$$\therefore k\left(\frac{d\theta'}{dt} - \frac{d\theta''}{dt}\right) + c^2 R = \cdot 4176 - \cdot 00083.$$

$$= \cdot 4168 \text{ Watts}$$

The mean difference in Temperature for this range was —

$$(\theta'' - \theta') = 104 \cdot 3^\circ$$

From equation (3)

$$\lambda\ (\theta'' - \theta') = k\left(\frac{d\theta'}{dt} - \frac{d\theta''}{dt}\right) + c^2 R$$

$$\therefore \lambda = \frac{\cdot 4168}{134 \cdot 3} = \cdot 00399$$

Substitute this value of $\lambda$ in equation ... ... ... ... ... 2

$$\lambda\ (\theta - \theta') = k\frac{d\theta'}{dt}$$

$$= \frac{\cdot 1315}{\cdot 00399} = \theta - \theta' = 3 \cdot 28^\circ$$

$\theta' = 41^\circ$ @ $240^\circ$ crank position

$\therefore \theta$ = gas temperature = $44 \cdot 28^\circ$

This gives the temperature of the gas at the mean position of the range 220 = 260. In this manner the gas temperatures have been calculated in Fig. (1—4 and 10—13)

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## Discussion.

Mr. G. A. Julius said: I think a paper bearing upon the question of Turbulence is very much in season at the present time, and I feel that I am possessed of as little true knowledge in connection with the gas engine at this moment as I am in regard to the condition of affairs in Europe from the information supplied by the Sydney daily papers. I will say, however, that after having read the paper through very carefully on two occasions, and also enjoyed the privilege of hearing it read by the author, I am convinced that it will have the effect of sweeping away many doubts and difficulties in regard to the operations in the cylinders of an internal combustion engine. I think you will all agree

with me when I say that nothing can be of greater importance in connection with things mechanical than a sound knowledge of the engine of which mention has been made, because no development which has taken place in engineering work has been more extraordinary than the development of the internal combustion engine. Only a few years ago motor-cars were practically unknown, while to-day they number hundreds of thousands. The difficulties which lay in the path of the would-be aviator have been solved practically through the development of the internal combustion engine. But it is not, I fear, appreciated by a large majority of engineers, and by the world in general, that the development referred to is the result of such work as we have heard described this evening. The paper, as read, unfortunately conveys, I think, but little to most of us, because it requires a great deal of time and study to digest the matter contained therein. At the same time, no one can fail to realise the magnitude and importance of the problem, and also the fact that the paper contains an immense amount of valuable information which will assist in its final solution. We, as members of this Association, and as residents in Australia, are in an unenviable position in so far as the matter of securing papers on original research work is concerned. Indeed, it is very rarely that we are able to obtain papers by the authors which afford us information in regard to their own work, and I therefore think that this Association is to be congratulated on account of the privilege they have enjoyed in listening to the remarks made by Mr. Swain during the course of the evening. The ingenuity of the methods displayed in regard to the measurement of temperatures, resistances and pressures is very marked, and I have no doubt that a closer study of the subject matter, as set out by the author, will have the effect of compelling us to consider the relative merits of the

problems which have arisen between the sleeve valve engine—or, as we know it here, the "Silent Knight" and the poppet valve engine. There can be no question about the fact that the turbulence—gas velocities—associated with the valve design, have played an enormous part in the efficiency of the internal combustion engine in just the same manner as they do in the old steam engine, in connection with which everyone knows the extraordinary loss of power and efficiency due to the inefficiency of the valve design.

Some years ago I carried out an investigation for one of the Governments in connection with a new design for an express locomotive, which produced some remarkable results at high speeds, and upon analysis it was shown that the whole trouble lay in the inefficiency of the valve-openers. The result of that investigation, however, enabled the Department to modify the design and obtain increased efficiency. So work performed in the able way in which it has been performed by the author of the paper, which has been read to us this evening, must enable thinkers and designers at Home—there are very few in this country—to arrive at a more exact knowledge of what has transpired in the cylinder of the internal combustion engine, and assist them in the work of perfecting what is already one of the most useful motors knows at the present time.

The paper, as read, does not, to my mind, permit very much in the way of a discussion upon its evident merit, as it is really a description of exact work carried out by an exact investigator. I feel that we are unable to attempt anything in the way of a criticism upon it without having read it through at least half a dozen times and testing it for about six months.

I have very great pleasure in moving a hearty vote of thanks to Mr. Swain for the valuable data which he has placed before us this evening.

Mr. J. W. Bragg said: I have the keenest pleasure in seconding the vote of thanks proposed by the previous speaker. I must confess that, although I succeeded in following the author through the first few paragraphs, I was soon left lamentably in the rear; but that did not in any way reduce my appreciation of his work. He has shown us the fruits of his labours and investigations in such a manner as to convince us of the magnitude of his task, and I feel that a further study of the facts placed before us will enable us to grasp, to some extent at any rate, the solution of many difficulties in connection with the subject.

Mr. J. Thompson said: I have very much pleasure in supporting the hearty vote of thanks which has been proposed. A little while ago I was fortunate enough to obtain a paper dealing with the subject of gas engine research work, and a couple of statements contained therein greatly assisted me in following the author this evening. The paper to which I have referred dealt largely with the turbulent gases in the gas engine, and indicated very conclusively that the efficiency of the gas engine depended to a great extent on the turbulence of the gases produced partly from the inrush of gas through the valve, and partly from the speed of the engine itself. The increased efficiency due to turbulence appeared remarkable. The experiments were made with the valves stripped, in which, of course, there was very little turbulence, and the difference in results was most marked, especially in regard to the inflammation of the gases. It was proved that the gases were inflamed 2½ times quicker when the engine was in its normal condition than when the gases were steadied. The indicator cards showed a very marked increase in efficiency.

Mr. H. Crams said: I think we are deeply indebted to Mr. Swain for the valuable data supplied this evening. Some time ago I was perusing volume 1 of Dr. Zeurner's

works on Technical Thermo Dynamics, in which it was stated that in the four phases of the 4-cycle engine—that is, the four half-strokes of the engine—the two phases, viz., the suction and the compression, had taken place in one cylinder, and at the point of explosion it was transferred into the other cylinder, where explosion and exhaustion took place. I thought at the time of reading that it was rather a novel experiment to carry out, and would like to ask the author if he has ever tried it.

MR. SWAIN said: I thank you for the cordial manner in which you have received my paper, and I can assure you it is a very great pleasure to me to find it has interested you. I do regret, however, that you are determined to let me off so little, although it is the result of experiments extending over a period of three years. In fact, it is only now that one realises the amount of time required to go exhaustively into such matters as those which have been discussed this evening. In reply to Mr. Crams, I may say that I have never heard of any engine working in the way he has described.