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FINAL REPORT ON COLD STARTING OF RECIPROCATING
AIRCRAFT ENGINES



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PREPARED BY

Committee S-4, Cold Starting Requirements

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FINAL REPORT
ON
COLD STARTING OF RECIPROCATING AIRCRAFT ENGINES

INTRODUCTION

Conventional internal combustion aircraft engines require the same basic conditions for starting in cold weather as they do in warm weather. These are:

- (1) The engine must be cranked at a reasonable speed.
- (2) A combustible mixture must be delivered to the cylinders.
- (3) An ignition spark must be supplied which is capable of igniting the charge at the proper time.
- (4) The fits and clearances of mating parts in the engine must be such that normal functions occur at all temperatures.
- (5) The engine must receive a usable lubricant.
- (6) The engine must develop sufficient power to overcome its own friction and accelerate itself to the desired operating speed.

Of these basic conditions, supplying a combustible mixture to the cylinders during the cranking period, the acceleration period after initial firing, and the interim idling period prior to the carburetor or fuel metering device becoming active, present the most difficult problems.

The use of an ignition system "booster" has been found necessary to insure an adequate spark to ignite the charge in the cylinders under all conditions. Spark plug icing, resulting from unsuccessful starting attempts, has been a major obstacle. By maintaining a steady and uniform supply of combustible mixture to the cylinders, resultant continuous firing prevents the formation of ice.

Oil dilution has been one of the most difficult problems because in practice it was not always possible to:

- (1) Anticipate correctly the temperature at the time of the next starting of the engine.
- (2) Obtain the desired amount of dilution, and
- (3) Prevent occasional associated difficulties such as oil spewing during warm-up and poor control over the dilution of the oil in the main reservoir.

Proper engine cranking from the standpoint of available electrical energy does not present a serious problem because cranking batteries must be kept warm. Therefore, with the proper use of oil dilution the starting motors are able to turn the engines at adequate speeds.

Since successful starting requires that the engine be undamaged as a result of the starting attempts, it is obvious that the fits and clearances of mating parts must be such that temperatures encountered under any conditions will not lead to internal failures. By the same token, oil dilution and special priming fuels must be carefully used so that scoring and scuffing do not result.

Allison Division, GMC, Pratt & Whitney Aircraft, Ranger Aircraft Engines, and Wright Aeronautical, conducted extensive laboratory cold weather tests on aircraft engines, Jack & Heintz and Electric Storage Battery conducted many investigations with electrical starting equipment, and the Standard Oil Development Company has spent considerable effort in the blending of high volatile priming fuels and the development of oils and greases for low temperature operation. These investigations have produced considerable data, the scope of which is too broad for this report. Reports of these investigations are listed in the addendum.

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OBJECT:

To devise, develop, and evaluate methods of cold weather starting of conventional internal combustion type aircraft engines.

CONCLUSIONS:

1. Conventional type aircraft engines can be started successfully in cold weather provided the necessary fuel, lubricant and equipment are used and the proper precautions are taken.
2. Of the several methods of starting engines in cold weather none have been developed to the point where the equipment used may be considered completely satisfactory.

RECOMMENDATIONS:

Although other forms of aircraft propulsion engines are being developed which may gradually displace the conventional engine the development of cold weather starting equipment should continue in order that military aircraft using conventional engines will have a quick and positive method of starting under cold weather conditions.

STARTING OF AIRCRAFT ENGINES

WARM ENGINE METHOD

OIL DILUTION	PRIMING FUEL	BATTERY HEAT	PREHEAT TO ENGINE
No	Regular Fuel	No	No
No, if oil system is warm.	Regular Fuel	Preferable	Preferable
No, if oil system is warm.	Regular Fuel	Yes	Yes
No, if oil system is warm.	Regular Fuel	Yes	Yes
No, if oil system is warm.	Regular Fuel	Yes	Yes

COLD ENGINE METHOD

OIL DILUTION	PRIMING FUEL	BATTERY HEAT	PREHEAT TO ENGINE
No	Regular Fuel	No	No
10% of mixture by volume	Regular Fuel	Preferable	No
20% of mixture by volume	Special Fuel Preferred. Possible to use Regular Fuel.	Yes	No
30% of mixture by volume	Special Fuel	Yes	No
35% of Mixture by volume	Special Fuel	Yes	No

TEMP
°F °C

30 -1

0 -18

-30 -36

-60 -50

-67 -55