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TURBO SUPERCHARGER OPERATION

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Some eighteen years ago an Army pilot, Major Schroeder, flew a LePere airplane to an altitude of 39,000 feet - a world record at that time. Chief among the various items of equipment of this airplane was an oxygen bottle for the pilot and an air pump for the engine; for the engine, like the pilot, needed additional breathing capacity to reach such an altitude. This air pump was the granddaddy of turbo superchargers.

Since that day, turbo superchargers have been installed in a comparatively small number of service airplanes. Twenty Martin Bombers and twelve DH4M2's were equipped with them shortly after Major Schroeder's record-breaking flight. It was some six or eight years later, however, that they again appeared on a limited number of service airplanes, namely, P-6D's and PB-2A's.

Notwithstanding the age of the turbo supercharger, it is safe to assume that only a small minority of Air Corps pilots have ever operated an airplane with this equipment installed. The turbo, however, has passed the embryo stage and will be an item of equipment on many of the aircraft now being procured for the Air Corps.

A turbo supercharger is a gas turbine coupled directly to a centrifugal air blower. By maintaining a constant absolute pressure in the exhaust manifold of the engine, the exhaust gases may be expanded to atmospheric pressure through the turbine, and the power thereby generated used to compress air in the centrifugal blower supplying it to the carburetor of the engine. As the airplane ascends, the atmospheric pressure decreases, thereby providing a greater pressure differential between exhaust manifold and the atmosphere with the resultant increase in power available to meet the increased demands of the engine supercharger.

At first glance, one might wonder why, since the weight of exhaust gas equals the weight of the air supplied to the carburetor plus the weight of the fuel burned, it is possible to expand the exhaust gas from approximately 14.7 lbs./sq. in. to atmospheric pressure and to obtain sufficient power to perform the work of compressing an almost equal weight of air from atmospheric pressure back to 14.7 lbs./sq. in. On second thought, however, it is obvious that since the exhaust gases are ejected at a temperature of approximately 1500° F, they expand to a volume three or four times the volume of an equal weight of air. Since the work accomplished by expanding a gas is a function of pressure times volume, and the work expended in compressing air is a similar function, there is more than enough energy in the exhaust gases to accomplish the required supercharging.

An automatic regulator is provided for maintaining approximately the same air pressure at the carburetor for any altitude up to the critical altitude of the supercharger which, in most present designs, is 25,000 feet.

The operation of the turbo supercharger by the pilot is extremely simple. The pilot sets the turbo regulator control to give the engine pressure desired, as indicated on a manifold pressure gauge. He then controls the engine by means of the throttle, as in the conventional airplane. For maximum efficiency in long range operation, the throttle remains wide open and refinements in power are controlled by setting the supercharger regulator control.

If the pilot adjusts the throttle for a certain manifold pressure, he no longer has to change the setting as he increases or decreases altitude to maintain the same manifold pressure. The turbo regulator does this for him, since it maintains a relatively constant pressure in the air duct to the carburetor.

There is no reason for the pilot to assume that the turbo is merely a gadget, like an oxygen bottle, to be used only at high altitude. The engine used in a turbo-equipped airplane is a sea level type and consequently it depends on the turbo to maintain rated power at any altitude above sea level. Furthermore, take-off power must usually be obtained by use of the turbo.

On the other end of its performance range, that is at rated altitude, say 25,000 feet, the turbo is not at all powerful and is not infinite in speed allowed. To prevent overspeeding, as in any other machine, power must be reduced. A good rule of thumb is to decrease rated manifold pressure one inch for each 1,000 feet of altitude above rated altitude.

There are other reasons why the turbo should not be turned off for normal operation. If full power is needed in an emergency, it is available if the turbo is maintaining sea level air pressure at the carburetor. If the turbo is off, manipulation of the turbo control is required and an additional time lag intervenes for the turbine wheel to come up to speed before the engine can develop full power.

One of the most important considerations is that of carburetor icing. Many of the new turbo installations have no provisions for heating carburetor air other than the heat of compression supplied to the air by the turbo compressor. In such installations it is absolutely essential to operate the turbo at all times when the humidity is high. In other installations, a control is provided for heating the carburetor air, but these provisions are not always adequate in severe icing conditions and the use of the turbo supercharger is an essential precaution.

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