In Melbourne the Board of Works did not like them to open up a hydrant on a big main. The ball valves might go wrong, then they would have to cut off that main. There were cases where there was a blank plate put on. The big mains had not sufficient hydrants on them, as a rule, to give anything near the capacity. It took the water from six fire plugs to run their big steamer at its full capacity, but there were not many places where they had placed six hydrants sufficiently close.

He would like to mention the excellent assistance they had received from the Metropolitan Board of Works. There was no legal necessity for the Board of Works to provide water for extinguishing fires. All they had to do was to provide a reasonable domestic supply. But the water supply officials turned out and helped the brigade right willingly. They gave them the fullest benefit they possibly could from the available water mains. Otherwise Melbourne would have had very much bigger fires than had been the case. Mr. Ritchie had referred to the wonderful work the brigade had done. It was in great measure due to the promptness and efficiency of the water supply officials, who turned out and gave them the best they could from the limited water mains at their disposal.

He did not think there was anything further to add, and he thanked members for the attention given him.

Discussion closed.
the freight areas of local centres was dealt with on the basis of lines of equidistance. The present brief notes are a development of the treatment in its extension to the problems of large segments of the sphere, arising as a sequence to the cutting of the Isthmus.

The geometric solution, which is fundamental, is all that is herein attempted. It is left to administrative engineers to themselves discern the applications in respect to their individual policies. The plates record the results for their use. The lesson is clear. For the principle is basic, and any policies that deviate therefrom can continue to do so only by a continuous and commensurate expenditure of energy withdrawn from other uses.

PREMISES.

Let it be granted that—

i. Racial energy and national resources—

ii. Power to economically dominate natural conditions by artificial restraint—

iii. Physical conditions (other than distance by alternative routes)—

are equal, or are in a numerically expressible ratio in regard to given national centres of concentration in their relations with any other points.

GEOMETRIC TREATMENT.

The relations—i.e., boundaries of spheres of influence, frontiers of equi-distance, lines of equal cost, consequent upon these premises in any given case may then be expressed as regular curves the necessary properties of which are, briefly, and in simple language, these:—

Curves:

If two points are given in a finite line, constituting the shortest distance between such points, elsewhere unrestricted as to form;

If the bisection of the whole line falls between such points;

If about such points as focii an hyperbola be described with its vertex at the point of bisection;

If any point is taken in the hyperbola and connected with the two focii by radii vectores, or straight lines,
Then, by the properties of the conic, the distances measured from any such point therein, along the respective radii vectores to the respective focii, thence along the line to the respective extremities, are equal.

If the two points taken are the extremities of the line, then the hyperbola assumes a limiting form, and becomes a straight line bisecting, at right angles, the straight line between the points.

If the whole line be, not bisected, but sectioned in some known ratio other than unity, then if a figure is constructed in the manner of the above hyperbola, but with the increments \((x, y)\) of the correlated radii vectores, not equal, but severally proportionate to the segments of the line with which they are associated—

Then the distances from any point in such curve, measured as above, to the extremities of the given line are not equal, but constantly in the given ratio of the segments of the line.

If the two points \((f, f')\) taken are at the extremities of the line, then the figure assumes a limiting form, and becomes a circle, of which \(A, B\) is an arc, but not with its centre at either of the given points. (By the use of Euclid, A, vi., and 31, iii.).

\[
\text{Ratio } \frac{y}{x} = \text{constant. } = \frac{f}{f'} \frac{B}{f B}
\]

The curves are, in brief, particular applications of hyperbolas, or variants thereof.* It will be found that they comply with the geometric equivalent of the actual geographical conditions, and with the premises of these notes.

*Which are, notwithstanding, closed curves when completed on the sphere.
Graphs.—The computation of such curves, in their spheric application, involves labour not always justified by the degree of accuracy essential and readily attainable by much simpler methods in solid graphics, which can be depended upon to within $\frac{1}{2}$ deg., or, with care, within 1-10th deg. of arc.

Bearing in mind the method of describing hyperbolas by connecting the intersections of successive arcs described from the focii as centres, no difficulty will be found in plotting them, with compass and a thin narrow steel scale, as spherics on a globe. All straight lines are to be treated as arcs of great circles, and all distances are to be thus measured.

The globe used in the present case was that exhibited. It is 10 inches in diameter, of hollow, smooth plaster, provided with two graduated circles, one on the axis, and one meridianally. The circles enable any given points or courses to be accurately plotted on the globe from charts, and the resultant curves to be, in turn, re-transferred from the globe to the chart.

But the distortions of all plane projection—particularly Mercator’s—of surfaces of double curvature, render it difficult, or quite impossible, to grasp the true relation of series of curves in three dimensioned space. Their connection, significance, and consequences, appeal to the understanding in a far more effective way when they are described and examined on their appropriate curved surfaces.

Graphic Equivalents of the Geometric Curves.—It is assumed that Plymouth and New York mark, very approximately, the concentration areas of the over-sea trades of the importing and exporting nations of Europe, and of the United States, respectively. They are taken as the “given points” of the first part of this section, of which the “given finite line” is the course, via Suez or Panama, as the case may be, in which, evidently, intermediate geographical points may be situated.

The results attained are appended as curves, first, on a Mercator’s projection of the world (Plate I.), second, on the larger scale diagram (Plate II.) of the Pacific section. The explanatory references are as follows:—

The solid curved lines are plane projections of the frontiers when equality of efficiency of the centres is assumed. They are, in reference to any particular point therein,
and the distance therefrom to those centres, lines of equi-distance, or equi-effect.

The dotted lines indicate the effect upon the frontier when inequality of the ratio of efficiency of those centres is premised. They are lines of constant relative efficiency, or equi-cost, not of equi-distance. The frontier of the more effective centre is more distant from that than from the centre of lesser efficiency. The spheres of influence are, therefore, lineally in the ratio of the assumed efficiency, but in respect to area they are of the order of the squares of the efficiencies. For the purposes of a numerical example a ratio of efficiencies of 4:3 is assumed. The triplicate groups of each of the two series of curves show the result when the greater efficiency is attributed to the east, and, alternatively, to the west.

The Atlantic Frontier of equi-distance or equi-efficiency is an arc of a great circle, any point in which is equi-distant from Plymouth and New York (Plate I.).

The Pacific Frontier of equi-distance, or equi-efficiency, is alternative. Each branch is formed by a projected hyperbola, both having a common focus at Panama, one having its second focus at Aden, the other its second focus at Singapore.* (Plates I. and II.).

Conclusion.

It will be noted that the line of equi-distance, or equi-influence between Plymouth, via Suez, and New York, via Panama, bisects Australia in an approximate way. Thus, in respect to New York, Panama tends to change the basis of transportation of the Eastern States of the Commonwealth, but less so in relation to Plymouth since the distance from thence, by either route to—say—Sydney, is, by the Admiralty track charts, about 1,300 miles in favour of Suez.

But, in fixing attention on Panama in its relations to Europe, let it not be forgotten that Port Darwin is as near to Asia as it is to Melbourne, or as Melbourne is to Fremantle; also that the great

*By reason of the necessity to follow courses south or north of Australia. The groups of curves are distinct, they approximate, but do not connect.
Chinese centre of concentration at Canton (Hong Kong, plate II.), is approximately four times nearer to Darwin than to Panama.

Since the Institute is precluded from considering phases of the question other than those distinctly relating to engineering, it would be unwise to hazard conclusions which could not be supported by discussion.

It is obvious, however, that changing geographical conditions require the consideration anew, perhaps the revision of Australian transport policies.

It is obvious, too, that the plan of all Australian internal transport engineering postulates that sea-control which is also the political determinant of sea frontiers.

Also, sea frontiers are modified when long alternative land lines intervene. Then the rail, supported by internal interchange,—the path across the ocean is a path across a desert—is a factor which must be considered, for it cannot be contended that the rail has approached its ultimate economic possibilities. It has yet to break away, as naval architecture and engineering have broken away, from the limitations of its past.

Canada must be considered. Africa must be considered, and when Asia—which is physically one with Europe—shall be traversed by trunk railway systems designed in a larger spirit of fitness for their future purpose, when it shall be reticulated with subsidiary systems, when the inevitable consequent homogeneity of industrialism shall have followed, Australia's engineering plan and commercial future may be no less closely knit with the East and the rail, than with Panama and the new sea route.
The solid curves are lines of equi-distance between Plymouth, via Suez, and New York, via Panama.

The dotted curves are lines of equi-efficiency, or equi-cost, when the efficiency of Plymouth to New York is as 4 to 3, and alternatively, as 3 to 4. (The greater the efficiency the more distant the boundary.)
The President said the opening of the great Panama Canal was drawing near, so near that perhaps many had begun to think seriously of the enormous economy the opening would introduce, and Mr. Smith had introduced some general principles on which they might do some serious thinking.

The paper was necessarily complex, and required consideration before one could even pretend to follow it in all its aspects.

Mr. Smith had referred to the possibility of such change in the engineering policy with regard to land transport as to seriously affect the conclusion to be arrived at from the ocean geometrical consideration of the problem alone. It was hoped that there would be an immense trade from the Atlantic to the Pacific coast, through the Canal, yet when he was in the United States recently he heard Americans boast that as soon as that competition started they would be quite ready to meet it. So that there was introduced into the problem of equi-distance, or proportional distance of direct sea routes, the possibility of alternative land routes, as Mr. Smith had clearly pointed out. The question was of worldwide significance, and also very specially of Australian signification, and if he might venture a point of view not strictly cognate with the matter of the paper as a whole, the whole question of distribution and distribution depots was going to be radically altered. The Suez route was very strictly limited by the draught in the canal. There would be a much bigger draught in Panama, and they could look forward to seeing a bigger tonnage.

Mr. J. A. Smith said they were arranging to deepen the Suez. Panama had forced the position.

The President said they had been talking of that for years. Their hand was being forced now. First of all they might look for a largely increased trade with America, both import and export, then ships of large tonnage, bringing merchandise to some distributing centre, and ships of lesser tonnage, transhipping in the harbour, thus indicating a distributing trade round the Australian coast. He thought the effect of the opening of Panama would be to make Sydney the great distributing depot of Australia. That was no idle speculation, but based on scientific analysis.

Mr. M. E. Kernot expressed the interest he had taken in what Mr. Smith had placed before them. Mr. Smith was always ori-
ginal, and his views were interesting and thought-provoking. He would like a little longer to think about the paper before expressing anything further.

Mr. Smith, in thanking members on the vote of thanks recorded in the "Proceedings," said he hoped the discussion would, in view of the importance of the matter, be keen and thorough.

Discussion postponed, and meeting adjourned.
DISCUSSION.

NOTES ON EUROPEAN-AMERICAN FRONTIER IN THE PACIFIC IN RELATION TO PANAMA AND AUSTRALIAN TRANSPORT PROBLEMS.

Mr. J. T. N. Anderson, Narbethong, wrote as follows:—

The writer fears that among casual, and the less reflective readers, this paper may be scanned and thrown aside, as too academic and fanciful a treatment for serious consideration from a practical, every-day standpoint. Were it not that he knew that anything coming from Mr. Smith’s pen is likely to contain a valuable kernel of commonsense, it is probable that he too would have treated it in the same fashion.

Bearing in mind that the paper only deals with one aspect of the great problem—and that aspect shorn of all complications—then the conclusion as to the alteration of spheres of influence is obviously as the author states it. That these ideal conditions should obtain, is, of course, impossible; but, at the same time, it was not a waste of time for the author to work out the problem, nor for us to consider it, because it is a real step, even if a small, timid, short step, towards the development of one of the biggest trade questions of the twentieth century.

The most definite and practical part of the author’s work was that concerning itself with Panama and Singapore, as trade centres. Here the disturbing factors which are so abundant in the large problems, are almost entirely eliminated.

To-day Singapore is the great British Straits port, just as Panama will be the great American Straits port. Plate II. shows that Australia will continue in the European sphere. New Zealand on the other hand is shown on the American side of the frontier.

The paper suggested to him dozens of other subjects for discussion, as, for instance, the probable fate of the Tehuantepec railway. But these are as much beside the present question as the influence of the trade winds as a disturbing factor in the curves of ocean frontier, marked by the author, and will have to be relegated to another place. The writer considers that the Institute is greatly indebted to Mr. Smith for having broken into
new and novel "grounds," or rather "deeps," and only regrets that the rules of the Institute, which forbid political discussion, shut out the opportunity to turn this fertile field to its proper uses.

The President said Mr. Smith's paper was valuable, as it showed what vast questions of economics, commerce, industry and engineering would be involved by the changing of the centre of gravity, brought about by the opening of the Panama Canal. In addressing himself to the paper previously the course followed by the author was clearly indicated, that he had dealt with ocean routes only, and had not considered the disturbing influences of land transport. As land transportation facilities were modified and improved, they would probably alter the exact location of the boundaries of commercial frontiers indicated by the author. There were other disturbing factors.

The author had not done himself full justice by omitting to speak in more elaborated language of the practical conclusions to which his paper pointed. For example, though he had realised for long that when Mr. Smith put anything to paper it was well worth close analysis, because there was always solid stuff in it; yet he (the speaker) had really failed to realise one very striking point, that at the present time the western coast of North America was no further from Plymouth than from New York by sea. Thus, to use the Atlantic route round the Horn was not a matter of more than a few miles difference from the route from Plymouth, so that, at the present time, the whole of the eastern portion of South America was equally distant from New York and Plymouth. The Canal was going to alter all that. These and many other considerations of the kind indicated what vast problems were involved, and how in the next generation or two trade relations, the course of trade, and even political relations were likely to be enormously modified by that great engineering work. Because they must remember always that the genesis of those prospects lay in one of the most wonderful, bold, courageous phases of engineering that the world had ever contemplated, and however great the statesmanship which formulated the scheme, it would have been helpless without engineering skill to carry it to perfection, so that in the end the engineer was the implement for bringing about such an enormous change in human affairs.
Mr. J. A. Smith, in reply, said he would first take Mr. J. T. N. Anderson's contribution to the discussion. He appreciated Mr. Anderson's kindly references to the paper and its author; but he thought Mr. Anderson had just a little missed the object of the paper and its full scope. Mr. Anderson had said that amongst casual or less reflective readers the paper might be put aside as hardly to be taken seriously. The paper was not intended to be read by casual or non-reflective readers. It dealt with a point of the very greatest importance to Australia, and not only to Australia, but to all the nations that Australia would feed. And he took it that any contribution to that matter, provided it broke new ground, and if it were definite, as far as it went, would be read by those who had a serious interest in the great problem of transportation, and it would be read by those men in the light of a lifetime's experience of the administrative engineering problems.

It was not intended to be a popular paper. He had dealt with the matter on more popular lines in the 1913 "Australia To-Day." It was intended to deal with one particular phase, and to deal with it in formal, geometric language, so that there should not be any question as to the accuracy of the deductions. Mr. Anderson did not question either the premises of the paper, the mathematical treatment, which he did not touch upon at all, or the conclusions, so that left him (the speaker) comparatively little to answer.

One point he had dealt with, and that was the statement (if he had heard and grasped it rightly) that Plate II. showed that the position of Australia in regard to its world environment had not been altered. Plate II. showed a number of things, which Mr. Anderson had not touched upon, but it certainly did not show that. It showed, on the contrary, that the European-American frontier which was now far east of Australia, when the Canal was opened would be brought west so that it would bisect Australia. In fact, the crux of the question in regard to the Commonwealth, was the great alteration that would take place. Mr. Anderson must have misread the paper in this respect.

One other point of contention was that Mr. Anderson considered Singapore as the Asiatic centre. He questioned whether that would be so. Singapore was a strategic point, undoubtedly; but it was on the extremity of a long isthmus, without a feed-
ing continent behind it, and beyond that, the fact remained, that the great railway centres of the east were developing at Canton, Shanghai and Saigon. He was not prepared to admit that the two points to be compared were Singapore and Panama. All traffic that passed from Panama passed through a ditch, and under the guns of the guarding forts. There was not the same necessity for traffic to pass close to Singapore. There was a very marked and fundamental difference.

Mr. Anderson appeared to consider the paper should have been on more popular lines. He had explained why it was not couched in popular terms. Mr. Anderson also thought he should have dealt with the great questions of international policy that arose. He could not think so. The paper was brief, and dealt with one point, and specifically he had stated that, "Since the Institute was precluded from considering phases of the question other than those distinctly relating to engineering, it would be unwise to hazard conclusions which could not be supported by discussion." He still thought it would be unwise to hazard an interpretation of the very secret and complicated process of foreign diplomacy, and he did not feel that he had the knowledge that would enable him to speak with authority on those matters.

He was glad to find the President coincided with him on so many points. On one point he had to differ from him in a friendly way—in regard to Sydney. At the last meeting the President had advanced the view that Sydney was to be the commercial distributing centre of Australia. He was not sure that he could agree with that. It might be held that since Panama would permit the passage of a ship of greater draught than Suez the first operation of the Canal would be the passage of heavy draught steamers from Europe to the Eastern coast of Australia—steamers so large that it would be a commercially sound policy to distribute by means of lesser coastal steamers to subsidiary ports. But as soon as the commercial situation justified it, Suez would surely be deepened. From Europe in the Mediterranean the route via Suez was much shorter. Whilst New York would be brought greatly nearer to Australia by the sea route via Panama, it must not be forgotten that the distance from Plymouth to Sydney, via Suez, was 1300 miles less than by the alternative route, via Panama. The advantage of Melbourne, Adelaide, and West Australia, in respect to Plymouth, was even greater. So he thought that would not tend to make Sydney
the centralisation point, because clearly the Western and Victorian ports were closer to Europe.

Taking the American trade only, and starting from Panama, the difference on the long distance from Panama to our coast was not material, whether Sydney or Melbourne was the terminus. If the trade for Australia was so small that one or two great vessels could carry it, then it might be sound to land it at one point and distribute; but in the near future the trade would be so great that there would be no difficulty whatever in loading the largest vessel that could pass through Panama, not only at Sydney, but at any one of a number of the ports all round the coast—north and south. Then, in regard to passenger traffic, there might be the few to whom time was everything, and money was little. They might leave the boat at Sydney, and go overland to Western Australia, if that were their destination, but the great majority would not tranship at Sydney, if the boat went on. He thought if they considered the enormous traffic that the future held in regard to Asia, they would find Darwin and Brisbane had a marked advantage over Sydney.

As to the interior lines of Australia, the ports that, beyond all others, commanded the greater area, were Adelaide and Port Pirie. If they compared the area within a given radius, they would be surprised how much of Victoria, New South Wales and Queensland naturally centred at Adelaide.

The rail through Canada was an alternative; he had not elaborated this phase, but it was an alternative route for a great proportion of the traffic from Europe eastward, when time was the essence of the proposition. He had mentioned the matter in the concluding paragraph of his paper, which, he thought, the President had overlooked in assuming that the alternative of land transport had escaped consideration. The paragraph read as follows:

"Also, sea frontiers are modified when long alternative land lines intervene. Then the rail, supported by internal interchange—the path across the ocean is a path across a desert—is a factor which must be considered, for it cannot be contended that the rail has approached its ultimate economic possibilities. It has yet to break away, as naval architecture and engineering have broken away, from the limitations of its past.

"Canada must be considered. Africa must be considered, and when Asia—which is physically one with Europe—shall be
traversed by trunk railway systems, designed in a larger spirit of fitness for their future purpose, when it shall be reticulated with subsidiary systems, when the inevitable consequent homogeneity of industrialism shall have followed, Australia's engineering plan and commercial future may be no less closely knit with the East and the rail, than with Panama and the new sea route."

Beyond those points he thought there was nothing for him to answer.

Mr. Smith then submitted and explained a number of lantern slides bearing on the paper and on the works at Panama.

The President thanked Mr. Smith for exhibiting the slides, which had added materially to the value of the formal discussion.

The discussion then closed, and the 1913 session terminated.
The European-American frontier in the Pacific in relation to Panama and Australian transport problems (Paper & Discussion)