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ADELAIDE UNIVERSITY ENGINEERING SOCIETY MAGAZINE

Graduation....

THE BIG DAY AT LAST . . . . SPEECHES, APPLAUSE, WELL-EARNED CONGRATULATIONS...BUT WHAT THEN?

WHAT road to take after graduation? That is a problem which confronts nearly every student on the threshold of his career. Whether possessed of a degree or diploma, he needs to find a position in which his educational qualifications can be best utilised and one in which opportunity is not lacking.

The Australian steel industry is vitally interested in helping the graduate solve his difficulty. Firstly, as one of the Commonwealth's greatest providers of employment, and secondly, by virtue of its employee training scheme, the Australian steel industry can materially assist the young graduate to find an outlet for his talents.

Iron ore winning, coal mining, iron ore smelting and steel refining which culminate in Australia's steel production, is an industry rich in promise as a field of employment for Australian youth. No other undertaking offers better or more diversified opportunities for the young Australian, be he apprentice or University graduate, than the iron and steel industry. The opportunities are all the more attractive because Australia's major steel producer, The Broken Hill Proprietary Co. Ltd., operates a comprehensive training scheme which ensures that its young employees (and those of its associated industries) may obtain specialised training.

Recognition of the importance of maintaining the supply of skilled workers for Australia's secondary industry influenced The Broken Hill Proprietary Co. Ltd. to inaugurate an employee training scheme in 1926. By this means, it was hoped to ensure a constant source of trained operatives for its manifold spheres of activity, and provide ambitious young men with the opportunity to fit themselves for advancement in the Company's service.

When the Newcastle Steel works was opened in 1915, its yearly output of steel was rated at about 150,000 tons; less than half the tonnage then imported. Few could have anticipated that the undertaking would develop to its present size or importance; its original productive capacity has been increased nearly tenfold, and the steel industry now provides direct employment for some 20,000 men. This growth has meant promotion for those who qualified themselves for it, and plenty of opportunities still exist today. Through the agency of the B.H.P. employee training scheme, there is no reason why a young man starting on the first rung of the ladder, may not become an executive, if he has the ambition and application to do so.

Entrants into the Company's employ are classified into groups, viz., apprentices, commercial trainees, technical trainees, technical cadets. Various study curricula, training and experience-giving schedules are embarked upon by the new recruit on his entry into the B.H.P. Company's service. Successful progress in his particular studies means increased remuneration, and on the completion of his course, the successful student is reimbursed the aggregate amount of his tuition fees.

For University graduates, splendid opportunities exist. They are enrolled as technical cadets, and first undergo a "conditioning" period of two years. During this time, they spend a brief period in various departments at the Steel Works gaining invaluable experience of steel industry operations. They learn to appreciate the value of co-operation with their professional associates and other employees, and they supplement their academic qualifications with practical knowledge.

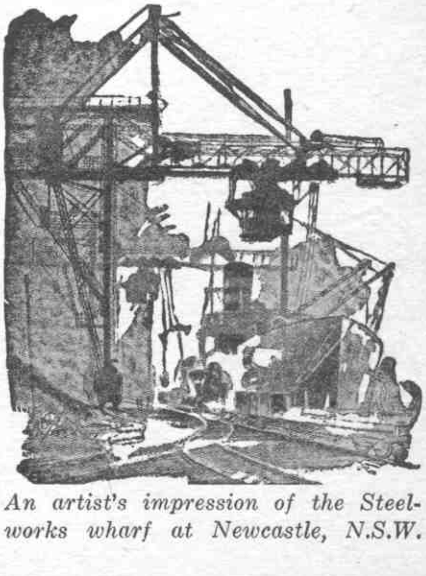
This two-year "conditioning" has a twofold purpose in that it enables both the management and the cadet to ascertain the section of the industry's diversified operations for which he is best adapted. The management is guided to some extent in its assessment of the cadet's capacity and personality by the periodic reports of the cadet's progress received from the heads of the departments through which he passes.

At the present time, B.H.P. and its subsidiary companies include amongst their employees approximately 100 graduates who, through the agency of the staff-training scheme, have been promoted to positions of substantial status.

The progress of the scheme has been substantial. In 1935, there were about 400 trainees and 360 apprentices working under it. At the close of 1945, there were 736 cadets and trainees and 1,830 indentured trade apprentices employed under training, and an additional 568 had entered the fighting forces. This wealth of trained manpower in the making will help to develop and maintain the efficiency of the nation's industrial undertakings.

In this swiftly-moving world, the prizes go to those who have gained by study and practice the knowledge of what to do, and how and when to do it.

With its many angles of activity, the Australian iron and steel industry offers many opportunities for those with ability and desire to learn. Students of to-day are the operatives of to-morrow, and the B.H.P. employee training scheme gives our ambitious young men a great deal of assistance towards carving out for themselves a satisfying and remunerative career.



An artist's impression of the Steelworks wharf at Newcastle, N.S.W.

THE ADELAIDE UNIVERSITY ENGINEERING SOCIETY MAGAZINE

Artium ubertas et scientiae

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EDITORIAL

IN 1945, the first issue of this magazine was produced, with the intention that the publication might become an annual feature. Before setting out this year, we had to consider the question, "Was the last magazine a success?"

Financially, the answer was no. The A.U.E.S. did not make a profit, but thanks to the ingenuity of Mr. Brokensha, the Society did not lose. Just how the books managed to balance to within twopence will forever remain a mystery.

But there are aspects other than the financial one. Some there are who scorn us, and say that the magazine contains little that could not be found in text books. In reply, I would like to point out that this magazine is not meant to be an Engineering text book, but a channel through which the ordinary student can express his views on any subject of interest to him. Consequently, no article has been rejected I think the venture was successful, and will be more so as the years progress, and the publishing of an Engineering students' journal, containing articles on anything from cabbages to kings, becomes traditional.

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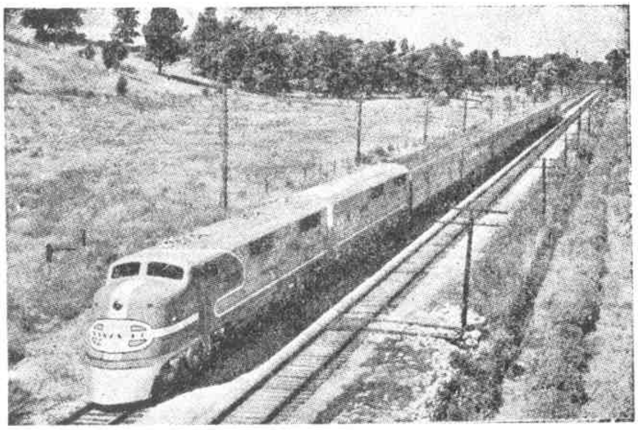
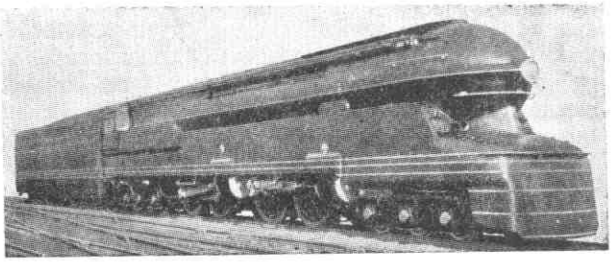
By J. R. MORITZ



THE "SANTA FE" (Diesel Electric)



MODERN RECIPROCATING STEAM ENGINE

TRANSPORT and progress in Australia always have been, and always must be, inseparably linked. The greater part of the population of this country, and the major part of its secondary industries are grouped in a few cities spaced up to hundreds, and even thousands, of miles apart. Quick and efficient passenger and freight services are of primary importance, and the best way to provide these, especially the latter, is to have a quick moving, well organised railroad service. It is in the comparison of methods of providing rapid and powerful locomotion that the question of the relative merits of the oil-burning Diesel electric system and the reciprocating steam engine arises.

It may be as well, before going into any detail, to outline the principles of the Diesel electric locomotive. Briefly, each unit consists of one or two Diesel engines, each being directly coupled to a d.c. generator. Each generator supplies a number of series traction motors mounted in the trucks, the motors usually being geared through a single reduction to the driving wheels. The steam locomotive, as commonly used, requires, of course, no introduction. Thus we have in the Diesel electric locomotive, two high efficiency systems used in conjunction, giving a unit of much higher overall efficiency than we have achieved with the steam locomotive.

The driver of the Diesel electric locomotive controls the engine speed and supply to the traction motors. He may, from the one position, control several units coupled together, this system generally being used with main line locos, and thus any required horsepower may be obtained. The most powerful Diesel electric unit yet built is a 3,000 h.p. locomotive, of which more will be said later, and by using three of these in one train, 9,000 h.p. can be obtained, which is more than has ever yet been achieved with a steam locomotive. This, however, is not such an advantage as it may at first seem, since the horsepower available in a single steam unit, with the advent of steam turbine and steam turbine electric drives, is rapidly approaching this figure, while a Diesel electric of this power is very heavy and long. Actually, the electrical equipment on hand is capable of supplying 6,000 h.p. from the same number of motors as is used on this 3,000 h.p. locomotive, the lower unit being imposed by the Diesel engine power which can be packed into the space available.

The Diesel electric loco. involves a considerably higher initial outlay than the steam locomotive, recent figures from U.S.A. being about 35 dollars per h.p. for a heavy, modern steam loco. and 85 dollars per h.p. for a corresponding Diesel electric loco. The difference would probably be even more marked in this country, as, while an entire steam locomotive can be manufactured here, the major parts of the Diesel electric loco. would at present have to be imported . Against this disadvantage, however, are the advantages in operation and maintenance costs possessed by the Diesel electric. Also, due to factors mentioned later, one Diesel electric loco. can do the work of nearly two ordinary steam locos.

Oil is not native to this country, but the coal position may over-rule this, as witness the fact that the Victorian Railways are converting their locomotives to burn crude oil, so that they may maintain services during coal shortages. Oil also is easier to transport, handle and store than is coal, and cleaner to use.

An important fact in favor of the Diesel electric is its negligible demand on water. The latest passenger loco. in this State evaporates up to 40,000 pounds of water per hour, while a recent heavy American freight locomotive evaporates 137,500 lbs. per hour. This feed water must, of course, be of fairly good quality, with low mineral content, if a reasonable boiler life is to be expected. Such water is not plentiful in this country, and water softening plants increase costs. Again, a large tender is required in dry country on long hauls, and this means increased dead weight. Since a Diesel electric requires no tender, there is no dead weight, and the whole locomotive weight may be evenly distributed over the driving wheels, giving lower axle loadings and higher tractive effort than for an equivalent h.p. steam loco. The tractive effort is the force utilised in propelling the train, and depends on the adhesion between wheel and track. It is usually taken at 25 per cent. of the weight on the driving wheels. It is found that the tractive effort of the Diesel electric at starting is almost twice that of the equivalent steam loco. with very nearly the same value as the speed approaches a maximum. The Diesel electric can thus shift a train of larger rolling resistance than a steam loco. can handle, and partly for this reason, is being increasingly used in U.S.A. for fast, heavy freight hauls over mountainous country. One railroad in that country switched from steam locos. to 5,400 h.p. Diesel electrics for freight purposes, and found that five such locos. could do the work of nine of their previous engines.

The latest Diesel electric freight loco. in use is the 3,000 h.p. unit previously mentioned. Capable of 117 m.p.h., it is to be used on an 85 m.p.h. freight service, hauling fresh fruit to the eastern cities, such as New York. It has two 8-cylinder turbo supercharged 1,500 h.p. Diesels, and 8 six-pole traction motors, four to each truck. The maximum axle loading is 51,000 lbs., total weight 577,000 lbs and tractive effort at starting 123,000 lbs.

A factor which is very much in favor of the Diesel electric is its high availability, i.e., time available for service. An average figure for passenger, freight and switching locos. is 95 per cent., a figure far in excess of any to be hoped for from steam locomotives, as the best of these must be coaled and watered, and dump its ashes frequently, though many fast passenger and freight steam locos. scoop up their water on the run from pits. Since interest and depreciation must be paid on idle locomotives, plus crew's wages, etc., a considerable saving may be effected here. A Diesel electric, for example, could pull a fast passenger train from Adelaide to Pirie, clipping an hour from the present schedule. After say, 40 minutes at Pirie to allow the crew to lunch, a fast freight service could be run back to Adelaide, arriving in time for the same locomotive to take the evening passenger train back to Pirie. If the traffic warranted it, another freight service could be run back to Adelaide during the night. This would be an impossible schedule for a steam locomotive, which would have to spend part of the time in the running sheds.

The horsepower of a steam locomotive increases steadily to reach a maximum at about 75 per cent. of its maximum speed. That of the Diesel electric, however, increases sharply to near maximum at about 20 per cent. of its maximum speed, and remains nearly constant thereafter. This, of course, again favors the Diesel electric A further advantage of this type of locomotive is that it has not the heavy reciprocating parts of the normal steam loco. The inertia of these parts may produce a varying drawbar pull and, more important, a hammer effect caused by out of balance forces on the wheels. These forces tend to lift the wheel at one point, possibly causing slip and wear, and produce an impact on the rail at another point. These inertia forces do not exist on the Diesel electric.

A use to which the Diesel electric locomotive is increasingly being put is switching, or shunting, for which it is very much suited, by reason, among other factors, of its high tractive effort, high availability, economy and ease of handling. As an example, an American railroad some time ago purchased three 1,000 h.p. switchers. After a year's experience with these, it ordered another 20. These figures scarcely need comment. With these locos. they were able to maintain a 24-hour working day, whereas with their steam switchers they were not always able to maintain a 16-hour day.

The fuel costs in 1944 were 1.75 dollars per hour for the steam switchers against 0.26 dollars per hour for the Diesels, while the overall operating costs, excluding crew's wages, were 4.62 dollars per hour for steam switchers against 0.68 dollars per hour for Diesels.

It is seen from the above figures that the Diesel electric system has much to recommend it. A final illustration of the fact that American railroad engineers recognise this is that in 1939, 249 Diesel electric locos. were ordered, against 119 steam locos. In 1941, 302 steam locos. were placed on order, while the figure for Diesels had risen to 1,104.

It may be of interest, before finishing, to mention some other types of locos. being investigated and built. Two gas turbine-electric locomotives, similar in principle to the Diesel electric, save that the Diesel engine is replaced by a gas turbine, have been in use in Europe for many years, one built by Brown, Boveri & Co. in Switzerland, and the other by Rateau in France. These have given good service, but are of low thermal efficiency. However, considerable work has been done in U.S.A. along these lines recently, and this type may yet become widely used. Also, a steam turbine locomotive of 6,900 h.p. has recently been put into service in U.S.A., in which the drivers are geared directly to the turbine. Another type of locomotive, found by American Army engineers in Germany, and repaired by them, is a steam loco. with a V-type twin-cylinder condensing engine connected to each set of drivers. It had been used in high speed passenger service until damaged by bombs.

However, to return to the main question, it would seem from the facts and figures given, that the use of Diesel electric power on our railways merits serious consideration and investigation, and although it can not entirely supplant steam power, the Diesel electric motor may yet find its place in this country, working in harness with its older brother, the steam loco., to provide a smooth working, powerful team.

DIAMOND DRILLING

By JOHN P. MORGAN

MR. Morgan, a past president of the Engineering Society, has had considerable experience with diamond drilling overseas. In this article, he sets out some of the objects of diamond drilling, and the methods by which they may be achieved.

This method of drilling derives its name from the fact that the drilling bit is faced with diamonds. The "stones" (diamonds) are set in soft metal and do the actual cutting of the rock formations which are penetrated.

The diamond drill may be defined as a hard-rock rotary drill which normally takes a core. This method of drilling has proved its worth and efficiency in prospecting for all types of mineral wealth; it is sometimes used by the civil engineer for prospecting for water and for testing foundations of power houses, bridges and dams.

The construction of the boring column is as follows:—A bit set with diamonds is screwed on to the end of a core barrel, which in turn is screwed to a string of hollow rods.

The drill rods are rotated by a compressed air, gasolene, diesel or electric motor. Drilling machines used underground are powered by electricity or compressed air, those used on the surface by gasolene or diesel motors.

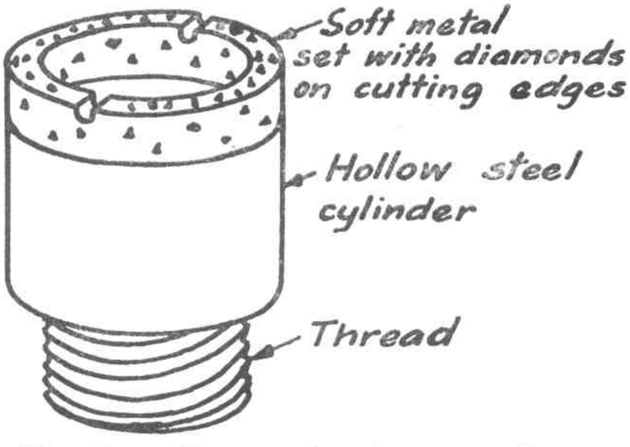


Fig. 1 — Typical diamond drill bit

The boring operation is achieved by the rotational movement of the bit which is pressed against the rock, a ring of material being cut out, leaving a central core that projects into the core barrel. When the bit is lifted off the bottom of the drill hole, a core lifter, which is situated behind the inner cutting surface of the bit, secures the core and prevents it from falling out of the core barrel as it is withdrawn from the drill hole.

Since the bits must be kept cool and the cuttings must be washed to the surface an adequate supply of water is necessary. The water is pumped through the hollow drill rods and core barrel to the cutting edge of the bit from where it flows outside the drill rods to the surface or the "collar" of the drill hole.

The core recovery may reach 100 per cent. in hard uniform rock, and it is at its lowest in soft, loose rock where the drill is run with a reduced flow of water.

As may be expected, the consumption of diamonds is due to:

(a) Diamonds wearing away.
(b) Diamonds being torn from the bit by hard, broken and faulted rock.

Diamonds may be recovered from bits considered unsuited for further boring by dissolving the surrounding metal in acid.

The present prices for diamonds are:

(a) High-grade diamonds, suitable for reaming, £4-£5 per carat.
(b) Low-grade diamonds, suitable for cast-set bits, 15/- to 25/- per carat.

Diamond drilling machines are designed to rotate the bit at speeds of 1,000-1,500 r.p.m. for the smaller diameter drill holes. Ultra high speeds of 2,500-3,000 r.p.m. have been used, but have not yet proved widely successful.

A drill hole of 10,700 ft. has been drilled in South Africa, and holes of 3,000 ft. have been drilled on the Broken Hill field. It is well known that deep holes are seldom straight, and those holes drilled on the Broken Hill leases deviated approximately 20 degrees in dip and 18 degrees in azimuth.

In laying out a programme for deep drilling allowance is made for deviation in order to reach given objectives.

A study of drilling for more than 20 years has brought to light one definite rule, viz., that diamond drill holes tend to deviate into a position normal to any structure existing in the rocks, as bedding, schistosity, gneissosity, or even parting or jointing, if the hole is started at almost any angle other than parallel with the structure.

The better developed the structure, the more quickly the hole will get into a position perpendicular to it.

These deviations are not indicated to the drillers by any action of the rods or machine.

It has often been said that there is a tendency for holes to "drift" in the direction of rotation. This is not true, for in a vertical hole since the azimuth is zero there is an infinite number of possible azimuth deviations. The final deviation is generally the result of structural influence.

It has been proved, however, that in homogeneous rock there is a tendency for the hole to corkscrew and that the direction of the spiral is in the same direction as rotation.

Diamond drilling is used extensively for exploratory work in mining, the costs being one-fifth to one-tenth as much as shafts, drives and cross-cuts. Hence it is possible to do five to ten times the footage for the same money.

It is also faster than driving or cross-cutting and therefore has an advantage with limited option periods.

The spacing of diamond drill holes is determined, primarily, by the shape and size of the ore body which it is desired to prospect.

The whole drilling programme should be thoroughly planned and carried through regardless of the odd blank hole or holes. The drilling should be at regular intervals and at regular horizons, the spacing of the holes being not too far apart, except for pilot or scout. holes which are, of course, drilled first.

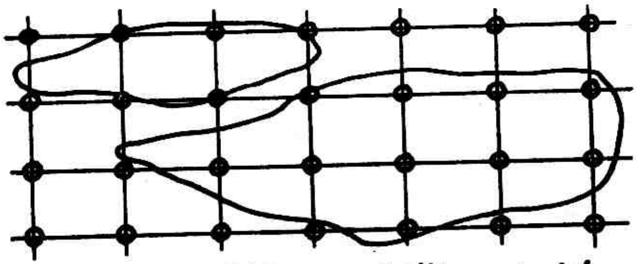
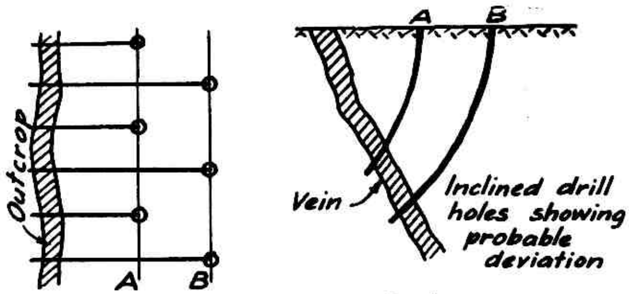


Fig. 2 - Oblong drilling grid



Plan

Section

Fig. 3 - Parallel line layout

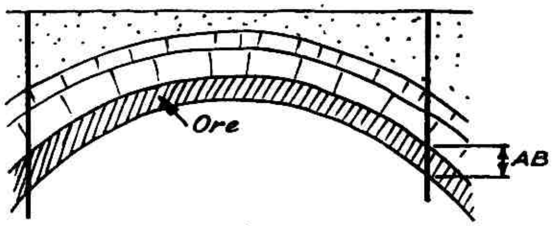


Fig. 4

Parallel Line Layout. Fig. 4.

The usual layout for a drilling programme from the surface is in the form of a grid.

The pattern of the holes is in the plane of the ore-body. The oblong pattern is used where one dimension of the outcrop is much larger than the other. (See Fig. 2).

The parallel line layout is suitable for dipping veins, as shown in the sketch. (Fig. 3).

Having planned the programme as far as the number of holes and their position is concerned, the next step is to plan the sequence of drilling. Some Engineers prefer to prove the limits of the ore by drilling outwards from the centre of the outcrop. Others prefer to drill the scout or pilot holes to a regular pattern which forms part of the proposed final pattern.

As opposed to drilling outward from a centre, on some ore bodies, there are occasional advantages in drilling remote holes first.

From the final drilling results, a reliable plan should be readily constructed from which underground development can be planned and carried out.

Careless use of data derived from diamond drill core can result in the misinterpretation of the structure which has been penetrated.

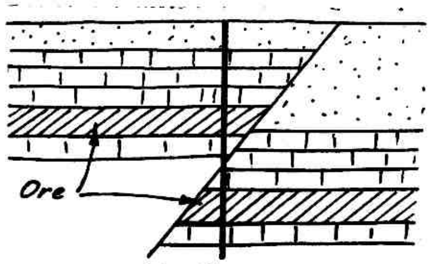


Fig. 5

In Examining and preparing a log of the core recovered from diamond drilling operations, it is the practice on operating mines to note the following features when the drill has penetrated the under-mentioned formations:—

1. **Country Rock:**

Rock classified, as quartzite, gneiss, schist, pigmatite, etc. Faults and shear zones noted, also the angle of the strata or banding.

2. Note predominant minerals present (both economic or gangere minerals). Note also the angle of bedding.

The above information should be entered into a diamond drill ledger, with essays of any samples which have been taken.

With the above information available, the Mining Engineers in charge of operations can more readily plan the location of development openings to avoid zones of weakness, and also plan more profitably the location of pillars for the support of stopes.

TRIALS AND TRIBULATIONS OF EARLY CHILDHOOD

By D. G. TONKIN

FEW people realise the trials which beset the life of the baby. Consider an unsuspecting child lying in a pram dreamily looking at the sky and the trees, at the same time being deep in thought. Suddenly the peace and serenity are shattered by loud cries of "Look! Isn't it like its father?" "What a bonny child!" and similar personal remarks. The baby, thus rudely awakened from its reverie, gazes around and a woman's face is thrust close to it, inspiring terror in its heart. The woman distorts her face into what she fondly imagines to be an ingratiating smile, and if the baby is inexperienced, a scream of pure animal fear leaps from its throat. This usually satisfies the woman; but if the baby is experienced, no such reaction is obtained, as it can take much more punishment than this, and trust the woman to deal it out. A finger jabs the baby in the stomach with the impact of a pile driver, and a honey-sweet voice says: "Does dat tickle, diddums?"

If the baby has been trained in the art of self-defence, its face assumes a delightful smile, while its eyes gleam blue murder. The woman, fondly imagining that her overtures have made an impression, unsuspectingly bends further into the pram to favor the baby with a kiss. She is quickly disillusioned, however; with a quick lunge, the baby drives its big toe deep into her eye, and she staggers back, stunned by such perfidy in one so young. The baby kicks its feet in the air and coos and gurgles with glee. Alas, poor child! its triumph is short-lived. Another woman takes up the attack. She bases her tactics on the complex language known as baby talk. The baby smiles a pitying smile and thinks, "You poor sap! How the devil do you think I can understand that drivel?"

However, the baby usually finds it best to assume an impassive expression when dealing with this mode of attack, and at last the woman gives it up in disgust. Gruelling as these afternoon outings are, they are mere child's-play compared to the grilling the baby receives when relatives call.

A loud voice calls invitingly, "Come to Uncle Charlie." Looking up, the baby sees an old fogy who would not attract a hungry man-eating tiger, let alone a baby whose sense of beauty is so much more developed. The baby measures the distance to the door from the corner of its eye; but it is too far—so, controlling its feeling of revulsion, the baby approaches Uncle Charlie, whose form of torment consists of rubbing the baby's face in his beard. As Uncle Charlie's beard is one that would turn a porcupine green with envy, the baby's enjoyment can scarcely be imagined.

After being practically scarred for life, the baby is passed to the next relative, who delights it with "Ride a cock-horse." The baby is almost overcome with ecstasy when bounced up and down on the tormentor's knee, which administers sharps blows at the base of the spine.

Eventually the relatives leave, and baby having collapsed into its pram, mother decides to take it out in the fresh air to see the neighbors.

The unsuspecting baby lies in its pram, dreamily looking at the sky and the trees, at the same time being deep in thought, when suddenly the peace and serenity are shattered . . . . .

———:o:———

THE ENGINEER

The Engineer, a mighty man
Controls the universe, but can
When necessary turn his mind
To subjects of a different kind.

He who the mighty bridge designs,
Or buries deep in mineral mines,
The genius of electricity
At home lives in simplicity.

The hand that moves the sliding rule
May well excell with gardening tool,
And he who with theodolite roams
Relaxes with a book of poems.

The magician of the strain and stress
Will revel in a game of chess.
The architect with mind sublime
Just dotes on Phillips Oppenheim.

Statistics say and never lie
The engineering marriage tie
Is firmer far than all the rest—
Like good foundations, stands the test.

Thus good people well should pray
That there will never come the day
When there occurs a fearful dearth
Of engineers—the salt of earth!

NEV.

THE ADELAIDE UNIVERSITY ENGINEERING SOCIETY

1946

ANNUAL REPORT

By THE SECRETARY

Committee for 1945-46

AT the 1945 Annual General Meeting, the following committee was elected:

President—C. G. Jose.
Vice-President—M. A. Otto.
Secretary—L. R. E. Trott.
Treasurer—P. Brokensha.

Second-Year Representatives: J. G. Allardice and W. M. Rice.

Men's Union Representatives: C. G. Jose, R. W. Parsons, P. G. B. Claridge.

Union Representatives: R. W. Parsons, P. G. B. Claridge.

Early in 1946 the Freshers' representatives , B. Stanton and R. Moffitt joined the committee, and have since proved themselves very keen and energetic men.

1945 Engineers' Dinner

The committee revived the annual function of the Engineers' Dinner after a lapse of several years, and about thirty Engineers, along with our Professor and several lecturers dined together at an Hindley Street Hotel. The Eve of exam. results cast a shadow for a while, but lubricating brought no earlier results. Short speeches by some of our staff provided ample entertainment. Unfortunately, to restrict the numbers we had to confine our guests to 3rd and 4th year men only, but we hope for a larger function this year.

New Members

The Society has vastly grown this year, as the Engineering faculty absorbed a good percentage of the huge numbers of fresher and ex-service men, and we have 75 financial members out of a faculty of 400 students.

It is disappointing that so few men take an interest in their faculty, reflected by the comparatively poor attendance at meetings, as some of the "lively" discussions and interesting speeches and, of course, suppers, leave nothing to be desired.

Meetings

All meetings this year have been addressed by guest speakers, it being hoped that the Debating Club would (or will) sponsor some student papers

Our first for the committee year was particularly interesting, Sir Harold Clapp, the Director-General of Land Transport, giving us an absorbing two-hour address on "The Standardisation of Australia's Railway Gauges." We were most fortunate to hear the man who is organising this huge task, and one to whom the project has been a life's ambition.

The next meeting, the first for 1946, was the official "greetings" to the freshers' by the Dean and his staff. Prof. Robin delivered some kindly words of welcome to the freshmen, with sound advice as to the kind of 'Varsity life which makes good engineers and citizens. We were so overawed by the vast numbers that a "welcome" was declared distinctly dangerous at a subsequent committee meeting. It was emphasised, however, that the tradition must not be dropped, but merely deferred for the year. Sketches by students kept the spirit of the party moving, and Mr. Robinson nearly brought the house down with some aspects of paternity.

At subsequent meetings we heard:—

Col. Tolley, of the E. & W.S. Dept., who gave a very interesting illustrated talk on "Irrigation of the River Murray Area."

Dr. Benko gave a very artistically illustrated address on "Modern Trends in Industrial Architecture."

Mr. Herriott, of the Lands Department, enlightened us all on the pressing problem of erosion with "Some Fundamentals of Soil Conservation."

Film Evening

In lieu of an Ordinary General Meeting, the Society received an invitation to see a film on "Lubrication," presented by the Caltex Company, and a number of engineers availed themselves of this illuminating address by the Company's expert, Mr. Tatton.

Visits by the A.U.E.S.

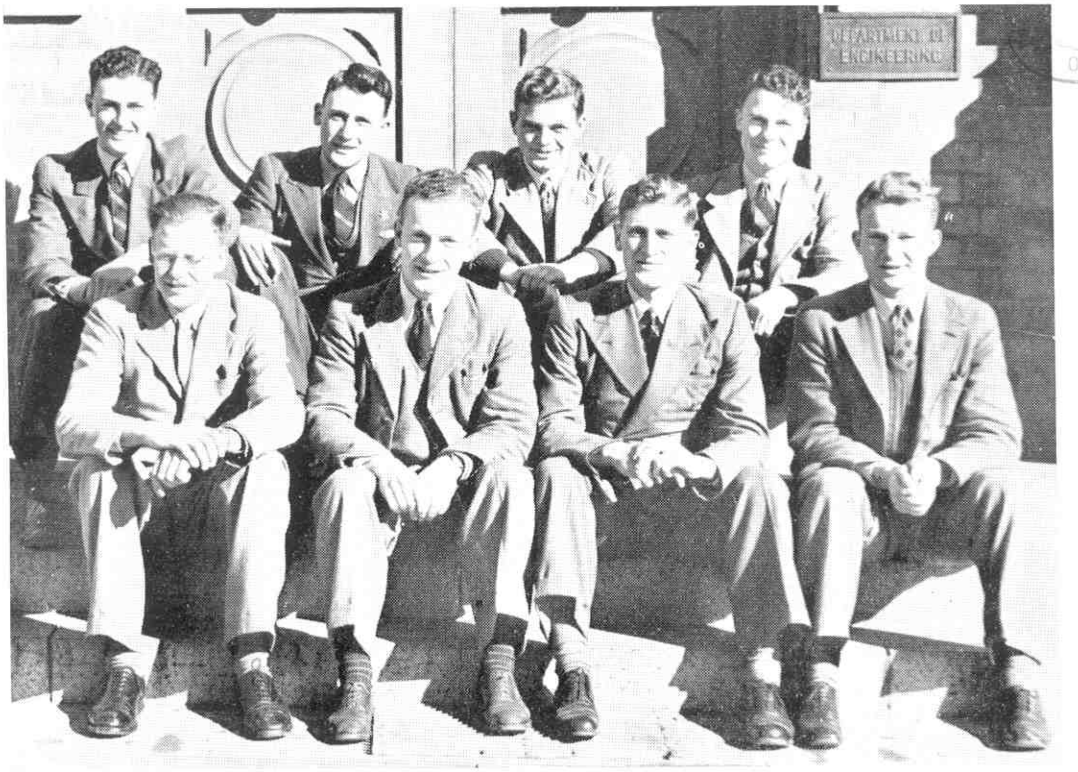
We were able to arrange a number of conducted tours to places of topical interest during the year.

The first of these was an evening visit last year to the British Tube Mills at Kilburn, when about 20 men were very courteously conducted through the factory.

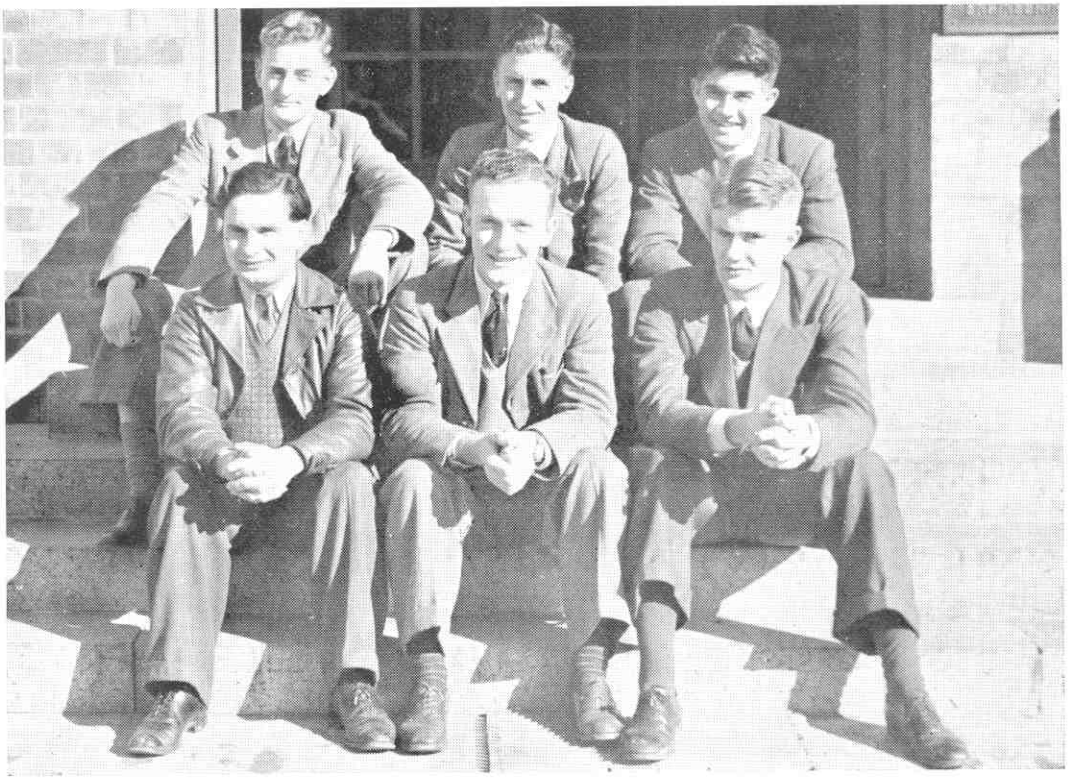
About a dozen of us were fortunate to "corner" an Engineer Officer in the engine-room of the Royal Navy submarine "Taciturn" when she visited Port Adelaide last year. We were given a most interesting survey of the power plant of the vessel.

The Royal Navy were our hosts again later on, when a party of Engineers saw the cruiser H.M.S. "Argonaut."

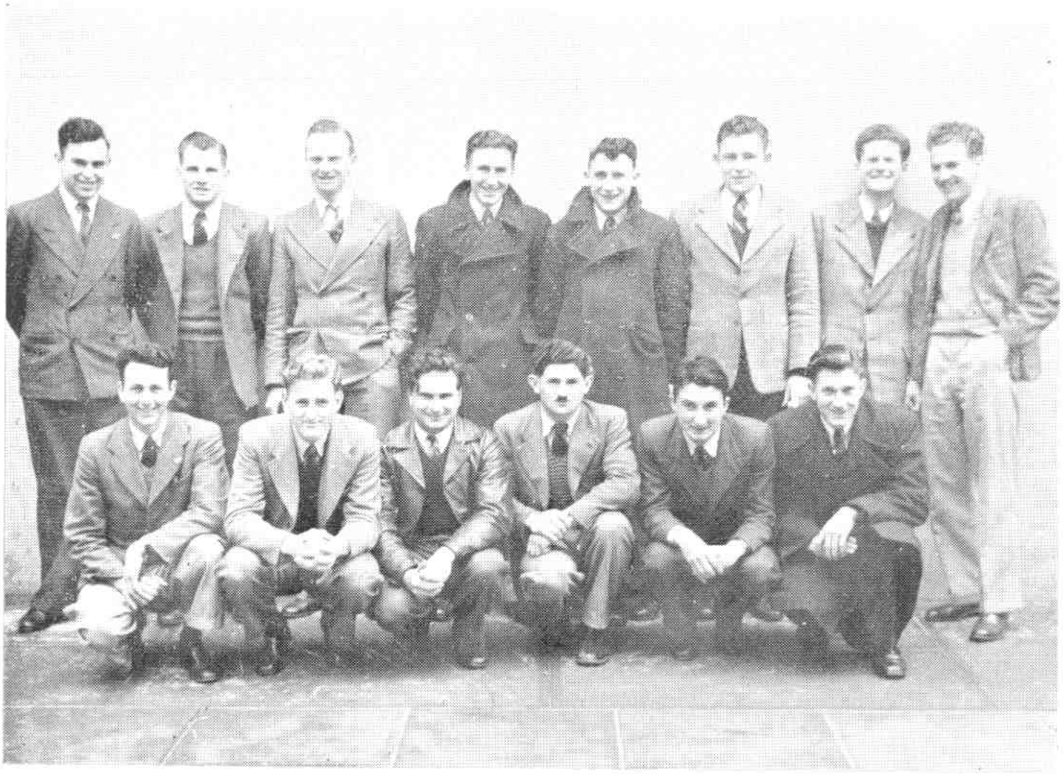
Imperial Chemical Industries Ltd., were most obliging in allowing a party of us to inspect their



THE A.U.E. COMMITTEE.
R. B. Moffitt, B. L. Stanton, J. G. Allardice, W. M. Rice,
L. R. Trott (Secretary), C. G. Jose (President), A. R. Curry, M. A. Otto.



THE MAGAZINE COMMITTEE.
D. Tonkin, F. J. Slattery, I. Donaldson, S. D. Kaneff, C. G. Jose, R. W. Parsons.



THE ADELAIDE UNIVERSITY ENGINEERING GLIDER CLUB.

Engineering v. Science Croquet Match. Claridge potting the red.

plant at Dry Creek one Wednesday afternoon in May.

Finally, the committee were very privileged to have as their guests to luncheon in the Refectory, Engineer Officers of H.M. Aircraft-carrier "Glory" when she was visiting Adelaide in July. After showing them round the 'Varsity buildings, which we believe interested them, as this was the only Australian University the officers had seen, about 20 engineers piled into all manner of vehicles and made (at high speed) to Outer Harbor. One of their number gave us a most exhaustive tour of the carrier, and we spent a good hour in the engine-room. We are very grateful to the officers and men of the Royal Navy for the interest and attention they have given us.

Committee Changes

We were very sorry when P. ("Champ") Brokensha was compelled to resign his post as treasurer in April. His place is, however, being capably filled by A. R. Curry, whose handling of the taxation department is to be admired.

1946 Engineers' Ball

Saturday, June 22, was the date of our big function held in the Refectory this year, and was quite in the keeping of the traditions of the Engineers' Ball. The two bands, with continuous dancing, proved very successful, and we raised £59/19/4½. Fifty per cent. of the proceeds were given to the Engineers' Glider Club, and a further £15 was donated to the World Student Relief Fund.

Glider Club

Under the enthusiastic leadership of Steve ("Leather skin") Kaneff, the Engineers' Glider Club is now a lively organisation, boasting a membership (financial) of 16, with more men interested. Blueprints for a primary glider have been purchased, and the necessary materials, including the timber, are on the way. Construction should start within a few weeks. (See report of A.U.E.G.C. elsewhere in this magazine).

Badges and Ties

Society badges should soon be available to all members of the faculty, as a new die has been struck and, manpower permitting, our order should soon be fulfilled. We are pleased that Engineers' ties are once more available, and that those who don't know round the 'Varsity can see that the Important Bloke is a "helluvan Engineer."

Laurels

We are proud to announce that once more the Engineers have distinguished themselves in the sports-field.

In the Engineers v. Science challenge football match, we won 16 goals 20 points to Science's 11 goals 10 points.

Further, there were Engineers in the Inter-'Varsity golf and athletic teams which went to the eastern States in June.

L. R. E. TROTT,
Hon. Secretary, A.U.E.S.

Engineering Glider Club (A.U.E.G.C.)

Towards the end of last year, the war having ended, and controls being relaxed, a group of us thought the time opportune to re-form the Engineering Glider Club.

You may or may not know that such a club functioned for several years in the 1930s. The original club built a primary glider, and used it, first at Tapley's Hill, and then at Sellick's Beach. It was at this latter location that an Australian gliding record of about 62 minutes' duration was set up. The activities were discontinued after numerous crashes, only a small percentage of which were fatal. So, for about 14 years, there has been no Glider Club at the University.

On December 6, 1945, the A.U.E.G.C. was inaugurated, and the developments from that date are as follows: It was decided to build a primary glider, and preliminary work was started. The first step was to find plans, as we did not feel inclined to design a machine and then fly in it. We were fortunate in obtaining, free of charge, a complete set of drawings from W.A.T.C.

Due to vacation employment outside Adelaide of some of the interested members, and also due to lack of funds, etc., little was done until the beginning of the University term of this year. Several meetings were then held, and questions of policy, finance, materials, etc., discussed. It was decided that the membership fee for 1946 would be 10/-.

The constitution decided on is as follows:

Constitution of A.E.E.G.C.

1.—Aim. The aim of the club shall be the fostering of knowledge concerning the theory, construction, and flying of heavier-than-air machines.

2.—The name of the club shall be "The Adelaide University Engineering Glider Club."

3.—The committee of the club shall consist of (a) a president, (b) a secretary, (c) a treasurer, (d) three committee members.

(Offices (a), (b), and (c) are at present held by Mr. S. D. Kaneff.—Ed.)

4.—All offices of the club shall be declared vacant at the annual general meeting, which shall be held not later than the fifth week in the third academic term.

5.—There shall be a patron and vice-patrons, who shall act for periods to be determined by the committee.

6.—The club shall take no responsibility for any injuries incurred at any time during membership of the club.

7.—All prospective members shall be subject to the approval of the committee, who reserve the right to discipline or expel any member for any reason deemed sufficient by the committee.

8.—The committee shall fix the membership fee from year to year.

9.—The committee shall have full control over all construction and flying.

At present, it is the policy of the club that all members who help with construction, shall have first preference in flights.

Membership of the club is open to all Engineering students, and applications for membership from others will also be considered. With sixteen financial members, the club is on its feet, and its success has been assured by the receipt of £30, being part of the net proceeds from the highly successful Engineering Ball.

The finances of the club as on July 10, 1946, stand as follows:—

Expenditure, Nil.

Assets.	
Membership fees, at 10/- per member	£8 0 0
Receipt from A.U.E.S. Ball	£30 0 0
Total	£38 0 0

The material for the primary glider has been ordered and should arrive soon, and in view of what has been said above, all those interested in the club should get in touch with me or with other members.

For the time being, we are content to aim at nothing more than a primary glider, but as the club finances and membership increase, we intend to build something more ambitious—a secondary glider or, perhaps, even a sailplane; and who knows, with all members extremely keen, these ambitions may be realised even sooner than we expect.

———:o:———

THE FIRST TIME

F. J. SLATTERY

"THERE ought to be nicer ways of making money," she mused, as she stood on the corner, waiting. This was her first experience of this kind of work, and she involuntarily winced as the passers-by eyed her strangely. She was slightly above medium height, with clear complexion, and sparkling blue eyes. Her shiny brunette hair encircled her head like a halo. She was quite attractive, and was relying mainly on her charm to "put her across."

She watched the passing crowd, looking for a likely victim. Suddenly she saw one. He was tall and good looking, not exactly handsome, but his height and broad shoulders gave him an air of superiority. Something marked him out from the rest of the crowd.

Here was her chance—just what she had been waiting for. She shuddered, but realised she must do it. She was almost going to stop back and wait for some one else, but, with a sudden burst of courage she stepped out towards him. With an engaging smile, she held out her hand towards him.

"Buy a badge, sir?"

Engine Combustion

By K. W. BOWEY

DUE to the mechanical construction of an internal combustion engine and also to the high speed of operation, difficulties have been met in the search by engineers for more knowledge of the chemical and physical processes of combustion. A phenomenon which was familiar to the practical engineer long before its far-reaching importance was realised is "knocking" or "pinking." It is highly objectionable and has been called "the cancer of engine combustion." The noise given out from the engine was like that produced by a sharp ringing blow upon the metal of the engine cylinder. Experiments proved that it was not due to some mechanical cause such as bearing slackness. A theory was then put forward that it must be due to a wave of high pressure travelling at great speed through the gas which formed the working substance. I mention this problem of "knocking" or detonation because after much research, Ricardo listed detonation as the main factor limiting the power output and efficiency of an engine.

It is not surprising, therefore, that much research has been carried out in an endeavour to understand the process of combustion. One of the first instruments used was an optical pressure indicator, which gave both pressure-volume cards and pressure-time cards. Another device used was known as a bouncing-pin indicator. It consisted of a diaphragm, a steel rod insulated at the upper end, and two contacts in an electric circuit. If the engine knocked the diaphragm was flexed sufficiently to cause the bouncing pin to close the contacts. The greater the knock intensity, the longer the circuit remained closed and hence the greater was the knock-meter indication. Such a device permitted a comparison of different fuels on the basis of a knock rating.

By providing a quartz window in the wall of the combustion space, it was possible to obtain a measure of heat radiation with a copper-constantan thermopile mounted in an evacuated tube, and connected to a sensitive galvanometer. Although this gave only quantitative results, it showed conclusively that much greater radiation occurred when knocking was present.

By placing a number of small quartz windows in various positions of the cylinder head, and using a specially built spectroscope to combine the dispersion or light separating effects of a diffraction grating, the combustion could be examined by the spectra recorded. The following is some of the information that was gained:—

1. There was a similarity between the composition of the flame inside the engine to the inner cone of the flame in a gasoline torch or a Bunsen burner.

2. That the absence of the hydrocarbon and carbon band from the region behind the flame, called the after-glow, showed that gasoline was not burning there. This indicated that the hydrocarbon combustion proper completed itself within the flame front which appeared as a relatively narrow region.

3. Within the zone of combustion when knock was present, the intensity of the CH and C bands in the flame front was reduced greatly. This suggests that some hydrocarbon reaction may have occurred within the region of the knock before the flame front arrived there.

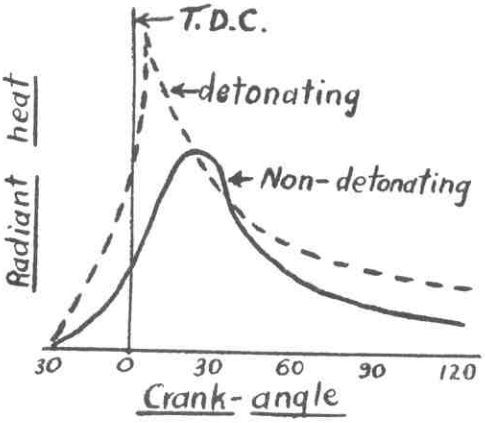


FIG. 1. Heat Radiated by Combustion.

Flame temperatures of the burning gases have been measured by using a similar arrangement of windows, optical train and spectroscope. Light from a tungsten-filament lamp whose temperature could be varied over a wide range was passed through the flames colored by a trace of sodium. A stroboscopic shutter was used to select the precise time at which each measurement was made. The temperature of the lamp filament was increased from below the temperature of the gas to be measured to above it. Hence a point appeared on the spectrum where there was neither emission nor absorption, i.e., there was no sodium line on the spectrum. This meant that the temperature of the lamp filament just matched that of the sodium atoms in the burning gas, and hence the temperature of the flame. This temperature may be as high as 5,000° F. absolute.

In all processes so far outlined, events have had to be noted individually, i.e., at different times for various points in the engine cylinder. Exact knowledge of the form of the flame front and of the manner in which the flame spread through the combustion space was next desired. Accordingly, a special cylinder head of fused quartz was developed. This gave a full view of the combustion chamber thus enabling the spark plug, the valves, the piston top and the combustion process to be examined during the actual process of combustion. The only type of engine permitting this was a side-valve engine having the spark plug in the cylinder block as shown, and not in the cylinder head as is usually the case.

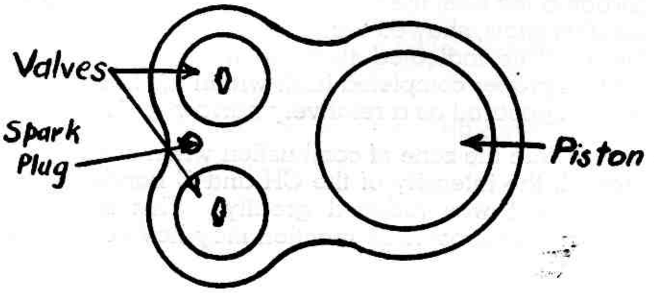


FIG. 2. View Through Quartz Head.

After considerable study of high speed motion picture cameras, a special camera containing 30 matched lenses was built. The lenses were mounted 2.4° apart along a sector of the circumference of a large disc carried by the crankshaft. A stellite mirror placed at 45° over the head reflected the views on to the disc. Each of the 30 lenses as it swept by a stationary master or field lens produced a picture of the state of events in the combustion space. The number of pictures taken, therefore, was proportional to the engine speed. Since the lenses were located for 72° of the disc, it means that for a speed of 2,000 r.p.m., 5,000 pictures per second would be taken. The set up included numerous other additions, such as covers to make it light tight and a means of moving the film behind the lenses.

By this method 30 pictures of a knock-free combustion could be compared with 30 pictures of a combustion with knock present. The successive pictures of a knock-free combustion showed that the flame moved forward in a progressive fashion despite the short time of say 1/200th sec. for the combustion process. However, with knock present, it was seen that the flame proceeded almost with knock-free combustion for portion of the combustion until a spot of wild flame was suddenly seen far in advance of the flame front proper. From this stage, the whole charge was rapidly consumed, whereas for the corresponding knock-free combustion there may still have been one-third of the charge unburnt. It was this formation of fire out in front of the normal flame, and the extremely rapid combustion that resulted from it, which gave a sudden elevation of gas pressure and the pinging noise called knock or more strictly "detonation."

Further use was made of the pictures taken by providing an elaborate system for taking a pressure card for each combustion photograph. Then, by analysis of the flame pictures and the corresponding pressure cards, it has been possible to derive a definite relationship between the volume and mass of charged burned. The method has also been used to note the effect of changes in point of ignition, in air-fuel ratio, and in degree of throttle opening.

Even in such a brief treatment of the subject as this, mention should be made of the use of the cathode ray indicator to give pressure time diagrams. The high speeds of modern engines make the use of standard indicators unreliable, due to inertia effects on the instrument. A cathode ray tube will give an indicator diagram for a high speed engine. In the tube there are two pairs of plates, arranged to be mutually perpendicular. One pair, known as the pressure plates, is subjected to voltage variations in proportion to the gas pressure within the engine cylinder. The other pair, known as time-base plates, receive voltage variations proportional to the position of the engine crank—i.e., to the time of occurrence of the observed pressures. The spot of light given by the electrons on the screen is therefore displaced in two directions at right angles, and if the phase relationship between the cylinder pressure and the crank angle is correct, it traces out a diagram of pressure upon a time base.

As a result of the knowledge of combustion proces gained by these research methods, the efficiency and reliability of the modern engine have been greatly improved. No doubt many of the methods developed for the study of the reciprocating type of internal combustion engine will prove useful in the development of the gas turbine, and so promote progress in the this field.

———:o:———

THE ENGINEER'S "IF"

BY X. Y. THROGMORTEN, F.B.E.

If you can hold your liquor in whatsoe'r it is,
When you see your mate is down, and losing grip on his;
If you can flirt with umpteen girls and treat them all the same,
And let each one think she's the lass that's gunna have your name;
If you can rave and swear like hell when all your bridges crash;
If you can live on all your friends, and borrow all your cash;
If with slide rub you can make your answers fit the book,
And make it seem you're pretty good, e'en though you've had to cook;
If you can take your staff man out, and level from here to there,
And come back with a couple of yards, or even more, to spare;
If you can design a dam or truss that fails quite abruptly,
Then prove the foreman in the wrong, that he built it most corruptly;
If when a youngster calls you Dad, you look quite calm and say,
"I'm sure I don't know you, you ——, who's your mother, pray?"
If you can do all this my son, and still pass your third year,
Well, then you're bound to be, you twirp a helluvan-engineer.

THE RECENTLY APPOINTED PROFESSORS OF ENGINEERING

Professor Willoughby has recently been appointed to the chair in Electrical Engineering.

He studied at Melbourne University, and at the Imperial College, London, gaining his M.A., B.E. (Electrical and Civil), and D.I.C. He is also a member of the Institute of Electrical Engineers.

Professor Willoughby has had considerable experience in broadcasting work in India, Malaya and Siam. He also designed the aerial and output circuits of an Admiralty station in England. During the war, he was engaged on research work relating to electrical equipment of aircraft, and did some important work on the frequency stabilisation of oscillators for work under variable temperature conditions.

In addition to maintaining a modification of the present power course in Electrical Engineering, he intends starting a course in Electronic Engineering, dealing, among other things, with the fundamentals of reception and transmission. An Honors Degree in Electrical Engineering will also be open to those with the ability to attempt it.

All this will not be brought about in a day, but we wish Professor Willoughby every success in his new venture, and hope that he will not meet with any unnecessary delays.

Professor Davis, who has been recently appointed to the Chair in Mechanical Engineering, commenced his education at King's School, Parramatta. He then proceeded to the University of Sydney, gaining the Honors degree in Mechanical Engineering in 1933, but his University education did not stop there. In 1934 he was awarded the W. J. Graham Research Scholarship, and in 1935 the Kolling Travelling Scholarship.

Proceeding to England, he attended Cambridge from 1935-38, and was awarded the degree of Doctor of Philosophy for "Rail Joint and Track Investigations with an Electric Accelerograph."

From 1940 until 1946 he was on the staff of the National Standards Laboratory, Sydney, being in charge of the Metrology and Mechanical Engineering sections for periods during his sojourn there. He has now capped his laurels by terrifying every fourth year Mechanical student with the prospect of seminar lectures. With the new Mechanical building under construction, Professor Davis should have ample scope for work which he may wish to undertake, and we wish him well in his new sphere of activity.

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WORK AND WORKERS

By "CHAMP."

The Editor of this Magazine asked me to write an article about "Labour or something"—evidently because of my interest in all things political. This is the result, although being a University student doesn't give me much knowledge about work and workers!

Whenever I have worked with men—whether in the steel works or coal mines at Newcastle, the silver lead mines at Broken Hill, or our local factories—I have tried to understand their problems and points of view.

I certainly do not claim to be an authority on the subject, and the only axe I have to grind, in a nutshell, is this—

University Engineers, as future leaders of men, should start now to take a lively interest in society, and especially in the workers they will ultimately control.

Work, in its multitude of forms, is, to a certain extent, a concrete expression of the personality of the person doing the work. It is only through doing useful work that a man justifies his place in society, and what is more important, in doing so he satisfies his own ego. Nothing is more tragic than a man's realisation that he is a failure, and that the world has no place for his work.

From successful work springs man's happiest emotions. Thus we may attempt to outline a philosophy of work. It is an interesting study, which can easily be verified by everyone.

In our free society no one need work. Instead of mining the coal or digging the ditches, the worker is perfectly free to stay at home all day, just as he is free to live in a mansion and own a Rolls Royce. However, the only commodity a worker possesses is his labour power, which he is forced to sell to the highest bidder in order that he may live. A workman may be compared with a machine—and like all machines, sometimes it won't work, and the engineer has to find the fault, and rectify it. Therefore he should know exactly the conditions under which his men are working, and should do whatever is in his power, by a sympathetic understanding of their grievances, to weld them into an efficient working unit. The causes of most stoppages are wages, hours, and conditions.

Wages.

How are wages determined? They cannot be correlated with the value of the work performed. A worker is paid the same rates for mining gold as he is for digging ditches. He is, however, paid a wage which enables him to subsist, and to raise children to take his place when he can no longer work.

He may not be paid less than a basic wage, which is fixed by the Arbitration Court. The first basic wage was fixed by Mr. Justice Higgins in 1907 at £2/2/- per week for Melbourne. This was not an estimation of the needs of an average family, but was the amount the Judge guessed industry could afford to pay. This £2/2/-, the amount considered reasonable for a family of five, was proportioned as follows: £1/5/5 for food, 7/- for rent, and 9/7 for all other expenditure (clothing, medical care, education, amusements, etc.).

This is the basis of the present basic wage, with certain minor alterations and small fluctuations with the retail price index.

A Royal Commission in 1920 attempted to find the actual requirements of a family of five. For Melbourne the amount recommended was £5/16/6 per week, while the actual basic wage in operation at the time was £3/18/—nearly £2 less! This recommendation was shelved.

The basic wage for Adelaide at present is about £4/15/-, and a large percentage of the working population receive near this wage.

No one will deny the inadequacy of £5 a week to keep a family in reasonable comfort. Hence the life of a basic wage worker is a struggle for existence—and he wants an increase of at least £1 a week for a start, which, with child endowment—actually another form of basic wage—will enable him to raise his standard of living.

The only way industry can afford to pay this increase is at the expense of profits. I have the quaint notion that these profits should go to those who worked to make them, instead of to the shareholders who "risked their money in the enterprise."

The worker, as a whole, does not want contract work. What he does want is a guaranteed fair wage, that will not only enable him to live a reasonably comfortable life, but will also allow him to save, and insure against possible contingencies. In short, he wants security.

Hours of Work.

Hours of work have decreased considerably since the last century. However, they have not decreased at anything like the same rate as production has increased. Industry has made such enormous strides in the last few years, and such enormous possibilities have been opened up, that before long a man will be able to do as much work in a day as formerly took him a week. Ultimately, I think hours of work will have to decrease rapidly, as technological improvements are made. At the present time, however, the world is in such a sorry state that if every worker and every machine worked night and day, it would take years to restore the battered and hungry countries and peoples of Europe, India, and China. With all their talk about U.N.O., are the prosperous nations of the world really interested in their starving fellows? But our world is run for profit, and you don't make profit out of feeding starving Indians.

So there should be no talk of reducing hours of labour in such a time of global crisis, if this labour were directed towards overcoming the crisis. However, Australian industry has stopped working for Australia, as it did during the war, and firms are returning to peace-time conditions. Hence the workers, who have endured long hours during the war years, are certainly entitled to shorter hours, and the matter of a 40-hour week for some million trade unionists is being decided by a panel of five judges. Is this the true democracy of which we boast—"government by the people, for the people"?

Leisure.

If the worker is given more leisure time, he will only go to the corner pub., and he would be better off working—so the critics say. Instead of dismissing this indisputable fact with a sneer, an attempt should be made to analyse the reasons for many spending their time at the pub. instead of with their families or at the libraries, art galleries, etc. He would perhaps not be at home because his abode is more like a hovel than a home, and his wife is a harassed creature trying to look after a brood of ragged children. He would probably not be passing his time in cultural pursuits, as theory says he should, because the economic position of his parents necessitated his removal from school the day he attained the age of 14, so that his natural intelligence has never had a chance to develop.

The advisability of a reduction of working hours calls forth another query, **Do the workers work?** "The Australian worker is inherently a loafer. He does as little work as possible, and his main interests are Beer and Bernborough." This is a lie, founded upon a half truth, and disseminated by people with a strong class bias. If any work place is visited, and the industry of the workers critically examined, the truth of this statement will be proved. The coal miners have had much scorn heaped upon their heads by a vociferous section of the community, led by the daily press. If one examines the statistics of coal production, it becomes evident that the strikes are being played up by the press as a means of anti-Labour propaganda.

Despite the fact that there were fewer miners employed in the industry in 1942, coal production rose markedly. Very little mechanisation has taken place in the period quoted below from the Government Official Handbook:

Year.	Coal production, in millions of tons.	No. employed, in thousands.	Tons per man per year
1938 -- -- --	11.68	21.1	556
1939 -- -- --	13.53	22.0	615
1940 -- -- --	11.73	22.7	517
1941 -- -- --	14.21	23.1	615
1942 -- -- --	14.9	22.8	654

Miners living in tight little communities have good memories, and they remember the lockouts after the last war, when reserves were high. By keeping reserves low they are holding the community to ransom for what they so justly deserve.

They want safer and less dusty pits. They want good change-house facilities, a guaranteed weekly wage, and, above all, a sense of security. Given these things, and strikes in the coalfields will be things of the past. This is borne out by the record of those pits with good conditions.

It is definitely a debatable point whether a strike, however just, should be allowed to paralyse the whole nation. Mr. Truman evidently thinks it should not, when he recently passed a Bill outlawing strikes in a national emergency. The solution should be to remove the cause of the trouble, and the Federal Government is doing this by implementing its long-range Coal Plan. I worked with a lot of miners at Broken Hill, and they certainly were not loafers. I wouldn't like to swing a spaller all day, to shovel the heavy lead ore, or to replace a horse by pushing a truck containing over a ton of ore.

These were contract men, and it is true to say that on many shifts wages men did little work. However, any mine or factory must keep sufficient men on hand to ensure its smooth working. Hence on some shifts there is little work to be done. On the other hand, I have always found that if men are given a definite job, they will pitch in and get it done. This, I think, is one of the most important things in getting men to work efficiently. They should be told the purpose of the job they are doing. The engineer should not keep a lofty silence, but should give even the humblest labourer the idea that he is an important link in a productive chain. The best way of getting work from men has been the subject of much research. Experiments have been tried, such as playing recorded music, using certain colour schemes, giving employees certain lengths of rest at certain intervals, and many other ideas. But men will never work hard and willingly unless their work means something to them.

During the war the workers took pride in their fatigue, because they knew they were working for the defeat of the enemy. In peace time they feel they are working to make profits for others, and who is going to "bust" himself doing that?

The solution is to either introduce profit-sharing, where the worker is partly working for himself, or to nationalise all industry, where the worker will realise that he is working for himself, as well as for the whole community. What better incentive is there than this?

THE NEW ENGINEERING BUILDINGS

By PROFESSOR R. C. ROBIN

THE University, realising the growing importance of industry to the State, has had in mind for some years the need to take its share in the development. The University realised that it could aid industry by taking a larger share in the training of engineering graduates, by the provision of honors courses in all the major branches of engineering, and above all, by providing facilities for research.

Accordingly men have been appointed to fill newly created chairs in electrical and mechanical engineering and a new agreement, giving the University a larger share in the teaching, reached with the School of Mines. Under this agreement the University will provide all instruction in third and fourth year mechanical engineering subjects with the exception of workshop practice. Engineering Drawing over the first two years and also laboratory work in Mechanical Engineering II will continue to be provided at the School of Mines.

In the department of Mining and Metallurgy it has been agreed that the teaching for the degree students will be divided approximately equally between the two institutions.

Further to the above, the unprecedented increase in enrolment in engineering subjects brought about by the Reconstruction Training Scheme has made the need for additional laboratory and drawing office accommodation imperative. The additional space required will be provided in the new engineering buildings.

The new buildings are situated close to the School of Mines Jubilee Building, thus grouping all engineering together. The University is erecting two buildings, namely the Main Engineering Building and the Mechanical Engineering Building.

Main Engineering Building

Starting from the western end the main building will house Civil Engineering, Electrical Engineering and Mining and Metallurgy in that order. The building will be 424 feet long and 60 feet wide except at the central section where the width is 70 feet. The two wings are at present to be only two storeys in height, but the central portion will be of three storeys. Provision is being made in stanchions and foundations so that the whole building can ultimately be raised to four storeys.

When the present building plan is completed the existing accommodation of the Civil and Electrical Engineering departments will be turned over to Physics.

The key to the numbered rooms is as set out below. The letters C, E, M following the rooms, refer to the departments of Civil Engineering, Electrical Engineering and Mining and Metallurgy respectively. The letter S indicates that the room will be shared by the departments.

Ground Floor:

1. Hydraulics C.
2. Materials Testing C.
3. Survey and Apparatus Store C.
4. Models and Senior Research C.
5. Students' Locker Room S.
6. High Tension Laboratory E.
7. Underground Battery Room E.
8. Electrical Machines E.
9. Constant Temperature underground C.

First Floor:

10. Students' Common Room S.
11. Demonstrators C.
12. Staff Drawing Office C.
13. Cadets C.
14. Seminar C.
15. Seminar C.
16. Lecture C.
17. Staff Rooms C.
18. Library and Catalogue C.
19. Staff Rooms C.
20. Large Lecture Room S.
21. Drawing Office C.
22. Plan Room C.
23. Well to testing laboratory.
24. Advanced Drawing Office C.
25. Electronic Research E.
26. Store E.
27. Seminar E.
28. Demonstrators E.
29. Staff E.
30. Classroom E.
31. Electronics E.

Second Floor:

32. Electronics E.
33. Electronics E.
34. Mining and Metallurgy.

    Also 35 and 36 on lower floors—Mining and Metallurgy.

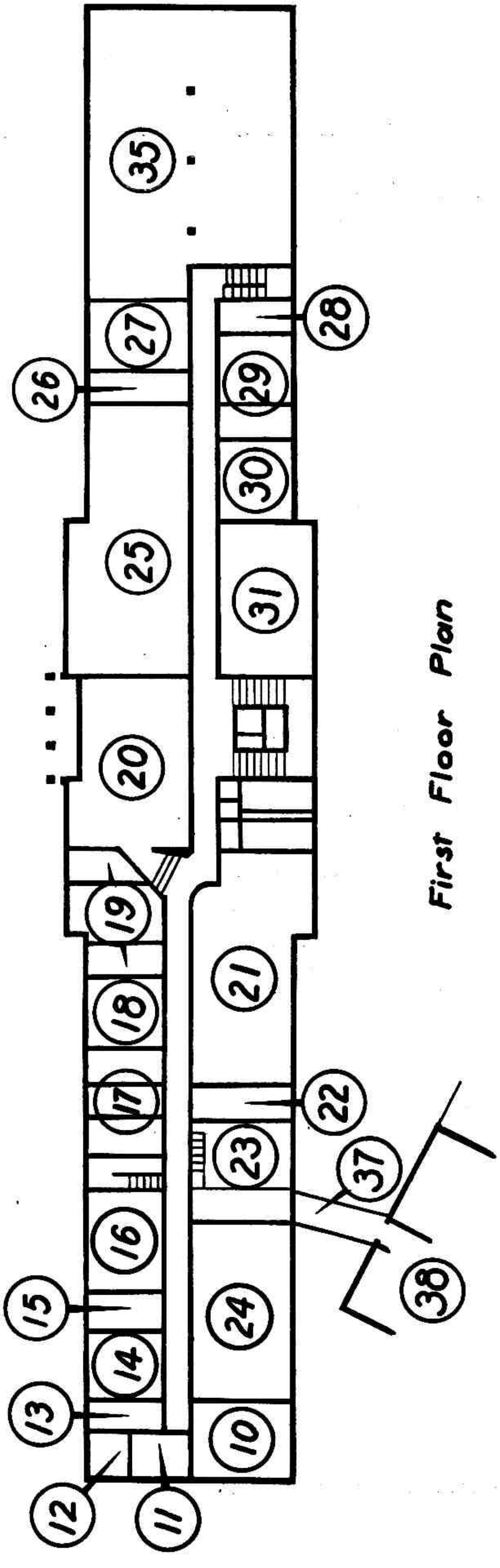
The accommodation for Mining and Metallurgy has been left undivided pending the appointment of the new Professor.

It will be noted that there is no Machine Shop in the main building. A large central workshop is provided on the eastern side of the Mechanical Engineering building and this will serve all the engineering departments.

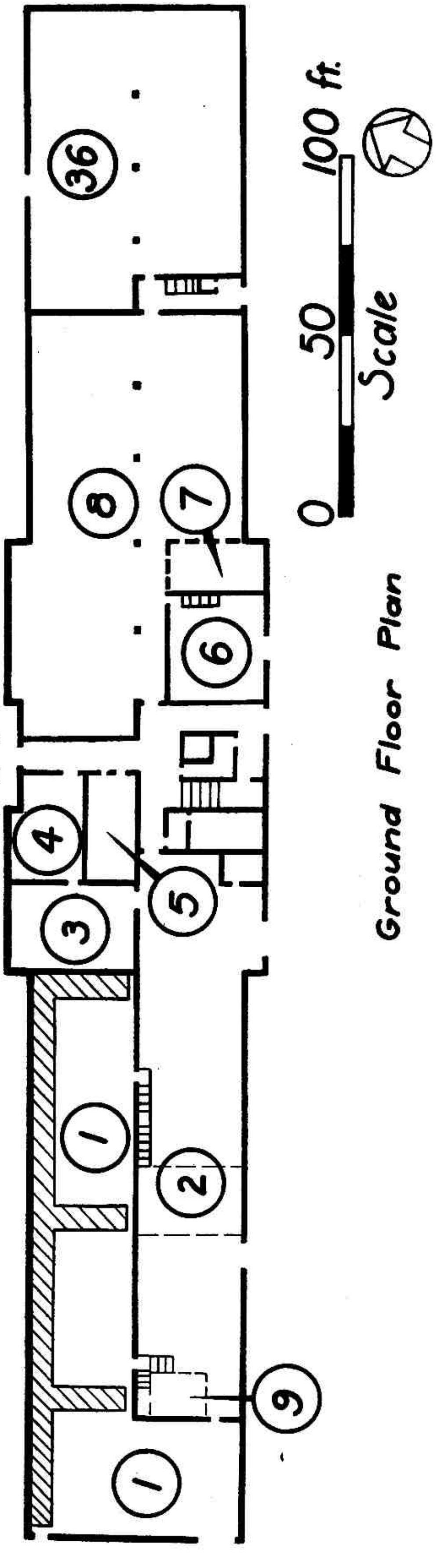
Dealing with the laboratories of the Civil Engineering Department in greater detail:

Hydraulic Laboratory:

A sump shown shaded, runs the full length of the laboratory thus allowing great elasticity in arrangement of equipment. The floor of the laboratory is sunk 5 ft., making the storey over this room 22 ft. This height was required to allow steel staging to be erected. The staging stretches from the central

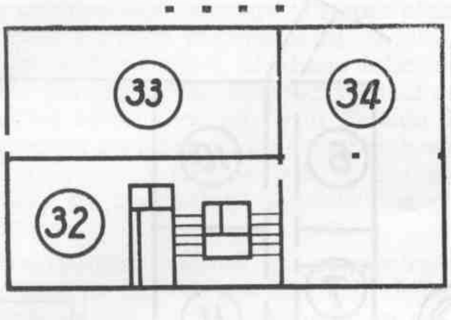


First Floor Plan



Ground Floor Plan

MAIN ENGINEERING BUILDING



Second Floor Plan

wall, separating hydraulics from testing, to the edge of the sump and gives in effect a mezzanine floor upon which two steel flumes and two wind tunnels will be placed. The flumes will be fed from a low head tank immediately over the western cross sump and just under the first floor. Under the staging special purpose cross flumes will be fed from a pipe manifold running along the southern wall of the laboratory, the manifold itself drawing its supply from the low head tank.

Another pipe manifold for higher pressure water will also run along the same wall. This will be fed from a tank placed just above the ceiling of the second floor in the central block. The eastern end of the laboratory floor below the staging will be devoted mainly to hydraulic machinery. The large bay at the western end is to be devoted to hydraulic models or large engineering works. Bins to hold sand and other materials suitable for such models are to be built in to the western wall. Investigations and research into such questions as the percolation through earth dams, scour caused by wires and similar structures.

Testing Laboratory:

In addition to the existing equipment, a large column testing machine, capacity 150 tons, and capable of testing sheets up to 13 ft. in length will be obtained. The well (23) is to give sufficient head room for this machine. Another item to be obtained is a fatigue machine capable of direct loads of up 25,000 lbs. This will be suitable for research on welded or riveted joints or on reinforced concrete beams. It is also hoped to obtain a large torsion machine suitable for research or reinforced concrete or structural shapes. A special testing machine which will approximate uniform loading upon footings of flat plates is also planned.

Concrete and Soil Mechanics:

Room 1 in the Mechanical Engineering building on the ground floor. In return for this space Mechanical Engineering will share the hydraulic laboratory with Civil. In addition to cement testing this room will have facilities for casting concrete specimens for research. A fog room will allow thorough curing, and an overhead runway beam will be used to transport heavy specimens into the testing laboratory. The runway beam is carried under the walkway connecting the main and Mechanical Engineering buildings. A large area in the laboratory will be devoted to soil mechanics, with adequate laboratory benches. Special soil-testing machines, including one for the triaxial test will be installed.

Other Civil Engineering laboratories will be the Models and Senior Research (room 4 on the ground floor of the main building), which will be used for experimental work on model structures, and the underground constant temperature room (9) to be used for work on the shrinkage of cements and mortars. A platform above the stair well (not shown on the plans) will provide for the star observations carried out by Surveying students.

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MECHANICAL ENGINEERING DEPARTMENT

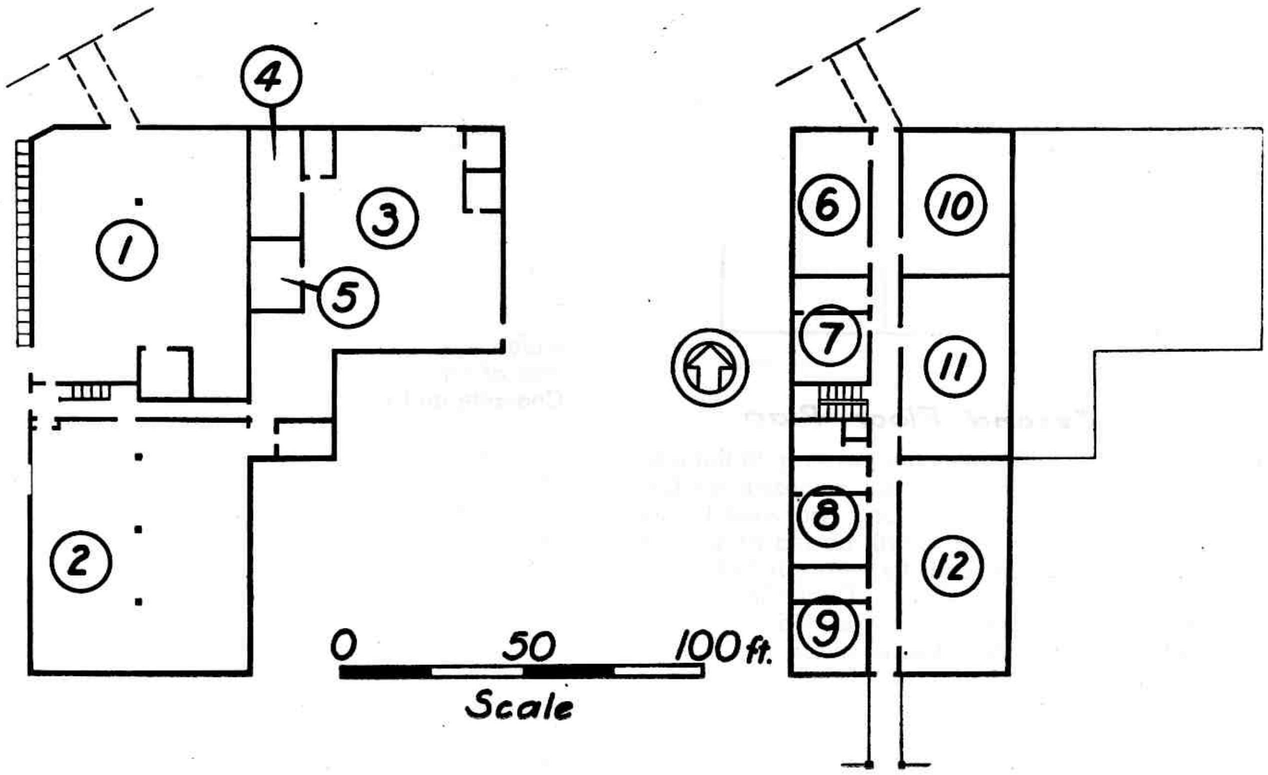
By PROFESSOR H. H. DAVIS

IT is hoped that the new Mechanical Engineering building now rapidly taking shape, and comprising approximately one-quarter of the proposed unit of buildings to house the Faculty of Engineering, will be completed by March, 1947.

A key to the building plan is given below:

1. Concrete and Soil Mechanics' Laboratory (Civil).
2. Advanced Laboratory for 3rd and 4th years.
3. Workshop—general machine and fitting.
4. Precision machine bay.
5. Tool store.
6. Engineering Drawing and Design IV.
7. Lecturers' offices.
8. Professor's office.
9. Library, catalogues and 4th year reading room.
10. Lecture room (90 seats).
11. Large lecture room (160 seats).
12. Engineering Drawing and Design III.
13. Students' Common room.
14. Model room, Museum and equipment store.
15. Research Laboratory.
16. Engineering Drawing and Design IV.
17. Staff room.
18. Locker room.
19. Photographic dark room.

The detailed planning, ordering, delivery, instal-



Ground Floor Plan

First Floor Plan

MECHANICAL ENGINEERING BUILDING

lation and testing of new plant will naturally take time. In addition, it is hoped to design and to fabricate in the new workshop an appreciable amount of specialised equipment and accessory apparatus. The laboratories will therefore gradually evolve over a period of years rather than become filled, on completion of the building, with an array of interesting new plant.

It may be of interest in this connection to take a glance at the present plans for equipping the new workshop, advanced laboratory for third and fourth years and the research laboratory.

Workshop:

A comprehensive range of good precision and general purpose machine tools and other workshop equipment has been ordered. The list includes:—Universal, surface and tool and cutter grinders; precision toolroom and general purpose lathes; universal miller; shaper; radial, sensitive and h.s. drills; power metal cutting band and hack saws; pantograph engraver; heat treatment furnace; oxy-acetylene and electric welding plant, and many other items.

In addition, a useful range of metrological equipment has been ordered to make possible a high degree of precision and finish of machined parts. The workshop has dimensions 70 feet x 60 feet with an annexe comprising welding shop and equipment store, 20 feet x 30 feet, in the south-west corner. Partitioned off in the main shop are a 15 feet x 30 feet bay for precision machine tools, a tool store and metrology room.

Built as a saw-tooth roofed, single-storied, annexe to the Mechanical Engineering building, the workshop will be under the general supervision of the Mechanical Department, but will be shared by all four Departments comprising the Faculty, each having their own staff.

Advanced Laboratory:

This 60 feet x 70 feet laboratory occupies approximately half of the ground floor area of the building, the northern half being the Concrete and Soil Mechanics Laboratory of the Civil Engineering Department.

As Mechanical Laboratory work for second year will still be carried on by the School of Mines, this Advanced Laboratory will supplement existing equipment in the School of Mines in covering the needs of third and fourth year students, and will probably accommodate some of the heavier equipment for research work.

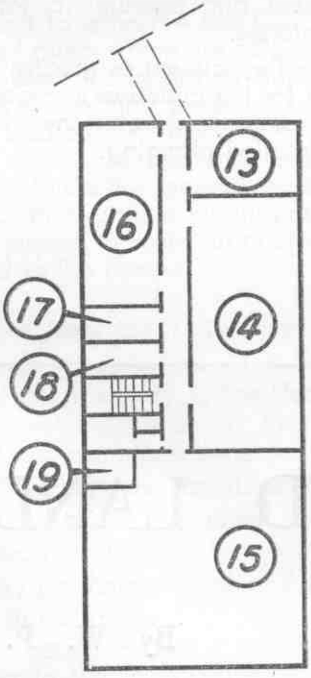
Present plans for equipping this laboratory are still in the developmental stage, but may be briefly outlined as follows:—

(a) **Steam Plant:** Steam plant may be brought through about 300 feet of well lagged pipeline from the new B. & W.. boiler plant to be shortly installed in the School of Mines. A small auxiliary superheater at the University end may be necessary to ensure dry superheated steam being supplied. As a fairly comprehensive range of steam plant, including a new Parsons experimental turbine, will be available in the School of Mines laboratory, it is probable that only a high speed vertical compound condensing steam engine, with Froude hydraulic dynamometer and a small De Laval high speed compound condensing turbine will be installed. The latter may be coupled to a multistage centrifugal air compressor.

(b) **Refrigeration Plant:** A conventional vapor compression plant, with electric motor drive and with balancing electric heating elements for performance tests, as well as a cooling chamber for experimental work. An experimental heat pump for warming air.

(c) **Air Compressors:** An experimental piston type with separate L.P. and H.P. units on either end of a d.c. electric swinging field dynamometer for power supply and measurement. H.P. and L.P. may be operated individually or as a two-stage unit, with inter and after-coolers, and facilities for temperature and air-flow measurements. An air motor.

A centrifugal multi-stage compressor coupled to the above-mentioned steam turbine with facilities for pressure, temperature and flow measurements.



Second Floor Plan

An axial-flow multi-stage compressor coupled to an experimental gas turbine unit as mentioned below.

A Roots type positive displacement blower for supercharging a Diesel engine mentioned below.

(d) **Internal Combustion Engines:** An A.S.T.M. Co-operative Fuel Research variable-compression engine universal dynamometer laboratory test unit.

An automobile petrol engine on test bed, with 150 h.p. electric torque reaction or swinging field dynamotor and comprehensive provision for fuel and air metering, temperature and heat flow measurements, ignition timing, exhaust gas analysis, cylinder, induction and exhaust pressure indicating, tachometer and stroboscope. Experimental silencer design and testing facilities.

A producer gas unit for alternative fuel supply to automobile engine.

A Petter Superscavenge 2-stroke heavy oil engine on test bed, coupled through an elctromagnetic torsiograph and transmission dynamometer and a fluid coupling to other end of the 150 h.p. electric torque reaction dynamotor on the petrol engine test bed. Provision for measurements of torsional oscillations and temperature, pressures, engine speed and other factors affecting performance, and performance of fluid coupling or torque converter.

A naval torpedo motor.

Single cylinder vertical engines, petrol and heavy oil, for experimental work involving modifications and developments.

Gas Turbines: An experimental tip jet reaction airscrew. A small experimental gas turbine unit coupled to the axial-flow compressor mentioned above and an electric starting motor.

(e) **Dynamics:** A dynamic balancing machine for high speed rotors, such as turbine and compressor rotors.

A vibration table for experimental testing of anti-vibration mountings, vibration absorbers and damper and resonance phenomena in machines. Vibrometer and accelerometer equipment.

A vibrating beam with mechanical and electrical oscillators for calibration of vibrometers and accelerometers and electric dynamic strain gauges.

Fatigue testing of materials.

Research Laboratory:

As one of the important functions of a University is to foster research work by staff, post-graduate scholars and senior students, provision is being made in the new building for a 60 feet x 60 feet research laboratory on the top floor. This area may be partitioned into smaller bays as required.

This section will naturally grow according to opportunity and the type of work undertaken, though certain basic equipment for measurement and experimental studies is being ordered now and includes cathode ray oscillographs and other electrical and electronic equipment used in the measurement of dynamic strains, vibrations, fluctuating pressures and similar phenomena; metrological equipment for examination and precision measurements of linear dimensions and form of surfaces; photographic equipment, including cinecamera and projector and the usual dark-room accessories, stroboscopic equipment for the examination of rapidly moving parts, and so on.

With the growth of industry in S.A., no doubt certain local problems will suggest lines of useful work. However, a University is usually considered to be less the place best suited for fundamental research, leaving the more specific problems of industries and government organisations to be tackled by the organisations themselves or by such bodies as C.S.I.R.

Investigations into aspects of outstanding problems in Mechanical Engineering may well be undertaken in any of such fruitful fields as:—dynamic testing and properties of materials, including fatigue and internal damping capacity; stress distribution in complex formed parts of machines, using modern experimental techniques, such as electric wire resistance strain gauging, brittle lacquer stresscoat and photoelasticity; mechanical vibration studies, including the development of electrical, mechanical and optical methods of measuring amplitude, velocity, acceleration, frequency and phase, the shockproof suspension of delicate instruments and vibration isolation of machinery and the development of viscous friction and harmonic dampers; creep of metals at high temperatures; problems associated with gas flow in compressors, blowers, turbines and piston engines; heat transfer problems and the design of heat exchangers; tuned induction and exhaust systems for internal combustion engines and the scientific design of silencers; new fuels and their utilisations; gas turbines; supersonic tip jet reaction airscrews; centrifugal refrigeration, and so on.

Hydraulics Laboratory:

This laboratory, for obvious reasons, will be combined with the Civil Engineering Department's Hydraulics Laboratory. Equipment of interest to Mechanical Engineering students will include that for the study of flow in pipes and channels, and methods of flow metering. In addition, a visual smoke-flow tunnel may be built.

Hydraulic machines will include the existing centrifugal pumps, Pelton wheel and Francis turbine, together with a multi-stage centrifugal pump, an axial flow pump and axial flow turbine, and a Hele-Shaw-Beacham pump and transmitter, a hydraulic piston engine and a piston-type positive displacement pump. Calibration equipment for pressure and vacuum gauges and air and fluid flowmeters.

Offices:

Office, library and reading room accommodation for staff and senior students are provided along the western side of the first floor.

Lecture and Drawing Rooms:

These are provided of dimensions adequate to accommodate the larger numbers of students which will be passing through during the next few years.

Equipment Room and Museum:

This large room on the second floor will allow of proper layout for exhibition or storage of all lecture demonstration models, museum exhibits and smaller accessory equipment and instruments for student or research laboratories.

The Engineering Department is greatly indebted to Professor Robin for his initiative in regard to the new building programme and for his energy in carrying through the detailed planning.

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THE PROMISED LAND

By W. P. TAPP

THE undergraduate engineer who is interested in water conservation cannot help but look to the future, and wonder what it holds in store for him. It may be expected that the demand for engineers will be heavy now that the war has ended, owing to the necessity during the past six years of heavily curtailing works programmes. However, the widespread shortage of materials of all kinds may have the effect of postponing the peak demand for years, this enabling even undergraduates who are fresh this year to partake in some of the Commonwealth's "urgent" reconstruction work.

All potential water conservation men will be forced to think on a national, rather than on a State basis. It is true that the Murray Bridge-Adelaide pipeline is a project in mind, but the Murray's supply of water is severely limited by the tremendous drain of irrigation settlements in this State and Victoria, the drain on the Murrumbidgee at Leeton and Griffith, and the demands on the many Victorian tributaries.

Victoria is, perhaps, the mast water-minded of the States—in fact, when N.S.W. awoke and began to investigate irrigation possibilities, she found that her sister State had been working busily while she slept, and that Victoria had most of the available Murray water "sewn up." Only now is a Commission succeeding in dividing the water on an equitable basis. The State with the greatest amount of water available for conservation is Queensland, with its long strip of the Great Divide in the tropical rainfall belt, and its many fine rivers, the Herbert, the Tully, the Clarke, the Burdekin, the Barwon and the rest pouring out millions of gallons of fresh water all day and every day. Strange waste for a thirsty country! Queensland, then, has the water without which the best of water conservation engineers are helpless. Can this be used? Can the engineers turn this wonderful supply of fresh water back into the interior?

The late Dr. Bradfield, supervising engineer of the Sydney Bridge, designer of the Storey Bridge, the Burrinjuck Dam and Murrumbidgee irrigation area, and Sydney's Cataract Dam, thought it could be done, and investigated the problem in great detail. Here is a precis of his findings

He planned to conserve the floodwaters of some of the coastal rivers which are now running to waste, and utilise them for irrigating and developing the resources of central and western Queensland, which has a low rainfall. At the cost of £30 millions he planned to divert the discharge from the Tully and the Herbert into the Burdekin River, thence by tunnel or aqueduct through the mountains, thus giving a permanent stream of water from Hughenden across Queensland to the border.

The waters from the Tully River, the catchment of which has a rainfall of 75 inches per annum, may be led per tributary to the Herbert River, also in a very heavy rainfall area. From a dam across the Herbert, the combined waters of the upper Tully and upper Herbert can be diverted to the upper Burdekin, here to be contained in a gorge which rises to a height of 400 feet. Water from the Burdekin and tributary catchment areas of 7,000 square miles will collect in this gorge.

According to the Bradfield plan the water then flows through the mountains at the Webb's Lake gorge to the Thompson River, from where it is carried by tunnel or aqueduct to any of the numerous suitable gorges in the upper Flinders River, near Hughenden.

The fall from Hughenden (1,100 feet above sea level) to Winton, Longreach and Windorah (all about 600 feet) would make possible the irrigation of 3,000 square miles of country up to 2 feet of water per year. The area between these three centres is of brown gravel, grey soil or fertile sandy soil, all of which are suitable for irrigation. Heavier nightly falls of dew will be an additional useful support to vegetation.

Dr. Bradfield estimated that irrigation at Leeton and Griffith covers 320,000 acres, or about one-sixth of the area covered by the above plan. Six such Leetons and Griffiths would prove a wonderful asset to Australia.

The scheme is very ambitious, and it seems more than likely that the Queensland State Government in particular, and the State Governments in general, will prefer to concentrate on numerous smaller schemes at present. Whether the Commonwealth Government will tackle Dr. Bradfield's scheme, which he was convinced was scientifically sound, remains to be seen.

Another scheme in which great interest is being shown by Queenslanders is for conservation of the waters of the Condamine River, which flows from above Killarney, through the Downs and the richest agricultural area in the State, into N.S.W., where it joins the Darling, whose outlet, via the Murray, is at Goolwa, in this State. At present, Victoria irrigation settlements benefit from the Condamine floods. Early in the century the first investigations into the Condamine plan were made, and as a result of various surveys from time to time, a complete set of levels exists between Warwick and Killarney. It is calculated that the storage capacity of the Condamine scheme will be more than 2½ thousand million cubic feet, which would supply 15,000 acre feet per annum. It seems possible that this work will have a high priority on the list of Queensland's public works.

Concerning the Northern River area of N.S.W., Sir Earle Page has recently outlined a plan embracing irrigation and electrification by the Clarence, Richmond and other rivers. His plan would include a considerable part of the South-Eastern part of Queensland, and supply with electricity every industry in the district. This plan also has been studied by engineers and pronounced quite practicable.

Obviously, opportunities must be present in Queensland for engineering graduates who wish to practice the conservation of water, and it scarcely need be pointed out that he who conserves the water of this country is doing a national service of the first importance.

BY ANALOGY—

By W. G. FORTE

From the beginning of consciousness we human beings depend almost entirely upon the use of similes to extend our knowledge. They enable us to express new thoughts in terms of previous associations, which, by stirring the imagination, free more mental energy, and permit better concentration on the subject in hand. All instruction, when analysed, is subtly based on similes, whether the instructor be the parent of a two-year-old child, or a University professor.

In engineering we prefer the more precise term "analogy." The purpose here is to find a relationship which will rouse the imagination, and at the same time be of technical value.

The qualitative type of analogy is of help in generally linking up the new with the old, but in the quantitative type we go much further, and seek to explain the relationships in mathematical terms. By transferring the new system accurately to the terms of the old we can often economise in time and effort in solving problems.

Models are a good example of analogies which use scale effects. Once the proper scale ratios (which are not necessarily simple linear ones) have been established, investigations on models offer an attractive and powerful method of settling specific design problems. Of course, a too enthusiastic devotion to models may lead to the danger of arriving at wrong full-scale conclusions from neglect of effects which may not be readily observable in the model. For instance, small models of telescopes may successfully point the way to the design of very large ones, but with large apertures, distortion of the image becomes worse, owing to the variable refractive state of the atmosphere in line with different parts of the optical receiving surface. Again, differential movements of the optical system, due to temperature changes, may be negligible in the model, but be disastrously large in the full-scale product. In general, all problems which we cannot easily reduce to two-dimensional ones are particularly adapted to scale analogies in the form of models.

The long water tanks developed by Froude in England, in which models of ships' hulls are towed at controlled speeds have yielded extremely satisfactory results in the development of large ships. The tests can be carried out either with still water or certain types of wave motion. One could scarcely think of a vessel like the Queen Mary successfully performing according to design unless this was based upon such tank tests (as, in fact, her hull design was).

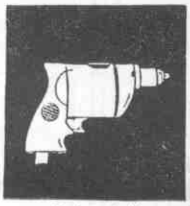
Wind tunnels for aerodynamic researches are now well known. Australia can actually boast two large modern installations at the Aeronautical Division of the C.S.I.R. at Fisherman's Bend, Victoria. In the later of these, not only the speed of the air stream but also the mean static pressure can be varied above and below atmospheric. This extends the flexibility of investigations very much indeed. Most aerodynamic research must of necessity use models, so that scale analogies are here in frequent use.

One can, however, go further than mere scale effects, and transfer to an entirely new system, as well as altering the scales. The most common transference is from mechanical to electrical systems, which offers the advantage of a well-established circuit analysis routine. In many cases the general solutions and behaviour of the circuits are well known, both for steady state and transient driving forces. It is even possible to suggest alterations and improvements to the mechanical system by an inspection of the equivalent electrical circuit, without even writing down an equation. In such devices as moving coil cone type loud-speakers there are the mechanical conditions associated with the air which has to be moved, the mass and compliance of the diaphragm, and the electrically driven actuating mechanism, all of which can most conveniently be reduced to an equivalent electrical circuit. Even this may not tell the whole story, because of the possible complicated modes of vibration of the diaphragm, but it serves very well for certain simplified modes. It may be recalled that gramophone recordings improved outstandingly about 20 years ago, when made by the so-called "electrical" method. While this "electrical recording" may have meant something mysterious to the layman, it was, in fact, nothing more than the development of an electromechanical recording head by two Americans, Maxfield and Harrison, which responded uniformly over a wide frequency range. This was done by a close study of all the electrical and mechanical features of the recording head, with its ultimate reduction to an electrical filter network. They then added the necessary elements to give correct frequency response, and finally translated these back into physical form. (A paper on this subject is in the Journal of American I.E.E., XLV 243, 1926.)

A very useful paper by A. Bloch in the English I.E.E. Journal, Vol. 92, Part 1, April, 1945, gives detailed information on electro-mechanical analogies and their applications. Some of the fundamental equivalents, such as mass = inductance, compliance (of a spring) = capacitance, and viscous resistance = electrical resistance, are more or less vaguely familiar to most engineering students, and can be used, as shown by Bloch, in the "direct" analogy where mechanical driving forces = e.m.f.s. and velocities = currents.

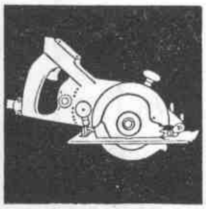
Not so familiar, but often of use, is the "inverse" analogy, in which mass = capacitance, compliance = inductance, and inverse viscous resistance = conductance. Here the driving forces = currents, and velocities = e.m.f.s. Further, levers, and hence gears, can be represented by ideal auto-transformers in so far as there are no discontinuities. Care must be taken in writing down the equivalent circuit to discriminate between series and parallel connections. Where the equivalent electrical circuit is rather cumbersome to investigate analytically, recourse can often be had to a model circuit, which permits easy measurement of resultant effects, and enables changes in parameters to be quickly tried out. An example in point is a long electrical or mechanical transmission line possessing continuously distributed effects, but which can be represented to any required degree of approximation by lumped effects, thus making the problem suitable for electric circuit models. As the exact solution of these particular problems are known, the models can be used for confirmatory evidence, as well as pointing the way to desirable changes in any given design problem.

Of course, there are many examples in mechanics, such as complicated, discontinuous lever movements, which cannot conveniently be translated into simple electrical circuit equivalents. Nevertheless, one can imagine making use of the discontinuities of thermionic valves to overcome some of these difficulties. Apart from these rather speculative ideas, the normal electro-mechanical analogy using linear parameters is definitely becoming more popular, and we can look forward to rapid developments in the near future of the scope and extent of such analogies.



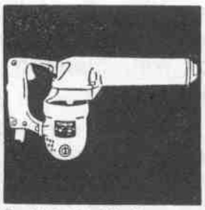
Holgun Drill

Utility Power Drills

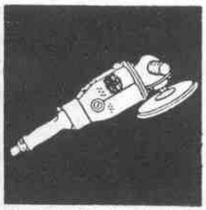


Portable Electric Saws

Bench Grinders



Portable Electric Hammers



Portable Electric Sanders

A METHOD OF PREPARATION OF TUNGSTEN WIRE

POWDER METALLURGY

By H. G. OLIPHANT

TUNGSTEN may be produced from wolframite, $FeO.\ WO_3$ by powder metallurgical methods. Here is an outline of one process:—

1. Opening up the Mineral.

Wolfram is opened up in the usual way, and crude tungstic acid, WO_3-hydrate, is precipitated with HCl. The tungstic acid is purified by dissolving in ammonia, filtering and reprecipitating with excess conc. HNO_3 added quite smartly; under these conditions the yellow hydrate is formed. The precipitate is filtered off and dried at 110° C. to give a yellow powder of 99.9% or better purity.

2. Reduction to Metal.

WO_3 is reduced with hydrogen at a red heat to the metal. The method of precipitation ensures small grains varying sufficiently in size to give a good aggregate. No fritting will take place during reduction.

3. Pressing.

Tungsten powder is pressed into bars 1 cm. square by about 20 cm. long under a pressure of about a ton per square inch if a binder is used, or higher without.

The design of the mould and condition of its surfaces are considered important. Bars pressed in moulds which are not well cleaned and polished often crack diagonally.

In the pressed condition, bars are most fragile, but rejects may be crushed and repressed.

4. Presinter.

The mouldered bars are presintered or frittered at about 1,400° C. in a gas furnace for about 6 hours. The strength of the presintered bars depends at least partly on the **shrinkage** obtained. Bars may crack in the presinter, and pressing cracks will show up here: rejects are not retreated.

5. Sinter.

The presintered bars are sintered at 2,900° C. in an atmosphere of hydrogen for about 20 minutes. This high temperature is obtained in a special furnace, the essentials of which are shown in the sketch. A high current at low pressure is passed through the presintered bar. Explosions within the furnace are avoided by (a) removing all air before switching on, and (b) increasing the flow of hydrogen before switching off to prevent water being sucked back from the trap. After the sintering process the bars are again measured to determine the shrinkage obtained, and examined for cracks.

6. Swaging.

Selected sintered rods are heated to a bright red heat in a gas furnace and swaged (i.e. forged) hot. To prevent cracking, rods must be annealed frequently, and the area must not be reduced greatly at each pass. Rods may be reduced to about 3 mm. dia. in this way.

7. Drawing.

The swayed rods are hot-drawn on a draw table about 30 feet long, and are not coiled. Experiment shows that the drawing is assisted if the rods are coated with a particular oxide of tungsten, which is ascertained by the color and nature of the surface.

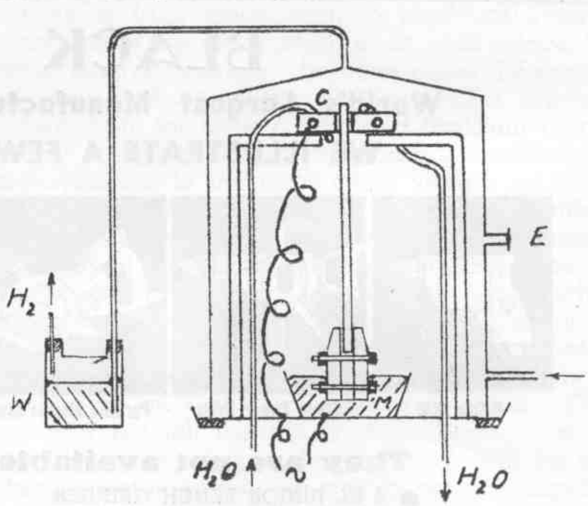


DIAGRAM OF FURNACE

The color of the wire before drawing is the whole secret of the process, and is kept as such.

Sinter Machine.

Current enters the bar through mercury M, and a heavy member (to prevent buckling) and leaves through another copper member surrounded by cooler C. E in an eyepiece to allow use of optical pyrometer. W is a water trap. To prevent explosions, the issuing hydrogen is burnt.

THE OLD MOAN

By BRIAN CLARIDGE

This is not a technical article.

You will see that it expresses no thoughts that have not been propounded before, but that does not make them any the less vital.

We have, of late, been made aware (or, rather, attempts have been made to make us aware) of the attitude of indifference and narrowness of views of students.

(I suppose that this is enough to make you shy off this article straight away. If it does, then it is merely your admission of the truth of the matter.)

But this is only one aspect of a much more general state of affairs, which has been recognised by a few, but passed glibly over by the vast majority of people.

Just over one hundred years ago, a Scottish essayist and historian, one Thomas Carlyle, produced a small volume called "Past and Present."

When he wrote it, England was in a mess. There was a great industrial depression, and almost starvation, and the usual strife and agitation between parties and classes.

Most of the misery was brought about by the fact that the factory system was now pretty well established, and new centres of population had sprung up. Industrial England flourished as far as the employers (capitalists) were concerned, but agricultural England began to back-pedal, or at least free-wheel, while the increased population cried for food and more food.

There was no attempt made to protect the workers from the grasping Mammonistic employers, who preyed upon the workers, causing them great unhappiness and degradation. Useless goods were shamelessly over-produced, while the meanest essentials to the workers' needs were overlooked, and what was produced was far above their means. So widespread was the poverty that about one-seventh (two millions) of the population relied upon poor relief. The work-houses (in which no work was done) were full of idle workers.

There was vast wealth, yet awful poverty, and the masses had no true representation in a country which boasted liberty. They had a few unsuccessful tries at revolution, but these demonstrations were quickly suppressed. The workers were thwarted, and nothing came of these attempts, for the simple reason that the masses of workers didn't know who or what to blame for their plight; they had no leader; they were bewildered, and unable to comprehend the frightful position in which they found themselves.

So much is history. But the reason for all this?

Carlyle tells us.

Merely by casting your eye down the list of contents of "Past and Present" you see the answer: "Gospel of Mammonism," "Gospel of Dilettantism," "Over-Production," "Unworking Aristocracy"—in a word, love of money, together with a failure by those in power, any everyone else generally, to realise their responsibilities.

The situation was certainly a bit on the nose, almost hopeless, yet Carlyle was able to show a way out. But his way was tough. It was to be "no Act of Parliament."

"There will be no 'thing' done that will cure you" —no "Morrison's pill" (or Bex tablet) will quickly bring the cure-all.

The remedy was to be a Universal Change in the Way of Life; a giving up of all sham, egotism, and dilettantism, and to become "a faithful and discerning soul."

For one thing, the government was to be taken out of the hands of "knaves and dastards," out of the hands of dilettantes and mammonists, and put into the hands of "the wisest."

But more than that, and first of all, the MASSES THEMSELVES had to pull up their socks and reform, detecting and throwing out all falsities, and recognising truth.

"Reform, like charity, begins at home," says Carlyle.

Everyone had to realise and meet their responsibilities to others. That was Carlyle's way.

This is necessarily a very brief summary of "Past and Present," but I think that it will serve to show that what follows refers to no new problem, for it is a fact that such problems are still with us.

In 1941, another work was published, which echoes in modern terms the very cries Carlyle uttered just a hundred years before.

This time J. B. Priestley takes up the strain in his "Out of the People." His little book is intended to deal with the problems of reconstruction "after the war," but, if read with Carlyle's words still in our minds, we are very much aware that we have made little progress in the century. And I say "WE" deliberately, for although Carlyle and Priestley wrote of conditions in England, too much of it is applicable to ourselves. The parallelism between conditions here in Australia and those in England are startlingly and painfully evident. Carlyle wrote of unemployment, hunger, bewilderment, false government; Priestley wrote in the midst of a war—not of our seeking? Douglas Reed, in his books, makes it all too clear that war was being courted long before it was won.

Although the results are different to-day, we still have the SAME CAUSES of Carlyle's time.

It is the same infection finding different places to erupt.

Australia has not suffered materially from the war, as has England. We have suffered only inconveniences, compared with the wholesale material destruction and want that has taken place in Europe.

We have not the material reconstruction to make, but we have as much social and moral reconstruction to make, which is not necessitated by any war, but is the outcome of national indifference.

Australia has seen depression (or The Depression); it has slums; it has industrial unrest; it has corrupt government, and we abuse and mistrust our politicians (see "On Dit," 31/5/46); and, above all, it has a most apathetic, indifferent, and selfish population, in which greed and egotism breed unchecked.

We point to "our war effort"; we just managed to fill a few Loans (under threat); we sang "There'll always be an England"; we spoke tremulously of the "folk at home"; we lined the streets to see the Victory Parade, and sang and danced in the streets. "Hooray, hooray! The horrid war is over!" While around us are homeless and jobless ex-servicemen, lousy, untrustworthy M.P.s; industrial uneasiness, slums, black marketeers, exploiters of essentials; and in sight—? a second depression? Whither are we heading?

Australia is said to be the land of opportunities—the young country ready and anxious to receive willing workers to advance its immense potentialities, and to make it a nation.

That may be Australia, but it is certainly not the PEOPLE. At the moment Australia is just one big PRETEND. It exhibits a gilded exterior, which covers hollow nothingness, and which takes us all in beautifully. It is a mere shell, covering a hoard of egoists, where selfishness and apathy weigh down the efforts of any far-seeing person.

Consider the Government, for instance. It is bound down by catch words and faulty tradition. Any young, enthusiastic politician is soon stifled by party politics—his ideas are turned to the benefit of the party leaders, who are concerned only with themselves. Such an enthusiast is quickly subdued to a mere cog in the party machine; his hopes of serving his electors vanish.

The fault is not his own. It is OURS.

A politician should represent the views of his electors, but, unless they are forthcoming, he is soon reduced to a puppet in the hands of his party leaders, who have no thought save for themselves.

Politicians yield to pressure, but that pressure should come from the electors, not from within.

Our elections end at the polling-booth. Our "duty" is done. After polling day the successful candidate is forgotten—he has, apparently, been whisked away out of our comprehension—he becomes just another lost soul, wandering we know not nor care not where. Actually, he has become a member of the "Parliamentarians' Mutual Aid Society"— Labor Branch or Liberal Branch, or what have you branch, wherein mutual brotherhood (WITHIN the branches, of course) is the keynote. They are all good fellows together, doing as the—er, Branch President?—bids them. After all, another election must come. And what else CAN he do? His electors have forsaken him, so he naturally turns to his party, and becomes subordinate to it. This is a sham which totally annihilates all the true nature of representation in a Government—Carlyle said it, it has been said a hundred years later, and in another hundred . . . ? Only the people, the electors, are to blame for this ridiculous and farcical situation which they allow to control their society. We are told by Carlyle and Priestley and others how this can be remedied, and it always boils down to having to realise and carry out our responsibilities.

We are all looking for a New Order—a mythical era of "security" for all. It is a phrase signifying "Peace on earth, goodwill toward man," or "Have a drink, mate," etc.

It is a way "out of all this" to "a better world."

It has become synonymous with Carlyle's "Morrison's Pill"; it is something which will be "brought about" somehow, some time—one day we will wake up and read in the morning papers, "New Order arrives to-day—Pubs open till 7." We've only got to wait for it.

As easily as that?

No, sir! The New Order, or any other Order, save Chaos, cannot come as easily as that.

If we WANT to get away from the appalling mess in which we find ourselves to-day we have to WORK for it. We have to DO something. And the first thing to do is to become a being with a SOUL, rather than just persons. We have to be able to recognise and execute unhesitatingly our obligations to others. We must throw off our own selfish hopes in favor of those that will benefit all.

Some like to see this as a return to Christianity—a finding of Jesus Christ. Others like to visualise it as the call of a new political group. But however we like to think of it, one thing sticks out a mile, and that is that THE STARTING LIES IN US. WE must make the move. It is said that without God or Christ such ventures are hopeless. I'm not going to argue one way or the other with that, but I think that, rather than being a definite MEANS to our hoped-for New Order, Christianity will be an END, if not THE end. Surely all we hope for in our new social arrangement is embodied in the principles of Christianity.

First we need the will to start, and it's no good praying for that; that, at least, must be our contribution. When WE have made the start, then, perhaps, is the time to start praying, for God helps those who help themselves.

We, here at the University, are training to "take up our place in the community."

Oh, yeah?

What we ARE doing is training to become professional men. We are training for a job which will enable us to hold a job a bit better than the next fellow, but we are certainly not training to be good citizens (by which I mean, we are not training to take our full share of social responsibilities, and to honor them).

We are old enough, and bright enough (sometimes) to learn about our proposed profession; **we are old enough, and bright enough (Heaven help Australia if we aren't) to learn about our inevitable obligations.** The two should go together, but they don't.

The University is, or should be, a place where one seeks knowledge and truth, urged on by a spirit of enquiry and research; but the Universities to-day have become degraded, and show an appearance that is a far cry from their initial and true purpose.

Within the walls of an institution which claims to impart knowledge and truth, which claims to give the opportunity of seeking out the mysteries and consequences of Nature's laws, and to reveal social obligations to those eager and anxious to learn, are people to whom these things mean nothing; to whom these things are extras and encumbrances, hindering their "work."

The number of people who come to the Universities with ideas other than of obtaining a degree which will enable them to secure jobs resulting in a certain degree of financial security is indeed pitiably small.

The Universities are just another sham with which our society is crammed. They are NOT places of learning, but merely means to mammonistic ends for the majority of people who use them.

This fact cannot be disputed, for the present (I'm going to say it) APATHETIC outlook of University students as regards national matters that affect even themselves is all too evident.

This is the atmosphere in which the "future leaders of the country" are being trained.

Half—no, nine-tenths—of their education is being neglected. Some of the blame lies with the Universities and their systems, but most of it lies with the students themselves, who sneeringly disregard and spurn any opportunity that may be offered them to take upon themselves any responsibilities or any work connected with other than their own particular learning. They will not put themselves out in any way.

So far as the blame can be put on the Universities and their systems, let it be put to see how much lies with the students themselves. The Universities are being invaded by more students than ever before, many of whom, but for Government assistance, would never have contemplated taking up a University course.

It is obvious that the Universities have hardly managed to keep their facilities abreast with the number of students, and courses have become crammed, and time for individual research and leisure sadly cut, as a consequence.

Government assistance is most commendable, and is in keeping with our ideas of making opportunities open to all, irrespective of one's means; but to continue as we are now is in no way helping our country to make its first steps towards bringing about an end to the corrupt state in which we find ourselves, from which all semblance of truth and sense of duty* has been banished; but rather it heaps coals to the fire, and makes the position even worse by teaching youth the creed to pursue only those things which bring personal benefit.

Perhaps this is the idea of those who are gaining from our present unhealthy muddle—and there must be many.

I am not advocating the discontinuance of the financial assistance scheme, nor a return to the days when the University was the happy hunting ground of "social butterflies," but rather am I attempting to draw attention to how we, University students, can make our start towards the hopes of Carlyle, Priestley, and others.

Whatever course will bring about our starting on the way will be worth while, even if it means, as it probably will, the laying aside of things WE thought vital.

I can make no claim to originality in subject matter. It is the Old Moan. But it is worth while thinking about. More than that, it is worth while DOING SOMETHING ABOUT.

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*No sense of duty?

Then had not the men and women who volunteered to defend this country with their lives any sense of duty?

Nndoubtedly.

But it is strange that men and women who are willing to protect their country in the face of outside armed conflict and aggression are not stirred to a fraction of that sense of duty when the danger to the future of their country comes from within, when the threat to their country comes from the very people themselves. Why does their sense of duty jail them then, as it certainly does?

FLOLEVISTICS

THEORY AND APPLICATION

By S. D. KANEFF

IT rarely happens that we have the opportunity to study for ourselves at first hand the beginnings of a new science, and the magazine committee should feel justly proud for including this article—at least, so the author tells us.

Not often can one be in the position of holding in the hollow of his hand the power to affect future trends in marine design. (Also the design of the A.U.E.G.C. Glider.—Ed).

First, might I bring to your notice the fact that through countless ages, from the dim, dark beginnings of civilisation to the dimmer and darker end of civilisation, mechanically-minded men have been seeking, seeking, seeking. (See fig. 1). You naturally ask, "What have they been seeking?" and as an Engineer (?) my answer is: a source of useful energy at no cost to the user. This article gives one method of using such energy for marine propulsion.

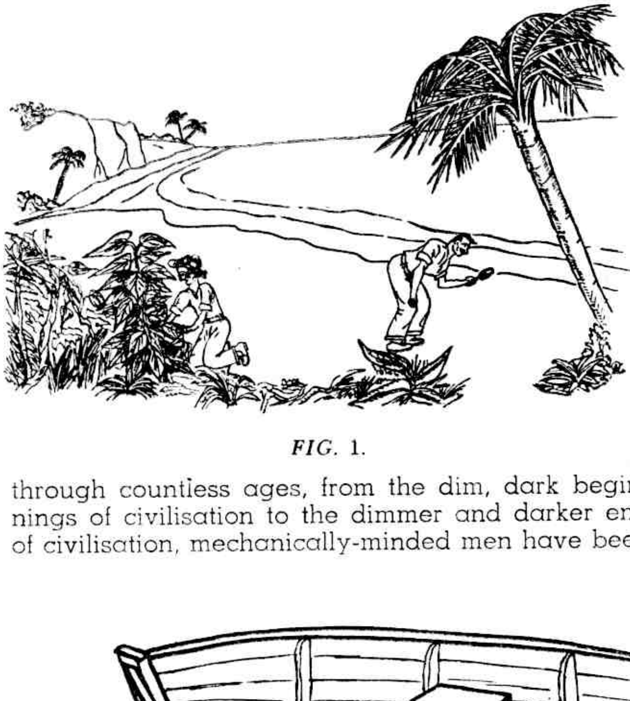


FIG. 1.

In anticipation of mockery and derision from the more conservative elements of society (e.g., the Editor), I would point out at this juncture that most great men have to withstand such treatment at some time or another. Do not think, however, that I will not accept criticism; on the contrary, I will treat all criticism with a perfectly unbiased mind, firmly convinced that it is just plain eyewash.

It gives me no small amount of satisfaction to think that while engineers and physicists have been wasting their time developing such things as the internal combustion engine, jet propulsion, atomic energy, and the like, I have been successfully devoting my time to an entirely new branch of science, viz., Flolevistics.

We all know how powerful are the waves of the sea, and no doubt may have considered the possibility of using this power. Flolevistics might be said to deal with the exploitation of wavepower by means of the Flolever. Then again, it might not. Here is a brief outline of the Flolever principle as I see it.

ILLUSTRATION OF A BOAT EQUIPPED WITH A FLOLEVER.

(See fig. 2). In its simplest form, the Flolever consists of a float on the end of a lever. This is pivoted on the stern of the boat, the other end being connected through a crank to paddles. The length of the lever between the pivot and the float can be altered in a horizontal and vertical direction to allow for the amplitude and wavelength of the waves. Because of the simplicity of the principle, it is a complete mystery to me why it was not discovered years ago.

A consideration of this original thesis will convince even the most critical that we have the potentialities of limitless power (i.e., Phi.—→ O) at our very doorstep, an dobviously the applications can be extended on such a scale as to make the atomic bomb look small.

Incidentally, boats with Flolevers should carry reliable auxiliary equipment, such equipment including:—

(a) A complete set of sails.

(b) A marine engine.

—:o:—

ON SCIENCE FICTION

WE have heard some agitation recently about the desirability of the "articulate engineer." I am all for the idea—in fact, most of us are. Yet few engineers seem to have any noticeable desire to get up and speak. If anything, we are too reticent. This is no good, you know. Let us enquire in the best engineering tradition what may be the fundamental reason. I suggest that it is simply that we have no great guiding inspiration. Engineering is to be our job, but how much more interesting if it were also the subject of our dreams and visions. For an increasing number of young men it is so; they are the readers and writers of scientific fiction. Gentlemen, allow me to introduce you to this mechanistic philosophy of the future, adapted to the trained intelligence of to-day's technocratic generation.

You have probably seen the brightly-colored magazines which rejoice in such titles as "Astounding Stories," "Amazing Stories," etc. Don't be misled by these titles—they are mostly from America. The stories are excellently written, with a sound scientific background; the plots are well-knit; there is plenty of action; you get new angles on familiar aspects of science; and the characters are likeable young engineers who speak our language. The best yarns open up inspiring visions of the far horizons which we have yet to explore.

In case you wonder how "Flash Gordon" and "Superman" fit into this picture, I assure you that they don't. "Superman," with his miraculous powers belongs to medieval or earlier times. The hero of classical mythology could always get out of a tight corner by calling on his particular Deity, who would swoop down from Mount Olympus with a handful of thunderbolts and obligingly eliminate the opposition. Now this stuff went down very well with all readers at the time, because they believed in all manner of super-natural forces, and yet had no idea that such things as natural laws existed. They just did not realise that water had a boiling-point, which was fixed by a law not made by man. Now that we have began to develop a scientific outlook, this is not good enough, and our heroes have to think their way through.

"But it's all so silly," says my wife, who regards science fiction as a sheer waste of time. I could, of course, refer to Jules Verne's prophecy of the submarine, and later prophecies of atomic power and rocket travel. But this is beside the point. The main justification of science fiction is that it stimulates the constructive imagination, and provides the inspiration to make of engineering a cause for us to follow.

Science fiction has an increasingly large following. The only one of last year's M.Sc's. whom I know well is a fan; I remember a fan-letter in one magazine from Leslie Charteris, of "Saint" fame; and I sometimes irreverently wonder if Prof. Kerr Grant reads it on the quiet.

Perhaps you remember when a network of American radio stations some years ago broadcast H. G. Wells' "War of the Worlds." Thousands panicked, believing the Martians were over-running their country, and whole towns took to the hills. Does not this show, that to many people, science has taken the place of the ancient gods, and is blindly credited with supreme power? This most certainly is not the scientific outlook, which we, as engineers, must cultivate and spread. We must be the link between the scientists and the public, and apply scientific method and reasoning. Let our inspiration then be these tales of such engineers, pioneering new worlds with imaginative blue-prints as well as bull-dozers, with our new philosophy as well as atom-powered space ships. Gentlemen, I recommend to your serious attention the current issues of "Astounding Stories." No, I don't get a commission on sales; I just think it's good fun.

THE PHILOSOPHICAL SAPPER

STRENGTH OF MATERIALS IN THE SOLID STATE

By STEPHEN KANEFF

Recent experimental and theoretical work in Physics and Engineering has revealed some startling facts about strengths of materials in the solid state. It has been found that actual strengths are very small fractions of calculated strengths.

It is fairly generally known that the strength of a material is influenced by such factors as degree of surface finish, medium in which the body is immersed, temperature, and sometimes very markedly by operations on the material during manufacture.

For example, the strength of some steels can be altered so that the endurance limit is increased threefold, merely by grinding off about 0.01 inches from the surface. Another peculiarity is that the rupture of polycrystalline steel under a blow from a pendulum changes from brittle to plastic at —120° C. This point is lowered by 20° C. if the surface of the steel is etched and polished, indicating that the tensile strength is increased by the removal of discontinuities from the surface.

Modern experimenters have tackled the problem of strength of solids from different aspects, and below appear some results and recent theories of Joffe, Griffith, Orowan, Obreimov, Smekal, Yarkov, Alexandrov, and others.

It is known that solid bodies consist of tightly packed collections of atoms. The majority of solids are crystalline, and X-ray analysis has supplied precise information about distances between individual atoms, and between the ordered rows of atoms in crystalline substances.

An estimate of the mechanical strength of a solid can be made from the knowledge of the general physical properties of atoms, taken in conjunction with a knowledge of the inner structure of solids. When such an estimate is made, a remarkable result is obtained. It is found that solids should be MANY THOUSAND TIMES stronger than is found experimentally by mechanical tests in the laboratory.

Apart from the extraordinary discrepancy which this offers between theory and practice, this fact is of great suggestive significance. If the tensile strength of solids is several thousand times less than their theoretical strength, the examination of the cause of the weakness may lead to great improvements. The appearance of materials a thousand times stronger than those in use to-day would have revolutionary effects on the whole field of human enterprise.

The disagreement between theory and practice is explained by an examination of the mechanism of rupture. The actual stress where rupture occurs is always many times greater than the average stress over the whole of the cross section.

Another indication that the strength of molecular cohesion is much greater than the average stress producing rupture is given by the fact that rupture often occurs where the material is still elastic. If the forces of molecular cohesion had broken down, the rupture would naturally have been expected to occur when the elasticity had disappeared, and not while the material was obeying Hooke's law.

The difference between theoretical and practical values is illustrated by the following: The calculated strength of a crystal of rock salt is about 200 kilograms per square millimetre (or 127 tons per square inch), while the measured strength is about 0.4 kilograms per square millimetre (¼ ton per square inch). The practical elastic limit of a crystal of rock salt seems to vary with the mechanical treatment of the crystal. X-ray analysis gave a value of 920 grams per square centimetre, mechanical tests gave 200 grams, an optical method gave 70 grams, while for a very pure crystal, the value was 10 grams per square millimetre (14 lbs. per square inch).

Now, it was stated above that the practical strength of rock salt is 0.4 kilograms per square millimetre. It has been demonstrated that the strength of rock salt increases by more than 20 times when immersed in hot water. Indeed, a value of 160 kilograms per square millimetre has been obtained for the strength when immersed in hot water. This is the more remarkable when it is considered that the theoretical strength is 200 kilograms per square millimetre.

The fact that the elastic limit of a single pure crystal is much lower than the elastic limit of an aggregate of crystals is not limited to rock salt. The elastic limit of single crystals of metals is also equally low, increasing rapidly as the amount of plastic deformation is increased. It appears, therefore, that the mechanical properties of a crystal are changed by plastic deformation.

The following is an account of the process of rupture as seen by modern experimenters:

About 25 years ago it was shown that the plastic deformation of a rock salt crystal distorts the crystal lattice, breaking the crystal along planes of slip. When the layers begin to slip, the energy developed between adjacent layers produces a rise in temperature, and while slip is taking place the cohesion in the boundary layers falls (sometimes to that of the liquid state), and crevices are produced inside and on the surface of the crystal by the sliding process. This formation of crevices results in a reduction of the strength of the crystal. At first sight this is an apparent contradiction to actual fact, since simple experiments on metals show that the elastic limit is increased by plastic deformation. However, there is no contradiction, because in these simple experiments on metals the elastic limit is increased mainly by distorting the crystal lattice. This prevents sliding up to a new higher limit, and therefore rupture does not occur.

As the material is stressed further, the amount of slip increases, the stresses at the discontinuities increase until at some point in the body the maximum strength is reached, and rupture begins.

If the elastic limit is made equal to the practical tensile strength, the material becomes brittle and fails, without plastic deformation, at a strength much below the theoretical, due to surface faults in the material.

The fact that materials can withstand forces approaching the theoretical strength is illustrated by the following experiment.

A sphere of rock salt crystal was cooled in liquid air so that it was of uniform temperature throughout, and then quickly plunged into hot water. After one or two seconds the core of the crystal should be stretched by the outer layers with a tensile force of 70 kilograms per square millimetre (44 tons per square inch), according to calculations. Despite the magnitude of the force, the sphere was not ruptured.

Experimenters conclude from results such as those given in this article that the practical weakness of materials is due mainly to cracks or sharp discontinuities on the surface.

Various phenomena point to the fact that the strength of substances such as glass and quartz is mainly influenced by the nature of the surface, and by the interior to a much lesser degree.

Experiments show that the tensile strength of glass in a rod increases as the diameter decreases, even when the pieces are taken from the same specimen of glass. A tentative suggestion was made that the strength of a fibre of glass was greater, due to a layer of orientated molecules, which had much greater strength than ordinary glass, on the surface. This was disproved by dissolving a thin glass rod in fluoric acid. The filament which remained was not weaker, but was about 4 times stronger than before.

There is a mass of evidence which shows that faults which cause rupture are distributed throughout the material, but become dangerous only when they reach the surface.

It might be thought that, since the tensile strength depends on surface cracks, the tensile strength would be subject to large variations, any particular value depending on the accidental existence of a large or small number of cracks. All practical evidence to date has shown that the strengths are fairly definite. The explanation lies in the fact that there is an extremely large number of small faults. The statistical effect of the large number and distribution is to confer reasonably definite strengths. This has been supported by results of tests on thin filaments. These give a large variation of strength, due to the increase in the irregularity of distribution of the faults.

By supposing that the strength of a material depends on faults on the surface, it is seen that the strength necessarily depends on the size of the largest crevice on the surface.

With decrease in diameter of a rod, the size of the largest crevice must also decrease, since, when the rod becomes extremely thin, the diameter may be less than the size of previous crevices. The size of the crack cannot be greater than the filament diameter, hence the sizes of faults must necessarily decrease with diameter.

Arguing along these lines, it is reasonable to suppose that the strength of a very thin filament approaches the theoretical strength. This has been found to be the case. For example, the strength of thin quartz fibres is sometimes as high as 2,000 kilograms per square millimetre (or 1,270 tons per square inch), compared with the normal value of 100 kilograms per square millimetre.

It is seen from the above that, for some substances at least, the calculated theoretical strength is approached in practical experiments. It is therefore not unreasonable to expect that the practical strength of materials used in construction work, etc., may be greatly increased at some future date, when more is known about the cause of the practical weaknesses, and when these weaknesses are reduced or eliminated.

WE wish to take this opportunity of thanking those firms who have advertised in the magazine. Without their co-operation the production of this hagazine would have been impossible, and we hope they will favour us with their business next year. We would also like to thank E. J. McAlister &Co. who printed and published the magazine.

SOME ASPECTS OF LARGE-SCALE CONCRETE CONSTRUCTION

By **CLEVE G. JOSE**

IN the last two decades concrete construction, particularly in dams, has made spectacular advances, and concrete is being mixed and placed on an increasingly large scale. This means that different methods have become economically available, and in fact, economically essential. In a structure such as the Grand Coulee Dam for example, where 11,250,000 cubic yards of concrete were placed, proper organisation of these operations means saving large amounts of money in labor costs and overhead expenses. This article is intended to outline some recent developments in large scale concrete construction. These have taken place mainly in U.S.A.

Recent advances in the science of concrete mixing, which is now done by accurate gravimetric methods instead of the old volumetric method, have resulted in the use of bulk cement. Cement is conveyed to the mixing plant in covered hopper rail cars, from which it is either discharged into a bin below the track, or unloaded by scrapers. From the bin it is elevated to a storage hopper either by a screw conveyor and bucket elevator, or by a compressed air pump and pipe line. If the rail head is distant from the plant, the cement is conveyed thereto by special tank motor trucks, discharged into a bin by screw conveyor, and pumped pneumatically into storage silos.

At the Fontana Dam, United States of America, cement was delivered in bulk in box trucks and unloaded by power scrapers into hoppers, over each of which was a magnetic vibrating screen. From there enclosed chain belt conveyors took it to three surge tanks above three air activated cement blowers, which in turn forced it through 6-inch pipes for 3,000 feet to four 1,000-ton silos. It was then blown to the mixing plant as required by three more air activated conveyors. The capacity of this cement plant was 1,600 tons per day.

Where large quantities of consistent high quality concrete are required, and to a low slump for machine placing, the central mixing plant is definitely the best solution. It gives a much greater output per man hour and is much easier to control. The water content and therefore the slump is largely automatic, and human error is eliminated to a great extent. It is therefore easy, and no more expensive, to produce first class work. Of course, to attain maximum efficiency of plant, the organisation before and behind the mixer must be of the first order. In plants for major works the time of operation is reduced considerably by providing separate weighing hoppers for each ingredient. This allows a batch of concrete to be delivered at a regular rate of two to three minutes. The mixers are placed under the weighing hoppers and around a centre from which the batch is taken. The concrete is discharged into a hopper also at the centre.

Fontana Dam, one of the T.V.A. projects on the Little Tennessee River, furnishes an excellent example of the latest construction methods of mixing and placing concrete. The concrete manufacturing plant will now be described, and reference will be made to methods of placing further on in the article.

The dam, which is the fourth largest in the world, is 470 feet high and has 2,800,000 cubic yards of concrete in the whole structure. The concrete was scheduled to be placed at the high rate of 8,000 cubic yards daily, and this figure was easily realised, the record being 10,755 cubic yards per day. This is believed to be a world record. Processed aggregate was required at the rate of 15,000 tons per day, and it was decided to obtain this from a quarry which was opened up about a mile downstream. Factors influencing this decision were the mountainous terrain, distance of main road and rail heads, and limited storage space. The rugged topography also dictated the use of belt conveyors for transport of the aggregate through the various stages of processing, as well as for transporting the mixed concrete, two miles of belt conveyors being used between the primary crushers and the dam itself. A single mixing plant was housed in an octagonal building erected on the mountain side at about the mid height of the dam. This contained eight bins of total capacity 1,200 tons, three bins being for sand, two for cobbles, and one each for fine, medium, and coarse aggregate. These were arranged symmetrically around two cement bins of 250 tons capacity. The weight batchers for aggregate cement and water were filled by gravity and discharged through a turnhead into any one of five 4 cubic yard, front charge, tilting mixers. Push-button control of all batching and mixing was managed by one man. After discharge from the mixers into a central cane hopper, the concrete was taken to the construction levels by conveyor belts.

In the construction of some of the other T.V.A. dams on the main Tennessee River, concrete was prepared in mixing plants on barges 40 feet by 90 feet, which were moved as required. Sand and gravel from the river bottom were barged upstream to feed them, and gantry cranes swung the concrete from the mixing barges to the forms.

Placing of concrete in large dams is generally done by means of cableways or cranes. The concrete is transferred from the mixing plant to the placing equipment by belt conveyors, rail trucks or motor trucks. In some cases concrete has been pumped pneumatically from the mixing plant to the job. Conditions at the dam site and rate of progress required are the main factors controlling the choice of handling equipment. The concrete placing buckets are of such a size as to take one or two complete batches from the mixer, and they are available in sizes from 1 to 8 cubic yards. Hand dumping of the smaller buckets is preferable, while those over 4 cubic yards are operated by compressed air.

Cranes used for concrete placing are usually either of the hammerhead type or of the "whirler" type, both on travelling gantries. The main advantages of the former are first, speed of hoisting, and second, smoothness of operation in placing heavy buckets in forms, since the buckets travel in a straight line rather than in a circle. Typical operating speeds for a hammerhead crane are as follows: lifting empty bucket, 750 feet per minute; lowering loaded bucket, 375 feet per minute; trolly travel on boom, 300 feet per minute. The electric whirler crane has increased in popularity in the U.S.A. for placing concrete in dams, it being particularly suited to wide valley sites and where rapid progress is required beyond the limit of cableways. A whirler crane is a full swing travelling derrick crane mounted on a gantry. This gantry travels along a railway track, and is usually of the portal type to allow the passage of other materials beneath the crane. They are built in sizes ranging from 5 to 50 tons and with booms of 65 to 80 feet. Their hoisting speed is 200 feet per minute. Steel trestles carry the cranes, and the trestle supports are often incorporated in the structure of the dam.

Referring again to the Fontana Dam, concrete was placed there by both whirler and hammerhead electric cranes on self-propelled gantries, operating from trestles at three different levels. After a few spans of trestles had been erected, pouring of concrete by cranes proceeded simultaneously with trestle erection. One trestle was erected just above the powerhouse, where one or two whirler cranes placed concrete in the toe of the dam and in the powerhouse. The second trestle, 230 feet above the foundations, carried two double cantilever hammerhead cranes of 24 tons capacity and horizontal reach of 300 feet, in between two whirler cranes of 40 tons capacity with 125 foot booms. Between the crane tracks it also carried three tracks for trains hauling concrete. After the dam had reached the height of this trestle, it was raised 204 feet exactly over its original position. The supports were set on completed concrete.

Concrete from the central hopper under the mixers (described above) was taken by a series of belt conveyors to storage, or transfer, hoppers at each trestle. These conveyor belts ranged in width from 24 inches to 42 inches, were hooded, and were protected by special chutes, curved to cushion the discharge. Rubber disc idlers were also placed at the loading points. Upward slopes of 13 degrees were used satisfactorily with concrete having a 3-inch slump. Belts carrying concrete up were run faster than those carrying it down.

From the transfer hoppers the concrete was delivered to the cranes in 4 cubic yard bottom dump buckets, set four in a row on a special flat truck with space for a fifth bucket. Air-operated gates under each compartment opened to fill each bucket in 15 seconds, as the truck, pulled by a Diesel locomotive, passed under the hopper. Loaded trucks moved out on to the trestles where an empty bucket from a crane was set on the truck, and the truck then moved to take a full bucket underneath the crane hook. As soon as the crane picked up one bucket the truck moved to another crane, where the process was repeated. The buckets were of a specially designed air-operated self-closing type, and 30 were in use at the dam.

An example of modern concreting methods nearer home was the recent construction of the Captain Cook graving dock at Sydney. Concrete for this job was mixed in a central plant from which a daily output of 2,000 cubic yards was obtained. The total quantity used was 300,000 cubic yards. From the mixing plant the concrete was taken in skips mounted on bogies, and hauled as a train by small locomotives along elevated tracks. The skips were unhooked from the train, lifted by travelling gantry, and the contents poured.

In recent years the use of cableways has increased on large projects, they being particularly suitable for the canyon type of dam. The cableway can span the works area and therefore frees it from the usual supports required for other types of hoisting equipment. Its load capacity varies from 10 to 25 tons, with spans of 1,000 to 2,000 feet.

For the building of the Norfolk Dam, U.S.A. (containing 1,500,000 cubic yards of concrete), hammerhead cranes were first proposed, but cableways were considered more economical since a system of trestles had to be constructed for the cranes. Two 2,846 foot long cableways with $2\frac{3}{4}$-inch diameter cable of locked coil type were used, extending from a single 150-foot head tower high on one abutment behind the mixing plant to two 105-foot tail towers on the other abutment. The latter towers operated on rails of sufficient length to permit the cableways to place all the concrete for dam and powerhouse. When it was decided during construction that speed of placing had to be increased, special methods were used to transport the concrete to the middle of the dam, from where it was taken by the cableways. One arrangement was to deliver concrete from the mixers by end dump, motor trucks dumping directly into a transfer hopper truck travelling on rails transverse to the dam axis. A rate of 80 cubic yards per hour was possible with this method. A later scheme was to transport the concrete in four cubic yard buckets, lifted by a special boom attachment, on motor trucks, and the rate of placing by this method was 120 cubic yards per hour. It was found that the cableways could pick up buckets near the middle of the dam as easily as at the mixing plant.

The Boulder Dam furnishes another example of the use of cableways. Twenty-ton buckets were used on cableways suspended between gantries, which travelled upon rail tracks on each side of the gorge. Another well-known dam, which need not be described is Shasta Dam, where the erection of a huge cableway tower enabled the work of placing concrete by 16-ton buckets to go on quickly and efficiently. At Madden Dam, a 25-ton cableway, with 1,325 feet span, placed 60,000 cubic yards of concrete in a month, and at Marshall Ford a 25-ton cableway, 2,100 feet span, placed 88,000 cubic yards in a month, working three 8-hour shifts. Ordinarily a 2,000-foot span of 8 cubic yard cableway will place a load every four minutes, including all loading and unloading time.

When delivery of concrete is effected at considerable heights above ground level, or congestion presents extra difficulties in placing, the solution is often to pump the concrete through a pipe line. By pumping from the mixing plant to the actual site on which the puddlers are working, a consistent rate of delivery is attained, with consequent increased output on the part of the men concerned. It is also claimed that density and strength are improved by pumping. The rapidity with which the pipe line can be shortened, lengthened, or have its course altered, confers great flexibility of operation, and positions otherwise inaccessible are easily reached. The method, however, requires the use of concrete with a higher water content (and therefore of lower quality), than that adopted for standard mass construction. The "Pumpcrete" unit used consists of an overhead storage hopper with agitator, a valve for charging the pump cylinder, another valve for discharging the concrete into the pipe line, and a direct-acting piston moving in a horizontal cylinder. Concrete can be pumped through a 6 to 8 inch diameter pipe line over a horizontal distance of 1,000 feet and a height of 120 feet. A typical pumping unit has a capacity of 20 to 24 cubic yards per hour, handling concrete with aggregate up to 2½ inches maximum size, and delivering through a six-inch pipe.

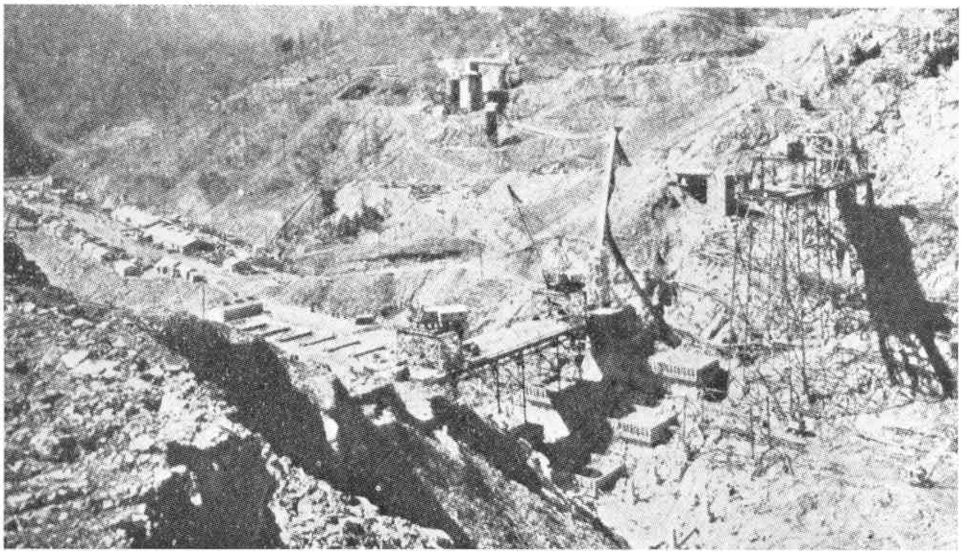
Use of truck mixers and agitators has developed considerably in recent years for conveying a ready mixed or dry batch of concrete from a central plant to the construction site. They are suitable auxiliary plant for major works, for conveying mixed concrete from the central plant to minor works outside the limit of the general placing equipment. Mixers of up to 5 cubic yards capacity can be mounted on trucks, and water can be added and the concrete mixed while en route to an isolated construction site.

The use of large masses of concrete under high pressures in modern dams generates heat within the mass, and tends to slow down setting. Artificial cooling was used at Boulder Dam, where this trouble was encountered. The dam was built in vertical sections, leaving slight gaps between each, that were afterwards filled with grouting under pressure. Into each successive layer were placed 2-inch pipes through which a continuous flow of cooling water was circulated by pumps. This water was maintained at near freezing point by a huge refrigeration plant. In the construction of the Norfolk Dam mentioned above, crushed ice was used during the summer to lower the placing temperature to below 67 degrees F. Ice was produced by a plant near the mixers, crushed to ½ inch maximum size and placed on the 42-inch conveyor belt delivering sand and aggregate. The water-cement ratio of the mix was reduced accordingly. It was found that the addition of 100 lbs. of ice to a 4 cubic yard batch lowered the placing temperature by 3 degrees F.

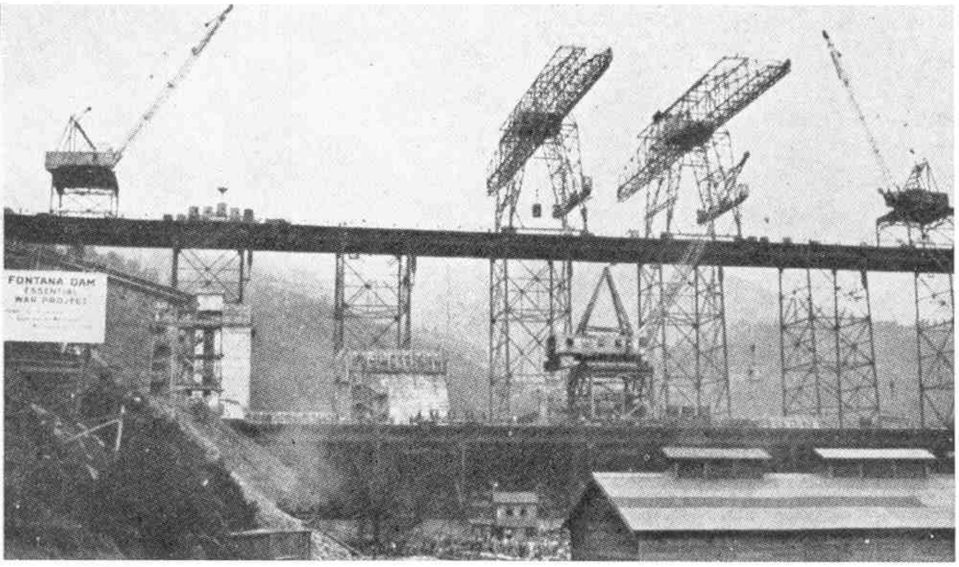
Another recent development in concrete construction is the vacuum curing process. This is an improvement on the use of forms with absorbent lining, which has previously been tried. The object is to obtain a dense, smooth face on the concrete by withdrawing surplus air and water from the surface layer. This treatment is becoming increasingly necessary in the spillways and tunnels of large dams, where the surface has to withstand water flowing at a very high velocity. Even minor irregularities in the surface cause cavitation to occur, and destruction follows. A compelling example of the truth of this was seen in the fact that a hole 112 feet long, 33 feet wide and 36 feet deep was eroded through the concrete lining and into the solid rock at the foot of the inclined spillway tunnel at Boulder Dam. This occurred during four months of 1941, when the average flow was 13,000 cusecs, about one-fifteenth of the maximum designed capacity of the tunnel.

In the vacuum process a special air-tight form is used, with a layer of expanded metal on the inner face, covered with flywire and finally with a layer of loosely woven cloth. Each form is connected by hose to a vacuum pump. When the vacuum is applied, the surplus water in the concrete is drawn through the cloth layer and passes through the hose to the collecting tank. At the same time the air pressure on the form compresses the concrete, and the result is a layer 6 inches or more thick of dense concrete, free from air bubbles. Early removal of forms is made possible by this process, as the concrete quickly develops sufficient strength to support itself. The process was used on the spillway at Shasta Dam and in the spillway tunnel at Fontana Dam.

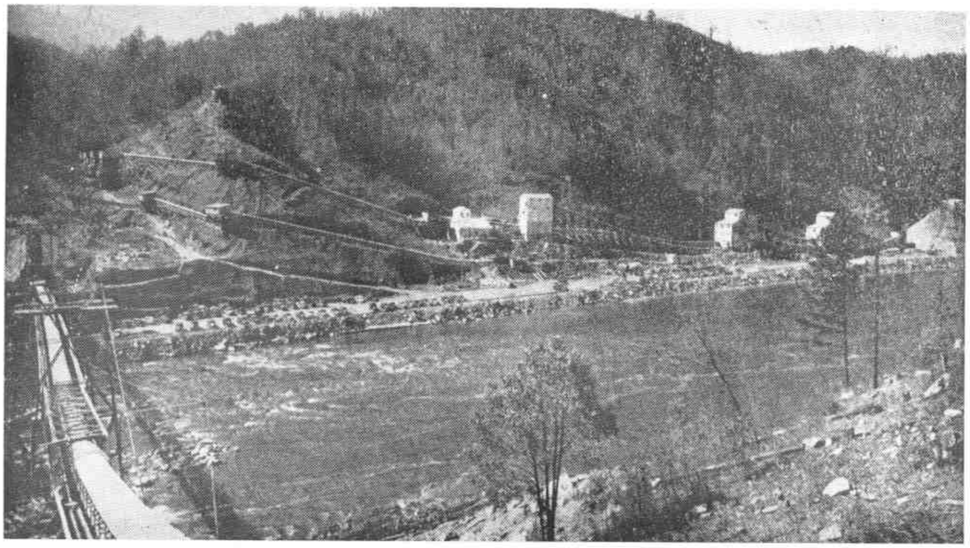
There seem apparent two general trends in large scale concrete construction to day. The first is careful organisation of operations so that mechanical handling can be used as much as possible, and so that concrete is handled in larger quantities at one central mixing plant. The second is that better quality concrete and better construction methods are found to be worth extra cost. For example, the use of vibrators causes extra shrinkage, which has to be paid for, but results in a denser and stronger concrete. It is evident that, simultaneously with advance in dam design, the construction engineer is constantly improving his methods and is giving to the designer the confidence necessary to depart from conservative practice and open up new fields.



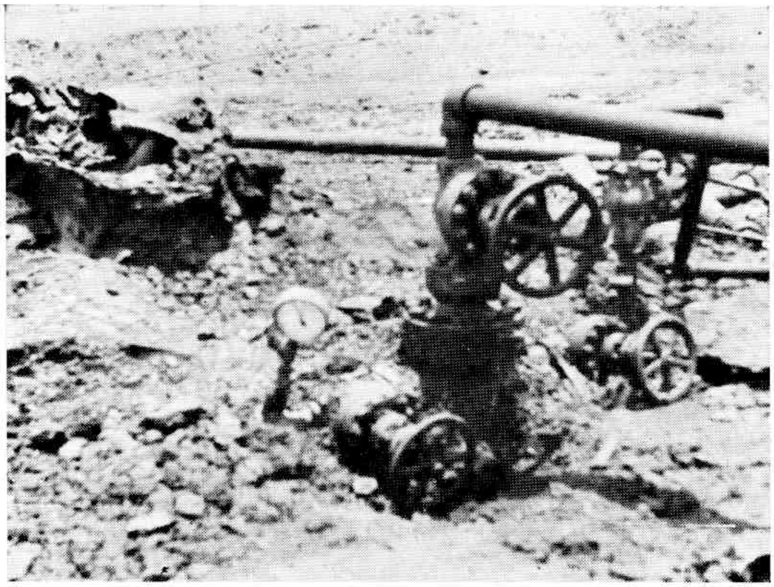
Fontana Dam site, showing erection of construction trestles. Concrete plant in background.



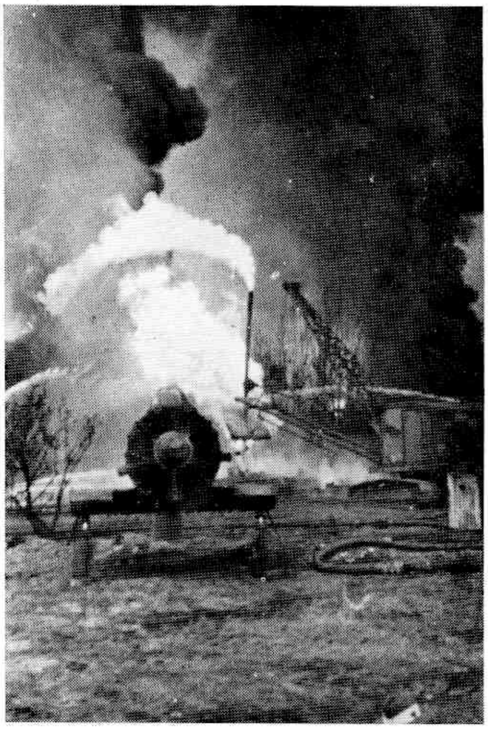
Construction trestles and cranes used at Fontana. Storage hoppers for wet concrete shown at left abutment.



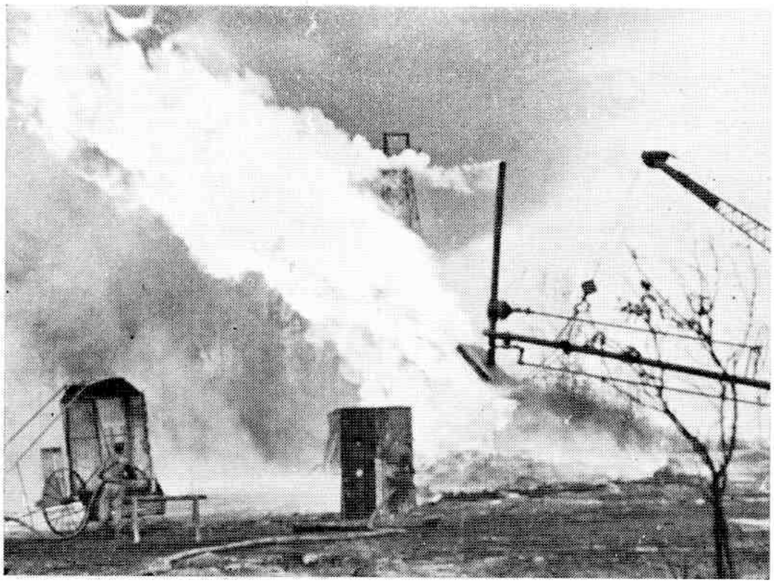
General view of aggregate plant and belt conveyors at Fontana.



THE "CHRISTMAS TREE."



Another view of an oil fire, showing Wirraway engine in foreground.



OIL FIRE BEING EXTINGUISHED.

BURNING OIL WELLS AT SERIA

By Miss. E. M. WOODS

A CHAP I know who was in the Welding Platoon of the 2/3rd Corps Field Park Engineers gave me the facts of this article. A photographer in his unit took the photographs and provided copies for those who wanted them.

Seria is an oil field near the border of Brunei and Sarawak—it is actually in Brunei—on the north-west coast of Borneo. The oil wells belong to the Shell Company, and the oil produced is reputed to be the purest in the world, the crude oil being used for fuel. The Japs. took possession of the field in January, 1942, and they drilled some new wells, and when the field was recovered by the Australians there were 180 oil wells in the field.

The 9th Division landed at Brunei on June 10, 1945. One gunboat went down to Seria and reported that the Japs. had left. However, they returned from the hills where they were hiding, and set fire to 39 oil wells. The 2/3rd Corps Field Park Engineers were given the job of extinguishing the fires.

Ten of the burning wells were relatively easy to deal with. While a stream of water was played over them, men in asbestos suits were able to approach the well-mouth and turn off the "Christmas Tree," the valve which is all the visible part of the well, and which is clearly seen in photograph A. When the valve was closed the fire was snuffed out.

Three or four of the fires were extinguished with steam, raised from about a dozen boilers coupled together. These had been brought for the purpose from the ruins of Kula-Belait, a town about 10 miles from Seria. The steam was played on the heart of the fire at the well-mouth, and the method was successful so long as the fire was extinguished within a minute. Any longer was too dangerous, as a highly explosive mixture of air and natural gas was formed, because the gas came from the well as soon as there was any decrease in the violence of combustion. Originally this gas was filtered from the oil mains and used as household gas.

At this stage two fire-fighting specialists arrived from America, and were given charge of the operation. The rest of the burning wells were extinguished by the following means:—

A mobile crane was used. Two six-inch pipes (a) were fixed to the jib of the crane, and a vertical pipe (b) connected at the end of these, so that water could be pumped through into (b). A valve (c), which closed the vertical pipe above its connection with (a) was provided with a long handle, so that it could be operated during the extinguishing of a fire. The steel platform (d) was to protect the connections above it from the fire, and the pipe (e) provided cooling water for the platform. (F) was a tapered pipe which fitted neatly into the inner casing of the well-mouth. This tapered pipe was manoeuvred into position over the well-mouth and dropped gently into it, so that all the fire and smoke came out of the pipe (b). Then the valve (c) was closed, and mud and water pumped through the pipes A, and the fire killed. Gas still escaped from the well, and a stream of water was played on the well while a new valve was screwed in. When the area had cooled, the water and mud were pumped out and the well was ready for use.

The heat near the burning wells was intense. The Americans requisitioned a Wirraway from Labuan,

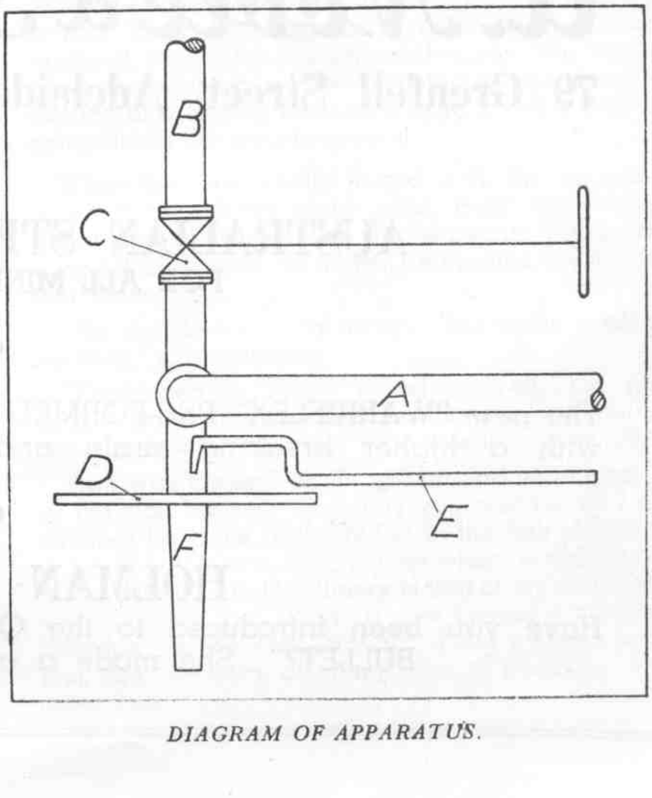
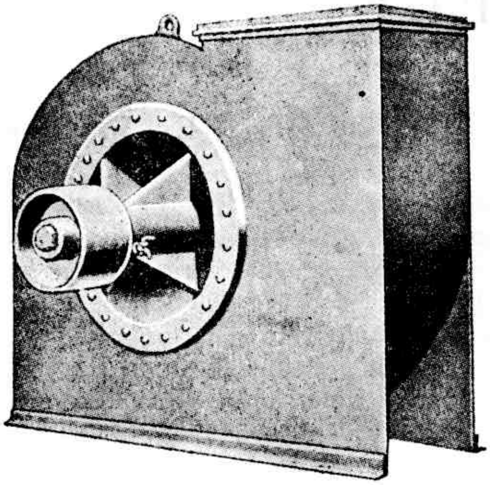


DIAGRAM OF APPARATUS.



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took off the wing-tips to save space, moved it close up to each well in turn, and kept the engine going during each operation so that the slipstream helped to cool the men. Corrugated iron shelters were used to help men with water hoses to approach the fire.

At two wells the derricks had melted, and the well carbonised, so that a great mess of steel, rubble and fire was spread over an area of 100 square yards or more about the well-mouth. This had to be removed before the fire could be put out. A steel platform was attached to the free end of an arm about 30 feet long, made of 6-inch pipe, and fixed to a tractor. A mass of about 1 cwt. of gun cotton was wrapped in gas capes and ground sheets, and fixed on the plate, and the tractor pushed the platform and its load as far as possible into the mass of rubble. About an inch of fuse projected from the fire-proof wrapping about the gun cotton, and this allowed the driver of the tractor to do some fast moving. Each explosion would destroy the platform and about 10 feet of the arm, and four or five such charges were used to clear each well.

The complete operation lasted between three and four months. At the beginning, with so much equipment to move, and preparations to be made, a week or more was spent over each well, but eventually two wells were dealt with per week.

———:o:———

THE SERGEANT-MAJOR

THERE was a sapper known as "Bing" in the two-bar-three pick-and-shovel company in Tobruk. The first time I saw him was when his Bren gun jammed as a Stukka flew low overhead. It would have been easy meat for "Bing," who was a dead shot, and he got mad. Shaking his fist at the sky he yelled, "Hughie, that's a dirty trick you've played on me. Come down here, you omnipotent, grey-haired, old basket. Come down, and fight me like a man."

That was at least an original line of blasphemy for an Australian. But "Bing" was original in many ways. He could have had a commission back in the early days in England. But he turned it down, so that he could lead the sappers in their forays against the deer on the estate of the Marquis of ——, and dynamite the fat trout in his streams, until even Scotland Yard were stirred to investigate, albeit in vain. Finally, the War Office decided that these Australians were having too good a time, so sent them to blaze away at gazelle in Libya.

Then came the famed "Benghazi Handicap," which most of us finished in Tobruk. Here "Bing" came into his own, laying mines under Jerry's nose, out past the Red Line, and, of course, dynamiting the fish in the harbor when things were quiet. At night there was always the big two-up school down at the advanced hospital, where "Bing" won and lost hundreds.

At Alamein he went out on a small raid, and brought back the other survivors of the party carried by German prisoners at the point of an empty revolver. They gave him the M.C. for that, but it was only one of the crazy things he did. The most amazing thing was that he always got away with it. I once saw him test out a mine, set to explode at two hundred pounds pressure; he simply jumped on it, and we all dived for cover, which was what he wanted. Yet that mine was set, complete with detonator and primary charge.

"Bing" was one of those born shots who automatically hit everything they aim at. His best-known exploit was shooting off a snake's head while on the march, holding his rifle under his armpit. With a light pistol he once brought down a kangaroo bounding through thick scrub, fifty yards away.

"Bing" stayed a sapper as long as he could, but he had the mob with him, and finally the O.C. decided he was wanted in a bigger job. So in a few months "Bing" was lance-corporal, corporal, platoon sergeant, and company sergeant-major. He was a good sergeant-major too, even though his favorite method of sounding Reveille was to let off a stick of gelignite on the parade ground.

When the Japs. finally turned it in, the company was in Burma. A few nights later, "Bing" was fooling about with his revolver in the sergeants' mess. He aimed it at some of his mates, and pulled the trigger four times.

"Put that b—— thing away. You make a bloke nervous," said someone.

"Frightened?" "Bing" asked. "Well, I'm not. Look!" He put the muzzle to his forehead and pulled the trigger the fifth time. The revolver went off.

That was the end of "Bing," an end as enigmatic as the man himself. Probably you wonder, as I do, whether he knew of the bullet in the fifth chamber, or whether this was the one time when he did not get away with it. Another theory is that of my mate Red, who suggests that "Bing" is now having it out with "Hughie" on his own ground. I don't know, but I feel that the story of "Bing" has to be told. It is quite true.

"THE SCRIBBLING SAPPER."

THE IRON BLAST FURNACE

By H. K. WELLINGTON

IRON is the most important metal to-day because of its abundance, relative ease of extraction and the various properties that can be induced into it by alloying small amounts of other elements with it. Although very abundant, only the richest, largest and most easily accessible deposits are worked economically. Any country not possessing great iron and steel industries is dependent on nations that have, and can never rise to be a major world power.

All the iron and steel produced is first reduced from the ore in a blast furnace; hence blast furnaces are the major units of any iron and steel plant, and without them would soon cease.

The first blast furnace was built in Germany about 1350. The English built their first about 1500. The early furnaces were charcoal fired and hence were located close to forests. Coal was tried in 1619 but was unsuccessful. In 1713 the first coke-fired furnace was built in England. From then on, coke gradually displaced charcoal until the latter has now almost completely disappeared from this field.

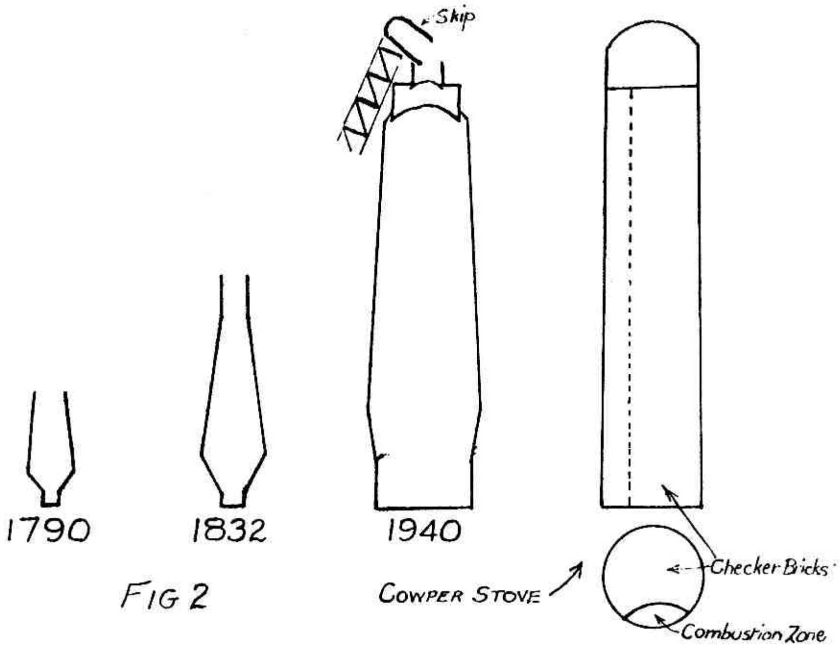


FIG 2

In 1828 the blast was first pre-heated by heating it with coal. The tuyeres were then water jacketed to give longer life under the more severe conditions. Then, with the coming of the bell charging devise, attempts were made to use blast furnace gas as a fuel. In 1831 some Scottish furnaces reverted to coal firing, which they use to-day.

In 1860 Cowper introduced his stove for preheating the blast. The stove was fired by blast furnace gas. In 1864 Vaughan built a furnace 75 feet high and the results were amazing. By referring to figure 1 you will see that in the stack a certain amount of preparation takes place before the charge is actually liquified at the bosh. Previously, with low furnaces, this preparation was not possible, and hence blast furnaces were very inefficient.

Figure 2 shows the relative sizes of blast furnaces of 1790, 1832, and 1940. The capacities of these would be about:—

	Tons of iron per week	Blast. Temp.	Lbs. coke per lb. of iron prod.
1790 . . .	15	15°C.	8
1832 . . .	50	300°C.	2-6
1940 . . .	7,000	650°C.	1.0

In 1870 about 1,200 tons per week was obtained, while to-day, single furnaces in Great Britain may produce this amount. What has caused such a steep increase in tonnage? While progress was always toward greater tonnages, little scientific reasoning was used to see where improvements could be made. The rule of thumb methods which operated last century are being displaced by carefully reasoned and experimentally proved rules. Metallurgy, however, demands a knowledge of what has gone before so that old processes are at hand to be adapted to meet some new demand.

Present-day furnaces have reached a maximum height of about 100 feet beyond which the coke fails to stand the burden pressure. To get greater production the hearth had to be widened to about 25 feet diameter, when the blast penetration prevented further widening. The massive nature of present-day furnaces calls for a circular structure to give the required strength. Maybe iron furnaces may follow lead and copper furnaces, and grow into rectangular shaped structures. However, many factors are against this; not least of which is the huge output that would fall off when such a furnace went down for repairs.

A typical 1,000 ton per day furnace consumes:—

Ore	2,000 tons
Flux (Limestone)	500 tons
Coke	1,000 tons
Total Solid	3,500 tons
Air	4,000 tons 1.2×10^8 cubic feet (at S.T.P.)
Produces:	
Iron	1,000 tons
Slag	500 tons
Total Liquid	1,500 tons
Gas	6,000 tons 1.8×10^8 cub. ft.

Thus it can be seen that with several such furnaces in operation at one plant, an efficient transport system is a vital necessity, as immense reserves would be necessary to maintain production if it failed.

The Furnace itself:

Diagram 1 shows a 1,000 ton a day furnace, it being very similar to No. 2 furnace, Port Kembla. The furnace is built on a concrete foundation, which projects about fifteen feet above the surrounding ground. Onto this is built the furnace as shown on the diagram. The furnace is lined throughout with fire brick in places many feet thick; the outside shell being of mild steel plate with cast-iron members round the bosh.

Like all arts and sciences, metallurgy has a jargon of its own, and I have endeavored to illustrate by means of the diagram the meanings of some of the terms used, which have exact meanings to metallurgists and none or totally different meanings to others.

The stack is supported by the columns attached to the mantle ring; the charge being supported by the blast and the bosh walls. To prevent overheating of the brickwork and excessive corrosion in the hottest parts, copper cooling blocks are inserted as shown, and through them water is kept circulating. The tuyeres and cinder (slag) notch are likewise water-cooled. The hearth is surrounded by cooling members.

Encircling the bosh is the bustle main. This is fire-brick lined and supplies the pre-heated blast to the tuyeres. The connecting pipe from tuyere to bustle pipe is called the goose-neck and is fire-brick lined. The peephole is a small quartz or mica covered hole about ½ inch diameter, through which the furnace operator peers with the aid of a blue glass, and can, by the appearance, see how well his furnace is running.

To resist abrasion near the stock line (level of top of charge) armour plates are let into the bricks for about five feet, followed by five more feet of sillimanite bricks to resist abrasion where plate is not effective or economical.

The skips dump into a hopper on the upper bell, which then falls and allows the charge to pass to the lower bell. The upper bell now closes and the lower bell falls, allowing the charge to fall into the furnace. The bell may be rotated, thus allowing even distribution of the charge. No interruption to the flow of gas is caused during charging.

Above the bells are fixed the skip sheaves and bleeder valves, giving the furnace to total height

Accessory Plant:

A power-house is needed to supply compressed air to the tuyeres and power for lighting and other smaller pieces of plant necessary for the blast furnace. Before the blast furnace gas can be used it must be cleaned and hence a cleaning plant generally of three or more units is installed.

For pre-heating the hot blast three or four Cowper stoves per furnace are required. Figure 2 gives some idea of the size of these units compared with the blast furnace they serve. Blast furnace gas is burnt in the combustion chamber and the hot gases so produced heat a chamber of checker bricks. This goes on for two hours, the air for the tuyeres is forced over the heated brickwork for one hour, and the process is repeated. The stoves are mounted at ground level and hence do not appear as large as illustrated in figure 2.

Reactions:

Figure 1 shows on the left-hand side the temperatures at the parts of the furnace on the same horizontal line as the temperature figures. Likewise are the reactions at the various parts of the furnace shown.

Operation:

Regularity and constancy are the watchwords of blast furnace operation. Changes should be made gradually; abrupt change may cause untold trouble, and weeks may elapse before normal running is again possible.

Stock piles serviced by a gantry keep the bins filled. A scale car draws its weighed amount of each constituent from the bins and dumps them into the skips, which in turn, dump into the furnace.

Slag is drained (flushed) periodically from the furnace and always immediately before a tapping of the iron notch. The cinder notch is water-cooled as slag is very corrosive.

The iron notch is tapped generally every four or six hours. First only iron emerges, then a mixture of iron and slag which are gravity separated. The

Materials Used:

In this section any analyses or figures quoted will refer to Port Kembla practice. Blast furnaces are, and must, run economically. Greater technical efficiency must be sacrificed by increased costs in notch is closed by a mud gun which swings into the hole and forces clay into the hole. Using the latest type gun there is no necessity for the blast to be turned off. Ladles receiving molten iron must be heated to red heat before use.

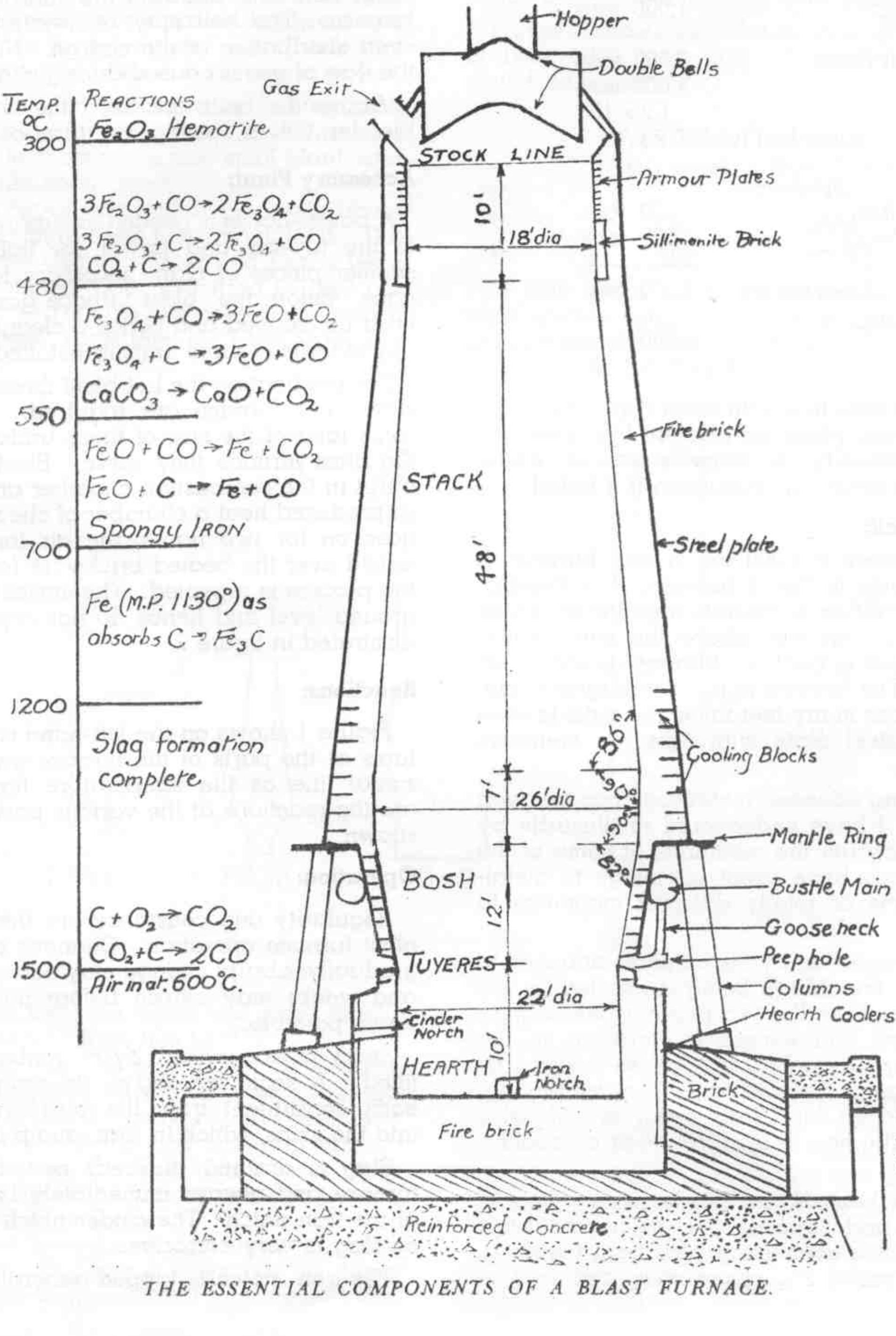
attaining such an objective, and a mean between greatest technical and the most economic efficiency is reached.

Ores:

To be a workable ore, the deposit should satisfy the following conditions:—

1. The ore should be of high grade, being low in phosphorus, sulphur, silicon, etc.
2. It should be a large deposit, capable of being cheaply mined by the open cut method.
3. The deposit should be easily accessible.

In other parts of the world hydrometallurgical operations are necessary for the concentration of the



THE ESSENTIAL COMPONENTS OF A BLAST FURNACE.

mineral prior to transportation to the blast furnaces. Our Australian deposits are so pure that the ore can be quarried and used directly in the blast furnaces.

The ore minerals are:—

Magnetite Fe_3O_4	72 per cent.
Hematite Fe_2O_3	70 per cent.
Limonite $2Fe_2O_3 3H_2O$	60 per cent.
Siderite $FeCO_3$	48 per cent.

(Per cent. Fe when pure)

Ores with as low as 30 per cent. Fe are used, but these are self-fluxing, i.e., no flux is required.

In Europe, where the best ores were exhausted years ago, limonites, after concentration, are smelted with difficulty. Some French blast furnaces have up to three rows of tuyeres for dealing with the high phosphate minette ores.

Here are anlyses of Iron Knob ores used at Kembla:—

Grade	Fe	Mn	P	Al_2O_3	SIO_2	MgO	H_2O
Basic	63	2	0.05	3.2	2.5	0.1	1.7
High Mn. .	58	8	0.05	1.0	1.5	0.1	1.5
Foundry . .	64	0.5	0.05	2.9	3.5	0.1	1.7

Coke:

Coke is made from blended coals, so that the best coke economically possible is obtained. On the South Coast the blend is roughly 85 per cent. No. 1 seam to 15 per cent. No. 3 seam. The resulting coke has an approximate analysis:—

Ash	S.	P.	C.
17	0.4	0.05	by diff.

Limestone:

This is quarried close to the blast furnaces or on their supply lines. It should be as free from MgO as possible, as Ca base slags have lower melting and forming temperatures than Mg base ones. Calcium is also a stronger base. Port Kembla draw most of their flux from Marulen close by, while Newcastle draws its from Rapid Bay, South Australia. Typical analyses are: —

Place.	CaO	MgO	SiO_2	Al_2O_3	Fe_2O_3	CO_2
Marulen	54.8	0.2	1.2	0.3	0.2	43.2
Rapid Bay . .	48.4	3.3	4.0	1.2	1.2	41.6

Other Charge Materials:

In Australia, for good operation, we add sand to the charge, and for foundry iron production some Nauru phosphate rock is put on the charge.

Sinter:

Materials too fine for direct use may be fritted together prior to charging into the blast furnace. This fritting process is called sintering. Flue dust is so treated in Australia. In America some furnaces are practically run on sinter and coke.

Blast:

Air is compressed by turbo blowers to about 25 lb. per square inch and passed through Cowper stoves, where it is pre-heated to 650 deg. C. From here it passes to the bustle main and thence to the tuyeres, of which there are 14 of 6 inches diameter on a modern 1,000-ton furnace. Water in the air, particularly in humid climates, causes irregularities in operation, but attempts to eliminate it are too costly compared with the gain in efficiency.

Products:

Two are valuable and are marketed, and the third, slag, may be sold, if high in phosphorous, as a fertilizer; or may be granulated and sold as concrete coarse aggregate. Generally it is used to fill up low-lying areas around the works.

Pig Iron:

Basic pig iron goes directly to the steel furnaces, but the many varieties of iron made for foundry work are cast into pigs and sold to various foundries for remelting and casting into cast iron shapes. Analyses of such are:

Type	Si	S	P	Mn	C
Foundry .	2.9	0.6	0.12	0.8	3.2
Basic . . .	1.0	0.02	0.11	1.9	3

Blast Furnace Gas:

This is a valuable fuel: the active fuel being carbon monoxide (CO) and a little Hydrogen (H_2). The chief disadvantage of the gas is the Nitrogen content (50 per cent. approx.).

Slag:

Consisting mainly of calcium silicates and aluminates, it is largely a waste product. In Australia it is used at the various plants for reclaiming land for future work sites. The slag is tipped molten to form the embankments from railway ladles.

In Australia we have six blast furnaces, all of which are run by the Broken Hill Proprietary Company or its subsidiary, Australian Iron and Steel Limited. Their location and daily tonnages are:—

3 at 670 tons at Newcastle, N.S.W., B.H.P.

1 at 1,000 tons at Port Kembla, N.S.W., A.I.S.

1 at 725 tons at Port Kembla, N.S.W., A.I.S.

1 at 700 tons at Whyalla, S.A., B.H.P.

A.I.S. are developing Yampi Sound, W.A., as a source of high grade ore to supplement the B.H.P. source at Iron Knob.

Despite the great distances raw materials have to travel, and the high labor cost at present ruling in Australia, we can produce iron cheaper than any other country in the world. This is largely due to our high grade raw material and the modern methods of mining and smelting used.

MAC.

He was just coming back from the Richmond.

"Mac—I want a word with you."

Mac unlocked the door of his cubby-hole under the stairs, which, for the past twenty-four years, has been his retreat and sanctuary in the Engineering building, and which, with him, holds many memories.

"Tell me about yourself," I asked him; "it's for the Engineers' Magazine; they want it as you're leaving us."

Did Mac need much prompting? You know him as well as I do, and in no time the little room under the stairs was being filled with remembrances of all the events which have made Mac an institution, and which have added continuously to his fame and to the respect held for him by the hundreds who know him.

You don't mind being called an institution, do you Mac? for only as such could you have guarded our territory, prepared countless suppers for a dozen societies, and, at the same time, survived the torments of unscrupulous wits; taking all with unmeasurable tolerance, and executing all with the highest sense of duty and ability.

"Before they built the refectory," Mac told me, "they used to have the suppers in the old Union Room, and I made the coffee in a copper out in the main drive. One night when I came for it, it wasn't there. I found the whole lot out in the middle of North Terrace, smoking like a steam engine . . ."

Mac claims to have had more to do with students than most men, but in all the years he has never had to report a single student—"They always obeyed orders, although I have had to report a whole group sometimes—like the engineers." he added significantly. But, Mac, that speaks volumes for your understanding and generous outlook, and it is that which has held you high in the esteem of those who played the wildest tricks against you. Like the time they washed away your so carefully laid-out supper with the fire hose so that your notorious sausage rolls were floating about for days after. Remember? And the time you followed four suspicious engineers (to this day still unknown) up into the building one dark night, and sat waiting for them in the dark corridor. They removed you, you might remember, by the simple expedient of firing a skyrocket down the passage from behind you—carefully calculated to explode under your chair. It came up to their expectations, didn't it?

"I've enjoyed my life here," Mac said . . .

To Mac the initiations were always "jollifications—they were always more of a jollification than anything else." Doubtless some people would beg to differ on that point, Mac, but a sense of humour, especially towards things directed against one's self, is a grand thing, as the way you recollect and laugh at your experiences at the hands of maniacal practical jokers shows us.

As I was leaving Mac gave me a hint as to his age—just a hint, mind you:

"I'll be seventy-five next January," he said.

The place isn't going to be quite the same without you, Mac. We'll miss you and your pipe (mostly you, though), and we'll miss your little reminiscences of the years gone by—we'll miss your coffee and your hectic sausage rolls . . .

Mac, all the embryo engineers here—and the hundreds of other students who knew you and played tricks on you, and confided in you, and listened to you—wish you, with all sincerity, the best of years to come, and the happiness that the memories of your years 'down here' must bring.

Happy Days—and Au Revoir, John McNiel.

—B. C.

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