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FIRE HAZARD TESTS
OF IGNITION EQUIPMENT

(POWER PLANT BRANCH REPORT)

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(Draft in full blocked report)
FIRE HAZARD TESTS OF IGNITION EQUIPMENT

OBJECT

The object of this experiment was to determine the extent of the fire hazard from ignition equipment, how the fires are started, and how the fire hazard can be eliminated.

RESULTS AND CONCLUSIONS

(a) Internal explosions may occur in all ignition apparatus now in use in the Air Corps when gasoline is sprayed over the outside.

(b) The gasoline on the outside of the magneto or distributor may be ignited by the flames blown out through the ventilating holes or other openings.

(c) Practically all existing types of ignition apparatus can be made to catch fire when sprayed with gasoline, but usually no fire occurs even when the magneto or distributor is thoroughly soaked with gasoline.

(d) A fireproof ventilating-hole cap has been developed which is applicable to all existing types of ignition apparatus.

(e) A standard method of testing all ignition apparatus for fire hazard has been worked out.

RECOMMENDATIONS

(a) A technical order should be issued requiring the use of fireproof vent caps on all service ignition equipment.

(b) All new types of ignition equipment should be required to pass suitable fire-hazard tests.

INTRODUCTION

As a result of a number of fires in service airplanes, the Matériel Division undertook a systematic investigation of the cause of fires. Since the ignition apparatus is a potential source of fire hazard, an investigation was made to determine the extent of the hazard, the manner in which fires originating at the ignition system are started and the methods required to eliminate the possibility of igniting gasoline or gasoline vapors in or about the ignition system. This investigation was limited to magneto and battery-ignition distributors.

DESCRIPTION OF SET-UP

Tests were made on the following types of ignition apparatus:

Dixie 800 magneto.
Splitdorf 38-12 magneto.
Scintilla 1G-12D magneto.
Liberty-Delco air gap distributor No. 5369.
Splitdorf 12-cylinder distributor for double magneto.

The test set-up is shown in Figure 1. The ignition apparatus was driven by a variable-speed motor and the spark leads connected to the required number of 3-point spark gaps at one side of the test stand. A blowtorch was used to spray gasoline onto the apparatus from all directions and an electric heater used to warm the distributor if desired. An air hose was used to force gasoline into the interior of the distributor and to dry out and ventilate the interior of the magneto or distributor after each internal explosion. Any fires were at once extinguished with the air hose or a hand fire extinguisher.

METHOD OF TEST

Considerable time was spent in trying to find out the conditions most likely to cause a fire. Contrary to what was expected, it was very difficult to cause the gasoline on the outside of the apparatus to ignite. It was easy to ignite the vapors inside the distributor, but in most instances the rate of burning was very slow and only a gentle puff resulted. About one out of ten times resulted in a snappy explosion. When this occurred, the flame could be seen coming out of the vent holes or any other openings around the distributor. But even when flames appeared, it was difficult to ignite gasoline around the vents as the force of the explosion seemed to blow the gasoline away without igniting it. Tufts of cotton saturated with gasoline could be blown several feet from the distributor without catching fire. The distributors were heated to see if this made the gases easier to ignite, but apparently this had little effect. The blowtorch was generated and the hot and completely vaporized gasoline allowed to collect around the distributor, but it was impossible to get an explosion either inside or outside. The electric fan was used to make a draft around the distributor, but no appreciable change was noted. 1/4 Motor 1/4 ether was also used to spray the distributor instead of gasoline, but it did not seem to catch fire as easily as gasoline.

However, fires resulted occasionally from sharp internal explosions, and for the purposes of this investigation it was assumed that any flames appearing outside the distributor constitute a fire hazard and must be eliminated to make the equipment safe.

Since the interior of a magneto or distributor, particularly the air gap type, requires some ventilation, it was decided to develop a type of vent that would give air ventilation and oil drainage and at the same time quench the flames from an explosion inside.

The first method tried was a small cup-like piece of 40-mesh brass screen pressed into a ¼-inch venthole in a molded distributor head. It was a great surprise.
to find that the flames apparently blew right through the screen. This was probably due to the volume of hot gases being sufficient to heat the screen above a red heat and thus permitting the gases to burn outside. It was also found that a hole \( \frac{3}{4} \) inch in diameter and \( \frac{3}{4} \) inch long through a thick portion of a molded rubber distributor did not cool the gases below the flame temperature. By reducing the size of the venthole to No. 54 drill size, 0.055 inch diameter, and counterboring the holes with a No. 29 drill, 0.136 inch diameter, to a depth of \( \frac{3}{4} \) inch the gases were sufficiently diffused and cooled to prevent flames from appearing outside the ventholes. Twelve such holes were drilled in the Splitdorf double-magneto distributors, as shown in the sketch, Figure 2, the inspection hole being plugged with a threaded rubber screw.

A small brass plate about \( \frac{3}{4} \) inch wide and \( \frac{3}{4} \) inch long was next tried as a baffle plate over a \( \frac{3}{4} \)-inch venthole in the breaker housing of a magneto. By offsetting the ends so as to support the plate about \( \frac{1}{4} \) inch away from the metal surface, the hot gases were made to impinge on the metal plate and escape through the narrow space between the two cool metal surfaces. This effectually quenched the flame and prevented any fires. Small rivets were used to hold the plate onto the magneto frame.

As a result of the successful operation of the baffle plate described above, a ventilating-hole cap was designed which can be applied to all service types of ignition apparatus without any extensive modifications. The details of this cap are shown in the drawing, Figure 3.

In passing through the venthole, the flame impinges on the vent cap and is expanded and cooled as it passes out through the triangular openings between the cap and the wall to which the cap is attached. It is only necessary to spot face the surface around the venthole, drill two small holes for the prongs of the vent cap, put it in place, and bend the ends of the prongs over inside. This vent was tested on a Liberty-Delco air-gap distributor, which gives particularly sharp explosions, without causing any fires and without any evidence of flames coming from the vent.

As a result of several hundred trials, the following procedure is recommended for determining the fire hazard of ignition apparatus:

(a) The magneto or distributor shall be mounted in a position similar to that when installed on an engine and the secondary terminals connected to separate 3-point gaps set at 0.4 inch (5 millimeters).

(b) Gasoline (Spec. W. D. 2-40) shall be introduced into the interior in such quantities as to result in a sharp explosion when the ignition apparatus is rotated and the spark switched on.

(c) Before switching on the ignition, the entire exterior of the ignition apparatus shall be thoroughly sprayed with gasoline.

(d) Ten (10) sharp explosions shall be obtained while the exterior of the apparatus is wet with gasoline without causing any fire outside the apparatus.

(e) The apparatus shall be operated at normal speed with the ignition on for 30 minutes. During this time the entire ignition apparatus shall be sprayed with gasoline and then allowed to dry off, this operation being repeated as often as possible during the 30-minute period. No fires outside the apparatus shall result from this test.

The following recommendations apply to the design of new types of ignition:

(a) The design of the ignition apparatus shall be such as to prevent as far as possible any gasoline from getting into the interior in case gasoline is accidentally sprayed on the outside.

(b) All electrical connections to the magneto shall be such as to prevent sparking due to vibration of the magneto or the cables.

(c) The ventilating holes shall be so designed as to act as oil drain holes, if necessary, without forming a permanent oil seal.

TESTS OF SERVICE TYPES OF IGNITION

The Dixie 800 magneto is of the carbon-brush type and has no ventilating holes. It was impossible to cause this magneto to catch fire even though explosions were obtained inside. No internal explosions were obtained by simply spraying the magneto with gasoline. This magneto is considered satisfactory as regards fire hazard.

The Splitdorf Model SS-12 magneto has very little protection against leakage of gasoline into the distributor, and since it has an air-gap distributor, little difficulty was experienced in obtaining internal explosions. Flames come out through the two \( \frac{3}{4} \)-inch ventholes in the sides of the distributor housing and also out of the \( \frac{3}{4} \)-inch drain hole under the breaker. The two holes in the distributor housing were plugged and the drain hole under the breaker covered with a vent cap. With these modifications, it was impossible to obtain any fires.

The Scintilla AG-12D magneto leaks gasoline into the distributor around the distributor blocks and around the booster and ground terminal block. The rubber gasket under this block is softened by the gasoline and soon squeezes out allowing the gasoline to drain down onto the distributor spool, thus internal explosions are very easy to obtain. This magneto has three \( \frac{3}{8} \)-inch drain holes in the base, one beneath the breaker, one under the rotating magnet, and one under the distributor gear. It is necessary to cover all these holes with vent caps before the fire hazard is eliminated.

The Liberty-Delco carbon brush type distributor has three \( \frac{3}{8} \)-inch drain holes in the bottom side of the distributor cup. When sprayed with gasoline, some liquid creeps into the distributor under the distributor head, but no internal explosions were obtained from sparks at the contacts or at the distributor brush. The auxiliary contacts were held open and the distributor run in the reverse direction to cause the sparks to jump to the segments. This made it possible to obtain internal explosions. Two of the \( \frac{3}{8} \)-inch drain holes were plugged and the middle one drilled to \( \frac{1}{4} \) inch diameter and covered with a vent cap. A similar vent was made on the opposite side of the distributor cup. This proved to be entirely fireproof.

Some of the Liberty-Delco air-gap type distributors have a \( \frac{1}{4} \)-inch diameter venthole in the back side of the distributor cup. This caused a fire almost every time an explosion occurred inside. Plugging this vent eliminated the fires from this source.
CONCLUSIONS

These tests show that the Dixie 800 magneto is entirely fireproof. The Liberty-Delco carbon-brush distributor is not likely to cause a fire when sprayed with gasoline, but a fire is possible under exactly the right combination of conditions. The Liberty-Delco air-gap distributor is more likely to cause a fire due to the sparks at the distributor segments. The Splittorf SS-12 magneto and the Scintilla AG-12D magneto will very probably cause a fire if wet with gasoline for any length of time.

The following generalizations are true of all types of ignition systems:

(a) Internal explosions may occur in all ignition apparatus when gasoline gets into the interior and is ignited by the sparking at the breaker contacts or in the distributor.

(b) The gasoline on the outside of the magneto is ignited by flames blown out through the ventilating holes or other openings large enough to permit a flame to pass.

(c) By proper diffusion and cooling, the flames coming through the ventholes can be quenched below the ignition temperature.

RECOMMENDATIONS

Since most of the ignition systems in service constitute a possible source of fire when accidentally sprayed with gasoline, it is recommended that a technical order be prepared giving the necessary instructions for providing fireproof ventilating holes. It is also recommended that all new types of ignition apparatus be required to pass the fire-hazard tests outlined above.

FIG. 1.—Set-up for fire hazard test of ignition apparatus
Fig. 2.—Experimental venting of Splitdorf distributor

DRILL #29 (136) 1/4 DEEP
5/64 (0.055) DRILL 1/2 HOLES EQUALLY SpACED
VENT CAP TO BE USED ON ALL VENT HOLES IN IGNITION EQUIPMENT TO ELIMINATE FIRE HAZARD FROM INTERNAL EXPLOSIONS.

Fig. 3.—Ignition vent cap—four times actual size