In conclusion, I have to gratefully acknowledge my thanks to the following gentlemen (in addition to those mentioned in the paper) for having supplied me with valuable data for inclusion in this paper:—

1. M. Cooper Day, Esq., Quantity Surveyor, Sydney.
2. G. H. Halligan, Esq. (by courtesy of J. Davis, Esq., M.I.C.E., Director-General of Public Works, N.S.W.).
3. Messrs. Morrow & Deputron, Architects, Sydney.
4. G. J. Oakeshott, Esq., Works Director for N.S.W. Commonwealth Dept. of Works and Railways.
5. H. D. Walsh, Esq., M.I.C.E. (Engineer in Chief, Sydney Harbour Trust).

Finally, I would reiterate that, in many instances, the various points have only just been touched upon, but it is hoped that what has been quoted will afford basis for an interesting discussion.

DISCUSSION.

MR. McEWIN: I have much pleasure in proposing a vote of thanks to Mr. Mitchell for the paper he has brought before us this evening, and I would like to congratulate him on the diligence he has displayed in getting up this information and the trouble he has taken in presenting the facts to us so clearly. He has shown us the methods used for estimating throughout the world, and the difficulties which arise in trying to arrive at a fair estimate when calculating costs. Engineers know how difficult this is, and in the building trade it is even more difficult. On a bill of quantities prepared by a Sydney quantity surveyor, in which prices ranged from £6,500 to £18,000, the man who quoted the smaller price got the job and made money out of it. In another case, where prices quoted were from £14,000 up to £40,000, the man who got the work lost £3,000 on it.

There are some illuminating remarks in this paper. The fact that methods that were used 200 years ago have not been improved upon throws some light on why estimating is unsatisfactory. A bricklayer at present will earn 15/- a day minimum wage, laying 450 bricks per day; allowing for time off the job, he lays one brick a minute. It would pay the interested parties to give a bonus to ensure the laying of more bricks. It would be to the advantage of both the employer and the workman if this method were used.

We have all complained at some time of the state of the roads in New South Wales. In the current number of "The Motor in Australia," a list of prices are quoted by Mr. E. W. Stern regarding the cost of payments in U.S.A. Mr. Stern was Chief Engineer of the Highways, Borough of Manhattan, New York. Mr. Stern has worked out the cost of the payment and the annual cost of each item in the different kinds of roadways as follows:—

CONCRETE 6 INCHES THICK.	s.	d.
Cost of 6in. foundation per sq. yard	3	4
Cost of 2in. surface per sq. yard	1	4
Total	4	8
Interest charge on payment, 4/8 at 4¼%	2.38d.	
Amortization on wearing surface, 1/4 at 3¼% ..	.52	
Annual repairs	1.	
Total: Annual cost per sq. yard in pence	3.9	

A summary of the various annual costs calculated as above runs out as under:—

	Annual Cost per sq. yd. in pence.
1 Concrete	3.9
2 Asphaltic Concrete on 6in. Con. base	5.5
3 Sheet Asphalt on 6in. Con. base	5.67
4 Brick on 6in. Concrete base ..	7.

	Actual cost per sq yd. in pence.
5 Bituminous Macadam	7.88
6 Asphalt Block	8.5
7 Water bound Macadam	8.88
8 Wood block	10.2
9 Granite Block	10.5

In each of the above items, the compiler has allowed for a foundation course of 6in. concrete.

The information regarding oiling roads does not state whether annual cost or cost of each application. It is no use oiling a road unless it is in first rate condition; it then preserves the road by keeping water out. A well crowned and oiled road will throw the water off and will last much longer than any other kind of macadamised road.

Mr. Mitchell's remarks on the Swahili make me think they resemble our own laborers, who make a good week's pay in two days and are then not available until the necessity arises for earning the means of taking another rest.

With regard to the high cost of hospital buildings, it seems strange that institutions which depend chiefly on charity for their maintenance should work out at such a high cost. The fact that the ornamental is often considered more than the useful in building largely accounts for their high cost. The object in building such structures should be to make them capable of accommodating as many patients as possible.

In concluding, I can only reiterate my very warm thanks to Mr. Mitchell for the trouble he has taken, and for the valuable information he has brought before us to-night.

MR. HART: I have very great pleasure in seconding the vote of thanks to Mr. Mitchell. I have read the paper and listened to the reading of it to-night with much interest, particularly because it gives a comparison between

what is done in this country and what is done in some other parts of the world. We are so apt to get into grooves and lose sight of what other people are going that it is good to have an opportunity to compare our local costs and practices with those of other places.

I notice that Mr. Mitchell refers to the market ruling here last May; it is hardly necessary to point out that all materials have gone up in price very much since that date, such things as fibro-cement and malthoid, and, indeed, all the articles mentioned in the paper, have risen to considerably higher prices, mostly, of course, on account of the increase in freights on imported articles.

It has always been a wonder to me how builders can go into an architect's office and take away the plans of a building, and go back next morning and deposit a tender. I think they must work largely on a basis of cubing, but it is a risky thing to do without an exceptionally good knowledge of what is involved, as the points which can affect costs are innumerable. To ensure successful estimating it is necessary that the estimator acquaint himself with labor awards and rates, a very difficult task owing to their number and variety. As an example, I may mention that on a reinforced concrete bridge job which I recently inspected, I found that the carpenters employed in constructing the concrete forms were paid 1/8. These men were less skilled than bridge carpenters—i.e., timber bridge builders—yet under the shire employees' award, bridge carpenters were paid 3/- a day less than were the concrete carpenters, for no other reason than that the latter were employed by a private firm, and so did not come under the shire employees' award.

The Federal award for laborers' pay again is different to the State award, and I have known repeated instances of employers being forced to pay wages much above those

they had estimated upon through the overlapping of different awards. Contrary to the results set out on the author's paper, I think it is unusual for day labor rates to compare favorably with contract prices.

The following is a basis of estimating costs which I have employed and find very useful as a basis of comparison between different works of a similar class:—

WORKS ANALYSIS.

Total Concrete.....cub yds Tender Overall cub. yd. Concrete.....
Total Steel..... .....Tons Tender Overall sq. yd. Floor..... ....
Ratio Concrete-Steel Average.....
Beams.....Slabs..... Walls .....Columns.. ..Footings.....
Price D D Site: Stone.. ...cub. yd. Sand.. ..cub yd Cement..... tons

DESCRIPTION OF WORK.

An analysis of this kind could be made for other classes of similar work, and I trust that the description of the method employed may be of some use to members.

I have much pleasure in seconding the vote of thanks to Mr. Mitchell for his valuable paper.

MR. TOURNAY-HINDE: I have much pleasure in supporting the vote of thanks to Mr. Mitchell for his very interesting paper, and I also compliment him on the precise arrangement of the data contained therein, which must have involved on his part much time and patience. When the cost of new works that are projected is under consideration, data such as that given by the author should prove valuable, as it is usually of material assistance to compare the known cost of completed with the estimated cost of proposed works.

Here I should like to call attention to the great variety of units of measurement and weight as shown in the paper. Why should there be a different unit of measurement for brickwork, concrete, timber, etc.? I am aware it is due to custom, and custom is proverbially difficult to change.

Much time would be saved in estimating if we enjoyed the advantages of the continental system of weights, measures and money. Some years ago I had occasion to take out an estimate of cost of a large works running into about £80,000. The plans were prepared in Germany, and all the dimensions were metrical. At that date I had not had any experience of metrical measurements, and I started by attempting to reduce all dimensions to their English equivalents, but I soon found that much time could be saved by working from the dimensions as they were, and after a day or two of experience with the metrical system of measurements was surprised at the saving in time that could be effected. I am afraid that until we have sense enough to adopt the metrical system estimating will remain the same irksome, tedious process.

The author has referred to the use of cubing for the purpose of preparing preliminary estimates, and has given many examples of the cost of various buildings per cubic foot. I consider that this method is a rather dangerous one unless the estimator is a very experienced man, especially so where, as in the author's examples, the whole building is cubed at one price per cubic foot. In my opinion, it is much safer to partially dissect the building and arrange a price per cubic foot for, say, various kinds of foundations, different methods of superstructure construction, and varying styles of roofs. Examples in support of my contention may be found in the schedules given by the author.

Take Schedule No. 2: The Croydon Post Office, two storey, costs 9.40d. per cube foot, yet the Mascot Post Office, apparently a similarly constructed building, but only one storey in height, costs 7.65d. The cost of the foundations in the former case would be a smaller proportion of the total cost of the whole building than they would in the latter case, yet the two storey building costs more per

cube foot. The reverse should be the case, and the result is apparently brought about by the author including as cost of building the "considerable excavation and filling in" as mentioned in the remark column.

I notice in connection with the dredging costs relating to the Sydney Harbor Trust that the quantities dredged are stated in tons instead of in cube yards, as is the case with the figures relating to Panama. How the Sydney Harbor Trust arrives at the weight of the material I do not know, but I presume it is probably by measurement, as they cannot possibly actually weigh it, and there seems to be no sound reason as to why the result should not be given in cube yards.

The table given by the author of the various rates of pay to artisans in British Columbia is interesting, as the relative rates vary considerably from what they are here.

In the estimate of cost per yard super of brick paving for hill climbing purposes, I note a slip in adding the profit. The author states 10 per cent. profit, but only adds one-tenth of the total to the total. This would only provide a true profit of a shade over 9 per cent.

Mr. McEwin referred to the number of bricks laid per day by bricklayers. In my experience this varies very considerably according to the class of work. In the case of fire-brick work in certain classes of furnaces, it may be as low as 150 per day. The average on ordinary work is about 600. I have actually timed bricklayers while laying bricks, and I recall one instance where a bricklayer was laying bricks on a 14in. wall in mortar, and during the period while he was actually placing the mortar, bedding, jointing, and setting up the bricks, the number laid was at the rate of 2,000 a day, yet the average of the same man per day did not exceed 650, the time being lost in plumbing, running lines, cutting bricks, etc.

Before sitting down I would like to call attention to one feature in connection with estimating, which generally seems to be overlooked. The cost of labor and material as given by the author do not constitute all the job will cost; in addition thereto it is necessary to add the cost of plant, such as barrows, shovels, planks, mixing boards, ladders, scaffolding, and so on, and as these things are continually having to be replaced, they should be allowed for. In some instances the upkeep and amortisation of certain kinds of plant may be more per unit of work than the actual wages paid to the man operating it.

In conclusion, I would ask Mr. Mitchell not to think that any criticism I may have made regarding his paper has been offered in a deprecatory sense, far from it, for I know and fully appreciate the difficulties of successful estimating.

MR. GALBRAITH: It affords me great pleasure to join in the vote of thanks to Mr. Mitchell for his interesting, instructive and valuable paper. The paper is unique, having covered examples of estimating work in four continents. It has been said with a great deal of truth that in estimating there are those who are capable of forming an opinion and those who think they are capable of forming an opinion. To be a successful estimator you must not only have a thorough ground work to begin with: you must also have a wide and varied experience.

There is one phase of the question which the author has not touched upon, and this is the legal liability of the estimator, and in the United Kingdom and Ireland this is largely considered. In the case of one quantity surveyor who made an error of £50 he was obliged to make it good. The Private Streets Act of 1892 has been adopted by the different Municipal Councils, but it is not compulsory. In this Act the estimator is confined to within 15 per cent. of his estimate. To the credit of municipal engineers and surveyors, I may say that I have never heard of this being exceeded.

There is another point which has not been dealt with tonight, that is, transport, and this of course increases the cost of materials. When I was in Uganda I asked why there was so little concrete used, but when I learned that it was necessary to pay £3 for a drum of cement to be carried from Lembassa to Uganda, 185 miles into the interior, I could well understand why so little was used.

Australian labor is more highly paid than labor in any other part of the world, but in British Columbia, Mr. Mitchell says, labor is paid at even a higher rate. I suppose, however, that the rate of living is higher there than in Australia.

In 1909 there was a question raised of importing indentured labor into Zanzibar, as local labor there was unsatisfactory. At that time a coolie could be got to do a day's work for the sum of 2d., and I have never heard of any cheaper labor than that. There are one or two errors I would like to draw attention to. With reference to the employment of Swahili women, I am afreid the author is incorrect; it should be men, not women. Women are largely employed in Zanzibar, and all parts of the East, but in Zanzibar they are employed only in carrying water, and are paid half a coolie's wage.

In dealing with labor matters it is necessary to make a close study of the labor laws, but even if this is done it will be found that constant disputes will arise; it seems as if everything possible and impossible will be tried to get more money out of the unfortunate employer. Taking into consideration the increasing rates of pay in the new labor awards, and the increasing cost of materials due to the war, it is almost impossible to estimate with any degree of accuracy—so much is this so, that I understand contractors are fighting shy of lump sum contracts. Regarding the contingencies that have to be put in estimates: as a rule 10 per cent. is allowed in the United Kingdom and 15 per cent. to 20 per cent. in Zanzibar, but one enthusiast has been heard of who said that contingencies should be left out.

I was much interested in Mr. McEwin's remarks about the number of bricks—450 per day. The greatest number I have known a day was 700, and that was on award work. Mr. Hart's method of estimating applies to iron and steel contracts, but would not be so applicable to many other methods of construction in which different materials are used.

As I have no doubt you all know, Lord Brassey rose, in the early Victorian days, from the position of ganger to the peerage, and his method of estimating was this: When he was tendering for any work he would have the estimate prepared by his staff, and go over it carefully to satisfy himself that it was right; then he would double it. He would then take it home and go into the matter with Lady Brassey, who would advise him to double it again, and this method I would strongly recommend to all estimators.

The PRESIDENT (Mr. D. F. J. Harricks) said it was very desirable that papers dealing with costs of plant and undertakings should from time to time be presented to the Association, for engineering as we knew it to-day did not exist without a business side. Every undertaking carried with it not only interest from the scientific point of view, but it had to pass the test of practical and economical accomplishment. It must not only be carried out on good principles, but also be satisfactory from a commercial standpoint. Engineers, he thought, as a rule, did not sufficiently bear in mind the business side of their work, but each one knew that in many cases, he was going to be successful or be judged as to his fitness for promotion very largely by his ability to estimate the commercial value and productiveness of undertakings. It is particularly noticeable by those who come in contact with young engineers how very often they have the most indefinite ideas even as to how the materials they are handling are bought and sold. He thought that there was some justice in the complaint that engineers were too often inclined to the view that anything having other than a technical interest was of little importance. No one would seriously suggest that the

business training of engineers should seriously displace technical training, but it would appear to him that some steps could be very profitably taken to give young engineers a better chance of coping with the business conditions they are likely to meet with in their occupations afterwards. It was only by the display of sound judgment and reasonable knowledge of commercial considerations that many engineers would fit themselves for higher executive positions. It was, no doubt, very easy to criticise, and criticism must lose most of its value if unaccompanied by suggestions for improvement, but it certainly should not be difficult to arrange during the training of engineers that some time be devoted to education in such subjects as the costing and pricing of materials or commodities and in the preparation of simple estimates. It need not be a lengthy period, but three months spent in the costing or estimating department of an engineering establishment at a time when the young man is inclined to appreciate the value of such training, would, he thought, enhance the value of the young engineers to the engineering industry. He realised that in certain cases the size of the shop would not allow of such an arrangement, but there were many where it was possible, and some where it was, to some extent, now done.

Mr. Mitchell's paper was full of data, and most of it was applicable to Australian practice, whilst the information with regard to work in other parts of the world was certainly of very great use in forming comparisons as to the efficiency with which engineering undertakings were carried out in this part of the world. He would like to remark upon the fact that many people were under the impression that because very cheap labor was available in certain parts of the world, it followed that work could be done far more cheaply there as a result thereof. It would, however, surprise many to know that in actual comparisons it was very often found that, although the cost per labor unit might be very much less, the total cost in the end was very much the same. This was brought about by the fact that where very cheap labor was available it was generally

found to be of very much inferior value per unit to that of the more expensive skilled labor.

It was interesting to notice in Mr. Mitchell's paper that turpentine piles could be obtained in Sydney at the present time for, say, 3/- per lineal foot, and that they cost fifty per cent. more than this thirty years ago, and he thought it was not sufficiently recognised what a very excellent article Nature has provided us with in the hardwood pile for the construction of harbor works.

Engineers were interested at the present time in watching the development of the Cunningham Carbo-Teredo process of charring, and if this proved all that was claimed, it would seem that we have in the charred turpentine pile a solution of one of the greatest problems that confront our harbor engineers. No doubt the idea arose from the experience so well known in this country of the relatively greater life of fencing posts which have been charred by bush fires as against those which have not been attacked by fire.

He had very much pleasure in conveying to Mr. Mitchell the thanks of the Association for the very great trouble he had gone to in preparing his paper, and the way in which it had been received by the meeting rendered any further remarks in commendation unnecessary.

Mr. Mitchell: Mr. Chairman, Mr. McEwin, Mr. Hart, Gentlemen, I thank you very much for the kind vote of thanks you have accorded me. With reference to the question raised as to the cost of wharves, the price mentioned is the cost per 100 sq. ft. of wharf area. As regards oiling roads, this work is done every year, and the cost refers to the amount expended each time the work is carried out.

Mr. Hart raised a question regarding the prices quoted. Prices are, of course, changing rapidly, but those quoted in my paper were given me only a few weeks ago.

As regards the amount of concrete turned out in a day, the primary reason I gave this was as an example for the purpose of calculating constants, although I have known labor on concrete to cost the sum quoted.

I quite agree with Mr. Hart that it is difficult to deal with the matter of awards, as they are continually changing. I also agree with Mr. Tourney-Hinde that the metric system is a great saving of time, and that estimating by cubical contents is very risky.

As regards dredging: The Sydney Harbor Trust and Panama Canal figures are quoted in tons and cubic yards respectively, these being the units adopted by the two bodies. The average weight of a cubic yard in Sydney Harbor equals approximately 1½ tons, and the quantity dredged is obtainable from the known capacity of the dredge.

As regards depreciation of plant, this has not been allowed for in the prices quoted by me, as the usual practice is for the same to be allowed for in bulk and included as a special item in the estimate.

As to Mr. Galbraith's question re transport, this is a difficult subject; it varies so much and has to be dealt with on its own merits; therefore, the matter has not been detailed in this paper.

Regarding rate of living in British Columbia, the rate of living corresponds to the high rate of wages, and is about the same as that ruling in Australia at the present time.

The Chairman raised a very nice point about students getting some experience in estimating in their early days. I quite realise from my own experience what an immense advantage it would be to students to obtain some training in this particular branch.

I think these are all the points which require answering at present. As for the preparation of my paper, it has been in a manner of speaking a labor of love, and has been well repaid by the interesting discussion which has taken place this evening.