Lamda (λ) is used to indicate the rate of loss of energy per degree centigrade difference in temperature between the heating temperature and the gas temperature. Lamda (λ) is therefore a measure of the Thermal Conductivity of the Gas.

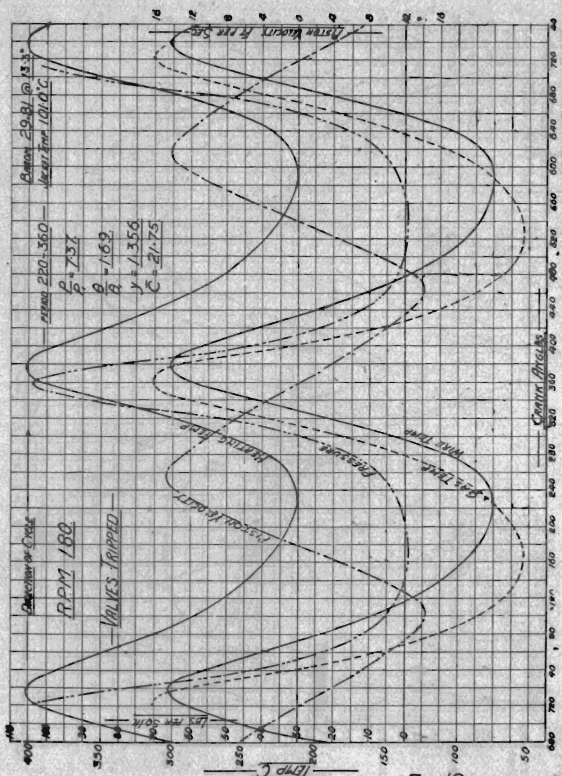
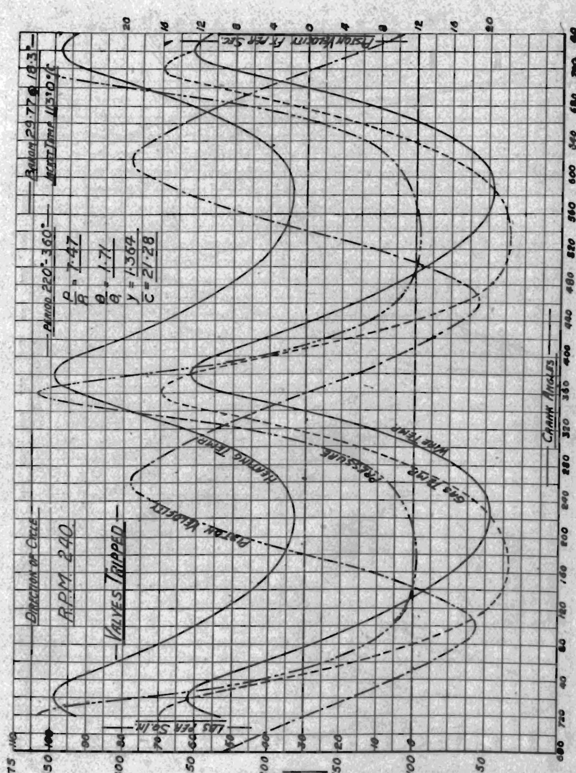


FIG 12.

Iron Vessel Experiments.— A cast-iron vessel, about 9 inches diameter and 9 inches deep (inside dimensions), fitted with a well-jointed cover, and provided with a carefully calibrated pressure gauge was connected to a cylinder of compressed air through a cock, by means of which pressures could be maintained in it at least equal to those met with during the engine cycle.

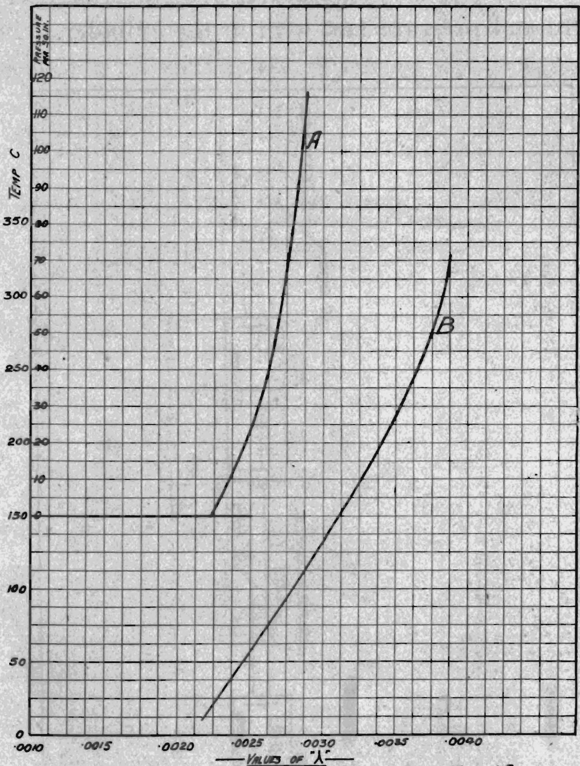
Two wires (No. 14 B.W.G.), insulated through the cover, reached to about the centre of the chamber, and supported at their extremity a length of about 5 c.m. of the fine platinum wire (.001 in. diameter).



— FIG 13. —

The resistance of this platinum was measured at various air pressures, both when a non-heating current of .003 amperes was used, and also when a heating current of .2 amperes was employed. The readings were taken some time after the compressed air had been admitted, in each case to obtain as steady a condition as possible.

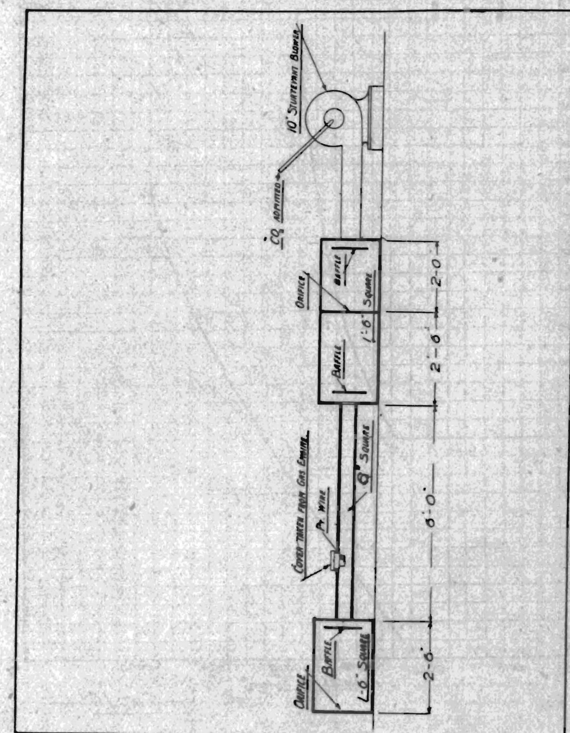
Temperatures were calculated from these resistances, and also the value of " λ ". The value of (λ) Lamda under various conditions of pressure and at constant pressure is shown plotted in Fig 14A.



—FIG 14—

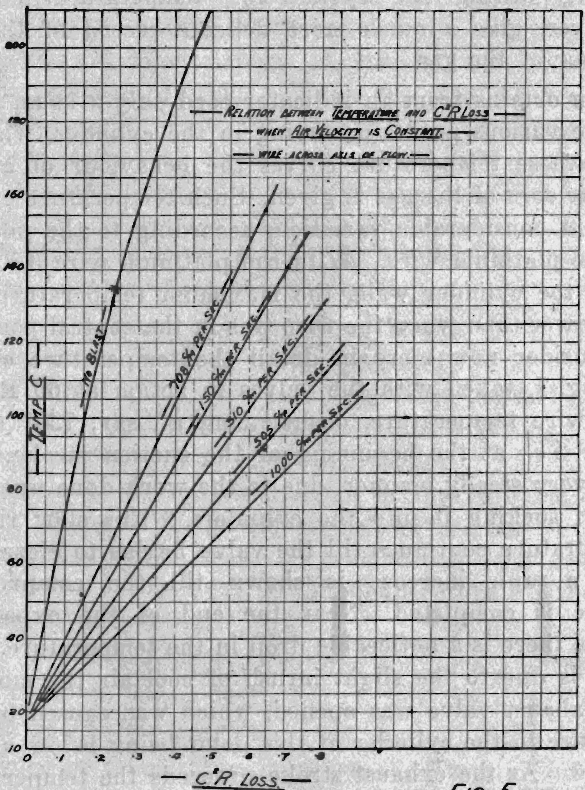
The same vessel was used to obtain the value of Lamda (" λ ") with the pressure constant and a range of temperature similar to that met with in the cylinder. The vessel was heated by a large bunsen burner.

The value of (" λ ") Lamda under various conditions of temperature with the pressure constant was shown plotted in Fig. 14B. From these experiments it was clear that the relative conductivity of air increased both with increase of pressure and also temperature within the limits met with in the engine cylinder. The increase was more marked in the case of temperature than pressure, amounting to over 28 per cent., due to pressure, and over 75 per cent., due to temperature, over the range of temperature and pressure met with in the cylinder.



— FIG 6 —

Constant Velocity Experiments.—In this series of experiments the resistance of a length of the platinum wire was measured in a stream of air moving at various constant velocities, both when a heating and a non-heating current was used. A sketch of the apparatus used is shown in Fig. 6. The temperatures of the wire, calculated from the resistances, have been plotted against energy supplied to the wire at different gas velocities, both when the platinum wire was across the axis of the pipe, and also when along the axis of the pipe. The curves in Fig. 5 give the relationship between temperature and energy when the wire is across the axis of the pipe. A similar set of curves was obtained when



— FIG. 5. —

the platinum wire was along the axis. With the heating current of .2 amperes there is a small loss by radiation when the air was still. This is shown in Fig. 5 by the slight curvature for the "no blast" curve. The error due to neglecting this small radiation effect was considered negligible in these results.

General Discussion of Curves.

Before proceeding to discuss the results of these investigations it would be advisable to consider in a general way the meaning the curves (Figs. 1 to 4 and 10 to 13) convey. The pressure curves need no comment, being simply replots of the indicator cards. The piston velocity curve is the curve of instantaneous piston velocity during the cycle. The temperature curves, however, give a much more delicate record of the behaviour of the gas.

One obtains from an indicator card only a mean value of the various events occurring in the cylinder, whereas with these temperature curves the behaviour of a particular core of the gas is given. Such temperature curves show a considerable variation, according to the position of the platinum wire. With the platinum wire 3.5 m.m. from the cylinder walls the maximum temperature was 30° lower than when the wire was in the central position.

Consider now more in detail the temperature curves of Fig. I, taken with the valves in action at 60 R.P.M. The wire temperature, commencing at, say, 720° crank angle, i.e., at the beginning of the suction stroke, rises in a very steady manner, due to the work done upon the air in sucking it into the cylinders. This slow rise in temperature continues till the valve begins to close, and then a rapid increase is shown till the compression stroke is completed. Near the end of the expansion stroke there is a noticeable drop in the temperature. This drop is due to the slight inrush of cool air the moment the exhaust valve was opened, which was caused by the pressure in the cylinder at this point being below atmospheric. As the exhaust stroke proceeds the temperature rises slowly, due to the work done on the gas in being expelled. The wire curve right through the cycle gives the idea of various events being performed in a very steady manner.

Next consider the heating curve (Fig. I). It must be remembered that the heating temperature is the temperature of the platinum wire, and is considerably hotter than the gas. From the beginning of the suction stroke the heating curve shows a reduction in temperature till about 100° crank piston is reached, when a rise in temperature occurs. The reduction in temperature shows a gradual increase in gas velocity, and this velocity appears as a function of the piston velocity, for the minimum heating temperature occurs at the position of maximum piston speed. The temperature of the heated wire then increases rapidly, showing that the gases are moving more slowly, i.e., the turbulence is diminishing. At 360°, i.e., at the top of compression, the air is practically at rest, but the increase of the temperature of the heated wire is not so marked as at the beginning of the compression, where a certain amount of turbulence existed. The reason is the increase of the relative conductivity of the air due to increase of temperature and pressure.

Continuing along the expansion stroke the difference in temperature between the heating and the wire curves becomes greater, due to the diminution of the turbulence. When the exhaust valve opens there is a huge drop in temperature, which shows particularly well the inrush of cool air due to the gas in the cylinder being below atmospheric pressure just before the exhaust occurs. After this drop in temperature the heating curve shows a continual rise in temperature till the beginning of the suction.

The curves (Fig. 2, 3, 4) showed similar characteristics right through the cycle to Fig. I, but the disturbances are all of greater magnitude, as shown by the smaller difference in temperature between the heating and wire temperature.

The curves (Figs. 10, 11, 12, 13) give results which show the elimination of the disturbances due to the valves. Neither the heating nor the wire curves show any evidence of turbulent motion, and it is quite certain that the gas has only a movement due to the piston motion, and is quite free from turbulence.

A comparison of Figs. 1 and 10 gives a fair estimate of the similarity of motion during the latter portion of the expansion strokes, which would suggest that there is little or no turbulence at that speed, viz., 60 R.P.M.. during that part of the stroke.

General Discussion of Results.

The values of λ have been calculated from curves (Figs. 1 to 4 and Figs. 10 to 13) at three points in the cycle, viz., 240°, 360°, and 480°, and are given in Table I. The reason for choosing these particular points of reference is as follows:—

—TABLE 1—

Engine Revs. per Min.	Crank Angle 240°	Gas Temp.	Crank Angle 360°	Gas Temp.	Crank Angle 480°	Gas Temp.	Remarks	Max. Press.
60 V.T.	·00346	35	·00631	230	·00318	11	V.T. in Revs. Column Signifies Valves out of Action	105·3
60	·00388	44	·00768	247	·00289	14·5		100·8
120 V.T.	·00327	75	·00640	300	·00296	57·5		104·5
120	·00515	47·5	00773	252	·00332	26·5		109·0
180 V.T.	00360	83	·00650	315	·00308	69		104·4
180	·00638	56	·00850	262·5	·00406	34		110·0
240 V.T.	·00336	55	·00745	275	·00334	48		104·0
240	·00815	61·1	·001048	274	·00424	40		113·0

—TABLE 2—

Engine Revs. per Min.	Crank Angle 240°	Gas Temp.	Crank Angle 360°	Gas Temp.	Crank Angle 480°	Gas Temp.	Remarks	Max. Press.
60 V.T.	·00324	15	·00307	15	·00321	15	V.T. in Revs. Column Signifies Valves out of Action	Atmospheric Pressures
60	·00352	15	·00366	15	·00289	15		
120 V.T.	·00274	15	·00290	15	·00260	15		
120	·00463	15	·00365	15	·00319	15		
180 V.T.	·00297	15	·00293	15	·00262	15		
180	·00563	15	·00397	15	·00382	15		
240 V.T.	·00296	15	·00344	15	·00299	15		
240	·00708	15	·00482	15	·00390	15		

(i) 360° is the top of compression, and in that position the air when not turbulent should be comparatively still.

(ii) 240° and 480° are positions of equal piston displacement on the compression and expansion strokes and when the engine is running normally, all the valves are closed during that period, and therefore the turbulence should show a subsidence.

The values of "λ", given in Table I, are all calculated at the various temperatures and pressures given on the curves (Figs. 1 to 4 and 10 to 13). Table 2 shows these values corrected to a temperature of 15° C., and atmospheric pressure by means of the results of the closed vessel experiments which are shown plotted in Fig. 14 A B.

The values of "λ", given in Table 2 for the different speeds with the valves out of action, are in substantially good agreement for the crank positions 240° and 480°, and show that the condition of the air in these two positions is very similar.

The values of "λ", when the valves are working normally, show quite clearly an increasing disturbance of the gas at 240° crank position with the increase of revolutions, and also a diminution of gas disturbances during the crank period 240° to 480°.

Fig. 7 shows the value of "λ" plotted against air velocity as obtained from the constant velocity experiments. Three curves are obtained as follows:—

(C) When the platinum wire is along the axis of the pipe.

(A) When the platinum wire is across the axis of the pipe.

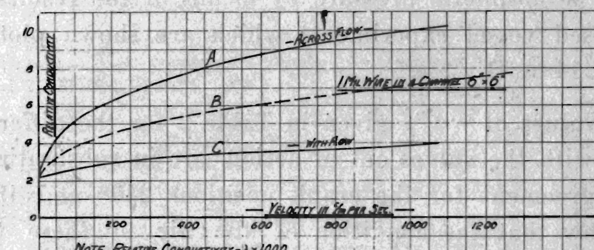
(B) A mean value of conditions (C) and (A).

It was considered a fair assumption to suppose the air in the cylinder behaving as in condition (B) owing to the shape of the combustion chamber, and also on account of the position of the wire relative to the exhaust valves.

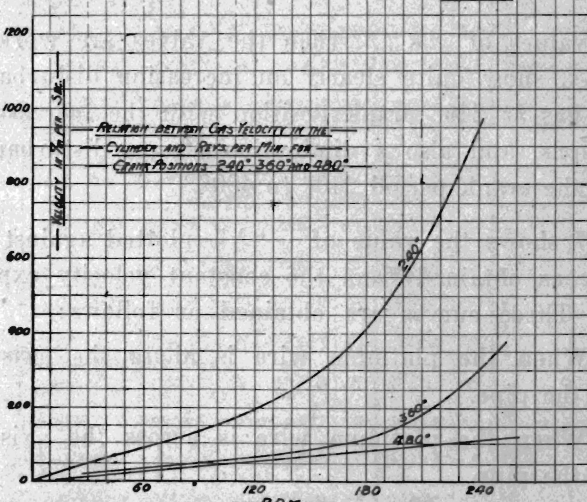
With the aid of curve (Fig. 7B) gas velocities were obtained for the various values of λ given in Table 2. These velocities have been determined, and are shown plotted in Fig. 8 for the various engine speeds.

Consider the curves (Fig. 8), more in detail.

Curve for 240° Crank Position.—The curve for 240° position infers that as the engine speed is increased from 60 to 120 R.P.M., the gas velocity is doubled,



—FIG. 7—



—FIG. 8—