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Navy Department

Report on

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Multi-Engine Synchronizer for Aircraft

Developed by

Naval Research Laboratory

Anacostia Station

Washington, D.C.

Tests Conducted at N.A.F., Philadelphia Navy Yard

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1. ABSTRACT.

The multi-engine synchronizer herein described was developed by the Naval Research Laboratory at the request of the Bureau of Aeronautics as a result of tests conducted by the Naval Research Laboratory at the Naval Aircraft Factory in August 1942.

This unit was built at the Naval Research Laboratory, installed in a navy XPBM-1 seaplane and tested both on the ground and in the air at Philadelphia during August 1943.

2. INTRODUCTION.

In an effort to minimize maintenance, a purely mechanical-electrical system was devised. However, the possibility that this system might be used with hydraulic controlled propellers as well as the Curtiss electric, was kept in mind.

The system adopted, operates on a principle of speed matching rather than the conventional frequency or voltage matching devices.

The elements consist of a governor controlled master motor; a set of differential contacts that are driven on one side by the master motor and on the other side by an indicator motor which turns at one half engine speed. A mechanical dithering arrangement was incorporated by which maximum sensitivity could be obtained.

The differential contacts control the propeller pitch by means of relays. In conjunction with the dithering mechanism; incremental adjustments are made when the propellers are near synchronism and continuous correction is applied when there is a large difference in speeds.

A block schematic of the system as tested at the Naval Aircraft Factory is shown in Plate 1.

3. GENERAL DESCRIPTION.

Master Motor - The master motor is a series wound direct current motor which is powered from the ship's twenty-four volt direct current system.

Governor - This governor is of the high-speed hunt type. Centrifugal weights operate a push rod which in turn operates a vacuum contactor. The force on the push rod is controlled by a screw knob arrangement to vary the set speed of the master motor. The vacuum contactor shorts a resistance, in series with the motor, thereby maintaining a balance between the centrifugal weights and the screw knob. In this manner the master motor is held at the desired speed.

Tachometer Indicator - The tachometer indicator is a standard Mark V indicator head geared to the master motor shaft to indicate the master motor and synchronizing speed.

Dithering Mechanism - The dithering mechanism has two gears, slightly different in diametric pitch, which are driven by the master motor. These gears in turn drive a cam and cam follower respectively. This gives a periodic fluctuation in the speed of the rotating shaft driving one side of the differential contacts.

Differential Contacts - The differential contacts are mounted on two discs. On the disc being driven by the dithering mechanism, there are two contacts. The second disc is friction driven by the shaft of a tachometer indicator motor. This disc has one contact which will make one or the other contacts, depending on whether it is being rotated above or below synchronous speed. One of two contacts on the first disc is connected to the increase prop pitch relay and the other to the decrease.

Prop Pitch Control - The prop pitch control system is operated by the differential contacts which increases or decreases the pitch of the prop depending on which side of synchronous speed the engine happens to be. As the engine approaches synchronous speed the dithering begins to function and brings about the phenomenon known as notching. The object of this notching is to suppress hunting where small changes in RPM are desired.

Tachometer Motor - The tachometer motor is a standard Mk V tachometer indicator with the dial head removed. This motor drives one side of a set of differential contacts thru a friction clutch.

Tachometer Generator - The tachometer generator is a standard Mk V tachometer generator and is mounted in the accessory section of the engine to be controlled. It turns at one-half engine speed. The output from this generator drives the tachometer motor so that the motor also turns at one-half engine speed.

4. INSTALLATION.

This engine synchronizer was installed in the XPBM-2 (Martin Mariner) at the Naval Aircraft Factory, Philadelphia for ground tests and flight tests.

5. RESULTS OF TESTS.

After installing the synchronizer and phasing out the various circuits, it was ground tested. The starboard engine synchronized with very little difficulty and locked in nicely, but the port engine would hunt. This hunting which occurred during the tests of this synchronizer might be attributed to over-sensitivity of the carburetion system.

It was attempted to ascertain the cause of this hunting, but no favorable results were experienced. The brake on the prop pitch control was overhauled. The tachometer generators mounted on the engines were changed around. The starboard synchronizing system was changed over to the port engine and still it hunted. The cause for the port engine hunting while the starboard engine locked in was never ascertained, but was attributed to the difference in characteristics of the two engines. The Naval Aircraft Factory Maintenance Personnel later determined that the carburetion system of the port engine was incorrect.

The hunting condition was corrected by putting pilot relays in the circuit with time delays. The sensitivity of the system was decreased by using this method, but the two engines locked in at synchronous speed. When the synchronizer was flight tested under these conditions, it locked in; but it synchronized a bit slowly and locked in about 50 RPM above master motor indicator speed. It was found that the indicator motor's pull-in torque was so small that the motor ran as an induction motor with a 50 RPM slip. This condition was corrected by decreasing the loading on the indicator motor shaft. The time delay relays used a condenser in parallel with the coil. The condenser size required was so large in capacity that electrolytics had to be used. At high altitudes the capacity of electrolytics drops off to nothing due to the decrease in temperature. The slugged relays that were ordered for this purpose came in, but were not as specified in the contract.

The slugged relays were installed, and a chopper was incorporated. When the synchronizer was flight tested this time, it synchronized perfectly, but slowly.

4. CONCLUSIONS AND RECOMMENDATIONS.

The Laboratory recommends that the Bureau of Aeronautics obtain a suitable source of manufacture for pre-production or production units and introduce this propeller control unit for a service test as soon as practical.

As a result of the tests it was found that by some redesigning it would be possible to greatly increase the speed of synchronizing. It is possible with this system to construct a four engine synchronizer of one-fourth to one-third the size shown in Plates 2, 3 and 4 and with a maximum weight of twelve pounds for the complete unit.

Drawings suitable for use in production are now being made at the Naval Research Laboratory and will be completed about the middle of October, 1943.

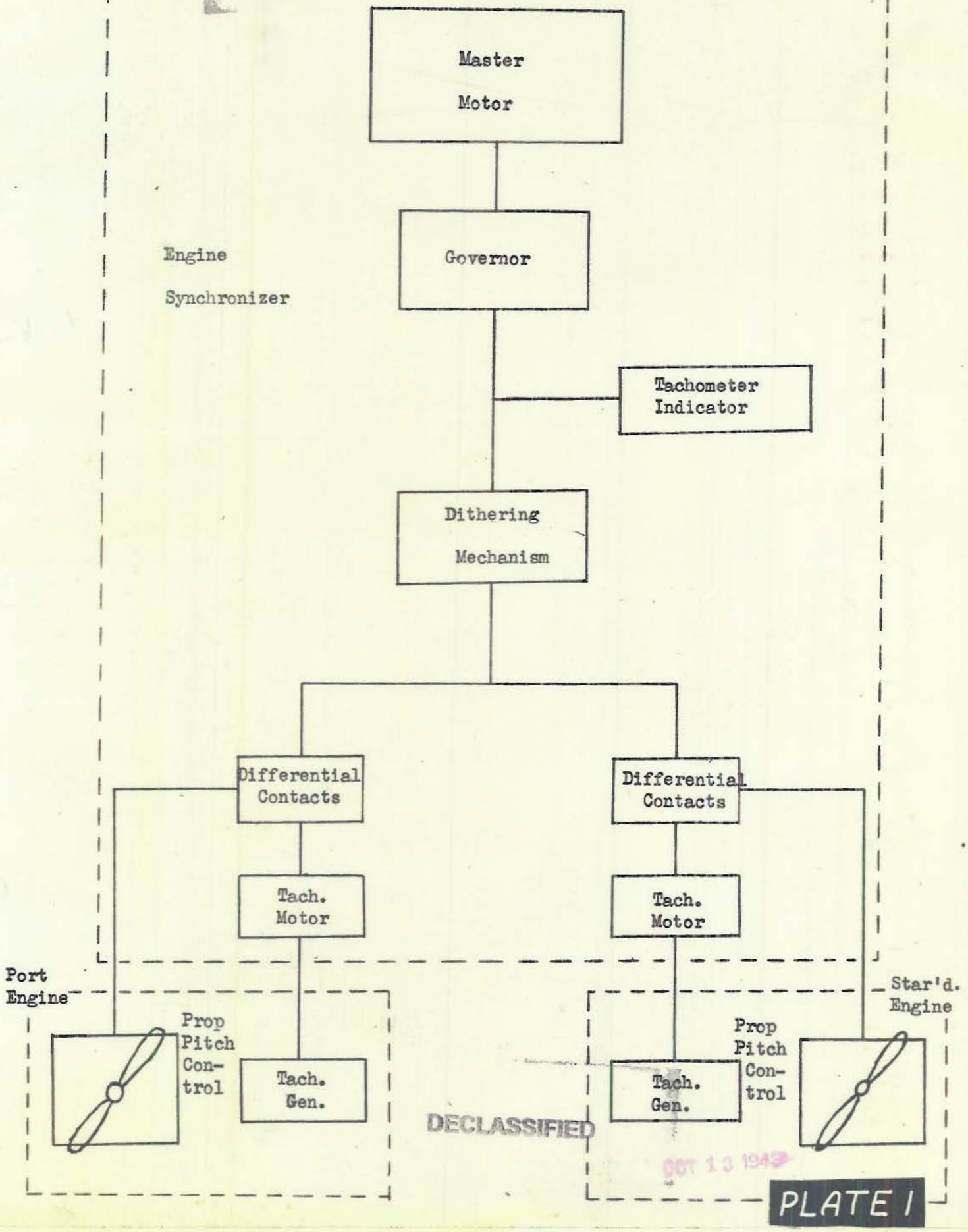

PLATE I

PLATE 2

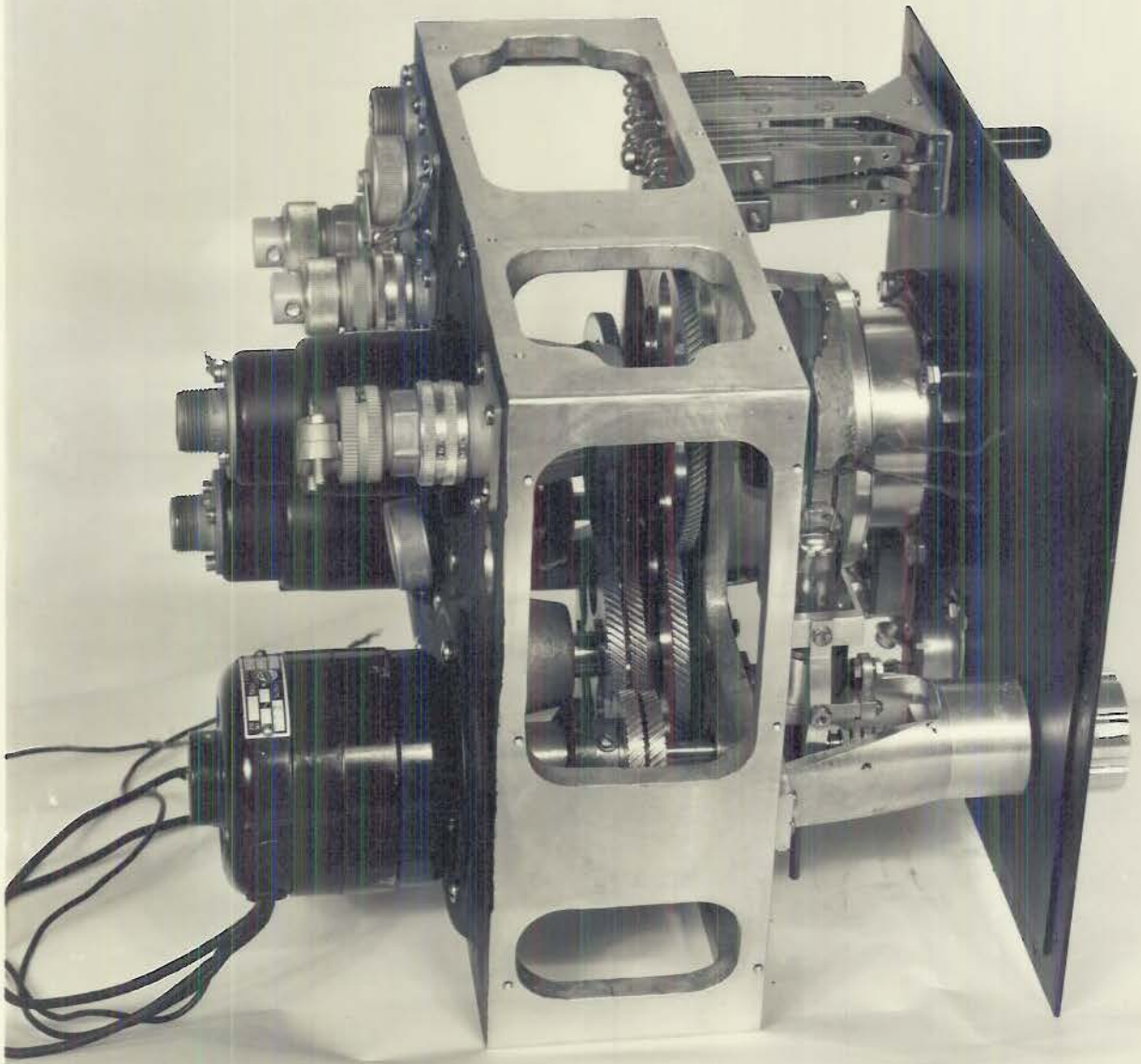

PLATE 3

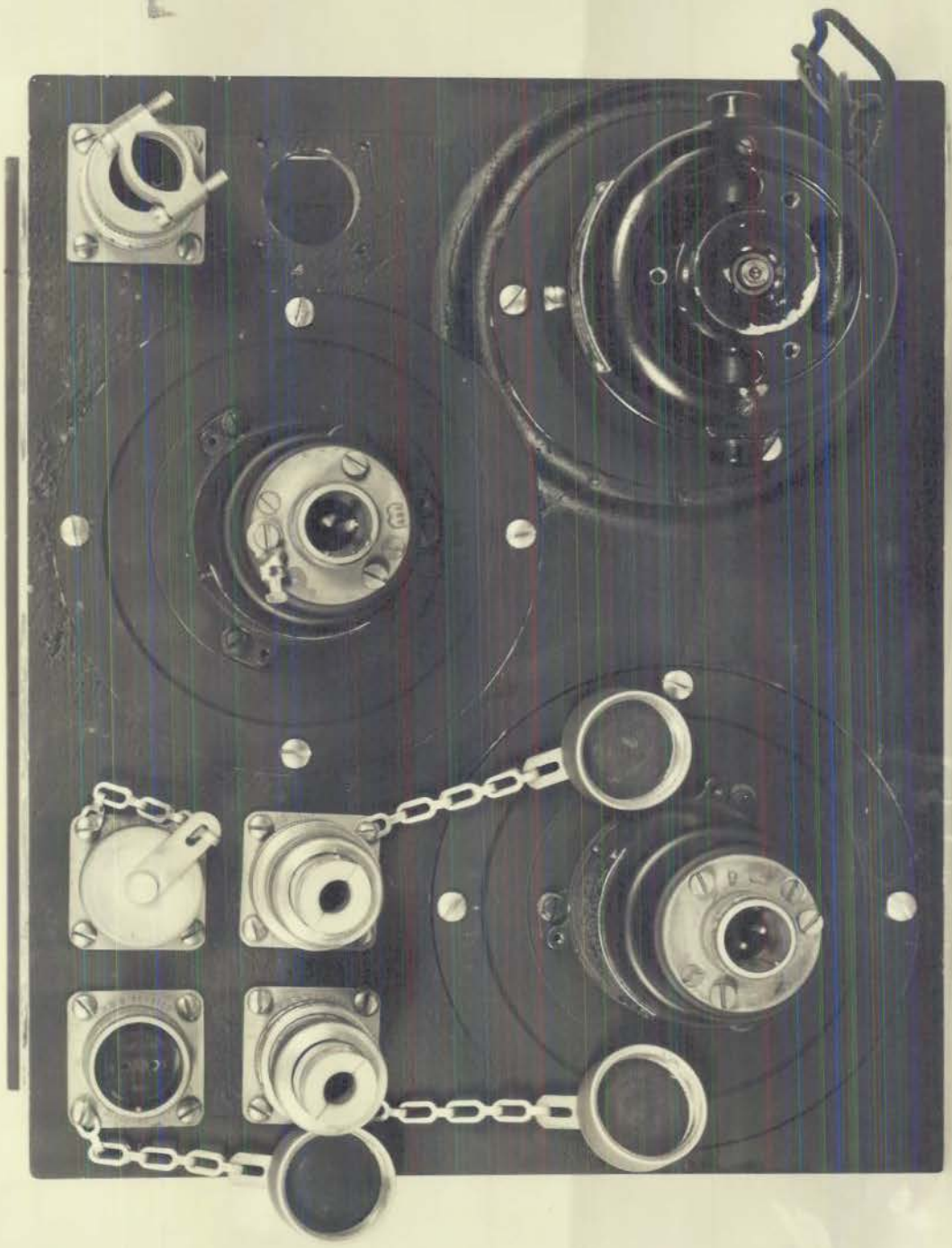

PLATE 4