INVESTIGATION OF THE EFFECTS ON CYLINDER PERFORMANCE OF VARIATION OF POSITION AND NUMBER OF SPARK PLUGS

(Power Plant Section Report)

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INVESTIGATION OF THE EFFECTS ON CYLINDER PERFORMANCE OF VARIATION OF POSITION AND NUMBER OF SPARK PLUGS.

OBJECT OF TEST.
The test has been undertaken to determine the effect on cylinder performance of variations in the positions and number of spark plugs in operation.

RESULT SUMMARY.
Straight line charts summarizing the results of the test are included in figures 2, 3, and 4. The following general conclusions seem warranted (spark set for best power in all cases):

(a) With detonation eliminated,
1. There is no definite drop in power with reduction in the number of plugs until ignition is restricted to one side of the combustion chamber.
2. There is little difference in power between intake and exhaust plug operation.
3. The required spark advance increases as the number of plugs decreases.

(b) With detonation tendency.
1. The power increases with an increase in the number of plugs.
2. The intake plugs appear to give better power than the exhaust plugs.
3. The spark advance for maximum power varies in general inversely as the number of plugs in operation.
4. Greater spark advance is possible with intake than with exhaust plugs.

METHOD OF TEST.
The results of tests with two similar types of cylinders—the Air Service model W-1 cylinder, 5½ by 6½ inches, and the Air Service W-2, 4½ by 7½ inches—are included in this report. Both cylinders have four plug bosses located horizontally at the sides of the combustion chamber at 90° as shown in figure 1. They were mounted individually on the Universal test engine (attached to a 100-horsepower Sprague dynamometer) and fitted with four single-cylinder Dixie magnetos with selective switches, making possible operation with any combination of plugs. A rotary spark indicator—a revolving pointer and stationary protractor ring forming a rotary gap—was provided to indicate the actual spark setting at each condition. A shunting switch for this system prevented any timing distortion by the auxiliary gap, except when it was opened to take readings. In all cases the spark was set at the position of maximum power.

This report is based on the results of the following runs:
Two runs—W-1 cylinder, 5½: 1 compression ratio, 1,600 revolutions per minute, full throttle, unblended aviation gasoline (W. D. Specification No. 2-40); all plug combinations.

Two runs—W-1 cylinder, 5½: 1 compression ratio, 1,600 revolutions per minute, full throttle, unblended aviation gasoline (W. D. Specification No. 2-40); all plug combinations.

Two runs—W-2 cylinder, 4½: 1 compression ratio, 1,400 revolutions per minute, full throttle, unblended aviation gasoline (W. D. Specification No. 2-40); all plug combinations.

One run—W-2 cylinder, 4½: 1 compression ratio, 1,400 revolutions per minute, full throttle, unblended aviation gasoline (W. D. Specification No. 2-40); all plug combinations.

Except in preliminary check runs, flash readings only of break load and spark advance were taken at each setting. Sufficient time was allowed before readings to insure uniform operation and freedom from excessive detonation. In order to note any temporary variations of engine performance due to other causes, every third reading was made with four plugs in operation.

The Universal test engine and dynamometer are described in Engineering Division Report Serial No. 1321 (W-1) and a memorandum on the W-2 cylinder to the chief of the power plant section dated July 25, 1921.

ANALYSIS.
These results as analyzed may be considered only as general indications of what probably is the influence on cylinder performance of the variations of number and locations of plugs. Because of the instability of conditions in single-cylinder testing and the personal inconsistency in setting controls and taking readings, no single set of runs may fairly be considered a basis for definite conclusions. Slight variations in results, therefore, must be regarded as insignificant or indicative of conditions which are at best speculative.

In discussing the results reference will be made to the straight line charts of test results in Figures 2, 3, and 4. The percentage mean effective pressures recorded there have been computed to eliminate variations due to other influences than plugs and spark settings. The mean effective pressures are expressed in percentage of the average of the two four-plug readings taken immediately before and after them, and called the “per cent of the maximum mean effective pressure.” The W-1 cylinder with 50 per cent benzol is assumed to be free from detonation and the W-2 cylinder at 4½: 1 compression ratio practically so, while with the W-1 cylinder, operating on unblended gasoline, the spark advance is limited by detonation.

The conclusions are tabulated below in three groups:
1. Effects of variations of the positions of the plugs, and the influence on spark advance as set for maximum power of variations and detonation.
2. Effects of variations of the number of spark plugs.
3. Combined effects of variations of the positions and the number of spark plugs.
I. Influence of the number of plugs in operation.

1. With detonation eliminated, four plugs, three plugs, and two (180°) plugs appear to give about the same mean effective pressure-spark set for best power. A definite drop is obtained when two (90°) plugs or single plugs are used.

2. Where detonation limits the spark setting a definite drop in mean effective pressure results from a decrease from four to three plugs. The difference between three and two (180°) plugs is slight. There is a distinct drop in power effected by a change from two (180°) plugs to two (90°) plugs, but little difference between two (90°) and single plugs. In general the power is improved by an increase in the number of plugs in operation when the detonating tendency is present.

II. The influence of the positions of the spark plugs in operation.

1. Three plug combinations.

It makes little difference in performance whether a combination of two intake and one exhaust plug or two exhaust and one intake plug is used.

2. Two plug combinations.

Any combination of one intake with one exhaust seems to show better power than two intake plugs or two exhaust plugs.

Plugs at 180° in all cases show better performance than do plugs at 90°.

With detonation eliminated there is little choice between exhaust and intake pairs, but the intake plugs appear to show better power in the presence of the detonation tendency.


Where detonation is eliminated slightly better power was obtained with exhaust plugs. Where the spark advance is limited by detonation, however, the intake plugs give better power.

III. The influence of number and position of plugs and detonation on spark advance.

1. Variation of spark advance with the number of plugs.

With detonation eliminated the spark advance for maximum power increases as the number of plugs decreases. In the presence of detonation the spark advance for maximum power varies less definitely, in general increasing, however, with the decrease in the number of plugs.

2. Variation of spark advance with the position of plugs.

(a) Three plug combinations.

Under no circumstances is there an appreciable variation of spark advance effected by a change from one intake and two exhaust plugs to one exhaust and two intake plugs.

(b) Two plug combinations.

With detonation eliminated 90° plugs appear to permit slightly more advance than do 180° plugs.

In the presence of detonation greater advance is possible with intake than with exhaust pairs of plugs and considerably more advance with 180° plugs than with 90° plugs.

(c) Single plugs.

Without detonation there is little difference between the advance for best power with intake and exhaust plugs.

With detonation less advance is possible with exhaust than with intake plugs.
Fig. 1.—W-1 and W-2 cylinders—diagrammatic top view showing plug locations and numbers.
FIG. 3. SPARK ADVANCE DEGREES
Fig. 4.