PART 2 - SYSTEMS

ENGINES

The aircraft is powered by two Pratt and Whitney Double Wasp R-2800-52W engines having integral two-speed engine blowers and using water injection for power increases of limited duration. The engines, with water injection, are rated at 2500 BHP when using 115/145 grade fuel or 2400 BHP when using 100/130 grade fuel. Engine exhaust augmentors are provided to assure adequate engine cooling. The augmentors are large tubes that extend aft from the firewall to the wing trailing edge. Two augmentors are installed in each nacelle. The exhaust stacks carry the exhaust gases from the cylinders to the forward ends of the augmentors.

Open space remains around the stacks where they terminate at the augmentors. The augmentors function as injection pumps to draw cooling air across the engine, and utilize the heat energy in the exhaust gas and engine cooling air for additional thrust. It is estimated that the augmentor type exhaust system adds 7 to 12 knots to the airspeed. Some of the engine cooling air enters muffs around the augmentors and becomes the heating air for the wing and tail anti-icing system and the heat exchanger of the cabin air-conditioning system. Carburetor air is taken from an integral ram air scoop in the engine cowl upper panel. Oil cooling and accessory cooling air is taken from a flush scoop in the lower panel of each cowl. A ventilation door in the nacelle top cowl panel allows air to flow continuously through the engine accessory section. The door is normally held open by a lock pin, but closes automatically and remains closed if the fire extinguishing agent is discharged. Four adjustable cowl flaps, controlled by the pilot, are provided for each engine to facilitate cylinder head temperature control. When the throttles, mixture control levers, or carburetor heat control levers are positioned, an anti-creep device in the pedestal quadrant automatically seizes the controls and prevents reverse cable loads from moving them inadvertently. Normal operation of any of the controls instantly releases the corresponding anti-creep device and allows easy operation to the new control setting, where the anti-creep device again takes effect.

Engine Controls

THROTTLES

Dual throttles (11, 33, figure 1-10) are provided for both the pilot and the copilot on the quadrant section of the pilot's pedestal. Each throttle quadrant has a forward thrust range, OPEN; a reverse thrust range, REVERSE OPEN; and a neutral midposition, CLOSE. Each throttle quadrant is provided with a detent at the CLOSE position, with a latch stop that prevents the throttle from being pulled aft into reverse thrust range unless the latch is released by pulling a manual override handle. The propellers are taken out of reverse by moving the throttles forward to, or beyond, the CLOSE detents. Throttle position electrically governs the operation of the propeller autofeathering, cabin compressor disconnect, and the landing gear and flap warning systems.

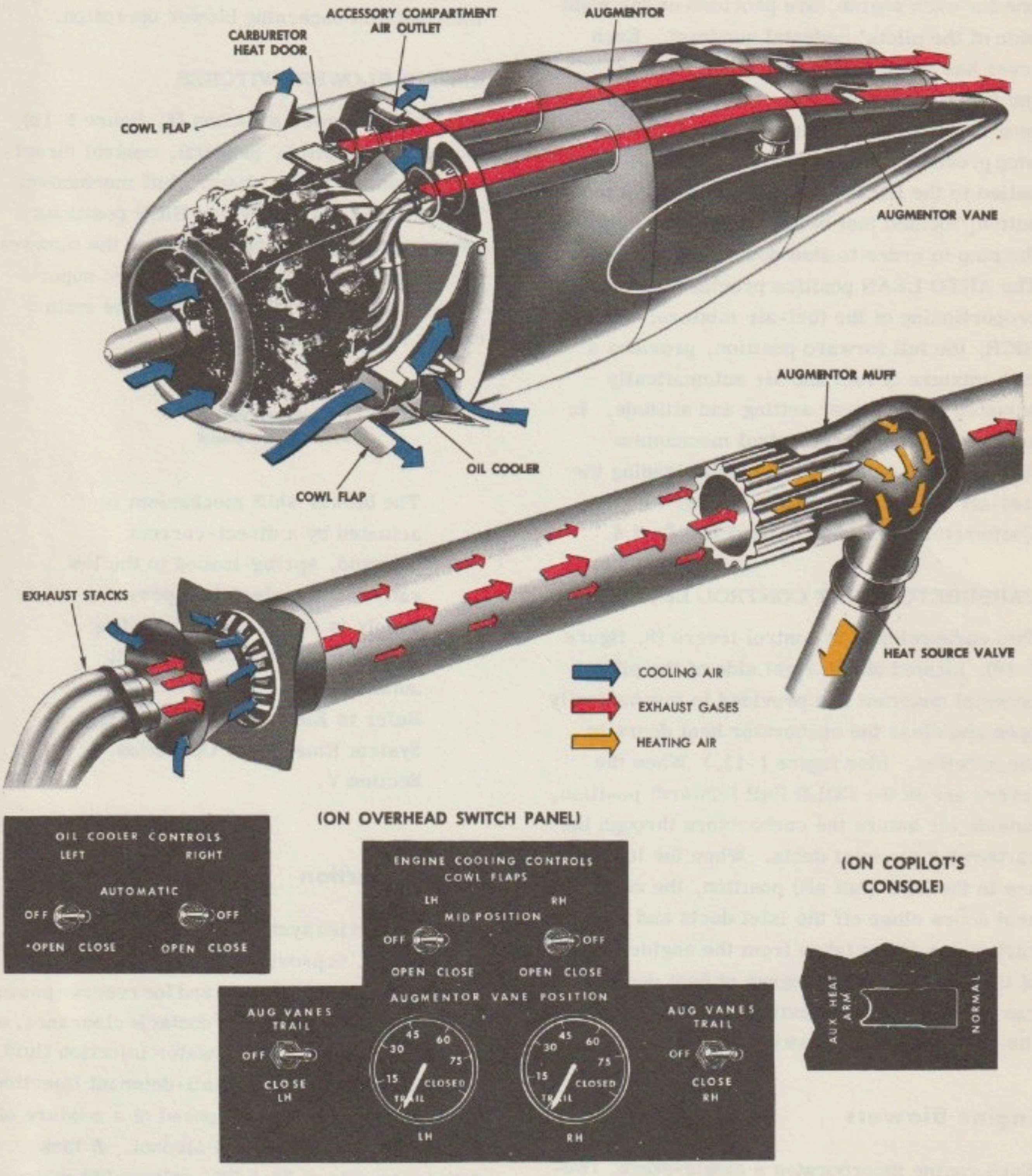

Figure 1-11. Engine Cooling

MIXTURE CONTROL LEVERS

Two mixture control levers (10, figure 1-10), one for each engine, are provided on the right side of the pilots' pedestal quadrant. Each lever has three positions. IDLE CUTOFF, the full aft position, stops the engine by stopping fuel flow at the carburetor. A mechanical stop prevents the levers from being inadvertently pulled to the IDLE CUTOFF position. A pushbutton, located just below the levers, releases the stop in order to shut down the engines. The AUTO LEAN position provides automatic proportioning of the fuel-air mixture. AUTO RICH, the full forward position, provides a rich mixture of fuel and air automatically adjusted to the power setting and altitude. In addition, the mixture control mechanism provides adjustment for manually leaning the fuel-air mixture for cruise. Refer to Carburetor Mixtures, Section III, Part 4.

CARBURETOR HEAT CONTROL LEVERS

Two carburetor heat control levers (9, figure 1-10), located on the right side of the pilots' pedestal quadrant are provided to mechanically open and close the carburetor heat doors in the nacelles. (See figure 1-11.) When the levers are in the COLD (full forward) position, outside air enters the carburetors through the carburetor air inlet ducts. When the levers are in the HOT (full aft) position, the carburetor heat doors close off the inlet ducts and all carburetor air is taken from the engine sections of the nacelles. The degree of heat desired can be obtained by adjusting the levers between the HOT and COLD positions.

Engine Blowers

Each engine incorporates a single-stage, two-speed engine blower (supercharger). In low ratio, the blower speed is 7.29 times engine speed. In high ratio, the blower speed is 8.58 to 1. Provisions are made for selection of the desired blower speed by the pilots. Refer to Section III, Part 4 for general information concerning blower operation.

ENGINE BLOWER SWITCHES

Two engine blower switches (4, figure 1-10), located on the pilots' pedestal, control direct-current power to the blower shift mechanism. The switches have LOW and HIGH positions corresponding to the two speeds of the blowers. Circuit protection is provided by two supercharger shift circuit breakers on the main circuit breaker panel.

CAUTION

> The blower shift mechanism is actuated by a direct-current solenoid, spring-loaded to the low ratio. If the electrical power supply is cut off while operating in high ratio, the blowers will automatically shift back to low. Refer to Electrical Power Supply System Emergency Operation, Section V.

Water Injection

A water injection system (figure 1-12), serving both engines, is provided to allow operation at increased maximum power and for reserve power in the event of a go-around, obstacle clearance, or similar emergency. The water injection fluid, commonly called "ADI" (anti-detonant injection) fluid, or "water," is composed of a mixture of distilled water and methyl alcohol. A tank with a capacity of 22.5 US. gallons (22 gallons usable), located in the right wing fillet, contains the water supply and the water pump.

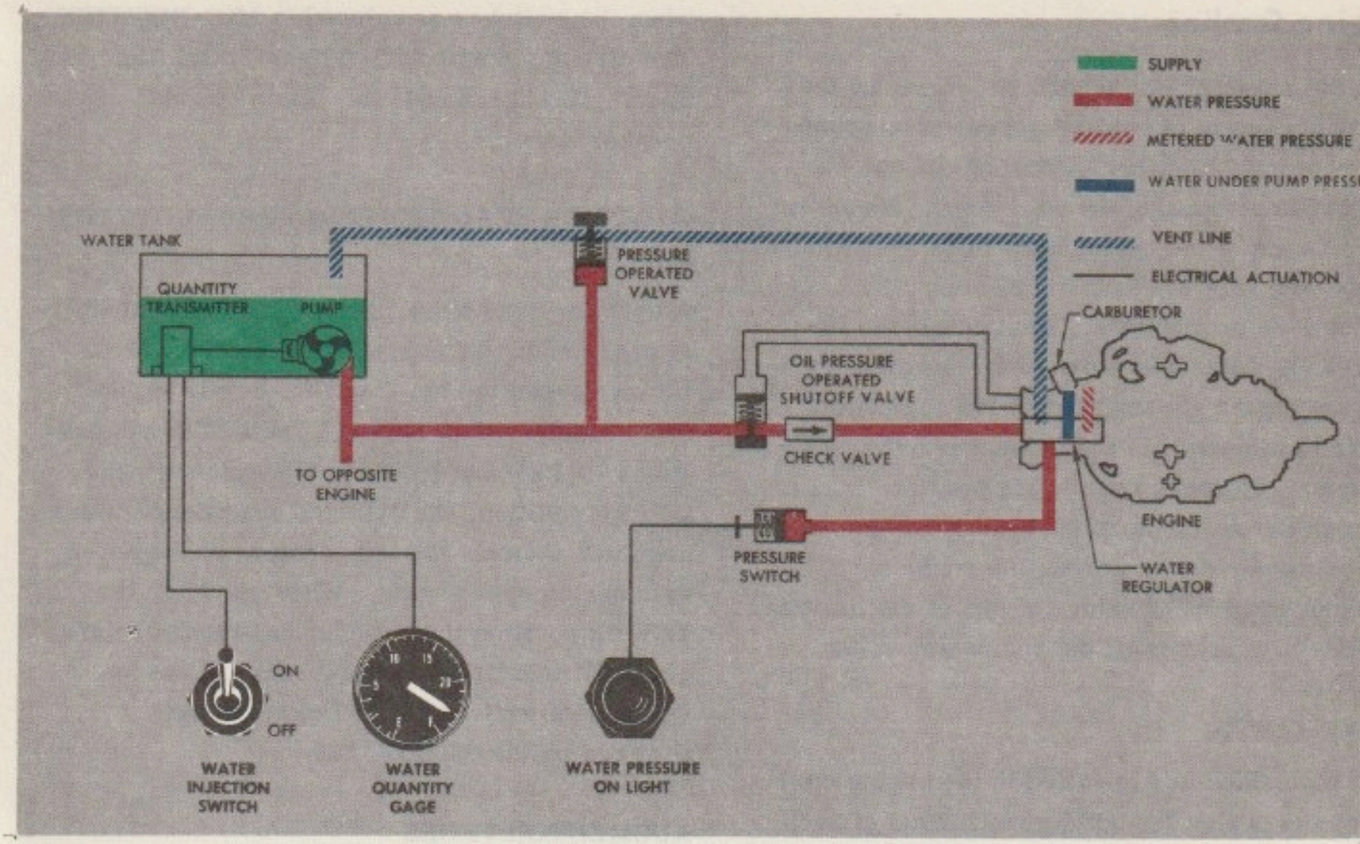

Figure 1-12. Water Injection System

A water quantity gage and pressure indicator lights are provided. Pressure-operated valves in the water injection system prevent flow of ter to the engines if engine oil pressure is less than 30 psi. Water is metered by a water regulator to meet engine power requirements. A derichment valve in the carburetor is actuated by water pressure from the regulator. This provides engine operation at or near "best power" fuel-air mixture during water injection operation.

WATER INJECTION SWITCH

The water injection switch (30, figure 1-10), located on the pilots' pedestal, has ON and OFF positions. The switch controls direct-current power from the main circuit breaker bus to the pump in the water injection supply tank. Circuit protection is provided by the WATER INJECTION PUMP circuit breaker on the side of the DC Power Distribution Box.

WATER INJECTION INDICATOR LIGHTS

Two water injection indicator lights (25, figure 1-8) are located on the engine instrument panel. When the water injection switch is turned ON the lights indicate green when a pressure of 19 ± 0.5 PSI or more is at the water regulator inlet valve. The indicator lights are powered by direct current from the main bus. Circuit protection is provided by the water pressure circuit breaker on the main circuit breaker panel.

WATER QUANTITY GAGE

A water quantity gage (28, figure 1-8) is located on the engine instrument panel. The gage indicates the amount of fluid in the supply tank and operates on direct current from the main bus. Circuit protection is provided by the WATER INJECTION circuit breaker on the main circuit breaker panel.

Engine Cooling

Cooling air is drawn across the engine by the jet-pump action of exhaust gases entering the augmentors. The flow of cooling air can be increased by opening the cowl flaps. Vanes in the aft ends of the augmentors can be positioned to restrict flow of exhaust gases and air through the augmentors. Restricting the flow increases the temperature of the augmentors and the heated air supplied by the augmentor muffs to the airplane's heating and anti-icing systems. Because restricting the flow through the augmentors decreases the amount of cooling air drawn across the engines, cylinder head temperature is one of the limiting factors in operation of the augmentor vanes.

COWL FLAPS

Two cowl flaps are installed in the engine cowl panel and two on the bottom cowl panel of each nacelle. The cowl flaps are driven by direct-current powered reversible motors. Opening the cowl flaps allows engine cooling air to vent directly from the engine section to the outside. When the cowl flaps are closed, engine cooling air flows through the augmentor tubes along with exhaust gases.

COWL FLAP SWITCHES

Two cowl flap switches (15, figure 1-9), one for each nacelle, are located on the overhead switch panel. Each switch has four positions: MID-POSITION, OPEN, CLOSE, and OFF. The switches connect direct-current power from the main bus to reversible motors located in the wheel wells. When the switches are placed in the OPEN or CLOSE positions, the cowl flaps will move toward the full open or closed positions, respectively. When the switches are placed in the OFF position the cowl flaps remain in the position they had reached at the time the switches were placed in the OFF position. This allows precision control of the cowl flaps. The top and bottom cowl flaps open two inches when the switches are placed in MID-POSITION. The circuits are protected by two cowl flap circuit breakers on the main circuit breaker panel.

NEW

CYLINDER HEAD TEMPERATURE SELECTOR SWITCH

A cylinder head temperature selector switch* is provided on the engine instrument panel for monitoring the No. 2 and No. 9 cylinder head temperature of each engine. The switch has positions UPPER and LOWER. When placed in the UPPER position, the cylinder head temperature gage will indicate the temperature of the No. 2 cylinder on each engine. When placed in the LOWER position the cylinder head temperature gage will indicate the temperature of the No. 9 cylinder of each engine. The gages are powered by the main DC bus.

AUGMENTOR VANES

A vane is installed near the aft end of each augmentor. The vanes are used to raise the temperature of air in the heat collector muffs at the augmentors in order to supply air at maximum temperature to the wing and tail anti-icing ducts or the cabin heat exchanger. The vanes in the two augmentors in each nacelle are linked to a direct-current-powered actuator. The actuator is energized to close or trail the vanes by operation of the augmentor vane switch when the heat anti-icing is operating or the auxiliary heat arm switch is in the ARM position. The vanes are normally kept in trail position. To protect the augmentors, thermally operated direct-current circuits will automatically position the vanes to trail if an overheat condition develops in the augmentor tubes. The vanes cannot be closed or partly closed as long as the overheat condition exists. The pilot is warned of the overheat condition by persistent ringing of the augmentor overheat warning bell in the flight compartment.

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*Not in typical aircraft.

AUXILIARY HEAT ARM SWITCH

A cover-guarded auxiliary heat arm switch (21, figure 1-7), located on the copilot's console, arms the direct-current power circuit to the augmentor vane switches when wing and tail anti-icing is not in operation. The switch has two positions: ARM and NORMAL. The ARM position connects direct-current power from the main bus to the augmentor vane switches and disconnects direct-current power from the trailing side of the augmentor vane actuators. The NORMAL position disconnects direct-current power to the augmentor vane switches and renders them incapable of operation unless the heat anti-ice button is in the PUSH ON position. Whenever the wing and tail anti-icing system is in operation the augmentor vane switches and the overheat safety circuits are armed regardless of the position of the auxiliary heat arm switch.

AUGMENTOR VANE SWITCHES

Two augmentor vane switches (14, figure 1-9), located on the overhead switch panel, control direct-current power from the main bus to the augmentor vane actuators.

NOTE

The augmentor vane switches are inoperative unless the auxiliary heat arm switch is in ARM position or the heat anti-ice button is in PUSH ON position. (Refer to Air-Conditioning System and to Wing and Tail Anti-Icing System, in this Section for additional information on the use of augmentor vanes.)

The three positions of the augmentor vane switches are TRAIL, CLOSE, and spring-loaded to OFF. Holding the switches in CLOSE position actuates the augmentor vanes to restrict the flow through the augmentors; holding the switches in TRAIL position actuates the vanes to their trail position, so that flow through the augmentors is unrestricted. Releasing the switches to OFF position stops the vanes in the position then indicated by the augmentor vane position indicators. If the augmentor vanes have been positioned to restrict flow through the augmentors and an overheat condition occurs in the augmentors, thermal switches at the augmentors automatically operate the augmentor vanes to trail position and the augmentor overheat warning bell rings. As long as the warning bell rings, the augmentor vane switches are in an open circuit and have no control over vane position.

AUGMENTOR VANE POSITION INDICATORS

Two augmentor vane position indicators, one for each nacelle, are located on the pilots' overhead switch panel (16, figure 1-9). The pointer of each indicator indicates the position of the augmentor vanes as long as 26-volt alternating current is supplied to the augmentor vane position transmitters. The indicators are operative, therefore, even when the augmentor vane control circuit has not been armed by the auxiliary heat arm switch, and also when the augmentor vane control circuit has been overridden by the augmentor overheat warning circuit.

AUGMENTOR OVERHEAT WARNING BELL

Overheat thermal switches that turn the vanes to trail when overheat occurs also operate an augmentor overheat warning bell on the flight compartment ceiling. The bell continues to ring as long as an overheat condition exists in any augmentor. No cutoff switch is provided. The electrical circuit for the bell is protected by the AUGR FIRE BELL circuit breaker on the main circuit breaker panel.

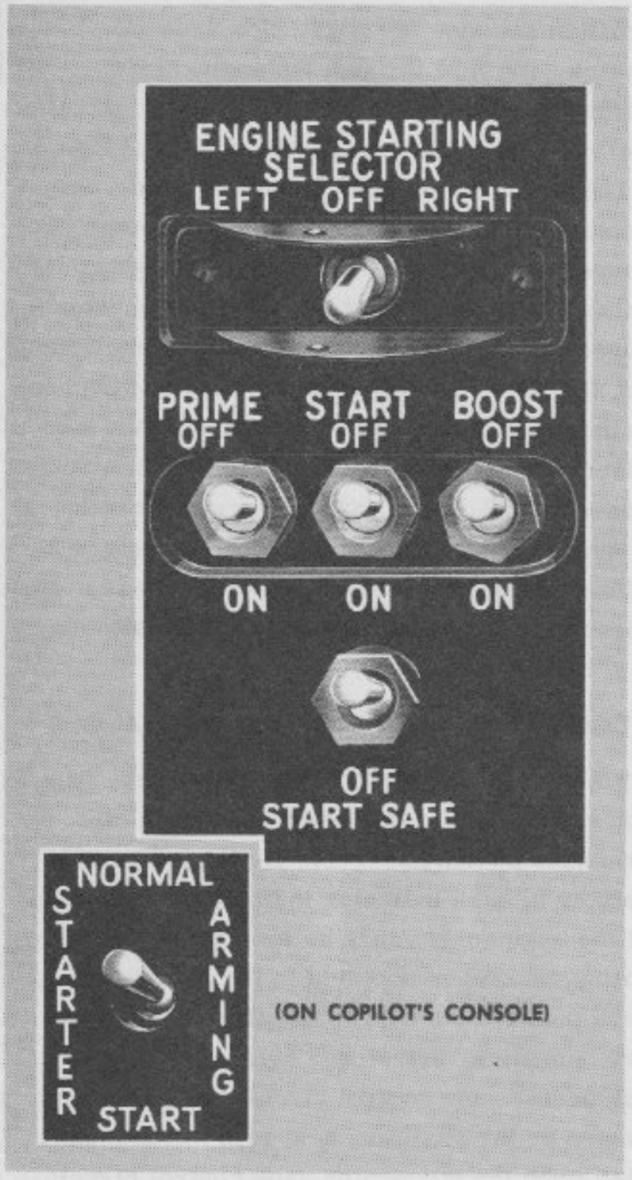

Figure 1-13. Engine Starting Contols

Ignition and Starting

Each engine is equipped with a low-voltage, high-altitude ignition system. A dual magneto supplies low-voltage current to two distributors, and the current remains at low voltage until it reaches transformers located at each cylinder. The current, stepped up to high voltage by the transformers, is then conducted through short high-voltage leads to the spark plugs. A booster vibrator coil is used during starting. A direct cranking starter is installed on each engine. The starter circuits are armed by a starter arming switch that also closes the cabin heat source valves to prevent the flow of fuel and oil fumes to the fuselage area during engine starting.

An engine starting selector switch routes direct-current power from the ignition boost, prime, start-safe, and start switches to the corresponding operating units, in turn, during engine starting.

IGNITION SWITCHES

Two standard dual-ignition switches (11, figure 1-9), one for each engine, are located on the overheat switch panel. Switch positions are: OFF, R, L, and BOTH.

STARTER ARMING SWITCH

The starter arming switch (23, figure 1-7) is located on the copilot's console. This switch is powered by direct current from the main bus and has NORMAL and START positions. In the START position the starter arming switch will trail the augmentor vanes and will override and close the heat source valves in each nacelle to prevent the flow of fuel and oil fumes to the fuselage area during starting. In the NORMAL position the heat source valves are opened (only when a demand is placed for heat), and the starting circuits are disconnected.

START-SAFE SWITCH

The start-safe switch (4, figure 1-9), located directly below the engine starting selector switch on the overhead switch panel, has ON and OFF positions and is spring-loaded to OFF. The switch receives direct-current power when the starter arming switch is in START position. This switch, in conjunction with the spring-loaded start switch, provides a double bridge in the starting circuit. Both switches must be held ON to complete the circuit to the engine starting selector switch.

START SWITCH

The start switch (5, figure 1-9), located directly below the engine starting selector switch on the overhead switch panel, has ON and OFF positions and is spring-loaded to OFF. The position of the engine starting selector switch determines which engine starter will be energized when the start and start-safe switches are held to ON. Operation of these switches supplies direct-current power to the selected engine starter.

ENGINE STARTING SELECTOR SWITCH

The engine starting selector switch (6, figure 1-9), located on the overhead switch panel, has LEFT, RIGHT, and OFF positions. When the left engine is to be started, the switch is placed in LEFT position. This connects direct-current circuits from the starter arming, start-safe, start, ignition boost, and prime switches to the corresponding operating units at the left engine. When these switches are held ON for engine starting, direct-current power is then supplied to the operating units through the circuits previously closed by the engine starting selector switch. When the right engine is to be started, positioning of the engine starting selector switch to RIGHT allows use of the same starter arming, start-safe, start, ignition boost, and prime switches for starting the right engine.

IGNITION BOOST SWITCH

An ignition boost switch (5, figure 1-9), located directly to the right of the start switch, is provided to afford a hot spark for engine starting. The switch has ON and OFF positions and is spring-loaded to OFF. As soon as the engine starts, magneto current is delivered to the spark plugs and ignition boost current is no longer supplied. When held to ON, the switch supplies direct-current power to a vibrator that produces low-voltage current. A circuit connects the vibrator to a movable contact of the engine starter selector. When the starter selector is in the LEFT or RIGHT position, the power can then flow to the right distributor of the engine selected, when the corresponding magneto switch is in the BOTH position. Each circuit is kept open by a switch-operated relay.

NEW NEW NEW NEW

PRIME SWITCH

A prime switch (5, figure 1-9), located on the overhead switch panel, spring-loaded to OFF, is held to ON intermittently during engine starting to introduce fuel directly into the engine blower case. The position of the engine starting selector switch determines which engine will be primed. The prime switch closes a direct-current circuit to a solenoid that opens the prime valve. The line from the valve bypasses the carburetor and leads directly from the fuel supply line to the throat of the engine blower.

PRIME-ALL-ENGINES SWITCH

A prime-all-engines switch, located on the overhead switch panel, (12, figure 1-9), has ON and OFF positions. The switch actuates priming solenoids on both engines simultaneously, thus supplying the engines with additional fuel. The switch is used in the torque-pressure-drop method of setting cruise mixture, for stopping engine surge caused by icing of the carburetor impact tubes and for defouling spark plugs by shock (cold fuel).