISH-AMERICAN MINING, METALLURGICAL, AND ALLIED TERMS.** By EDWARD HALSE, A.R.S.M. Cloth. 10s. 6d. net.
- GETTING GOLD.** A Gold-mining Handbook for Practical Men. By J. C. F. JOHNSON, F.G.S., A.I.M.E. THIRD EDITION. 3s. 6d.
- GOLD-SEEKING IN SOUTH AFRICA.** A Handbook of Hints. By THEO. KASSNER. Illustrated. 4s. 6d.
- STRATIGRAPHICAL GEOLOGY AND PALÆONTOLOGY (on the Basis of Phillips).** By R. ETHERIDGE, F.R.S. 34s.
- AIDS IN PRACTICAL GEOLOGY.** By Prof. G. COLE, M.R.I.A. SIXTH EDITION. 10s. 6d.
- GEOLOGY FOR ENGINEERS.** By Lieut.-Col. R. F. SORSBIE. Fully Illustrated. 10s. 6d. net.
- MINERAL WEALTH AND GEOLOGY OF CHINA.** By C. Y. WANG.

London: Charles Griffin & Co., Limited, Exeter Street, Strand.

MODERN MINE VALUATION.

BY

M. HOWARD BURNHAM, B.Sc., M.A.I.M.E., ETC.,
LATE H.M. ASST. INSPECTOR OF MINES FOR THE TRANSVAAL.

WITH 19 ILLUSTRATIONS.



LONDON:
CHARLES GRIFFIN AND COMPANY, LIMITED:
EXETER STREET, STRAND.

1912.

[*All Rights Reserved.*]

TN 272

B8

MINING DEPT.

THE
MINE
DEPARTMENT

To My Friends

OF THE SIERRAS AND VELDT,
OF CAMP FIRE AND CAMPAIGN,
OF RIFLE, THEODOLITE, AND GREAT HOPE:
TO THESE BUILDERS OF NATIONS,
BUT EVER VICTIMS TO THEIR OWN TRUST,

This Book is Dedicated.

P R E F A C E.

MINING is essentially an industry, and its economic justification, like that of any other commercial undertaking, must ultimately depend upon whether it can be made to yield an adequate financial return on the capital sunk in it. But as this depends upon whether the mineral deposits warrant the expenditure necessary for their exploitation, it is evident that the real basis upon which sound mining operations must depend is sound valuation. In the present work it has been the author's object to afford the means of making this valuation by introducing therein the principal considerations governing accuracy. Incidentally, also, it affords a means of ascertaining whether a given valuation is sound and checking the data upon which it is based.

By a large section of the public mining is regarded both as a speculation and as one which is often more than usually "speculative." But the element of chance enters into other industries as well, and may be reduced in mining almost to a minimum, if the valuation be rightly conducted. The author has been at pains to point out to what extent speculation may, in this particular industry, be regarded as legitimate, and to what extent it may degenerate into a mere

“gamble.” He has, therefore, written his book as much for the guidance of investors as for that of the engineer, and although he has assumed his readers to be possessed of some knowledge of the subject, he has written it, as far as possible, also from the standpoint of an educated member of the public desirous of ascertaining the nature of the securities he is being invited to acquire.

It may be added that the book is the expression of over twenty years of mining and examination practice in some fifteen different countries, and the main conclusions come to may be summed up as follows:—

(a) The most common cause of serious loss of capital in mining enterprises is due to a neglect to apply ordinary business principles and methods in setting the terms of purchase when acquiring properties; and that no sound valuation is possible which ignores these factors. This neglect is thought so radical a defect in our present practice that precedence is given to the discussion of the economic principles which should govern terms of purchase.

(b) The next most fruitful source of loss is the failure to set appropriate values on blocks of ore in different stages of development. In other words, to give practical recognition to the manifest fact that the risk varies with the uncertainty. A method and some twenty tables for such allowances are offered both for application to blocks of ore and for share valuation. The tables incorporate not only the actuarial calcula-

tions incidental to the life, but to the delay and risk incidental to realising upon each block of ore.

(c) It is also thought that a large proportion of mining failures would have been avoided had engineers felt obliged not only to collect but to submit the fullest field data with their reports. This refers more especially to a graphical representation of sampled faces, giving as well plotted and detailed assay values. A system of such graphical presentation is given, with a closed transverse method of checking sample section measurements.

(d) As part of a consulting engineer's work calls for the valuation of mining shares, ten tables have been worked out to meet the varying rates for risk from 0 per cent. to 20 per cent., as well as life, which the engineer may wish to assign.

(e) Consulting engineers having constantly to recommend or depend upon others for work abroad, they are frequently at a loss to know if such are adequately grounded in the basic principles governing the selection and setting out of field data. Hence the book should be found a useful guide to subordinates as setting out definitely what may be expected of them. Naturally, a knowledge of technical detail is assumed, such, for example, as is set out in "Mine Sampling."*

The book may thus be regarded as a companion volume to Lawn's *Mine Accounts*,† although the sub-

* "Mine Sampling," by T. A. Rickard, *Mining Magazine*, London.

† *Mine Accounts and Mining Book-keeping*, by Prof. J. Gunson Lawn. C. Griffin & Co., Ltd., London.

ject with which it deals is valuation, pure and simple. A number of diagrams and illustrations have been introduced, and numerous tables given to simplify calculations and check results. The author hopes that the work will prove useful to those for whom it has been designed, and not less so because he has, in dealing with his subject, covered a somewhat wider ground and introduced considerations of a more general nature than are generally found in works of this description.

M. H. B.

LONDON, *June*, 1912.

CONTENTS.

INTRODUCTION.

PAGE

Preliminary Considerations, 1

CHAPTER I.

Block Calculations, 39

CHAPTER II.

Bases of Sound Valuation, 77

CHAPTER III.

Sampling, 105

CHAPTER IV.

Explanation of the Sinking-fund Table (xxii.), 116

APPENDIX, 145

INDEX, 157

MODERN MINE VALUATION.

INTRODUCTION.

PRELIMINARY CONSIDERATIONS.

THE practice and principles of valuation, as generally met with in the English-speaking mining world, often

ny
all-

ERRATA.

- Page 34, line 15, for (18) read (17).
,, 52, line 9, for *k* read *k'*.
,, 60, Table III., col. 6, for Feet read Dollar-feet.
,, 66, line 7 from bottom, for 20 feet read 26 feet.
,, 70, line 6, for three read two.
,, 96, line 5, for Fig. 14 read Fig. 13.
,, 107, line 15, for L read H-g.
,, 109, line 1, for *f-g-h* read *f-g-H*.
2, for *g-h* read *g-H*.
3, for O'-H read O'-H'.
,, 110, line 3, delete "green."
,, 116, line 4 from bottom, for $\frac{.03}{(1 - .03) - 1}$ read $\frac{.03}{(1 + .03)^n - 1}$.
,, 116, line 5 from bottom, for $\frac{r'}{R - 1}$ read $\frac{r'}{R^n - 1}$.
,, 151, line 7 from bottom, for $S - (1 + s)$ read $S = (1 + s)$.
,, 153, line 23, for £300,000 read £80,000.

ure
ur,
the
ich
op-
the
on-
be

any
of

data forming the basis of valuation is altogether inadequate in the case of nine out of ten mining reports, even where large sums of money are involved.

—

MODERN MINE VALUATION.

INTRODUCTION.

PRELIMINARY CONSIDERATIONS.

THE practice and principles of valuation, as generally met with in the English-speaking mining world, often leave much to be desired, and are open to a good many criticisms, despite the fact that they embody many well-established conventions.

Many mining projects which may be called pure speculation have much to be urged in their favour, providing the enterprise be plainly labelled, and the adventurers given an honest run for their money, which usually means that all capital outlay goes to development. At the same time, the warping of facts and the distorted deduction which so often deliberately confuses the two stages in mining enterprises, may be branded as contemptible, to put it mildly.

Especially with reference to mines in the Company stage, it is held that the collection and certification of data forming the basis of valuation is altogether inadequate in the case of nine out of ten mining reports, even where large sums of money are involved.

If one but compare the time and detail, the collection of and compilation from signed vouchers which lie behind the balance sheets of large commercial enterprises, with those forming the basis of mine valuations of similar magnitude, the impartial critic can hardly fail to be struck by the difference so often displayed, and the apparent regard for what, in the first instance, are habitually regarded as guiding principles. In other words, it is held that, while the true inwardness of a report, where the mine has reached the Company stage, can and should be set out on a single sheet of paper—in fact, nearly as concisely as a balance sheet—yet the data forming the basis should be collected and vouched for at each successive step in a manner identical in principle with that obtaining in ordinary commercial valuations.

For example, a sampler should sign each vein section sampled by him, just as the surveyor signs a plan, or a chemist an assay certificate. Again, the field data, as well as the tabulated analyses of these results, should be as clearly arranged as the time-books and store-sheets of a manufacturing enterprise or producing mine. In a word, it may safely be said that, in point of certified accuracy, mine valuation, as generally obtaining, is woefully behind the usual standard of commercial undertakings, both in principle and practice.

While tabular forms for data and calculations are found further on, they are simply those used by the writer in ordinary work, and should, of course, be modified to meet varying local conditions and the convenience of those employing them.

In the valuation of mines in the Company stage, it is held that two essentially different features must be clearly set out, one being the appraisal of the blocked ore bodies or probably profitable portion of the deposit, the other being, in the case of veins or tabular deposits, the estimate of shoot dimensions in economic units, the latter as a bearing upon shoot extension in depth. It should hardly be necessary to add that the last may not be the only factors in such calculation ; in fact, when a vein cuts different types of country rock, or neighbouring veins show, say, zinc and coincident reduction of precious metal values, these, instead of the shoot dimension, may be the dominant consideration.

While the present work deals with elements only, it is not meant for beginners, nor those to whom the commoner problems of mining are wholly unknown. Much is taken for granted, both with regard to the technique of the subject and to those phases of human nature especially evident in more speculative undertakings. The aim is to touch upon features of what may be called Investment, as distinct from Speculative Mining, and the writer would again emphasise the great difference between the two in spite of the fact that they must merge one into the other. This should not, however, be read as a reflection upon the latter. Many forget that the modern small Syndicate for opening up mines in Africa and far lands is but the present-day descendant of our forefathers' "Adventurers' Companies," who sailed the seas, looted the Spaniard, and lost life and treasure like men. How often has one to uncover, as it were, before the spirit shown in the winding-up meetings

of these Syndicates and Companies, and one's faith in the race grows with such evidences of its gameness. *Apropos* of this healthy outlook, one recalls regretfully the great lodes, virgin to work and full of promise which one sees occasionally, and upon which one would gladly advise some small expenditure if only sure that it would go to actual development. Too often prominent engineers lack the courage to advise outlay save on developed properties, and the lesser man, copying the others, would outdo them in an affected caution.

The shrewd student of modern economic development will not have failed to notice the over-emphasis on mechanical, as distinct from administrative, organisation. Similarly our theories and practice of Mine Sampling, while covering a wide field, have apparently failed to develop a practical expedient tending to act as an automatic check upon the vagaries or indifference of the sampler. A system devised by the writer to meet this difficulty is offered, though, bearing in mind the large amount of literature devoted to Mine Sampling, it would seem well to do this with a becoming show of diffidence, more especially as an effort will be made to present other features of the work as well in a new light.

A thorough study of even the elements of the subject must be incomplete without a discussion of the principles underlying "Data and Deduction therefrom"; also, "Probability and its Applications." These, however, must be left untouched, fascinating and important though they be.

It may be mentioned that the writer's system of

sampling, as dealt with later, was devised some twelve years ago on the Rand, to meet the needs of a 30-foot stope, and while the principles here set out are of nearly universal application, it should be borne in mind that every mine demands variations in sampling practice. The above system, for instance, is of special value when dealing with large veins of banded pay and final examinations, though the cost and time might possibly preclude its use for preliminary work or the valuation of small veins.

Most of the tables at the end of the book were compiled some ten years ago, to meet the author's needs, and while some of them will be found to be old friends dressed in modern garb, this very change may be an agreeable innovation when compared with the cumbrous terminology usually employed.

To those who find interest only in such theory as has had application in practice, it may be mentioned that the ideas expressed are the outcome of a mine examination resulting in the single cash payment of nearly a million pounds sterling, during the course of which work the writer found himself at issue with several well-known engineers, it being found that the views held were so widely divergent as to involve, not only the elements of block valuation, but the principles of economics.

It must be clearly understood that the whole argument is based on the general underlying premise that mining is to be regarded as an industry, and that the status of the engineer is that of a specialist, intermediate between the scientist and financier—*i.e.*, his claim to

social utility must rest as much upon his knowledge of economics as of natural science.

Divisions of the Subject.—Mining valuation may conveniently be divided into the study of reserves or assets, and the more variable quantities or possibilities, and while an attempt will be made to deal with the former somewhat fully, the latter will only be touched upon sufficiently to set out differences. As will be seen later, it is held that mining reserves may be valued in a more rational manner than that now in general use, and a method is offered which, if accepted, should tend to the development of the industry. An apology is offered engineers of more modern views for the statement of self-evident facts and perhaps unnecessary elaboration of elementary premises, the excuse being that a somewhat intimate knowledge of both English and American conditions appears to indicate the advisability of dealing rather fully with the subject, even at the risk of redundancy.

Because of the demand for rifle as well as theodolite, for courage as well as technique, for travel as well as toil, for languages as well as science, probably no profession calls more insistently for accuracy, pluck, ability, and sound general education than that of mining. Because, however, of the facility with which ineptitude and fraud may be covered by a puerile parade of technicalities, or hidden in distant mountains, the profession is too often represented in the public eye by men of inferior attainments.

FUNDAMENTAL PREMISES.

Premise I. — *A sense of economic proportion is essential to effective examination work.*

It would be idle to ignore the fact that a large portion of the examining engineer's energy, particularly while he is "winning his spurs," must be spent in seeking graceful and effective compromises between honesty and expediency, but the later developed sense of economic proportion, or related civic proportion, ultimately urges expediency to accuracy beyond arithmetic, even to that phase of calculation which deals with the ratio of dividends to capital.

Reporting Engineers may well admit that in the body politic we are but hucksters ; vendors of wisdom seeking sale for our wares. Our fragile commodity may be a work of art ; a creation born of inspiration, polished by travel, tempered by experience, and yet be unsaleable. To fetch a good price it must take the public fancy, and yet be approved by those clever connoisseurs and shrewd purchasers of our products known as Financiers.

The latter claim with much feeling and some justice that the engineer is not a business man, meaning thereby that they lack a sense of economic proportion. For example, when sent to examine a property upon which an option is held, his sole idea seems to be to approve, or otherwise, of the purchase. If his report condemn at the price, he in nine cases out of ten makes no effort to secure more reasonable terms ; if the ore "blocked out" be insufficient to justify the outlay, he would seem to consider it inconsistent with his professional dignity to negotiate a new option with time in which to develop.

Again, in the case of a going concern, overlooking the

limitations of geological knowledge, he voices his fears as if they were facts. In other words, he at times inflicts an immediate market loss on shareholders through airing his geological postulates of mere possibilities, thereby seeking to display technical ingenuity, or perhaps having regard to a fear of rigid professional criticism.

Still, again, there is a notion prevalent with the more honest engineers that they and their offices only are essential to the industry ; that the men who at trouble, expense, and the exercise of sound judgment—the result perhaps of years of experience and loss—get together the capital wherewith to operate, are necessarily parasites.

Here, again, we have the same narrow vision which, in the field, often operates disastrously by studying too limited a geological horizon ; which confines itself to pure or stereotyped sampling ; which ignores the habit of the ore shoots in adjoining mines as a means of gauging probabilities touching the one in question.

Again, the most puritanical of engineers must have admitted during the latter “ 90’s ” the flotational value of an eastern extension on the Rand covered by the coal measures, even though the data for definite valuation had been wanting.

As mentioned elsewhere, honest and well-informed speculation is as legitimate an enterprise as investment, and a sense of economic proportion would demand, not only a careful consideration of features governing the risk-rate, but a well-balanced knowledge of these factors which affect popular judgment, and hence facilitate the often arduous task of securing capital, necessary alike to clean and unclean promotion.

As before mentioned, it is held that the mining engineer is more inseparably connected with the larger financial aspects of his operations than are the other professions referred to with theirs. If this view be well taken, it would seem fair to examine his pretensions by the light of his development of what might be called "Economic Units."

Units.—If an Electrical Engineer were asked the practical possibilities of a stream of any magnitude, he would at once state it as so many thousand kilowatts in the season of a minimum flow.

It will be noticed that here is an expression of uncertainty; and acknowledgment that Nature may step in and render calculations abortive. Yet this does not affect his development and use of comprehensive units.

If, on the other hand, the mining engineer were asked to compare a vein in cobalt with a reef on the Rand, he would be at a complete loss to find a common measure for the possibilities of each without long and special calculation; he would appear to be at the mercy of various untoward contingencies incidental to ore bodies. Yet the civil engineer, again, develops his own units; calculates his stresses and strains to multiply by a factor of safety of two, four, or ten, accepting without comment the fact that chance too may prove his calculations wrong, and cast his edifice to the ground.*

But the energy of many mining engineers seems to find its chief expression in a study of the cost of ore

* It may have escaped the attention of younger students that what appears to be an unnecessary refinement is *really scientific, even though inexact*, as it is the effort to reduce the effects of the "personal equation."

drinking or of metallurgical operations, which, however important to the mining engineer, cannot be of the first magnitude in his ultimate views, which should be mainly directed on the *source of income*.

What is needed is a common measure of practical possibility or probability based on the data at the time available; gauging the potentialities of the stream, as it were, by the measurements taken, though allowing for dry seasons; approximately appraising shoots, beds, or chambers, by a common factor which must be economic not geological. Such considerations have led to the invention of such numerical aids to valuation as value-feet, cost-loss feet (or combination factor), profit-feet, and shoot-feet. In a general way this latter may be said to be derived from average profit-feet and aggregate shoot-length.

Thus harmless diversion may be derived by plotting value-feet minus combination-factor or cost-loss-feet at each point sampled on the deepest full shoot level of the mine, although it may be seen that this curve of profit-feet has at times an uncomfortable habit of dropping below zero, a planimeter will give the shoot-feet (see Figs. 5*a* and 5*b*). Many will refuse dealings with an innovation hiding behind its simplicity so many demands upon exactitude, and so given to uncovering to nakedness mining in waste places; but the shrewder Daniels of the potential directorates will recognise the value of shoot-feet in classifying and relegating, while it often spells more than "ore blocked out."

Combination - Factor.—The term "Combination-

Factor" is meant to cover loss in as well as cost of treating each ton of ore. For balance-sheet purposes—*i.e.*, taking the mine as an asset—the features of which are being studied, whether the values be left in the ore, fills, sorting dumps, or sands; whether it be expended in mining or milling, the result is much the same. It is, of course, evident that in mine development stoping costs and losses will vary with the position, thickness, parting slips, and character of the ore bodies and blocks. Hence the combination-factor will vary; its weighting will call for experience and intelligent study; it will not be exact, but more so than the expression of an average cost applied to all stopes. One ventures to add that its possibilities grow upon one with use.

Premise II.—*Modern reporting practice calls for a full presentation of data, calculations, and deductions therefrom.*

Balance-Sheet and other Schools.—As elsewhere mentioned, there may be said to be two schools with regard to mining reports; one would seem to aim at expressing a guarded opinion only, eschewing the publication of data, and thereby making sure of successful evasion in case of criticism, while protecting itself against the detection of slovenly work. The other, the balance-sheet school, is largely the outcome of modern scientific teaching, and tends to regard the presentation of data and calculations as important as the expression of opinion. The rise of the consulting engineer with his field assistants and managers is also responsible for this more modern demand with respect to reports. How often, through want of adequate detail, one has to reject another's opinion of a property where, had full data been submitted,

the point of difference might have been allowed for, and an adjustment made leading to promising adventure.

Field Notes.—To the writer's mind field notes belong to the one paying for the report, and should have the same value assigned them as that given the field books of a railway survey. Further, one may and should demand a clear statement of such data and deductions therefrom, as is called for by Premises III. to X., thereby enabling another, not only to resample any section in the mine itself, but to check each step in the subsequent calculations.

The point specially emphasised is, that from the first stage of physical measurements at school, on to the development of empirical formula in workshop or laboratory, the engineer, though subordinate to manager, is ever calculating, studying, deducing from or submitting data collected. His presentation of costs and losses in many annual reports are monuments, not only to his courage with regard to criticism, but to the thoroughness of his belief in the justice of the demands upon him for detail. Moreover, when the practical sequence of examination work of any magnitude is considered, with which we are now principally dealing, one has to admit the succession of engineers from junior to senior and to super-senior before favourable finality is reached. Such being the case, unless detailed reports be forthcoming, apart from an expression of pure opinion, the labour, knowledge, and experience of each would be practically unavailable for his successor. The only legitimate ground for disagreement concerning this premise is with regard to what may be considered a *full* representation

of data. Naturally, that required of assistants or colleagues by the consulting engineer will depend upon the latter's training, standards, and personal equation. Nevertheless, the current literature and proceedings of technical societies furnish a rough guide to what may be considered good practice.

The fulness of detail formerly shown by reports on Rand properties is perhaps a high water-mark of excellence in this respect, though the data set out in recent examinations of some of the great American copper properties leave little to be desired.

The great stumbling-block to conciseness, particularly with regard to final deductions, is the disinclination on the part of engineers to face the truth concerning their own responsibility in the matter of capital outlay. In their reports some touch on "gross value," yet seek to slur over the "gross"; others play with "annual profit": some few show an academic interest in the return of the capital embarked. But how many have the courage to start with the assumption that the essential to sound investment is the return of both capital and interest? When to this be added an interest commensurate with risk, as demanded in practice by at least two eminent engineers known to the writer, one meets a spirit and exactitude never to be expected, save perchance under the lime-light of technical analysis.

Mine Reserves.—Mine reserves in the sense used hereafter may be defined as bodies or blocks of ore or mineral, concerning the value of which sufficient physical data is available to warrant an immediate cash purchase.

It will be noticed that this definition implies a common

concept concerning the nature both of value and data, something that does not exist, but to the establishment of which it is hoped the present effort will contribute.

Value as used here has the meaning usually attached to it when represented in monetary units, as shown by Premise III. With regard to both the sufficiency and interpretation of data, even apart from geological ideas, the greatest difference is noticeable, due, according to the writer's belief, to the over-emphasis of technique or its equivalent—the under-weighting or economic factors.

Premise III. may be stated as:—

Premise III.—*Any investment implies the expectation of a return of the original capital, 3 per cent. annually to represent the rate received by investments conceived to involve a minimum risk, and a further rate of interest, commensurate with the risk, and counting from the date when the investment was made.*

Corollary (a).—When dividends are deferred or suspended, those received must make good the loss due to such deference or suspension of interest.

Corollary (b).—As the interest during the deferred period may be regarded as a further investment of capital in the undertaking, interest on this at the risk-rate is to be expected; in other words, allowances for loss due to deference of dividends should regard the interest as compounding during the deferred period.*

Corollary (c).—As blocks of ore in a mine vary in tonnage and value, and data (or number of sample sections) available, as well as time of exhaustion,

* See Appendix A, which deals with the systems of computing the value of deferred annuities.

estimates of their present value involve a consideration of "life," risk, and deference for each.

As outlined in Premise III., the return of capital as well as interest is a fundamental concept of industrial economy, hence any undertaking which jeopardises the return of either involves risk.

While we cannot draw a sharp line between speculation and investment, we may say that, in general, the one seeks increase in market or capital value, and the other a satisfactory return of interest; the one largely looks to the variable human element for advantageous changes, and the other to the constant demand for livelihood or its equivalent as insuring interest on capital so embarked.

In the long run the demand for a higher rate from those projects considered to entail greater risk is reflected in its equivalent market value, so we can say that, at least in public estimation, the risk varies directly with the rate expected; this, of course, assumes a free market, and selling, as distinct from nominal or exchange quoted value.

The difference between investment and speculation may be noted by the varying weight given the data submitted, having its corresponding expression in the rates of interest demanded. At times the public will feel so certain of the data concerning a man's integrity and ability, that little more than his name is necessary to give or maintain market value, at least for a time. Again, the most complete detail may be ignored if the names attached be unknown or unsatisfactory. In such cases one sees at times the economic significance of a name for commercial honesty.

The two features of a going mining concern—quotations and dividends—based on the above elements, have to be carefully borne in mind, and while the factors affecting human optimism, aberration, and hysteria, ~~hence~~ ^{and} market fluctuation are too complex to be dealt with, they, more often than real value, dominate the outward situation ; seldom, however, over long periods.

It would seem more than probable that the possibilities attached to the finding of bonanza—hence the hope of enrichment independent of market manipulation—are at the root of the attractiveness of mining ventures ; this very legitimate phase of speculation appertains essentially to the engineer's work, as distinct from that of the financier.

The universal demand for a higher rate from those undertakings involving the greater risk is of such universal acceptance that it would seem to form a common premise ; it is, of course, based on experience such as underlies the probability curves,* upon which rest nearly all scientific measurement.

The Insurance Principle.—The demand then of an investment acknowledged to involve risk are :—

The return of the capital embarked ;

A rate of annual interest, such as is judged by non-hazardous investments as, say, 3 per cent. ;

A further rate of annual interest ; this to be a function of the risk.

The first two requirements would seem to call for no discussion, at least of their theoretical aspect ; the last,

* See Formulæ (17) and (18).

however, implies the recognition of the insurance principle, though applied inversely. For instance, an Insurance Company receives small annual payments over a series of years, which, in the case of the man of average life, more than repays that paid out at his death. Yet the insurance might have to be paid out immediately after the receipt of the first premium, which would in itself have been a bad investment or risk. And yet when a large number of such risks are undertaken, a business is built up which is ordinarily considered to be of the soundest nature. In the case of speculation, the tendency and the expectation of enlightened people are a number of small losses succeeded by a great gain. Naturally the man in the street expects to keep clear of the losses, and so to time or chose his adventure as to reap during the fat years, and escape the lean ones. This is somewhat analogous to the man who only insures when ailing. From this it will be seen that theoretically a considerable number of adventures must be made in order to constitute sound practice, a fact ordinarily lost sight of.

The above general demand for a higher rate of interest from mere speculative projects is a curious case of unconscious cerebration regarding probability, even where no intention exists of embarking upon further ventures of a similar nature.

It may be contended that a higher rate demanded of an investment will not protect against loss in case of failure before redemption of capital and interest thereon. This is true, but if this high rate be expressed in terms of lower present value, the amount risked is less ; or,

expressed differently, a high rate of return will pay off a larger part of the capital risked, should failure occur before all was repaid.

The unconscious application of the risk-rate principle is shown by the issues of the City of New York, which, while it cannot borrow at 3 per cent., can do so at 4 per cent. ; evidently in case of repudiation, the extra per cent. is no protection against loss, but it reduces it were any dividends received. Again, the City of Rio de Janeiro cannot borrow at the rate of 4 per cent., but should it offer 10 per cent. large sums would be forthcoming, even though the conditions affecting the risk were unchanged.

From the above it will be seen that the essence of financial practice is to demand a rate which varies with the risk, whether this be soundly estimated or not ; in other words, there is an unconscious application of the principle of probabilities and its series of investments, even though the dominant thought is profit and a single venture.

Expressed otherwise, we will not buy Honduras 6 per cent. paper at 90, but would at 40. Why? There would be a loss in either case were repudiation to take place within a few years. Simply because with the higher rate a greater part of the capital is returned, giving further opportunity to re-adventure. The financier will from daily practice have little difficulty in accepting the principle of the demand for a rate varying with the risk, but perhaps, because of the unhappy lack of sense of economic proportion on the part of engineers, the true significance of the principle would seem to have escaped them.

The foregoing may be expressed as—

Formula (1). $D = r' + r'' + r'''.$

D standing for yearly dividends in percentage of capital, and assumes a uniform rate of dividends throughout the life of the mine ; r' is 3 per cent. ; r'' the rate set aside to redeem capital ; r''' is the risk-rate.

*x has
also a
er rate
risk.*

The idea at the back of Formula (1) is not put forward as a novelty, but it has heretofore, in the writer's opinion, been most insufficiently weighted ; it is to both the financier and reporting engineer what Newton's Principia are to the mechanical man ; it is talked of, acted upon, and unknown. The possibilities of its application would appear to be unsuspected even by many thinking men ; it is the touchstone of speculative morality.

As will have been gathered, the basal idea is that whatever the rate of dividend received, it may be divided in such manner that each part will serve a special purpose. This seems the simplest way of regarding and treating the subject of capital redemption and deferred annuities. It may be as well to again point out that the applications of such calculations and tables therefrom are not meant as a certain determination of value, but a simple mathematical presentation of principles, having in view the practical recognition of the insurance principle, hence the necessity of isolating those factors in the formula representing risk, with which one is here principally concerned. For instance, redemption is taken at 3 per cent., because even 4 per cent. represents a greater risk, as is indicated by the purchase of Government paper to

bear only 3 per cent., the great desideratum of the latter being security.

Formula (2). Let $C = \frac{D}{r}$ for (n) years,

the assumption being made that D is a uniform dividend, which is to run (n) years, the estimated life of block, or number of annual payments; C stands for the capital or present value; and r for the annual rate of dividends, but

Formula (2a). $r = r' + r'' + r''' + r''''$.

Where r' = the rate paid by Government paper here taken at 3 per cent. per annum;

r'' = the rate which it would be necessary to receive for (n) years in order to redeem capital C

(*i.e.*, sinking fund or $\frac{r'}{(R^n - 1)}$). See p. 24.

r''' = a factor of safety, so to speak, which if set aside would be sufficient to repay the loss due to unforeseeable events, providing a number of similar ventures were made—*i.e.*, r''' is an insurance allowance.

r'''' = the rate set aside which during (n) years would make good the interest when dividends are delayed (d) years. As shown on p. 24, this is—

$$(S^d - 1)(r'' + s),$$

where $s = (r' + r''')$ and $S = (s + 1)$.

From the above one may write—

Formula (3). $C = \frac{D}{r' + r'' + r''' + r''''}$

In the case of a going concern paying dividends at the time of purchase, $r'''' = 0$, as would also r'' and r''' in the case of a good Government security selling at par.

If the dividends are expressed in percentages of capital, then the value of C will be in decimals, hence may be used with pounds, dollars, or other monetary units.

The variables, represented in Formula (3) by D, r''' , n , and d are given in the following tables, some of which are arranged to give D different values expressed in percentages, while in Tables xxvi. to xxxix. it has a value of 1, as in an annuity of £1.

It is believed that they will be bound to conform more closely to modern ideas, as well as to advance the use of financial analyses.

It will be noted, when considering the tables, that the risk rate (r''') is taken as the rate paid by, or demanded of, the investment beyond r'' the sinking fund rate, and r' (or 3 per cent.). This is based upon the contention that all business practice of to-day leads us to as certainly count upon 3 per cent. interest as upon capital return, hence only the portion of the rate above these two is available for insurance—*i.e.*, to cover risk.

Delayed Dividends.*—The ordinary treatment of the subject of deferred dividends, where two rates of interest obtain, seems to take into consideration the risk to capital only, disregarding the claim of interest on that capital for risk-rate during the deferred period.

* In keeping with the effort to employ general business concepts only, delay means the time by which the receipt of dividends exceeds one year, as no one expects a dividend under one year from date of investment (neglecting semi-annual dividends). See also Appendix A.

The commonly accepted reason for a higher rate being asked of one investment than another is the greater risk in the one, and that the difference between the two rates is to be regarded as an insurance. If we endorse this view, then from the very nature of insurance, when risks are spread over several investments, the difference between the rates obtained and that had from, say, Consols is set aside to make good the losses in one or other of the undertakings ; hence the difference between the rates is essentially to *make good interest loss as well as loss of capital*.

If this be ceded, then the rate of interest during the deferred period upon the interest which should be considered as accruing must be such as will recoup any loss of interest ; in other words, the interest during the deferred period should be compounded at the high rate, inasmuch as both capital and interest during this period are essentially embarked in the undertaking itself ; in fact, from the nature of insurance the two are identical.

It is ceded as an axiom that the owner of a deferred annuity must be in the same position at the end of the period of investment as he would have been had there been no deferred period. On this basis only by a risk-rate on the deferred high rate of interest would he be in the position sought.

It will be noticed that this essential difference of view from that of several accepted authorities lies in the definition of insurance ; also that its numerical recognition (r''') in mining calculations calls for higher rates than are ordinarily considered.

One may here stop to wonder if the fact is grasped that it is not stated that money may be invested in practice and compounded at a risk rate of, say, 20 per cent., such as some block calculations would entail in theory, in order to arrive at sound estimates of value.

Returning to Formula (3)—

Formula (4). $C = \frac{1}{s + r'' + r'''} = \text{the present value,}^*$

where the (s) now stands for $(r' + r''')$, or the rate we expect to receive as interest, dividends being unity.

It follows from the above that, when r'''' is set aside for (n) years and accumulates at r' interest, we should have

$$\left(r'''' \frac{(R^n - 1)}{r'} \right). \dagger \quad \mathcal{R} = (1 + r')^n$$

This must make good the interest and risks during the deferred period (*d*), treating this accumulation as new capital, which must have interest paid on it, at r''' rate for (n) years, though compounding at r' , and not at s , as was found necessary during the deferred period.

From the above reasoning we can write—

Formula (5).

$$r'''' \frac{(R^n - 1)}{r'} = \left[(s) \frac{(S^d - 1)}{s} \right] + \left[(s) \frac{(S^d - 1)}{s} (s) \frac{(R^n - 1)}{r'} \right],$$

where $S = (s + 1)$. $s = r' + r''' \quad \mathcal{S} = r' + r''' + 1$

* This is sometimes known as the Hosvold formula; this and others will be more fully discussed in the Appendix. It is hoped that the more intelligent reader will realise that the aim is not to insist on one formula, but to urge that the deference principle must find practical recognition.

† See Formula (10).

Formula (6).

$r'''' = (S^d - 1)(r'' + s) = (S^d - 1)r'' + (S^d - 1)s$,
i.e., r'''' must redeem the new capital $(S^d - 1)$ and pay interest on same at the $(r' + r''')$ rate.

If the value of r'''' be substituted in Formula (4), we have—

$$\text{Formula (7). } C = \frac{1}{(s + r'') + (S^d - 1)(s + r'')}.$$

$$\text{Formula (8). } = \frac{1}{S^d(s + r'')} = \frac{1}{(1 + s)^d r'' + (1 + s)^d s}.$$

$$\text{Formula (9). } = \frac{1}{[(1 + r' + r''')^d][r' + r'' + r''']}.$$

From any algebra setting out of the principles of annuities, the amount C at the end of n years is:—

$$\text{Formula (10). } C = \frac{D(R^n - 1)}{R - 1} = \frac{D(R^n - 1)}{r'}.$$

Where C = capital to be redeemed by the annual dividends received ;

D = annual dividends received, in per cent. of capital ;

r' = Consol rate, also the rate realised upon the investment of the annuity ;

$R = (1 + r')$;

n = life of mine in years.

But by Formula (1)—

Formula (11). $D = r' + r'' + r'''$; and as the rate necessary to redeem unit capital is alone considered ;

$r' = 0 = r'''$, hence

$D = r''$ and (10) becomes

Formula (12). $1 = \frac{r''(R^n - 1)}{r'}$.

Formula (13). $r'' = \frac{r'}{(R^n - 1)}$ { when C is taken at unity.

Formula (13a). $r'' = \frac{r'}{\left(1 + \frac{r'}{m}\right)^{mn} - 1}$ { where interest is received and re-invested m times per year. 2

Hence our basic formula for block calculation is—

Formula (14).

C (the present value) } = $\frac{1}{(1 + s)^d \frac{r'}{R^n - 1} + (1 + s)^d s}$, or

Formula (15). $C = \frac{1}{(1 + r' + r''')^d \left(r' + r''' + \frac{r'}{R^n - 1}\right)}$, or

Formula (16). $C = \frac{1}{(1 + s)^d \left(s + \frac{r'}{R^n - 1}\right)}$.

External Factors effecting the Risk - Rate.—

While the application of the risk-rate principle to that phase of valuation with which we specially deal is indicated by corollary (c) of Premise III., both its use and developments call for further discussion; for example, the value to be given to the risk-rate (r''') in order to allow for variation in the selling value of other metals than gold, as well as the profit per ton in the ore, is worth more than a passing thought, but will be only touched on here. Sometimes we see that copper shares, for instance, are purchased at such figures as to bring the

interest paid by a company producing copper at £50 per ton to the same basis as one producing at £30 when the selling price of copper is, say, £60; this in spite of the fact that a fall of £10 in the price obtained for the metal will cut off dividends entirely from the one and only reduce those of the other.

As a matter of fact, while an exact adjustment of the risk-rate (r'''), whereby to meet the vagaries of the metal market, would be impossible, it will appear that the probability of a cessation or reduction of dividends would follow the ordinary probability law expressed by

Formula (17).
$$y = \frac{k}{x^n}^*$$
 or possibly by

Formula (18).
$$y = \frac{k}{n^x}^*$$

where y is the probability of loss, x the difference between the cost of production of the metal and its mean selling price, while n and k are constants as determined by experience.

It is a source of constant wonder that people invest in copper or silver ventures on the same basis as gold—*i.e.*, that they accept, say, 6 per cent. return on copper shares, and ask the same of gold. If such investors could bring themselves to abandon their attitude of self-deception for a moment they would no doubt admit that what they really want is share speculation, but in order to indulge themselves comfortably in such pastime, they seek to be told that it is “investment.”

Taken broadly, the value of r''' is essentially the

* These formulæ are offered simply as illustrating one of the many factors making up the risk involved in any undertaking marketing a product varying greatly in price.

practical measure of speculation, even though no exact line be drawn.

Table I. gives what appears at first sight to be the risk-rate (r''') demanded by the public of four well-known Rand shares; the examples given have been taken at random. The amazing fact will be noted that buyers appear to be content to ask less of these mines than of standard railway shares, thus tending to confirm the cynical view that the public finds in mining only a convenient table upon which to gamble.

TABLE I.

Company.	Life in Years.	Rate of Dividend on Par Value.	Rate Paid on Market Value of Share.	Rate Necessary to Redeem Capital.	Rate compared with 3 Per Cent. Consols. + Higher. - Lower.
		Per Cent.	Per Cent.	Per Cent.	Per Cent.
A	30	40	7	2	+ 2
C	8	30	14	11	0
D	16	35	9	5	+ 1
E	12	17	9	7	- 1

Average risk-rate, half of 1 per cent.

Figures taken from the *Mining Magazine*, March, 1910.

While no doubt there is truth in this, the moment an engineer admits that he has no concern in providing a good return on capital, this essentially meaning r' , r'' , and r''' , he becomes but a croupier in the game, as it were, and his position in society should be, and often is, so regarded.

Reverting to Table I., showing the Rand risk-rate as

apparently estimated by the public, one has to take several things into consideration before deciding what is demanded.

First, ignorance of the effect of "life" allowance in increasing the rate to be legitimately asked; second, the degree of risk run; third, the imperfection of the data upon which the investment was made; fourth, the disinclination of shareholders to reduce the value as set in a time of speculative hysteria when the major part invested; fifth, the hope that others more venturesome than themselves might yet take their holdings.

The very fact that prices paid for mining shares often, if not usually, imply the loss of part of the capital embarked, demonstrates the needs of the consulting engineer as a technical adviser, whose first duty should be to estimate, however approximately, the value of r'' , r''' , and r'''' . Those who consider the latter in their daily calculations are too few in number, unknown to many, and have status only as special advisers to the larger and more reputable concerns. Their light often has a bushel kept carefully over it, lest the public, learning of their existence, should demand favourable reports from them on new ventures.

It may be contended that it is useless to employ a risk-rate when so many factors influencing it must remain indeterminate; as, for example, the various personalities effecting the enterprise.

On the contrary, because of the possibility of the adverse factors synchronising, as it were, it should be the more advisable to use it. The varying weights given to the reports of different engineers is expressed to a certain extent by the market values of shares in ventures

recommended by them ; this is an unconscious employment of a factor of safety, but expressed in terms of present value.

Where engineers check one another's work, a rate of risk applicable to each other may on occasion be approximated ; for instance, the results obtained from a reconnaissance inspection of a Chilean nitrate pampa indicated that by using the data from the careful examination of a few points as unity, the accuracy of an earlier report might be allowed 0·66, and on this basis the pampa was given 18,000,000 quintals, while the final and exhaustive examination by a third engineer gave 20,000,000.

Again, in the preliminary examination of the mine referred to by the Table II. and Fig. 1, the errors found in the methods of sampling alone gave rise to the prediction that others yet more serious would be found in the block calculations.

TABLE II.

Classes of Ore.	Part of Block Sampled.	Amount.	Net Value.	Ratio of Value to Purchase Price.	Ratio to Capital of Company.
		Tons.	£	Per Cent.	Per Cent.
Positive ore :	Patches.	175,000	182,000	17	14
Block A. {	Top, imperfectly.	55,000	112,000	11	9
Block B. {	Top and bottom.	77,000	200,000	19	16
Probable ore :	Half of top ;				
Blocks {	virgin below.	318,000	560,000	53	61
D and E. {					
Totals,		625,000	1,054,000		

First payment made—£1,000,000.

This was borne out in the next work, which, though uncompleted, showed an error of £80,000, as was published subsequently.

The proportion of the so-called "positive" to "probable" ore, and of these to "possible" ore, when a purchase is recommended, is one that must greatly influence the value to be given to r''' , and is often the best criterion of an engineer's qualities, moral and technical. The practical definition of each of the above

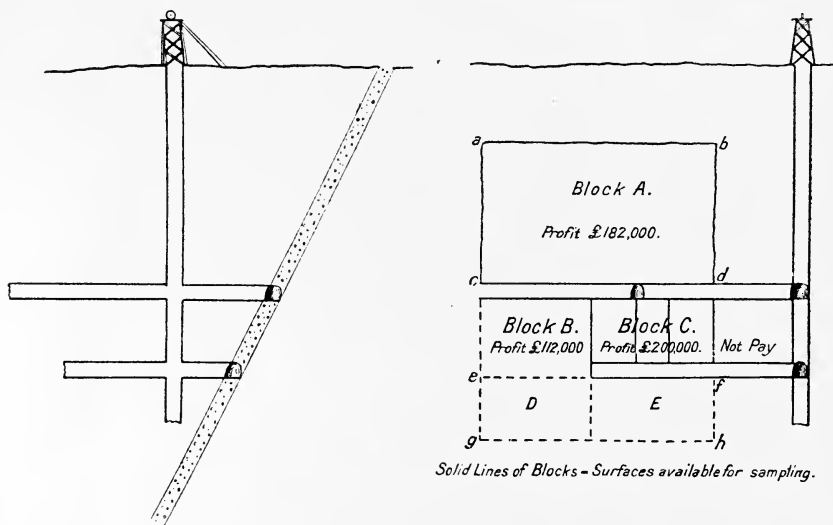


Fig. 1.

classes of ore varies, the interpretation of the local data, geological and economic, largely affects it, and unfortunately gives an opening for many plausibly to misuse terms and introduce a skilful ambiguity leading to a successful public exploitation.

It is a common practice among the more careful engineers to demand that the dividends from the "positive" or four-sided ore must be at least equal to the

Consols basis (*i.e.*, $r' + r''$), leaving the "probable" to represent r''' , and, one might add, the "possible" ore, to give the zest so essential to embarking upon new undertakings.

The statement * that 7 per cent. is the minimum to be given to r''' in any class of mine investment is well worth careful consideration. In a general way one may say that the estimation of r''' is that portion of the reporting engineer's work which makes the greatest demand upon his knowledge of economic geology; for on the above basis, $r' + r''$ is covered by the ore actually blocked out. The sampling of the latter calls for little more than a knowledge of mining as practised or practicable locally, a good eye and a sound grasp of the principles of sampling and deductions therefrom, though the last would seem to be little enough understood, even by the fraternity.

From this aspect of the risk-rate (r'''), the probable occurrence of ore beyond the pick-point, whether it be the continuation of an ore-shoot in a typical vein, or the lateral extension of a mineralised part of the porphyry flow, though often calling for the most exhaustive study of the surrounding district, is the practical object of geological work. For instance, the idea that a fair allowance for shoot-extension would be a wedge having a base equal to the shoot-length on the lowest level, and terminating at a point distant one-half of the shoot-

* See "Principles of Mining." by H. C. Hoover. The above 7 per cent. for risk may be read as corresponding to the writer's $r''' = 4$ per cent.

length below,* is another estimate of r''' . The practical application of this allowance calls for the careful study of the type of deposit, as well as of adjoining mines, especially if they be deeper or near the same depth, and is admissible only if they show no cause to suspect a sudden diminution in the pay-ore.

Many will insist that mines may not be bought on a basis of the ore proved. This is often true, but in the

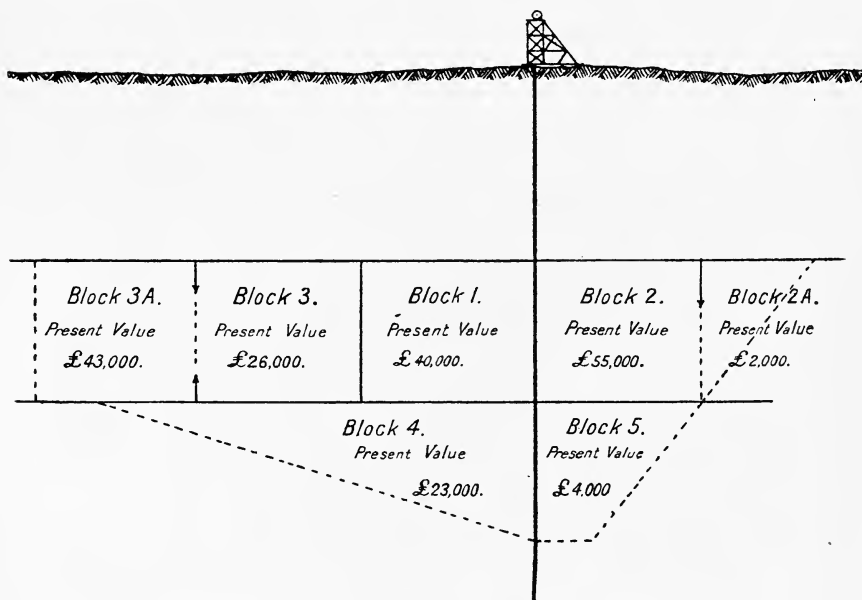


Fig. 1a.—Diagrammatic Sketch of Mine.

Solid lines = work done ; dotted lines = estimated boundaries of blocks.

case of undertakings calling for a heavy outlay on equipment, terms approximating these can usually be made, especially if the engineer be possessed of tact, and has

* See "Principles of Mining," by H. C. Hoover.

the intelligent support of a financial group intent on making a good purchase.

Internal Factors of Risk-Rate.—As is indicated above, the risk-rate is composite, being made up of factors, one in effect is made a function of the time; another being a function of the specific data available. In the case of the ordinary banking risk, where a higher rate is asked of the individual than of another bank, the discount of a man's paper places a larger sum to the credit of the bank's reserve at the end of three years than if discounted for three months only. This is tantamount to saying that, apart from ordinary interest (say 3 per cent.) and capital redemption, the contributions made to meet possible loss shall be a function of the time, and independent of the risk appertaining to the individual himself. This seems defective, but it may be said that practical experience proves the number of events likely to vitiate the accuracy of a forecast, to be a function of the time; and that, instead of setting a constant as the special contribution to the reserve fund for each customer, beyond the bank rate, it has been found simpler and more effective to make the individual's contribution a function of the time. So with the unit value in blocks of ore carrying the same risk-rate, there are two risks; one external to the block, and representing the many risks incidental to war, pestilence, famine, and maladministration, hence a function of the time. The other might strictly be considered to be independent of time and purely a function of the data available for the block. For instance, if 2 per cent. (or 5 per cent return) were considered to be an adequate

external risk-rate, the aggregate contribution for the risk of one pound for ten years would be $\cdot 229$ (after subtracting the amount at the Consol rate). If, however, the time ran to twenty years, and the same risk-rate of 2 per cent. were applied, the same reasoning would show that a contribution to the reserve fund of $\cdot 537$ (allowing redemption and 3 per cent.) would be required. This is analogous to the banker's demand, and may seem defective, yet experience, and perhaps convenience, has sanctioned the custom of making this contribution a function of the time. In the case of blocks of ore having the same amount of data and same deference, but of a different profit per ton—hence a greater risk—special allowance might be made in accordance with the principles discussed in connection with Formula (17), but it would seem safer and certainly simpler to follow the banker's procedure. On rare occasions one sees a report having the net profit reduced in proportion to the sample surface thought necessary. For instance, where a winze and a level of a block are alone available for sampling, the tonnage and profit in block 4 of Fig. 1 (a) might be reduced by one half, and the present value determined on the basis of the external risk-rate only. This would obviate some of the manifest defects in the banking system, but would not allow for variation in profit per ton—*i.e.*, the attendant greater risks with ore having a value near the cost of production. On the whole, it would seem that, as in commercial life, it were better to make the contribution to the reserve fund, so to speak, greater in the cases of longer deference, always bearing in mind, of course, that the most one can hope is that the

under-valuation of certain blocks will be offset by the over-valuation of others. The really vital point is that a full presentation of both data and the methods of collecting same be submitted, together with the means of applying the facts to the estimate of present value; this, of course, is nothing more than a demand that the scientific habit of mind be observed, the essential of the latter being the elimination, as far as possible, of the personal factor.

The Redemption Factor.—The life factor, r'' , or $\frac{r'}{R^n - 1}$,* the portion of the annual rate to be set aside to redeem capital in “ n ” years, naturally carries with it many practical considerations, one being the capacity of the reduction plant, which, of course, not only determines the life of any block, the tonnage of which is known, but largely influences the working costs, hence has signal bearing upon the blocks to be left, thus reacting on the life. Very much has been written on the subject of the most profitable magnitude of plant (or life), and while of great moment to those operating engineers, who may count upon more capital for the plant extension if needed, for practical purposes of block valuation, life is fixed by existing plant, or by the convenience of the financiers finding the capital. While a plant treating anything from 50 to 1,000 tons a day may be calculated upon in reporting practice, larger ones than this are usually matters of growth after further capital expenditure has been justified by reduction results already obtained, as well as by greater proved tonnages. Naturally, the

* Sinking Fund rate (see pp. 24 and 25).

promised magnitude of the deposit must largely influence the size of the plant, but usually the financial weight of those for whom the report is made is the dominant factor, though evidently sound field work will record data in such a way as to permit of calculation based on various sized plants. Few things are more noticeable than the practical disregard of the redemption factor, not only in the valuation of shares and blocks of ore, but by the operating engineer in secondary calculations appertaining to plant additions. It seems certain that were this feature to find expression in all estimates where relevant, a much clearer idea of the real cost of improvement would obtain than where the lesser capital outlays are charged to renewals. In fact, were it not for the tendency to surreptitiously charge off working expenses to capital outlay, such an account could well be introduced with a view to commitment of the manager to intelligent estimates, these involving not only a statement of the savings in costs expected through the outlay, but the presentation of the real gain after redeeming the latter in a few years.

The Deference Factor.—When surveying current valuation practice, few things are more remarkable than the studied avoidance of the deference factor (r'''), though the engineer in touch, even superficially, with finance has it thrust upon him when either cumulative shares or debentures are mentioned. The former of these two holdings essentially implies that though dividends be deferred at the outset or suspended later, the loss of simple interest must be made up by the dividends when these are resumed. In the case of debentures, the right

of foreclosure as soon as interest is defaulted involves the same principle coupled with that of capital return. Even apart from the elementary common sense so aptly applicable, the above fact that the principle is daily recognised on the share market, renders the ordinary engineer's neglect to apply it to the valuation of reserves the more inscrutable, and no doubt gives rise to the attitude of amused contempt with which intelligent financiers regard his pose of an all-round business capacity.

It is the rarest event to meet a report on a metal mine having the assets set out in such a manner as to allow for this simplest of economic principles, and the resulting magnitude of the error in valuation, if even suspected at other points in an examination, would not only condemn the engineer out of hand, but stamp his report as inept.

As seen by Formulas (4) and (15), or by Tables XXVI. to XLII., the deference principle tends to bring the value of certain blocks, in a property with a long life, to the vanishing point, which, however, may be offset by an increased rate of exhaustion should further capital for equipment be available.

While more pertinent to the economics of operation than to those of valuation, it may be mentioned in passing that the risk-rate and deference principle operate somewhat divergently in the case of expenditure on development. Here capital is laid out, upon which no return is made until the block is worked ; in other words, the risk-rate applicable to the block is, within the limits set by the standard dimensions, a function of the expenditure on

development. This is one of the many similar problems ever before operating engineers, who study the broader aspects of the work, but may not be touched now. As used here, *development* essentially implies exploratory work, or that undertaken to secure data as distinct from that properly charged to stoping such as many winzes, stop-drives, etc.

CHAPTER I.

BLOCK CALCULATIONS.

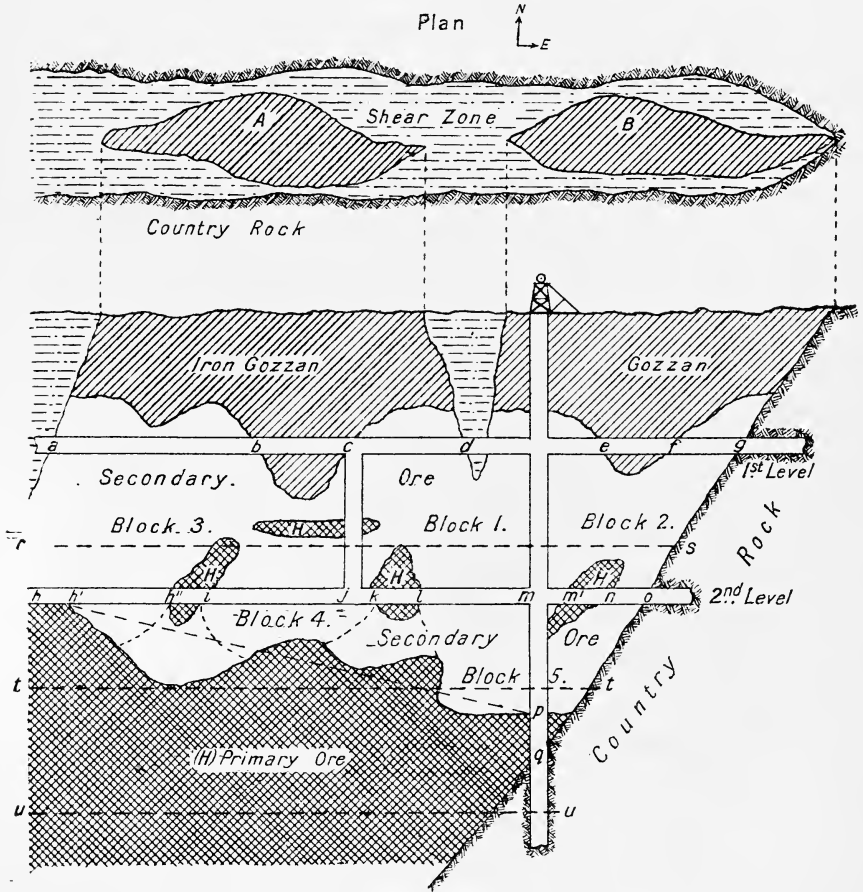
CALCULATIONS being numerical deductions from accumulated data, it may be urged that the nature and manner of collecting the latter should be first discussed.

As, however, calculations must rest on Premise III. and its corollaries, the more convenient sequence would seem to follow the latter, lest the underlying philosophy become obscured by what may be called pure technique.

The definitions of reserves being a body of ore or mineral concerning which sufficient physical data is available to warrant purchase, it follows that upon the interpretation of the data must be based the value. It is well, therefore, to have clearly in mind the significance of the word "physical." For example, by referring to Fig. 2, the suppositious case of a copper deposit capped by a worthless gozzan, it will be seen that when an engineer advises outlay, either for purchase or development before ore is actually reached, no physical data is available.

Those finding the capital may be said to support the engineer's or geologist's hope and prediction that payable ore in payable quantities will be met with at depth. It follows that if definite values may not be assigned a block of ore, it of necessity falls under the same category, regardless of its position in the mine ; becomes one

of hope only. Expressed otherwise, while no such thing as certainty exists in any undertaking, the whole of business life is one of outlay *on estimates of probability*, hence the convenient expression "*possibility*" for the



Section.

Fig. 2.

"*probability*," which is thought too remote to adventure upon, beyond that incidental to exploration.

Evidently the ore in the interior of a block, though

sampled on four sides, may be said to exist only in the imagination, but the fact that in the latter *continuity* only must be assumed, against *occurrence and continuity* in the former case, throws the block into the category of *probability, which may be paid for*. The philosophy bearing upon the amount of these payments has already been touched upon in the introduction.

Shoot Indications.—A feature of the greatest importance, though constantly overlooked in reporting practice, when dealing with undeveloped properties, is the area of the out-crop formerly mineralised, or that which otherwise indicates the magnitude of the ore bodies expected. For instance, the sum of the areas A and B of Fig. 2, other geological data being favourable, may be said to be a guide to the area of a horizontal slice through the ore bodies at $r-s$. While, as indicated by the sketch, this estimate may be erroneous, it is invaluable, not only as the guide above mentioned, but, when set out in a report, as an evidence and measure of sound field work.

A great advance would be made were it definitely recognised that the failure to furnish a plan and section sketch of the out-crop to scale; in other words, the neglect to supply the primary data to justify the outlay advised, was a mark of incompetence. In those cases where no brecciated zone or other surface indication is available, the only guide may be the magnitude of the bodies found in a similar horizon. For example, the wonderfully rich bonanzas of silver chlorides at Huautahaya in Chili occur at the juncture of small, usually barren veins, with a limestone-andesite contact. In this

case the only guide to the economic importance of new bodies sought for, would be the magnitude of those previously met with under similar geological conditions in neighbouring properties, yet this is pertinent data.

In general it is convenient to conceive of a slice one foot thick through the existing or hoped-for ore bodies, perpendicular to the major axis. If, instead of thinking of this in terms of its physical dimensions, but of its economic magnitude, a very effective unit by which to compare the possibilities of different properties is had. For instance, if the slice indicated by $r-s$ of Fig. 2 were 1,000 feet long by 15 feet thick, yielded £1 per ton profit, and the specific gravity constant were 15, the economic magnitude would be 1,000 sovereign-feet.

A concise statement, then, of the engineer's report advising outlay on development would be—"Based on the evidence of similar geological conditions known to me, and upon the area of the leached out-crop, I expect to meet the top of a shoot of about 1,000 sovereign-feet in magnitude, counting a sovereign a ton profit, at about 500 feet in depth. The expenditure for exploration work is estimated at £15,000, or £15 per unit of economic shoot, which, allowing a further £15,000 for plant outlay, works out at £30 a unit, thus comparing favourably with other mines; see Table IV. attached."

The above is a case of the estimation of possibilities and presents, aside from extra plant allowances, no difference from that of the "possibilities" of the shoot below the deepest level in a mine, *not ranked as "reserves."*

If, however, the out-crops A and B of Fig. 2 be conceived to be adequately sampled, and to carry gold

values payable under the local conditions and plant equipment financially convenient to those for whom the report is made, the whole aspect of the case is changed, insomuch as physical data is in hand as distinct from the geological surmise regarding the copper contents below. In other words, the position, apart from provision for plant, is similar to the deepest full-shoot level in the typical mine—*i.e.*, where data from sampling one side of a block of ore is available.

The Standard Block.—When calculations refer to a block of ore having the whole vein-width exposed on four sides, one is immediately confronted, not only with the distance between the sample sections as determined by the homogeneity of the ore, but with the depth of enrichment perpendicular to the sampled surface. In other words, one can sample, as a rule, but four of six sides of a block, hence investigate but a shallow zone on the periphery, the depth of which may not be assumed greater than the distance between the sample-sections.

It may be said that the ratio of the cubic contents of this zone to that of the block is a measure of the uncertainty attaching to the valuation, if the above view hold good. From this it will be seen that to be fairly sure of a block, the dimensions may not be greater than the depth of impregnation, as indicated by the intervals between the sections, thus reducing the size of the blocks by an amount impossible in mining practice. For instance, if it were not allowable to take one section more than 20 feet apart, one would not be justified in spacing levels and winzes more than 40 feet distant one from the other.

The above view would not seem adequately to cover the ground if we study closely almost any carefully prepared assay-plan wherein the sections are, for example, 5 feet apart. Here it will be seen that there is a general tendency of the ore found in the shoot, which alone is now being dealt with, to maintain for several sample-sections a yield, let us say, barely profitable. The next number of sections may be rich, and so on, around the whole periphery of the block. If those parts carrying the same value be coloured, it will be seen that in many ore-shoots at least, there is a tendency of the leaner (or

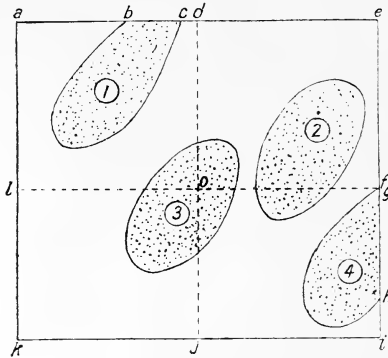


Fig. 3.

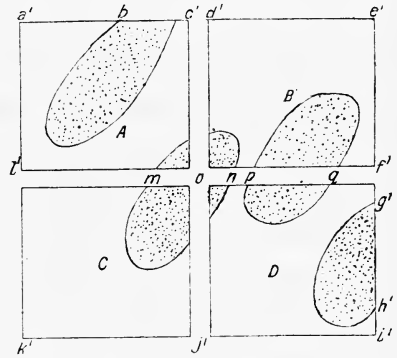


Fig. 4.

richer) portions to assume a form roughly indicated by Fig. 3, which aims to illustrate such a block of ground.*

After a little consideration of the principles governing the weighing of data, it will be seen that in order to give the minor areas indicated by (1), (2), and (4) of Fig. 3 their proper weight in the calculations, the number of sample sections taken in the distance *b-c* and *g-h* should bear the same ratio to the total number of periphery

* The shape and magnitude of these patches, as indicated by the assay-plan, is manifestly worth the most careful attention.

sections as the areas indicated by the dotted portions bear to the area of the whole block. As will be seen from Fig. 3, however, the distances between $b-c$ and $g-h$ form but a small proportion of the total periphery—that is, areas 2 and 3 are unsampled, and fail to affect the mean value of the block as determined by sampling the periphery $a-e-i-k-a$.

If we divide the block as is shown in Fig. 4, it will be seen at once that the minor blocks A, B, C, and D contain each of them a portion of the areas 1, 2, 3, and 4; hence a nearer approximation to the mean value of the whole block is obtained by sub-dividing it—that is, *the accuracy varies with the data available, or the risk varies inversely.*

Theoretically, of course, complete accuracy is never obtained until the whole block is carefully crushed and sampled, the essential principle involved being the same as that governing the quartering of a sample. Inasmuch, however, as this process is so expensive in mining work, it is necessary to make a compromise between the demands of theory and the same when economically weighed so to speak; expressed otherwise, the exigencies of mining largely determine the distance between levels and connections. Nevertheless, should a preliminary sampling show such variations or patches as are indicated by Fig. 3, it would be either sub-divided or an allowance made approximating it, as a theoretical equivalent. In other words, depending upon a preliminary sampling or upon a judgment based on previous experience with similar ore-shoots, consciously or unconsciously one has to decide upon the dimensions of

a standard block—that is, having a given ratio of periphery to cubic contents.

The writer's practice is to take sections at 30 feet intervals, sub-dividing these to as small as 5 feet, if marked variations either in thickness or value are noted in the first series. The great number of sections usually taken is due to an unconscious effort to minimise the tendency of accidentals to vitiate the mean value, as well as to define the habit of the rich and poor patches.

While the demand incidental to winning the ore largely affect the distance between levels, the general habit in vein mining is to space levels about 100 feet apart, even where this distance could profitably be increased, having reference to the mining cost alone. This spacing of levels is no doubt partially the outcome of generations of experience in the matter of variations in value within the ore-shoot, and in general it may be considered safer to space winzes further apart than the levels.

It will be apparent that the conditions illustrated by Figs. 2, 3, and 4 are fairly common to tabular deposits, though the shape and size of the lean patches will vary greatly as affected by secondary enrichment and impoverishment, by cross-fissuring, contacts, and a host of other geological factors beyond the scope of this work.

Fig. 2 illustrates a not unusual occurrence of ore bodies in the typical copper mine where one ordinarily meets greater changes in the same distance than in gold or even silver deposits. In such a case the allowances made by different engineers for each block would doubtless vary, but where full plans accompany a report,

coupled with detail, as is set out in the tables and elsewhere, adjustments can easily be made.

Block 4 of Fig. 2 especially illustrates a case of where geological data, as indicated in the second level and at the points p - q in the shaft, would tend to prevent any such allowance for shoot-extension as set out in Formula (22). On the other hand, the occurrence of the secondary ore from h' to m and from m to p , would seem to justify a tonnage allowance, shown by the dotted line h' - p , weighted in accordance with the principles to be set out. It will, of course, be evident that, under certain circumstances, largely depending upon the information furnished by the assay plan, greater weight might be given to the same length of sampled periphery on a level than in a winze. On the other hand, were the richer or leaner portion to take the form of sills, like that of the body marked by the upper H in block 3 of Fig. 2, equal or greater weight might be given the winzes.

The point urged is not the fixation of rules like this, local conditions greatly modifying these, but the necessity of setting out the fullest particulars, which must include not only the field data, but each step in the calculations and deductions, in a manner indicated by the discussion of the following premises.

Those familiar with the Transvaal will recognise at once, by comparing the shoot conditions found on the Black Reef and Pilgrims with those of the Central Rand, the significance of the different dimensions allowed the standard block. In parts of the Rand one might feel safe in allowing 500 by 500 feet, and feel doubtful of 50 by 100 feet in another geological district.

If the necessity for, and significance of, the dimensions of the standard block be seen, it becomes possible to repeat with greater emphasis the contention that—

*The risk-rate (r''') for each block varies inversely with the number of sample sections taken.**

For instance, were the dimensions of Block A in Fig. 4 set as a standard when sampled around its whole periphery $a'-c'-o'-l'$ at, say, 10 feet intervals, then the r''' selected would be a corresponding standard value. If, now, Block B were valued on the basis of sampling, only the surfaces $d'-e'$ and $e'-f'$, our data would be but one-half that demanded as standard, hence the r''' would be doubled. Again, if only $k-j-i$ were sampled, and the dimensions of A be still taken as the standard, then the ratio of the data available to that demanded would be as the distance $k-i$ is to the whole periphery $a-e-i-k$ plus $l-f$ plus $d-j$, and the risk-rate (r''') allowable would be six times that given to the standard block.

From the foregoing it will appear that, while there is room for considerable divergence of opinion regarding the dimensions of the standard block applicable to

* It will be noted that this theorem may be written algebraically, $r''' = \frac{k}{x^n}$ where $k = 1$, $n = 1$, and $x =$ the number of sample sections. Others, of course, may assign different values to k and n . The above theorem might be written $r''' = \frac{k' k''}{x}$ for each block, where $k' =$ the risk-rate for the standard block, k'' the number of sample sections required, and x the number of sections taken.

each ore-shoot, a carefully prepared assay-plan will often shed a most illuminating light on this as on other points.

The value to be accorded the risk-rate (r''') for the standard block again calls for consideration, and though a multitude of influences affect it theoretically, a low value can usually be given with propriety, especially when dealing with gold properties, though in the case of copper and tin the law indicated by Formula (17) might be considered.

On the assumption that the dimensions of the standard block have been carefully determined, in the case of a gold property it would appear that a risk-rate of 3 per cent. should be sufficient, though this must cover the danger of losses through war, pestilence, famine, theft, strikes, and adverse legislation, all exterior to the mine itself.

In the case of a property similarly situated, the dividends from which are principally dependent upon the sale of silver, a risk-rate of 5 per cent. would appear a more reasonable allowance, particularly if the profit per ton were small.

Shoot Extension.—As the ore-shoot extension allowable below the deepest level is the source of the greatest doubt regarding the value of a mine, hence the root of most parasitic financial growths, definite criteria of sound valuation are impossible without determination of such allowance. A formula expressing the above fundamental principle in simple form applicable to extension of the typical ore-shoot may be written—

$$\text{Formula (19). } r''' = P \left[\frac{(l + y) l' + k l y}{l'} \right].$$

$$\text{Formula (20). } = P \frac{k l y}{l'} + P (l + y) = P + y \left(P + \frac{P k l}{l'} \right),$$

where P = the standard risk-rate ;

y = the number of zones or levels below the lowest one proved ;

l' = the length of shoot as shown by the lowest level ;

k = the number of winzes there should be between two levels in order to make them into standard blocks ;

l = the distance between levels on the dip.

Referring to Fig. 3, and assuming that $k-i$ were the shoot length on the lowest level, and P were taken at 5 per cent., $l' = 200$ feet, and $l = 100$ feet.

$$r''' = 0.05 \frac{(1 + 2) 200 + (3) (100) (2)}{200} = 30 \text{ per cent.}$$

Reverting to the case last cited, where it was found necessary to allow a risk-rate of 30 per cent., in order to weight the uncertainty attaching to the ground below the last level sampled, it will be seen at once that if our dividends were only 30 per cent., the principle of probabilities as incorporated in the above theorem would limit the shoot-extension to two levels.

From the foregoing it follows that the old uncertain nomenclature of "probable ore" is discarded, but that probability is defined in terms of annual interest—that is, it has now an exact financial equivalent. Among other points of practical significance attaching to the same definition of probability is the fact that, *under*

certain circumstances, the ore below the lowest working must be regarded as a reserve, when properly weighted, the same as any other block, but of even greater moment is the fixation of the shoot-extension that may be allowed on a given estimate of dividends to come from that zone.

In order that the above principles be given adequate expression, it is necessary to give greater attention to the effect of deference with reference to determining the present value of each block, as set out in Formula (15), which is the bases of Tables XXVI. and XLII.

Returning to the shoot-extension allowable below the deepest level, and neglecting for the time being the effect of r'''' , the basic Formula (1) may be written—

$$\text{Formula (21).} \quad D - r' = r'' + r'''.$$

$$\text{Formula (22).} \quad D - r' = \frac{r'}{R^n - 1} + \frac{P}{l'} [(l + y) l' + k l y].$$

where D = the average annual dividend in percentage of the capital ;

r' = the Consol rate, or 3 per cent. ;

r'' = the rate necessary to redeem unit capital in n years ;

$$= \frac{r'}{R^n - 1} ;$$

R = $(1 + r')$;

n = the life of the mine, n years ;

r''' = the risk-rate ;

r'''' = the rate necessary to make up the loss of interest during the deferred period.

This, unlike Formula (19), takes into consideration

the part of the annual dividend that must be set aside to redeem unit capital in n years, as well as the risk-rate.

Evidently D , the annual dividend, must be on a certain capital, which implies a known crushing plant that in turn determines the life that may be allowed to each zone or distance between levels l , hence n of the above equation can be expressed in terms of y , the number of zones, and be written $k'y$, where k is the number of years' life allowed to each level.

In the case of going mines where part of the capital has been repaid in dividends from the upper levels in n' years, n of Formula (22) may be written—

$$\text{Formula (23).} \quad D - r' = \frac{r'}{R^{n'+k'y} - 1} + \left(\frac{Pkl y}{l'} + P(l+y) \right).$$

As y also appears in the exponential form, solutions are obtained by the trial and error method, but it will be seen at a glance that the above simple formula, based on the ordinary insurance concept inverted, *limits the depth to which sound practice may allow shoot-extension, yet places this ground in the category of a reserve.* At the same time, it takes into consideration such factors as shoot-length and thickness, the profit per ton, and the crushing capacity of the plant, the number of levels already exhausted and the "patchiness" of the ground in the ore-shoot.

The above may be summed up in the statement that allowance for shoot-extension into unknown ground should be a *function* of the *magnitude of the economic shoot*, instead of purely a function of the physical dimension of the shoot, as is loosely held by present practice.

This will be seen to be in harmony with the ideas expressed in Formula (17), though very brief thought should show the fallacy of the older concept.

As will be seen, Formula (23) demands a greater allowance for shoot-extension in the case of rich than of poor ore-shoots, which also is in accordance with probabilities as just touched on.

It may be well to call the casual reader's attention to the fact that the above formula is *not a certain prediction of the shoot-extension to be encountered, but is a simple statement of what is thought to constitute sounder practice in estimation of probabilities*; as mentioned before, one may successfully wager ten to one that the ace of hearts will be the first card in a pack, but another may well question the wisdom of the hazard as of the man taking such chances, even should he be successful.

The Economic Shoot.—In the ordinary course of mining operations, the successive economic stages may be roughly summarised as follows, though the varying degrees of development in different parts of a developed mine may involve problems peculiar to an earlier stage. These may be said to be—

- (1) The period of purely geological surmise ;
- (2) The period of definite quantities and values, as well as of surmise.

Finance, at least such phases of it as legitimately concern the reporting engineer, calls for a careful consideration of the above stages, and of the first—that of geological surmise—one may write without much fear

of contradiction. "Unless profitable ore be found on the surface, sound valuation does not permit of cash expenditure, save on exploratory work." Manifestly this implies the belief that the ore bodies will repay the outlay necessary not only to exploration, but to development and plant, wherewith to realise the values contained; in other words, even the stage of geological surmise implies a postulate of dimension and value.

The first stage is more especially noticeable when dealing with copper outcrops, where profitable ore is rare at the surface.

On the other hand, in the case of, say, a gold prospect stripped along the outcrop and sampled, one may be justified in paying the vendors in cash, the amount of which would depend upon the profit per ton, length and thickness of shoot, and capacity of plant, the value of which must be redeemed, beside other factors.

It follows, then, that payment for property is not a question of development, but of data available, and it is conceivable that a well-sampled outcrop with favourable geological conditions may be given the same value as the deepest level in a mine.

If it be admitted that expenditure on the strength of geological surmise unsupported by assay values, other than that on exploration, be unsound, then a purchase involving payment for ore below that allowable as determined by the assay-values, is also unsound.

Stripped of technicality, one may say that where outlay is made independent of values, the investors are "backing" the geologist's surmise, and while they might cheerfully support a specialist of the first rank, it is

doubtful if sound practice would permit payment to vendors before ore was found. Furthermore, the specialist would have at least some idea of the economic magnitude of the ore-body expected, whether a "saddle" at Bendigo, or a zone of secondary enrichment below a brecciated gozzan.

If the foregoing be accepted, then the expenditure on exploration per unit of ore-body expected should be a measure in current practice. As it would seem to be impracticable to predict the depth allowable unsampled or "surmised" ore, the unit used will be the sovereigns of profit in a horizontal slice through the ore-shoot, one foot thick. This is a basic feature common to both stages, and will be called the "economic shoot"; as it serves as an index and means of classifying the possibilities of each, and should be clear from the following figure, which reproduces a common type of undeveloped prospect, having in general an appearance like that shown in (a) of Fig. 5; (b) gives a longitudinal section of the same when developed to, say, the company stage.

It would seem that the most casual speculative thought would go a step beyond the idea conveyed by the ordinary word "shoot," inasmuch as the boundaries of the latter are necessarily economic.

Surely the most obdurate must admit that a term, which in its very essence is economic, yet which conveys no definite meaning, suggests either stupidity or intention to mislead. Surely, when a shoot may be, say, 1,500 feet long, and yet be either 6 inches or 60 feet thick, when it may yield 6 pence or 6 sovereigns per ton in profit,

the use of mere shoot-length as a measure of magnitude is ineffective, to say the least.

This estimated dimension of the economic shoot applies, not only to the prospect, but to the developed

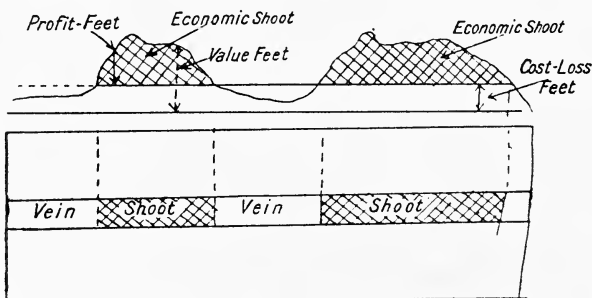


Fig. 5a.—Surface of Prospect—Plan (Syndicate Stage).

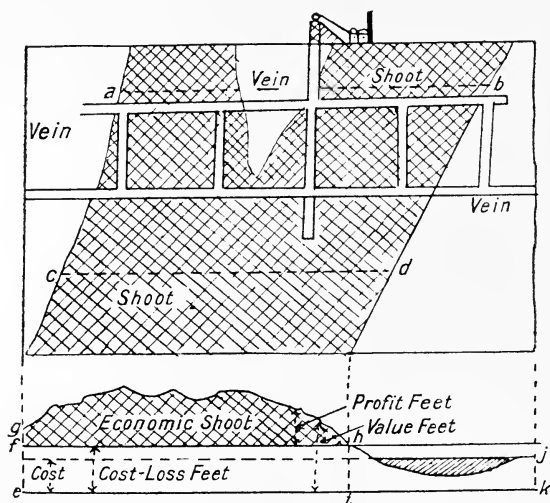


Fig. 5b.—(Company Stage) Longitudinal Section.

Area $efghie$ = Gross value shoot.

Area $fghf$ = Economic shoot.

mine; it is often as applicable to iron as to gold; to china clay as to copper; to a bed of banket as to the

channel of an ancient river ; whether the major axis be horizontal, vertical, or inclined.

The one point of difference to be made between prospects and mines, between the syndicate and company stages, is that the latter usually calls for definite assets or "blocked ore," and, if well financed at the time of purchase, has the economic shoot with its possibilities thrown in.

Classification of Prospects.—Prospects may be conveniently divided into two types, depending as in all such classification upon the validity of the data offered. These are—

- (a) The geological surmise type, as, for instance, petroleum prospects in new fields ;
- (b) Proved shoot type ; with ore to be sampled on one side only, as, for instance, an ancient working in Rhodesia accessible to sampling ; or a well-exposed outcrop.

In the case of (a) it may be stated that only upon rare occasions could it be considered sound practice to lay out capital save for development work, while, as before mentioned in dealing with (b), if local geological data were favourable a payment to vendors might be made in accordance with the principles already enunciated.

From the foregoing it will appear that finance during both the syndicate and company stages is vitally concerned with the magnitude of the economic shoot, while the ratio of that portion of the paid-up capital of the company not represented by the present value of the

proved ore, to the units in the economic shoot, furnishes a means of comparing valuations.

It will have been noted that "probability" as a term defining ore-bodies has been eliminated, it having been incorporated in the risk-rate principle. There remains, however, "possibility," which, as before mentioned, refers to the economic shoot below the ore allowed for. For example, when considering two mines having different economic-shoots, the possibilities of securing the always hoped-for bonanza in the ground beyond that for which payment may be made, might be said to be greater with the bigger economic shoot, as a single foot in depth would yield a greater profit in the case of the greater shoot. For instance, in Fig. 5*b*, though we may pay for the ore to the point *c d*, the ore beyond is "possible" only. In other words, we pay for probability, but hope for possibility, and one measure of ability is the price paid for a unit of this comforting sensation, as discussed later. (See Table IV.)

The foregoing may be said to bear particularly upon what is permissible, and while ideas will vary somewhat both as to the risk-rate applicable and as to the dimensions of the standard block, once these are determined, there would seem to be small room for great variations of opinion as to what constitutes sound valuation.

Economics of Purchase.—Evidently, the measure of the reporting engineer *per se* is his ability to comprehensively express technical facts and postulates in economic units, in order that outlay should be made in such a manner as to incur the least risk, or to invest the least capital incidental to securing a given profit.

Where the present total value at a low risk-rate is paid to the vendors of a mine, it may be safely said that either the mine was over-valued by the engineer, or the financiers neglected the very elements of their work, which are intelligent negotiation after valuation. It must be confessed that even the degree of self-appreciation common amongst engineers cannot obscure the fact that a little intelligent handling of the personal factors governing the vending interests, thus obtaining a deference of payments, will often secure benefits that make ordinary technical economies seem paltry; this is too often entirely overlooked. As before mentioned, an opinion as to the value of shares, large blocks of which are often offered for underwriting, is a constant demand, and while the basement complex of personality which affects the market and division of profits from such sources, concern the financier only, the economics of the enterprise, as well as the training, experience, and good name of the engineers upon whose recommendation flotations are made, concern the consulting or reporting engineer. From the foregoing it follows that, not only the relation of the proved ore-bodies to the purchase price plus equipment outlay must be considered, but also the payment made for the possibility of the economic shoot, though the latter can only be ascertained by combining a study of company construction and technical reports.

Economics of Finance.—Table III. gives a list of five well-known companies, with the approximate magnitude of their economic shoot expressed in sovereign-feet.

TABLE III.—THE ECONOMIC SHOOT.

Mine.	Metal.	Length of Shoot.		Average Width.		Gross Value per Ton.	Mean Sectional Value.	Combination Factor (Loss and Cost).	Mean Sectional Profit-feet.	Sovereign Shoot-feet.
		Feet.	Feet.	%	\$ Feet.	%				
Pilares (Mexico),	Copper	1,700	600	8·10	4,860	6·1	1,200	27,000		
Mt. Morgan (Queensland),	Gold-Copper	800	500	13·70	6,850	8·87	2,330	25,000		
Santa Gertrudis (Mexico),	Silver	1,500	15·5	23·20	360	10·8	193	4,000		
Mother Lode (B.C.),	Gold	1,200	150	6·70	1,012	5·7	150	2,500		
Camp Bird (Colorado)	Gold	1,700	4	31·50	126	15·4	64	1,500		

Table IV. may serve to emphasise the significance of the economic shoot as expressed in terms of company-capital and market-value. The present value of the reserves—that is, the deference factor—is neglected for simplicity's sake, and round numbers only are given.

To those also interested in the economics of finance, Table IV. should be of interest, though through lack of the latest facts the figures given must not be read as being exact, the idea being illustration from current practice, and not information concerning the mines mentioned. In some cases costs and losses have not been given in the official statements, and these have been approximated, as for example, in the case of the Prestea.

Columns 3, 4, and 5 are the proved shoot-lengths, mean thicknesses, and profit per ton, as given in published plans or statements only—that is, they are not

TABLE IV.—VALUATION AND FINANCE OF POSSIBILITIES.

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Name of Mine.	Metal.	Aggregate Length Proved Ore-shoot.	Thickness in Ore-shoot.	Estimate Profit per Ton Lowest Level.	Approx. Number of Sovereign Shoot-feet.	Approx. Present Profit in Reserves above Lowest Level.	Issued Capital of Company.	Capitalisation per Shoot-foot.*	Capital, less Reserves.	Engineers' Valuation of Possibilities. Rate per Shoot-foot.†	Market Selling Price of Co. (approx.)	Market Selling Price less Value Reserves (present approx.)	Finance of Possibilities. Price paid per Sovereign-shoot-foot or Depth to Recover Capital.
		Ft.	Ft.	£	£	£	£	£	£	£	£	£	£
(a) Abosso (West Africa),	Gold	3,200	4·0	0·50	500	125,000	400,000	800	275,000	800\$	550,000	425,000	850
(b) Prestea A. (West Africa),	Gold	4,000	7·0	0·85	2,000	500,000	850,000	425	350,000	425\$	1,275,000	775,000	390
(c) Gt. Boulder Proprietary (W. Australia),	Gold	1,500	7·5	1·75	1,500	1,287,000	175,000	117	..	117\$	1,750,000	463,000	310
(d) Santa Gertrudis (Mexico),	Silver	1,500	15·5	2·50	4,000	500,000‡	1,275,000	(300)*	775,000	194	1,275,000	775,000	194
(e) Redjang Lebong (Sumatra),	Gold	900	40·0	1·90	5,500	110,000‡	200,000	37	90,000	17	1,600,000	1,030,000	187
(f) Alaska Mexican (United States),	Gold	1,000	300·0	0·36	8,500	375,000	180,000	21	..	21\$	540,000	165,000	20
(g) Alaska United (United States),	Gold	800	300·0	0·34	9,000	310,000	180,000	20	..	20\$	540,000	230,000	26
(h) St. John del Rey (Brazil),	Gold	350	300·0	0·30	700	724,000	656,000	(940)	..	..	525,000	..	0

* Column 9 is significant only if there be no reserves at the time of flotation.

† Column 11 is also only of interest at the time of flotation, but is then an accurate measure of both engineer and financier.

‡ This applies to time of flotation. § In default of relevant data this assumes no reserves at time of flotation.

private estimates. Column 6 is the keynote of the table, and, as before explained, is the measure of the ordinary mine, apart from the reserves, being the profit in sovereigns to be expected from each foot in depth as the proved ore-shoots are exhausted. It is held that this is a far more comprehensive measure of the probable future magnitude than the ore blocked out, as a small shoot may have been worked systematically and show large reserves, while a large one of equal profit per ton may have no reserves above the lowest level. In this figure of economic shoot are condensed the work and innumerable technical calculations incidental to sampling, assaying, losses, costs of transport, taxes, duties, refining charges, and a host of others, the enumeration of which obscures, often designedly, the real issue, which is the estimated future magnitude of the mine. Evidently costs and losses bear a relation to capital outlay on plant, hence such estimates are also incorporated in the economic shoot. The last word is used advisedly, for the boundaries of any shoot are essentially variables as determined by costs and losses, hence are economic, while the ordinary idea of shoot magnitude as expressed by area (length and thickness) does not express the profit per ton ; it is therefore entirely misleading.

As the shoot bears on the future of the mine, and not on the proved reserves, the lowest full-shoot level is where one looks for data, and while the economic shoot at one level will vary from point to point, it remains an approximate measure of what one may expect in depth, assuming no vitiating geological features like the danger zone so common at about the same level in some silver

camps where zinc ores begin to appear. Occasionally, of course, an expanding or contracting rake of shoot, as indicated by assay-plans, might be considered, but usually this would be considered when dealing with reserves lying below the deepest level.

Column 7, giving the net value of the reserves, calls for little comment beyond suggesting that the validity of the estimates depends so much upon the size of the blocks and methods of sampling and appraisal, that one must take those of Table IV. as they stand. In reality, their actual value is inadequately expressed by the above figures, inasmuch as only their *present values* should be considered, *by allowing interest at a rate commensurate with the risk incidental to each until they may be realised upon.* For the purpose, however, of comparing the "possibilities," the above figures will answer.

According to the formulæ set out, the reserves in certain cases should include ore below the deepest level to a certain point to be determined by simple calculation. As, however, only those familiar with the local geology may say if such an estimate be permissible, those reserves lying above the lowest level are alone considered in the table.

Column 8 is of great importance as expressing definitely the valuation (when shares are issued at par) of the mine as estimated by the financiers, and to which, it is contended, the engineer is sponsor, more particularly with regard to the first flotation. This figure, coupled with the kind of shares issued (deferred, debentures, ordinary, etc.) is not only a measure of the engineer, moral and technical, but frequently a sure guide, if full

detail be published, to the business acumen, or the reverse, of the financiers responsible.

Column 9, or the ratio of the capital of the company to the number of sovereigns of profit to be expected from exhausting the shoots to a depth of one foot, may be said to be the payment made per unit of possibility, and is essentially the measure of business ability. To some it will be more convenient to regard it as the number of feet to which the shoots must be exhausted in order to repay the capital of the company (neglecting interest). This is another way of saying that those responsible for the flotation predict that the mine will not be exhausted before a certain depth is reached, for no one can conceive of risking money without believing that he will at least have his capital returned. *In other words, then, capitalisation beyond that represented by the present value of the reserves is equivalent to an estimate of shoot-extension in depth, whether this be on the engineer's advice or not.* In comparing new flotations, then, if no ore may be classed as a reserve, this ratio (Column 9) is the key to the economic position.

Column 10, or the issued capital (at par) less the reserves, is of particular interest only at the time of flotation, for the capital less the net value of the reserves must represent the amount paid for the estimated possibilities of the mine.

Column 11, the rate paid per shoot-foot, or the depth to which the shoots must be exhausted in order to repay the nominal issued capital less reserves, is also significant only at the time of flotation. For example, those responsible for the Santa Gertrudis flotation practically state

that independent of dividends the mine warrants a payment for shoot-extension to a depth of not less than 194 feet, while the financing of the Redjang Lebong called for 17 feet only. One would read it that the engineers and financiers of the Redjang Lebong must have looked to dividends, and an appreciation of their shares through development of the mine, rather than ask subscribers to gamble that the unproved ore would extend to depth.

Columns 12, 13, and 14, or the market selling-price of the mine, is affected by too many factors other than dividends, to bear upon those economics of finance with which we are dealing. On the other hand, column 14 is extremely interesting as illustrating what may be called the *finesse* of finance as distinguished from economics. This subject, however, calls for a subtlety of mind possessed but rarely by engineers.

The last four cases in Table IV. are of great interest, theoretically, and encouraging to those who follow mining for mining's sake, or who are concerned with the economics of finance.

It may be said that—

- (r) Cash expended on an unproved unsampled prospect other than that incidental to exploration is unsound ; and
- (s) The cost of exploration divided by the number of economic shoot-feet expected is a measure of outlay on possibilities ;

- (*t*) Ore in a developed mine lying below that which the engineer is willing to class as a reserve,* and pay for, is "possible" only, hence is of the same nature as the unsampled prospect. Therefore, outlay other than for exploration is also unsound ;
- (*u*) The issued capital of a company (at par) less the value of the reserves divided by the number of units in the economic shoot, is the outlay made per unit of possibility, and is a measure of the finance valuation of possibilities.

The last is equivalent to the number of feet in depth necessary to exhaust the mine in order to repay the capital, hence a very fair idea, in default of modifying geological data, of the relative promise of capitalised mines may be had by applying the above (*u*) ; that (*r*), (*s*), (*t*) are not academic postulates finding no expression in current practice is shown by reference to column 11 of Table I., where it is seen that the capitalisation of the above-mentioned three great properties has not allowed for more than 26 feet of shoot-extension.

Those responsible for the last three flotations mentioned in Table IV. being known as exceptionally able and honourable engineers, the shoot-extension allowed may be fairly taken as what is thought to constitute sound practice, while the approximate agreement between them is of interest ; nor should the fact be overlooked

* The above table classes as reserves only the ore lying above the deepest level. The writer holds that in many of the mines cited an allowance should be made for ore below, as already discussed.

that these extensions, of less than 20 feet, also include the promotional profits taken by the financiers concerned.

Referring to Fig. 1 and Table V., it will be seen, out of a capital of £1,275,000, only £346,000 was represented by the present value of the reserves above the lowest level. While nothing was mentioned touching the dimensions of what was thought a standard block, the fact that 174 sample sections were considered necessary to the valuation of the smallest block in the shoot, necessarily fixed the ratio of the number of peripheral sample sections to cubic contents for the others. This is a very important point to bear in mind in dealing with all reports where assay plans are published.

The upper reserves being taken at £346,000, leaves £929,000 as the estimated present value of the dividends to come from the ground below the deepest level, inasmuch as not less than par was actually paid by subscribers. The economic shoot working out at 4,000 sovereign feet, the dividends from this ground should, allowing 1 level of 100 feet as worked per year, amount to £400,000 annually, or 43 per cent. on £929,000, which would begin three years later if, as would normally obtain, the upper blocks were worked first. The problem becomes: to what depth does a payment of £929,000 postulate the shoot-extension, assuming that the ground will yield dividends of £400,000 per annum, exhausting one level of 100 feet on the dip each year?

The above figures show that 230 feet must be allowed to recover the capital, but as no one adventures to secure a return of capital only, the real inwardness of

business concepts applied to mining risks remains to be considered.

The practical recognition of the deference factor implies that the dividend equation must be written—

Formula (24). $D = r' + r'' + r''' + r''''$, or

Formula (25). $D - r' = r'' + r''' + r''''$, which, by substituting the value of r'''' from Formula (6), becomes—

$$D - r' = r'' + r''' + (S^d - 1) r'' + (S^d - 1) s.$$

Formula (26). $D = (1 + r' + r''')^d (r' + r'' + r''')$.

In order to express the above payment in terms of shoot-extension, one may take a uniform risk-rate for the blocks of 10 per cent., manifestly too low, but sufficient for illustration purposes.

Substituting in Formula (26), allowing k' the value of 1—*i.e.*, one year's life to a level of 100 feet on the dip, and y the number of levels below, by trial and error method using Table XXIII. for the value of r'' , it is seen that nearly 500 feet must be sunk below the then deepest level before the property will return the capital and 10 per cent. for risk. If one allow only 5 per cent. for risk, the shoot-extension must continue to a depth of nearly 400 feet.

The same solution and result may, of course, be had without calculation by referring to Table XXXIII., where it will be seen that, allowing 10 per cent. for risk, and deferring two years, the present value of an annuity, one pound is £2.46—*i.e.*, $n = 5$ years. This will be clear to those who have followed the elementary philosophy

BLOCK CALCULATIONS.

TABLE V.

Block.	Ore.	Life.	Delay	Net Profit.	Annual Profit, Pounds Sterling.	Number of Sample Sections Taken.	Number of Sections Required.	Ratio, Cols. 6 to 7.	Risk-Rate (r'').	Factor from Tables.	Present Value, Basis A.	Present Value on Basis of Capital, £1,275,000.	Paid for Possi- bilities.	Remarks.
		Years	Years						%					
A.	175,000	1	1	£182,000	£182,000	135	750	0.18	25	0.61035	£111,000	£1,275,000		
B.	55,000	1	2	112,000	112,000	96	174	0.52	10	0.69305	77,000			
C.	77,000			200,000	200,000	174	standard	1.00	5	0.79383	158,000			
D.														
E.														
TOTAL,	..	..	..	494,000	..	..	..	..	..	..	346,000	..	£929,000	

underlying the development of $C = \frac{D}{r}$, and the division of r into its constituent parts to allow for ordinary remuneration, risk, redemption, and deference.

For instance, in the last case $D = 1$, and $r = \cdot 43$, hence $\frac{1}{\cdot 43} = \frac{1}{r' + r'' + r''' + r''''} = 2\cdot 32$, therefore the nearest present value, when the deference is ^{Two}~~three~~ years, gives nearly five as n , or the number of levels in question.

TABLE Va.

Block.	Net Tons.	Years of Life.	Years of Deferment.	Net Profit.	Number of Sample-sections	Risk-Rate.	Factor from Table 26.	Present Value.
1	50,000	1	2	£50,000	100	%	0·79383	£40,000
2	60,000	1	3	80,000	75	7	0·68301	55,000
2A	10,000	1	f 4	5,000	25	20	0·35520	2,000
3	40,000		\ 4	40,000	80	6	0·64993	26,000
3A	60,000	1	5	90,000	50	10	0·48032	43,000
4	70,000	1	f 7	50,000	75	7	0·46651	23,000
5	20,000		\ 6	10,000	50	10	0·42506	4,000
Total	..	..	..	325,000	..	..	.	193,000

Narrow Veins.—The first thing presenting itself, when the veins to be mined are so narrow as to necessitate stopes wider than themselves, is the possibility of leaving portions of the block unstoped ; in other words, a process of sorting which does not imply first breaking the ground, a consideration almost universally overlooked in the valuation of reserves, pointing either to indifference or to a lack of underground operating experience on the part of reporting engineers. Yet before the extent to which

this is possible may be determined, the amount of ore which may be hand-sorted in stopes and on surface must also be approximated as well as the costs of the different operations. As will be dealt with later, under Premises IV. and V., the flexibility, or facility, with which the stopes may be contracted in strike and dip, is also a factor, the value of which is a matter of practical mining knowledge.

The question of costs will not be dealt with, it being assumed that the reporting engineer has had enough experience in various countries and conditions to approximate these. In general, however, particularly in parts remote from railway transport, there may be said to be a tendency to underestimate costs, the usual habit being to base them on those of a similar property operating elsewhere. Above all, in estimates of construction this transportation factor is given too little weight, not so much through the failure to approximate the cost per ton for carriage, as through overlooking the heavy losses due to idle staff and men, where plant fails to arrive as arranged for.

With reference to the possibilities of hand-sorting in stopes, underground practice will determine this to a large extent, such as the necessity for fills, size of waste broken, value and amount of fines, etc. When dealing with narrow veins, however, because of the superior supervision and mechanical facilities available on the surface, the usual custom is to sort there, and this will be dealt with, though the principle involved is identical both for underground and surface sorting as, in fact, for subsequent metallurgical operations. The first essential

is to determine if the advantage obtained by sorting offsets the drawback of multiplying operations.

Let B = the assumed (+ or -) profit per ton through sorting ;

P = the percentage sorted out. (Of the ore sent to the surface.)

Q = the tons of quartz sent to the surface ;

W = the tons of country rock or waste sent to the surface ;

S = the cost per ton for sorting. (Over the tonnage sent to surface.)

L' = the total loss in the part sorted out divided by tonnage sent to surface ;

C'' = the total cost of reduction operations (after sorting) divided by tonnage sent to the surface ;

L'' = the value in the final rejecta, divided by the tonnage sent to the surface.*

This may be written—

$$\text{Formula (27). } B(Q+W) + S(Q+W) + L'(Q+W) + C'' \\ (1-P)(Q+W) + L''(1-P)(Q+W) = (C'' + L'')(Q+W).$$

$$\text{Formula (28). } B = P(C'' + L'') - (S + L'P).$$

From which it is evident that so long as the costs and losses of reduction exceed the costs and losses of sorting, the operation is advisable (neglecting outlay on sorting plant).

In Fig. 6 it is assumed that the areas A, B, C, D

* This assumes that reduction works run the same, sorting or not sorting, and that the value of the rejecta does not vary greatly. The right-hand number represents the costs and losses if there were no sorting.

represent the total ore sent to the surface from which $P(Q+W)$ is sorted out.

Evidently $P(Q+W) = P'W + P''Q$, where P' is the percentage sorted out of the total *tonnage of waste*, and P'' the percentage of the total quartz sorted out.

$$\text{Formula (29).} \quad P' = \frac{P(Q+W) - P''Q}{W}.$$

Assuming, as in many cases, that the tonnage of quartz rejected is negligible,

$$\text{Formula (30).} \quad P' = \frac{P(Q+W)}{W} = P\left(1 + \frac{Q}{W}\right),$$

hence the areas C and D have P' , not P sorted out. The factor needed is the effective stoping thickness $(Q+W) - P'W$ at each section, if the really unpayable parts of the ground are to be determined.

For instance, if the flexibility of the stoping operations permit leaving the part shown between sections 205 and 215 (assuming of course a corresponding dip dimension), it would evidently be important to do this should they fall below the point set as profitable.

For illustration,

$$\text{Let } P = 20 \% \text{ and } \left(\frac{Q}{W} + 1\right) = 2, \text{ then } P' = 40 \%,$$

hence the thickness of waste will be reduced by this amount (*i.e.*, multiplied by .60).

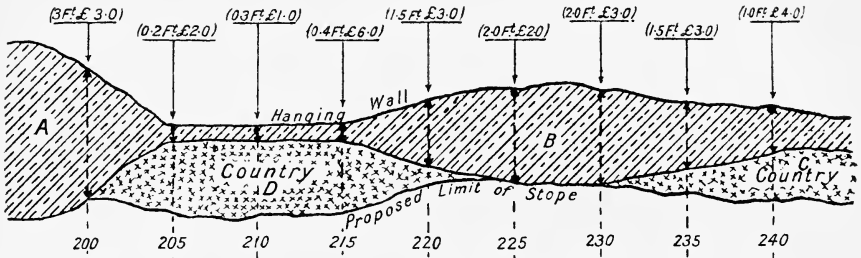
Formula (31). The stoping value S' will be

$$S' = \frac{v' t'}{t' + (1 - P')W},$$

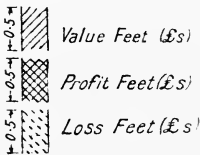
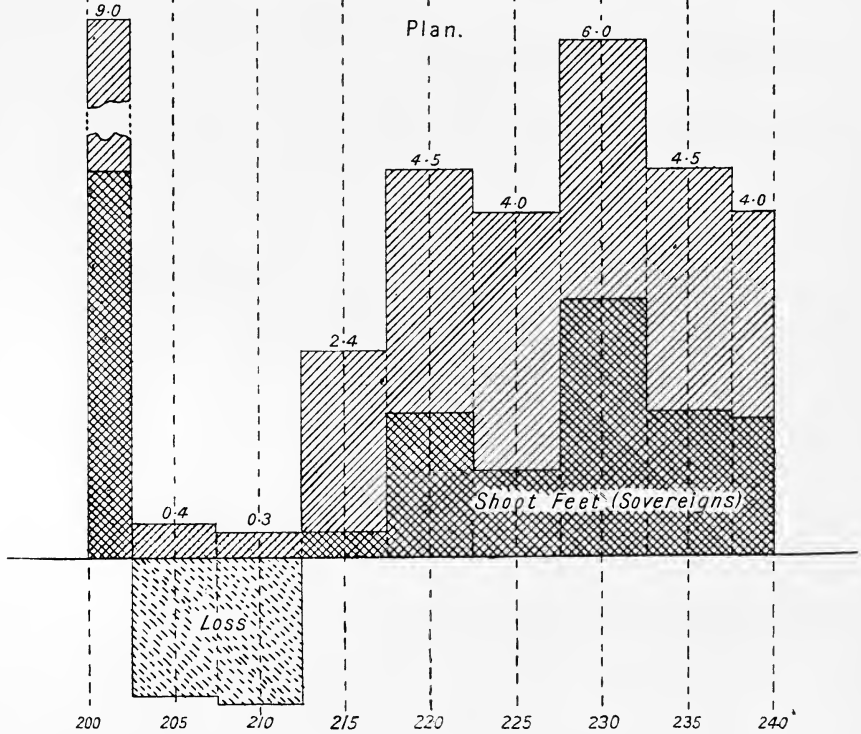
where v' is the assay over t' , and t' is the thickness sampled.

Table VI. sets out the calculations incidental to the continuous section system shown by Fig. 6, while Fig.

Fig. 6.



Plan.



Costs - Losses = £1.50.
 Waste Rejected = 60%
 Minimum Slope = 2Ft

Fig. 7.

7 is the economic summary of the same whereby to finally determine the profit in this block, the periphery of which, so far as possible, should be sampled and reproduced in the above manner. It will be evident that all the data is given by the above figures whereby, not only to make such allowances as the mining conditions demand, but give the number both of the desired and the obtained sample sections wherewith to determine the risk-rate for the block.*

It will be seen that the shoot-feet calculation is but a weighting of the sample sections by the distance between them, and that the total profit in the block is:—

Formula (31a).
$$P = F \frac{ld}{k(2l + 2d)}$$

if the block is sampled on four sides, where F = number of sovereign shoot-feet, l = length of block, d = depth of block, and k = specific gravity constant.

* This assumes a knowledge of the “stopping factor” discussed under Premise V., and that all the drives and winzes are laid out like Figs. 6 and 7; should there be any breaks, these will increase the risk-rate for the block, as elsewhere dealt with.

TABLE VI.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
M Section.	Assay Value, \mathcal{L} ' in \mathcal{L} .	Thickness of Sample in Feet = \mathcal{L} .	Value-feet, \mathcal{L} ' \mathcal{L} .	Thickness Waste Mined	Weighted Stoping Thickness, $\mathcal{L}'(1-P)W$, Basis A.	Stoping Value, $\mathcal{L}' \mathcal{L}$ $\frac{\mathcal{L}' \mathcal{L}}{\mathcal{L}' + (1-P)W}$	* Stoping Profit per Ton.	* Profit-feet, Basis A.	* Profit-feet, Basis B.	Sovereign Shoot-feet, Basis A.	Sovereign Shoot-feet, Basis B
200, .	3.00	3.0	9.0	0.0	3.0	3.0	+1.5	+4.5	4.5	+11.25	+11.25
205, .	2.00	0.2	0.4	1.8	1.3	0.3	-1.2	-1.6	..	-8.00	..
210, .	1.00	0.3	0.3	1.7	1.3	0.2	-1.3	-1.7	..	-8.50	..
215, .	6.00	0.4	2.4	1.6	1.4	1.7	+0.2	+0.3	0.3	+1.50	+1.50
220, .	3.00	1.5	4.5	0.5	1.9	2.4	+0.9	+1.7	1.7	+8.50	+8.50
225, .	2.00	2.0	4.0	0.0	2.0	2.0	+0.5	+1.0	1.0	+5.00	+5.00
230, .	3.00	2.0	6.0	0.0	2.0	3.0	+1.5	+3.0	3.0	+15.00	+15.00
235, .	3.00	1.5	4.5	0.5	1.9	2.4	+0.9	+1.7	1.7	+8.50	+8.50
240, .	4.00	1.0	4.0	1.0	1.6	2.5	+1.0	+1.6	1.6	+4.00	+4.00
Totals and averages,		..	..	..	1.76	..	+0.53	+0.93	1.8	+37.25	+53.75

* REMARKS.—Minimum stoping thickness, $T = 2.0$, P at crusher = 20 per cent., $P' = 40$ per cent.

Sorting percentages. Total costs and losses allowed = £1 10s. "Stoping factor" is taken at two sections.

To illustrate only, Basis B allows that the distance covered by Sections 205 and 210 will permit of leaving this ground unstopped.

Figure (6) allows 5 units of length between small Sections.

CHAPTER II.

BASES OF SOUND VALUATION.

WHEN a report on a property is submitted, certain things are taken for granted, and while many of them have been discussed in several works, and in the proceedings of technical societies from time to time, they do not seem to have heretofore been set out *seriatim*.

The following is a list of the premises thought necessary to sound valuation, the first three having been discussed in the preface and introduction, while the remaining, bearing more especially upon sampling, follow in this chapter.

Premise I.—*A sense of economic proportion should be preserved even in examination work.**

Premise II.—*Modern reporting practice calls for a full presentation of data, calculations, and deductions therefrom.*

Premise III.—*Any investment implies the expectation of a return of the original capital, 3 per cent. annually to represent the rate received by investments conceived to involve a minimum risk, and a further rate of interest, commensurate with the risk and counting from the date when the investment was made.*

Corollary (a).—When dividends are delayed or suspended, those received must make good the loss due to such deference or suspension of interest.

* This a more euphonious way of stating that common sense, on the ground as well as in choice of sampling and calculating systems, is a useful adjunct to accuracy.

Corollary (b).—As the interest during the deferred period may be regarded as a further investment of capital in the undertaking, interest on this at the risk-rate is to be expected; in other words, allowances for loss due to deference of dividends should regard the interest as compounding during the deferred period, thereafter reinvested at 3 per cent. annually.

Corollary (c).—As blocks of ore in a mine vary in tonnage and value-data (or number of sample of sections) available, as well as in time of exhaustion, estimates of their present value involve a consideration of “life,” rate for risk, and deference for each.

Premise IV.—*Sound deductions as to value must be based upon mining operations as practised or practicable.*

Premise V.—*Sampling should conform to and clearly set out those variations in strike, thickness, colour, texture, parting, and pay, such as might be observed when stoping; as practised or practicable. These features to be shown, not only in cross-section, but in continuity of strike and dip.*

Premise VI.—*Cross-sectional measurement to be reduced to a line perpendicular to the dip of the vein.*

Premise VII.—*In each sample the pound-footage to be uniform.*

Premise VIII.—*Each unit of length in a sample to represent proportionate parts of the true vein thickness.*

Premise IX.—*The pound-footage to be determined by the distribution of the metal in the ore and by the breaking character of the surfaces sampled.*

Premise X.—*The spacing of sample sections should be governed by variations in sectional widths and values rather than by accessibility or convenience in calculation.*

Discussion of Premise IV.—*Sound deductions as to value to be based upon mining operations, as practised or practicable.*

As mining work is ordinarily divided into two classes, exploratory or development, and stoping or winning, so in sampling it is imperative to have these two operations in view. With reference to exploratory work; from its very nature we may deduce Premise V.; in fact, it is but a corollary of IV.

Discussion of Premise V.—*Sampling should conform to and clearly set out those variations in strike, thickness, colour, texture, parting, and pay, such as might be observed when stoping; as practised or practicable. These features to be shown, not only in cross-section, but in continuity of strike and dip.*

As mentioned above, Premise V. is really but a special form of Premise IV., the application of which calls for discussion.

Disappearance of Pay Streaks.—As the tendency of veins is to vary in strike, and when to this is added the sinuosities due to the vagaries of contractors on development work, a common result is that the "Pay" disappears behind either side of drives or raises; more particularly is this true of large deposits, especially where it is difficult to distinguish the ore from other vein-filling or wall rock.

True Block Values.—It frequently happens in the case of large veins, that there is both a foot and hanging pay streak, and when considerable lengths of, say, a drive expose only one or neither of these, the average value along that portion is evidently not a true index to that of the block above or below.

Variations in Stopes.—In practical stoping operations the constant effort is to widen or contract the stope in order to include available "pay" or to reject un-

payable parts and is one of the marks of sound underground practice; it must be taken as a premise, though not so stated.*

Stoping Practice the Guide to Sampling.—As in actual operations, the differences in texture, position of partings-slips and pay generally determine the lateral limits of the stope, likewise the same variations should govern the sampling across each vein section.

In practice, each mine has what may be called its "Stoping Factor"*—that is, the stopes can profitably be expanded or contracted in width and length within certain limits only, according to the ground, system of stoping, and methods of timbering and drilling. To illustrate; if "bunches" of unpayable ore with dimensions $10' \times 10' \times 1'$ were to exist on either wall, and machine drills were in use, it would probably be cheaper to stope than to leave this ore; if, on the other hand, these bodies were $40' \times 40' \times 3'$, and hand labour were employed, they would undoubtedly be left, especially if mining and treatment costs and losses were high.

Stoping Practice leads to "Continuous Section" Principles.—From the above it follows that, as in actual mining operations stopes are varied, having regard to

* This is referred to below as the *stopping* factor, the significance of which will be appreciated by those familiar with the wonderfully successful results obtained in Spanish countries by the ancient and much abused *coyote-ing* system. The more intelligent reader will see that Figs. 6 and 7, with Table VI., are nothing but the calculations incidental to counting the pros and cons of such a system. Many good mines have been needlessly closed through applying the wholesale idea to narrow veins; also, vast sums squandered in the purchase of rich but narrow veins only suited to the above system.

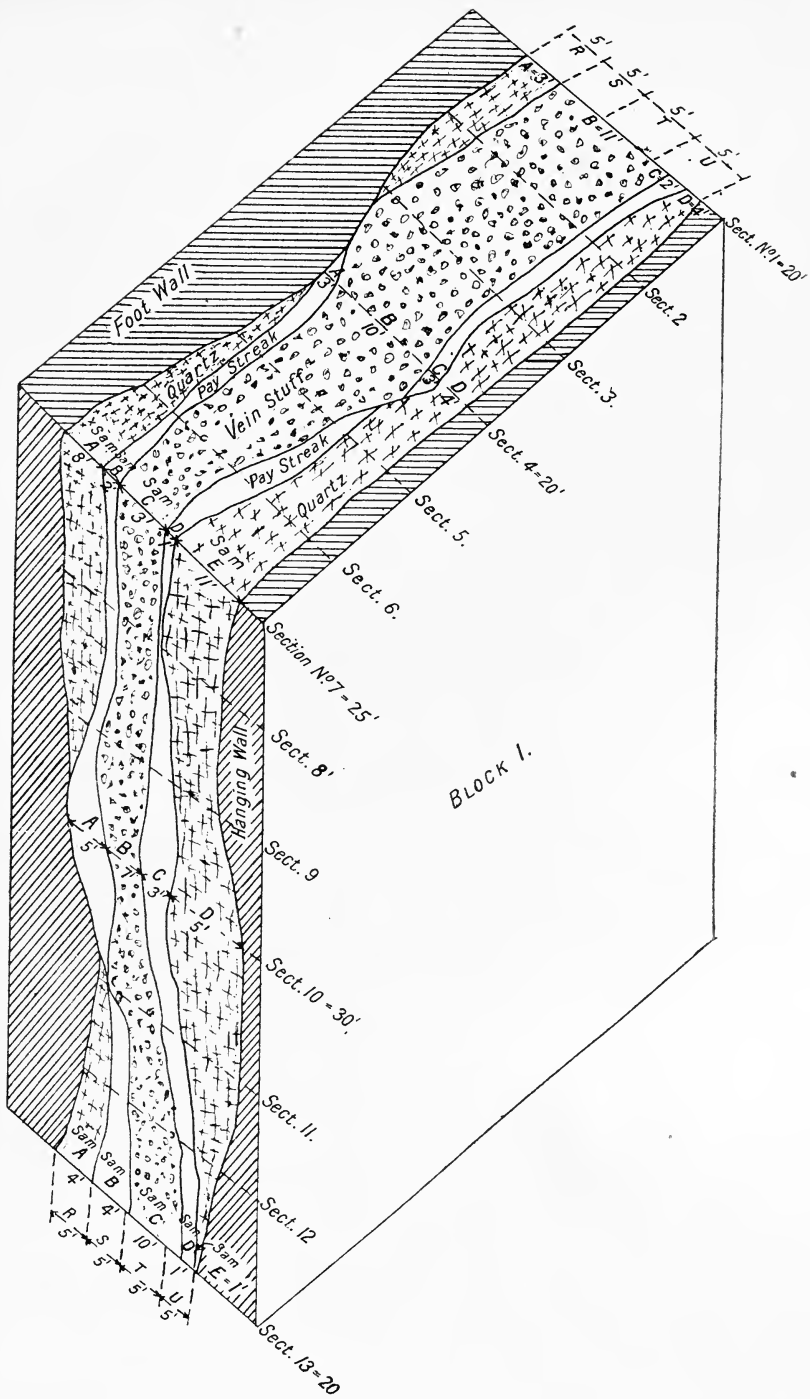


Fig. 8.

the dimensions of the payable of unpayable streaks, so, in order to intelligently calculate the value of a block of ground, sound sampling practice should allow for and record such variations in continuity or thickness as might be observed in stoping. We thus come to the continuous section system of sampling.

Fig. 8 will serve to illustrate, showing a block of ore such as occurs in the development of many veins.

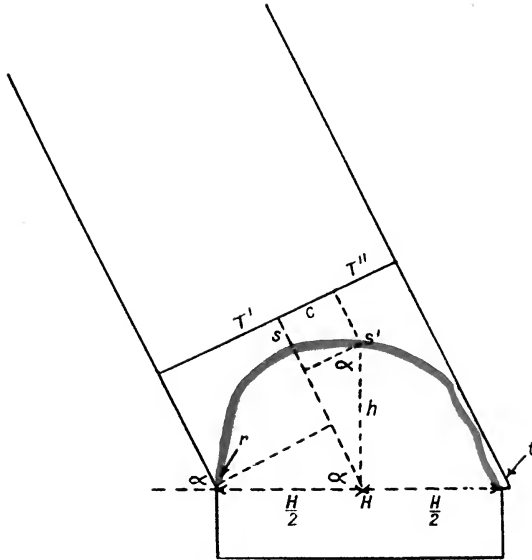
Methods in Current Sampling Practice.—There may be said to be at least five methods in current sampling practice, each purporting to give the true sectional value at the points sampled. They are :—

- (a) Cutting from wall to wall, thereby making one sample ;
- (b) Dividing the section as projected on to the horizontal, into equal parts, making a sample of each ;
- (c) Dividing the section haphazard, or as determined by convenience in sampling ;
- (d) Dividing the section according to the pay and parting streaks ;
- (e) Dividing the section having regard to both stoping conditions and the angle of cut.

First Method (a) of Cutting Samples.—The practice of cutting from wall to wall in one sample (a) will not be dealt with, beyond stating that it would be permissible only if the vein were of uniform grade throughout the section, or the “ back ” presenting an unarched surface, conditions rarely met with.*

* The errors incurred by sampling in this manner will be seen by reading the discussion following.

To face p. 83.]



$$T' = \frac{H}{2} \sin \alpha + h \cos \alpha.$$

$$T'' = \frac{H}{2} \sin \alpha - h \cos \alpha.$$

$$\text{Error} = \pm h \cos \alpha [f(\text{value } c)].$$

Fig. 9.

Second Method (b) of Cutting Samples.—With regard to (b)—that is, to dividing the projected section into equal parts, and making a sample of each—very serious errors occur, as dealt with under Premises V. and VI., but for the moment only those shown by a study of Fig. 9 will be touched on. This will serve to show the error incurred when an ordinary section is divided into two equal horizontal parts, separately assayed, and each multiplied by $\frac{H}{2} \sin \alpha$ to get the value feet. From this it will be seen that the assay of the arch $r-s'$ should be weighted by T' —*i.e.*, by $\frac{H}{2} \sin \alpha + h \cos \alpha$. Or, expressed differently, the part of the sample trench $s-s'$ will vitiate the true value of $r-s'$ accordingly as it be richer or poorer. In other words, if it also be expected to know in which part of the section the pay lies, this method of equal horizontal division will give rise to an error, which will be a function of the cosine of the dip of the vein (α); of the difference in height between the ends of the sample; and of the value of the ore between the samples. (See Fig. 9 and Table VII.)

TABLE VII.—TABLE OF ERRORS THROUGH HORIZONTAL EQUI-SPACING OF SAMPLES IN SECTIONS.

Section No.	Cos (Dip 65°).	Height above Horizontal (h).	$h \cos 65^\circ$.	True Thickness.	Horizontal Width allowed by A.	Corrected by A, using Sin.	Error in Feet.	Error in per cent.
1,000	·4226	6·3	2·7	6·6	4·3	3·9	2·7	40
1,001	·4226	4·6	1·9	5·5	4·0	3·6	1·9	35
1,002	·4226	7·0	2·9	6·0	5·0	4·5	1·5	25
1,005	·4226	1·5	0·6	5·1	5·0	4·5	0·6	10
1,006	·4226	5·1	2·1	6·8	5·0	4·5	2·1	30

Table VII. shows the results of the study of five sections met with in recent practice, yet accepted as sound.

Turning to Fig. 8 and to Table VIII., the value of sections 1, 4, 7, 10, 13 is given as found by sampling according to pay and parting streaks, while Table IX. gives the results had from dividing the section into five-foot samples.

Assuming for the moment that the section permits of making the cut perpendicular to the dip of the vein, the sectional value-feet would be the same.* If, however, it be ceded that sampling is but a guide to probable profits, and that these are largely, if not principally, dependent upon the "pay" and "cost" features of the stoping operations, the errors of "Equal Division" should be evident. Not only this, but deductions from the data collected may not only be inadequate, but misleading, when applied to block valuations. For example, in Fig. 8 the quartz streak in the hanging sample D has, according to Tables VIII. and IX., a mean assay of \$1.50, and is unpayable. By the equal division method the mean value of the hanging 5' sample has, however, an assay value of \$12.20. In other words, would pay to extract if a combination factor † of \$9 were assigned in each case.

But the mean assay value of the whole block would show by this last method of sampling that it could be stoped only at a loss. A study of Fig. 8 and Table X.

* These calculations being for illustration purposes only, the effect of the corner and terminal samples are neglected.

† Costs plus losses.

TABLE VIII. (see Fig. 8).—BLOCK I.

Section.	Sample A.			Sample B.			Sample C.			Sample D.			Sample E.			Thick.	Total Value-feet.	Average Value.	Section Cost-loss-feet.	Section Profit-feet.
	Assay Value.	Thick.	Value-feet.	Assay Value.	Thick.	Value-feet.	Assay Value.	Thick.	Value-feet.	Assay Value.	Thick.	Value-feet.	Assay Value.	Thick.	Value-feet.					
1, .	\$11.0	3	33	2.0	11	22	\$55	2	100	\$1.5	4.0	6	..	..	..	20	8.5	180	- 9
4, .	20.0	3	60	1.5	10	15	100	3	300	2.5	4.0	10	..	..	..	20	19.2	180	+204
7, .	2.0	8	16	11.0	2	22	3	9	50.0	1.0	15.0	15	1	11	11	25	4.3	225	-117	
10, .	10.0	5	50	2.0	7	14	15	3	45	1.0	15.0	15	..	..	..	30	4.1	270	-147
13, .	1.5	4	60	12.0	4	48	6	10	60	75.0	1.0	75	5	1	5	20	9.7	180	+ 14	
Totals,	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	115	8.5	..	-55*
																23				

* It should be clearly understood that as these sections are for illustration purposes only, the effects of the terminal samples and of Section 7 are neglected—i.e., the shoot-foot basis is neglected, though shown in Fig. 7.

clearly shows this to be another error for assuming that the stoping factor and physical conditions permitted, the quartz hanging streak would remain unstoped, thereby giving + 118 profit-feet, against - 55 by the equal division method.

Mistaken Block Calculations.—Summing up, one may say that sampling by (b), or the method of dividing the section into equal horizontal sample lengths, does not permit of block calculations based upon stoping conditions, and may lead to an error resulting in the rejection of a payable block.

Continuity of Section Imperative.—The assumption will be noticed in the above argument that we are in possession of the necessary data bearing upon continuity, though not necessarily indicated by Tables VIII., IX., and X. But are we?

Referring to Fig. 8, it will be seen that the sections are taken at 10' intervals; also from Table VIII. that there are no adequate data whereby to recognise the same streak in different sections; in other words, no record of continuity along the strike. But this very recognition is the *sine quâ non* of sound calculation, as based on effective stoping practice.

The tabular information being insufficient, this must be forthcoming from other data, to be had from a study of the faces themselves, and may be presented graphically in practically the form set out by Fig. 8, or may be indicated in the field books to be described later.

The essential point is to set out the continuity of each streak, and the writer emphasises his preference for the graphical presentation of factors governing stoping

MODERN MINE VALUATION.

TABLE X.—BLOCK I.—ANALYSIS.

Section.	Sample A.			Sample B.			Sample C.			Sample D.			Sample E.			Total Value-feet.	Total Profit-feet, Basis A.	Total Profit-feet, Basis B.	Stopping, Thickness Basis B.
	Value-feet.	Profit-feet, Basis A.	Profit-feet, Basis B.	Value-feet.	Profit-feet, Basis A.	Profit-feet, Basis B.	Value-feet.	Profit-feet, Basis A.	Profit-feet, Basis B.	Value-feet.	Profit-feet, Basis A.	Profit-feet, Basis B.	Value-feet.	Profit-feet, Basis A.	Profit-feet, Basis B.				
1.	33	+6	+3	20	-77	-88	110	+92	+90	6	30	-9	-5	16	
4.	60	+33	+30	15	-75	-85	300	+270	+270	10	26	..	..	..	+204	+215	16
7.	16	-56	-64	22	+4	+2	9	-18	-21	50	+41	+40	11.0	-88	-117	-43	14		
10.	50	+5	0	14	-49	-56	45	+18	+15	15	-120	..	..	..	-147	-41	15
13.	6.0	-30	-36	48	+12	+8	60	-30	-40	75	+66	+65	5.0	-4	+14	-8	19		
Totals,	219	-42	-67	119	-186	-219	524	+334	-314	156	-69	+105	16.0	-92	-55	+118	16		
																+11.5			

Basis A assumes stoping from wall to wall, Combination factor of \$9.0

Basis B assumes stoping of those samples marked s, " " " 10.0

practice as obtaining in each block, especially in examinations of importance, while perhaps favouring the book-entry method for stope face work in routine stope administration during operation.

Organisation to secure Administrative Efficiency.—As mentioned in the Preface, mine reporting organisation bearing upon administrative efficiency is woefully lacking, and this method of graphical record is found to be one of the strongest incentives to adequate underground study. Particularly in examinations, the tendency is to regard the work as of passing importance, wherein no check upon accuracy can be forthcoming, aside from resampling. But the Tiro himself realises that Nature gainsays a certain duplication of assay returns, even when resampling the same trench, with the result that the most slovenly work prevails and passes undetected; especially is this true if sample trenches be not carefully plotted and clearly shown with corresponding numbers on plan and in underground workings. Hence the graphical record is an invaluable adjunct to effective administrative control during examination work, for even those most indifferent to accuracy can scarce bring themselves to signing such a damning document as this presents.

Another equally important check upon administrative efficiency will be set out in the discussion of Premise VIII.

*Stoping Factor.**—Reverting to Fig. 8, it will be seen that were stoping conditions favourable, and with a stoping factor of, say, 20', instead of the 30' set out

* See also page 80.

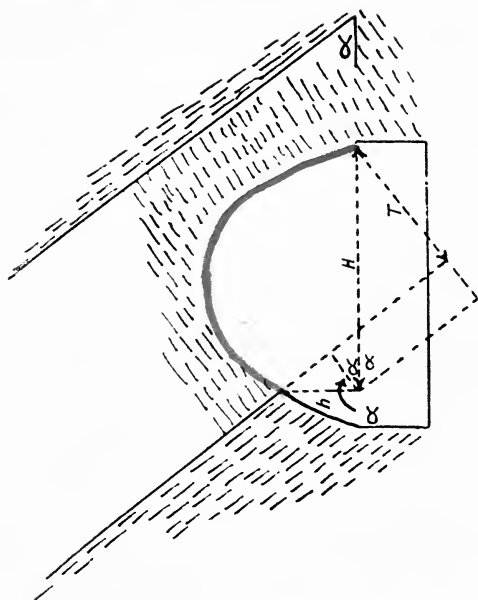
in the previous calculations, the body of ore shown on the foot-wall at sections 5, 6, 7, 8, and 9, as the A sample, could be left, to the further advantage of the profit-feet in the block. In fact, such a continuous section presents many features leading to intelligent study and sound conclusion, if the reporting engineer be really in touch with the technique of his subject. In practice, the records call for a delineation of the walls, parting-slips, and breaking character, such as govern underground operations; details of this kind, however, will be supplied from the knowledge and ingenuity of the experienced, without which qualities the whole system would be unintelligible or unacceptable.

Third Method (c) of Cutting Samples.—With reference to (c), the method of dividing the section haphazard, or as found physically convenient, the same objections apply as in the case dealt with above.

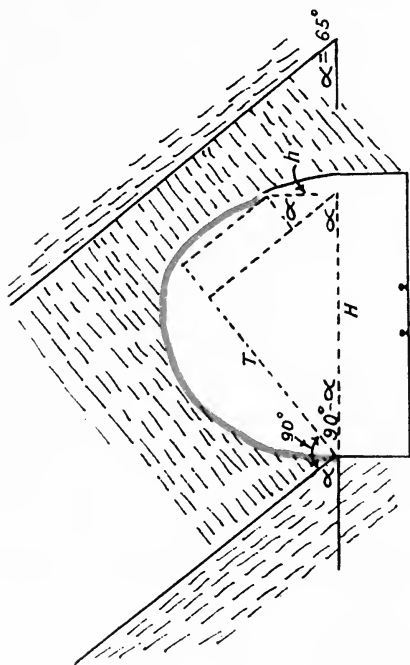
Fourth Method (d).—Concerning (d), the division of the section according to the pay-streaks and partings, but *without* the continuous section adjunct, it will appear upon a little study of Fig. 8 that the data are insufficient wherewith to certainly identify the same streak in the different sections. Yet upon this very feature hangs the sound valuation of the block as a whole, and upon these in turn must be based the appraisalment of final value.

Fifth Method (e) of Cutting Samples.—With reference to (e), the method of sectional valuation based upon such variations of “pay” and physical features as might be observed in stoping practice, the principal points will have appeared from the foregoing discussion, while the angle of the cut will be dealt with under Premise VIII.

[To face p. 90.



$$T = H \sin \alpha + h \cos \alpha.$$



$$T = H \sin \alpha - h \cos \alpha.$$

$$T = H \sin \alpha \pm h \cos \alpha.$$

Figs. 10 and 11.

To amplify these points, however, that their application to and use in current practice may be quite clear, the following brief outline is offered :—*

Continuous Section System.—If one imagine a roll of tracing cloth fastened against and along the whole top of the drive, and to have traced upon it the veins, partings, and slip-faces, together with the sides of the drive ; if we now transfer this to the drawing table, and reduce it to a convenient scale, we have the principle of the continuous section system ; naturally in practice a scale sketch only is made, preferably on squared paper.

Of course, if feasible, measurements at right angles to the dip of the vein would be taken, a common practice being to measure out intervals of 10 feet, if the reefs be fairly uniform in thickness and value ; samples are then taken of each streak and separately assayed.

The widths of the streaks, partings, distances to sides of drives and slip-faces, to which the stope would naturally break, are taken at each of these points for plotting, washing down the faces or backs, if necessary, to be assured of the continuity.

Fig. 12 will perhaps serve to show this more clearly.

Let sub-figures A, B, C (Fig. 12) be cross-sections of the same drive at 10-foot distances apart.

Figures D, E, F will be the longitudinal sectional appearances of the same along the line A-B.

If, now, the intervening spaces in the drive between 1,500 feet, 1,510 feet, 1,520 feet be filled in as in Fig. G,

* See the "Continuous Section System of Mine Sampling" by the writer in the *Proceedings of the London Institute of Mining and Metallurgy* for December 19th, 1901.

we have a graphic office record of what reefs are followed, and where lost.

Fig. H shows the same sections as they appear in practice, where the outside * lines show the sides of the drive, and the short inner † lines the slip faces to which the rock would break in stoping.

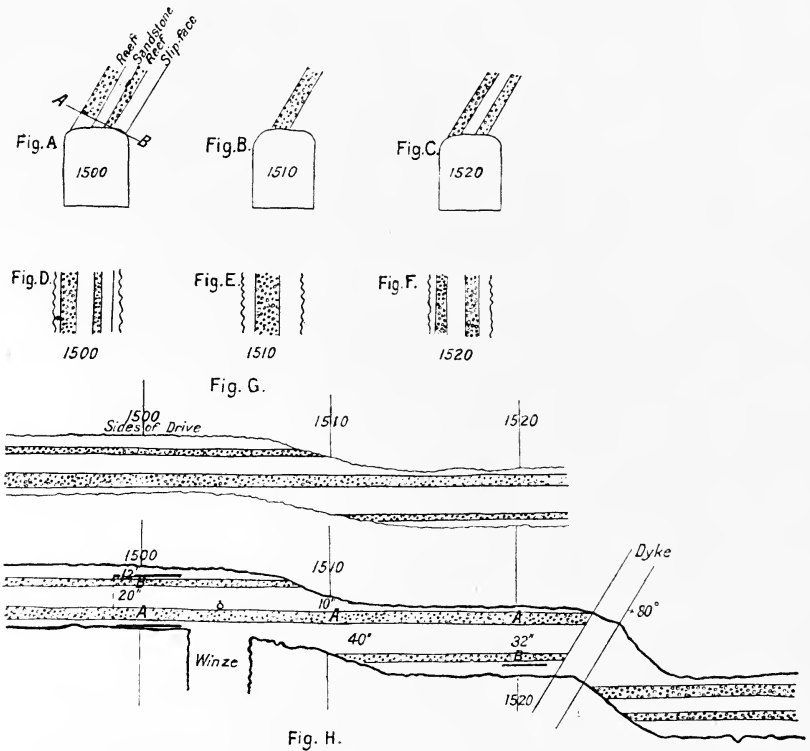


Fig. 12.

It is sometimes found simpler to put the dimensions of the partings on the sketch, and to designate the reefs by A, B, C, etc., with the particulars of those to one side.

* In practice these would be indicated by a blue pencilled line.

† This would be shown by a red line in the field book.

Advantages of Continuous-Section System.—One of the most powerful aids given by the continuous graphic system is the independence of mere value for the recognition and correlation of vein features.

As will be seen by these sketches, if the foot wall streak of Section 1,500 carry the pay, and it were lost before 1,510 were reached, the ordinary way of recording data would shed no light, and if another leader were picked up, the erroneous inference of a fault might easily be made, while were no “pay” met with thereafter, a valuable block might be condemned. Again, no calculations even approximating stoping conditions could be made without data similar to that shown, at least in cross-section.

Premise VI.—*Cross-sectional measurement to be reduced to a line perpendicular to the dip of the vein.*

Insomuch as block calculations entail estimates of cubic contents, this reduction is taken as imperative.

The Price of Carelessness.—The failure to adequately recognise the above premise led, as hereinafter mentioned, to errors which, if obtaining throughout the mine, would represent some £50,000 Sterling in an examination known to the writer (see Table XI.).

It would appear at first thought that so simple and so commonly accepted a Premise should need no enlarging upon, but, as will be shown, the haziest notions appear to obtain with regard to its practical application.

From Fig. 9 the true thickness of the vein $T' + T''$ is the horizontal distance (H) into $\sin \alpha$, where α is the dip of the reef.

So much will be granted by both old and new schools,

but in use, in systems aiming at the suitable application of theory, they appear to be at complete variance.

The figures numbered 14, 15, 16, 17, and 18 are reproductions to scale of sections met with in current practice, and are actual plotted results obtained by taking 1-foot off-sets from the horizontal to the sample trench, which is picked out in jagged red from *a* to *i*; these show the neglect of the above elementary premise, as well as of others.

TABLE XI.—TABLE OF ERRORS WHEN USING THE COSINE CORRECTION.

No. of Section.	h Difference in Height, Ends of Section.	h $\times \cos 65.$	T True Thickness Vein.	Horizon- tal Meas.	Reported Thickness of Vein.	Error in Feet.	Error in Per-centage.
1,000	3.0	1.3	13.1	13	11.8	1.3	— 10
1,001	2.2	0.9	8.2	8	7.3	0.9	— 10
1,002	1.1	0.5	9.5	10	9.1	0.4	— 4
1,005	1.0	0.4	14.0	15	13.6	0.4	— 3
1,006	3.2	1.3	14.9	15.0	13.6	1.3	— 9
250	5.4	2.3	14.0	13	11.8	2.2	— 15
151	2.7	— 1.1	9.7	12	10.9 (?)	1.2	— 10

Premise VII.—*In each sample the pound-footage to be uniform.*

Uniformity of Cut.—By pound-footage is meant the number of pounds per linear foot of sample. In practice this is usually recognised by cutting a trench or groove of uniform depth and breadth; occasionally, also, where the arch may not be avoided, by broadening the cut at the centre to offset the tendency to greater depth at the ends of the sample. When a separate sample is made

To face p. 95.]

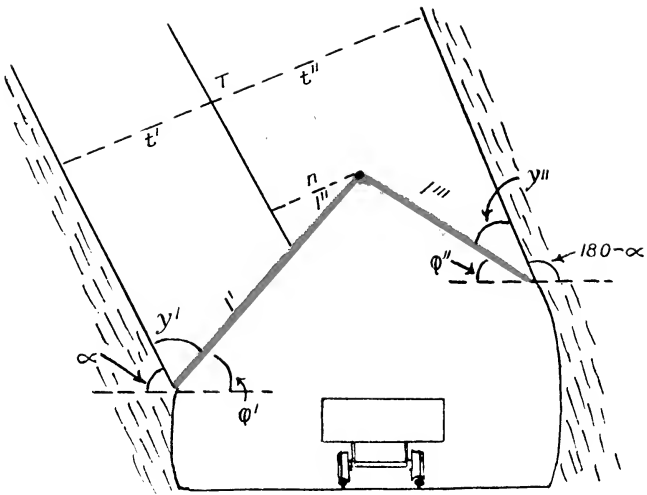


Fig. 13.

of each pay streak, care in this is evidently of less importance.

Premise VIII.—*Each unit of length in a sample should represent proportionate parts of the true vein thickness.*

To illustrate ; if the trench of a single sample measure 4 feet long, and the projection of the true vein thickness gives 2 feet, then each single foot of the sample must correspond to 6 inches in thickness. A phase of this is sometimes expressed as the “ Terminal Sample Principle,” indicating that the ends of the sample may not vary in slope from that of the centre.

This very manifest principle would appear to call for little discussion, and yet by Table XII. one sees that practice would have us believe that it may be neglected ; that errors of a thousand per cent. are of no practical import ; that systems correcting such mistakes may be relegated to visionaries.

Referring to Fig. 13, it is assumed that each streak (t' and t'') is uniform in value both across and for some distance along the dip, and that each contains different values.

Wanted V the average value across the true vein thickness T.

t' = true thickness of lower streak.

t'' = true thickness of upper streak.

l' = length of straight cut in lower streak.

l'' = length of other straight cut in upper streak.

l''' = length of other straight cut in same upper streak.

v' = true value, per ton, of t' .

v'' = true value, per ton, of t'' .

A = Assay value of whole sample cut, L.

L = $l' + l'' + l'''$.

$$y'' = 180 - (\phi'' + 180 - \alpha) \\ = \alpha - \phi''.$$

Referring to Fig. 12,

$$\text{Formula (38). } V = \frac{t'v' + t''v''}{T}.$$

$$\text{Formula (39). } A = \frac{l'v' + l''v'' + l'''v'''}{L}.$$

E = Error.

$$\text{Formula (40). } E = \frac{t'v' - t''v''}{T} - \frac{l'v' + l''v'' + l'''v'''}{L}.$$

If there be no error, $V - A = 0$ and $L(t'v' + t''v'') - T(l'v' + l''v'' + l'''v''') = 0$.

But from the figure, $T = (l' \sin y') + (l'' \sin y') + (l''' \sin y'')$, and $l' = \frac{t'}{\sin y'}$; hence

Formula (41).

$$L(t'v' + t''v'') - T \left(\frac{t'v'}{\sin y'} + \frac{nv''}{\sin y'} + \frac{(t'' - n)v''}{\sin y''} \right) = 0,$$

when $\sin y' = \sin y''$, $L \sin y' = T$; hence error = 0 only when $y' = y''$.

From the above it may be stated that a sample may not be carried around curved surfaces composed of streaks varying in value, without error, except when the cut makes equal angles with the parallel walls; the error would be a function of the slope of each component and the streak thickness, as well as of their values.

Table XII. will show the result of studying the six sections before referred to, and may be found interesting and perhaps instructive; at least with regard to what passes current as sound practice. The errors set out

were calculated on the assumption that if the sample l' (Fig. 13) were to be mixed with l'' and l''' , in order that there should be no error.

Formula (42).
$$\frac{l'}{t'} = \frac{l''}{n} = \frac{l'''}{t'' - n}.$$

Formula (43).
$$\text{Error} = \frac{l'}{t'} - \frac{l''}{t''}.$$

Formula (44).
$$= \frac{l'}{t'} - \frac{l'''}{t'' - n}.$$

TABLE XII.—TABLE OF INTERNAL RATIO SAMPLE ERRORS.

1	2	3	4		
Section No.	Letters showing Portion of Sample.	Length of Portion of Sample. Feet.	Length Projection on to Line perpendicular to Dip.	Ratio of Columns 3 to 4.	Error in Percentage.
1,000	<i>g-h</i>	1.0	0.8	1.3*	260
1,000	<i>h-i</i>	1.4	0.3	4.7	
1,001	<i>a-b</i>	4.6	3.3	1.4	40
1,001	<i>b-c</i>	2.1	2.0	1.0*	
1,002	<i>a-a'</i>	2.6	0.2	13.0	1,200
1,002	<i>c-d</i>	2.8	2.7	1.0*	
1,005	<i>e-f</i>	1.4	1.3	1.0*	50
1,005	<i>f-g</i>	3.6	2.3	1.5	
1,006	<i>g-h</i>	3.6	1.8	2.0	100
1,006	<i>f-g</i>	1.7	1.6	1.0*	
1,007	<i>c-d</i>	2.3	1.8	1.3*	900
1,007	<i>d-e.</i>	1.3	0.1	13.0	

The deduction from the above analysis is that the

* These are taken as the *correct* ratio, and the error of *principle* as the ratio of the difference in ratios to the ratio marked with an asterisk. As seen by Formula (6), the error in *value* of the section is a function of the value and thickness of the pay streaks, as well as of the angles of cut.

sampling of curved surfaces should conform to the pay streaks—*i.e.*, each streak should be sampled separately, in order to arrive at the true sectional value. Practice, however, often shows a series of streaks, making up the arch, and of such a nature that stoping practice would compel their being brought down together.

According to Fig. 13, with the value of l' and l'' substituted, the value feet across such a section would be—Formula (45). $TV = (l' \sin y'v') + (l'' \sin y'v'') + (l''' \sin y''v'')$ with as many members on the right as there are separate samples.

If the preceding reasoning be sound, then only by determining each factor of the above equation can the value feet of the section be arrived at. The length and assay values of each sample is obtained as in ordinary practice, but the measurement of y' , y'' constitutes an innovation so far as the writer knows.

Automatic Elimination of several Errors.—Referring to Fig. 14, it will be clear that the inclination of l' from the horizontal can be taken by means of the spirit level or pendulum inclinometer, hence the value of ϕ' obtained; also from the same figure that $y' = [180 - (\alpha + \phi')]$.

Substituting this in (45), we have—
Formula (45a).

$TV = l' \sin (\alpha + \phi') v' + l'' \sin (\alpha + \phi') v'' + l''' \sin (\alpha - \phi'') v''$, where α is the dip of the reef, and all the factors necessary to theoretically sound method are at hand.

In Table XIII. is shown the field-book expression of the above formula, the only additional work entailed, aside from sample calculation, being the measurement of the slope or dip of each sample, with a pendulum or

rule inclinometer,* an operation requiring but a few seconds of time, with the result that, not only is the method a precise one, but three important results are obtained ; these being—

Advantages of Closed-Traversal System of Sampling.—(a) *A very exact check on the measurements by reason of the “closed traverse” principle employed, hence an administrative feature of the first importance.*

(b) *The true thickness of the vein section being obtained, hence there is no possibility of the “cosine correction” errors of Tables XI. and XII.*

(c) *The true thickness of each streak being available, after the correlation of streaks is made, the data are in hand for the block calculations of the continuous section system.*

Tables XIV. and XV. show a tabulation of results intermediate between the field-book, Table XIII., and the Tables XVI., XVII., and XVIII. of the block calculations.

* The ordinary American carpenter's foot rule with spirit level and hinge joint graduated to degrees answers very well.

A table of sines, cosines, etc., will be found in the Appendix, for writing in the note-book should this be necessary.

TABLE XIII.—FIELD BOOK,* LEFT PAGE. SKETCH TO ACCOMPANY *en face* ON CO-ORDINATE PAPER.

No. of Section.	Letter of Sample.	l Length of Sample.	ϕ Dip of Sample from Horizontal.	Cos ϕ .	$l \cos \phi$ Horizontal Thickness of Sample.	Horizontal Thickness of Section.		Dip of Vein from Horizontal.	Remarks.
						Calcul.	Taped.		
101	A,								Sample A corresponds with B of Sect. 100.
	B,								
	C,								
	D,								
	E,								
	F,								
	G,								
	H,								
	I,								
	J,								
	K,								
	L,								
	Total,								

Mine,
Sampler's signature,
Level,
Date,

* NOTE.—American transit book usually used, they having not only tables of natural sines and cosines in back, but left page is in columns, while right is "squared" paper, and used for sketch of section.

TABLE XIV.

1st OFFICE SHEET.*

No. of Section.	Letter of Sample.	l Length of Sample.	ϕ Dip of Sample from Horizontal.	y or $180 - (a + \phi)$.	$\sin y$.	Actual Thickness Sample.	Actual Thickness Section.	Remarks.
	A, B, C, D, E, F, G, H, I, J, K, L.							

Mine, _____ Date _____
 Signature of sampler, _____ Level, _____
 Name of calculator, _____

* This sheet is kept by the head sampler, who checks each section taken by each man, and makes the continuous section sketch.

TABLE XV.

2ND OFFICE SHEET.*

No. of Section.	Letter of Sample.	True Thickness of Sample in Feet and Decimals.	Assay Number.	Assay Value of Sample. †	Value-Feet.	Profit per Ton.	P. Profit-Feet in Section, Basis A.	P. Profit-Feet in Section, Basis B.	Remarks.
	A, B, C, D, E, F, G, H, I, J, K, L,								
	Totals,								

Combination Factors, Basis A =
" " B =

* This sheet is made up by the Engineer himself, having the continuous section before him, and should be signed.
† See signed Assay Sheet for values assigned each metal.

TABLE XVI.

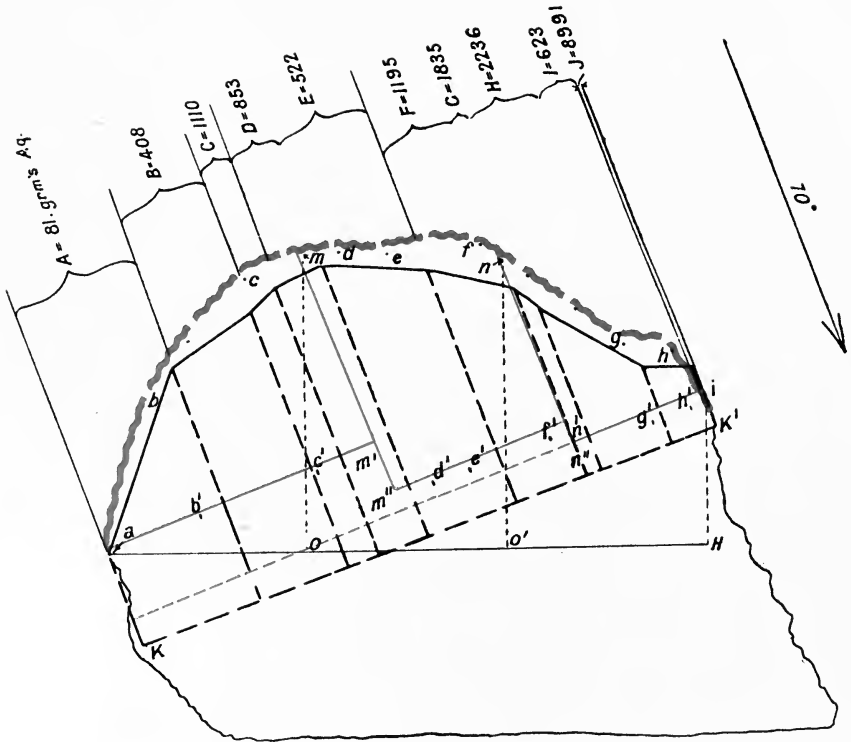
Block.	1	2	3	4	5	6	7
	Area or Perimeter (to be stope d).	Height (H).	Length (L).	Average Thickness (T).	Minable Tons in Block.	Average Profit (P).	Profit in Block.

1. Comes from the continuous section plan. 2 and 3. Are from the Surveyor's signed plan. 6 and 7. Come from preceding tables which are plotted like Fig. 7, and are determined by planimeter or by calculation from tables. In the case of irregular spacing between the sample sections, these must, of course, be suitably weighted.

THE
OF
CALIFORNIA

Faint, illegible text, possibly bleed-through from the reverse side of the page.

To face p. 105.]



Sam.	Leng.	Proj.	Sam.	Leng.	Proj.	Sam.	Leng.	Proj.
A,	4.2	2.6	a-H,	12.8		a-b-m,	7.9	6.1
B,	2.0	2.0	K-K',	12.9		m-n,	4.4	3.9
C,	.7	.7	a-o,	.42		n-i,	5.6	2.9
D,	1.3	1.0	a-m',	6.1		c-d,	2.1	2.1
E,	2.3	2.0	a-o',	4.2		f-g,	3.7	2.1
F,	1.7	1.6	m''-n',	3.9		h-i,	1.4	0.4
G,	.7	.3	O'-H,	4.2				
H,	2.5	1.6	n''-i,	2.9				
I,	1.0	1.0						
J,	.8	.1						

Fig. 14.

CHAPTER III.

SAMPLING.

Sampling Lodes.—If Figs. 14, 15, 16, 17, and 18 be turned to, sections taken from the examination before-mentioned will be seen reproduced to scale, but before beginning the discussion of these reproductions from practice, it may be worth while to emphasise the difference between the sampling of small and large veins; with the former the dip is usually well before one, while the latter often implies working in difficult places and over irregular contours, with the result that a sample may easily run along a surface with nearly the same inclination as the vein without the fact being noticed. This is one reason that the closed traverse system of measurements is of so much value when dealing with large bodies with banded pay, the errors being corrected automatically.

Sampling Narrow Veins.*—On the other hand, the sampling of veins smaller than the stoping width present their own peculiar sources of error because of the inevitable admixture of waste in stoping, a portion of which only can be sorted out, whether in the mine or on the surface. As will be seen here also, the continuous graphic system of recording field data would seem to be the only one by means of which a consulting engineer can

* See also page 70.

feel sure that sound principles have governed the field work.

Figs. 6 and 7, with Table VI., illustrate such a continuous section and attendant calculations, as applied to small veins.

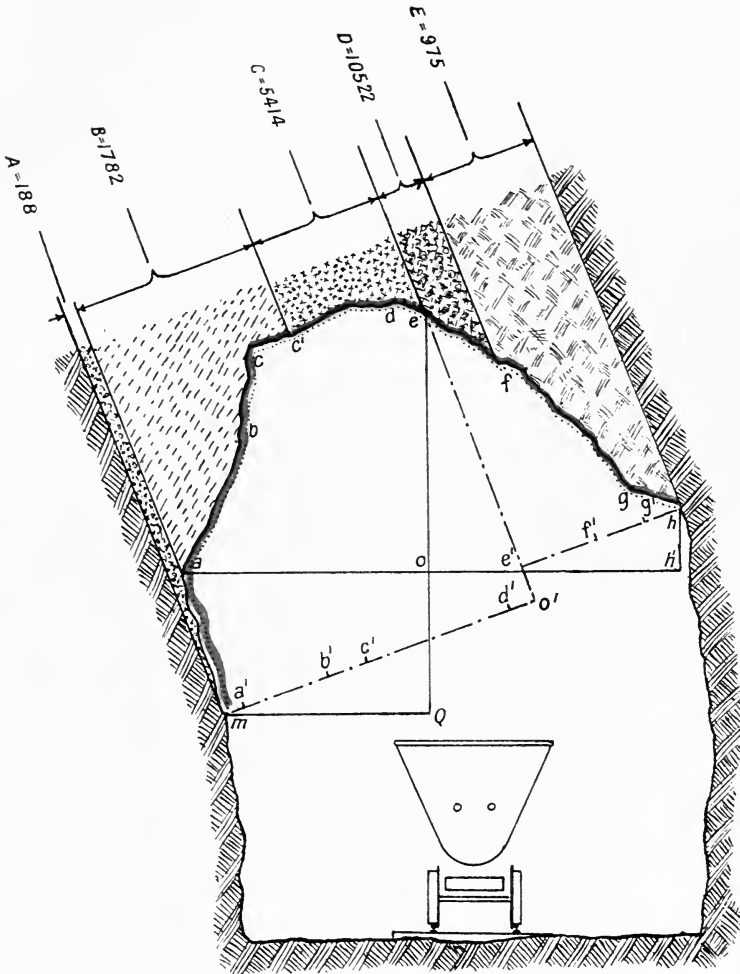
Discussion of Fig. 15.—Referring to Fig. 15, the broken black lines show the division of the section into two equal parts, the sampled surface being in red, $a'-e$ making one sample, and $e-h$ the other.

It will be seen that $a'-a$, running with the dip of the vein, was mixed with $a-b$, $b-c$, and $c-c'$, $c'-d$, and $d-e$, with the result that, according to the analysis of the figure, we have a theoretical error of 1,200 per cent. when comparing the projections of $a'-a$ and $c-e$. In the succeeding examination this sample trench was re-sampled according to the stoping practice system, with results as shown in the figure, the silver contents being expressed in grammes.

As seen by Fig. 15, the true thickness of the foot-wall sample is $m-o'$, or 5.8, while that reported was $a-o$ into the cos of 65° , or 4 feet, an error of 35 per cent. Here again the horizontal width was corrected by cosin *reduction*, instead of being increased as demanded by the section contour shown.

To automatically annul errors of both types, the "angle of cut" method, or closed-traverse system, was devised, and by it such a sample as $m-a$ can be taken with perfect propriety, and yet be correctly weighted in the calculation.

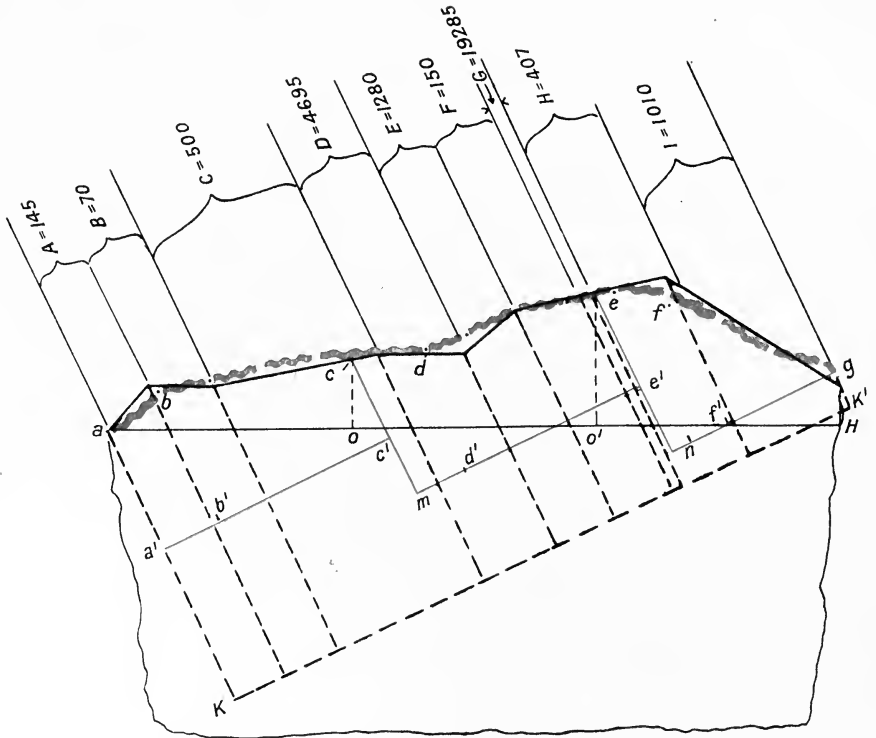
It will be seen that sample B in the contour $a-b-c-c'$ (Fig. 15) was taken in the second examination in one cut,



No.	Sam.	Leng.	Sam.	Proj.	No.	Sam.	Leng.	Sam.	Proj.
A,	2.66	0.20	$a'-o$,	2.6	0.20	$g-h$,	0.8		0.7
B,	4.50	3.25	$a-b$,	2.5	1.7	$a'-o'$,	5.80		
C,	2.33	2.20	$b-c$,	1.8	0.9	$a-h'$,	8.80		
D,	1.20	1.00	$c-d$,	2.7	2.7	$m-o' + e'-h$,		8.85	
E,	4.50	2.20	$d-f$,	2.4	1.5	$m-o'$	6.0		
$a-c-e$,	10.0	5.85	$f-g$,	2.9	1.15	$m-Q$,	3.6		
$e-f-h$,	5.7	3.0							

Heavy red lines = sample trench or cut, divided into two samples, equal on the horizontal.

Fig. 15.



No. Sam.	Leng.	Sam. Proj.	No. Sam.	Leng.	Sam. Proj.	No. Sam.	Leng.	Sam. Proj.
A,	1.2	1.1	a-H,	14.4		a'-b-c,	5.1	5.0
B,	1.3	1.2	K K'		13.4	c-d-e,	4.9	4.8
C,	3.3	3.2	a-o,	4.8		e-f-g,	5.0	3.6
D,	1.7	1.6	a-c',		5.0	d-e,	3.8	
E,	1.3	1.3	o-o',	4.8		d'-e',		3.7
F,	1.3	1.3	m-e',		4.8	f'-g,	3.6	
G,	0.2	0.2	o'-H,	4.8		f'-g,		2.3
H,	1.5	1.5	n-g,		3.6			
I,	4.0	2.2						

Heavy red lines = sample trench or cut, divided into three samples, equal on the horizontal.

Fig. 16.

which could be justified only by the supposition that the ore along this part of the section was of even tenour.* The fact that it was uniform from a mechanical point of view would not warrant such practice unless sure of the uniformity in grade from a to c' . Where a streak is of considerable thickness, as, say, 3 feet or more, it would seem safer at the outset to sample having regard to the contour. For instance, in the case of Sample B, Fig. 15, it were better to make a sample each of $a-b$, $b-c$, $e-c'$ until fairly certain of the characteristics indicating an even grade, when such a sampling as B might be thoroughly sound practice, but only in that event.

Fig. 16, the reproduction of sample trench 1,005 shows the small error of 3 per cent. in the estimate of the vein thickness, the height $\frac{H}{L}$ being small.

On the other hand, the surface $a-b-c$ taken in one sample was given only $a-o \sin 65^\circ$, when entitled to $a'-c'$ or $a-o (\sin 65^\circ) + (o-c \cos 65^\circ)$, an error of over 10 per cent. Again, in sampling, $e-f-g$, $e-f$ was mixed with $f-g$, which, according to the principles set out in the analysis, gives an error of 50 per cent.

The value of the streaks marked A, B, and C should be carefully noticed; for taking the combination factor at \$10.8, and the silver at \$2 per 100 grammes, streaks A, B, C, running \$2.90, \$1.40, and \$10, would evidently not pay to extract, and their aggregate thickness being 5.5 feet, they could probably be left, thus saving the costs of stopping and treating, while bringing up the grade of D, E, F, G, H, I correspondingly. Before this could be definitely calculated, however, the continuity

* See discussion of Fig. 14.

into the adjoining sections should be assured, the whole being preferably plotted in continuous section. If, then, the stoping factor were taken at, say, 20 feet vertically and longitudinally, also at, say, 1 foot latterally, and the continuity of the streaks established over three sections (20 feet), the corrections due to these features should enter into the block calculations.

The following tabular analyses would show that by sampling according to stoping practice, the value of the section could be made some 6 per cent. higher.

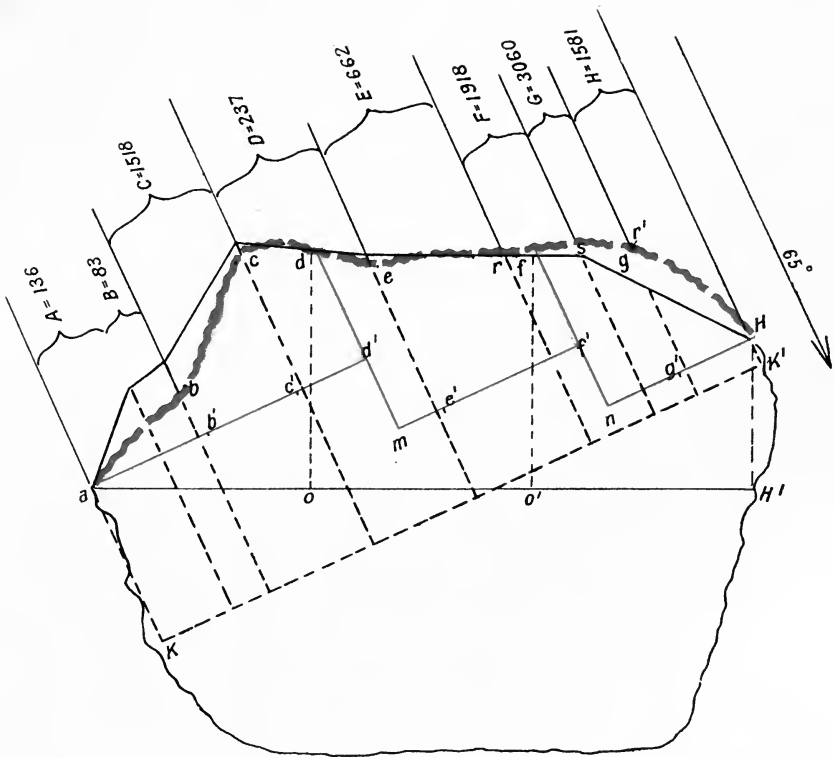
TABLE XIX.—APPLYING TO FIG. 16.

Sample.	Thickness.	Assay Value.	Value-feet.	Profit-feet, Basis A.	Profit-feet, Basis B.
A, . . .	1.1	2.9	3.2	8.6	..
B, . . .	1.2	1.4	1.7	11.3	..
C, . . .	3.2	10.0	32.0	2.6	..
D, . . .	1.6	93.9	1.2	126.1	126.1
E, . . .	1.3	25.6	33.3	19.3	19.3
F, . . .	1.3	3.0	3.9	10.1	10.1
G, . . .	0.2	385.7	77.1	74.9	74.9
H, . . .	1.5	1.1	201.5	188.3	185.3
I, . . .	2.2	20.2	44.4	20.7	20.7
Totals, .	13.6	39.7	537.7	390	416.3

With both Bases A and B, Combination Factor = 10.8.

Discussion of Fig. 17.—Turning to Fig. 17, Section No. 1,006, we find a sectional error of 9 per cent., while the foot-wall sample *a-b-c-d* was allowed $a-o \sin 65$ for the thickness, instead of $a-d'$, or $(a-o \sin 65) + (o-d \cos 65)$ —that is, an error of over 30 per cent.

Looking more closely into this sample, it will be seen that the richer streaks *b-c*, or C figure, are 40 per cent. out of proportion, as compared with *c-d*.

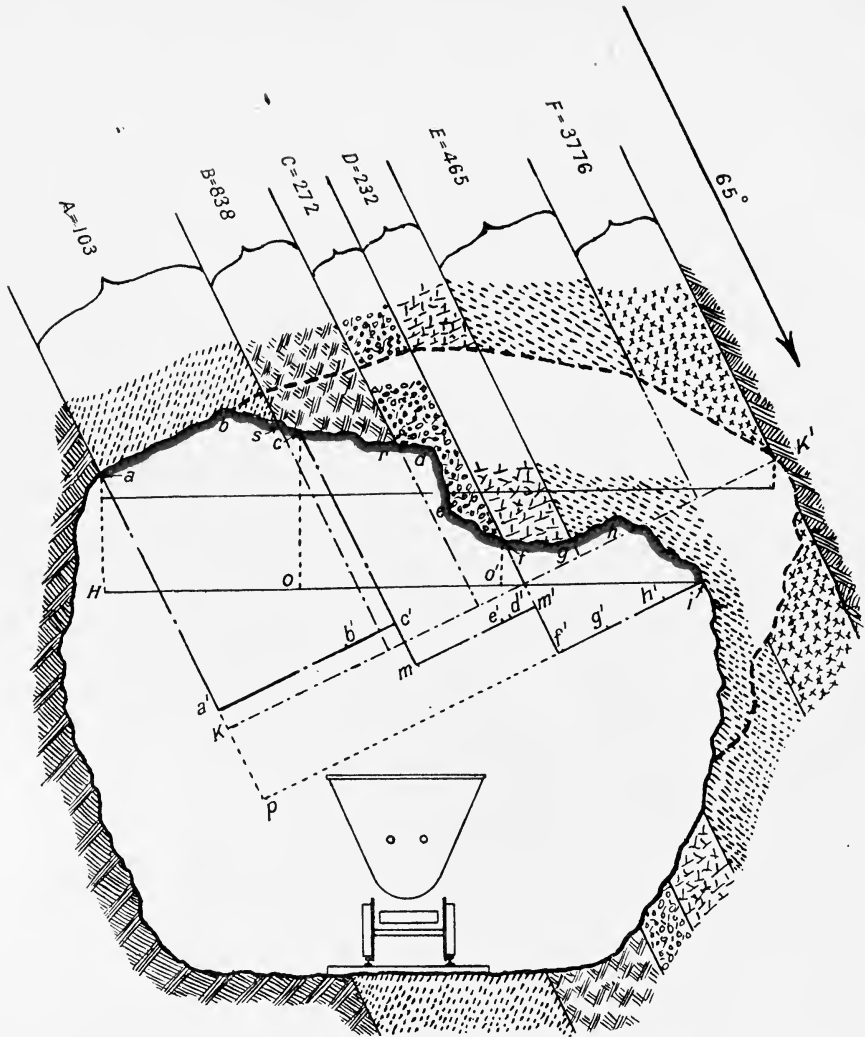


No. Sam.	Leng.	Sam. Proj.	No. Sam.	Leng.	Sam. Proj.	No. Sam.	Leng.	Sam. Proj.
A,	2.3	1.6	a-b,	3.0	2.7	a-d',		6.3
B,	0.9	0.9	b-c,	3.0	2.1	o-o',	4.63	
C,	3.0	2.4	c-d,	1.6	1.5	m-f'',		4.3
D,	2.7	2.4	d-e,	1.4	1.1	o'-H,	4.63	
E,	2.9	2.7	e-f,	3.3	3.2	n-h,		3.4
F,	1.7	1.5	f-g,	1.7	1.6	l-r,	2.8	2.7
G,	1.6	1.0	g-h,	3.6	1.8	r-f,	0.6	0.6
H,	2.2	1.5	o-H,	14.0		f-s,	0.7	0.8
a-b-c-d,	7.6	6.3	K-K',		14.0	s-g'',	1.1	1.0
d-e-f,	4.7	4.3	a-o,	4.63		g''-h,	3.2	1.5
f-g-h,	5.3	3.4						

Heavy red lines = sample trench or cut, divided into three samples.

Fig. 17.





No. Sam.	Leng	Sam. Proj.	No. Sam.	Leng.	Sam. Proj.	
A,	3.1	3.1	a-b,	2.5	2.5	H-o = o-o' = o-i = 3.6
B,	1.8	1.7	b-c,	1.3	1.0	H-K' 12.1
C,	1.0	1.0	c-d,	2.3	1.8	H-i, 10.8
D,	1.2	1.1	d-e,	1.3	0.1	p-i, 8.7
E,	2.85	2.3	e-f,	1.0	0.5	H-K', 10.9
F,	2.85	1.7	f-g,	1.1	1.0	c-r = 1.8 (1.3)
a-b-c,	3.8	3.5	g-h,	1.1	1.1	c-f = 9.5 (2.3)
c-f,	4.6	2.3	h-i,	1.8	0.8	s-c = 0.4 (0.4)
f-i,	4.0	2.9				

Heavy red lines = sample trench or cut, divided into three samples.

Fig. 18.

Sample $f-g-h$ will also show that, aside from the irrational dimensional weighting of $g-h$ in the mixing, the very rich sample F, G, H is weighted as $O'H \sin 65^\circ$ when entitled to only $n-h$, or an error of 23 per cent.

By tabular analysis we would find as follows:—

TABLE XVI.—REFERRING TO FIG. 17.

Sample.	Thickness.	Assay Value.	Value-feet.	Profit-feet, Basis A.	Profit-feet, Basis B.
A, . . .	1.6	2.7	4.3	13.0	..
B, . . .	.9	1.6	1.4	8.3	..
C, . . .	2.4	30.4	73.0	47.1	47.1
D, . . .	2.4	4.7	11.3	14.6	14.6
E, . . .	2.7	13.2	35.6	6.4	6.4
F, . . .	1.5	38.4	57.6	41.4	41.4
G, . . .	1.0	61.2	61.2	50.4	50.4
H, . . .	1.5	31.6	47.4	31.2	31.2
Totals, .	14.0	20.8	291.8	139.8	161.1

This table, being for illustration only, the Combination Factor used for Bases A and B is the same—\$10.80.

Discussion of Fig. 18.—Turning to Fig. 18 (No. 1,007), one meets the same error in estimating the true vein thickness, only it is plus, corresponding to that shown in Fig. 11, being also $-h \cos \alpha$, and amounting to 11 per cent.

Even a casual inspection of the sample trench $c-r-d-e-f$ will show the great error due to mixing $c-r$, representing 1.8 feet of sample (and 1.3 of vein) with $r-d-e-f$, representing 2.8 feet of sample, and only 0.9 foot of vein.

Again, the richer part of the section is given a dimensional weight of $O-O'$, while entitled to only $m-m'$ —*i.e.*, an error of over 40 per cent.

After the sample trench *a-b-d-h-i'* was measured, stoping above the level was begun, and, when resampled, had the outline shown by the ~~green~~ lines, exposing the hanging-wall pay streak.

By the ordinary system of sampling, the true value of the whole section would not be even approximated, the effect being to reduce the real value in proportion as the section shown in red was lower than the mean value of the block. By the continuous section system, however, the passing of the hanging-wall streak into the side of the level at other points would be noted and plotted, while in the block calculations a value would probably be given it, as indicated by those of the nearer samples in the same streak.

This loss of pay is a common occurrence in all exploration work on big veins, and is unavoidable, inasmuch as development drives are seldom as wide as the vein. The ordinary practice is, of course, to put in cross-cuts from time to time, something the reporting engineer should insist on having done whenever in serious doubt. This is often resented by the management, but if the owners be made to realise that it is altogether in favour of themselves much can be effected. By the graphical continuous system the consulting engineer has the data whereupon to telegraph, if necessary, for further work to be done at any point pending another examination.

It may be contended that an assay plan giving values only would serve the same purpose. If, however, the streak B in Fig. 18 ran sufficiently high to bring up the stoping value of the section to pay, it would not be suspected that the hanging streak had been left. Again,

even if the lower values gave cause to suspect some such occurrence, it could not be definitely known in the office whether the lost pay streak were in the foot or the hanging.

This section (Fig. 18) also indicates that the foot-wall streak could be very profitably left behind, providing, of course, that the adjoining section were to show similar occurrences, and the stoping factor permitted.

Premise IX.—*The pound-footage to be determined by the distribution of the metal in the ore, and by the breaking character of the surfaces sampled.*

Cross-Sectional Area of Cut.—This means that, if the breaking character be equal, one can with equal probability of error take samples of smaller pound-footage when sampling, say, iron ores, than when sampling gold quartz.

It also means, other things being equal, that one can more safely take long trenches of small cross-sectional area when sampling, say, soft sandstone reefs, than when working with “blocky ground.”

It should be evident that, as the distribution of values in gold and silver ores are more irregular than most others, the weight per foot of sample trench should be greater—*i.e.*, is a function of the value of the metallic content.

In general, the writer stipulates for not less than 20 lbs. weight per running foot when sampling gold ores, and more if the ground be “blocky.”

Premise X.—*Spacing or sample sections should be governed by variations in sectional widths and value, rather than by convenience in calculation.*

In other words, were we sampling a "patchy" vein of gold quartz with marked variations in thickness, these features should determine the distance between the sections, and not the desire to avoid arithmetical calculations.

Fig. 19 will serve to illustrate a not uncommon section, particularly in veins which conform to the bedding of argilacious rocks, though, of course, met with in other types of deposits.

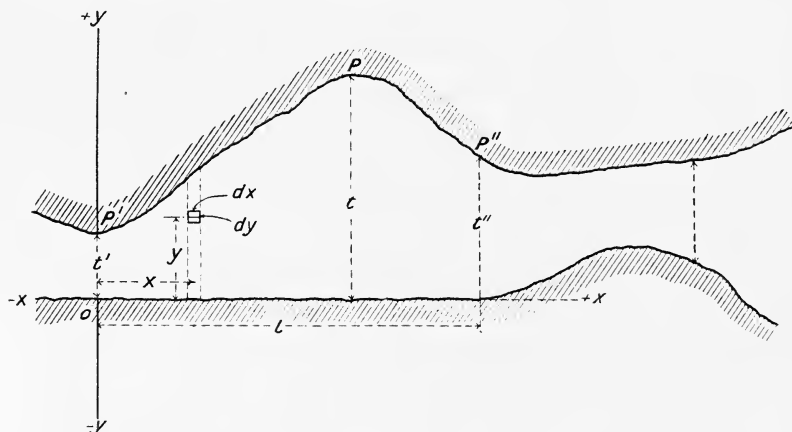


Fig. 19.

Discussion of Fig. 19.—Two sources of error arise from a regular spacing of sample sections, especially when they fall in a manner illustrated by the above figure. The two errors refer—one to the calculation of the area of the horizontal reef section, and the other to the estimates of the metal in the reef; the plus error of the area between two sample sections may compensate for the minus error in area between two others, as may the errors in value; or, again, one set of errors decrease the other, but this should not be counted upon.

In practice, where there is marked variations in thickness, the sounder procedure is to space the samples with reference to such changes, especially where preliminary assays indicate great variation in value, afterwards taking intermediate sample sections.

Referring to Fig. 19, the magnitude of the errors may be arrived at as follows :—

Let v = The value of the metal if the small area $dy dx$ were sampled.

V = The average value over the area $o-P'-P''-x'-o$.

y = The vertical height of the sample area above o , which for convenience is taken as being a horizontal line.

x = The horizontal distance of the small area from the y axis.

t' = The thickness of the vein at o .

t'' = The thickness of the vein at x' .

v' = The assay value found by sampling over $o-P'$.

v'' = The assay value found by sampling over $x'-p''$.

a = Constant.

k = Constant.

By the ordinary calculus—

Formula (46).
$$V = \frac{\int_0^t \int_0^{f(x)} v dx dy}{\int_0^t \int_0^{f(x)} dx dy}.$$

The ordinary assumption that the mean of the values found at t' and t'' is the average value between them,

implies that the value follows the straight line law, or

$$v = a + kx = v' + \frac{v'' - v'}{l} x.$$

Likewise, the average thickness is usually taken at $\frac{t' + t''}{2}$, and the area at $l \left(\frac{t' + t''}{2} \right)$, whereas, as will be seen from the figure, the true area is

$$\int_0^l \int_0^{f(x)} dx dy = \int_0^l f x dx.$$

From the figure alone it will be clear that, in order to substitute a straight line law for the complex curve of the walls, the distance l must be such that the portion of the wall from P'-P and P-P'' will be fairly straight, in order to secure even an approximation.

With the cuts taken at P' and P'', and calculated in the ordinary way, all the area P'-P-P''-P' would be missing from the denominator of Formula (46), and V be correspondingly too high, assuming, of course, that $\int_0^l \int_0^{f(x)} v dx dx$ were given its true value between o-P-P'-P''-x'-o.

While samples may be spaced with reference to the contour of the walls, thereby securing an approximation to a straight line, sample cuts may not be arranged so as to escape the danger that the value in a cut taken, say, at P shall prove higher or lower than that found either at P' or P''.

On this account we must say that, failing other data, the law of probability would have us postulate that the value will vary as—

$$\text{Formula (47). } v = a + kx = v' + \frac{v'' - v'}{l} x = \frac{(v'' - v')x + v'l}{l},$$

also

$$\text{Formula (48). } y = c + mx = t' + \frac{t'' - t'}{l} x = \frac{(t'' - t')x + t'l}{l}.$$

Substituting these in Formula (46)—

$$\text{Formula (49). } V = \frac{\int_0^l \frac{(t'' - t')x + t'l}{l} dx \frac{(v'' - v')x + v'l}{l}}{\int_0^l \frac{(t'' - t')x + t'l}{l} dx}$$

$$\text{Formula (50). } = \frac{l}{6} \frac{(2v''t'' + v''t' + v't'' + 2v't')}{l \left(\frac{t'' + t'}{2} \right)}.*$$

By the ordinary calculations—

$$\text{Formula (51). } V = \frac{t'v' + t''v''}{t' + t''},$$

hence the difference between Formula (50) and Formula (51) will be the ordinary error, E.

$$\text{Formula (52). } E = \frac{t''(v' - v'') + t'(v'' - v')}{3(t' + t'')},$$

and this will equal 0 only when

$$t'' - t' = 0, \text{ that is, when } t'' = t',$$

or when $v'' - v' = 0$, that is, when $v'' = v'$.

In other words, the ordinary calculations of value introduce an error whenever the vein varies both in thickness and metal contents at the two points sampled.

Whether the cost and delay incidental to the calculations of Formula (50) may be justified must be referred to our friend economic proportion, of Premise I., and Formula (52) will perhaps be referred to her.

* An excellent presentation of this same principle using the graphics of three dimensions will be found in an article by Mr. Crosley in the *Transactions of the I. M. M.* of some years ago.

CHAPTER IV.

EXPLANATION OF THE SINKING-FUND TABLE (XXII.).

THE ordinary tables are expressed in terms of unity—that is, the decimal parts of one which are to be set aside each year, in order to redeem unit capital (C) at the expiration of a given term (n). As the whole effort of the book is to identify the engineer with economics and finance, the table has been expressed in terms of percentages, the ordinary enquiry being, How many per cent. must be put aside each year to redeem an original outlay of one pound (or dollar)? Evidently this is merely a matter of pointing off, and the entries in this table will be found to correspond with those of other tables if they be pointed off two to the left.

In accordance with the general principle of defining risks, and the belief that in general those securities accepted as standard, bearing 3 per cent. per annum, and selling at par, a sinking fund compounding annually at 3 per cent. is the only one dealt with.

The table is also of use in solving those formulas which involve the expression r'' or $\frac{r'}{R^n - 1}$, the table being $\frac{\cdot 03}{(1 + \cdot 03)^n - 1}$.

Example.—Shares in a mine have been purchased at 30s., which yield 30 per cent. per annum, the life of the mine being taken at 12 years. What must be the

amount of yearly interest left after setting aside where-
with to redeem the capital? The shares yield 30 per
cent. on one pound, or $\frac{30}{1.5}$ on 30s.—*i.e.*, 20 per cent. on
the investment. Looking at the left-hand column
marked “Life in Years (*n*),” against 12 years will be
found 7.05 per cent., which, taken from 20 per cent.,

TABLE XXII. — SINKING FUND (r''), OR MORE SENSIBLE SHARE-
GAMBLER'S TABLE. $r'' = \frac{r'}{R^n - 1}$. (See also Table XXIII., Col. 6.)

Life in Years (<i>n</i>).	r'' or Rate Investment must yield in order to redeem Unit Capital in <i>n</i> years.		
	Redemption at 3 per cent.	Redemption at 4 per cent.	Redemption at 5 per cent.
1,	100.0000	100.0000	100.0000
2,	49.2611	49.0196	48.7805
3,	32.3530	32.0349	31.7209
4,	23.9027	23.5490	23.2012
5,	18.8355	18.4627	18.0975
6,	15.4598	15.0762	14.7017
7,	13.0506	12.6610	12.2820
8,	11.2456	10.8528	10.4722
9,	9.8434	9.4493	9.0690
10,	8.7231	8.3291	7.9505
11,	7.8077	7.4149	7.0389
12,	7.0462	6.6552	6.2825
13,	6.4030	6.0144	5.6456
14,	5.8526	5.4669	5.1024
15,	5.3767	4.9941	4.6342
16,	4.9611	4.5820	4.2270
17,	4.5953	4.2199	3.8699
18,	4.2709	3.8993	3.5546
19,	3.9814	3.6139	3.2745
20,	3.7216	3.3582	3.0243
25,	2.7428	2.4012	2.0952
30,	2.1019	1.7830	1.5051
35,	1.6539	1.3577	1.1072
40,	1.3262	1.0523	0.8278
45,	1.0785	0.8262	0.6262
50,	0.8866	0.6550	0.4777

For basis of table and formula, see pp. 24, 25.

leaves, say, 12·9 per cent. as the real return on the investment.

Basis of Table XXIV.*—This will be found set out in Formulas (10), (11), (12), and (13) of the Introduction.

Whenever the purchase price and other outlay on a mine exceeds the present value of the reserves, the difference is the price paid for the “possibilities” of a mine. As the life of many mines is either not published, or may not be even approximated, it is of great importance to know how many years’ life this excess payment represents, for in far the majority of cases it is inadvisable to postulate a life very much greater than that of the reserves.

Evidently when this excess payment represents a certain life, the yearly tonnage mined, with the economic dimensions of the shoot, will give the depth which this payment really means ; this, of course, allows no deference. For this last see Tables XXVII. to XLII., and Example, which illustrate their use.

Example.—The dividends from a mine being, and likely to remain at, 30 per cent. per annum with the shares at £1·5, and the life of the reserves 2 years, how many years’ life below must be assumed if one allow a uniform risk-rate of 10 per cent. ?

The yield on the capital invested will be $\frac{30}{1\cdot5} = 20\%$.

By referring to Table XXIV., column 7, against 20 per cent. dividends, it will be seen that 11·9 years, or, say, 12 dividends, must be received. As the reserves have a life of two years only, the purchase at 30s. means paying for an assumption of ten years’ life.

* See also p. 120.

TABLE XXIII.—TABLE OF GENERAL FACTORS.

$r' = 3$ per cent. $r''' = 0$.

Year. <i>n</i> . (1)	One Pound.		One Pound per Annum.		Sinking Fund. $r'' = \frac{r'}{R^n - 1}$. (6)
	Amount. $(1 + r')^n$. (2)	Present Value.* $\frac{1}{(1 + r')^n}$.† (3)	Amount. $\frac{R^n - 1}{r'}$. (4)	Present Value. $\frac{1}{r' + r''}$. (5)	
1	1·03000	·97087	1·00000	·97087	1·000000
2	1·06090	·94260	2·03000	1·91347	·492611
3	1·09273	·91514	3·09090	2·82861	·323530
4	1·12551	·88849	4·18363	3·71710	·239027
5	1·15927	·86261	5·30914	4·57971	·188355
6	1·19405	·83748	6·46841	5·41719	·154598
7	1·22987	·81309	7·66246	6·23028	·130506
8	1·26677	·78941	8·89234	7·01969	·112456
9	1·30477	·76642	10·15911	7·78611	·098434
10	1·34392	·74409	11·46388	8·53020	·087231
11	1·38423	·72242	12·80780	9·25262	·078077
12	1·42576	·70138	14·19203	9·95400	·070462
13	1·46853	·68095	15·61779	10·63496	·064030
14	1·51259	·66112	17·08632	11·29607	·058526
15	1·55797	·64186	18·59891	11·93794	·053767
16	1·60471	·62317	20·15688	12·56110	·049611
17	1·65285	·60502	21·76159	13·16612	·045953
18	1·70243	·58739	23·41444	13·75351	·042709
19	1·75351	·57029	25·11687	14·32380	·039814
20	1·80611	·55368	26·87037	14·87748	·037216
21	1·86029	·53755	28·67649	15·41502	·034872
22	1·91610	·52189	30·53678	15·93692	·032747
23	1·97359	·50669	32·45288	16·44361	·030814
24	2·03279	·49193	34·42647	16·93554	·029047
25	2·09378	·47761	36·45926	17·41315	·027428
26	2·15659	·46369	38·55304	17·87684	·025938
27	2·22129	·45019	40·70963	18·32703	·024564
28	2·28794	·43708	42·93092	18·76411	·023293
29	2·35656	·42435	45·21885	19·18846	·022115
30	2·42726	·41199	47·57542	19·60044	·021019

† Delayed or deferred (*d*) years = *n* - 1 years.

* Present value = $\frac{1}{r' + r'' + r'''} = \frac{1}{(1 + r')^{d+1}} = \frac{1}{(1 + r')^n}$, as r'' or $\frac{r'}{R^n - 1}$ (the sinking fund) = 1.

† Note that *d* (the delay) begins after first year—i.e., $d = n - 1$. See also Table XXII.

BASIS OF TABLE XXIV. (*continued*).From Formula (53). $D = r' + r'' + r'''$.

$$r'' = D - r' - r'''$$

From Formula (54). $r'' = \frac{r'}{R^n - 1}$,hence $R^n - 1 = \frac{r'}{D - r' - r'''}$,

$$n \log R = \log \left(\frac{r'}{D - r' - r'''} + 1 \right).$$

Formula (55).
$$n = \frac{\log \left(1 + \frac{r'}{D - r' - r'''} \right)}{\log (1 + r')}$$
TABLE XXIV.—ENGINEER'S TABLE—LIFE IN TERMS OF DIVIDENDS.
Redeeming at 3 per cent.

1	2	3	4	5	6	7	8
Yearly Dividend in per cent. of Capital.	Redeeming Capital only. $r' = 0$ per cent. $r''' = 0$ "	Consols Basis. $r' = 3$ per cent. $r''' = 0$ "	Consols and 3 per cent. for Risks. $r' = 3$ per cent. $r''' = 3$ "	Consols and 5 per cent. for Risks. $r' = 3$ per cent. $r''' = 5$ "	Consols and 7 per cent. for Risks. $r' = 3$ per cent. $r''' = 7$ "	Consols and 10 p.c. for Risks. $r' = 3$ per cent. $r''' = 10$ "	Consols and 15 p.c. for Risks. $r' = 3$ per cent. $r''' = 15$ "
	Years of Life (n).	Years of Life (n).	Years of Life (n).	Years of Life (n).	Years of Life (n).	Years of Life (n).	Years of Life (n).
3%	22.9	..	..	..	..	..	..
4%	18.9	46.9	..	..	..	..	..
5%	15.9	31.0	..	..	..	..	..
7%	11.9	18.9	46.9	..	..	..	..
10%	8.9	11.9	18.9	31.0	..	..	..
12%	7.5	9.5	13.9	18.9	31.0	..	..
15%	6.2	7.5	9.5	11.9	15.9	31.0	..
20%	4.7	5.6	6.6	7.5	8.9	11.9	31.0
25%	3.6	4.4	4.9	5.6	6.2	7.5	11.9
30%	3.2	3.5	4.0	4.4	4.7	5.6	7.5
35%	2.8	3.0	3.3	3.5	3.6	4.4	5.6
40%	2.4	2.6	2.8	3.0	3.2	3.6	4.4
45%	2.2	2.3	2.5	2.6	2.8	3.0	3.6
50%	1.9	2.1	2.2	2.3	2.4	2.6	3.0

For basis of table and formula, see p. 118.

SENSIBLE INVESTOR'S TABLE (XXV.).

The query is often made as to the rate of dividends an investment must pay when one allows a given rate for

TABLE XXV.—SENSIBLE INVESTOR'S TABLE.

RATE PER CENT. INVESTMENT MUST YIELD TO BE EQUIVALENT TO CONSOLS AND PAY r''' PER CENT. TO COVER RISK.

Risks of Loss. Redemption at 3 or 4 per cent.

Years of Life.	1		2		3		4		5		6	
	Rate for Risk $r''=3$ p. cent.		Rate for Risk $r'''=5$ p. cent.		Rate for Risk $r'''=7$ p. cent.		Rate for Risk $r'''=10$ p. cent.		Rate for Risk $r'''=15$ p. cent.		Rate for Risk $r'''=20$ p. cent.	
	$r'=3$ p. cent	$r'=4$ p. cent	$r'=3$ p. cent	$r'=4$ p. cent	$r'=3$ p. cent	$r'=4$ p. cent	$r'=3$ p. cent	$r'=4$ p. cent	$r'=3$ p. cent	$r'=4$ p. cent	$r'=3$ p. cent	$r'=4$ p. cent
1	..	..	..	..	..	..	..	..	..	..	..	..
2	55.3	55.0	57.3	57.0	59.3	59.0	62.3	62.0	67.3	67.0	72.3	72.0
3	38.3	38.0	40.3	40.0	42.3	42.0	45.3	45.0	50.3	50.0	55.3	55.0
4	29.9	29.5	31.9	31.5	33.9	33.5	38.9	36.5	43.9	41.5	48.9	46.5
5	24.8	24.5	26.8	26.5	28.8	28.5	31.8	31.5	36.8	36.5	41.8	41.5
6	21.5	21.1	23.5	23.0	25.5	25.0	28.5	28.0	33.5	33.0	38.5	38.0
7	19.0	18.7	21.0	20.7	23.0	22.7	26.0	25.7	31.0	30.7	36.0	35.7
8	17.2	16.8	19.2	18.8	21.2	20.8	24.2	23.8	29.2	28.8	34.2	33.8
9	15.8	15.4	17.8	17.4	19.8	19.4	22.8	22.4	27.8	27.4	32.8	32.4
10	14.7	14.3	16.7	16.3	18.7	18.3	21.7	21.3	26.7	26.3	31.7	31.3
11	13.8	13.4	15.8	15.4	17.8	17.4	20.8	20.4	25.8	25.4	30.8	30.4
12	13.0	12.6	15.0	14.6	17.0	16.6	20.0	19.6	25.0	24.6	30.0	29.6
13	12.4	12.0	14.4	14.0	16.4	16.0	19.4	19.0	24.4	24.0	29.4	29.0
14	11.8	11.5	13.8	13.5	15.8	15.5	18.8	18.5	23.8	23.5	28.8	28.5
15	11.4	11.0	13.4	13.0	15.4	15.0	18.4	18.0	23.4	23.0	28.4	28.0
16	11.0	10.6	13.0	12.6	15.0	14.6	18.0	17.6	23.0	22.6	28.0	27.6
17	10.6	10.2	12.6	12.2	14.6	14.2	17.6	17.2	22.6	22.2	27.6	27.2
18	10.3	9.9	12.3	11.9	14.3	13.9	17.3	16.9	22.3	21.9	27.3	26.9
19	10.0	9.6	12.0	11.6	14.0	13.6	17.0	16.6	22.0	21.6	27.0	26.6
20	9.7	9.4	11.7	11.4	13.7	13.4	16.7	16.4	21.7	21.4	26.7	26.4
25	8.7	8.4	10.7	10.4	12.7	12.4	15.7	15.4	20.7	20.4	25.7	25.4
30	8.1	7.8	10.1	9.8	12.1	11.8	15.1	14.8	20.1	19.8	25.1	24.8
35	7.6	7.4	9.6	9.4	11.6	11.4	14.6	14.4	19.6	19.4	24.6	24.4
40	7.3	7.0	9.3	9.0	11.3	11.0	14.3	14.0	19.3	19.0	24.3	24.0
45	7.0	6.8	9.0	8.8	11.0	10.8	14.0	13.8	19.0	18.8	24.0	23.8
50	6.9	6.6	8.9	8.6	10.9	10.6	13.9	13.6	18.9	18.6	23.9	23.6

risk, and the life of the property is known or assumed. As some may care to consider re-investing their interest at 4 per cent. per annum, a special column is allowed for this.

Example.—What rate of interest must a mine pay which has a life of 9 years, if an allowance of 5 per cent. be made for risk, with a redemption fund rate of 3 per cent. ? In column 2 against 9 years of life will be found 17·8 per cent. as the rate of dividends one must expect of the mine.

Block Valuation, Bases of Tables Nos. XXVI. to XLII.

As discussed in the text, the two facts that in business life a greater rate is demanded of those undertakings understood to involve greater risk, and that, when dividends are deferred, this loss must be made good, are the basis of the valuation of blocks of ore, insomuch as each of these usually imply a different risk ; also each block of one year's life means a difference in the deference factor applicable.

Table XXVI. is compiled on the supposition that, for ordinary calculation purposes, the mine is opened out into blocks, or may be considered to be made up of zones having a life of one year each. Evidently the tonnage in such a block or zone will depend upon the amount of ore mined each year—*i.e.*, the capacity of the reduction plant is the dominant factor.

Tables XXVI., XXVII., and XLII. are essentially the same as Table XXVI., but cover blocks with a greater life than one year.

As discussed in the Introduction, and as set out in Formula (15)—

The present value of each pound of annual profit in a block being C ,

$$\text{Formula (56). } C = \frac{1}{(1+r'+r''')^d \left(r' + r''' + \frac{r'}{(1+r')^n - 1} \right)},$$

where d is the years of deferrence, and n the years of life of the block.

When the block has one year's life only, the factor $\frac{r'}{(1+r)^n - 1}$ becomes 1, hence Formula (56) may be written—

$$\text{Formula (57). } C = \frac{1}{(1+r'+r''')^{d+1}}$$

which is the basis of Table XXVI, where

d is the delay (in years) in exhausting the block ;

r' is 3 per cent., and

r''' the risk-rate from 0 to 20 heading the vertical columns.

This table is particularly interesting as showing the rapidly diminishing present values of the lower blocks of a mine with long life, more especially with the high risk-rates, which the lack of data concerning them necessarily implies.

TABLE XXVI.—REAL OR PRESENT VALUE OF UNIT OF ANNUAL PROFIT IN A BLOCK OF ORE.
FOR BLOCK OF 1 YEAR'S LIFE ONLY. VARYING RISK-RATES (r''').

(d) The delay in years in exhausting the Block.	Risk-Rate $r''' = 0$ per cent.	Risk-Rate $r''' = 1$ per cent.	Risk-Rate $r''' = 2$ per cent.	Risk-Rate $r''' = 3$ per cent.	Risk-Rate $r''' = 4$ per cent.	Risk-Rate $r''' = 5$ per cent.	Risk-Rate $r''' = 6$ per cent.	Risk-Rate $r''' = 7$ per cent.	Risk-Rate $r''' = 8$ per cent.	Risk-Rate $r''' = 9$ per cent.	Risk-Rate $r''' = 10$ per cent.
0	-97087	-96154	-95238	-94340	-93458	-92593	-91743	-90909	-90090	-89286	-88496
1	-94260	-92456	-90703	-89000	-87344	-85734	-84168	-82645	-81162	-79719	-78315
2	-91514	-89890	-88384	-86830	-85326	-83873	-82418	-80961	-79511	-78065	-76630
3	-88849	-87480	-86270	-85109	-84000	-82943	-81938	-80983	-80077	-79219	-78365
4	-86261	-85033	-83922	-82919	-81922	-80930	-80041	-79154	-78277	-77409	-76552
5	-83748	-82622	-81608	-80696	-80784	-80872	-80960	-81048	-81136	-81224	-81312
6	-81309	-80282	-79356	-78530	-77704	-76878	-76052	-75226	-74400	-73574	-72748
7	-78941	-78015	-77189	-76363	-75537	-74711	-73885	-73059	-72233	-71407	-70581
8	-76642	-75816	-75090	-74364	-73638	-72912	-72186	-71460	-70734	-70008	-69282
9	-74409	-73683	-72957	-72231	-71505	-70779	-70053	-69327	-68601	-67875	-67149
10	-72242	-71516	-70790	-70064	-69338	-68612	-67886	-67160	-66434	-65708	-64982
11	-70138	-69412	-68686	-67960	-67234	-66508	-65782	-65056	-64330	-63604	-62878
12	-68095	-67369	-66643	-65917	-65191	-64465	-63739	-63013	-62287	-61561	-60835
13	-66112	-65386	-64660	-63934	-63208	-62482	-61756	-61030	-60304	-59578	-58852
14	-64186	-63460	-62734	-62008	-61282	-60556	-59830	-59104	-58378	-57652	-56926
15	-62317	-61591	-60865	-60139	-59413	-58687	-57961	-57235	-56509	-55783	-55057
16	-60502	-59776	-59050	-58324	-57598	-56872	-56146	-55420	-54694	-53968	-53242
17	-58739	-58013	-57287	-56561	-55835	-55109	-54383	-53657	-52931	-52205	-51479
18	-57029	-56303	-55577	-54851	-54125	-53400	-52674	-51948	-51222	-50496	-49770
19	-55368	-54642	-53916	-53190	-52464	-51738	-51012	-50286	-49560	-48834	-48108
20	-53755	-53029	-52303	-51577	-50851	-50125	-49400	-48674	-47948	-47222	-46496
21	-52189	-51463	-50737	-50011	-49285	-48559	-47833	-47107	-46381	-45655	-44929
22	-50669	-49943	-49217	-48491	-47765	-47039	-46313	-45587	-44861	-44135	-43409
23	-49193	-48467	-47741	-47015	-46289	-45563	-44837	-44111	-43385	-42659	-41933
24	-47761	-47035	-46309	-45583	-44857	-44131	-43405	-42679	-41953	-41227	-40501
25	-46369	-45643	-44917	-44191	-43465	-42739	-42013	-41287	-40561	-39835	-39109
26	-44919	-44193	-43467	-42741	-42015	-41289	-40563	-39837	-39111	-38385	-37659
27	-43708	-42982	-42256	-41530	-40804	-40078	-39352	-38626	-37900	-37174	-36448
28	-42435	-41709	-40983	-40257	-39531	-38805	-38079	-37353	-36627	-35901	-35175
29	-41199	-40473	-39747	-39021	-38295	-37569	-36843	-36117	-35391	-34665	-33939
30	-39999	-39273	-38547	-37821	-37095	-36369	-35643	-34917	-34191	-33465	-32739

TABLE XXVI.—Continued.

(d) The delay in years in exhausting the block.	Risk-Rate r^{11} per cent.	Risk-Rate r^{12} per cent.	Risk-Rate r^{13} per cent.	Risk-Rate r^{14} per cent.	Risk-Rate r^{15} per cent.	Risk-Rate r^{16} per cent.	Risk-Rate r^{17} per cent.	Risk-Rate r^{18} per cent.	Risk-Rate r^{19} per cent.	Risk-Rate r^{20} per cent.
0	-87719	-86956	-86207	-85470	-84746	-84034	-83333	-82645	-81967	-81301
1	-76947	-75614	-74316	-73051	-71818	-70616	-69444	-68301	-67186	-66098
2	-67497	-65752	-64066	-62437	-60863	-59341	-57870	-56447	-55071	-53738
3	-59208	-57175	-55229	-53365	-51579	-49867	-48225	-46651	-45140	-43690
4	-51937	-49718	-47611	-45611	-43711	-41905	-40188	-38554	-37000	-35520
5	-45559	-43233	-41044	-38984	-37043	-35214	-33490	-31863	-30328	-28878
6	-39964	-37594	-35383	-33319	-31392	-29592	-27908	-26333	-24859	-23478
7	-35056	-32690	-30502	-28478	-26604	-24867	-23257	-21763	-20377	-19088
8	-30751	-28426	-26295	-24340	-22546	-20897	-19381	-17986	-16702	-15549
9	-26974	-24718	-22668	-20804	-19106	-17560	-16150	-14864	-13690	-12617
10	-23662	-21494	-19542	-17781	-16192	-14756	-13459	-12284	-11221	-10257
11	-20756	-18691	-16846	-15197	-13722	-12400	-11216	-10152	-9198	-8339
12	-18207	-16253	-14523	-12989	-11629	-10420	-93346	-8390	-7789	-66780
13	-15971	-14133	-12519	-11102	-9855	-8757	-7789	-6934	-6180	-55512
14	-14010	-12289	-10793	-9489	-8352	-7359	-6490	-5731	-5065	-44481
15	-12289	-10686	-9304	-8110	-7078	-6184	-5409	-4736	-4152	-36643
16	-10780	-9292	-8020	-6932	-5998	-5196	-4507	-3914	-3403	-2962
17	-99456	-8080	-66914	-5924	-5083	-4367	-3756	-3235	-2789	-2408
18	-8295	-7026	-5961	-5064	-4308	-3669	-3130	-2673	-2286	-1958
19	-7276	-6110	-5138	-4328	-3650	-3084	-2608	-2209	-1874	-1592
20	-6383	-5313	-4430	-3699	-3094	-2591	-2174	-1826	-1536	-1294
21	-5599	-4620	-3819	-3162	-2622	-2177	-1811	-1509	-1259	-1052
22	-4913	-4017	-3292	-2702	-2220	-1830	-1509	-1247	-1032	-8855
23	-4308	-3493	-2838	-2310	-1883	-1538	-1258	-1031	-8846	-7695
24	-3780	-3038	-2446	-1974	-1596	-1292	-1048	-852	-6993	-6065
25	-3315	-2641	-2109	-1687	-1352	-1086	-873	-704	-568	-460
26	-2908	-2297	-1818	-1442	-1146	-909	-728	-582	-466	-374
27	-2551	-2097	-1567	-1232	-997	-767	-607	-481	-382	-304
28	-2237	-1737	-1351	-1053	-823	-644	-505	-397	-313	-247
29	-1963	-1510	-1165	-900	-697	-541	-421	-328	-256	-201
30	-1721	-1313	-1004	-769	-659	-545	-435	-371	-291	-2163

TABLE XXVII.— r''' OR RISK-RATE = 2 PER CENT.

REAL OR PRESENT VALUE OF £1 OR \$1 OF ANNUAL PROFIT IN BLOCK.

Rate to be realised (s) = 5 per cent.

Years of Delay (d) in Realising Dividends from Block.	Life of Block (n) in Years.				
	1	2	3	4	5
0*	.95238	1.84294	2.67716	3.45988	4.19543
1	.90703	1.75513	2.54966	3.29511	3.99568
2	.86384	1.67162	2.42825	3.13814	3.80546
3	.82273	1.59204	2.31262	2.98873	3.62424
4	.78353	1.51621	2.20250	2.84640	3.45173
5	.74622	1.44401	2.09762	2.71090	3.28731
6					
7					
8					
9					
10					

For basis of table and formula, see p. 123 and Appendix A.

* In using these tables it is important to note that "delay" means the time after the end of the first year; hence those entries against "0" correspond to the present value shown in some tables where deference is called 1. Accurate to four places.

TABLE XXVIII.— r''' OR RISK-RATE = 3 PER CENT.

REAL OR PRESENT VALUE OF £1 OR \$1 OF ANNUAL PROFIT IN BLOCK
Rate to be realised (s) = 6 per cent.

Years of Delay (d) in Realising Dividends from Block.	Life of Block (n) in Years.				
	1	2	3	4	5
0	·94340	1·80959	2·62736	3·34415	4·02657
1	·89000	1·70715	2·47862	3·15487	3·79867
2	·83962	1·61054	2·33836	2·97628	3·58359
3	·79209	1·51936	2·20599	2·80781	3·38078
4	·74726	1·43336	2·08112	2·64887	3·18939
5	·70496	1·35223	1·96333	2·49894	3·00888
6					
7					
8					
9					
10					

For basis of table and formula, see p. 123.

TABLE XXIX.— r''' OR RISK-RATE = 4 PER CENT.

REAL OR PRESENT VALUE OF £1 OR \$1 OF ANNUAL PROFIT IN BLOCK.
Rate to be realised (s) = 7 per cent.

Years of delay (d) in realising Dividends from Block.	Life of Block (n) in Years.				
	1	2	3	4	5
0	·93458	1·77743	2·54110	3·23596	3·87072
1	·87344	1·66116	2·37485	3·02425	3·61755
2	·81630	1·55248	2·21951	2·82638	3·38089
3	·76290	1·45092	2·07430	2·64152	3·15966
4	·71299	1·35601	1·93851	2·46871	2·95299
5	·66634	1·26728	1·81176	2·30718	2·75976
6					
7					
8					
9					
10					

TABLE XXX.— r''' OR RISK-RATE = 5 PER CENT.

REAL OR PRESENT VALUE OF £1 OR \$1 OF ANNUAL PROFIT IN BLOCK.

Rate to be realised (s) = 8 per cent.

Years of Delay (d) in Realising Dividends from Block.	Life of Block (n) in Years.				
	1	2	3	4	5
0	·92593	1·74639	2·47813	3·13453	3·72641
1	·85734	1·61702	2·29456	2·90234	3·45038
2	·79383	1·49725	2·12460	2·68735	3·19480
3	·73503	1·38634	1·96722	2·48829	2·95815
4	·68058	1·28365	1·82150	2·30397	2·73902
5	·63017	1·18857	1·68656	2·13329	2·53620
6					
7					
8					
9					
10					

TABLE XXXI.— r''' OR RISK-RATE = 7 PER CENT.

REAL OR PRESENT VALUE OF £1 OR \$1 OF ANNUAL PROFIT IN BLOCK.

Rate to be realised (s) = 10 per cent.

Years of Delay (d) in Realising Dividends from Block.	Life of Block (n) in Years.				
	1	2	3	4	5
0	·90909	1·68745	2·36111	2·94959	3·46796
1	·82645	1·53404	2·14646	2·68147	3·15268
2	·75132	1·39458	1·95133	2·43770	2·86608
3	·68301	1·26780	1·77393	2·21609	2·60552
4	·62092	1·15255	1·61268	2·01463	2·36866
5	·56447	1·04777	1·46606	1·83147	2·15336
6					
7					
8					
9					
10					

TABLE XXXII.— r''' OR RISK-RATE = 9 PER CENT.

REAL OR PRESENT VALUE OF £1 OR \$1 OF ANNUAL PROFIT IN BLOCK.

Rate to be realised (s) = 12 per cent.

Years of Delay (d) in Realising Dividends from Block.	Life of Block (n) in Years.				
	1	2	3	4	5
0	.89286	1.63236	2.25464	2.78531	3.24302
1	.79719	1.45746	2.01317	2.48688	2.89555
2	.71178	1.30131	1.79738	2.22043	2.58532
3	.63552	1.16188	1.60481	1.98252	2.30832
4	.56743	1.03740	1.43286	1.77011	2.06020
5	.50663	.92624	1.04397	1.48034	1.84016
6					
7					
8					
9					
10					

TABLE XXXIII.— r''' OR RISK-RATE = 10 PER CENT.

REAL OR PRESENT VALUE OF £1 OR \$1 OF ANNUAL PROFIT IN BLOCK.

Rate to be realised (s) = 13 per cent.

Years of Delay (d) in Realising Dividends from Block.	Life of Block (n) in Years.				
	1	2	3	4	5
0	.88496	1.60614	2.20493	2.70981	3.14120
1	.78315	1.42136	1.95126	2.39808	2.77978
2	.69305	1.25784	1.72679	2.12220	2.46002
3	.61332	1.11314	1.52812	1.87804	2.17699
4	.54276	.98508	1.35232	1.66196	1.92656
5	.48032	.87175	1.19674	1.47076	1.70491
6					
7					
8					
9					
10					

TABLE XXXIV.— r''' OR RISK-RATE = 12 PER CENT.

REAL OR PRESENT VALUE OF £1 OR \$1 OF ANNUAL PROFIT IN BLOCK.

Rate to be realised (s) = 15 per cent.

Years of Delay (d) in Realising Dividends from Block.	Life of Block (n) in Years.				
	1	2	3	4	5
0	·86956	1·55615	2·11180	2·57052	2·95548
1	·75614	1·35318	1·83634	2·23523	2·56998
2	·65752	1·17667	1·59682	1·94368	2·23477
3	·57175	1·02319	1·38854	1·69016	1·94328
4	·49718	·88973	1·20743	1·46970	1·68980
5	·43233	·77369	1·04995	1·27800	1·46962
6	·37594	·67277	·91299	1·11129	1·27776
7	·32690	·58502	·79390	·96635	1·11107
8	·28426	·50871	·69035	·84030	·96616
9	·24719	·44236	·60031	·73070	·84009
10	·21494	·38466	·52201	·63539	·73057

TABLE XXXV.— r''' OR RISK-RATE = 15 PER CENT.

REAL OR PRESENT VALUE OF £1 OR \$1 OF ANNUAL PROFIT IN BLOCK.

Rate to be realised (s) = 18 per cent.

Years of Delay (d) in Realising Dividends from Block.	Life of Block (n) in Years.				
	1	2	3	4	5
0	·84746	1·48674	1·98598	2·38648	2·71478
1	·71818	1·25995	1·68303	2·02244	2·30066
2	·60863	1·06776	1·42630	1·71393	1·94971
3	·51579	·90488	1·20873	1·45249	1·65230
4	·43711	·76685	1·02434	1·23092	1·40025
5	·37043	·64987	·86809	1·04314	1·18667
6	·31393	·55074	·73567	·88402	1·00565
7	·26604	·46673	·62345	·74918	·85225
8	·22546	·39553	·52835	·63489	·72225
9	·19107	·33520	·44775	·53804	·61207
10	·16191	·28407	·37945	·45597	·51871

TABLE XXXVI.— r''' OR RISK-RATE = 17 PER CENT.

REAL OR PRESENT VALUE OF £1 OR \$1 OF ANNUAL PROFIT IN BLOCK.
Rate to be realised (s) 20 per cent.

Years of Delay (d) in Realising Dividends from Block.	Life of Block (n) in Years.				
	1	2	3	4	5
0*	·83333	1·44381	1·91011	2·27776	2·57497
1	·69444	1·20318	1·59176	1·89814	2·14580
2	·57870	1·00265	1·32646	1·58178	1·78817
3	·48225	·83554	1·10539	1·31815	1·49014
4	·40188	·69628	·92116	1·09846	1·24179
5	·33490	·58024	·76763	·90537	1·03483
6	·27908	·48353	·63969	·76282	·86236
7	·23257	·40294	·53308	·63568	·71863
8	·19381	·33578	·44422	·52973	·59886
9	·16151	·27982	·37019	·44144	·49005
10	·13459	·23318	·30849	·36787	·41588

* Dividends end first year is no delay, being the ordinary occurrence.

TABLE XXXVII.— r''' OR RISK-RATE = 20 PER CENT.

REAL OR PRESENT VALUE OF £1 OR \$1 OF ANNUAL PROFIT IN BLOCK.
Rate to be realised (s) = 23 per cent.

Years of Delay (d) in Realising Dividends from Block.	Life of Block (n) in Years.				
	1	2	3	4	5
0	·81301	1·38387	1·80658	2·13206	2·39034
1	·66098	1·12509	1·46877	1·73337	1·94337
2	·53738	·91471	1·19441	1·40924	1·58000
3	·43690	·74367	·97083	1·14574	1·24454
4	·35520	·60471	·78929	·93149	1·04433
5	·28878	·49155	·64211	·75779	·84960
6	·23478	·39964	·52169	·61570	·69029
7	·19088	·32491	·42415	·50066	·56121
8	·15517	·26415	·34484	·40697	·45627
9	·12617	·21476	·28036	·33087	·37095
10	·10257	·17460	·22793	·26900	·30158

TABLE XXXVIII.— r''' OR RISK-RATE = 25 PER CENT.

REAL OR PRESENT VALUE OF £1 OR \$1 OF ANNUAL PROFIT IN BLOCK.
Rate realised (s) = 28 per cent.

Years of Delay (d) in Realising Dividends from Block.	Life of Block (n) in Years.				
	1	2	3	4	5
0	·78125	1·29431	1·65692	1·92667	2·13516
1	·61035	1·01112	1·29446	1·50521	1·66808
2	·47684	·78999	1·01131	1·17594	1·30320
3	·37253	·61718	·79008	·91871	1·01812
4	·29104	·42817	·61725	·71774	·79514
5	·22737	·37610	·48223	·56074	·62145
6	·17764	·29429	·37674	·43808	·48548
7	·13878	·22992	·29433	·24225	·37928
8	·10842	·17962	·22994	·26738	·29631
9	·08470	·14033	·17964	·20889	·23149
10	·06617	·10963	·14035	·16320	·18085

TABLE XXXIX.— r''' OR RISK-RATE = 30 PER CENT.

REAL OR PRESENT VALUE OF £1 OR \$1 OF ANNUAL PROFIT IN BLOCK.
Rate realised (s) = 33 per cent.

Years of Delay (d) in Realising Dividends from Block.	Life of Block (n) in Years.				
	1	2	3	4	5
0	·75188	1·21564	1·53015	1·75738	1·92920
1	·56532	·91402	1·15050	1·32133	1·45054
2	·42505	·68732	·86503	·99348	1·09062
3	·31959	·51719	·65039	·74698	·82001
4	·24029	·38851	·48902	·56164	·61655
5	·18067	·29212	·36768	·42229	·46357
6	·13584	·21963	·27645	·31751	·34855
7	·10214	·16514	·20786	·23873	·26207
8	·07680	·12416	·15629	·17947	·19704
9	·05774	·09336	·11751	·13496	·14815
10	·04341	·07010	·08835	·10147	·11139

TABLE XL.— r''' OR RISK-RATE = 35 PER CENT.

REAL OR PRESENT VALUE OF £1 OR \$1 OF ANNUAL PROFIT IN BLOCK.

Rate realised (s) = 38 per cent.

Years of Delay (d) in Realising Dividends from Block.	Life of Block (n) in Years.				
	1	2	3	4	5
0	·72464	1·14598	1·42140	1·61543	1·75948
1	·52510	·83043	1·03000	1·17060	1·27499
2	·38051	·60176	·74638	·84826	·92390
3	·27573	·43606	·54085	·61468	·66963
4	·19980	·31598	·39192	·44542	·48514
5	·14479	·22895	·28400	·32277	·35155
6	·10492	·16592	·20580	·23389	·25480
7	·07603	·12023	·14913	·16949	·18460
8	·05509	·08713	·10806	·12282	·13377
9	·03992	·06313	·07831	·08900	·09693
10	·03002	·04575	·05674	·06449	·07024

TABLE XLI.— r''' OR RISK-RATE = 40 PER CENT.

REAL OR PRESENT VALUE OF £1 OR \$1 OF ANNUAL PROFIT IN BLOCK.

Rate to be realised (s) = 43 per cent.

Years of Delay (d) in Realising Dividends from Block.	Life of Block (n) in Years.				
	1	2	3	4	5
0	·69930	1·08388	1·32701	1·49470	1·61721
1	·48902	·75796	·92803	1·04525	1·13091
2	·34197	·53004	·64898	·73094	·79085
3	·23914	·37066	·45383	·51115	·55304
4	·16723	·25920	·31736	·35719	·38674
5	·11694	·18126	·22193	·24996	·27045
6	·08178	·12675	·15520	·17480	·18912
7	·05719	·08864	·10853	·12224	·13225
8	·03999	·06199	·07589	·08548	·09249
9	·02797	·04335	·05307	·05978	·06468
10	·01956	·03031	·03711	·04180	·04523

TABLE XLII.— r''' OR RISK-RATE = 50 PER CENT.

REAL OR PRESENT VALUE OF £1 OR \$1 OF ANNUAL PROFIT IN BLOCK.

Rate to be realised (s) = 53 per cent.

Years of Delay (d) in Realising Dividends from Block.	Life of Block (n) in Years.				
	1	2	3	4	5
0	·65359	·97789	1·17160	1·30034	1·38207
1	·42719	·63914	·76576	·84989	·90986
2	·27921	·41774	·50050	·55548	·59468
3	·18249	·27303	·32712	·36307	·38868
4	·11927	·17845	·21380	·23730	·25404
5	·07796	·11664	·13974	·15510	·16604
6	·05095	·07623	·09133	·10136	·10852
7	·03330	·04938	·05969	·06625	·07093
8	·02177	·03257	·03902	·04330	·04636
9	·01423	·02128	·02550	·02830	·03030
10	·00961	·01391	·01667	·01850	·01980

Tables of Real Values of Shares, Nos. XLIII. to LI.

Both engineers and investors have constant occasion to appraise the present or real value of shares, assuming, of course, that the data furnished regarding the amount, continuity, and number of dividends, is reliable.

As will be seen, each table is based on a different allowance for risk, such as the investor may care to allow, in accordance with his own information and views. The number of annual dividends or life is shown each year up to 20 years, and thereafter each five years up to 50 years.

The tables are calculated on the assumption that the dividends shall accumulate at 3 per cent. only, as in

accordance with the general idea set out elsewhere, a rate greater than 3 per cent. involves appreciable risk with which it were inaccurate to saddle the sinking fund if risks are to be segregated, this being the basis of all the writer's calculations.

Example.—Shares are offered at 25s. paying 25 per cent. annually on the par value. The mine is given a life of 8 years, and the investors believe that the political conditions and management are such as to warrant one in allowing a risk-rate of 5 per cent. per annum, or a return of 8 per cent. Are the shares a good purchase at 25s.? The return being 25 per cent. at par means $\frac{25}{1.25}$, or 20 per cent., on the market selling price. Looking up Table XLVII., which allows a risk-rate of 5 per cent., it is seen that under the column of annual dividends, at 20 per cent., and a life of 8 years, the real or present value is £1.03, or say 20s., hence the shares stand at too high a figure when selling at 25s.

Bases of Tables XLIII. and LI.—The discussion of Formulæ (1), (2), (3), and (4) in the Introduction will make clear the philosophy of the tables, they being simply the expression of

Formula (58).
$$C = \frac{D}{r' + r'' + r'''}$$

A separate table is allowed each risk-rate from 1 to 20 per cent., and the n or life of the property varies from 1 to 50 years.

TABLE XLIII.—REAL VALUE OF SHARES, ALLOWING 1 PER CENT. FOR RISK.

i.e., A Return of 4 per cent.

Years of Life (<i>n</i>).	$r' = 3$ per cent.					$r'' =$ variable.					$r''' = 1$ per cent.				
	Annual Dividends in percentage.—Capital at par.														
	3%	4%	5%	6%	7%	10%	12%	15%	20%	25%	30%	35%	40%	45%	50%
1	·03	·04	·05	·06	·07	·0962	·12	·14	·19	·24	·29	·34	·38	·43	·48
2	·06	·08	·09	·11	·13	·1878	·23	·28	·38	·47	·56	·66	·75	·85	·94
3	·08	·11	·14	·17	·19	·2751	·33	·41	·55	·69	·83	·96	1·10	1·24	1·38
4	·11	·14	·18	·21	·25	·3584	·43	·54	·72	·90	1·08	1·25	1·43	1·61	1·79
5	·13	·18	·22	·26	·31	·4379	·53	·66	·88	1·09	1·31	1·53	1·75	1·97	2·19
6	·15	·21	·26	·31	·36	·5139	·62	·77	1·03	1·28	1·54	1·80	2·06	2·31	2·57
7	·18	·23	·29	·35	·41	·5865	·70	·88	1·17	1·47	1·76	2·05	2·35	2·64	2·93
8	·20	·26	·33	·39	·46	·6559	·79	·98	1·31	1·64	1·97	2·30	2·62	2·95	3·28
9	·22	·29	·36	·43	·51	·7224	·87	1·08	1·44	1·81	2·17	2·53	2·89	3·25	3·61
10	·24	·31	·39	·47	·55	·7860	·94	1·18	1·57	1·96	2·36	2·75	3·14	3·54	3·93
11	·25	·34	·42	·51	·59	·8469	1·02	1·27	1·69	2·12	2·54	2·96	3·39	3·81	4·23
12	·27	·36	·45	·54	·63	·9053	1·09	1·36	1·81	2·26	2·72	3·17	3·62	4·07	4·53
13	·29	·38	·48	·58	·67	·9613	1·15	1·44	1·92	2·40	2·88	3·36	3·85	4·33	4·81
14	·30	·41	·51	·61	·71	1·0150	1·22	1·52	2·03	2·54	3·04	3·55	4·06	4·57	5·07
15	·32	·43	·53	·64	·75	1·0665	1·28	1·60	2·13	2·67	3·20	3·73	4·27	4·80	5·33
16	·33	·45	·56	·67	·78	1·1159	1·34	1·67	2·23	2·79	3·35	3·91	4·46	5·02	5·58
17	·35	·47	·58	·70	·81	1·1634	1·40	1·75	2·33	2·91	3·49	4·07	4·65	5·24	5·82
18	·36	·48	·60	·73	·85	1·2091	1·45	1·81	2·42	3·02	3·63	4·23	4·84	5·44	6·05
19	·38	·50	·63	·75	·88	1·2529	1·50	1·88	2·51	3·13	3·76	4·39	5·01	5·64	6·26
20	·39	·52	·65	·78	·91	1·2951	1·55	1·94	2·59	3·24	3·89	4·53	5·18	5·83	6·48
25	·44	·59	·74	·90	1·04	1·4831	1·78	2·22	2·97	3·71	4·45	5·19	5·93	6·67	7·42
30	·49	·66	·82	·98	1·15	1·6388	1·97	2·46	3·28	4·10	4·92	5·74	6·56	7·37	8·19
35	·53	·71	·88	1·06	1·24	1·7687	2·12	2·65	3·54	4·42	5·31	6·19	7·07	7·96	8·84
40	·56	·75	·94	1·13	1·31	1·8775	2·25	2·82	3·75	4·69	5·63	6·57	7·51	8·45	9·39
45	·59	·79	·98	1·18	1·38	1·9691	2·36	2·95	3·94	4·92	5·91	6·89	7·88	8·86	9·85
50	·61	·82	1·02	1·23	1·43	2·0464	2·46	3·07	4·09	5·12	6·14	7·16	8·19	9·21	10·23

TABLE XLIV.—REAL VALUE OF SHARES, ALLOWING 2 PER CENT. FOR RISK.

i.e., A Return of 5 per cent.

Years of Life (<i>n</i>).	$r' = 3$ per cent.			$r'' =$ variable.						$r''' = 2$ per cent.					
	Annual Dividends in per cent.—Capital at par.														
	3%	4%	5%	6%	7%	10%	12%	15%	20%	25%	30%	35%	40%	45%	50%
1	.03	.04	.05	.06	.07	.0952	.11	.14	.19	.24	.29	.33	.38	.43	.48
2	.06	.07	.09	.11	.13	.1843	.22	.28	.37	.46	.55	.64	.74	.83	.92
3	.08	.11	.13	.16	.19	.2677	.32	.40	.54	.67	.80	.94	1.07	1.20	1.34
4	.10	.14	.17	.21	.24	.3460	.42	.52	.69	.86	1.04	1.21	1.38	1.56	1.73
5	.13	.17	.21	.25	.29	.4195	.50	.63	.84	1.05	1.26	1.47	1.68	1.89	2.10
6	.15	.20	.24	.29	.34	.4888	.59	.73	.98	1.22	1.47	1.71	1.96	2.20	2.44
7	.17	.22	.28	.33	.39	.5540	.66	.83	1.11	1.38	1.66	1.94	2.22	2.49	2.77
8	.18	.25	.31	.37	.43	.6155	.74	.92	1.23	1.54	1.85	2.15	2.46	2.77	3.08
9	.20	.27	.34	.40	.47	.6737	.81	1.01	1.35	1.68	2.02	2.36	2.69	3.03	3.37
10	.22	.29	.36	.44	.51	.7287	.87	1.09	1.46	1.82	2.19	2.55	2.91	3.28	3.64
11	.23	.31	.39	.47	.55	.7808	.94	1.17	1.56	1.95	2.34	2.73	3.12	3.51	3.90
12	.25	.33	.42	.50	.58	.8301	1.00	1.25	1.66	2.08	2.49	2.91	3.32	3.74	4.15
13	.26	.35	.44	.53	.61	.8770	1.05	1.32	1.74	2.19	2.63	3.07	3.51	3.95	4.38
14	.28	.37	.46	.55	.64	.9314	1.11	1.38	1.84	2.30	2.76	3.22	3.69	4.15	4.61
15	.29	.39	.48	.58	.67	.9637	1.16	1.45	1.93	2.41	2.89	3.37	3.85	4.34	4.82
16	.30	.40	.50	.60	.70	1.0039	1.20	1.51	2.01	2.51	3.01	3.51	4.02	4.52	5.02
17	.31	.42	.52	.63	.73	1.0422	1.25	1.56	2.08	2.61	3.13	3.65	4.17	4.69	5.21
18	.32	.43	.54	.65	.76	1.0786	1.29	1.62	2.16	2.70	3.24	3.78	4.31	4.85	5.39
19	.33	.45	.56	.67	.78	1.1134	1.34	1.67	2.23	2.78	3.34	3.90	4.45	5.01	5.57
20	.34	.46	.57	.69	.80	1.1466	1.38	1.72	2.29	2.87	3.44	4.01	4.59	5.16	5.73
25	.39	.52	.65	.77	.90	1.2915	1.55	1.94	2.58	3.23	3.87	4.52	5.17	5.81	6.46
30	.42	.56	.70	.84	.99	1.4081	1.69	2.11	2.82	3.52	4.22	4.93	5.63	6.34	7.04
35	.45	.60	.75	.90	1.05	1.5029	1.80	2.25	3.01	3.76	4.51	5.26	6.01	6.76	7.51
40	.47	.63	.79	.95	1.11	1.5807	1.90	2.37	3.16	3.95	4.74	5.53	6.32	7.11	7.90
45	.49	.66	.82	.99	1.15	1.6451	1.97	2.47	3.29	4.11	4.94	5.76	6.58	7.40	8.23
50	.51	.68	.85	1.02	1.19	1.6988	2.04	2.55	3.40	4.25	5.10	5.95	6.80	7.64	8.49

TABLE XLV.—REAL VALUE OF SHARES, ALLOWING 3 PER CENT.
FOR RISK.

i.e., A Return of 6 per cent. Redemption at 3 per cent.

Years of Life (<i>n</i>)	r' = 3 per cent.			r'' = variable.					r''' = 3 per cent.						
	Annual Dividends in percentage.—Capital at par.														
	3%	4%	5%	7%	10%	12%	15%	20%	25%	30%	35%	40%	45%	50%	
1	.03	.04	.05	.06	.09	.11	.14	.19	.23	.28	.33	.38	.42	.47	
2	.05	.07	.09	.12	.18	.22	.27	.36	.45	.54	.63	.72	.81	.91	
3	.08	.11	.13	.18	.26	.31	.39	.52	.65	.78	.91	1.04	1.17	1.30	
4	.10	.13	.17	.23	.33	.40	.50	.67	.84	1.00	1.17	1.34	1.60	1.67	
5	.12	.16	.20	.28	.40	.48	.60	.80	1.00	1.21	1.41	1.61	1.81	2.01	
6	.14	.19	.23	.33	.46	.56	.70	.93	1.16	1.40	1.63	1.86	2.00	2.32	
7	.16	.21	.26	.37	.52	.63	.79	1.05	1.31	1.57	1.84	2.10	2.36	2.62	
8	.17	.23	.29	.40	.58	.69	.87	1.16	1.45	1.74	2.03	2.32	2.51	2.90	
9	.19	.25	.31	.44	.63	.76	.95	1.26	1.56	1.89	2.21	2.52	2.84	3.15	
10	.20	.27	.34	.47	.68	.82	1.02	1.36	1.70	2.04	2.38	2.72	3.06	3.40	
11	.22	.30	.36	.51	.72	.87	1.09	1.44	1.81	2.17	2.52	2.90	3.26	3.62	
12	.23	.31	.38	.54	.77	.92	1.15	1.53	1.92	2.30	2.68	3.07	3.45	3.83	
13	.24	.32	.40	.56	.81	.97	1.21	1.61	2.01	2.42	2.82	3.23	3.63	4.04	
14	.25	.34	.42	.59	.84	1.01	1.26	1.69	2.11	2.52	2.95	3.37	3.80	4.22	
15	.26	.35	.44	.61	.88	1.05	1.31	1.77	2.20	2.63	3.08	3.51	3.95	4.40	
16	.27	.36	.45	.64	.91	1.09	1.37	1.92	2.28	2.75	3.19	3.65	4.10	4.56	
17	.28	.38	.47	.66	.94	1.13	1.41	1.89	2.36	2.83	3.31	3.77	4.25	4.71	
18	.29	.39	.49	.68	.97	1.17	1.46	1.95	2.43	2.92	3.41	3.90	4.38	4.87	
19	.30	.40	.50	.70	1.00	1.20	1.50	2.00	2.50	3.00	3.51	4.01	4.51	5.01	
20	.31	.41	.51	.72	1.03	1.23	1.54	2.06	2.57	3.08	3.59	4.11	4.63	5.14	
25	.34	.45	.55	.81	1.14	1.37	1.71	2.29	2.86	3.43	4.00	4.47	5.15	5.72	
30	.37	.49	.61	.86	1.23	1.48	1.75	2.47	3.08	3.70	4.32	4.94	5.55	6.17	
35	.39	.52	.65	.91	1.31	1.56	1.84	2.61	3.26	3.91	4.57	5.23	5.88	6.53	
40	.41	.54	.68	.95	1.36	1.64	2.05	2.73	3.41	4.09	4.68	5.36	6.14	6.82	
45	.42	.56	.70	.99	1.41	1.69	2.11	2.82	3.53	4.24	4.94	5.65	6.36	7.06	
50	.44	.58	.72	1.02	1.45	1.74	2.20	2.90	3.55	4.36	5.08	5.81	6.53	7.25	

For basis of Table and Formula, see p. 135.

TABLE XLVI.—REAL VALUE OF SHARES, ALLOWING 4 PER CENT.
FOR RISK.

i.e., A Return of 7 per cent.

Years of Life (<i>n</i>)	$r' = 3$ per cent.			$r'' = \text{variable.}$					$r''' = 4$ per cent.						
	Annual Dividends in percentage.—Capital at par.														
	3%	4%	5%	7%	10%	12%	15%	20%	25%	30%	35%	40%	45%	50%	
1	.03	.04	.05	.06	.09	.11	.14	.18	.23	.28	.33	.37	.42	.46	
2	.05	.07	.07	.12	.18	.22	.26	.36	.44	.53	.60	.72	.78	.88	
3	.08	.10	.13	.18	.25	.30	.38	.50	.62	.76	.89	1.01	1.14	1.27	
4	.10	.13	.16	.22	.32	.39	.49	.64	.80	.98	1.13	1.29	1.56	1.61	
5	.12	.16	.19	.27	.39	.48	.58	.78	.96	1.17	1.35	1.56	1.74	1.93	
6	.13	.18	.22	.31	.44	.54	.66	.88	1.12	1.32	1.55	1.78	2.00	2.23	
7	.15	.20	.25	.35	.50	.60	.75	1.00	1.25	1.50	1.74	2.00	2.24	2.49	
8	.16	.22	.27	.38	.55	.66	.82	1.10	1.37	1.65	1.92	2.20	2.47	2.74	
9	.18	.24	.30	.41	.59	.72	.90	1.18	1.48	1.80	2.09	2.37	2.67	2.97	
10	.19	.25	.32	.45	.64	.75	.95	1.28	1.59	1.92	2.23	2.56	2.76	3.18	
11	.20	.27	.34	.47	.67	.81	1.01	1.34	1.69	2.02	2.36	2.70	3.04	3.38	
12	.21	.28	.36	.50	.71	.84	1.06	1.42	1.78	2.13	2.49	2.85	3.20	3.56	
13	.22	.30	.37	.53	.75	.90	1.12	1.50	1.87	2.25	2.63	3.00	3.40	3.75	
14	.23	.31	.39	.55	.78	.93	1.16	1.58	1.95	2.34	2.73	3.12	3.51	3.90	
15	.24	.32	.40	.57	.81	.96	1.21	1.62	2.02	2.43	2.83	3.24	3.63	4.04	
16	.25	.33	.42	.58	.84	.99	1.25	1.64	2.09	2.52	2.92	3.28	3.76	4.18	
17	.26	.34	.43	.60	.86	1.02	1.30	1.72	2.15	2.59	3.02	3.45	3.88	4.31	
18	.27	.35	.44	.62	.89	1.05	1.33	1.78	2.22	2.67	3.10	3.56	4.00	4.44	
19	.27	.36	.45	.64	.91	1.08	1.36	1.82	2.27	2.73	3.21	3.64	4.10	4.55	
20	.28	.37	.47	.65	.93	1.11	1.40	1.86	2.33	2.80	2.26	3.73	4.20	4.66	
25	.31	.41	.50	.70	.03	1.23	1.54	2.06	2.52	3.03	3.58	4.10	4.61	5.03	
30	.33	.44	.55	.77	1.10	1.32	1.65	2.20	2.74	3.30	3.84	4.38	4.94	5.49	
35	.35	.46	.58	.81	1.15	1.38	1.73	2.30	2.89	3.47	4.04	4.62	5.20	5.78	
40	.36	.48	.60	.84	1.20	1.44	1.80	2.40	3.00	3.60	4.20	4.80	5.40	6.00	
45	.37	.49	.62	.87	1.24	1.47	1.85	2.48	3.09	3.72	4.33	4.95	5.57	6.19	
50	.38	.51	.63	.89	1.27	1.53	1.90	2.54	3.16	3.81	4.43	5.07	5.70	6.33	

For basis of Table and Formula, see p. 135.

TABLE XLVII.—REAL VALUE OF SHARES, ALLOWING 5 PER CENT.
FOR RISK.

i.e., A Return of 8 per cent.

Years of Life (<i>n</i>)	$r' = 3$ per cent.			$r'' =$ variable.						$r''' = 5$ per cent.					
	Annual Dividends in percentage.—Capital at par.														
	3%	4%	5%	7%	10%	12%	15%	20%	25%	30%	35%	40%	45%	50%	
1	.028	.04	.05	.07	.093	.12	.14	.19	.23	.29	.35	.37	.42	.46	
2	.052	.07	.09	.12	.173	.28	.26	.35	.43	.52	.63	.70	.80	.87	
3	.074	.10	.12	.17	.248	.30	.37	.49	.62	.74	.84	.98	1.08	1.24	
4	.094	.11	.16	.22	.313	.33	.47	.63	.78	.94	1.12	1.06	1.44	1.56	
5	.112	.15	.19	.26	.373	.45	.56	.75	.93	1.12	1.33	1.50	1.71	1.86	
6	.127	.17	.21	.29	.426	.51	.63	.85	1.06	1.27	1.47	1.70	1.89	2.13	
7	.142	.19	.24	.32	.475	.57	.71	.95	1.18	1.42	1.68	1.90	2.16	2.37	
8	.155	.21	.26	.36	.519	.63	.78	1.03	1.30	1.55	1.82	2.06	2.34	2.59	
9	.168	.22	.28	.39	.560	.66	.84	1.12	1.40	1.68	1.96	2.24	2.52	2.80	
10	.179	.24	.30	.42	.598	.72	.90	1.19	1.50	1.79	2.10	2.38	2.70	2.99	
11	.189	.25	.32	.45	.633	.75	.94	1.26	1.58	1.89	2.24	2.52	2.88	3.16	
12	.199	.27	.33	.46	.665	.81	1.00	1.33	1.66	1.99	2.31	2.66	2.97	3.32	
13	.207	.28	.35	.49	.694	.84	1.03	1.39	1.73	2.07	2.45	2.78	3.15	3.47	
14	.217	.29	.36	.50	.722	.87	1.08	1.44	1.80	2.17	2.52	2.88	3.24	3.61	
15	.224	.30	.37	.52	.748	.90	1.02	1.49	1.87	2.24	2.59	2.99	3.33	3.74	
16	.231	.31	.38	.52	.771	.93	1.15	1.54	1.92	2.31	2.66	3.08	3.42	3.84	
17	.238	.32	.40	.56	.794	.96	1.19	1.59	1.98	2.38	2.80	3.18	3.60	3.97	
18	.244	.33	.41	.58	.815	.98	1.22	1.63	2.03	2.44	2.87	3.26	3.69	4.07	
19	.250	.33	.42	.59	.835	.99	1.25	1.67	2.08	2.50	2.94	3.34	3.78	4.17	
20	.256	.34	.43	.60	.853	1.02	1.28	1.71	2.13	2.56	3.01	3.42	3.87	4.26	
25	.279	.37	.46	.64	.931	1.11	1.40	1.86	2.32	2.79	3.22	3.72	4.14	4.65	
30	.297	.39	.49	.68	.990	1.17	1.48	1.98	2.47	2.97	3.43	3.96	4.41	4.95	
35	.310	.41	.52	.73	1.036	1.23	1.55	2.07	2.58	3.10	3.64	4.14	4.68	5.16	
40	.322	.43	.54	.75	1.072	1.29	1.61	2.14	2.68	3.22	3.78	4.28	4.86	5.36	
45	.330	.44	.55	.77	1.101	1.32	1.65	2.20	2.75	3.30	3.85	4.40	4.95	5.50	
50	.337	.45	.56	.78	1.125	1.35	1.68	2.25	2.82	3.37	3.92	4.50	5.04	5.62	

For basis of Table and Formula, see p. 135.

TABLE XLVIII.—REAL VALUE OF SHARES, ALLOWING 7 PER CENT. FOR RISK.

i.e., A Return of 10 per cent.

Years of Life (<i>n</i>).	r' = 3 per cent.			r'' = variable.					r''' = 7 per cent.						
	Dividends in percentage.—Capital at par.														
	3%	4%	5%	7%	10%	12%	15%	20%	25%	30%	35%	40%	45%	50%	
1	.03	.04	.05	.06	.091	.12	.14	.18	.22	.27	.32	.36	.41	.45	
2	.05	.07	.08	.11	.169	.21	.24	.33	.42	.49	.56	.66	.75	.84	
3	.07	.09	.12	.17	.236	.27	.35	.47	.59	.70	.84	.94	1.08	1.18	
4	.09	.12	.15	.21	.295	.36	.44	.59	.73	.88	1.05	1.18	1.35	1.47	
5	.10	.14	.17	.24	.347	.42	.52	.69	.81	1.04	1.19	1.38	1.53	1.73	
6	.12	.16	.20	.28	.393	.48	.59	.79	.88	1.18	1.40	1.58	1.80	1.96	
7	.13	.17	.22	.31	.434	.51	.65	.87	1.08	1.30	1.54	1.74	1.98	2.17	
8	.14	.19	.23	.32	.471	.57	.70	.94	1.17	1.41	1.61	1.88	2.07	2.35	
9	.15	.20	.25	.35	.504	.60	.75	1.01	1.25	1.51	1.75	2.02	2.25	2.52	
10	.16	.21	.27	.38	.534	.63	.80	1.07	1.33	1.60	1.89	2.14	2.43	2.67	
11	.17	.22	.28	.39	.561	.66	.84	1.12	1.40	1.68	1.96	2.24	2.52	2.80	
12	.18	.23	.29	.41	.587	.69	.88	1.17	1.46	1.76	2.03	2.34	2.61	2.93	
13	.18	.24	.30	.42	.610	.72	.91	1.22	1.52	1.83	2.10	2.44	2.70	3.05	
14	.19	.25	.31	.43	.631	.75	.94	1.26	1.57	1.89	2.17	2.52	2.79	3.15	
15	.19	.26	.32	.45	.650	.76	.97	1.30	1.62	1.95	2.24	2.60	2.88	3.25	
16	.20	.26	.33	.46	.668	.78	1.00	1.33	1.67	2.00	2.31	2.66	2.97	3.34	
17	.20	.27	.34	.48	.685	.81	1.02	1.36	1.71	2.04	2.38	2.72	3.06	3.42	
18	.21	.28	.35	.49	.701	.84	1.05	1.40	1.75	2.10	2.45	2.80	3.15	3.50	
19	.21	.29	.36	.50	.715	.86	1.07	1.43	1.78	2.14	2.52	2.86	3.20	3.57	
20	.22	.29	.36	.52	.729	.87	1.09	1.45	1.82	2.18	2.62	2.90	3.27	3.64	
25	.23	.30	.39	.55	.785	.90	1.17	1.57	1.86	2.35	2.73	3.02	3.52	3.92	
30	.25	.33	.41	.57	.826	.99	1.23	1.67	2.06	2.47	2.87	3.34	3.71	4.13	
35	.26	.34	.43	.60	.858	1.02	1.28	1.71	2.14	2.57	3.01	3.42	3.86	4.29	
40	.27	.35	.44	.62	.883	1.05	1.32	1.77	2.21	2.65	3.08	3.54	3.97	4.41	
45	.27	.36	.45	.63	.903	1.08	1.35	1.80	2.25	2.70	3.15	3.60	4.06	4.51	
50	.28	.37	.46	.64	.918	1.11	1.37	1.83	2.30	2.75	3.22	3.66	4.13	4.59	

For basis of Table and Formula, see p. 135.

TABLE XLIX—REAL VALUE OF SHARES, ALLOWING 10 PER CENT.
FOR RISK.

i.e., A Return of 13 per cent.

Years of Life (<i>n</i>)	$r' = 3$ per cent.			$r'' =$ variable.					$r''' = 10$ per cent.						
	Dividends in percentage.—Capital at par.														
	3%	4%	5%	7%	10%	12%	15%	20%	25%	30%	35%	40%	45%	50%	
1	.03	.03	.04	.06	.088	.10	.13	.17	.22	.26	.31	.34	.39	.44	
2	.05	.06	.08	.11	.161	.19	.24	.32	.40	.48	.56	.62	.72	.80	
3	.07	.09	.11	.15	.220	.27	.33	.44	.55	.66	.77	.88	.99	1.10	
4	.08	.11	.13	.19	.271	.33	.40	.54	.62	.81	.94	1.08	1.21	1.35	
5	.09	.13	.16	.22	.314	.39	.47	.63	.78	.94	1.10	1.26	1.44	1.57	
6	.10	.14	.17	.24	.351	.42	.52	.70	.87	1.05	1.22	1.40	1.57	1.75	
7	.11	.15	.19	.27	.384	.45	.57	.77	.96	1.15	1.34	1.54	1.62	1.92	
8	.12	.16	.21	.29	.412	.48	.62	.82	1.03	1.24	1.44	1.64	1.82	2.06	
9	.13	.17	.22	.31	.438	.51	.65	.87	1.08	1.31	1.54	1.74	1.98	2.19	
10	.14	.18	.23	.32	.460	.54	.69	.92	1.15	1.38	1.61	1.84	2.07	2.30	
11	.14	.19	.24	.33	.480	.57	.72	.96	1.20	1.44	1.68	1.92	2.16	2.40	
12	.15	.20	.25	.35	.499	.60	.73	.99	1.24	1.47	1.75	1.98	2.25	2.49	
13	.15	.21	.26	.36	.515	.62	.77	1.03	1.28	1.54	1.80	2.06	2.31	2.57	
14	.16	.21	.26	.37	.530	.64	.80	1.06	1.32	1.59	1.85	2.12	2.38	2.65	
15	.16	.22	.27	.38	.544	.66	.82	1.09	1.36	1.63	1.90	2.18	2.44	2.72	
16	.17	.22	.28	.39	.557	.67	.84	1.11	1.39	1.67	1.94	2.22	2.49	2.78	
17	.17	.23	.28	.40	.568	.68	.85	1.13	1.42	1.70	1.98	2.26	2.55	2.84	
18	.17	.23	.29	.40	.579	.69	.86	1.15	1.44	1.73	2.02	2.30	2.60	2.89	
19	.18	.23	.29	.41	.589	.70	.88	1.17	1.47	1.76	2.06	2.34	2.64	2.94	
20	.18	.24	.30	.42	.598	.72	.90	1.19	1.50	1.79	2.09	2.38	2.69	2.99	
25	.19	.25	.32	.44	.635	.75	.95	1.27	1.58	1.90	2.21	2.56	2.85	3.17	
30	.20	.26	.33	.46	.662	.78	1.00	1.32	1.65	1.99	2.32	2.64	2.98	3.31	
35	.20	.27	.34	.48	.682	.81	1.02	1.36	1.70	2.05	2.39	2.72	3.07	3.41	
40	.21	.28	.35	.49	.698	.83	1.04	1.39	1.75	2.09	2.45	2.78	3.14	3.49	
45	.21	.28	.35	.50	.710	.84	1.06	1.42	1.77	2.13	2.48	2.84	3.19	3.55	
50	.22	.29	.36	.51	.720	.87	1.08	1.44	1.80	2.16	2.52	2.88	3.24	3.60	

For basis of Table and Formula, see p. 135.

TABLE L.—REAL VALUE OF SHARES, ALLOWING 15 PER CENT.
FOR RISK.
i.e., A Return of 18 per cent.

Years of Life (<i>n</i>)	$r' = 3$ per cent.			$r'' =$ variable.					$r''' = 15$ per cent.					
	Dividends in percentage.—Capital at par.													
	3%	4%	5%	7%	10%	12%	15%	20%	25%	30%	35%	40%	45%	50%
1	.02	.03	.04	.06	.085	.10	.12	.17	.21	.25	.28	.34	.36	.42
2	.04	.06	.07	.10	.149	.17	.22	.29	.37	.44	.49	.58	.63	.74
3	.06	.08	.10	.14	.198	.23	.30	.39	.49	.59	.70	.78	.90	.99
4	.07	.09	.12	.17	.239	.29	.36	.47	.59	.73	.84	.96	1.08	1.19
5	.08	.11	.13	.18	.271	.32	.40	.54	.67	.81	.91	1.08	1.17	1.35
6	.09	.12	.15	.21	.299	.35	.45	.60	.74	.89	1.05	1.20	1.35	1.49
7	.10	.13	.16	.22	.322	.38	.48	.64	.80	.96	1.12	1.28	1.44	1.61
8	.10	.14	.17	.24	.342	.41	.51	.68	.85	1.03	1.19	1.36	1.53	1.71
9	.11	.14	.18	.25	.359	.43	.53	.71	.89	1.07	1.26	1.42	1.62	1.79
10	.11	.15	.19	.26	.374	.45	.56	.75	.93	1.12	1.30	1.50	1.71	1.87
11	.12	.15	.19	.27	.387	.46	.58	.77	.96	1.16	1.35	1.54	1.75	1.93
12	.12	.16	.20	.28	.399	.47	.59	.79	.98	1.19	1.40	1.58	1.80	1.99
13	.12	.16	.20	.29	.410	.49	.61	.82	1.02	1.23	1.44	1.64	1.85	2.05
14	.12	.17	.21	.29	.419	.50	.62	.83	1.04	1.25	1.47	1.66	1.89	2.09
15	.13	.17	.21	.30	.428	.51	.64	.85	1.07	1.28	1.50	1.70	1.94	2.14
16	.13	.17	.22	.31	.435	.52	.65	.87	1.09	1.30	1.54	1.74	1.98	2.17
17	.13	.18	.22	.32	.442	.53	.67	.88	1.10	1.33	1.58	1.76	1.99	2.21
18	.13	.18	.22	.32	.449	.54	.67	.89	1.12	1.34	1.60	1.78	2.03	2.24
19	.14	.18	.23	.32	.455	.54	.68	.91	1.13	1.36	1.61	1.82	2.07	2.27
20	.14	.18	.23	.32	.460	.55	.69	.92	1.15	1.38	1.62	1.84	2.09	2.30
25	.15	.19	.24	.33	.482	.58	.72	.96	1.20	1.45	1.68	1.92	2.16	2.41
30	.15	.20	.25	.35	.497	.59	.74	.99	1.24	1.49	1.75	1.98	2.25	2.48
35	.15	.20	.25	.36	.509	.61	.76	1.02	1.27	1.53	1.78	2.04	2.30	2.54
40	.15	.21	.26	.36	.517	.62	.77	1.03	1.29	1.55	1.80	2.06	2.31	2.58
45	.16	.21	.26	.36	.524	.63	.78	1.05	1.31	1.57	1.81	2.10	2.32	2.62
50	.16	.21	.26	.36	.529	.63	.79	1.06	1.32	1.58	1.82	2.12	2.34	2.64

For basis of Table and Formula, see p. 135.

TABLE LI.—REAL VALUE OF SHARES, ALLOWING 20 PER CENT.
FOR RISK.

i.e., A Return of 23 per cent.

Years of Life (<i>n</i>).	$r' = 3$ per cent.			$r'' =$ variable.					$r''' = 20$ per cent.						
	Dividends in percentage.—Capital at par.														
	3%	4%	5%	7%	10%	12%	15%	20%	25%	30%	35%	40%	45%	50%	
1	.02	.03	.04	.06	.081	.10	.12	.16	.20	.24	.28	.32	.36	.40	
2	.04	.05	.07	.08	.138	.16	.20	.27	.35	.41	.49	.54	.63	.69	
3	.05	.07	.09	.12	.181	.20	.27	.36	.45	.54	.63	.72	.81	.90	
4	.06	.08	.11	.15	.213	.24	.32	.43	.53	.64	.77	.86	.99	1.06	
5	.07	.09	.12	.17	.239	.28	.35	.48	.60	.71	.84	.96	1.08	1.19	
6	.08	.10	.13	.18	.260	.32	.39	.52	.65	.78	.91	1.04	1.14	1.30	
7	.08	.11	.14	.19	.277	.33	.41	.55	.69	.83	.98	1.10	1.26	1.38	
8	.09	.12	.15	.21	.292	.35	.44	.58	.73	.88	1.05	1.16	1.34	1.46	
9	.09	.12	.15	.22	.304	.36	.45	.61	.76	.91	1.08	1.22	1.35	1.52	
10	.09	.13	.16	.22	.315	.37	.47	.63	.78	.94	1.10	1.26	1.44	1.57	
11	.10	.13	.16	.22	.324	.38	.48	.65	.81	.97	1.12	1.30	1.46	1.62	
12	.10	.13	.17	.23	.333	.40	.50	.67	.83	1.00	1.17	1.34	1.52	1.66	
13	.10	.14	.17	.23	.340	.41	.51	.68	.85	1.02	1.18	1.36	1.53	1.70	
14	.10	.14	.17	.24	.346	.42	.52	.69	.86	1.04	1.19	1.38	1.54	1.73	
15	.11	.14	.18	.25	.352	.42	.53	.70	.88	1.06	1.23	1.40	1.56	1.76	
16	.11	.14	.18	.25	.358	.43	.53	.71	.89	1.07	1.24	1.42	1.58	1.79	
17	.11	.14	.18	.25	.362	.44	.54	.72	.91	1.09	1.25	1.44	1.60	1.81	
18	.11	.15	.18	.25	.366	.44	.55	.73	.92	1.10	1.26	1.46	1.61	1.83	
19	.11	.15	.18	.25	.370	.44	.55	.74	.93	1.11	1.27	1.48	1.62	1.85	
20	.11	.15	.19	.26	.374	.45	.56	.74	.94	1.12	1.32	1.48	1.66	1.87	
25	.12	.16	.19	.27	.389	.46	.58	.78	.97	1.17	1.33	1.56	1.71	1.94	
30	.12	.16	.20	.28	.398	.47	.59	.80	.98	1.19	1.39	1.60	1.76	1.99	
35	.12	.16	.20	.28	.406	.48	.61	.81	1.02	1.22	1.40	1.62	1.78	2.03	
40	.12	.16	.20	.28	.411	.49	.61	.82	1.03	1.23	1.41	1.64	1.80	2.05	
45	.12	.17	.21	.29	.415	.50	.62	.83	1.04	1.24	1.46	1.66	1.85	2.07	
50	.12	.17	.21	.30	.419	.50	.62	.84	1.05	1.25	1.47	1.68	1.89	2.09	

For basis of Table and Formula, see p. 135.

APPENDIX A.

ALLOWANCES FOR DELAYED DIVIDENDS.

IN order that the underlying bases of delayed dividends be understood, it would seem necessary to go back to the very beginning of human industry, and we may say :—

(a) From the results of sowing and reaping, experience justifies the expectation of a return of the seed capital and a further increment ; this last corresponds to interest in commercial life with the transaction closed in one season. Where sowing produces several crops, as, say, from an orchard, the transaction is extended over several seasons.

(b) From the above return a part is put aside as a reserve against the next sowing, while a portion is used for sustenance. The first may be regarded as the prototype of the capital redemption fund, and the second as ordinary interest.

(c) Experience shows that crops fail, occasionally several seasons in succession, demonstrating the necessity of providing a reserve greater than that called for by the next sowing or planting. This experience of failure and provision to meet it first taught the lesson of deference of increment, risk, probability, and the formation

of a reserve fund, and that the magnitude of the latter should be a function of the number of untoward events.

(d) As commerce developed, it became increasingly a part of general experience that loss was a function of the data available, varying inversely, as, for instance, the greater the knowledge of routes and conditions, human and other, the fewer the failures. Experience also taught that the longer the trip or voyage undertaken the greater the probability of failure; * but the length of the voyage being a function of the time, the habit developed of regarding the probability of failure as a function of the time as well as of specific data.

From the foregoing it is seen that probability, a series of ventures, risk a function of the time, risk a function of the data, interest, a reserve fund, a function of the number of failures (risk) and delay or deference, are all basic concepts, the outcome of bitter experience dating from the dawn of commerce—*i.e.*, are not mere academic postulates.

✓ The great impediment to sound reasoning seems to be the confusion of hope with calculation. Assuredly hope of success impels to action, but it is or should be conditioned by conscious or unconscious rationation involving experience—*i.e.*, probability. Unless hope be moderated by such considerations, it becomes but a pleasurable mental excitement, as seen in most forms of gambling.

While all business is of necessity speculation or hazard, the calculation of risk largely distinguishes it from

* Note that for "number of failures" we now use "probability of failure—*i.e.*, probability postulates a number of events.

gambling. Speculation may not be definitely differentiated from ordinary business, but the magnitude of the reserve fund is, from the foregoing, greater in the case of speculation ; but the annual risk-rate is only an expression of this reserve, hence the more speculative an undertaking the greater the risk-rate called for. ✓

The status of the engineer being that of an intermediary, or interpreter between the scientist and financier, it is imperative that his education should be sufficiently comprehensive to familiarise him with the discoveries of the one and the demands of the other ; assuming, of course, that the latter are consonant with economics in its broader aspects—*i.e.*, with civic proportion—a sense of which it is seen must find place even in calculations of profit.

In this office of interpreter the engineer is the one who legitimately sets the risk-rate by the light of his knowledge of science, and this position is one which calls for the analysis and comparison of the merits of different ventures, essentially expressed in monetary units.*

Perhaps the greatest difficulty the engineer has to meet is his necessity of facing the civic demand that an equivalent return be made for service rendered, or outlay made. For instance, the client investing in the more ordinary undertaking has two possible sources of profit in his mind ; that of realising upon the ignorance of others as expressed in the share market quoting inflated values, and that of profit from dividends received. While the share market is manifestly an indispensable adjunct to

* Note that “ a fine showing,” “ favourable geological conditions,” etc., are meaningless terms if not expressed in monetary units.

civilisation as a convenience in readily realising upon capital, yet the hope of the client to secure from it the windfalls of credulity or greed can find no legitimate place in the engineer's calculations.

From the above reasoning it will be evident that the generally accepted premises forming the basis of appraisal of business venture may be stated as follows :—

Premise I.—Capital outlay in a venture of a terminable life assumes the return of the original capital (reproduction rate, r'') ; an equal annual rate of contribution to the reserve fund (r''') * and a sustenance rate (r').

Corollary to Premise I.—The reserve fund contribution (r''') is an integral part of the annual increment, and represents both or either capital and the sustenance rate, when failure occurs to one or more in a series of ventures.

Premise II.—When dividends are delayed or deferred beyond one year from the date of investment, the losses due to the delay shall be made good by the subsequent payments.

Premise III.—A comparison of ventures entails the consideration of equal times of investment.

Premise IV.—The minimum rate of interest (r') is assumed to be the return from the investment representing the minimum risk.

* It is especially necessary to realise that the sustenance rate (r' , or say 3 per cent.) is as vital as the return of capital itself ; further, that the accumulated reserve is really nothing but capital (and perhaps sustenance) when failure occurs in one or more of a series of investments.

The sustenance rate (r') is also taken as that of the security involving the minimum risk.

Premise V.—Only one rate for risk and one rate of redemption to be used when comparing two ventures.

Premise VI.—The sustenance and redemption rates shall be equal and represent the minimum rate (r').

In the following, two enterprises are considered, one of which shall yield (n) dividends commencing one year from date of investment, and the other be delayed (d) years beyond the other, but then to yield the same number (n) of dividends, and at the same rate.

Taking investment A, which yields equal and yearly dividends commencing one year from date of investment, it will be seen that for n years the return is $r' + r'' + r'''$, where r' is the sustenance rate, r'' the rate put aside and compounded at r' for n years when it equals the original capital; and r''' , the stipulated annual contribution to the reserve fund. As at the end of n years investment A has not completed its term, according to *premise III.* it is necessary to re-invest the proceeds, which is made in a venture entailing no risk, hence calls for no risk-rate, nor r'' as it sells at par.

At the end of the first year investment A yields D per cent., or $(r' + r'' + r''')$ per cent., hence B makes its annual contribution to sustenance and the reserve whereby to protect the original capital. Investment B at the end of the first year yields nothing, and no contribution is made to the reserve fund. Similar results are had at the end of the second year, investment A

contributing to the reserve fund and B failing; and on for d years. At the end of the first year the contribution to the reserve and redemption fund made by A is invested in a venture entailing no risk, hence its capital is protected to that extent in case of failure to realise dividends later on. Investment B, on the other hand, has no such protection. The one way to secure protection to the latter, and to provide for the sustenance rate (r') is to find the necessary additional capital each year during the delay. The new capital, $(r' + r''') \frac{R^d - 1}{r'}$, will amount to $(r' + r''') \frac{R^d - 1}{r'} \frac{R^n - 1}{r'}$ in n years from the end of the deferred period. As seen by Formula (4), the present value of a deferred annuity or delayed dividend is—

$$\text{Formula (59).} \quad C = \frac{1}{r' + r'' + r''' + r''''}$$

where r'''' is the annual rate or portion of the dividend (when received) to meet the loss due to the delay. This annual rate r'''' when invested at r' amounts in n years to $r'''' \frac{R^n - 1}{r'}$, which, as above, must meet the losses to the new capital and r' interest on same for n years—*i.e.*,

Formula (60).

$$r'''' \frac{R^n - 1}{r'} = (r' + r''') \frac{R^d - 1}{r'} + (r' + r''') \frac{R^d - 1}{r'} (r') \frac{R^n - 1}{r'}$$

$$r'''' = \left[(r' + r''') \frac{R^d - 1}{r'} \right] \left[\frac{r'}{R^n - 1} + r' \right],$$

but by Formula (13) $\frac{r'}{R^n - 1} = r''$, hence the present value—

$$\text{Formula (61). } C = \frac{1}{r' + r'' + r''' + \left[(r' + r''') \frac{R^d - 1}{r'} (r' + r'') \right]}.$$

This gives results identical with Mr. O'Donahue's* formula, which is—

$$\text{Formula (62). } C = \frac{1}{r'' + r''(r' + r''') \frac{R^{n+d} - 1}{r'}}.$$

But while the original capital has been protected during the period of delay by finding new capital to contribute to the reserve fund, how about an insurance for this new capital? Clearly none exists; it must look to the enterprise itself for repayment, hence calls for a corresponding risk-rate.

This new capital then at the end of the first year is $(r' + r''')$, and as it is also entitled to sustenance and an insurance rate, or $(r' + r''')$, it becomes $\frac{s(S^d - 1)}{s}$ at the end of the period of the delay; $s = (r' + r''')$ and $S = (1 + s)$.

From the reasoning preceding Formula (16)—

Formula (63).

$$C = \frac{1}{S^d (r'' + s)} = \frac{1}{(1 + r' + r''')^d \left(r' + r''' + \frac{r'}{R^n - 1} \right)}.$$

The essential point of difference between Formulæ (63) and (62), that of Mr. O'Donahue, is the failure on the part of the latter to recognise that the new capital

* See *The Valuation of Mineral Properties*, by T. A. O'Donahue.

is also entitled to the risk-rate, though it demands an insurance for the original capital. In a word, most writers on the subject, save the late Mr. Hoskold,* would appear to have overlooked the essence of a risk-rate, which is the identity of the reserve fund with capital itself when the broader aspects of insurance are considered.

It may be urged that as the capital remaining in the undertaking—*i.e.*, unredeemed by r'' —is ever growing less, the risk-rate (r''') should be applied to the remaining part only. In reality one is bound by the conventions of the business world which does not fix a reserve or even a sinking fund, but merely exacts an annual rate which must satisfy the above requirements. In fact, selling at par is the ordinary sinking fund, but in order to intelligently compare the merit of different ventures, particularly those with a limited life, the above postulates have to be made. The student would do well to remember, however, that in order to serve the main purpose—*i.e.*, reduce the “personal equation”—in other words, to effectively eliminate “inspiration methods”—theories of valuation must conform to business concepts in order to find acceptance, which last is evidently the real aim.

This practical demand for a rate sufficient to meet the $r' + r'' + r'''$ requirement is productive of some apparent anomalies, as, for instance, the fact that r''' is made to accumulate to a larger sum in the case of longer

* While the writer's formula is developed differently from that of the late Mr. Hoskold, it is identical in construction, nor is there occasion to believe that the latter failed to overlook the underlying philosophy, even though unstated in his book, *Mine Valuers' Assistant*.

deference, even though the *rate for risk per annum* be made the same. This aggregate allowance for risk, or accumulation of reserve, is seen to be in accordance with experience, if one but contemplate the future which shows that uncertainty varies with the time.

In the case of two blocks of ore, each with the same risk-rate above the standard rate, but worked at different times, it will be seen—if one conceives of laying out new capital to meet the stipulation for contribution to the reserve during delay—that a portion of the risk-rate varies with the data, while the other, the standard portion, is fixed, though both demand an insurance fund varying with the time. At first thought, it would seem unusual to so penalise what purports to be an allowance for a difference in data only. In reality the premise is an annual rate which is made a function of the data, *and not a reserve fund* which shall vary with the data and remain independent of the time. In other words, the course followed is like that of the ordinary business world, the reserves of which are expressed by the rates of dividend alone, or the equivalent, their present value.

When a banker discounts two bills at 4 per cent., due at different times, the extra per cent. above, say, 3 per cent. may be said to represent an annual allowance for a shortage in data concerning the undertakings; the ultimate contribution of each to the bank's reserve fund will vary, however, with the time, even though the data as expressed by the extra per cent. be the same.

It may be well to again point out that allowances for risk, whether for the mine as a whole, for the standard block, or for that addition to the risk rate designed to

allow for defective data, are much like the allowances for ignorance of certain facts when calculating the strength of beams. The latter calculations are of necessity wanting, to meet which we employ a factor of safety of hundreds of per cent. *Yet are these allowances sound, when they meet general acceptance, for the essence of accuracy, is the elimination so far as possible of the personal error, whether this be accidental or intentional; and standardised calculations even where defective serve this end.*

Angle.	Sine.	Tangent.	Co-tangent.	Cosine.	Angle.
0°	0	0	∞	1	90°
1	·0175	·0175	57·2900	·9998	89
2	·0349	·0349	28·6363	·9994	88
3	·0523	·0524	19·0811	·9986	87
4	·0698	·0699	14·3006	·9976	86
5	·0872	·0875	1·4301	·9962	85
6	·1045	·1051	9·5144	·9945	84
7	·1219	·1228	8·1443	·9925	83
8	·1392	·1405	7·1154	·9903	82
9	·1564	·1584	6·3138	·9877	81
10	·1736	·1763	5·6713	·9848	80
11	·1908	·1944	5·1446	·9816	79
12	·2079	·2126	4·7046	·9781	78
13	·2250	·2309	4·3315	·9744	77
14	·2419	·2493	4·0108	·9703	76
15	·2588	·2679	3·7321	·9659	75
16	·2756	2867	3·4874	·9613	74
17	·2924	·3057	3·2709	·9563	73
18	·3090	·3249	3·0777	·9511	72
19	·3256	·3443	2·9042	·9455	71
20	·3420	·3640	2·7475	·9397	70
21	·3584	·3839	2·6051	·9336	69
22	·3746	·4040	2·4751	·9272	68
23	·3907	·4245	2·3559	·9205	67
24	·4067	·4452	2·2460	·9135	66
25	·4226	·4663	2·1445	·9063	65
26	·4384	·4877	2·0503	·8988	64
27	·4540	·5095	1·9626	·8910	63
28	·4695	·5317	1·8807	·8830	62
29	·4848	·5543	1·8040	·8746	61
30	·5000	·5774	1·7321	·8660	60
31	·5150	·6009	1·6643	·8572	59
32	·5299	·6249	1·6003	·8480	58
33	·5446	·6494	1·5399	·8387	57
34	·5592	·6745	1·4826	·8290	56
35	·5736	·7002	1·4281	·8192	55
36	·5878	·7265	1·3764	·8090	54
37	·6018	·7536	1·3270	·7986	53
38	·6157	·7813	1·2799	·7880	52
39	·6293	·8098	1·2349	·7771	51
40	·6428	·8391	1·1918	·7660	50
41	·6561	·8693	1·1504	·7547	49
42	·6691	·9004	1·1106	·7431	48
43	·6820	·9325	1·0724	·7314	47
44	·6947	·9657	1·0355	·7193	46
45	·7071	1·0000	1·0000	·7071	45
	Cosine.	Co-tangent.	Tangent.	Sine.	Angle.

I N D E X.

A

ACCIDENTALS, 46.
 Accuracy, 45.
 Administration efficiency, 89.
 „ organisation, 4.
 Angle of cut, 155.
 Annual increments, 145, 148.
 Assay plan, 47.
 Assays of out-crop, 41.
 Attractiveness of mining, 16.

B

BALANCE sheet, 2.
 Bank discounts, 33.
 „ reserves, 33, 34.
 Block calculations, 39, 75.
 „ „ Table of, 76.
 „ reef, 47.
 „ subdivisions, 45.
 „ The Standard, 45, 46, 47, 48.
 „ values, 79.
 Bonanzas, 41.

C

CALCULATIONS, Significance of, 154.
 „ Weighting of, 44.
 Capital of company and economic shoots, 66.
 Capital of company and ore reserves, 66.
 Capitalisation of shoot extension, 64.
 Cash and sample surfaces, 65.

Cash outlay, 54.
 „ „ on plant, 54.
 Checks on sampling, 4.
 Civic proportion, 7.
 Closed-traverse principle, 98, 99.
 Combination factor, 10.
 Commercial honesty, 15.
 Continuous section, 73, 74, 80, 82, 87, 89, 91.
 Cost of errors, 93.
 „ feet, 74.
 „ loss, 10, 72, 73, 74.
 „ value, 13.
 Costs, 71.
 „ and construction, 71.
 „ and delays, 71.
 „ and geography, 71.
 Coyote-ing system, 80.
 Criteria of sound practice, 49, 50.
 Cross-section sampling, 78.
 Cross-sections, 111.
 Cubic contents, 43.
 Cumulation shares and deference, 36.

D

DATA, 2.
 Debentures and deference, 36.
 Deepest level, 54.
 Deference, 14, 23, 24, 36, 146.
 „ and investment, 19.
 Depth of enrichment, 43.
 Development, 1, 4.
 Dividend, Division of, 19.
 Dividends and capital, 7.
 „ Delayed, 21, 77, 145.

E

- ECONOMIC proportion, 7, 18, 27.
 „ shoot, 41, 42, 51, 52, 53, 55,
 56, 58, 59, 60, 61.
 „ „ and company capital,
 61.
 „ „ and market value, 61.
 „ „ extension, 55.
 „ „ Graphics of, 74.
 „ „ of different mines, 60,
 61, 62, 63.
 „ „ Variations in, 62, 63.
 „ units, 3, 9.
 Economics of finance, 59, 61.
 „ geography, 31.
 „ purchase, 59.
 Engineer's responsibility, 63.
 „ table, 120.
 „ „ Basis of, 119.
 Engineers and financiers, 7, 59.
 „ and risk-rate, 28, 29.
 „ Measure of, 58.
 Errors, a function of angle of cut, 96.
 „ costing £800,000, 30.
 „ Elimination of, 98, 154.
 „ from practice, Table of, 83.
 „ in division of sample, 84.
 „ sampling formula, 96, 97.
 „ table from practice, 97.
 „ Table of, 94.
 Examination, Errors in, 29, 30.
 Expenditure on exploration, 55.
 Exploration, 55.
 „ and economic shoot, 65.

F

- FIELD book, 100.
 „ data, 47.
 „ notes, 12.
 Figures of sample sections, Figs. 9, 10,
 11, 12, 13.
 Fills, 71.
 Finance, 53, 57, 71.
 „ and economic shoots, 57.
 „ and present value, 57.
 „ and science, 107.

- Finance of possibilities, 66.
 Financiers, 8.
 Flotational aspects, 8.
 Formulæ for calculating deferred pay-
 ments, 23, 24, 25, 149, 150, 151.
 Formulæ for calculating value shares,
 123.

G

- GEOLOGICAL data, 47.
 „ limitations, 8.
 „ surmise, 57.
 Geology and payments to vendors, 57.
 Gozzan, 39, 40, 55.
 Graphical records, 87, 89; *see also* Figs.
 1, 1a, 5b, 7, and 12.

I

- IMPREGNATION, 43.
 Ineptitude, 6.
 Inspiration methods, 152.
 Insurance principle, 16, 17, 22.
 Interest, 19, 22.
 „ Compound, 22.
 „ minimum rate, 148.
 „ redemption rate, 149.
 „ sustenance rate, 148.
 Investment *versus* speculation, 3, 4.
 Investor's table, 121.

L

- LEVELS, Distance between, 45, 46.
 Life, 14, 15.
 „ and plant, 35, 36.
 „ in terms of dividends, 118.

M

- MACHINE drilling, 80.
 Mark of incompetence, 41.
 Market value, 15.
 Metal in ore, 78, 111.

Mine reserves, 13.
 Minimum stope, 74.
 Mining an industry, 5, 6.
 „ operations the basis of sampling
 practice, 78.

N

NECESSITY of Plans, 41.

O

OFFICE sheets, 100, 101, 102, 103, 104.
 Operating engineers, 38.
 Ore in interior of block, 40, 41.
 „ occurrence and continuity, 41.
 „ Patches of, 44, 80.
 „ Primary, 47.
 „ reserves, 66.
 „ shoot, 40, 44, 45.
 „ sills, 47.
 Out-crop, 41, 42.

P

PATCHES of ore, 44, 46.
 Pay-streak, 81, 82, 90, 91.
 Personal equation, 152.
 „ factor, 34.
 Pilgrim's Rest, 47.
 Plans, 41.
 Possibility, Unit of, 64.
 Pound-footage, 111.
 Premise II., 11.
 „ III., 13.
 Present value, 17, 34.
 „ and risk-rate, 63.
 „ formula, 23, 24, 25, 145.
 „ of shares, Table, pp. 136-
 144.
 Present values, rate of change, 123, 124.
 „ when dividends delayed,
 Tables, pp. 124-134.
 Prices of shares, 28.
 Probability, 17, 58, 145, 146.

Probability and possibility, 40, 42, 58.
 Profit-feet, 10, 74, 76.
 Profit in block, 75.
 Promotion, Clean and unclean, 8.
 Prospect, 57.
 Purchase price and data, 54.
 „ Permissible, 54.
 „ per unit of possibility,
 64, 65.

R

RAND, 6.
 Redemption, 14, 15, 34, 35, 36.
 „ formula, 24, 25.
 Reduction in value of reserves, 34.
 Reserves and capitalisation, 64.
 „ and deference, 34.
 „ and shoot extension, 52.
 Return of capital, 16, 18.
 Risk-rate, 14, 15, 17, 22, 78.
 „ a banking practice, 33.
 „ and insurance, 145, 146, 147,
 148.
 „ and reserves, 33.
 „ and sample sections, 48.
 „ Anomalies of, 152, 153.
 „ external factor, 33.
 „ internal factor, 25.
 „ on Rand, 27, 28.
 „ use in business world, 152.
 „ varying with metal, 49.
 „ „ profit, 26.

S

SAMPLE section, Division of, 82, 83.
 „ „ errors, 98.
 „ sections, 44, 46.
 „ „ discussed, 106, 107,
 108, 109, 110.
 „ „ from practice, Figs.
 16, 17, 18.
 Sampling, continuous graphical system,
 91, 92, 93.
 „ errors, Tables of, from prac-
 tice, 83.

- Sampling errors, Table of internal, 97.
 „ narrow veins, 70, 105.
 „ out-crop, 42.
 „ parting slips, 80.
 „ pound-footage, 78, 94.
 „ practice, 82.
 „ „ Variation in, 5.
 „ principles, 78.
 „ sections, Distances between,
 43, 45, 78, 111, 112, 113,
 114, 115.
 „ uniformity of cut, 94.
 Scientist and financier, 5.
 Share market, 147.
 Shoot, Capitalisation of, 64.
 Shoot extension, 3, 31, 32, 41, 47, 49,
 61, 63, 65, 66, 67.
 „ and deference factor,
 68, 69.
 „ and geology, 63.
 „ and probability, 53.
 „ and value of ore, 53.
 „ Example of, 67.
 „ Limitations of, 50, 51,
 52.
 Shoot-feet, 75, 76.
 Shoot-length, 50, 51, 52.
 Sinking fund, 116.
 „ tables, 117, 119.
- Sorting, 70.
 „ calculations, 72, 73, 74
 „ Underground, 70.
 Source of income, 10.
 Spanish system, 80.
 Speculation, 1, 8, 15, 144.
 Stope valuation, 79, 80.
 „ widths, 76.
 Stopes, 70.
 „ Flexibility of, 71, 80.
 „ Sorting in, 71.
 Stopping factor, 80, 89.
 „ practice, 80.
 „ value, 73, 76.
- V**
- VALUATION errors, 37.
 „ Premises to sound, 77, 78.
 Value-feet, 83.
 Vein sections, Signing of, 2.
 „ thickness, 99.
 Veins, Narrow, 69, 70.
- W**
- WASTE, 71.



CHARLES GRIFFIN & COMPANY,
LIMITED.

A SELECTION FROM
CHARLES GRIFFIN & CO.'S PUBLICATIONS.

SCIENTIFIC AND TECHNICAL WORKS.



MESSRS. CHARLES GRIFFIN & COMPANY'S PUBLICATIONS may be obtained through any Bookseller in the United Kingdom, or will be sent on receipt of a remittance to cover published price and postage. To prevent delay, Orders should be accompanied by a Cheque or Postal Order crossed "UNION OF LONDON AND SMITH'S BANK, Chancery Lane Branch."

Telephone—
1634 City.

LONDON:

Telegrams—
Explanatus.

12 EXETER STREET, STRAND.

M.T. 64. G-xii.

	PAGE		PAGE
ADAMS (W. P.), Motor Car Mechanism, -	22	LAFAR, Technical Mycology, -	59
AITKEN (T.), Road Making, -	65	LAMBERT, Glue, Gelatine, &c., -	67
ALFORD (C. J.), Mining Law, -	42	LARARD (C. E.), Eng. Calculations, -	26
ALLINGHAM (W.), Meteorology, -	35	LAW (E. F.), Alloys, -	49
ANGLIN (S.), Design of Structures, -	15	LAWN (J. G.), Mine Accounts, -	42
AROBUTT & DEELEY, Lubrication, -	21	LEEDS (F. H.), Acetylene, -	63
ASKLING & ROESSLER, Internal Combustion Engines, -	23	LEVY (D. M.), Copper Smelting, -	51
ATHERTON (Wm.), Design of Beams, -	15	LIECKFELD (G.), Oil Motors, -	2
BARKER (D. W.), Works, by, -	35	LIVERSIDGE, Engine-Room Practice, -	20
BERINGER (J. J. & C.), Assaying, -	51	MACKENZIE (T.), Mechanics, -	36
BICHEL & LARSEN, Explosives, -	43	MACLEOD and WALKER, Met. Chem., -	51
BILES (Prof.), Construction of Ships, -	33	M'LAREN, (R. S.), Elem. Mech. Eng., -	26
BJÖRLING (P. R.), Peat, -	61	McMILLAN (R. A.), Marine Eng. Calc., -	19
BLOUNT & BLOXAM, Chemistry, -	56	McMILLAN (W. G.), Electro-Metallurgy, -	53
BLYTH (A. Wynter), Foods and Poisons, -	57	— & BOROCHERS, Electric Smelting, -	53
BOHLE, Elect. Photography, -	32	McWILLIAM, Foundry Practice, -	54
BOHLE & ROBERTSON, Transformers, -	30	MASSELIION, Celluloid, -	60
BORCHERS (Dr.), Electric Smelting, -	53	MESSUM (S.), Hydrographic Surveying, -	16
BROUGH (B. H.), Mine Surveying, -	41	MIDDLETON (R. E.), Water Supply, -	64
BRUCE (R.), Food Supply, -	45	MILL (Dr. R. H.), New Lands, -	45
BUCK (H. C.), Algebra & Trigonometry, -	36	MILLAR (W. J.), Latitude & Longitude, -	37
BURNS (D.), Colliery Electricity, -	42	MITCHELL (C. A.), Flesh Foods -	57
BUTLER, Works by, -	17, 22	— & HEPWORTH (T. C.), Luks, -	65
BUTTERFIELD, (W. J. A.), Gas, -	63	MORGAN (J. J.), Works by, -	53, 54
CADMAN & HALDANE, Air of Mines, -	39	MUNRO & JAMIESON'S Elect. Pkt.-bk., -	31
CAIN & THORPE, Synthetic Dyestuffs, -	68	MUNRO (R. D.), Works by, -	24
CARTER (H. R.), Long Fibre Spinning, -	69	NAYLOR (W.), Trades' Waste, -	62
CASTELL-EVANS, Chemical Tables -	56	NICHOLSON (W.), Smoke Abatement, -	63
CHATLEY (H.), Works by, -	24, 33	NORMANDY (F.), Sea Water Distillation, -	20
COLE (Prof. G. A. J.), Works by, -	46, 73	NORTH (S.), Oil Fuel, -	55
COLE (W. H.), Light Railways, -	21	OPPENHEIMER (C.), Works by, -	59
COLLINS (H. F.), Lead and Silver, -	49	PARK (J.), Works by, -	41, 44
COSTE (J. H.), Calorific Power of Gas, -	63	PEARCE (W. J.), Painting, -	66
COX (S. H.), Prospecting or Minerals, -	45	PETTIGREW (W. F.), Loco. Eng., -	21
CRAWFORD (W. J.), Graphic Statics, -	27	PHIPSON (Dr. T. L.), Earth's Atmosphere, -	47
CROUCH (A.), Telegraphic Systems, -	31	PÖSCHL (V.), Chemistry of Colloids, -	62
CUNNINGHAM, Docks and Harbours, -	16	POYNTING (J. H.), Mean Density, -	75
DAVEY (H.), Pumping Machinery, -	17	— & THOMSON, Physics, -	76
DAVIS (J. R. A.), Works by, -	72, 91, 92	PRAEGER (R. L.), Open Air Botany, -	73
DIXON (C.), Bird Life, -	73	PUPPE (J.), Rolling Mills, -	24
DONKIN (Bryan), Works, -	22, 23	RAND METALLURGICAL PRACTICE, -	52
DUEBE (Geo.), Bleaching, &c., -	70	RANKINE'S Works, -	29
DUNBAR (Prof.), Sewage Treatment, -	62	RAWSON, GARDNER, & LAYCOCK, Dictionary of Dyestuffs, -	68
DUPRE & HAKE, Manual of Chemistry, -	30	REDGRAVE (G. R.), Cements, -	62
EICHENBORN, Wireless Telegraphy, -	70	REDWOOD (Sir Boverton), Petroleum, -	55
ETHELBERG (R.), Geology, -	46	— & THOMSON, Handbook, Petroleum, -	55
FARNSWORTH, Cons. Steel Work, -	15	REID (Geo., M.D.), Sanitation, -	64
FARBRELL (F. J.), Dyeing and Cleaning, -	15	RICHMOND (H. D.), Works by, -	58
FIDLER (Prof.), Bridge Construction, -	12	RIEMER (J.), Shaft Sinking, -	43
FIELD (E. R.), Mining Report Book, -	42	ROBERTS-AUSTEN, Metallurgy, -	48
FOSTER (Sir F. Le Neve), Works by, -	39	ROBINSON (Prof.), Hydraulics, -	17
GAIRNS (J. E.), Loco. Compounding, -	21	ROSE (T. L.), Gold Metallurgy of, -	48
GATEHOUSE (F.), Cement Handbook -	62	ROTHWELL (C. F. S.), Textile Printing, -	70
GINSBURG (Dr.), Shipmasters' Duties, -	61	SCHWARTZ (Dr. von), Fire Risks, -	63
GISSING (E. T.), Peat, -	61	SEARLE (A. B.), Works by, -	61
GOLDING (H. A.), Works by, -	26	SEATON (A. E.), Works by, -	19
GROSSMANN (J.), Chem. Engineering, -	70	SEXTON (Prof.), Works by, -	52, 71
GRUNWALD (J.), Enamelling on Metal, -	53	SHOWELL (P. G.), Navigation Definitions, -	38
GULLIVER (G.), Metallic Alloys, -	53	SINDALL, Paper Technology, -	60
GURDEN (R.), Traverse Tables, -	43	SMITH (C. A.), Suction Gas Plants, -	23
GUTTMANN (O.), Blasting, -	43	SMITH (J. W.), Dustless Roads, -	65
HALDANE (J. S.), Air Analysis, -	39	SMITH (Prof. R. H.), Works by, -	27
HALSE (E.), Spanish Mining Terms, -	42	SMITH (W.), Shipmaster's Medical Help, -	37
HANNAN (W. L.), Textile Fibres, -	70	SOLOMON (H. G.), Electricity Meters, -	30
HARBORD & HALL, Steel, -	50	OLON, Ceramic Literature, -	61
HARRISON (J. W.), Sanitation, -	64	SORSBIE (Lt.-Col.), Geology for Engineers, -	46
HATFIELD (W. H.), Cast Iron, -	51	STEWART (R. W.), Elementary Physics, -	74
HEIL & ESCH, Rubber Goods, -	67	STOCKS (H. B.), Water Analysis, -	60
HEWLETT (G.), Dict. Sea Terms, -	38	STRICKLAND (F.), Petrol Motors, -	22
HEYLIN (H.), Cot. Weavers' Handbook, -	69	SUPLÉE (H. H.), Works by, -	23, 27
HICKS (J. A.), Mineral Oil Testing, -	55	SYKES (Dr. W. J.), Brewing, -	59
HILL (C.), Electric Crane Construction, -	30	TAYLOR (F. N.), Works by, -	18
HOBBS (L.), Engine Design, -	18	TRAILL (T. W.), Boilers, -	20
HOERNES (Lieut.-Col.), Aviation, -	33	TROTMAN (S. R.), Works by, -	67, 69
HUGHES (H. W.), Coal Mining, -	13	TUNZELMANN (G.), Electrical Theory, -	31
HUGHES-GIBB (Mrs.), Works by, -	70	TURNER (Thos.), Works by, -	50, 52, 54
HURST (Chas.), Works by, -	25	WALTON (T.), Works by, -	34
HURST (G. H.), Works by, -	66	WANG (C. Y.), Works by, -	46, 50
INGLE (H.), Agricultural Chemistry, -	58	WEBER (Dr. C. O.), India Rubber -	67
JAGGER (J. E.), Mechanical Drawing, -	55	WELLS (S. H.), Engineering Drawing, -	25
JAMIESON (Prof.), MANUALS, -	28	WIGLEY (T. B.), Jeweller's Art, -	54
JOHNSON (J. C. F.), Getting Gold, -	44	WILLOUGHBY (Dr. E. F.), Milk, -	58
JØRGENSEN (A.), Micro-Organisms, -	58	WILKES, (W. H.), Shipmasters' Duties, -	38
JUDE (A.), Steam Turbine, -	20	WOOD (Francis), Sanitary Engineering, -	64
JULIAN & SMART, Cyaniding, -	44	WORDINGHAM, Electrical Stations, -	31
KASSNER (T.), Gold Seeking, -	44	WRIGHT (Dr. A.) Oils and Fats, -	56
KERR (G. L.), Works by, -	62	YULE (G. U.), Theory of Statistics, -	76
KERSHAW (G. B.), Sewage Disposal, -	40	ZERR (G.), Works by, -	65
KNECHT, Works by, -	68, 69		

FIFTH EDITION, Revised. In Large 8vo. Pp. i-xxiv + 511. With 255 Diagrams, Examples, and Tables, and a Chapter on Foundations. Cloth, 16s.

THE DESIGN OF STRUCTURES:

A Practical Treatise on the Building of Bridges, Roofs, &c.

By S. ANGLIN, C.E.,

Master of Engineering, Royal University of Ireland, late Whitworth Scholar, &c.

"We can unhesitatingly recommend this work not only to the Student, as the BEST TEXT-BOOK on the subject, but also to the professional engineer as an EXCEEDINGLY VALUABLE book of reference."—*Mechanical World*.

In Large Crown 8vo. Cloth. Pp. i-xiv + 236. With 201 Illustrations. 6s. net.

AN INTRODUCTION TO THE DESIGN OF BEAMS, GIRDERS, AND COLUMNS IN MACHINES AND STRUCTURES.

With Examples in Graphic Statics.

By WILLIAM H. ATHERTON, M.Sc., M.I.MECH.E.

"A very useful source of information. . . . A work which we commend very highly."—*Nature*.

FOURTH EDITION, Thoroughly Revised. Royal 8vo. Pp. i-xxx + 456. With 239 Illustrations in the Text, and 13 Lithographic Plates. Handsome Cloth. Price 30s.

A PRACTICAL TREATISE ON BRIDGE-CONSTRUCTION:

Being a Text-Book on the Construction of Bridges in Iron and Steel.

FOR THE USE OF STUDENTS, DRAUGHTSMEN, AND ENGINEERS.

By T. CLAXTON FIDLER, M. INST. C. E.,

Late Prof. of Engineering, University College, Dundee

"The new edition of Mr. Fidler's work will again occupy the same CONSPICUOUS POSITION among professional text-books and treatises as has been accorded to its predecessors. SOUND, SIMPLE, AND FULL."—*The Engineer*.

In Medium 8vo. Pp. i-xv + 248. With 103 Illustrations. Price 10s. 6d. net.

CONSTRUCTIONAL STEELWORK:

Being Notes on the Practical Aspect and the Principles of Design, together with an Account of the Present Methods and Tools of Manufacture.

By A. W. FARNSWORTH,

Associate Member of the Institute of Mechanical Engineers.

A worthy volume, which will be found of much assistance. . . . A book of particular value."—*Practical Engineer*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

SECOND EDITION, Revised. In Large 8vo. Handsome Cloth, Gilt.
With 37 Folding Plates and nearly 500 Illustrations in
the Text. 30s. net.

The Principles and Practice of DOCK ENGINEERING.

BY BRYSSON CUNNINGHAM.

GENERAL CONTENTS.

Historical and Discursive.—Dock Design.—Constructive Appliances —
Materials.—Dock and Quay Walls.—Entrance Passages and Locks.—
Jetties, Wharves, and Piers.—Dock Gates and Caissons.—Transit Sheds
and Warehouses.—Dock Bridges.—Graving and Repairing Docks.—
Working Equipment of Docks.—INDEX.

"We have never seen a more profusely-illustrated treatise. It is a most important
standard work, and should be in the hands of all dock and harbour engineers."—*Steamship*.
"Will be of the greatest service to the expert as a book of reference."—*Engineer*.

In Large 8vo. Pp. i-xii + 283. With 18 Plates, 11 Tables, and 220
Illustrations in the Text. 16s. net.

A COMPANION VOLUME TO "DOCK ENGINEERING."

THE PRINCIPLES AND PRACTICE OF HARBOUR ENGINEERING.

BY BRYSSON CUNNINGHAM.

CONTENTS.—Introductory.—Harbour Design.—Surveying, Marine and
Submarine.—Piling.—Stone, Natural and Artificial.—Breakwater Design.—
Breakwater Construction.—Pierheads, Quays, and Landing Stages.—
Entrance Channels.—Channel Demarcation.—INDEX.

"The best and most complete book we have seen on the subject."—*Steamship*.
"This is a standard work . . . sure to prove a valuable book of reference."—
Shipping World.

In Crown 8vo. Handsome Cloth. Pp. i-xiv + 504. With many Illus-
trations, including 7 Coloured and 15 Other Plates. 12s. net.

HYDROGRAPHIC SURVEYING.

For the Use of Beginners, Amateurs, and Port and
Harbour Masters.

BY COMMANDER S. MESSUM, R.N.,

Instructor in Nautical Surveying, R.N. College, Greenwich.

CONTENTS.—Sextant.—Protractor.—Station Pointer.—Theodolite.—Projections.—
Symbols and Abbreviations.—Plotting and Triangulation of a Small Plan.—Mast-head
Angle Survey.—Meridian Distances.—APPENDIX.—INDEX.

"Eminently practical from beginning to end."—*Engineer*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

THIRD EDITION, *Thoroughly Revised and Enlarged.* Pp. i-xvi + 227.
 With 60 Plates and 71 other Illustrations. Handsome Cloth. 25s. net.

HYDRAULIC POWER AND HYDRAULIC MACHINERY.

By HENRY ROBINSON, M.INST.C.E., F.G.S.,

FELLOW OF KING'S COLLEGE, LONDON; PROF. EMERITUS OF CIVIL ENGINEERING,
 KING'S COLLEGE, ETC., ETC.

CONTENTS—Discharge through Orifices.—Flow of Water through Pipes.—Accumulators.—Presses and Lifts.—Hoists.—Rams.—Hydraulic Engines.—Pumping Engines.—Capstans.—Traversers.—Jacks.—Weighing Machines.—Riveters and Shop Tools.—Punching, Shearing, and Flanging Machines.—Cranes.—Coal Discharging Machines.—Drills and Cutters.—Pile Drivers, Excavators, &c.—Hydraulic Machinery applied to Bridges, Dock Gates, Wheels and Turbines.—Shields.—Various Installations.—Meters.—INDEX.

"The standard work on the application of water power."—*Cassier's Magazine.*

Second Edition, Greatly Enlarged. Pp. i-xiv + 336. With Frontispiece,
 12 Plates, and 279 other Illustrations. 21s. net.

THE PRINCIPLES AND CONSTRUCTION OF PUMPING MACHINERY (STEAM AND WATER PRESSURE).

With Practical Illustrations of ENGINES and PUMPS applied to MINING,
 TOWN WATER SUPPLY, DRAINAGE of Lands, &c., also Economy
 and Efficiency Trials of Pumping Machinery.

By HENRY DAVEY, M.INST.C.E., M.INST.MECH.E., &C.

CONTENTS—Early History of Pumping Engines—Steam Pumping Engines—Pumps and Pump Valves—General Principles of Non-Rotative Pumping Engines—The Cornish Engine, Simple and Compound—Types of Mining Engines—Pit Work—Shaft Sinking—Hydraulic Transmission of Power in Mines—Electric Transmission of Power—Valve Gears of Pumping Engines—Water Pressure Pumping Engines—Water Works Engines—Pumping Engine Economy and Trials of Pumping Machinery—Centrifugal and other Low-Lift Pumps—Hydraulic Rams, Pumping Mains, &c.—INDEX.

"By the 'one English Engineer who probably knows more about Pumping Machinery than ANY OTHER.' . . . A VOLUME RECORDING THE RESULTS OF LONG EXPERIENCE AND STUDY."—*The Engineer.*

In Medium Svo. Cloth. With about 300 Illustrations.

MODERN PUMPING AND HYDRAULIC MACHINERY.

By EDWARD BUTLER, M.I.Mech.E.

(Author of "Carburettors, Vaporisers, and Distributing Valves.")

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

In Medium 8vo. With over 1000 Illustrations. Cloth. 25s. net.

A MANUAL OF CIVIL ENGINEERING PRACTICE,

Specially Arranged for the Use of Municipal and County Engineers.

By F. NOEL TAYLOR, CIVIL ENGINEER.

CONTENTS.—Ordnance Maps.—Chain Surveying.—Surveying with Angular Instruments.—Levelling.—Adjustment of Instruments.—Mensuration of Areas, Volumes, &c.—The Mechanics of Engineering, &c.—Beams.—Pillars, Stanchions and Shafting.—Design of Structure.—Arches.—Graphic Statics.—Materials of Construction.—Engineering Foundations.—Brickwork and Masonry.—Walls.—Constructional Carpentering.—Road Materials.—Road Construction.—Reinforced Concrete Construction.—Masonry Bridges and River Work.—Hydraulics.—Land Drainage.—Pumping Machinery and Stations.—The Use of Water-Power.—Main Drainage.—Sewage Disposal.—Royal Commission on Sewage Disposal.—Salford Sewage Works.—Sanitation, House Drainage and Disinfection.—Refuge Disposal.—Waterworks, Preliminary Considerations and Sources of Supply.—Construction, Filtration and Purification.—Water-works.—Distribution.—Chimneys, Brick and Steel.—Steel Construction; Stanchions, Rivets and Bolts.—Steel Construction; Beams and Girders.—Combined Structures in Iron and Steel.—Specification.—Electric Tramways.—Appendix.—INDEX.

“A veritable *vade mecum* . . . would prove an acquisition to the library of any Municipal Engineer.”—*Surveyor*.

In Medium 8vo. Fully Illustrated. Cloth.

THE MAIN DRAINAGE OF TOWNS.

By F. NOEL TAYLOR, Civil Engineer.

CONTENTS.—Maps, Plans, Sections, and Preliminary Considerations.—Principles of Hydraulics and Hydrostatics.—Calculations in reference to Design of Sewage Works.—Practical Construction, Trenches, and Tunnels.—Forms of Sewers.—Ventilation of Sewers.—Manholes, Lampholes, Storm Overflows, etc.—Pumping Sewage.—House Drainage.—Sewage Disposal from a Theoretical Standpoint.—Sewage Disposal Works.—Special Constructions.—TABLES.—INDEX.

In Medium 8vo. Handsome Cloth. With 116 Illustrations. 15s. net.

MODERN DESTRUCTOR PRACTICE.

By W. FRANCIS GOODRICH, Assoc. Inst. C.E.,
F.I. San. Engrs., &c.

CONTENTS.—Some Alternative Methods of Refuse Disposal.—Representative Types of British Destructors.—Systems of Charging Destructors.—Destructors combined with Sewage Works.—With Electricity Works.—Refuse Destruction in U.K.—Site.—Specifications.—Design and Operation.—Operative Costs.—Residuals.—Foreign and Colonial Practice.—INDEX.

In Crown Quarto. Handsome Cloth. Illustrated. 8s. 6d. net.

Building Construction in Earthquake Countries.

Translated from the Italian of ING. ALFREDO MONTEL.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

SEVENTEENTH EDITION. Thoroughly Revised Throughout, and Greatly Enlarged. Large 8vo. Cloth. Profusely Illustrated.

**A MANUAL OF
MARINE ENGINEERING :**
COMPRISING THE DESIGNING, CONSTRUCTION, AND
WORKING OF MARINE MACHINERY.

By **A. E. SEATON, M.I.C.E., M.I.Mech.E., M.I.N.A.**

GENERAL CONTENTS.—PART I.—Principles of Marine Propulsion.
PART II.—Principles of Steam Engineering. PART III.—Details of
Marine Engines: Design and Calculations for Cylinders, Pistons, Valves,
Expansion Valves, &c. PART IV.—Propellers. PART V.—Boilers.
PART VI.—Miscellaneous.

"The Student, Draughtsman, and Engineer will find this work the **MOST VALUABLE**
HANDBOOK of Reference on the Marine Engine now in existence."—*Marine Engineer*

TENTH EDITION, Thoroughly Revised. Pocket-Size, Leather. 8s. 6d.

**A POCKET-BOOK OF
MARINE ENGINEERING RULES AND TABLES,**
FOR THE USE OF
**Marine Engineers, Naval Architects, Designers, Draughtsmen,
Superintendents and Others.**

By **A. E. SEATON, M.I.C.E., M.I.Mech.E., M.I.N.A.,**

AND

H. M. ROUNTHWAITE, M.I.Mech.E., M.I.N.A.

"The best book of its kind, and the information is both up-to-date and reliable. —
Engineer

In Large 8vo. Handsome Cloth. With Frontispiece, 6 Plates,
65 other Illustrations, and 60 Tables. 12s. 6d. net.

THE SCREW PROPELLER

And other Competing Instruments for Marine Propulsion.

By **A. E. SEATON, M.Inst.C.E., M.I.Mech.E., M.I.N.A.**

"Contains all that is useful to know about the screw propeller. . . . Thoroughly
up-to-date."—*Steamship*.

In Demy 8vo. Cloth. Fully Illustrated.

**CALCULATIONS FOR MARINE ENGINEERS,
AS REQUIRED AT BOARD OF TRADE EXAMS.,**

Including Use of Logarithms.

By **R. A. McMILLAN, B.Sc., Wh.Ex., EXTRA 1ST CLASS
ENGINEER (B.O.T.),**

Head of the Engineering Department, Bootle Technical School.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET STRAND

SECOND EDITION, Revised and Enlarged. Pp. i-xv + 425.
With 377 Illustrations and 3 Folding Plates. 18s. net.

THE THEORY OF THE STEAM TURBINE.

A Treatise on the Principles of Construction of the Steam Turbine,
with Historical Notes on its Development.

By ALEXANDER JUDE.

CONTENTS—Fundamental.—Historical Notes on Turbines.—The Velocity of Steam.—Types of Steam Turbines.—Practical Turbines.—The Efficiency of Turbines, Type I.—Trajectory of the Steam.—Efficiency of Turbines, Types II., III. and IV.—Turbine Vanes.—Disc and Vane Friction in Turbines.—Specific Heat of Superheated Steam.—Strength of Rotating Discs.—Governing Steam Turbines.—Steam Consumption of Turbines.—The Whirling of Shafts.—Speed of Turbines.—INDEX.

"One of the latest text-books . . . also one of the best . . . there is absolutely no padding."—*Sir William White* in the *Times* Engineering Supplement.

SEVENTH EDITION, Revised. Large Crown 8vo. Pp. i-xi + 394. With
5 Plates and 110 Illustrations in Text. 6s. net.

ENGINE-ROOM PRACTICE;

A Handbook for Engineers and Officers in the Royal Navy and Mercantile
Marine, including the Management of the Main and Auxiliary
Engines on Board Ship.

By JOHN G. LIVERSIDGE, ENGR.-COMM. R.N., A.M.I.C.E.

"This VERY USEFUL BOOK. . . ILLUSTRATIONS are of GREAT IMPORTANCE in a work of this kind, and it is satisfactory to find that SPECIAL ATTENTION has been given in this respect."—*Engineers' Gazette*.

In Large Crown 8vo. Cloth. Pp. i-xxviii + 244. With 25 Illustrations. 6s. net.

SEA WATER DISTILLATION.

By FRANK NORMANDY, of the Middle Temple, Barrister-at-Law.

CONTENTS.—Distilling Machinery.—Sea Water.—Steam.—Multiple Distillation.—The Evaporator.—The Distilling Condenser.—Pumping Machinery.—Useful Memoranda.—The Filter, Prevention of Corrosion and Decay of Metals, Removal of Scale, Cleaning, Overhauling, &c.—INDEX.

"The analytical treatment of the problem is concise and comprehensive in its scope."
—*Marine Engineer*.

FOURTH EDITION, Revised. Pocket-Size, Leather. Pp. i-xiii + 583.
12s. 6d.

BOILERS, MARINE AND LAND: THEIR CONSTRUCTION AND STRENGTH.

A HANDBOOK OF RULES, FORMULÆ, TABLES, &c., RELATIVE TO MATERIALS,
SCANTLINGS, AND PRESSURES, SAFETY VALVES, SPRINGS,
FITTINGS AND MOUNTINGS, &c.

FOR THE USE OF ENGINEERS, SURVEYORS, BOILER-MAKERS,
AND STEAM USERS.

By T. W. TRAILL, M. INST. O. E., F. E. R. N.,

Late Engineer Surveyor-in-Chief to the Board of Trade.

"Contains an ENORMOUS QUANTITY OF INFORMATION arranged in a very convenient form. . . A MOST USEFUL VOLUME . . . supplying information to be had nowhere else."—*The Engineer*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND

THIRD EDITION, Revised. Pp. i-xv+356. With Frontispiece, 8 Plates and 218 Illustrations in the Text. 21s.

A MANUAL OF LOCOMOTIVE ENGINEERING:

A Practical Text-Book for the Use of Engine Builders,
Designers and Draughtsmen, Railway
Engineers, and Students.

By WILLIAM FRANK PETTIGREW, M.INST.C.E.

Contents.—Historical Introduction, 1763-1863.—Modern Locomotives: Simple.—Modern Locomotives: Compound.—Primary Consideration in Locomotive Design.—Cylinders, Steam Chests, and Stuffing Boxes.—Pistons, Piston Rods, Crossheads, and Slide Bars.—Connecting and Coupling Rods.—Wheels and Axles, Axle Boxes, Hornblocks, and Bearing Springs.—Balancing.—Valve Gear.—Slide Valves and Valve Gear Details.—Framing, Bogies and Axle Trucks, Radial Axle Boxes.—Boilers.—Smokebox, Blast Pipe, Firebox Fittings.—Boiler Mountings.—Tenders.—Railway Brakes.—Lubrication.—Consumption of Fuel, Evaporation and Engine Efficiency.—Repairs, Running, Inspection, and Renewals.—Three Appendices.—Index.

"The work CONTAINS ALL THAT CAN BE LEARNED from a book upon such a subject. It will at once rank as the STANDARD WORK UPON THIS IMPORTANT SUBJECT."—*Railway Magazine.*

In Large 8vo. Pp. i-xxi+189. With Frontispiece and 148 other Illustrations. 8s. 6d. net.

LOCOMOTIVE COMPOUNDING AND SUPERHEATING.

By J. F. GAIRNS.

In Large 8vo. Handsome Cloth. Pp. i-xi+339. With 9 Plates. 16s.

LIGHT RAILWAYS AT HOME AND ABROAD.

By WILLIAM HENRY COLE, M.INST.C.E.,

Late Deputy-Manager, North-Western Railway, India.

"The whole subject is EXHAUSTIVELY and PRACTICALLY considered. The work can be cordially recommended as INDISPENSABLE to those whose duty it is to become acquainted with one of the prime necessities of the immediate future."—*Railway Official Gazette.*

THIRD EDITION, Revised and Enlarged. Large 8vo, Handsome Cloth. 25s. net.

Lubrication & Lubricants:

A Treatise on the Theory and Practice of Lubrication, and on the Nature, Properties, and Testing of Lubricants.

BY
LEONARD ARCHBUTT, F.I.C., F.C.S.,
Chemist to the Mid. Ry. Co.

AND
R. M. DEELEY, M.I.Mech.E., F.G.S.,
Late Chief Loco. Super., Mid. Ry. Co.

CONTENTS.—I. Friction of Solids.—II. Liquid Friction or Viscosity, and Plastic Friction.—III. Superficial Tension.—IV. The Theory of Lubrication.—V. Lubricants, their Sources, Preparation, and Properties.—VI. Physical Properties and Methods of Examination of Lubricants.—VII. Chemical Properties and Methods of Examination of Lubricants.—VIII. The Systematic Testing of Lubricants by Physical and Chemical Methods.—IX. The Mechanical Testing of Lubricants.—X. The Design and Lubrication of Bearings.—XI. The Lubrication of Machinery.—INDEX.

"A most valuable and comprehensive treatise on a subject of the greatest importance to engineers."—*Engineering.*

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND

In Crown 8vo, Handsome Cloth. Very Fully Illustrated.

MOTOR-CAR MECHANISM AND MANAGEMENT.

By W. POYNTER ADAMS, M. Inst. E. E.

PART I.—THE PETROL CAR. 5s. net.

THIRD EDITION. Revised and Greatly Enlarged.

"Should be carefully studied by those who have anything to do with motors."—*Automobile and Carriage Builders' Journal*.

**PART II.—ELECTRICAL AND PETROL ELECTRICAL
MOTOR CARS.** 5s. net.

Pp. i-x + 202. With 50 Illustrations, including Frontispiece and
3 Plates, contains also 13 page Glossary.

"Cleverly written . . . will be found of considerable value."—*Practical Engineer*

In Large 8vo. Handsome Cloth. Pp. i.ix + 376. With 12 Folding
Tables and 329 Illustrations. 18s. net

A MANUAL OF PETROL MOTORS AND MOTOR-CARS.

Comprising the Designing, Construction, and Working of Petrol Motors.

By F. STRICKLAND.

"Thoroughly practical and scientific. . . . We have pleasure in recommending it to all."
—*Mechanical Engineer*.

In Medium 8vo. Handsome Cloth. Pp. i-xv + 272. With 306
Illustrations. 15s. net.

OIL MOTORS.

Their Development, Construction, and Management.

By G. LIECKFELD. (Authorised English Edition).

CONTENTS.—Liquid Fuels for Power Production.—Development of the Petrol and
Paraffin Motors.—Working of the Later Paraffin and Petrol Engines.—Ignition Devices.
—Examples of Stationary Petrol, Alcohol, Paraffin, and Crude Oil Engines.—Automobiles.
—Ship Boat, and Air-ship Engines.—Vehicles, &c., Driven by Internal Combustion
Engines.—Erection and Attendance of Engines Driven with Liquid Fuel.—Correcting
Irregularities in Running.

"One of the most comprehensive publications we have perused, and one that can be
thoroughly recommended."—*Petroleum Review*.

In Medium 8vo. Handsome Cloth. Fully Illustrated.

THE GAS TURBINE, Theory, Construction, and Working Results of Two Machines in Actual Use.

By HANS HOLZWARTH.

Translated by A. P. CHALKLEY, B.Sc.

In Demy 8vo. Handsome Cloth. Pp. i-xi + 176. With
130 Illustrations. 6s. net.

CARBURETTORS, VAPORISERS, & VALVES, *used in Internal Combustion Engines.*

By EDWARD BUTLER, M.I.Mech. E.

"Mr. Butler writes with an intimate practical knowledge of his subject, and the book
is one we have every pleasure in recommending."—*Mechanical Engineer*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND

FIFTH EDITION, Revised and Enlarged. With additional Illustrations.
Large 8vo, Handsome Cloth. 25s. net.

A TEXT-BOOK ON GAS, OIL, AND AIR ENGINES.

By BRYAN DONKIN, M.INST.C.E., M.INST.MECH.E.

Revised throughout by T. GRAVES SMITH. With important New Matter
by Prof. BURSTALL.

"A very much up-to-date classic."—*Daily Telegraph*.

In Quarto, Handsome Cloth. With Numerous Plates. 25s.

THE HEAT EFFICIENCY OF STEAM BOILERS (LAND, MARINE, AND LOCOMOTIVE).

With Tests and Experiments on Different Types, Heating Value of Fuels.
Analyses of Gases, Evaporation, and Suggestions for Testing Boilers.

By BRYAN DONKIN, M.INST.C.E.

"Probably the MOST EXHAUSTIVE *resumé* that has ever been collected. A PRACTICAL
Book by a thoroughly practical man."—*Iron and Coal Trades Review*.

In Handsome Cloth. Fully Illustrated Throughout. 12s. 6d. net.

Internal Combustion Engines and Gas Producers.

By C. W. ASKLING, M.E., AND E. ROESLER, M.E.

CONTENTS.—Comparison of Internal Combustion and other Heat Engines—The
Production, Preparation, Composition, and Qualities of Fuels used in Gas and Oil Engines.
—Gas Producers, with Accessories: General Principles of Design.—Management of
Suction-Gas Plant.—Producers for Power Purposes.—Principal Cycles of Internal Com-
bustion Engines.—Gas Engines.—Oil Engines.—Combustion.—INDEX.

In Large Crown 8vo. Cloth. Pp. i-vii+198. With 55 Illustrations.
5s. net.

SUCTION GAS PLANTS.

By PROF. C. A. SMITH, of the East London Technical College.

"This book is one we can cordially recommend as affording a complete knowledge of
the theoretical aspect of Suction Plants."—*Gas World*.

In Handsome Cloth. Pp. i-iv+262. With 93 Illustrations. 12s. 6d. net.

THE GAS TURBINE.

Progress in the Design and Construction of Turbines
Operated by Gases of Combustion.

By HENRY HARRISON SUPLEE, B.Sc.

"Will be of considerable assistance to gas power engineers."—*Gas World*

In Large Crown 8vo. Handsome Cloth. 4s. 6d. net.

THE THERMO-DYNAMIC PRINCIPLES OF ENGINE DESIGN.

By LIONEL M. HOBBS,

Engineer-Lieutenant, R.N.; Instructor in Applied Mechanics and Marine Engine
Design at the Royal Naval College, Greenwich.

"Serves its purpose admirably . . . should prove of invaluable service . . . well
up-to-date."—*Shipping World*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

In Crown 8vo, Cloth. Illustrated with Diagrams. 3s. net.

THE FORCE OF THE WIND.

By HERBERT CHATLEY, B.Sc. ENG. (LOND.),

Professor of Civil Engineering, Tong Shan Engineering College, N. China.

CONTENTS. — Practical Importance of Wind Pressure. — Impulsive Force of the Wind. — Variations in Velocity. — Stream Line Theory. — Stress in Structures due to Wind. — Windmills. — Train and Motor Resistance. — Effect of Wind on Water. — Scouring Effect of Wind. — INDEX.

"Could not well be more terse or pointed."—*Symon's Meteorological Magazine.*

In Crown 8vo. Handsome Cloth. With 22 Diagrams. 3s. 6d. net.

STRESSES IN MASONRY.

By HERBERT CHATLEY, B.Sc. ENG. (LOND.).

CONTENTS. — Strength of Stone. — Walls. — Columns and Piers. — Brackets and Cantilevers. — Simple Arches. — Vaults and Skew Arches. — Domes. — Retaining Walls and Domes. — Artificial Stone. — Re-inforced Concrete. — INDEX.

"A most useful aid to surmounting the difficulties which this subject presents."—*Surveyor.*

In Handsome Cloth. With 11 Folding Tables. 12s. 6d. net.

EXPERIMENTAL INVESTIGATIONS ON THE POWER REQUIRED TO DRIVE ROLLING MILLS.

TRANSLATED FROM THE GERMAN OF J. PUPPE.

"The thoroughness with which the work is undertaken is exemplified in the Tables."—*Ironmonger.*

FIFTH EDITION. Pp. i-xii+157. With 50 Illustrations. Cloth, 4s. 6d.

STEAM - BOILERS; THEIR DEFECTS, MANAGEMENT, AND CONSTRUCTION.

By R. D. MUNRO,

Chief Engineer of the Scottish Boiler Insurance and Engine Inspection Company.

"A valuable companion for workmen and engineers engaged about Steam Boilers, ought to be carefully studied, and ALWAYS AT HAND."—*Coll. Guardian.*

By THE SAME AUTHOR.

KITCHEN BOILER EXPLOSIONS: Why they Occur, and How to Prevent their Occurrence. A Practical Handbook based on Actual Experiment. With Diagram and Coloured Plate. 3s.

In Crown 8vo, Cloth. Pp. i-xii+180. With 143 Illustrations. 5s. net.

EMERY GRINDING MACHINERY.

A Text-Book of Workshop Practice in General Tool Grinding, and the Design, Construction, and Application of the Machines Employed.

By R. B. HODGSON, A.M.INST.MECH.E.

"Eminently practical . . . cannot fail to attract the notice of the users of this class of machinery, and to meet with careful perusal."—*Chem. Trade Journal.*

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

In Crown Quarto. Cloth. With 126 Figures, 88 Drawings, and sample Blue and White Prints, also Tracing. 10s. 6d. net.

AN ELEMENTARY TEXT-BOOK ON
MECHANICAL DRAWING.

By JOHN E. JAGGER, M.Sc.(VIC.), WHIT. SCH.

"An admirable book . . . all the information it contains is of a thoroughly practical kind, and the numerous engravings accompanying the text cannot be praised too highly."—*Engineer*.

SIXTH EDITION, Thoroughly Revised and Greatly Enlarged. Pp. i-x + 291.
With 12 Plates and 262 other Illustrations. Price 9s. net.

VALVES AND VALVE-GEARING:

A Practical Text-book for the use of Engineers, Draughtsmen, and Students.

By CHARLES HURST, PRACTICAL DRAUGHTSMAN.

PART I.—Steam Engine Valves.

PART II.—Gas Engine Valves and Gears.

PART III.—Air Compressor Valves and Gearing.

PART IV.—Pump Valves.

PART V.—Safety and Relief Valves.

"MR. HURST'S VALVES AND VALVE-GEARING will prove a very valuable aid, and tend to the production of Engines of SCIENTIFIC DESIGN and ECONOMICAL WORKING. . . . Will be largely sought after by Students and Designers."—*Marine Engineer*.

"As a practical treatise on the subject, the book stands without a rival."—*Mechanical World*.

Hints on Steam Engine Design and Construction. By CHARLES HURST, "Author of Valves and Valve Gearing." SECOND EDITION, Revised. In Paper Boards, 8vo., Cloth Back. Pp. i-vi + 62. With 32 Illustrations. Price 1s. 6d. net.

CONTENTS.—I. Steam Pipes.—II. Valves.—III. Cylinders.—IV. Air Pumps and Condensers.—V. Motion Work.—VI. Crank Shafts and Pedestals.—VII. Valve Gear.—VIII. Lubrication.—IX. Miscellaneous Details.—INDEX.

"A handy volume which every practical young engineer should possess."—*The Model Engineer*

FIFTH EDITION. In Two Parts, Published Separately.

A TEXT-BOOK OF
Engineering Drawing and Design.

By SIDNEY H. WELLS, WH.Sc., A.M.I.C.E., A.M.I.MECH.E.

VOL. I.—PRACTICAL GEOMETRY, PLANE, AND SOLID.

Pp. i-xi + 149. With 101 Illustrations, and an Appendix of 43 pages with 70 Illustrations. 4s. 6d.

VOL. II.—MACHINE AND ENGINE DRAWING AND DESIGN.

Pp. i-xi + 321. With over 200 Illustrations. 4s. 6d.

"A CAPITAL TEXT BOOK, arranged on an EXCELLENT SYSTEM, calculated to give an intelligent grasp of the subject, and not the mere faculty of mechanical copying. . . . Mr. Wells shows how to make COMPLETE WORKING-DRAWINGS, discussing fully each step in the design."—*Electrical Review*

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

SECOND EDITION, Enlarged. In Crown 8vo. Cloth. Pp. i-xiii + 463.
With 212 Illustrations. 6s. net.

PRACTICAL CALCULATIONS FOR ENGINEERS.

BY CHARLES E. LARARD,

A.M.Inst.C.E., M.I.Mech.E., Wh.Exh.,
Head of the Mechanical Engineering Department at the Northampton Institute, London, E.C.

AND H. A. GOLDING, A.M.I.Mech.E.

"Exactly what it should be in order to make it useful to students and practitioners of engineering."—*Manchester Guardian*.

SECOND EDITION. In Crown 8vo. Cloth. Pp. xiii + 302.
With 125 Illustrations. 5s. net.

MECHANICAL ENGINEERING FOR BEGINNERS.

By R. S. M'LAREN.

CONTENTS.—Materials.—Bolts and Nuts, Studs, Set Screws.—Boilers.—Steam Raising Accessories.—Steam Pipes and Valves.—The Steam Engine.—Power Transmission.—Condensing Plant.—The Steam Turbine.—Electricity.—Hydraulic Machinery.—Gas and Oil Engines.—Strength of Beams, and Useful Information.—INDEX.

"The best of its kind we have seen, and should be in the hands of every apprentice."
—*Steamship*.

SIXTH EDITION. Folio, strongly half-bound, 21s.

TRAVERSE TABLES:

Computed to Four Places of Decimals for every Minute of Angle
up to 100 of Distance.

For the Use of Surveyors and Engineers.

BY RICHARD LLOYD GURDEN,

Authorised Surveyor for the Governments of New South Wales and Victoria.

* * * Published with the Concurrence of the Surveyors-General for New South
Wales and Victoria.

"Those who have experience in exact SURVEY-WORK will best know how to appreciate the enormous amount of labour represented by this valuable book. Every Surveyor in active practice has felt the want of such assistance FEW KNOWING OF THEIR (the Tables) PUBLICATION WILL REMAIN WITHOUT THEM."—*Engineer*.

Strongly Bound in Super Royal 8vo. Cloth Boards. 7s. 6d. net.

BONUS TABLES:

For Calculating Wages on the Bonus or Premium Systems.

For Engineering, Technical and Allied Trades.

BY HENRY A. GOLDING, A.M.I.MECH.E.,

"Cannot fail to prove practically serviceable to those for whom they have been designed."—*Scotsman*.

HORSE-POWER COMPUTERS.

BY H. A. GOLDING, A.M.I.MECH.E., A.M.I.A.E.

For Steam, Gas, and Oil Engines. Complete with Explanatory
Pamphlet. In Box. 5s. net.

For Petrol Motors. Complete with Explanatory Pamphlet. In
Envelope. 6d. net.

Detailed Prospectus on Application.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

SECOND EDITION, *Revised. In Crown 8vo, extra, with Diagrams and Folding-Plate. 7s. 6d. net.*

THE CALCULUS FOR ENGINEERS AND PHYSICISTS,

INTEGRATION AND DIFFERENTIATION,

With Applications to Technical Problems;

AND

CLASSIFIED REFERENCE LIST OF INTEGRALS.

By PROF. ROBERT H. SMITH, A.M. INST. C.E., M.I. MECH. E., &c.

"Interesting diagrams, with practical illustrations of actual occurrence, are to be found here in abundance. THE VERY COMPLETE CLASSIFIED REFERENCE TABLE will prove very useful in saving the time of those who want an integral in a hurry."—*The Engineer*.

In 4to, Boards. 7s. 6d.

MEASUREMENT CONVERSIONS

(English and French):

43 GRAPHIC TABLES OR DIAGRAMS, ON 28 PLATES.

Showing at a glance the MUTUAL CONVERSION of MEASUREMENTS in DIFFERENT UNITS

Of Lengths, Areas, Volumes, Weights, Stresses, Densities, Quantities of Work, Horse Powers, Temperatures, &c.

For the use of Engineers, Surveyors, Architects, and Contractors.

By PROF. ROBERT H. SMITH, A.M. INST. C.E., M.I. MECH. E., &c.

THIRD EDITION. Pocket Size, Leather Limp, with Gilt Edges and Rounded Corners, printed on Special Thin Paper, with Illustrations, pp. i-xii + 834. Price 18s. net.

THE MECHANICAL ENGINEER'S REFERENCE BOOK.

By HENRY HARRISON SUPLEE, B.Sc., M.E.

"We feel sure it will be of great service to mechanical engineers."—*Engineering*.

In Crown 8vo. Handsome Cloth. Profusely Illustrated. 2s. 6d. net.

ELEMENTARY GRAPHIC STATICS.

By W. J. CRAWFORD, D.Sc.,

Lecturer in Mechanical Engineering, The Municipal Technical Institute, Belfast.

ABRIDGED CONTENTS.—Introduction.—Some Easily Performed Experiments to Illustrate the Simple Laws of Graphic Statics.—Miscellaneous Examples.—Parallel Forces and Moments of Forces.—The Funicular or Link Polygon.—Solution of Frameworks Having External Loads.—The Force of Gravity.—The Use of Graphic Statics to find Bending Moments and Shearing Forces.—Some Miscellaneous Practical Problems.—APPENDIX.

With Diagrams. Crown 8vo. Cloth, 4s. 6d.

THE STUDENT'S MECHANICS:

An Introduction to the Study of Force and Motion.

By WALTER R. BROWNE, M.A., M. INST. C.E.

"Clear in style and practical in method, 'THE STUDENT'S MECHANICS' is cordially recommended from all points of view."—*Athenaeum*.

By THE SAME AUTHOR.

FOUNDATIONS OF MECHANICS

Papers reprinted from the *Engineer*. In Crown 8vo, 1s.

WORKS BY

ANDREW JAMIESON, M.INST.C.E., M.I.E.E., F.R.S.E.,
Formerly Professor of Electrical Engineering, The Glas. and W. of Scot. Tech. Coll.

PROFESSOR JAMIESON'S ADVANCED TEXT-BOOKS.

In Large Crown 8vo. Fully Illustrated.

STEAM AND STEAM-ENGINES, INCLUDING TURBINES

AND BOILERS. For the Use of Engineers and for Students preparing for Examinations. With over 800 pp., over 400 Illustrations, 12 Plates, many B. of E., C. and G., Questions and Answers, and all Inst. C.E. Exams. on *Theory of Heat Engines*. Volume I. SEVENTEENTH EDITION, Revised. 10s. 6d.

"The BEST BOOK yet published for the use of Students."—*Engineer*.

Volume II., dealing with Entropy; Air, Gas, Oil, and other Heat Engines. *At Press.*

APPLIED MECHANICS & MECHANICAL ENGINEERING.

In Five Volumes. Large Crown 8vo. *Including All the Inst. C.E. Exams.* in Section A, (1) Applied Mechanics; (2) Strength and Elasticity of Materials; (3a) Theory of Structures; Section B (Group ii.), Hydraulics; Theory of Machines. Also B. of E.; C. and G. Questions.

- VOL. I.—**Applied Mechanics.** EIGHTH EDIT. Pp. i-xviii + 400. 6s.
 ,, II.—**Strength of Materials.** EIGHTH EDIT. Pp. i-xviii + 314. 5s.
 ,, III.—**Theory of Structures.** EIGHTH EDIT. Pp. i-xviii + 232. 5s.
 ,, IV.—**Hydraulics.** EIGHTH EDITION. Pp. i-xvi + 274. 5s.
 ,, V.—**Theory of Machines.** SEVENTH EDIT. Pp. i-xx + 502. 7s. 6d.

. *In Five volumes, each complete in itself, and sold separately.*

PROFESSOR JAMIESON'S INTRODUCTORY MANUALS.

Crown 8vo. With Illustrations and Examination Papers.

HEAT ENGINES: STEAM, GAS AND OIL (Elementary

Manual of). For First-Year Students, forming an Introduction to the Author's larger Work. THIRTEENTH EDITION, Revised and Enlarged. 3/6

"Should be in the hands of EVERY engineering apprentice."—*Practical Engineer*.

MAGNETISM AND ELECTRICITY (Practical Elementary

Manual of). For First-Year Students. With Stud Inst. C.E. and B. of E. Exam. Questions. EIGHTH EDITION, Revised and Enlarged. 3/6

"A THOROUGHLY TRUSTWORTHY Text-book. PRACTICAL and clear."—*Nature*.

APPLIED MECHANICS (Elementary Manual of).

For First-Year Students. With B. of E., C. and G.; and Stud. Inst. C.E. Questions. NINTH EDITION, Revised and Greatly Enlarged. 3/6

"The work has VERY HIGH QUALITIES, which may be condensed into the one word CLEAR."—*Science and Art*.

A POCKET-BOOK of ELECTRICAL RULES and TABLES.

For the Use of Electricians and Engineers. By JOHN MUNRO, C.E., and Prof. JAMIESON. Pocket Size. Leather, 8s. 6d. NINETEENTH EDITION. [See p. 31.]

WORKS BY W. J. MACQUORN RANKINE, LL.D., F.R.S.

Thoroughly Revised by W. J. MILLAR, C.E.

A MANUAL OF APPLIED MECHANICS: Comprising the Principles of Statics and Cinematics, and Theory of Structures, Mechanism, and Machines. With Numerous Diagrams. Crown 8vo, Cloth. EIGHTEENTH EDITION. 12s. 6d.

A MANUAL OF CIVIL ENGINEERING: Comprising Engineering Surveys, Earthwork, Foundations, Masonry, Carpentry, Metal Work, Roads, Railways, Canals, Rivers, Waterworks, Harbours, &c. With Numerous Tables and Illustrations. Crown 8vo, Cloth. TWENTY-FOURTH EDITION. 16s.

A MANUAL OF MACHINERY AND MILLWORK: Comprising the Geometry, Motions, Work, Strength, Construction, and Objects of Machines, &c. With nearly 300 Illustrations. Crown 8vo, Cloth. SEVENTH EDITION. 12s. 6d.

A MANUAL OF THE STEAM-ENGINE AND OTHER PRIME MOVERS. With a Section on GAS, OIL, and AIR ENGINES, by BRYAN DONKIN, M.Inst.C.E. With Folding Plates and Numerous Illustrations. Crown 8vo, Cloth. SEVENTEENTH EDITION. 12s. 6d.

USEFUL RULES AND TABLES: For Architects, Builders, Engineers, Founders, Mechanics, Shipbuilders, Surveyors, &c. With APPENDIX for the use of ELECTRICAL ENGINEERS. By Professor JAMIESON, M.Inst.C.E., M.I.E.E. EIGHTH EDITION. 10s. 6d.

A MECHANICAL TEXT-BOOK: A Practical and Simple Introduction to the Study of Mechanics. By Professor RANKINE and E. F. BAMBER, C.E. With Numerous Illustrations. Crown 8vo, Cloth. FIFTH EDITION. 9s.

. The "MECHANICAL TEXT-BOOK" was designed by Professor RANKINE as an INTRODUCTION to the above Series of Manuals.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

ELECTRICAL ENGINEERING.

SECOND EDITION, Revised. In Large 8vo. Cloth. Pp. i-xvi+496.
With 145 Illustrations, including 7 Plates. 24s. net.

CENTRAL ELECTRICAL STATIONS:

Their Design, Organisation, and Management.

By CHAS. H. WORDINGHAM, A.K.C., M. INST. C.E., M. INST. MECH. E.,
Late Memb. of Council Inst. E. E., and Electrical Engineer to the City of Manchester;
Electrical Engineer-in-Chief to the Admiralty.

"One of the MOST VALUABLE CONTRIBUTIONS to Central Station literature we have had for some time."—*Electricity*.

In Medium 8vo. Pp. i-xx+313. With 366 Figures and 23 Tables.
25s. net.

ELECTRIC CRANE CONSTRUCTION.

By CLAUDE W. HILL, A.M. INST. C.E. M.I.E.E., &c.

CONTENTS.—Overhead Cranes.—Locomotive and Portable Jib Cranes.—Derrick Cranes.—Transporters.—Sheer Legs.—Revolving Cantilever Cranes.—Cableways.—Power required for Crane Driving.—Starting Torque and Acceleration.—Design of Crane Structures.—Design of Machinery.—Brakes.—Toothed Gearing.—Hooks, Lifting Magnets, Ropes and Cranes.—Design of Magnets.—Motors, Controllers and Collectors.—Crane Installations.—INDEX.

"The whole work is straightforward, and may be recommended as being written from a thoroughly engineering point of view."—*Electrical Engineering*.

Large 8vo. Cloth. Pp. i-x+333 and 307 Illustrations. 16s. net.

ELECTRICITY METERS.

By HENRY G. SOLOMON, A.M. INST. E.E.

"An earnest and successful attempt to deal comprehensively with modern methods of measuring current or power in electrical installations."—*Engineering*.

In Large 8vo. Handsome Cloth. Fully Illustrated. 21s. net.

TRANSFORMERS.

By HERMANN BOHLE, M.I.E.E.,
Prof. of Electrotechnics, S.A. College, Cape Town,

AND PROFESSOR DAVID ROBERTSON, B.Sc., A.I.E.E., OF BRISTOL.

CONTENTS.—General Principles.—Magnetising and No-Load Currents.—Losses in Transformers.—Iron Losses.—Copper Losses.—Temperature Rise.—Magnetic Leakage.—Leakage Inductance.—Vector Diagrams for Transformers.—Systematic Testing of Transformers.—Insulating Materials.—Examples of Construction.—Design of Transformers.—Applications of Transformers.—Regulating and Phase-Changing Transformers.—INDEX.

"This very complete treatise . . . model of what technical publications should be."—*Nature*.

In Large 8vo. Pp. i-x+116. With 79 Illustrations. 8s. 6d. net.

WIRELESS TELEGRAPHY.

By GUSTAVE EICHHORN, Ph.D.

"Well written . . . and combines with a good deal of description a careful investigation of the fundamental theoretical phenomena."—*Nature*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

In Large Crown 8vo. Cloth. Pp. i-xvi + 268. With 222 Illustrations.
5s. net.

TELEGRAPHIC SYSTEMS, AND OTHER NOTES.

A Handbook of the Principles on which Telegraphic Practice is Based.

By ARTHUR CROTCH, of the Engineer-in-Chief's Department, G.P.O.

CONTENTS.—Batteries, Primary and Secondary.—Universal Battery Working, Duplex Telegraphy.—Duplex and Quadruplex Telegraphy.—Automatic Telegraphy.—Multiplex Telegraphy.—The Hughes Type Printing Instrument.—The Bandot System.—The Murray Type Printing Telegraph.—Test and Battery Boxes.—Circuit Concentration, &c.—Repeaters.—Submarine Telegraphy.—Wireless Telegraphy.—INDEX.—LIST OF DIAGRAMS OF CONNECTIONS.

"This book is a particularly good one . . . we can thoroughly recommend it . . . a handy book of ready reference."—*Electrical Review*.

"The treatise will be of much help to the telegraph engineer, and to the student in his preparatory training and it can be thoroughly recommended."—*Electrician*.

NINETEENTH EDITION. Leather, Pocket Size, with 810 pages. 8s. 6d.

A POCKET-BOOK OF ELECTRICAL RULES & TABLES

FOR THE USE OF ELECTRICIANS AND ENGINEERS.

By JOHN MUNRO, C.E., & PROF. JAMIESON, M. INST. C.E., F.R.S.E.

"WONDERFULLY PERFECT. . . . Worthy of the highest commendation we can give it."—*Electrician*.

GRIFFIN'S ELECTRICAL PRICE-BOOK: For Electrical, Civil, Marine, and Borough Engineers, Local Authorities, Architects, Railway Contractors, &c. Edited by H. J. DOWSING. SECOND EDITION. 8s. 6d.

In Large Crown 8vo. Handsome Cloth. 15s. net.

ELECTRICAL THEORY AND THE PROBLEM OF THE UNIVERSE.

By G. W. DE TUNZELMANN, B.Sc., LONDON,

Member of the Institute of Electrical Engineers; formerly Professor of Natural Philosophy and Astronomy, H.M.S. "Britannia," Dartmouth.

CONTENTS.—Fundamental Electrical Phenomena.—Units and Measurement.—Meaning and Possibility of a Mechanical Theory of Electricity.—The Ether.—The Ether as a Framework of Reference for Motion.—The Relations between Ether and Moving Matter.—Electric Conduction in Gases.—The Faraday-Maxwell Theory.—The Electron Theory.—Magnetism and the Dissipation of Energy.—Contract Electrification and Electrolysis.—Metallic Conduction.—Optical Phenomena.—The Mechanism of Radiation.—General Phenomena of Radio Activity.—Transmutations of Radio-Active Substances.—Ages of the Sun and Earth.—The Solar Corona, The Aurora, and Comets' Tails.—Radio-Activity in Stars and Nebulae.—Arrangement and Number of Atoms in a Molecule.—Changes in the Aspect of Fundamental Mechanical Principals.—Gravitation and Cohesion.—The Place of Mind in the Universe.—Mathematical and other Appendices.—INDEX.

"One of the most valuable contributions to electrical literature the year has produced."—*Times*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND

In Large Svo. Handsome Cloth. Fully Illustrated.

ELECTRICAL PHOTOMETRY.

By PROF. HERMANN BOHLE, M.I.E.E.,

Professor of Electrotechnics, S. A. College, Cape Town.

THIRD EDITION. In Handsome Cloth. Revised, Enlarged, and Re-written. Pp. i-xv + 425. Fully Illustrated. 12s. 6d. net.

A TREATISE ON

ELECTRO-METALLURGY:

Embracing the Application of Electrolysis to the Plating, Depositing, Smelting, and Refining of various Metals, and to the Reproduction of Printing Surfaces and Art-Work, &c.

By W. G. McMILLAN, F.I.C., AND W. R. COOPER, M.A., B.Sc.
(See also page 53.)

SECOND EDITION. Thoroughly Revised and Enlarged. In Large Svo. With Numerous Illustrations and Three Folding Plates. 21s. net.

ELECTRIC SMELTING & REFINING:

A Practical Manual of the Extraction and Treatment of Metals by Electrical Methods.

Being the "ELEKTRO-METALLURGIE" of DR. W. BORCHERS.

Translated from the Latest German Edition

By WALTER G. McMILLAN, F.I.C., F.C.S.

(See also page 53.)

THIRD EDITION. In Crown Svo. Handsome Cloth. With 30 New Illustrations. 7s. 6d. net.

Electrical Practice in Collieries.

By PROF. D. BURNS, M.E., M.INST.M.E.,

Professor of Mining and Geology to the Glasgow and West of Scotland Technical College.

Units of Measurement, Conductors, &c.—The Theory of the Dynamo.—The Dynamo: Details of Construction and Working.—Motors.—Lighting Installations in Collieries.—Pumping by Electricity.—Electrical Haulage.—Coal Cutting.—Miscellaneous Applications of Electricity in Mines.—Coal Mines Regulation Act (Electricity).—INDEX.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

In Large 8vo. Handsome Cloth. Profusely Illustrated. IN TWO VOLUMES, Each Complete in itself, and SOLD SEPARATELY.

THE DESIGN AND CONSTRUCTION OF SHIPS.

By JOHN HARVARD BILES, M.INST.N.A.,
Professor of Naval Architecture in Glasgow University.

Volume I.—CALCULATIONS AND STRENGTH. With 36 Folding Plates, and 245 other Illustrations. Pp. i-viii + 423. Complete with Index. 25s. net.

CONTENTS.—PART I.—Areas, Volumes, and Centres of Gravity. PART II.—Ship Calculations. PART III.—Strength of Ships.

"No teacher of naval architecture nor scientifically-equipped student of the same subject can afford to be without it . . . A work with up-to-date information which will doubtless remain the standard for many years."—*Times' Engineering Supplement.*

Volume II.—STABILITY, RESISTANCE, PROPULSION, AND OSCILLATIONS OF SHIPS. With 4 Folding Plates and 316 other Illustrations. Pp. i-x + 430. Complete with Index. 25s. net.

CONTENTS.—PART IV.—Stability. PART V.—Resistance. PART VI.—Propulsion. PART VII.—Oscillations of Ships.

"This able treatise is one which no one engaged in ship-designing can afford to be without."—*Shipbuilder.*

Royal 8vo Handsome Cloth. With numerous Illustrations and Tables. 25s.

THE STABILITY OF SHIPS.

By SIR EDWARD J. REED, K.C.B., F.R.S., M.P.,

"SIR EDWARD REED'S 'STABILITY OF SHIPS' IS INVALUABLE. THE NAVAL ARCHITECT will find brought together and ready to his hand, a mass of information which he would otherwise have to seek in an almost endless variety of publications, and some of which he would possibly not be able to obtain at all elsewhere."—*Steamship.*

AERONAUTICAL ENGINEERING.

SECOND EDITION, Revised. In Large 8vo. Cloth. With many Illustrations. 10s. 6d. net.

THE PROBLEM OF FLIGHT.

A TEXT-BOOK OF AERIAL ENGINEERING.

By HERBERT CHATLEY, B.Sc.(ENG.), LONDON,
Professor of Civil Engineering, Tong Shan Engineering College, N. China.

CONTENTS.—The Problem of Flight.—The Helix.—The Aéroplane.—The Aviplane.—Dirigible Balloons.—Form and Fittings of the Airship.—APPENDICES (*The Possibility of Flight, Weight, A Flexible Wing, Theory of Balance, Bibliography*).—INDEX.

"An epitome of the knowledge available on the subject."—*Scotsman.*

In Handsome Cloth. Illustrated. Pocket Size. 2s. 6d. net.

A COMPENDIUM OF AVIATION AND AEROSTATION, Balloons, Dirigibles and Flying Machines.

By LIEUT.-COL. H. HOERNES.

Translated and Supplemented with Facts of Interest to English readers—*i.e.*, details regarding British Dirigibles, Aeroplanes, Flying Grounds, &c.—with an Introduction and Biographical Sketch of the Author by J. H. LEDEBOER, Editor of *Aeronautics.*

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

WORKS BY THOMAS WALTON,
NAVAL ARCHITECT.

FOURTH EDITION. Pp. i-xvi + 332. With 18 Plates and 237 other Illustrations, including 59 Folding Diagrams. 18s. net.

STEEL SHIPS:
THEIR CONSTRUCTION AND MAINTENANCE.

*A Manual for Shipbuilders, Ship Superintendents, Students,
and Marine Engineers.*

BY THOMAS WALTON, NAVAL ARCHITECT,

AUTHOR OF "KNOW YOUR OWN SHIP."

CONTENTS.—I. Manufacture of Cast Iron, Wrought Iron, and Steel.—Composition of Iron and Steel, Quality, Strength, Tests, &c. II. Classification of Steel Ships. III. Considerations in making choice of Type of Vessel.—Framing of Ships. IV. Strains experienced by Ships.—Methods of Computing and Comparing Strengths of Ships. V. Construction of Ships.—Alternative Modes of Construction.—Types of Vessels.—Turret, Self Trimming, and Trunk Steamers, &c.—Rivets and Rivetting, Workmanship. VI. Pumping Arrangements. VII. Maintenance.—Prevention of Deterioration in the Hulls of Ships.—Cement, Paint, &c.—INDEX.

"So thorough and well written is every chapter in the book that it is difficult to select any of them as being worthy of exceptional praise. Altogether, the work is excellent, and will prove of great value to those for whom it is intended."—*The Engineer*.

In (loth. Pp. i-xii. + 224. With 9 Plates and 163 other Illustrations, including 40 Folding Diagrams. 7s. 6d. net.

PRESENT-DAY SHIPBUILDING.

For Shipyard Students, Ships' Officers, and Engineers.

BY THOS. WALTON.

GENERAL CONTENTS.—Classification.—Materials used in Shipbuilding.—Alternative Modes of Construction.—Details of Construction.—Framing, Plating, Rivetting, Stem Frames, Twin-Screw Arrangements, Water Ballast Arrangements, Loading and Discharging Gear, &c.—Types of Vessels, including Atlantic Liners, Cargo Steamers, Oil carrying Steamers, Turret and other Self Trimming Steamers, &c.—INDEX.

"Simple language . . . clear and easily followed illustrations."—*Times Engineering Supplement*.

"We heartily recommend it to all who have to do with ships."—*Steamship*.

TWELFTH EDITION. In Crown 8vo. Cloth. Pp. i-xvi + 363. With 142 Illustrations, including 2 Folding Diagrams. 7s 6d.

The Chapters on Tonnage and Freeboard have been brought thoroughly up to date, and embody the latest (1906) Board of Trade Regulations on these subjects.

KNOW YOUR OWN SHIP.

BY THOMAS WALTON, NAVAL ARCHITECT.

Specially arranged to suit the requirements of Ships' Officers, Shipowners Superintendents, Draughtsmen, Engineers, and Others,

CONTENTS.—Displacement and Deadweight.—Moments.—Buoyancy.—Strain.—Structure.—Stability.—Rolling.—Ballasting.—Loading.—Shifting Cargoes.—Effect of Admission of Water into Ship.—Trim Tonnage.—Freeboard (Load-line).—Calculations.—Set of Calculations from Actual Drawings.—INDEX.

"The work is of the highest value, and all who go down to the sea in ships should make themselves acquainted with it."—*Shipping World* (on the new edition).

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

GRIFFIN'S NAUTICAL SERIES.

FIFTH EDITION, *Thoroughly Revised*. Pp. *i-xvi* + 243. With Frontispiece, 24 Plates (3 Coloured), and 63 Illustrations in the Text and new Chapter on Clouds. Price 6s.

**A MANUAL OF
ELEMENTARY SEAMANSHIP.**

BY

D. WILSON-BARKER, MASTER MARINER; F.R.S.E., F.R.G.S., &c., &c.
YOUNGER BROTHER OF THE TRINITY HOUSE.

GENERAL CONTENTS.—The Building of a Ship; Parts of Hull, Masts, &c.—Ropes, Knots, Splicing, &c.—Gear, Lead and Log, &c.—Rigging, Anchors—Sailmaking—The Sails, &c.—Handling of Boats under Sail—Signals and Signalling—Rule of the Road—Keeping and Relieving Watch—Points of Etiquette—Glossary of Sea Terms and Phrases—Index.

"This ADMIRABLE MANUAL, by CAPT. WILSON-BARKER of the 'Worcester,' seems to us PERFECTLY DESIGNED, and holds its place excellently in 'GRIFFIN'S NAUTICAL SERIES.' Although intended for those who are to become Officers of the Merchant Navy, it will be found useful by ALL YACHTSMEN."—*Athenæum*.

SECOND EDITION, *Revised*. Pp. *i-xvii* + 156. With 61 Illustrations. Price 3s. 6d.

**NAVIGATION:
PRACTICAL AND THEORETICAL.**
BY DAVID WILSON-BARKER, R.N.R., F.R.S.E., &c., &c.,

AND

WILLIAM ALLINGHAM,

FIRST-CLASS HONOURS, NAVIGATION, SCIENCE AND ART DEPARTMENT.

With Numerous Illustrations and Examination Questions.

GENERAL CONTENTS.—Definitions—Latitude and Longitude—Instruments of Navigation—Correction of Courses—Plane Sailing—Traverse Sailing—Day's Work—Parallel Sailing—Middle Latitude Sailing—Mercator's Chart—Mercator Sailing—Current Sailing—Position by Bearings—Great Circle Sailing—The Tides—Questions—Appendix: Compass Error—Numerous Useful Hints &c.—Index.

"A CAPITAL LITTLE BOOK . . . specially adapted to the New Examinations. The Authors are CAPT. WILSON-BARKER (Captain-Superintendent of the Nautical College, H.M.S. 'Worcester,' who has had great experience in the highest problems of Navigation), and MR. ALLINGHAM, a well-known writer on the Science of Navigation and Nautical Astronomy."—*Shipping World*.

Handsome Cloth. Pp. *i-xvi* + 182. With 10 Plates and 34 other Illustrations. Price 7s. 6d.

**MARINE METEOROLOGY,
FOR OFFICERS OF THE MERCHANT NAVY.**

BY WILLIAM ALLINGHAM,

Joint Author of "Navigation, Theoretical and Practical."

With numerous Plates, Maps, Diagrams, and Illustrations, and a facsimile
Reproduction of a Page from an actual Meteorological Log-Book.

"Quite the BEST publication, AND certainly the MOST INTERESTING, on this subject ever
presented to Nautical men."—*Shipping Gazette*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

GRIFFIN'S NAUTICAL SERIES.

THIRD EDITION, REVISED. Pp. i-xii+175. With 54 Illustrations.
Price 3s. 6d.

PRACTICAL MECHANICS:
Applied to the Requirements of the Sailor.

By THOS. MACKENZIE, *Master Mariner, F.R.A.S.*

GENERAL CONTENTS.—Resolution and Composition of Forces—Work done by Machines and Living Agents—The Mechanical Powers: The Lever; Derricks as Bent Levers—The Wheel and Axle: Windlass; Ship's Capstan; Crab Winch—Tackles: the "Old Man"—The Inclined Plane; the Screw—The Centre of Gravity of a Ship and Cargo—Relative Strength of Rope: Steel Wire, Manilla, Hemp, Coir—Derricks and Shears—Calculation of the Cross-breaking Strain of Fir Spar—Centre of Effort of Sails—Hydrostatics: the Diving-bell; Stability of Floating Bodies; the Ship's Pump, &c.

"WELL WORTH the money . . . will be found EXCEEDINGLY HELPFUL."—*Shipping World.*

"NO SHIPS' OFFICERS' BOOKCASE will henceforth be complete without CAPTAIN MACKENZIE'S 'PRACTICAL MECHANICS.' Notwithstanding my many years' experience at sea, it has told me *how much more there is to acquire.*"—(Letter to the Publishers from a Master Mariner).

WORKS BY RICHARD C. BUCK,

of the Thames Nautical Training College, H.M.S. 'Worcester.'

FOURTH EDITION, Revised and Corrected. Pp. i-viii+113.
With 38 Illustrations. Price 3s. 6d.

A MANUAL OF TRIGONOMETRY:

With Diagrams, Examples, and Exercises.

** Mr. Buck's Text-Book has been SPECIALLY PREPARED with a view to the Examinations of the Board of Trade, in which Trigonometry is an obligatory subject.

"THIS EMINENTLY PRACTICAL and RELIABLE VOLUME."—*Schoolmaster*

SECOND EDITION, Revised. Pp. i-viii+158. Price 3s. 6d.

A MANUAL OF ALGEBRA.

Designed to meet the Requirements of Sailors and others.

** These elementary works on ALGEBRA and TRIGONOMETRY are written specially for those who will have little opportunity of consulting a Teacher. They are books for "SELF-HELP." All but the simplest explanations have, therefore, been avoided, and ANSWERS to the Exercises are given. Any person may readily, by careful study, become master of their contents, and thus lay the foundation for a further mathematical course, if desired. It is hoped that to the younger Officers of our Mercantile Marine they will be found decidedly serviceable. The Examples and Exercises are taken from the Examination Papers set for the Cadets of the "Worcester."

"Clearly arranged, and well got up. . . . A first-rate Elementary Algebra."—*Nautical Magazine.*

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

GRIFFIN'S NAUTICAL SERIES.

SECOND EDITION, Revised. With Diagrams. Price 2s.

LATITUDE AND LONGITUDE: How to Find them.

BY W. J. MILLAR, C.E.,

Late Secretary to the Inst. of Engineers and Shipbuilders in Scotland.

"CONCISELY and CLEARLY WRITTEN . . . cannot but prove an acquisition to those studying Navigation."—*Marine Engineer.*

"Young Seamen will find it HANDY and USEFUL, SIMPLE and CLEAR."—*The Engineer.*

THIRD EDITION, Revised. In Crown 8vo. Pp. i-xv+268. Price 5s.

THE LEGAL DUTIES OF SHIPMASTERS.BY BENEDICT WM. GINSBURG, M.A., LL.D. (CANTAB.),
Of the Inner Temple and Northern Circuit; Barrister-at-Law.

General Contents.—Qualification for Position of Shipmaster.—Contract with Shipowner.—Duty in respect of the Crew: Engagement; Apprentices; Discipline; Provisions, Accommodation, and Medical Comforts; Payment of Wages and Discharge.—Passengers.—Financial Responsibilities.—Cargo.—Casualty.—Duty to certain Public Authorities.—Pilots, Signals, Flags, and Light Dues.—Arrival at the Port of Discharge.—Appendices on Legal Matters: B.O.T. Certificates, Dietary Scales, Stowage of Grain Cargoes, Load Line Regulations, Life-saving Appliances, Carriage of Cattle.—INDEX.

"No intelligent Master should fail to add this to his list of necessary books. A few lines of it may SAVE A LAWYER'S FEE, BESIDES ENDLESS WORRY."—*Liverpool Journal of Commerce.*

FIRST AID AT SEA.

THIRD EDITION, Revised. Pp. i-xviii+349. With 82 Illustrations and the latest Regulations on the Carriage of Medical Stores. 6s.

A MEDICAL AND SURGICAL HELP

For Shipmasters and Officers in the Merchant Navy.

BY WM. JOHNSON SMITH, F.R.O.S.,

Principal Medical Officer, Seamen's Hospital, Greenwich.

. The attention of all interested in our Merchant Navy is requested to this exceedingly useful and valuable work. It is needless to say that it is the outcome of many years PRACTICAL EXPERIENCE amongst Seamen.

"SOUND, JUDICIOUS, REALLY HELPFUL."—*The Lancet.*

TWELFTH EDITION, Revised and Enlarged. Price 7s. 6d.

KNOW YOUR OWN SHIP.

BY THOMAS WALTON, NAVAL ARCHITECT.

Specially arranged to suit the requirements of Ships' Officers, Shipowners, Superintendents, Draughtsmen, Engineers, and Others.

For Contents and further particulars of this work, and other works by the same author, see p. 34.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

OTHER WORKS OF INTEREST TO SAILORS.

In Crown 8vo. Cloth. Fully Illustrated. 2s. 6d. net.

NOTES ON THE PRACTICAL DUTIES OF SHIPMASTERS.

By CAPT. W. HARRY WILKES, LIEUT. R.N.R., &c.

"We should like to commend this volume to the attention of all Officers in Command . . . a compact and concise mass of information."—*Shipping World*.

In Pocket Size. With 368 Pages. 3s. 6d. net.

ENGLISH-SPANISH AND SPANISH-ENGLISH SEA TERMS AND PHRASES.

By FLEET-PAYMASTER GRAHAM-HEWLETT.

"Most complete . . . useful . . . we can heartily recommend it."—*Steamship*.

In Crown 8vo. Handsome Cloth. Many Diagrams. 2s. 6d. net.

DEFINITIONS IN NAVIGATION & NAUTICAL ASTRONOMY.

By P GROVES-SHOWELL,

Head of the Navigation Department, L.C.C. School, Poplar.

CONTENTS.—Definitions.—General.—Navigation.—Nautical Astronomy.—Time.—Miscellaneous.—Notes. Measurements.—Mariner's Compass.—Chronometer.—Azimuth Compass.—Pelorus.—Sextant.—Vernier.—Artificial Horizon.—Sounding Machine.—Log.—Station Pointer.—Barometer.—Thermometer.—Hygrometer.—Hydrometer. Miscellaneous.—Star Nomenclature.—Greek Alphabet.—Planetary Symbols.—Weights and Measures.—Areas.—Volumes.—Useful Notes.—INDEX.

"Mr. Groves-Showell writes with a full knowledge of his subject, and with admirable clearness."—*Shipbuilder*.

Attention is also drawn to the following:—

HYDROGRAPHIC SURVEYING. By COMMANDER S. MESSUM, R.N. [See page 16.]

THEODOLITE SURVEYING. By Professor JAMES PARK. [See page 41.]

THE FORCE OF THE WIND. By HERBERT CHATLEY, B.Sc. [See page 24.]

THE EARTH'S ATMOSPHERE. By Dr. T. L. PHIPSON. [See page 46.]

WIRELESS TELEGRAPHY. By GUSTAVE EICHORN, PH.D. [See page 30.]

LONDON: CHARLES GRIFFIN & CO., LIMITED, EYETER STREET, STRAND.

WORKS BY
SIR CLEMENT LE NEVE FOSTER, D.Sc., F.R.S.

SIXTH EDITION. With Frontispiece and 712 Illustrations. Price 28s. net.

ORE & STONE MINING.

BY SIR C. LE NEVE FOSTER, D.Sc., F.R.S.,
LATE PROFESSOR OF MINING, ROYAL COLLEGE OF SCIENCE.

REVISED, AND BROUGHT UP-TO-DATE

BY PROF. S. H. COX, Assoc. R.S.M.,
PROFESSOR OF MINING, ROYAL COLLEGE OF SCIENCE.

GENERAL CONTENTS.

INTRODUCTION. Mode of Occurrence of Minerals.—Prospecting.—Boring.—Breaking Ground.—Supporting Excavations.—Exploitation.—Haulage or Transport.—Hoisting or Winding.—Drainage.—Ventilation.—Lighting.—Descent and Ascent.—Dressing—Principles of Employment of Mining Labour.—Legislation affecting Mines and Quarries.—Condition of the Miner.—Accidents.—Index

"We have seldom had the pleasure to review a work so thorough and complete as the present one. Both in manner and in matter it is FAR SUPERIOR TO ANYTHING ON ITS SPECIAL SUBJECT HITHERTO PUBLISHED IN ENGLAND."—*Athenæum*.

"Not only is this work the acknowledged text-book on metal mining in Great Britain and the Colonies, but that it is so regarded in the United States of America is evidenced by the fact that it is the book on that subject recommended to the students in most of the mining schools of that country."—*The Times*.

SECOND EDITION, Revised. In Crown 8vo. Handsome Cloth.
With nearly 300 Illustrations. Price 7s. 6d. net.

THE ELEMENTS OF MINING AND QUARRYING.

An Introductory Text-book for Mining Students.

BY SIR C. LE NEVE FOSTER, D.Sc., F.R.S.,
Late Professor of Mining at the Royal College of Science.

Revised by Prof. S. H. Cox, A.R.S.M., &c.

GENERAL CONTENTS.—INTRODUCTION.—Occurrence of Minerals.—Prospecting.—Boring.—Breaking Ground.—Supporting Excavations.—Exploitation.—Haulage or Transport.—Hoisting or Winding.—Drainage.—Ventilation.—Lighting.—Descent and Ascent.—Dressing, &c.—INDEX.

"A remarkably clear survey of the whole field of mining operations."—*Engineer*.
"Rarely does it fall to the lot of a reviewer to have to accord such unqualified praise as this book deserves. . . . The profession generally have every reason to be grateful to Sir C. Le Neve Foster for having enriched educational literature with so admirable an elementary Text-book."—*Mining Journal*.

In Crown 8vo. Handsome Cloth. Illustrated. 5s. net.

METHODS OF AIR ANALYSIS.

BY J. S. HALDANE, M.D., LL.D., F.R.S.,
Reader in Physiology and Fellow of New College, Oxford.

An Account of Methods of Air Analysis suitable for work in Physiology, Hygiene, Investigations of Mine Air, Flue Gases, Exhaust Gases from Engines, &c.

In Crown 8vo. Handsome Cloth. Illustrated.

THE AIR OF MINES.

BY JOHN CADMAN, D.Sc., Prof. of Mining, University of Birmingham,
AND J. S. HALDANE, M.D., LL.D., F.R.S.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

WORKS ON COAL-MINING.

FIFTH EDITION, Revised and Greatly Enlarged. With 4 Plates and
690 Illustrations. Price 24s. net.

A TEXT-BOOK OF COAL-MINING:

FOR THE USE OF COLLIERY MANAGERS AND OTHERS
ENGAGED IN COAL-MINING.

BY HERBERT WILLIAM HUGHES, F.G.S.,
Assoc. Royal School of Mines, General Manager of Sandwell Park Colliery.

GENERAL CONTENTS.—Geology.—Search for Coal.—Breaking Ground.—Sinking.—Preliminary Operations.—Methods of Working.—Haulage.—Winding.—Pumping.—Ventilation.—Lighting.—Works at Surface.—Preparation of Coal for Market.—INDEX.

"Quite THE BEST BOOK of its kind . . . as PRACTICAL in aim as a book can be . . . The illustrations are EXCELLENT."—*Athenæum*.

"We cordially recommend the work."—*Colliery Guardian*.

"Will soon come to be regarded as the STANDARD WORK of its kind."—*Birmingham Daily Gazette*.

FIFTH EDITION, Thoroughly Revised and Greatly Enlarged. Re-set
throughout. Large Crown 8vo. Handsome Cloth.

PRACTICAL COAL-MINING:

**A MANUAL FOR MANAGERS, UNDER-MANAGERS,
COLLIERY ENGINEERS, AND OTHERS.**

With Worked-out Problems on Haulage, Pumping, Ventilation, &c.

BY GEORGE L. KERR, M.E., M.INST.M.E.

CONTENTS.—The Sources and Nature of Coal.—The Search for Coal.—Sinking.—Explosives.—Mechanical Wedges.—Rock Drills and Coal-cutting Machines.—Coal-cutting by Machinery.—Transmission of Power.—Modes of Working.—Timbers.—Roadways.—Winding Coal.—Haulage.—Pumping.—Ventilation.—Safety Lamps.—Surface Arrangements, Surveying, Levelling, &c.

"AN ESSENTIALLY PRACTICAL WORK, and can be confidently recommended. No department of Coal-Mining has been overlooked."—*Engineers' Gazette*.

THIRD EDITION, Revised. In Crown 8vo. Handsome Cloth.

ELEMENTARY COAL-MINING:

FOR THE USE OF STUDENTS, MINERS, AND OTHERS
PREPARING FOR EXAMINATIONS.

BY GEORGE L. KERR, M.E., M.INST.M.E.

CONTENTS.—Sources and Nature of Coal.—Exploration and Boring for Coal.—Breaking Ground.—Explosives, Blasting, &c.—Sinking and Fitting of Shafts.—Modes of Working.—Timbering Roadways.—Winding and Drawing.—Haulage.—Pumping and Drainage.—Ventilation.—Cleaning and Sorting Coal.—Surveying, &c.

"An abundance of information conveyed in a popular and attractive form. . . . Will be of great use to all who are in any way interested in coal mining."—*Scottish Critic*.

LONDON: CHARLES GRIFFIN & CO., LIMITED. EXETER STREET. STRAND

FOURTEENTH EDITION, Revised. With Numerous Diagrams.
Cloth, 7s. 6d.

A TREATISE ON MINE-SURVEYING:

*For the use of Managers of Mines and Collieries, Students
at the Royal School of Mines, &c.*

By BENNETT H. BROUGH, Assoc.R.S.M., F.G.S.

Revised by S. WARREN PRICE, Professor of Mine Surveying in
University College of South Wales and Monmouthshire.

CONTENTS.—General Explanations.—Measurement of Distances.—Miners Dial.—Variation of the Magnetic Needle.—Surveying with the Magnetic Needle in the Presence of Iron.—Surveying with the Fixed Needle.—The German Dial.—The Theodolite.—Traversing Underground.—Surface Surveys with the Theodolite.—Plotting and Survey.—Calculation of Areas.—Levelling.—Connection of the Underground and Surface Surveys.—Measuring Distances by Telescope.—Setting-out.—Mine-Surveying Problems.—Mine Plans.—Application of the Magnetic Needle in Mining.—Photographic Surveys.—APPENDICES.—INDEX.

"Its CLEARNESS of STYLE, LUCIDITY of DESCRIPTION, and FULNESS of DETAIL have long ago won for it a place unique in the literature of this branch of mining engineering, and the present edition fully maintains the high standard of its predecessors. To the student, and to the mining engineer alike, ITS VALUE is inestimable. The illustrations are excellent."—*The Minn. Journal*.

In Crown 8vo. Handsome Cloth. Fully Illustrated. 7s. 6d. net.

A HANDBOOK ON THEODOLITE SURVEYING AND LEVELLING.

For the use of Students in Land and Mine Surveying.

By PROFESSOR JAMES PARK, F.G.S.

CONTENTS.—The Scope and Object of Surveying.—Land Surveying.—The Theodolite.—Chains and Steel Bands.—Obstacles to Allignment.—Meridian and Bearings.—The Theodolite Traverse.—Co-ordinates of a Station.—Calculation of Omitted or Connecting Line in a Traverse.—Calculation of Areas.—Subdivision of Land.—Triangulation.—Determination of True Meridian, Latitude and Time.—Levelling.—Railway Curves.—Mine Surveying.—Surveying Boreholes.—INDEX.

"A book which should prove as useful to the professional surveyor as to the student."—*Nature*.

SECOND EDITION, Revised. Crown 8vo. Handsome Cloth. Illustrated.
6s. net.

MINING GEOLOGY.

A TEXT-BOOK FOR MINING STUDENTS AND MINERS.

By PROF. JAMES PARK, F.G.S., M.Inst.M.M.,

Professor of Mining and Director of the Otago University School of Mines; late Director
Thames School of Mines, and Geological Surveyor and Mining Geologist to the
Government of New Zealand

GENERAL CONTENTS.—Introduction.—Classification of Mineral Deposits.—Ore Veins, their Filling, Age, and Structure.—The Dynamics of Lodes and Beds.—Ore Deposits Genetically Considered—Ores and Minerals Considered Economically.—Mine Sampling and Ore Valuation.—The Examination and Valuation of Mines.—INDEX.

"A work which should find a place in the library of every mining engineer."—*Mining World*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

WORKS FOR MINERS AND STUDENTS.

THIRD EDITION. *In Crown 8vo. Handsome Cloth. With 30 New Illustrations. 7s. 6d. net.*

ELECTRICAL PRACTICE IN COLLIERIES.

By PROF. D. BURNS, M.E., M.INST.M.E.,

Professor of Mining and Geology to the Glasgow and West of Scotland Technical College.

Units of Measurement, Conductors, &c.—The Theory of the Dynamo.—The Dynamo, Details of Construction and Working.—Motors.—Lighting Installations in Collieries.—Pumping by Electricity.—Electrical Haulage.—Coal Cutting.—Miscellaneous Applications of Electricity in Mines.—Coal Mines Regulation Act (Electricity).—INDEX.

"A clear and concise introduction to electrical practice in collieries."—*Mining Journal.*

In Crown 8vo, Handsome Cloth. 8s. 6d. net.

MINING LAW OF THE BRITISH EMPIRE.

By CHARLES J. ALFORD, F.G.S., M.Inst.M.M.

CONTENTS.—The Principles of Mining Law.—The Mining Law of Great Britain.—British India.—Ceylon.—Burma.—The Malay Peninsula.—British North Borneo.—Egypt.—Cyprus.—The Dominion of Canada.—British Guiana.—The Gold Coast Colony and Ashanti.—Cape of Good Hope.—Natal.—Orange River Colony.—Transvaal Colony.—Rhodesia.—The Commonwealth of Australia.—New Zealand, &c.—INDEX.

"Cannot fail to be useful . . . we cordially recommend the book."—*Mining World.*

SEVENTH EDITION. *In Large 8vo. Price 10s. 6d.*

MINE ACCOUNTS AND MINING BOOK-KEEPING.

For Students, Managers, Secretaries, and others.

With Examples taken from Actual Practice of Leading Companies.

By JAMES GUNSON LAWN, A.R.S.M., A.M.Inst.C.E., F.G.S.,

Head of the Mining Department, Camborne School of Mines.

EDITED BY SIR C. LE NEVE FOSTER, D.Sc., F.R.S.

"It seems impossible to suggest how Mr. LAWN'S book could be made more COMPLETE or more VALUABLE, careful, and exhaustive."—*Accountants' Magazine.*

THIRD EDITION. *In Pocket Size, Strongly Bound in Leather, 3s. 6d.*
Provided with Detachable Blank Pages for MS.

**THE MINING ENGINEERS' REPORT BOOK
AND DIRECTORS' AND SHAREHOLDERS' GUIDE TO MINING REPORTS.**

By EDWIN R. FIELD, M.INST.M.M.

With Notes on the Valuation of Property, and Tabulating Reports, Useful Tables, and Examples of Calculations, &c.

"An ADMIRABLY compiled book which Mining Engineers and Managers will find EXTREMELY USEFUL."—*Mining Journal.*

In Crown 8vo. Handsome Cloth. Illustrated. 10s. 6d. net.

**A DICTIONARY OF
SPANISH-ENGLISH AND SPANISH-AMERICAN MINING,
METALLURGICAL, AND ALLIED TERMS.**

To which some Portuguese and Portuguese-American (Brazilian) Terms are added.

By EDWARD HALSE, A.R.S.M.,

Mem. Inst. Ming. and Metall., of the Eng. Inst. of Ming. and Metall. Engrs., &c., &c

"Will be found of the greatest service to the mining profession."—*Mining Journal.*

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND

WORKS ON SINKING, EXPLOSIVES, &c.

In Medium 8vo, Handsome Cloth. With 18 Figures in the Text,
and 19 Folding Plates. 10s. 6d. net.

SHAFT-SINKING IN DIFFICULT CASES.

By J. RIEMER,

TRANSLATED BY J. W. BROUGH, A.M. INST. C.E.

CONTENTS.—Shaft Sinking by Hand.—Shaft Sinking by Boring.—The Freezing Method.—The Sinking Drum Process.—BIBLIOGRAPHY.—INDEX.

“The translator deserves the thanks of the mining community for placing this valuable work before them. . . . The work is one which every mining engineer should include in his library.”—*Mining World*.

SECOND EDITION, Revised. In Large 8vo, with Numerous Illustrations
and Folding Plates. 10s. 6d.

BLASTING: AND THE USE OF EXPLOSIVES.

By OSCAR GUTTMANN, M. INST. C.E., F.I.C., F.C.S.

CONTENTS.—Historical Sketch.—Blasting Materials.—Qualities and Handling of Explosives.—The Choice of Blasting Materials.—Preparation of Blasts.—Chamber Mines.—Charging of Boreholes.—Determination of Charge.—Blasting in Boreholes.—Firing.—Results of Working.—Various Blasting Operations.—INDEX.

“Should prove a *vade-mecum* to Mining Engineers and all engaged in practical work.”—*Iron and Coal Trades Review*.

In Medium 8vo, Cloth. With many Illustrations in the Text.
Four Full Page Plates and Four Folding Tables. 6s. net.

NEW METHODS OF TESTING EXPLOSIVES.

By C. E. BICHEL.

TRANSLATED AND EDITED BY ALEX. LARSEN, M. INST. C.E.

CONTENTS.—Introductory.—Historical.—Testing Stations.—Power Gauges.—Products of Combustion.—Rate of Detonation.—Length and Duration of Flame.—After-Flame Ratio.—Transmission of Explosion.—Conclusions.—Efficiency.

“Its pages bristle with suggestions and actual experimental results to an extent seldom found in a volume of five times its size.”—*Arms and Explosives*.

In Crown 8vo. Handsome Cloth. Fully Illustrated.

A MANUAL ON ELECTRICAL SIGNALLING IN MINES.

By GERALD J. HOOGHWINKEL, M. INST. E. E., M. I. MIN. E.

CONTENTS.—SECTION I.—Electric Haulage Signals—(a) Acoustic Signals.—(b) Optical Signals.—(c) Acoustic Optical Signals.—Current Supply.—Batteries.—Accumulators.—Main Supply.—Design and Construction of Signalling Installations.—Maintenance of Signalling Installations. SECTION II.—Electric Shaft Signals—(a) Acoustic Signals.—(b) Electro-Mechanical Signals.—(c) Optical Acoustic Signals.—Signals for Winding Minerals.—For Winding Men.—Signalling from the Cage.—Emergency Signals.—Bells.—Mine Telegraphs.—Mine Telephones. SECTION III.—Special Applications in Mines.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND

SECOND EDITION, *Revised Throughout. In Medium Svo. With Numerous Plates, Maps, and Illustrations. 21s. net.*

CYANIDING GOLD & SILVER ORES.

A Practical Treatise on the Cyanide Process; its Application, Methods of Working, Design and Construction of Plant, and Costs.

BY H. FORBES JULIAN,

Mining and Metallurgical Engineer; Specialist in Gold; Late Technical Adviser of the Deutsche Gold und Silber Scheide Anstalt, Frankfurt-on-Maine.

AND EDGAR SMART, A.M.I.C.E.,

Civil and Metallurgical Engineer.

"A handsome volume of 400 pages which will be a valuable book of reference for all associated with the process."—*Mining Journal*.

"The authors are to be congratulated upon the production of what should prove to be standard work."—*Page's Magazine*.

In Large Crown Svo. With 13 Plates and many Illustrations in the Text. Handsome Cloth. 7s. 6d. net.

THE CYANIDE PROCESS OF GOLD EXTRACTION.

A Text-Book for the Use of Metallurgists and Students at Schools of Mines, &c.

BY JAMES PARK, F.G.S., M.INST.M.M.,

Professor of Mining and Director of the Otago University School of Mines; late Director Thames School of Mines, and Geological Surveyor and Mining Geologist to the Government of New Zealand.

FOURTH ENGLISH EDITION. Thoroughly Revised and Greatly Enlarged. With additional details concerning the Siemens-Halske and other recent processes.

"Deserves to be ranked as amongst the BEST OF EXISTING TREATISES."—*Mining Journal*.

THIRD EDITION, Revised. *With Plates and Illustrations. Cloth, 3s. 6d.*

GETTING GOLD; A GOLD-MINING HANDBOOK FOR PRACTICAL MEN.

BY J. O. F. JOHNSON, F.G.S., A.I.M.E.,

Life Member Australasian Mine-Managers' Association.

GENERAL CONTENTS.—Introductory: Prospecting (Alluvial and General)—Lode or Reef Prospecting—Genesiology of Gold—Auriferous Lodes—Drifts—Gold Extraction—Lixiviation—Calcination—Motor Power and its Transmission—Company Formation—Mining Appliances and Methods—Australasian Mining Regulations.

"PRACTICAL from beginning to end . . . deals thoroughly with the Prospecting, Sinking, Crushing, and Extraction of gold."—*Brit. Australasian*.

In Crown Svo. Illustrated. Fancy Cloth Boards. 4s. 6d.

GOLD SEEKING IN SOUTH AFRICA:

A Handbook of Hints for intending Explorers, Prospectors, and Settlers.

BY THEO KASSNER,

Mine Manager, Author of the Geological Sketch Map of the De Kaap Gold Fields.

With a Chapter on the Agricultural Prospects of South Africa.

"As fascinating as anything ever penned by Jules Verne."—*African Commerce*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND

GRIFFIN'S "NEW LAND" SERIES.

*Practical Hand-Books for the Use of Prospectors, Explorers,
Settlers, Colonists, and all Interested in the opening
up and Development of New Lands.*

EDITED BY GRENVILLE A. J. COLE, M.R.I.A., F.G.S.,
Professor of Geology in the Royal College of Science for Ireland, and Examiner in
the University of London.

*In Crown Svo. Handsome Cloth. 5s.
With Numerous Maps Specially Drawn and Executed for this Work.*

NEW LANDS:

THEIR RESOURCES AND PROSPECTIVE ADVANTAGES.

By HUGH ROBERT MILL, D.Sc., LL.D., F.R.S.E.,

"A want admirably supplied. . . . Has the advantage of being written by a pro-
fessed Geographer."—*Geographical Journal*.

With many Engravings and Photographs. Handsome Cloth, 4s. 6d.

FOOD SUPPLY.

By ROBERT BRUCE,

Agricultural Superintendent to the Royal Dublin Society.

With Appendix on Preserved Foods by C. A. MITCHELL, B.A., F.I.C.

"The work is one which will appeal to those intending to become farmers at home
or in the Colonies, and who desire to obtain a general idea of the true principles of
farming in ALL ITS BRANCHES."—*Journal of the Royal Colonial Inst.*

SIXTH EDITION. *With Illustrations. Handsome Cloth, 5s.*

PROSPECTING FOR MINERALS.

*A Practical Handbook for Prospectors, Explorers, Settlers, and all
interested in the Opening up and Development of New Lands.*

By S. HERBERT COX, Assoc.R.S.M., M.Inst.M.M., F.G.S.,

Professor of Mining at the Royal School of Mines.

GENERAL CONTENTS.—Introduction and Hints on Geology—The Determination of Minerals: Use of the Blow-pipe, &c.—Rock forming Minerals and Non-Metallic Minerals of Commercial Value: Rock Salt, Borax, Marbles, Lithographic Stone, Quartz and Opal, &c., &c.—Precious Stones and Gems—Stratified Deposits: Coal and Ores—Mineral Veins and Lodes—Irregular Deposits—Dynamics of Lodes; Faults, &c.—Alluvial Deposits—Noble Metals: Gold, Platinum, Silver, &c.—Lead—Mercury—Copper—Tin—Zinc—Iron—Nickel &c.—Sulphur, Antimony, Arsenic, &c.—Combustible Minerals—Petroleum—General Hints on Prospecting—Glossary—Index.

"This ADMIRABLE LITTLE WORK . . . written with SCIENTIFIC ACCURACY in a
CLEAR and LUCID style. . . . AN IMPORTANT ADDITION to technical literature . . .
—*Mining Journal*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND

Demij 8vo, Handsome cloth, 34s

Stratigraphical Geology & Palæontology,

ON THE BASIS OF PHILLIPS.

BY ROBERT ETHERIDGE, F. R. S.,

OF THE NATURAL HIST. DEPARTMENT, BRITISH MUSEUM, LATE PALÆONTOLOGIST TO THE
GEOLOGICAL SURVEY OF GREAT BRITAIN, PAST PRESIDENT OF THE
GEOLOGICAL SOCIETY, ETC.

With Map, Numerous Tables, and Thirty-six Plates.

" . . . Must take HIGH RANK AMONG WORKS OF REFERENCE."—*Athenæum*.

In Crown 8vo. Fully Illustrated. Cloth. 10s. 6d. net.

GEOLOGY FOR ENGINEERS.

By LIEUT.-COL. SORSBIE, R.E.

CONTENTS.—Dynamical and Structural Geology.—Rocks and Minerals.—Historical
Geology.—Geological Observation.—Practical Geology.—Coast Erosion.—INDEX.

"Should be in the possession of every engineer."—*Mining World*.

In Crown 8vo. Handsome Cloth. 3s. net.

A BIBLIOGRAPHY OF THE

MINERAL WEALTH AND GEOLOGY OF CHINA.

By C. Y. WANG, M. A., B. Sc., M. Am. Inst. Min. Eng., M. Iron & Steel Inst

SIXTH EDITION, Thoroughly Revised. With Illustrations. Cloth. 10s. 6d.

AIDS IN PRACTICAL GEOLOGY:

WITH A SECTION ON PALÆONTOLOGY.

By PROFESSOR GRENVILLE COLE, M.R.I.A., F.G.S.

GENERAL CONTENTS.—

Part I.—Sampling of Earth's Crust. | Part III.—Examination of Rocks.
Part II.—Examination of Minerals. | Part IV.—Examination of Fossils.

"That the work deserves its title, that it is full of 'AIDS,' and in the highest degree
PRACTICAL,' will be the verdict of all who use it."—*Nature*.

OPEN-AIR STUDIES IN GEOLOGY.

By PROF. G. COLE.

[See p. 73.

In Crown 8vo. Handsome Cloth. 2s. 6d.

RESEARCHES on the PAST and PRESENT HISTORY of THE EARTH'S ATMOSPHERE.

Including the latest Discoveries and their Practical Applications.

By DR. THOMAS LAMB PHIPSON.

"The book should prove of interest to general readers, as well as to meteorologists and
other students of science."—*Nature*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET. STRAND.

Griffin's Metallurgical Series.

STANDARD WORKS OF REFERENCE

FOR

Metallurgists, Mine-Owners, Assayers, Manufacturers,
and all interested in the development of
the Metallurgical Industries.

EDITED BY

Sir W. ROBERTS-AUSTEN, K.C.B., D.C.L., F.R.S.

In Large 8vo, Handsome Cloth. With Illustrations.

INTRODUCTION to the STUDY of METALLURGY.

By the EDITOR. SIXTH EDITION. (See p. 48.)

GOLD (The Metallurgy of). By THOS. KIRKE ROSE, D.Sc., Assoc. R.S.M., F.C.S., Chemist and Assayer of the Royal Mint. FIFTH EDITION. 21s. (See p. 48.)

LEAD (The Metallurgy of). By H. F. COLLINS, Assoc. R.S.M., M.Inst.M.M. SECOND EDITION. (See p. 49.)

SILVER (The Metallurgy of). By H. F. COLLINS, A.R.S.M., M.Inst.M.M. SECOND EDITION. (See p. 49.)

IRON (The Metallurgy of). By T. TURNER, A.R.S.M., F.I.C., F.C.S. THIRD EDITION, Revised. 16s. net. (See p. 50.)

STEEL (The Metallurgy of). By F. W. HARBORD, Assoc. R.S.M., F.I.C., and J. W. HALL, A.M.Inst.C.E. FOURTH EDITION. In Two Volumes. Profusely Illustrated. (See p. 50.)

ALLOYS. By EDWARD F. LAW, Assoc. R.S.M. With Frontispiece in Colours, and Fine Series of Micro-photographs. 12s. 6d. net. (See p. 49.)

ANTIMONY. By C. Y. WANG, M.A., B.Sc. Fully Illustrated. 12s. 6d. net. (See p. 50.)

Will be Published at Short Intervals.

METALLURGICAL MACHINERY: the Application of Engineering to Metallurgical Problems. By HENRY CHARLES JENKINS, Wh.Sc., Assoc. R.S.M.

COPPER (The Metallurgy of). By THOS. C. CLOUD, Assoc. R.S.M.

* * Other Volumes in Preparation.

LONDON: CHARLES GRIFFIN & CO., LIMITED EXETER STREET, STRAND.

GRIFFIN'S METALLURGICAL SERIES.

SIXTH EDITION, thoroughly Revised and considerably Enlarged. Large 8vo, Pp. i-xv + 478. With numerous Illustrations and Micro-Photographic Plates of different varieties of Steel. 18s. net.

An Introduction to the Study of
METALLURGY.

BY

Sir W. ROBERTS-AUSTEN, K.C.B., D.C.L., F.R.S., A.R.S.M.,
 Late Chemist and Assayer of the Royal Mint, and Professor of Metallurgy
 in the Royal College of Science.

Revised throughout by F. W. HARBORD, A.R.S.M., F.I.C.

GENERAL CONTENTS.—The Relation of Metallurgy to Chemistry.—Physical Properties of Metals.—Alloys. The Thermal Treatment of Metals.—Fuel and Thermal Measurements.—Materials and Products of Metallurgical Processes.—Furnaces.—Means of Supplying Air to Furnaces.—Thermo-Chemistry.—Typical Metallurgical Processes.—The Micro-Structure of Metals and Alloys.—Economic Considerations.

"No English text-book at all approaches this in the COMPLETENESS with which the most modern views on the subject are dealt with. Professor Austen's volume will be INVALUABLE, not only to the student, but also to those whose knowledge of the art is far advanced."—*Chemical News*.

FIFTH EDITION, Revised, Considerably Enlarged, and in part Re-written.
 With Frontispiece and numerous Illustrations. 21s.

THE METALLURGY OF GOLD.

BY

T. KIRKE ROSE, D.Sc.Lond., Assoc.R.S.M.

Chemist and Assayer of the Royal Mint.

GENERAL CONTENTS.—The Properties of Gold and its Alloys.—Chemistry of the Compounds of Gold.—Mode of Occurrence and Distribution of Gold.—Shallow Placer Deposits.—Deep Placer Deposits.—Quartz Crushing in the Stamp Battery.—Amalgamation in the Stamp Battery.—Other Forms of Crushing and Amalgamating Machinery.—Concentration in Gold Mills.—Dry Crushing.—Re-grinding.—Roasting.—Chlorination: The Plattner Process, The Barrel Process, The Vat-Solution Process.—The Cyanide Process.—Chemistry of the Cyanide Process.—Refining and Parting of Gold Bullion.—Assay of Gold Ores.—Assay of Gold Bullion.—Statistics of Gold Production.—Bibliography.—INDEX.

'A COMPREHENSIVE PRACTICAL TREATISE on this important subject.'—*The Times*.

'The MOST COMPLETE description of the CHLORINATION PROCESS which has yet been published.'—*Mining Journal*.

'Adapted for all who are interested in the Gold Mining Industry, being free from technicalities as far as possible, but is more particularly of value to those engaged in the industry.'—*Cape Times*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

GRIFFIN'S METALLURGICAL SERIES.

EDITED BY SIR W. ROBERTS-AUSTEN, K.C.B., F.R.S., D.C.L.

*In Large 8vo. Handsome Cloth. With Illustrations.*SECOND EDITION, Revised Throughout and Enlarged. Pp. i-xx + 538.
With 314 Illustrations, including 12 Folding Plates. 21s. net.**THE METALLURGY OF LEAD.**

By H. F. COLLINS, Assoc.R.S.M., M.INST.M.M.

Contents.—INTRODUCTORY.—The Properties of Lead and its Principal Compounds.—Lead Ores.—LEAD SMELTING in Reverberatories.—Lead Smelting in Hearths.—Roasting Lead and Silver Ores.—Blast-Roasting of Lead Ores.—Blast-Furnace Lead Smelting: Principles, Plant, Practice, Products, Examples, Costs and Losses, Ore Purchasing.—Flue-Dust: Composition, Collection, and Treatment.—DESILVERISATION.—Softening and Refining for Market.—Pattinson Process.—Parkes Process.—Cupellation and Refining.—Electrolytic Refining.—SUPPLEMENTARY: Works Assaying and Analytical Methods.—Zinc-Lead Sulphides.—Flotation Processes.—INDEX.

"A THOROUGHLY SOUND and useful digest. May with EVERY CONFIDENCE be recommended."—*Mining Journal*.

SECOND EDITION, Revised Throughout and Enlarged. In Preparation.

THE METALLURGY OF SILVER.

By H. F. COLLINS, Assoc.R.S.M., M.INST.M.M.

Comprising Details regarding the Sources and Treatment of Silver Ores, together with Descriptions of Plant, Machinery, and Processes of Manufacture, Refining of Bullion, Cost of Working, &c.

"The author has focussed A LARGE AMOUNT OF VALUABLE INFORMATION into a convenient form. . . . The author has evidently considerable practical experience, and describes the various processes clearly and well."—*Mining Journal*.

Frontispiece in Colours, and Beautiful Series of Photo-micrographs.
12s. 6d. net.

A L L O Y S**AND THEIR INDUSTRIAL APPLICATIONS.**

By EDWARD F. LAW, A.R.S.M.

CONTENTS.—Introduction.— Properties of Alloys.— Methods of Investigation.— Constitution.— Influence of Temperature on Properties.— Corrosion of Alloys.— Copper Alloys, Brass, Bronzes.— Special Brasses and Bronzes.— German Silver and Miscellaneous Copper Alloys.— White Metal Alloys.— Anti-Friction Alloys.— Aluminium Alloys.— Silver and Gold Alloys.— Iron Alloys.— Miscellaneous Alloys (Amalgams, &c.)—INDEX.

"Concise and practical . . . a valuable amount of information that will be appreciated by student and manufacturer alike."—*Foundry Trades' Journal*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND

GRIFFIN'S METALLURGICAL SERIES.

FOURTH EDITION, Thoroughly Revised Throughout. With Numerous Illustrations. Large 8vo. Two Volumes. Handsome Cloth. 36s. net.

With Additional Chapter on The Electric Smelting of Steel.

THE METALLURGY OF STEEL.

BY F. W. HARBORD, Assoc.R.S.M., F.I.C.,

AND J. W. HALL, A.M. INST. C.E.

Vol. I.—Metallurgy.

Vol. II.—Mechanical Treatment.

(N.B.—These Volumes are not Sold Separately.)

ABRIDGED CONTENTS.—The Plant, Machinery, Methods and Chemistry of the Bessemer and of the Open Hearth Processes (Acid and Basic).—The influence of Metalloids, Heat Treatment, Special Steels, Microstructure, Testing, and Specifications.—The Mechanical Treatment of Steel comprising Mill Practice, Plant and Machinery.

The *Engineers* says, at the conclusion of a review of this book:—"We cannot conclude without earnestly recommending all who may be interested as makers or users of steel, which practically means the whole of the engineering profession, to make themselves acquainted with it as speedily as possible, and this may be the more easily done as the published price, considering the size of the book, is extremely moderate."

THIRD EDITION, Revised and Enlarged. With many new Plates.
16s. net.

THE METALLURGY OF IRON.

BY THOMAS TURNER, Assoc.R.S.M., F.I.C.,

Professor of Metallurgy in the University of Birmingham.

General Contents.—Early History of Iron.—Modern History of Iron.—The Age of Steel.—Chief Iron Ores.—Preparation of Iron Ores.—The Blast Furnace.—The Air used in the Blast Furnace.—Reactions of the Blast Furnace.—The Gaseous Products of the Blast Furnace.—The Fuel used in the Blast Furnace.—Slags and Fluxes of Iron Smelting.—Properties of Cast Iron.—Foundry Practice.—Wrought Iron.—Indirect Production of Wrought Iron.—The Puddling Process.—Further Treatment of Wrought Iron.—Corrosion of Iron and Steel.

"A THOROUGHLY USEFUL BOOK, which brings the subject UP TO DATE. OF GREAT VALUE to those engaged in the iron industry."—*Mining Journal*.

. For Professor Turner's *Lectures on Iron-Founding*, see page 53

In Large 8vo. Handsome Cloth. Fully Illustrated. 12s. 6d. net.

ANTIMONY:

Its History, Chemistry, Mineralogy, Geology, Metallurgy, Uses and Preparation, Analysis, Production and Valuation.

By C. Y. WANG, M.A., B.Sc.,

Mem. Am. Inst. Mining Eng.; Mem. Iron and Steel Institute; Geologist for the Quang Si Province, China, &c., &c.

"A book which stands alone, inasmuch as there is not, to our knowledge, any other complete treatise on antimony among all the English text-books."—*Iron and Coal Trades' Review*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

In Medium 8vo. Handsome Cloth. Profusely Illustrated.

**LECTURES ON
MODERN COPPER SMELTING**

By DONALD M. LEVY, M.Sc., A.R.S.M.,

Assistant Lecturer in Metallurgy University of Birmingham

ABRIDGED CONTENTS.—Historical.—Price and Cost of Production and Statistics.—Uses of Copper as Metal and Alloy.—Effect of Impurities.—Compounds.—Ores.—Preliminary Treatment.—Sintering.—Reverberatory Smelting Practice.—Blast Furnace Practice.—Bessemerising of Copper Mattes.—Purification and Refining of Crude Copper.—INDEX.

In Medium 8vo. Handsome Cloth. With Illustrations. 10s. 6d. net.

**CAST IRON
IN THE LIGHT OF RECENT RESEARCH.**

By W. H. HATFIELD, B.Met., A.M.I.Mech.E.

CONTENTS.—INTRODUCTION.—Cast Iron from the Standpoint of the Equilibrium Diagram of the Non-carbon System.—Influence of Silicon.—Of Phosphorus.—Of Sulphur.—Of Manganese.—Of Other Elements.—Of Casting Temperature.—Shrinkage and Contraction.—Growth of Cast Iron under Repeated Heatings.—Effect of Superheated Steam.—Malleable Cast Iron.—Heat Treatment of Cast Iron.—Decarburisation of White Cast-iron Castings.—Mechanical Properties of Cast and Malleable Cast Iron.—Slags.—APPENDICES.—INDEX.

TWELFTH EDITION. With Tables and Illustrations. Cloth, 10s. 6d.

A TEXT-BOOK OF ASSAYING:

For the use of Students, Mine Managers, Assayers, &c.

By J. J. BERINGER, F.I.C., F.C.S.,

Public Analyst for, and Lecturer to the Mining Association of, Cornwall.

AND C. BERINGER, F.C.S.,

Late Chief Assayer to the Rio Tinto Copper Company, London,

GENERAL CONTENTS. — PART I. — INTRODUCTORY; MANIPULATION: Sampling; Drying; Calculation of Results—Laboratory-books and Reports. METHODS: Dry Gravimetric; Wet Gravimetric—Volumetric Assays: Titrometric, Colorimetric, Gasometric—Weighing and Measuring—Reagents—Formulæ, Equations, &c.—Specific Gravity.

PART II.—METALS: Detection and Assay of Silver, Gold, Platinum, Mercury, Copper, Lead, Thallium, Bismuth, Antimony, Iron, Nickel, Cobalt, Zinc, Cadmium, Tin, Tungsten, Titanium, Manganese, Chromium, &c.—Earths, Alkalies.

PART III.—NON-METALS: Oxygen and Oxides; The Halogens—Sulphur and Sulphates—Arsenic, Phosphorus, Nitrogen—Silicon, Carbon, Boron—Useful Tables.

"A REALLY MERITORIOUS WORK, that may be safely depended upon either for systematic instruction or for reference."—*Nature*.

Large 8vo. Cloth. With Illustrations. 12s. 6d. net.

METALLURGICAL ANALYSIS & ASSAYING:

A THREE YEARS' COURSE FOR STUDENTS OF SCHOOLS OF MINES.

By W. A. MACLEOD, B.A., B.Sc., AND CHAS. WALKER, F.C.S.

"The publication of this volume tends to prove that the teaching of metallurgical analysis and assaying in Australia rests in competent hands."—*Nature*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

VOL. I. NOW READY.

In Handsome Cloth, Leather Back. Price 21s. net.

RAND METALLURGICAL PRACTICE.**VOLUME I. contains—**

Introduction by RALPH STOKES.

Breaking and Sorting—Sand Treatment, by J. E. THOMAS, A.I.M.M., &c.
Stamp Milling, by G. O. SMART, A.I.M.M., &c.

Tube Milling: Slime Treatment, by W. R. DOWLING, M.I.M.M., &c.

Slime Treatment, by H. A. WHITE, Mem. Council of C.M. and M.Soc.S.A.

Precipitation: Clean-up and Smelting, by E. H. JOHNSON, M.I.M.M., &c.

Chemistry of Basket Ore Treatment, by W. A. CALDECOTT, D.Sc., F.C.S.,
F.R.S., &c.

Assaying, Testing, by A. M^cA. JOHNSTON, M.A., M.I.M.M., F.C.S., &c.

RAND METALLURGICAL PRACTICE.**VOLUME II. contains—**

Design and Construction of Plant, Transport of Materials, by C. O.
SCHMITT, M.I.M.M., Member Council of Transvaal Institution of
Mechanical Engineers.

In Crown 8vo. Handsome Cloth. Fully Illustrated. 3s. net.

AN INTRODUCTION TO**PRACTICAL METALLURGY.**

BY PROF. THOMAS TURNER, A.R.S.M., F.I.C.

"It is an excellent and handy book for its purpose, and will have a far wider range of usefulness than for class work alone."—*Practical Engineer.*

FOURTH EDITION, Revised. With Numerous Illustrations. 6s.

A TEXT-BOOK OF**ELEMENTARY METALLURGY.**

Including the Author's PRACTICAL LABORATORY COURSE.

BY A. HUMBOLDT SEXTON, F.I.C., F.C.S.

"Just the kind of work for Students COMMENCING the study of Metallurgy, or for ENGINEERING Students."—*Practical Engineer.*

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

In Crown 8vo. Handsome cloth. With 102 Illustrations. 6s. net.

**A HANDBOOK ON
METALLIC ALLOYS:**

Their Structure and Constitution.

By GILBERT H. GULLIVER, B.Sc., F.R.S.E.

A valuable addition to existing literature on alloys.—*Foundry Trades' Journal*.

In Large 8vo. Handsome Cloth. Price 4s.

QUANTITATIVE METALLURGICAL ANALYSIS.

TABLES FOR LABORATORY USE.

ON THE PRINCIPLE OF "GROUP" SEPARATIONS.

By J. JAMES MORGAN, F.C.S., M.S.C.I.

"The Author may be CONGRATULATED on the way his work has been carried out."—*The Engineer*.

THIRD EDITION. In Handsome Cloth. Revised, Enlarged, and Re-written. Pp. i-xv + 425. Fully Illustrated. 12s. 6d. net.

**A TREATISE ON
ELECTRO-METALLURGY:**

Embracing the Application of Electrolysis to the Plating, Depositing, Smelting, and Refining of various Metals, and to the Reproduction of Printing Surfaces and Art-Work, &c.

By W. G. McMILLAN, F.I.C., AND W. R. COOPER, M.A., B.Sc.

"CONTENTS.—Introductory and Historical.—Theoretical and General.—Sources of Current.—General Conditions to be Observed in Electro-Plating.—Plating Adjuncts and Deposition of Plant.—The Cleansing and Preparation of Work for the Depositing-Vat, and subsequent Plating of Plated Goods.—The Electro-deposition of Copper.—Electro-typing.—The Electro-deposition of Silver, Gold, Nickel and Cobalt, Iron, Platinum, Zinc, Chromium, Cadmium, Tin, Lead, Antimony, Bismuth, and Palladium; Electrochromy.—The Electro-deposition of Alloys.—Electro-metallurgical Extraction and Refining Processes.—The Recovery of certain Metals from their Solutions or from Waste Substances.—The Determination of the Proportion of Metal in certain Depositing Solutions.—Power required for Electrolytic Work.—Modern Theories of Electrolysis.—Glossary.—Addenda.—INDEX.

"A most valuable cyclopedia as well as a guiding text-book . . . gives a wonderful amount of information."—*Metal Industry*.

SECOND EDITION, Thoroughly Revised and Enlarged. In large 8vo. With Numerous Illustrations and Three Folding-Plates. 21s. net.

ELECTRIC SMELTING & REFINING:

A Practical Manual of the Extraction and Treatment of Metals by Electrical Methods.

Being the "ELEKTRO-METALLURGIE" of DR. W. BORCHERS.

Translated from the Latest German Edition by WALTER G. McMILLAN, F.I.C., F.C.S.

"COMPREHENSIVE and AUTHORITATIVE . . . not only FULL of VALUABLE INFORMATION, but gives evidence of a THOROUGH INSIGHT into the technical VALUE and POSSIBILITIES of all the methods discussed."—*The Electrician*.

LONDON: CHARLES GRIFFIN & CO., LIMITED EXETER STREET, STRAND.

SECOND EDITION. *In Medium Svo. Handsome Cloth. Fully Illustrated.*

GENERAL FOUNDRY PRACTICE:

A Practical Handbook for Iron, Steel and Brass Founders, Metallurgists, and Students of Metallurgy.

By A. McWILLIAM, A.R.S.M., AND PERCY LONGMUIR.

"The student of foundry work . . . needs no other text-book. . . . The book contains a tremendous amount of information, and is well written."—*Engineering Times.*

SECOND EDITION. *Extra Crown Svo. With many Illustrations.*
3s. 6d. net.

LECTURES ON IRON-FOUNDING.

By THOMAS TURNER, M.Sc., A.R.S.M., F.I.C.,

Professor of Metallurgy in the University of Birmingham.

CONTENTS.—Varieties of Iron and Steel.—Application of Cast Iron.—History.—Production.—Iron Ores.—Composition.—The Blast Furnace.—Materials.—Reactions.—Grading Pig Iron.—Carbon, Silicon, Sulphur, Phosphorus, Manganese, Aluminium, Arsenic, Copper, and Titanium.—The Foundry.—General Arrangement.—Re-melting Cast Iron.—The Cupola.—Fuel Used.—Changes due to Re-melting.—Moulds and Moulding.—Foundry Ladles.—Pouring and Pouring Temperature.—Common Troubles.—Influence of Shape and Size on Strength of Castings.—Tests.
"Ironfounders will find much information in the book."—*Iron Trade Circular Ryland's*.

In Crown Svo. Handsome Cloth. 1s. 6d. net.

BLAST FURNACE PRACTICE.

By J. JAMES MORGAN, F.C.S., M.S.C.I.,

Author of "Quantitative Metallurgical Tables," &c.

CONTENTS.—Requirements.—Iron Ores.—Fuel.—Flux.—Slags.—Quantity of Slag.—Burden, Charge, Round.—The Blast.—Ore Mixing.—Amount and Composition of the Iron.—Calculation of Flux.—Heating the Blast; Stoves—Drying, Changing, and Cleaning.—Drying the Furnace.—Filling the Furnace, and Lighting.—Charging the Furnace.—Descent of the Charge.—Flushing.—Tapping.—Hard Tapping Hole.—Running down the Beds (Casting).—Judging the Temperature.—Controlling the Temperature.—Temperature and the Reduction of Silicon.—The Pig Iron.—Fuel Consumption.—Economy in Fuel Consumption.—Tuyeres: Leaky, Changing.—Cooler or "Jumbo."—Obstructions—Pillaring.—Breakouts.—Hot Spots.—Scaffolds (Hanging).—Slips.—Damping Down.—Blowing Out.—INDEX.

"Excellent. . . . It is essentially suitable for the practical man, and to the beginner particularly it should prove valuable."—*Iron and Coal Trades Record.*

SECOND EDITION, *Revised. In Demy Svo. With 145 Illustrations and 12 new Plates.* 7s. 6d. net.

THE ART OF THE GOLDSMITH AND JEWELLER.

**A Manual on the Manipulation of Gold and the
Manufacture of Personal Ornaments.**

By THOS. B. WIGLEY,

Headmaster of the Jewellers and Silversmiths' Assoc. Tech. School, Birmingham.

ASSISTED BY J. H. STANSBIE, B.Sc. (LOND.), F.I.C.,

Lecturer at the Birmingham Municipal Technical School.

"A recognised standard work."—*Jewellers' and Watchmakers' Trade Advertiser.*

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

SECOND EDITION, Revised, Enlarged, and Re-set Throughout on Larger Page.
With Valuable Bibliography, New Maps, Illustrations, &c. 45s. net.

IN TWO VOLUMES.
A TREATISE ON

PETROLEUM.

By SIR BOVERTON REDWOOD,
D.Sc., F.R.S.E., Assoc. Inst. C.E., F.I.C.

CONTENTS.—SECTION I.: Historical Account of the Petroleum Industry.—SECTION II.: Geological and Geographical Distribution of Petroleum and Natural Gas.—SECTION III.: The Chemical and Physical Properties of Petroleum and Natural Gas.—SECTION IV.: The Origin of Petroleum and Natural Gas.—SECTION V.: The Production of Petroleum, Natural Gas, and Ozokerite.—SECTION VI.: The Refining of Petroleum.—SECTION VII.: The Shale Oil and Allied Industries.—SECTION VIII.: The Transport, Storage, and Distribution of Petroleum.—SECTION IX.: The Testing of Crude Petroleum, Petroleum and Shale Oil Products, Ozokerite, and Asphalt.—SECTION X.: The Uses of Petroleum and its Products.—SECTION XI.: Statutory, Municipal, and other Regulations relating to the Testing, Storage, Transport, and Use of Petroleum and its Products.—APPENDICES.—BIBLIOGRAPHY.—INDEX.

"It is indisputably the most comprehensive and complete treatise on petroleum, and this statement is true, no matter on what branch of the industry a test of its merits is made. It is the only book in existence which gives the oil man a clear and reliable outline of the growth and present-day condition of the entire petroleum world. . . . There is a wonderfully complete collection of plates and illustrations."—*Petroleum World*.

SECOND EDITION, Revised. With Illustrations. Price 8s. 6d. net.

A HANDBOOK ON PETROLEUM. FOR INSPECTORS UNDER THE PETROLEUM ACTS,

And for those engaged in the Storage, Transport, Distribution, and Industrial Use of Petroleum and its Products, and of Calcium Carbide. With suggestions on the Construction and Use of Mineral Oil Lamps.

By CAPTAIN J. H. THOMSON,
H.M. Chief Inspector of Explosives,
AND SIR BOVERTON REDWOOD,

Author of "A Treatise on Petroleum."

"A volume that will enrich the world's petroleum literature, and render a service to the British branch of the industry. . . . Reliable, indispensable, a brilliant contribution."—*Petroleum*.

SECOND EDITION, Revised. In Crown 8vo. Fully Illustrated.

THE LABORATORY BOOK OF MINERAL OIL TESTING.

By J. A. HICKS,
Chemist to Sir Boverton Redwood
Should be on the shelves of every analytical chemist in practice."—*Chemical Trade Journal*.

SECOND EDITION. In Large Crown 8vo, Cloth. Fully Illustrated 6s. net.

OIL FUEL: ITS SUPPLY, COMPOSITION, AND APPLICATION.

By SIDNEY H. NORTH,

THOROUGHLY REVISED AND ENLARGED BY ED. BUTLER. M.I.MECH.E.

CONTENTS.—The Sources of Supply.—Economic Aspect of Liquid Fuel.—Chemical Composition of Fuel Oils.—Conditions of Combustion in Oil Fuel Furnaces.—Early Methods and Experiments.—Modern Burners and Methods.—Oil Fuel for Marine Purposes.—For Naval Purposes.—On Locomotives.—For Metallurgical and other Purposes.—Appendices.—INDEX.

"Everyone interested in this important question will welcome Mr. North's excellent text-book."—*Nature*.

THE PETROLEUM LAMP: Its Choice and Use. A Guide to the Safe Employment of the Paraffin Lamp. By CAPT. J. H. THOMSON and SIR BOVERTON REDWOOD. Illustrated. 1s. net.

"A work which will meet every purpose for which it has been written."—*Petroleum*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND

In Two Vols., Large 8vo. With Illustrations. Sold Separately.

CHEMISTRY FOR ENGINEERS AND MANUFACTURERS.

BY

BERTRAM BLOUNT, F.I.C., & A. G. BLOXAM, F.I.O.

VOLUME I.—Chemistry of Engineering, Building, and Metallurgy.—*General Contents.*—INTRODUCTION.—Chemistry of the Chief Materials of Construction.—Sources of Energy.—Chemistry of Steam-raising.—Chemistry of Lubrication and Lubricants.—Metallurgical Processes used in the Winning and Manufacture of Metals. SECOND EDITION. 14s.

VOLUME II.—The Chemistry of Manufacturing Processes.—*General Contents.*—Sulphuric Acid Manufacture.—Alkali, &c.—Destructive Distillation.—Artificial Manure.—Petroleum.—Lime and Cement—Clay and Glass.—Sugar and Starch.—Brewing and Distilling.—Oils, Resins, and Varnishes.—Soap and Candles.—Textiles and Bleaching.—Colouring Matters, Dyeing and Printing.—Paper and Pasteboard.—Pigments and Paints.—Leather, Glue, and Size.—Explosives and Matches.—Minor Manufactures. SECOND EDITION, Reprinted. Illustrated. 16s.

SECOND EDITION. In Large 8vo. Handsome Cloth. With 800 pages and 154 Illustrations. 25s. net.

OILS, FATS, BUTTERS, AND WAXES:

THEIR PREPARATION AND PROPERTIES, AND MANUFACTURE THEREFROM OF CANDLES, SOAPS, AND OTHER PRODUCTS.

By C. R. ALDER WRIGHT, D.Sc., F.R.S.,

Late Lecturer on Chemistry, St. Mary's Hospital Medical School; Examiner in "Soap" to the City and Guilds of London Institute.

Thoroughly Revised, Enlarged, and in Part Rewritten

By C. AINSWORTH MITCHELL, B.A., F.I.C., F.C.S.

"Will be found ABSOLUTELY INDISPENSABLE."—*The Analyst.*

"Will rank as the STANDARD ENGLISH AUTHORITY ON OILS and FATS for many years to come."—*Industries and Iron.*

In Two Volumes, Half Morocco, each complete in itself.

PHYSICO-CHEMICAL TABLES

For the Use of Analysts, Physicists, Chemical Manufacturers and Scientific Chemists.

Volume I.—Chemical Engineering, Physical Chemistry.

Pp. i-xxxii + 548. 24s. net.

Volume II.—Chemical Physics, Pure and Analytical Chemistry.

Pp. i-xiv + 549 to 1235. With Index to the two Volumes. 36s. net.

By JOHN CASTELL-EVANS, F.I.C., F.C.S.

The Work comprehends as far as possible ALL RULES and TABLES required by the Analyst, Brewer, Distiller, Acid- and Alkali-Manufacturer, &c., &c.; and also the principal data in THERMO-CHEMISTRY, ELECTRO-CHEMISTRY, and the various branches of CHEMICAL PHYSICS. Every possible care has been taken to ensure perfect accuracy, and to include the results of the most recent investigations.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

SIXTH EDITION, Thoroughly Revised. Fully Illustrated. 21s.

FOODS: THEIR COMPOSITION AND ANALYSIS.

BY A. WYNTER BLYTH, M.R.C.S., F.I.C., F.C.S.,

Barrister-at-Law, Public Analyst for the County of Devon, and
Medical Officer of Health for St. Marylebone.

AND M. WYNTER BLYTH, B.A., B.Sc., F.C.S.

GENERAL CONTENTS.—History of Adulteration.—Legislation.—Apparatus.—“Ash.”—Sugar.—Confectionery.—Honey.—Treacle.—Jams and Preserved Fruits.—Starches.—Wheaten-Flour.—Bread.—Oats.—Barley.—Rye.—Rice.—Maize.—Millet.—Potatoes.—Peas.—Lentils.—Beans.—Milk.—Cream.—Butter.—Oleo-Margarine.—Cheese.—Lard.—Tea.—Coffee.—Cocoa and Chocolate.—Alcohol.—Brandy.—Rum.—Whisky.—Gin.—Arrack.—Liqueurs.—Absinthe.—Yeast.—Beer.—Wine.—Vinegar.—Lemon and Lime Juice.—Mustard.—Pepper.—Sweet and Bitter Almonds.—Annatto.—Olive Oil.—Water Analysis.—Appendix: Adulteration Acts, &c.

“A new edition of Mr. Wynter Blyth's Standard work, ENRICHED WITH ALL THE RECENT DISCOVERIES AND IMPROVEMENTS, will be accepted as a boon.”—*Chemical News*.

FOURTH EDITION, Thoroughly Revised. In Large 8vo, Cloth, with
Tables and Illustrations. 21s. net.

POISONS: THEIR EFFECTS AND DETECTION.

BY A. WYNTER BLYTH, M.R.C.S., F.I.C., F.C.S.,

Barrister-at-Law, Public Analyst for the County of Devon, and
Medical Officer of Health for St. Marylebone.

GENERAL CONTENTS.—I.—Historical Introduction. II.—Classification—Statistics—Connection between Toxic Action and Chemical Composition—Life Tests—General Method of Procedure—The Spectroscope—Examination of Blood and Blood Stains. III.—Poisonous Gases. IV.—Acids and Alkalies. V.—More or less Volatile Poisonous Substances. VI.—Alkaloids and Poisonous Vegetable Principles. VII.—Poisons derived from Living or Dead Animal Substances. VIII.—The Oxalic Acid Group. IX.—Inorganic Poisons. Appendix: Treatment, by Antidotes or otherwise, of Cases of Poisoning.

“Undoubtedly THE MOST COMPLETE WORK on Toxicology in our language.”—*The Analyst*.
“AS A PRACTICAL GUIDE, we know no BETTER WORK.”—*The Lancet (on the Third Edition)*

Crown 8vo, Handsome Cloth. Fully Illustrated. 10s. 6d.

FLESH FOODS:

With Methods for their Chemical, Microscopical, and Bacteriological Examination.

A Practical Handbook for Medical Men, Analysts, Inspectors and others.

BY C. AINSWORTH MITCHELL, B.A., F.I.C., F.C.S.

“A compilation which will be most useful for the class for whom it is intended.”—*Athenæum*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND

SECOND EDITION. With Numerous Tables, Fully Illustrated.

DAIRY CHEMISTRY

FOR DAIRY MANAGERS, CHEMISTS, AND ANALYSTS

A Practical Handbook for Dairy Chemists and others
having Control of Dairies.

By H. DROOP RICHMOND, F.I.C.,
CHEMIST TO THE AYLESBURY DAIRY COMPANY.

Contents.—I. Introductory.—The Constituents of Milk. II. The Analysis of Milk. III. Normal Milk: its Adulterations and Alterations, and their Detection. IV The Chemical Control of the Dairy. V, Biological and Sanitary Matters. VI. Butter. VII. Other Milk Products. VIII. The Milk of Mammals other than the Cow.—Appendices.—Tables—Index.

“ . . . In our opinion the book is the BEST CONTRIBUTION ON THE SUBJECT THAT HAS YET APPEARED in the English language.”—*Lancet* (on the First Edition).

In Crown 8vo, Fully Illustrated. 2s. 6d. net.

THE LABORATORY BOOK OF DAIRY ANALYSIS.

By H. DROOP RICHMOND, F.I.C.,
Analyst to the Aylesbury Dairy Co., Ltd.

“Without doubt the best contribution to the literature of its subject that has ever been written.”—*Medical Times*.

Fully Illustrated. With Photographs of Various Breeds of Cattle, &c.
6s. net.

MILK: ITS PRODUCTION & USES.

With Chapters on Dairy Farming, The Diseases of Cattle, and on the Hygiene and Control of Supplies.

By EDWARD F. WILLOUGHBY,
M.D. (Lond.), D.P.H. (Lond. and Camb.).

“We cordially recommend it to everyone who has anything at all to do with milk.”
Dairy World.

In Large Crown 8vo. Cloth. Fully Illustrated. 4s. 6d. net.

ELEMENTARY AGRICULTURAL CHEMISTRY.

By HERBERT INGLE, B.Sc., F.I.C., F.C.S.

CONTENTS.—Introduction.—The Atmosphere.—The Soil—Natural Waters.—The Plant.—Manures.—Crops.—The Animal.—Foods and Feeding.—The Dairy.—Miscellaneous.—INDEX.

FIFTH EDITION. In Demy 8vo. Revised Throughout. Pp. i xi + 489.
With 101 Illustrations. In Cloth. 15s. net.

MICRO-ORGANISMS AND FERMENTATION.

By ALFRED JÖRGENSEN.

TRANSLATED BY SAMUEL H. DAVIES, M.Sc.

CONTENTS.—Microscopical and Physiological Investigations.—Biological Examination of Air and Water.—Bacteria.—Moulds.—Yeasts.—Pure Culture of Yeast on a large scale.—BIBLIOGRAPHY.—INDEX.

“The student taking up this subject would do well to work through this book first and then take Lafar’s.”—*Brewing Trade Review*

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

THIRD EDITION. In Handsome Cloth. Fully Illustrated. 21s. net.
PRINCIPLES AND PRACTICE OF BREWING.
 FOR THE USE OF STUDENTS AND PRACTICAL MEN.

By WALTER J. SYKES.

REVISED BY ARTHUR R. LING, F.I.C., F.C.S.,
 Editor of the Journal of the Institute of Brewing.

CONTENTS.—Physical Principles Involved.—The Chemistry of Brewing.—The Microscope.—Vegetable Biology.—Fermentation.—Water.—Barley and Malting.—Arrangement of Brewery Plant.—Quantities of Materials.—Fermentation.—Antiseptics.—Finings.—Characteristics of Beer.—Diseases of Beer.—INDEX.

"A thorough and comprehensive text-book . . . up-to-date . . . a standard text-book."—*Brewers' Journal*.

In Large 8vo. Complete in Two Volumes.

Each Volume Complete in Itself, and Sold Separately.

TECHNICAL MYCOLOGY:
The Utilisation of Micro-organisms in the Arts and Manufactures.

By DR. FRANZ LAFAR,

Prof. of Fermentation-Physiology and Bacteriology in the Technical High School, Vienna.

TRANSLATED BY CHARLES T. C. SALTER.

Vol. I.—**SCHIZOMYCETIC FERMENTATION.** 15s. net.

Vol. II.—**EUMYCETIC FERMENTATION.** 24s. net.

NOTE.—Part I. of Vol. II. was issued separately at 7s. 6d. Copies of Part II., Vol. II., have, therefore, been bound up to enable those possessing Part I. to complete their copies. The price of Vol. II., Part II., is 18s. net.

"The first work of the kind which can lay claim to completeness in the treatment of a fascinating subject. The plan is admirable, the classification simple, the style is good, and the tendency of the whole volume is to convey sure information to the reader."—*Lancet*.

Crown 8vo, Handsome Cloth. With Diagrams. 7s. 6d. net.

[Companion Volume to "FERMENTS," by the same Author.]

TOXINES AND ANTITOXINES.

By CARL OPPENHEIMER, PH.D., M.D.,

Of the Physiological Institute at Erlangen.

TRANSLATED FROM THE GERMAN BY

C. AINSWORTH MITCHELL, B.A., F.I.C., F.C.S.

With Notes, and Additions by the Author, since the publication of the German Edition.

"For wealth of detail, we have no small work on Toxines which equals the one under review"—*Medical Times*

In Crown 8vo, Handsome Cloth. Price 7s. 6d. net.

FERMENTS: AND THEIR ACTIONS.
A Text-book on the Chemistry and Physics of Fermentative Changes.

By CARL OPPENHEIMER, PH.D., M.D.

TRANSLATED BY C. AINSWORTH MITCHELL, B.A., F.I.C., F.C.S.

"Such a veritable *multum in parvo* has never yet appeared."—*Brewers' Journal*.

LONDON: CHARLES GRIFFIN & CO., LIMITED. EXETER STREET, STRAND

In Medium 8vo. Fully Illustrated.

A TREATISE ON
CHEMICAL ANALYSIS,
WITH SPECIAL REFERENCE TO THE SILICATE INDUSTRIES.

By J. W. MELLOR, Sc.D.

In Medium 8vo. Handsome Cloth. Illustrated.

CELLULOID.
ITS MANUFACTURE, APPLICATIONS, AND SUBSTITUTES.
Translated from the French of MASSELOU, ROBERTS, and CILLARD.
By H. H. HODGSON, M.A.(Camb.), B.Sc.(Lond.), Ph.D.(Heidelberg).

In Crown 8vo. Fully Illustrated. 4s. 6d. net.

WATER ANALYSIS,
FOR SANITARY AND TECHNICAL PURPOSES.

By HERBERT B. STOCKS, F.I.C., F.C.S.

CONTENTS.—Physical Examination, including Colour, Odour, Taste, &c.—Sanitary Analysis, including Estimation of Total Solids, Free and Albuminoid Ammonia, Organic Carbon and Nitrogen, Nitrogen as Nitrates and Nitrites, Chlorine, Oxygen Absorbed, Hardness, &c.—Mineral Analysis, Estimation of Bases and Acids and Calculation of Results.—Gases Dissolved in Water.—APPENDIX.—TABLES.—INDEX.

In Medium 8vo. Handsome Cloth. Profusely Illustrated. 15s. net.

Modern Destructor Practice.

By W. FRANCIS GOODRICH, Assoc.Inst.C.E., F.I.San.Engrs., &c.
(See page 18.)

SECOND EDITION, Revised. In Medium 8vo, Cloth. Illustrated.
12s. 6d. net.

PAPER TECHNOLOGY:
AN ELEMENTARY MANUAL ON THE MANUFACTURE, PHYSICAL QUALITIES,
AND CHEMICAL CONSTITUENTS OF PAPER AND OF
PAPERMAKING FIBRES.

With Selected Tables for Stationers, Publishers, and Others.

By R. W. SINDALL, F.C.S.

"Exceedingly instructive and particularly useful."—*Paper Makers' Monthly Journal.*

LONDON: CHARLES GRIFFIN & CO., LIM TED, EXETER STREET, STRAND.

In Crown Svo. Handsome Cloth. Fully Illustrated. 6s. net.

PEAT: Its Use and Manufacture.

By PHILIP R. BJÖRLING AND FREDERICK T. GISSING.

GENERAL CONTENTS.—Introduction.—The Formation of Peat.—Area and Depth of Bogs in Principal Countries.—Manufacture of Peat Fuel, &c.—Cut Peat, Dredged Peat, and Manufactured Peat.—Machinery employed in the Manufacture of Peat Fuel.—Peat Moss Litter, and the Machinery employed in its Manufacture.—Peat Charcoal and its Manufacture.—Cost of making Peat Fuel and Charcoal.—Other Productions derived from Peat, such as Tar, Manure, Candles, Dyes, Paper, &c.—BIBLIOGRAPHY.—INDEX.

"The treatment throughout is clear and interesting . . . excellent plates."—*Engineering*.

Companion Volume to the above. In Crown Svo. Cloth. Fully Illustrated. 6s. net.

COMMERCIAL PEAT:

Its Uses and Its Possibilities.

By F. T. GISSING.

"A useful and instructive epitome of the development of the industry."—*Mechanical Engineer*.

In Crown Svo. Pp. i-xi+451. Price 7s. 6d. net.

British Clays, Shales & Sands.

By A. B. SEARLE, CANTOR LECTURER ON BRICKMAKING.

SECOND EDITION, Thoroughly Revised. In Crown Svo. Handsome Cloth. 6s. net.

THE CLAYWORKER'S HANDBOOK.

A Manual for all engaged in the Manufacture of Articles from Clay.

By ALFRED B. SEARLE, Cantor Lecturer on Brickmaking.

GENERAL CONTENTS.—Materials used in Clayworking: Clays, Engobes, Glazes, Colours, Water, Fuel, Oils, and Lubricants.—The Preparation of the Clay, Mining and Quarrying, Weathering, Washing, Grinding, Tempering, and Fugging.—Machinery: Boilers, Engines, General Machinery, Sieves, Mixing Machinery, Presses, &c.—Dryers and Drying.—Engobing and Glazing.—Setting or Charging, Transport.—Kilns.—Firing.—Discharging, Sorting, and Packing.—Defects and Waste.—Tests, Analysis and Control.—BIBLIOGRAPHY.—TABLES.—INDEX.

"We can thoroughly recommend this handy little book to all our readers."—*Brick and Pottery Trades' Journal*.

In Imperial Svo. Strongly and Elegantly Bound in Half Leather.

Enclosed in Case. Pp. i-xviii + 660. £2 2s. net.

CERAMIC LITERATURE.

Compiled, Classified, and Described by M. L. SOLON,

President of the English Ceramic Society.

An Analytical Index to the Works Published in all Languages on the History and the Technology of the Ceramic Art; also to the Catalogues of Public Museums, Private Collections, and of Auction Sales in which the Description of Ceramic Objects occupy an important place; and to the most important Price Lists of the Ancient and Modern Manufactories of Pottery and Porcelain.

"A work of inestimable value to all serious study of Ceramics."—*Burlington Magazine*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND

In Medium 8vo. Cloth. Pp. i-xiii + 356. With Tables, Illustrations in the Text, and 36 Plates. 21s. net.

**MODERN METHODS OF
SEWAGE PURIFICATION.**

By G. BERTRAM KERSHAW,

Engineer to the Royal Commission on Sewage Disposal.

CONTENTS.—Introduction.—Historical.—Conservancy Methods and Purification of Sewage.—Drainage Area and Water Supply.—Sewerage Systems.—Rainfall and Storm Water.—Variations in Flow of Sewage.—Composition and Classification of Sewages.—Considerations to be Observed in Selecting the Site for Disposal Works.—Preliminary Processes.—Sludge Disposal.—Land Treatment.—Contact Beds.—Percolating Filters.—Treatment of Trade Refuse.—Effluents and Standards.—Appendix.—INDEX.

"A large and comprehensive work . . . replete with information."—*Journal Royal Sanitary Institute.*

In Large 8vo. Cloth. With 147 Illustrations. 15s. net.

A MANUAL OF

THE PRINCIPLES OF SEWAGE TREATMENT.

By PROF. DUNBAR,

Director of the Institute of State Hygiene, Hamburg.

ENGLISH EDITION BY HARRY T. CALVERT, M.Sc., Ph.D., F.I.C.,
Chief Chemical Assistant, West Riding of Yorkshire Rivers Board.

"We heartily commend the book as a peculiarly fair and impartial statement of the present position of the sewage problem."—*Lancet.*

*Beautifully Illustrated, with Numerous Plates, Diagrams, and
Figures in the Text. 21s. net.*

TRADES' WASTE :

ITS TREATMENT AND UTILISATION.

Handbook for Borough Engineers, Surveyors, Architects, and Analysts.

By W. NAYLOR, F.C.S., A.M. INST. C.E.,

Chief Inspector of Rivers, Ribble Joint Committee.

"There is probably no person in England to-day better fitted to deal rationally with such a subject."—*British Sanitarian.*

SECOND EDITION. In Medium 8vo. Thoroughly Revised and Re-Written.
15s. net.

CALCAREOUS CEMENTS :

THEIR NATURE, PREPARATION, AND USES.

With some Remarks upon Cement Testing.

By GILBERT R. REDGRAVE, Assoc. INST. C.E.,

Assistant Secretary for Technology, Board of Education, South Kensington,

AND CHARLES SPACKMAN, F.C.S.

"We can thoroughly recommend it as a first-class investment."—*Practical Engineer.*

In Handsome Cloth. 5s. net.

A HANDBOOK FOR CEMENT WORKS' CHEMISTS.

By FRANK B. GATEHOUSE, F.C.S.

GENERAL CONTENTS.—Introduction.—Chemicals and Apparatus.—Books.—Analysis and Calculations of Raw Materials.—Analysis of Fuel, Kiln Gases, Lubricants and Water.—Cement Analysis.—Gypsum, Plaster, &c., Burnt Lime.—APPENDICES.—INDEX.

"Concise . . . excellent . . . a useful addition to Cement Literature."—*Concrete.*

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

In Large Crown 8vo. Fully Illustrated. In Two Volumes.

VOLUME I. FOURTH EDITION. Price 7s. 6d. net.

„ II. THIRD EDITION. READY SHORTLY.

THE CHEMISTRY OF

GAS MANUFACTURE :

A Hand-Book on the Production, Purification, and Testing of Illuminating Gas, and the Assay of the Bye-Products of Gas Manufacture.

By W. J. ATKINSON BUTTERFIELD, M.A., F.I.C., F.C.S.,
Formerly Head Chemist, Gas Works, Beckton, London, E.

“The BEST WORK of its kind which we have ever had the pleasure of reviewing.”—*Journal of Gas Lighting.*

In Large Crown 8vo. Handsome Cloth. Illustrated. 6s net.

THE CALORIFIC POWER OF GAS.

By J. H. COSTÉ, F.I.C., F.C.S.

CONTENTS.—Historical.—Calorific Standards.—Constituents of Coal Gas and Similar Gaseous Mixtures.—Their Thermal Properties.—Calorimetry.—Appendix.—INDEX.

SECOND EDITION, Rewritten. Illustrated. 8s. 6d. net.

ACETYLENE :

THE PRINCIPLES OF ITS GENERATION AND USE.

By F. H. LEEDS, F.I.C., F.C.S.,

AND W. J. ATKINSON BUTTERFIELD, M.A., F.I.C., F.C.S.,
Consulting Chemist, Author of “The Chemistry of Gas Manufacture.”

“We can thoroughly recommend the book to the manufacturer as a reliable work of reference, to the user as supplying valuable hints on apparatus and methods of procedure, and to the student as a safe and certain guide.”—*Acetylene.*

Large 8vo. Handsome Cloth. Price 16s. net.

FIRE AND EXPLOSION RISKS :

A Handbook of the Detection, Investigation, and Prevention of Fires and Explosions.

By DR. VON SCHWARTZ.

Translated from the Revised German Edition by C. T. C. SALTER.

ABBREVED GENERAL CONTENTS.—Fires and Explosions of a General Character—Dangers arising from Sources of Light and Heat.—Dangerous Gases.—Risks Attending Special Industries.—Materials Employed.—Agricultural Products.—Fats, Oils, and Resins.—Mineral Oils and Tar.—Alcohol, &c.—Metals, Oxides, Acids, &c.—Lightning Ignition Appliances, Fireworks.

“The work affords a wealth of information on the chemistry of fire and kindred topics.”—*Fire and Water.*

In Handsome Cloth. With 59 Illustrations. 6s. net.

SMOKE ABATEMENT.

A Manual for the Use of Manufacturers, Inspectors, Medical Officers of Health, Engineers, and Others.

By WILLIAM NICHOLSON,
Chief Smoke Inspector to the Sheffield Corporation.

“We welcome such an adequate statement on an important subject.”—*British Medical Journal.*

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET. STRAND.

SIXTEENTH EDITION, Thoroughly Revised. Price 6s.

PRACTICAL SANITATION: **A HAND-BOOK FOR SANITARY INSPECTORS AND OTHERS** **INTERESTED IN SANITATION.**

By **GEORGE REID, M.D., D.P.H.,**
Fellow, Mem. Council, and Examiner, Sanitary Institute of Great Britain,
and Medical Officer to the Staffordshire County Council.

With an Appendix on Sanitary Law.

By **HERBERT MANLEY, M.A., M.B., D.P.H.,**
Barrister-at-Law.

GENERAL CONTENTS.—Introduction.—Water Supply: Drinking Water, Pollution of Water.—Ventilation and Warming.—Principles of Sewage Removal.—Details of Drainage; Refuse Removal and Disposal.—Sanitary and Insanitary Work and Appliances.—Details of Plumbers' Work.—House Construction.—Infection and Disinfection.—Food, Inspection of; Characteristics of Good Meat; Meat, Milk, Fish, &c., unfit for Human Food.—Appendix: Sanitary Law; Model Bye-Laws, &c.

"A VERY USEFUL HANDBOOK, with a very useful Appendix. We recommend it not only to SANITARY INSPECTORS, but to HOUSEHOLDERS and ALL interested in Sanitary Matters."—*Sanitary Record.*

In Handsome Cloth. With 53 Illustrations. 3s. 6d. net.

LESSONS ON SANITATION.

By **JOHN WM. HARRISON, M.R.SAN.I.,**

Mem. Assoc. Mun. and County Engineers; Surveyor, Wombwell, Yorks.

"Accurate, reliable, and compiled with conciseness and care."—*Sanitary Record.*

SECOND EDITION, Revised. In Crown 8vo. Handsome Cloth. Profusely Illustrated. 8s. 6d. net.

SANITARY ENGINEERING:

A Practical Manual of Town Drainage and Sewage and Refuse Disposal
For Sanitary Authorities, Engineers, Inspectors, Architects,
Contractors, and Students.

By **FRANCIS WOOD, A.M.INST.C.E., F.G.S.,**

Borough Engineer and Surveyor, Fulham; late Borough Engineer, Bacup, Lancs.

GENERAL CONTENTS.

Introduction.—Hydraulics.—Velocity of Water in Pipes.—Earth Pressures and Retaining Walls.—Powers.—House Drainage.—Land Drainage.—Sewers.—Separate System.—Sewage Pumping.—Sewer Ventilation.—Drainage Areas.—Sewers, Manholes, &c.—Trade Refuse.—Sewage Disposal Works.—Bacterial Treatment.—Sludge Disposal.—Construction and Cleansing of Sewers.—Refuse Disposal.—Chimneys and Foundations.

"The volume bristles with information which will be greedily read by those in need of assistance. The book is one that ought to be on the bookshelves of EVERY PRACTICAL ENGINEER."—*Sanitary Journal*

"A VERITABLE POCKET COMPENDIUM of Sanitary Engineering. . . . A work which may, in many respects, be considered as COMPLETE . . . COMMENDABLY CAUTIOUS . . . INTERESTING . . . SUGGESTIVE."—*Public Health Engineer.*

With Four Folding Plates and Numerous Illustrations. Large 8vo.
8s. 6d. net.

WATER SUPPLY:

A Practical Treatise on the Selection of Sources and the Distribution of Water.

By **REGINALD E. MIDDLETON, M.INST.C.E., M.INST.MECH.E., F.S.I.**

"As a companion for the student, and a constant reference for the technical man, we anticipate it will take an important position on the bookshelf."—*Practical Engineer.*

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

SECOND EDITION. *In Large 8vo. Handsome Cloth. Beautifully Illustrated. With Plates and Figures in the Text. 21s. net.*

ROAD MAKING AND MAINTENANCE:

A Practical Treatise for Engineers, Surveyors, and Others.

WITH AN HISTORICAL SKETCH OF ANCIENT AND MODERN PRACTICE.

By THOS. AITKEN, Assoc. M. INST. C. E.,

Member of the Association of Municipal and County Engineers; Member of the Sanitary Inst.; Surveyor to the County Council of Fife. Cupar Division.

WITH NUMEROUS PLATES, DIAGRAMS, AND ILLUSTRATIONS.

CONTENTS.—Historical Sketch.—Resistance of Traction.—Laying out New Roads.—Earthworks, Drainage, and Retaining Walls.—Road Materials, of Metal.—Quarrying.—Stone Breaking and Haulage.—Road-Rolling and Scarifying.—The Construction of New, and the Maintenance of existing Roads.—Carriage Ways and Foot Ways.

"The Literary style is EXCELLENT. . . . A COMPREHENSIVE and EXCELLENT Modern Book, an UP-TO-DATE work. . . . Should be on the reference shelf of every Municipal and County Engineer or Surveyor in the United Kingdom, and of every Colonial Engineer."—*The Surveyor*.

In Handsome Cloth. Fully Illustrated. 10s. 6d. net.

DUSTLESS ROADS.

TAR MACADAM.

By J. WALKER SMITH,

City Engineer, Edinburgh.

CONTENTS.—Necessity for Improved and Standard Road Construction.—Tar.—Standardisation of Matrix.—Aggregate for Macadam.—Different Modes of Preparing and Laying.—Mechanical Mixing.—Effects of Wear, Density, Porosity, Distribution of Weight.—Scavenging; Watering and Maintenance.—Camber; Gradient, Noiselessness, Hygienic Advantages.—Rolling.—Tractive Effort.—Statistics.—Tar Spraying on Ordinary Macadam Surfaces.—APPENDICES.—INDEX.

"The book is in every respect up-to-date and very suggestive. It is practical in the best sense of the term."—*County and Municipal Record*.

A MANUAL OF CIVIL ENGINEERING PRACTICE.

By F. NOEL TAYLOR, CIVIL ENGINEER. [See p. 18.]

ALSO

THE MAIN DRAINAGE OF TOWNS.

By THE SAME AUTHOR. [See p. 18.]

In Demy 8vo. Handsome Cloth. With Many Tables. 6s. net.

THE THEORY AND PRACTICE OF

ENAMELLING ON IRON AND STEEL.

By JULIUS GRÜNWARD,

Technical Chemist and Works' Manager.

CONTENTS.—Introduction.—The Raw Materials.—The Mixing, Dissolving, and Application of Enamel.—Heating and Pickling Goods in the Rough.—Correct laying on.—Baking Enamelled Ware.—Decoration of Enamelled Objects.—Photo-Ceramics in their Application to Enamels.—General and Statistical Chapter.—The History of Enamels and their Uses.—INDEX.

"Combines the theory and practice of enamelling in a most effective manner."—*Iron and Steel Trades' Journal*.

In Large 8vo. Handsome Cloth. With Plates and Illustrations, 7s. 6d. net.

THE MANUFACTURE OF INK.

Handbook of the Production and Properties of Printing, Writing, and Copying Inks

By C. A. MITCHELL, B.A., F.I.C., F.C.S., & T. C. HEPWORTH

"Thoroughly well arranged . . . and of a genuinely practical order."—*British Printer*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

In Large 8vo. Handsome Cloth. Profusely Illustrated. 30s. net.

A TREATISE ON
COLOUR MANUFACTURE.

A Guide to the Preparation, Examination, and Application of all the
Pigment Colours in Practical Use.

By GEORGE ZERR AND DR. R. RÜBENCAMP.

AUTHORISED ENGLISH TRANSLATION BY DR. C. MAYER, OF BURGDORF.

"This comprehensive guide . . . useful and interesting."—*Oil and Colour Trades Journal*.

In Medium 8vo. Handsome Cloth. Pp. i-xii + 230. Price 10s. 6d. net.

TESTS FOR COAL-TAR COLOURS IN ANILINE LAKES.

By GEORGE ZERR.

TRANSLATED BY DR. C. MAYER OF BURGDORF.

ABSTRACT OF CONTENTS.—Introductory.—Reactions of Aniline Lakes.—Classification of the Coal-Tar Colour Lakes according to Solubility.—INDEX.

"Of the highest scientific accuracy . . . leaves nothing to be desired in clearness."—*Decorator*.

FIFTH EDITION, Revised and Enlarged. With Illustrations.

PAINTERS' COLOURS, OILS, AND VARNISHES :

A PRACTICAL MANUAL.

By GEORGE H. HURST, F.C.S.

GENERAL CONTENTS.—Introductory—THE COMPOSITION, MANUFACTURE, ASSAY, and ANALYSIS of PIGMENTS, White, Red, Yellow and Orange, Green, Blue, Brown, and Black—LAKES—Colour and Paint Machinery—Paint Vehicles (Oils, Turpentine, &c., &c.)—Driers—VARNISHES.

"A THOROUGHLY PRACTICAL book . . . Satisfactorily treats of the manufacture of oils, colours, and pigments."—*Chemical Trades' Journal*

In Crown 8vo. Handsome Cloth. With Illustrations. 5s.

THE PAINTER'S LABORATORY GUIDE.

A Student's Handbook of Paints, Colours, and Varnishes.

By GEORGE H. HURST, F.C.S.

"This excellent handbook, . . . the model of what a handbook should be."—*Oils Colours, and Distilleries*.

THIRD EDITION, Revised. In Crown 8vo. extra. With Numerous Illustrations and Plates (some in Colours), including Original Designs 12s. 6d.

Painting and Decorating :

*A Complete Practical Manual for House
Painters and Decorators.*

By WALTER JOHN PEARCE,

LECTURER AT THE MANCHESTER TECHNICAL SCHOOL FOR HOUSE-PAINTING AND DECORATING.

"A THOROUGHLY USEFUL BOOK . . . GOOD, SOUND, PRACTICAL INFORMATION in a CLEAR and CONCISE FORM."—*Plumber and Decorator*.

LONDON : CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

THIRD EDITION. In Large 8vo. Handsome Cloth. With 4 Plates and Several Illustrations. 16s. net.

THE CHEMISTRY OF INDIA RUBBER.

Treatise on the Nature of India Rubber, its Chemical and Physical Examination, and the Determination and Valuation of India Rubber Substitutes.

Including the Outlines of a Theory on Vulcanisation.

By CARL OTTO WEBER, PH.D.

"Replete with scientific and also with technical interest. . . . The section on physical properties is a complete *résumé* of every thing known on the subject."—*India-rubber Journal*.

In Handsome Cloth. Fully Illustrated. 10s. 6d. net.

THE MANUFACTURE OF RUBBER GOODS.

By ADOLF HEIL AND DR. W. ESCH.

TRANSLATED BY EDWARD W. LEWIS, A.C.G.I., F.C.S.,

Chemist to Messrs. J. G. INGRAM & SON, London.

GENERAL CONTENTS.—Raw Material and its Preparation.—Vulcanisation.—Rubber Mixings.—Manufacture of Soft Rubber Goods.—Manufacture of Hard Rubber Goods.—Regeneration of Waste Rubber.—Specific Gravity of Rubber Goods.—INDEX.
"Can be recommended as a very practical and useful work."—*Nature*.

In Large Crown 8vo. Fully Illustrated. 5s. net.

GLUE, GELATINE, AND THEIR ALLIED PRODUCTS,

A Practical Handbook for the Manufacturer, Agriculturist, and Student of Technology.

By THOMAS LAMBERT,

Analytical and Technical Chemist.

CONTENTS.—Historical.—GLUE.—GELATINE.—Size and Isinglass.—Treatment of Effluents produced in Glue and Gelatine Making.—Liquid and other Glues, Cements, &c.—Uses of Glue and Gelatine.—Residual Products.—Analysis of Raw and Finished Products.—APPENDIX.—INDEX.

"A sufficient account of modern methods of working, chiefly from a practical standpoint. A book . . . of real value."—*Chemical News*.

In Large 8vo. Handsome Cloth. Fully Illustrated. 15s. net.

LEATHER TRADES' CHEMISTRY.

A Practical Manual on the Analysis of Materials and Finished Products.

By S. R. TROTMAN, M.A., F.I.C.,

Public Analyst for the City of Nottingham, Member of the International Association of Leather Trades' Chemists.

SYNOPSIS OF CONTENTS.—Standard Solutions.—Acids, Alkalies, &c.—Water.—Depilation and Deliming.—Fleshings, &c.—Glue.—Spent Liquors.—Mineral and Vegetable Tanning Agents.—Oils.—Soaps.—Varnishes.—Skin.—Leather.—Dyestuffs.—Degreasing Agents.—Effluents.—GLOSSARY.—INDEX.

"Mr. Trotman has admirably succeeded in his aim. . . . Practically every section of the leather trade chemistry is gone into."—*Leather Trades' Review*.

In Crown 8vo. Handsome Cloth. Pp. i-vi + 114. 3s. 6d. net.

THE CHEMISTRY OF THE COLLOIDS.

TRANSLATED FROM THE GERMAN OF DR. VICTOR PÖSCHL

By DR. H. H. HODGSON.

"An excellent little summary of the subject."—*Chemical News*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

THE TEXTILE INDUSTRIES.

SECOND EDITION, *Thoroughly Revised Throughout. In Two Large Volumes. Handsome Cloth. 45s.*

A MANUAL OF DYEING:
FOR THE USE OF PRACTICAL DYERS, MANUFACTURERS, STUDENTS,
AND ALL INTERESTED IN THE ART OF DYEING.

E. KNECHT, Ph.D., F.I.C.,

Head of the Chemistry and Dyeing Department of
the Technical School, Manchester; Editor of "The
Journal of the Society of Dyers and Colourists;"

BY

CHR. RAWSON, F.I.C., F.C.S.,

Late Head of the Chemistry and Dyeing Department
of the Technical College, Bradford; Member
Council of the Society of Dyers and Colourists;

AND RICHARD LOEWENTHAL, Ph.D.

GENERAL CONTENTS.—Chemical Technology of the Textile Fabrics—
Water—Washing and Bleaching—Acids, Alkalies, Mordants—Natural
Colouring Matters—Artificial Organic Colouring Matters—Mineral Colours
—Machinery used in Dyeing—Tinctorial Properties of Colouring Matters—
Analysis and Valuation of Materials used in Dyeing, &c., &c.

"This authoritative and exhaustive work . . . the MOST COMPLETE we have yet seen
on the subject."—*Textile Manufacturer.*

In Large 8vo, Handsome Cloth. Pp. i-xv + 405. 16s. net.

THE SYNTHETIC DYESTUFFS,

AND

THE INTERMEDIATE PRODUCTS FROM WHICH THEY ARE DERIVED.

By JOHN CANNELL CAIN, D.Sc. (MANCHESTER AND TUBINGEN),
Technical Chemist,

AND JOCELYN FIELD THORPE, Ph.D. (HEIDELBERG), F.R.S.,
Lecturer on Colouring Matters in the Victoria University of Manchester.

Part I. Theoretical. Part II. Practical. Part III. Analytical.

"We have no hesitation in describing this treatise as one of the most valuable books
that has appeared. . . . Will give an impetus to the study of Organic Chemistry
generally."—*Chemical Trade Journal.*

*Companion Volume to Knecht & Rawson's "Dyeing." In Large 8vo.
Handsome Cloth, Library Style. 16s. net.*

A DICTIONARY OF

DYES, MORDANTS, & OTHER COMPOUNDS
USED IN DYEING AND CALICO PRINTING.

*With Formulae, Properties, and Applications of the various substances described
and concise directions for their Commercial Valuation,
and for the Detection of Adulterants.*

By CHRISTOPHER RAWSON, F.I.C., F.C.S.,

Consulting Chemist to the Behar Indigo Planters' Association; Co-Author of "A Manual
of Dyeing;"

WALTER M. GARDNER, F.C.S.,

Head of the Department of Chemistry and Dyeing, Bradford Municipal Technical College;
Editor of the "Journ. Soc. Dyers and Colourists;"

AND W. F. LAYCOCK, Ph.D., F.C.S.,

Analytical and Consulting Chemist.

"Turn to the book as one may on any subject, or any substance in connection with the
trade, and a reference is sure to be found. The authors have apparently left nothing out."
—*Textile Mercury.*

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

In Crown 8vo. Cloth. With Numerous Illustrations. 6s. net.

THE COTTON WEAVERS' HANDBOOK.

A Practical Guide to the Construction and Costing of Cotton Fabrics, with Studies in Design.

By HENRY B. HEYLIN,

Of the Royal Technical Institute, Salford.

"Mr. Heylin's text-book is a very reliable one. It is difficult to mark out any special points among so much excellent matter."—*Dyer and Calico Printer*.

Large 8vo. Profusely Illustrated with Plates and Figures in the Text.
16s. net.

THE SPINNING AND TWISTING OF LONG VEGETABLE FIBRES

(FLAX, HEMP, JUTE, TOW, & RAMIE).

A Practical Manual of the most Modern Methods as applied to the Hackling, Carding Preparing, Spinning, and Twisting of the Long Vegetable Fibres of Commerce.

By HERBERT R. CARTER, Belfast and Lille.

"Meets the requirements of the Mill Manager or Advanced Student in a manner perhaps more than satisfactory. . . . We must highly commend the work as representing up-to-date practice."—*Nature*.

In Medium 8vo. Handsome Cloth. With about 750 Pages.

The PRINCIPLES & PRACTICE of TEXTILE PRINTING

By E. KNECHT, PH.D., AND J. B. FOTHERGILL.

CONTENTS.—Part I. Introduction.—Part II. Methods of Printing.—Part III. Preparation of Cloth for Printing.—Part IV. Preparation of Printing Colours.—Part V. Treatment of Goods after Printing.—Part VI. Mordants.—Part VII. Styles of Printing: (a) Direct; (b) Dyed; (c) Insoluble Azo-Colour; (d) Discharge; (e) Resist or Reserve; (f) Raised; (g) Printing of Linings; (h) Metal Printing; (i) Crepon or "Crimp."—Part VIII. Finishing of Printed Calicoes.—Part IX. Wool and Half Wool Printing. Part X. Silk and Half Silk Printing.—INDEX.

In Medium 8vo. Handsome Cloth. Fully Illustrated. 16s. net.

THE BLEACHING AND FINISHING OF COTTON.

By S. R. TROTMAN, M.A., F.I.C., AND E. L. THORP, M.I.MECH. E.

CONTENTS.—Structure of Cotton Fibre.—Constituents of Cotton Fibre.—Cotton Testing.—Carbohydrates.—Water.—Bacteria in Bleaching.—Cotton Piece Goods.—Steeping.—Transmission of Cloth.—Alkali Boiling.—Soap.—Soap Making.—Organic Solvents.—Keirs.—Washing Machines.—Bleaching and Bleaching Powder.—Bleaching and Souring Apparatus.—Sodium Hypochlorite and Electrolytic Bleaching Solutions.—Other Bleaching Agents.—Souring Acids and Souring Apparatus.—Processes.—Coloured Goods.—Stains and Discolourations.—Finishing and Materials Used.—Mangling, Drying, and Conditioning.—Stiffening and Mangles.—Auxiliary Machines and Processes.—Stenters.—Beetling.—Calendering.—Finishing Processes.—INDEX.

"Deserves the attention of practical bleachers, and we can recommend it to them with confidence."—*Textile Mercury*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

In Large 8vo, Handsome Cloth, with Numerous Illustrations. 9s. net.

TEXTILE FIBRES OF COMMERCE. **A HANDBOOK OF**

The Occurrence, Distribution, Preparation, and Industrial Uses of the Animal, Vegetable, and Mineral Products used in Spinning and Weaving.

By WILLIAM I. HANNAN,

Lecturer on Botany at the Ashton Municipal Technical School, Lecturer on Cotton Spinning at the Chorley Science and Art School, &c.

"USEFUL INFORMATION. . . . ADMIRABLE ILLUSTRATIONS. . . ."—*Textile Recorder*.

In Large 8vo, with Illustrations and Printed Patterns. Price 21s.

TEXTILE PRINTING: **A PRACTICAL MANUAL.**

Including the Processes Used in the Printing of
COTTON, WOOLLEN, SILK, and HALF-SILK FABRICS.

By C. F. SEYMOUR ROTHWELL, F.C.S.,

Mem. Soc. of Chem. Ind.; late Lecturer at the Munic. Tech. School, Manchester.

"By FAR THE BEST and MOST PRACTICAL BOOK ON TEXTILE PRINTING which has yet been brought out, and will long remain the standard work on the subject."—*Textile Mercury*.

Large 8vo. Handsome Cloth. 12s. 6d.

BLEACHING & CALICO-PRINTING.

A Short Manual for Students and Practical Men.

By GEORGE DUERR,

Director of the Bleaching, Dyeing, and Printing Department at the Accrington and Bacup Technical Schools; Chemist and Colourist at the Irwell Print Works.

ASSISTED BY WILLIAM TURNBULL

(of Turnbull & Stockdale, Limited).

With Illustrations and upwards of One Hundred Dyed and Printed Patterns designed specially to show various Stages of the Processes described.

"Mr. DUERR'S WORK will be found MOST USEFUL. . . . The information given is of GREAT VALUE. . . . The Recipes are THOROUGHLY PRACTICAL."—*Textile Manufacturer*.

THIRD EDITION. New Appendix. Cloth. 76 Illustrations. 5s. net.

DYEING AND CLEANING.

By FRANK J. FARRELL, M.Sc., &c.

GENERAL CONTENTS.—Technology of the Textile Fibres.—Dry Cleaning.—Wet Cleaning.—Dyeing.—Dry Dyeing.—Special Methods, Cleaning and Dyeing Skin Rugs, Feathers, and Hats.—Finishing.—APPENDICES.—INDEX.

"Timely and valuable . . . well got up in every way."—*Dyer and Calico Printer*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET STRAND.

THIRD EDITION, Revised, Enlarged, and Re-issued. Price 6s. net.

A SHORT MANUAL OF INORGANIC CHEMISTRY.

By A. DUPRÉ, Ph.D., F.R.S.,
AND WILSON HAKE, Ph.D., F.I.C., F.C.S.,
Of the Westminster Hospital Medical School

"AN EXAMPLE OF THE ADVANTAGES OF THE SYSTEMATIC TREATMENT of a Science over the fragmentary style so generally followed BY A LONG WAY THE BEST of the small Manuals for Students."—*Analyst*.

In Handsome Cloth. With nearly 50 Illustrations. 3s. 6d. net.

THE ELEMENTS OF CHEMICAL ENGINEERING.

By J. GROSSMANN, M.A., Ph.D., F.I.C.

WITH A PREFACE BY

SIR WILLIAM RAMSAY, K.C.B., F.R.S.

CONTENTS.—The Beaker and its Technical Equivalents.—Distilling Flasks, Liebig's Condensers.—Fractionating Tubes and their Technical Equivalents.—The Air-Bath and its Technical Equivalents.—The Blowpipe and Crucible and their Technical Equivalents.—The Steam Boiler and other Sources of Power.—General Remarks on the Application of Heat in Chemical Engineering.—The Funnel and its Technical Equivalents.—The Mortar and its Technical Equivalents.—Measuring Instruments and their Technical Equivalents.—Materials Used in Chemical Engineering and their Mode of Application.—Technical Research and the Designing of Plant.—Conclusion.—Chemicals and Materials.—INDEX.

"Excellent. . . . Every student of chemistry attending a technical course should obtain a copy."—*Chemical News*.

LABORATORY HANDBOOKS BY A. HUMBOLDT SEXTON,

Professor of Metallurgy in the Glasgow and West of Scotland Technical College.

OUTLINES OF QUANTITATIVE ANALYSIS.

FOR THE USE OF STUDENTS.

With Illustrations. FIFTH EDITION. Crown 8vo, Cloth, 3s.

"A COMPACT LABORATORY GUIDE for beginners was wanted, and the want has been WELL SUPPLIED. . . . A good and useful book."—*Lancet*.

OUTLINES OF QUALITATIVE ANALYSIS.

FOR THE USE OF STUDENTS.

With Illustrations FOURTH EDITION, Revised. Crown 8vo, Cloth, 3s. 6d.

"The work of a thoroughly practical chemist."—*British Medical Journal*.

"Compiled with great care, and will supply a want."—*Journal of Education*.

ELEMENTARY METALLURGY:

Including the Author's Practical Laboratory Course.

[See p. 52.]

LONDON: CHARLES GRIFFIN & CO., LIMITED. EXETER STREET. STRAND.

THIRD EDITION, Revised and Enlarged. Large Crown 8vo, with numerous Illustrations. 3s. 6d.

THE FLOWERING PLANT,
WITH A SUPPLEMENTARY CHAPTER ON FERNS AND MOSES,
As Illustrating the First Principles of Botany.

By J. R. AINSWORTH DAVIS, M.A., F.Z.S.,
Prof. of Biology, University College, Aberystwyth; Examiner in Zoology,
University of Aberdeen.

It would be hard to find a Text-book which would better guide the student to an accurate knowledge of modern discoveries in Botany. . . . The SCIENTIFIC ACCURACY of statement, and the concise exposition of FIRST PRINCIPLES make it valuable for educational purposes. In the chapter on the Physiology of Flowers, an *admirable résumé*, drawn from Darwin, Hermann Müller, Kerner, and Lubbock, of what is known of the Fertilization of Flowers, is given "*Journal of Botany*."

POPULAR WORKS ON BOTANY BY MRS. HUGHES-GIBB.

With Illustrations. Crown 8vo. Cloth. 2s. 6d

HOW PLANTS LIVE AND WORK:

A Simple Introduction to Real Life in the Plant-world, Based on Lessons originally given to Country Children.

By ELEANOR HUGHES-GIBB.

"The attention of all interested in the Scientific Training of the Young is requested to this DELIGHTFULLY FRESH and CHARMING LITTLE BOOK. It ought to be in the hands of every Mother and Teacher throughout the land.

"The child's attention is first secured, and then, in language SIMPLE, YET SCIENTIFICALLY ACCURATE, the first lessons in plant-life are set before it."—*Natural Scientist*.

"In every way well calculated to make the study of Botany ATTRACTIVE to the young."—*Scotman*.

With Illustrations. Crown 8vo. Gilt 2s. 6d.

**THE MAKING OF A DAISY;
"WHEAT OUT OF LILIES;"**

And other Studies from the Plant World.

A Popular Introduction to Botany.

By ELEANOR HUGHES-GIBB,

Author of *How Plants Live and Work*.

"A BRIGHT little introduction to the study of Flowers."—*Journal of Botany*.

"The book will afford real assistance to those who can derive pleasure from the study of Nature in the open. . . . The literary style is commensurable."—*Knowledge*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

"Boys COULD NOT HAVE A MORE ALLURING INTRODUCTION to scientific pursuits than these charming-looking volumes."—Letter to the Publishers from the Headmaster of one of our great Public Schools.

SECOND EDITION, Revised. Handsome Cloth. 6s. net.

OPEN-AIR STUDIES IN BOTANY:

SKETCHES OF BRITISH WILD FLOWERS
IN THEIR HOMES.

By R. LLOYD PRAEGER, B.A., M.R.I.A.

Illustrated by Drawings from Nature by S. Rosamond Praeger,
and Photographs by R. Welch.

GENERAL CONTENTS.—A Daisy-Starred Pasture—Under the Hawthorne—By the River—Along the Shingle—A Fragrant Hedgerow—A Connemara Bog—Where the Samphire grows—A Flowery Meadow—Among the Corn (a Study in Weeds)—In the Home of the Alpines—A City Rubbish-Heap—Glossary.

"A FRESH AND STIMULATING book . . . should take a high place . . . The illustrations are drawn with much skill."—*The Times*.

"BEAUTIFULLY ILLUSTRATED. . . . One of the MOST ACCURATE as well as INTERESTING books of the kind we have seen."—*Athenæum*.

"Redolent with the scent of woodland and meadow."—*The Standard*.

With 12 Full-Page Illustrations from Photographs. Cloth.

Second Edition, Revised. 3s. 6d.

OPEN-AIR STUDIES IN GEOLOGY:

An Introduction to Geology Out-of-doors.

By GRENVILLE A. J. COLE, F.G.S., M.R.I.A.,

Professor of Geology in the Royal College of Science for Ireland,
and Examiner in the University of London.

GENERAL CONTENTS.—The Materials of the Earth—A Mountain Hollow—Down the Valley—Along the Shore—Across the Plains—Dead Volcanoes—A Granite Highland—The Annals of the Earth—The Surrey Hills—The Folds of the Mountains.

"The FASCINATING 'OPEN-AIR STUDIES' of PROF. COLE give the subject a GLOW OF ANIMATION . . . cannot fail to arouse keen interest in geology."—*Geological Magazine*.

"A CHARMING BOOK, beautifully illustrated."—*Athenæum*.

Beautifully Illustrated. With a Frontispiece in Colours, and Numerous
Specially Drawn Plates by Charles Whymper. 7s. 6d.

OPEN-AIR STUDIES IN BIRD-LIFE:

SKETCHES OF BRITISH BIRDS IN THEIR HAUNTS.

By CHARLES DIXON.

The Spacious Air.—The Open Fields and Downs.—In the Hedgerows.—On Open Heath and Moor.—On the Mountains.—Amongst the Evergreens.—Copses and Woodland.—By Stream and Pool.—The Sandy Wastes and Mudflats.—Sea-laved Rocks.—Birds of the Cities.—INDEX.

"Enriched with excellent illustrations. A welcome addition to all libraries."—*Westminster Review*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

AN ELEMENTARY TEXT-BOOK OF PHYSICS.

By R. WALLACE STEWART, D.Sc. (LOND.)

In Four Volumes. Crown 8vo. Cloth. Each Fully Illustrated. Sold Separately.

VOL. I. Pp. i-vii+414. With 187 Illustrations. 4s. 6d. net.

GENERAL PHYSICS.

CONTENTS.—Introductory.—Scalar and Vector Quantities.—Measurement of Length, Area, and Volume.—Measurement of Time.—Measurement of Mass.—Velocity.—Acceleration.—Circular Motion and Simple Harmonic Motion.—Force.—Work and Energy.—Composition and Resolution of Forces.—Centre of Gravity.—Equilibrium of Forces.—Friction.—The Balance.—General Properties of Matter.—Properties of Solids.—Hydrostatics.—Experimental Determination of Specific Gravity and Density.—Properties of Liquids.—Properties of Liquids (*continued*).—Properties of Gases.—INDEX

VOL. II. Pp. i-vii+141. Profusely Illustrated. 2s. 6d. net.

SOUND.

CONTENTS.—Simple Harmonic Vibration.—Production of Sound.—Wave Motion.—Propagation of Sound.—Characteristics of Sound.—Reflection and Refraction of Sound.—Velocity of Sound in Air and Water.—Transverse Vibration of Strings.—Longitudinal Vibration of Rods and Columns of Air.—INDEX.

"Should supply the much-felt need of an elementary treatment of this subject . . . distinctly good."—*Nature*.

VOL. III. Pp. i-vii+219. With 142 Illustrations. 3s. 6d. net.

LIGHT.

CONTENTS.—Introductory.—Rectilinear Propagation of Light.—Photometry.—Reflection at Plane Surfaces.—Reflection at Spherical Surfaces.—Refraction.—Refraction through Lenses.—Dispersion.—INDEX.

"This elementary treatise resembles Part II. (*Sound*) in its attractiveness . . . the treatment is good . . . excellent diagrams . . . very clear."—*Journ. of Inst. of Teachers in Technical Institutes*.

VOL. IV. Pp. i-v+242. With 84 Illustrations. 3s. 6d. net.

HEAT.

CONTENTS.—Introductory.—Thermometry.—Expansion of Solids.—Expansion of Liquids.—Expansion of Gases.—Calorimetry.—Specific Heat.—Liquefaction and Solidification.—Vaporisation and Condensation.—Conduction of Heat.—Convection.—Mechanical Equivalent of Heat.—Radiation.—INDEX.

In Large 8vo. With Bibliography, Illustrations in the Text, and Seven Plates. 12s. 6d.

THE MEAN DENSITY OF THE EARTH.

An Essay to which the Adams Prize was Adjudged in 1893 in the University of Cambridge

By J. H. POYNTING, Sc.D., F.R.S.

"Cannot fail to be of great and general interest."—*Athenaeum*.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

DR. STEWART'S ELEMENTARY TEXT-BOOK OF PHYSICS
was designed as an introduction to the following:—

A TEXT-BOOK OF PHYSICS.

By J. H. POYNTING, Sc.D., F.R.S.,
Professor of Physics, Birmingham University,

And Sir J. J. THOMSON, M.A., F.R.S.,
Professor of Experimental Physics in the University of Cambridge.

In Five Volumes. Large 8vo. Sold Separately.

INTRODUCTORY VOLUME. FIFTH EDITION, Revised. Fully Illustrated.
10s. 6d.

PROPERTIES OF MATTER.

CONTENTS.—Gravitation.—The Acceleration of Gravity.—Elasticity.—Stresses and Strains.—Torsion.—Bending of Rods.—Spiral Springs.—Collision.—Compressibility of Liquids.—Pressures and Volumes of Gases.—Thermal Effects Accompanying Strain.—Capillarity.—Surface Tension.—Laplace's Theory of Capillarity.—Diffusion of Liquids.—Diffusion of Gases.—Viscosity of Liquids.—INDEX.

"We regard this book as quite indispensable not merely to teachers but to physicists of every grade above the lowest."—*University Correspondent*.

VOLUME II. FIFTH EDITION. Fully Illustrated. Price 8s. 6d.

SOUND.

CONTENTS.—The Nature of Sound and its chief Characteristics.—The Velocity of Sound in Air and other Media.—Reflection and Refraction of Sound.—Frequency and Pitch of Notes.—Resonance and Forced Oscillations.—Analysis of Vibrations.—The Transverse Vibrations of Stretched Strings or Wires.—Pipes and other Air Cavities.—Rods.—Plates.—Membranes.—Vibrations maintained by Heat.—Sensitive Flames and Jets.—Musical Sand.—The Superposition of Waves.—INDEX.

"The work . . . may be recommended to anyone desirous of possessing an **UP-TO-DATE STANDARD TREATISE ON ACOUSTICS**."—*Literature*.

VOLUME III. FOURTH EDITION, Revised. Fully Illustrated. Price 15s.

HEAT.

CONTENTS.—Temperature.—Expansion of Solids—Liquids.—Gases.—Circulation and Convection.—Quantity of Heat; Specific Heat.—Conductivity.—Forms of Energy; Conservation; Mechanical Equivalent of Heat.—The Kinetic Theory.—Change of State; Liquid, Vapour.—Critical Points.—Solids and Liquids.—Atmospheric Conditions.—Radiation.—Theory of Exchanges.—Radiation and Temperature.—Thermodynamics.—Isothermal and Adiabatic Changes.—Thermodynamics of Changes of State, and Solutions.—Thermodynamics of Radiation.—INDEX

"Well up-to-date, and extremely clear and exact throughout. . . . As clear as it would be possible to make such a text-book"—*Nature*.

Remaining Volumes in Preparation—

LIGHT; MAGNETISM AND ELECTRICITY.

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

SECOND EDITION, Revised. In Crown 8vo. With Diagrams. Cloth.

AN INTRODUCTION TO
THE THEORY OF STATISTICS.

By G. UDNY YULE,

Honorary Secretary of the Royal Statistical Society of London, &c.

CONTENTS.—Introduction. **Part I.—The Theory of Attributes.**—Notation and Terminology.—Consistence.—Association.—Partial Association.—Manifold Classification. **Part II.—The Theory of Variables.**—Frequency Distribution.—Averages.—Measures of Dispersion, &c.—Correlation.—Do., Practical Applications and Methods.—Miscellaneous Theorems Involving the use of the Correlation Coefficient.—Partial Correlation. **Part III.—Theory of Sampling.**—Simple Sampling of Attributes.—Effects of Removing the Limitations of Simple Sampling.—The Binomial Distribution and the Normal Curve.—Normal Correlation.—The Simpler Cases of Sampling for Variables.—Percentiles and Mean.

“Well calculated to hold the attention of the student or teacher of economic subjects.”—*Statist.*

Twenty-eighth Annual Issue. Handsome cloth, 7s. 6d.

(To Subscribers, 6s.).

THE OFFICIAL YEAR-BOOK

OF THE

**SCIENTIFIC AND LEARNED SOCIETIES OF GREAT BRITAIN
 AND IRELAND.**

COMPILED FROM OFFICIAL SOURCES.

Comprising (together with other Official Information) LISTS of the PAPERS read during the Session 1910-1911 before all the LEADING SOCIETIES throughout the Kingdom engaged in the following Departments of Research:—

- | | |
|--|--|
| 1. Science Generally: <i>i.e.</i> , Societies occupying themselves with several Branches of Science, or with Science and Literature jointly. | § 6. Economic Science and Statistics. |
| § 2. Mathematics and Physics. | § 7. Mechanical Science, Engineering, and Architecture |
| § 3. Chemistry and Photography. | § 8. Naval and Military Science. |
| § 4. Geology, Geography, and Mineralogy. | § 9. Agriculture and Horticulture. |
| § 5. Biology, including Microscopy and Anthropology. | § 10. Law. |
| | § 11. Literature |
| | § 12. Psychology. |
| | § 13. Archæology. |

§ 14. MEDICINE.

“FILLS A VERY REAL WANT.”—*Engineering.*

“INDISPENSABLE to any one who may wish to keep himself abreast of the scientific work of the day.”—*Edinburgh Medical Journal.*

“It goes almost without saying that a Handbook of this subject will be in time one of the most generally useful works for the library or the desk.”—*The Times.*

Copies of the **FIRST ISSUE**, giving an Account of the History Organization, and Conditions of Membership of the various Societies, and forming the groundwork of the Series, may still be had, price 7/6. *Also Copies of the Issues following.*

LONDON: CHARLES GRIFFIN & CO., LIMITED, EXETER STREET, STRAND.

UNIVERSITY OF CALIFORNIA LIBRARY
BERKELEY

Return to desk from which borrowed.
This book is DUE on the last date stamped below.

MINERAL TECHNOLOGY LIBRARY

OCT 17 1955

JAN 6 56

YC 33810

263069

UNIVERSITY OF CALIFORNIA LIBRARY

