

Boeing 707

**Flight Controls
Spoilers**

Training manual

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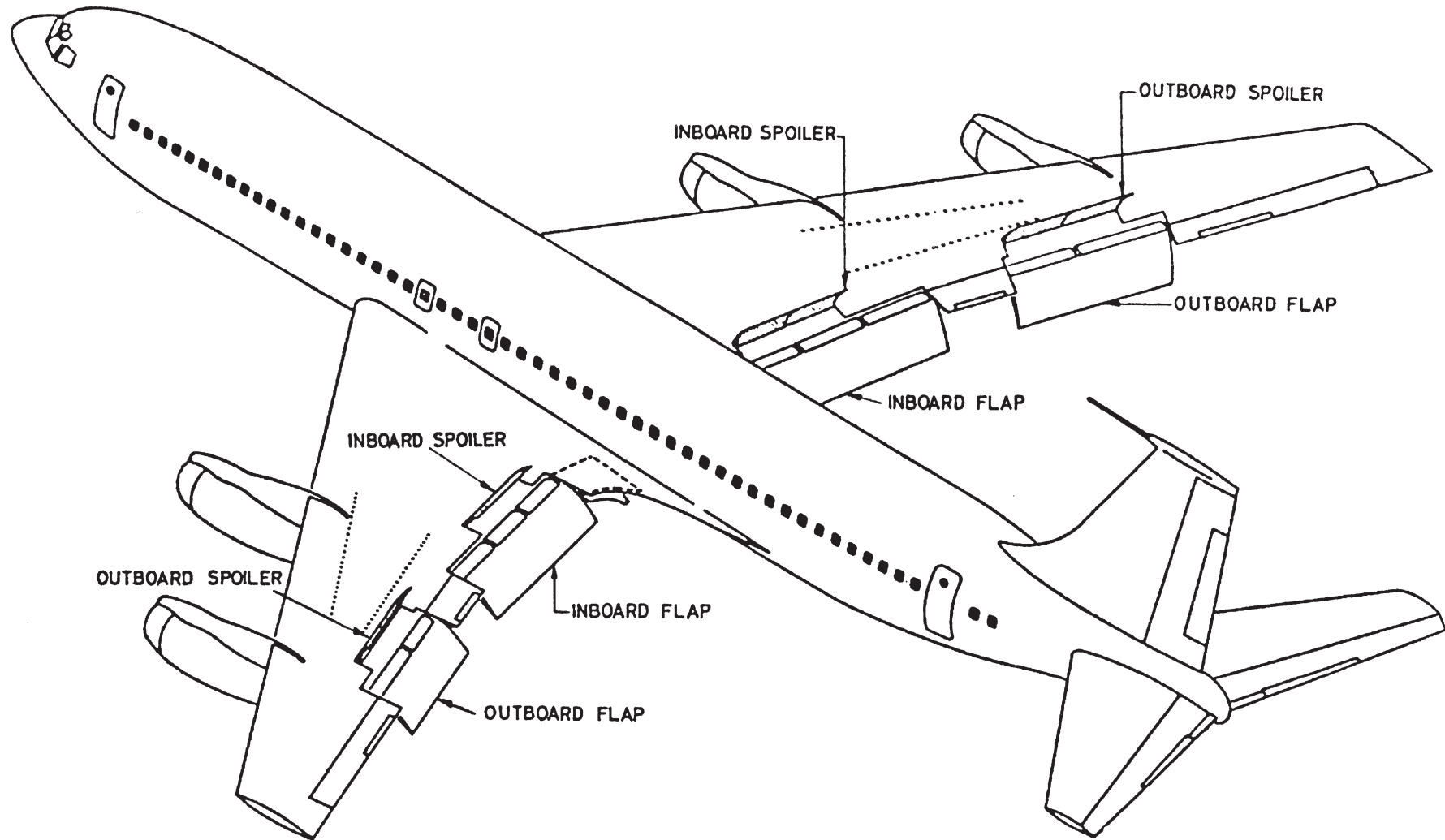
ABBREVIATIONS AND ACRONYMS

1. GENERAL.

The spoilers operate with the ailerons to provide lateral control about the roll axis of the airplane. Four spoilers are located in the upper surface of each wing. The spoilers are mounted in pairs, with one pair forward of each of the main flaps. The spoilers are positioned hydraulically, and are controlled directly from the aileron control system. The spoilers also serve as speed brakes, and when used for this purpose, are controlled by a speed brake control lever located on the control stand.

When an up aileron signal is received at an inboard aileron control quadrant, linkage operates the spoiler control valves. Hydraulic power is directed to the actuators, and so positions the spoilers relative to the ailerons. The inboard spoilers on the up aileron wing will extend to 41° and the outboard spoiler to 42° when the control wheel is rotated hard over.

When the speed brakes are used, aileron induced motion to the spoilers is controlled by the differential linkage. The spoilers have no motion when the ailerons are faired, except through a speed brake signal. With ailerons faired, a speed brake signal extends all spoilers equally on both wings, up to a maximum of 60°. With a 60° speed brake setting, flaps up and 93° rotation of the control wheel, the spoilers will extend 60° on the up aileron wing; on the down aileron wing, Inboard spoilers will extend 19° and outboard spoilers 18°.



SPOILER - GENERAL 1

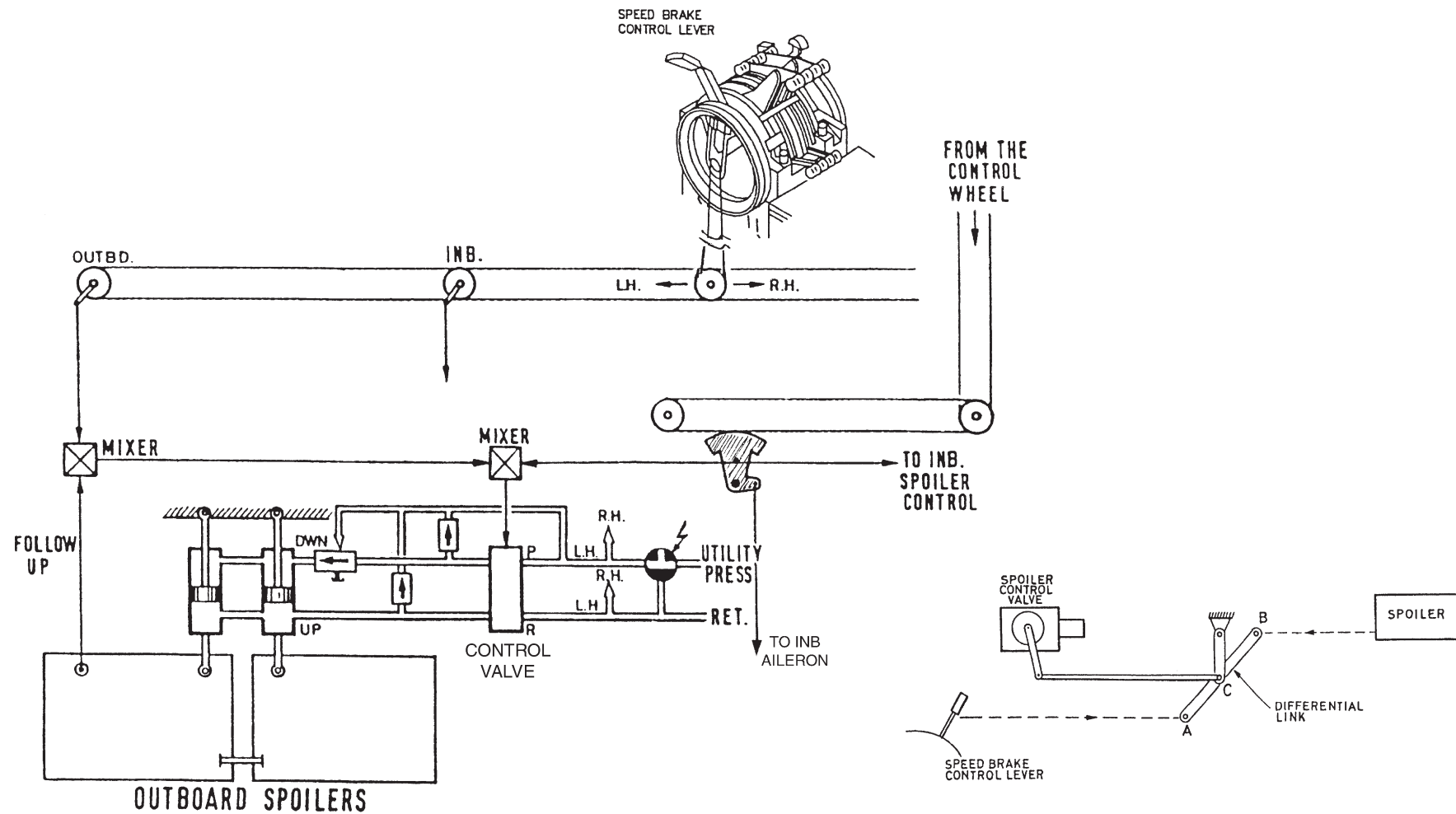
1.1. Principle.

Hydraulic power to operate the outboard spoilers is obtained from the 3000 psi utility hydraulic system. The 3000 Psi auxiliary hydraulic system provides power to operate the inboard spoilers. Hydraulic pressure and return lines are routed to the inboard and the outboard spoiler control valves in each wing.

Each valve controls the operation of the two spoiler actuators which position each spoiler pair. Swivel joints are installed in the hydraulic lines to the actuators to permit rigid tubing to be connected to the movable actuators. The control valves are positioned through spoiler control linkages which connect each valve to the inboard aileron control quadrant.

Movement of the inboard aileron control quadrant, caused by rotation of the aileron control wheel, will position the control valves causing the spoilers to be positioned proportional to aileron control signal. When the spoilers have reached the desired position, a spoiler follow-up linkage which is connected to the spoilers will close the control valve.

The spoilers will then remain in this position until another signal is introduced into the system. When the speed brakes are used, a differential linkage, in conjunction with the follow-up linkage, provides additional control to the spoilers.



SPOILER - GENERAL 2

2. OPERATION.

Lateral control is achieved by simultaneous action of spoilers and ailerons. The lateral control system is designed to provide a nearly constant roll rate throughout the wide range of speeds encountered.

The difference in roll rate can hardly be detected by a pilot. At low speed the roll rate is higher than figured because lowering the outboard flaps will allow outboard aileron action.

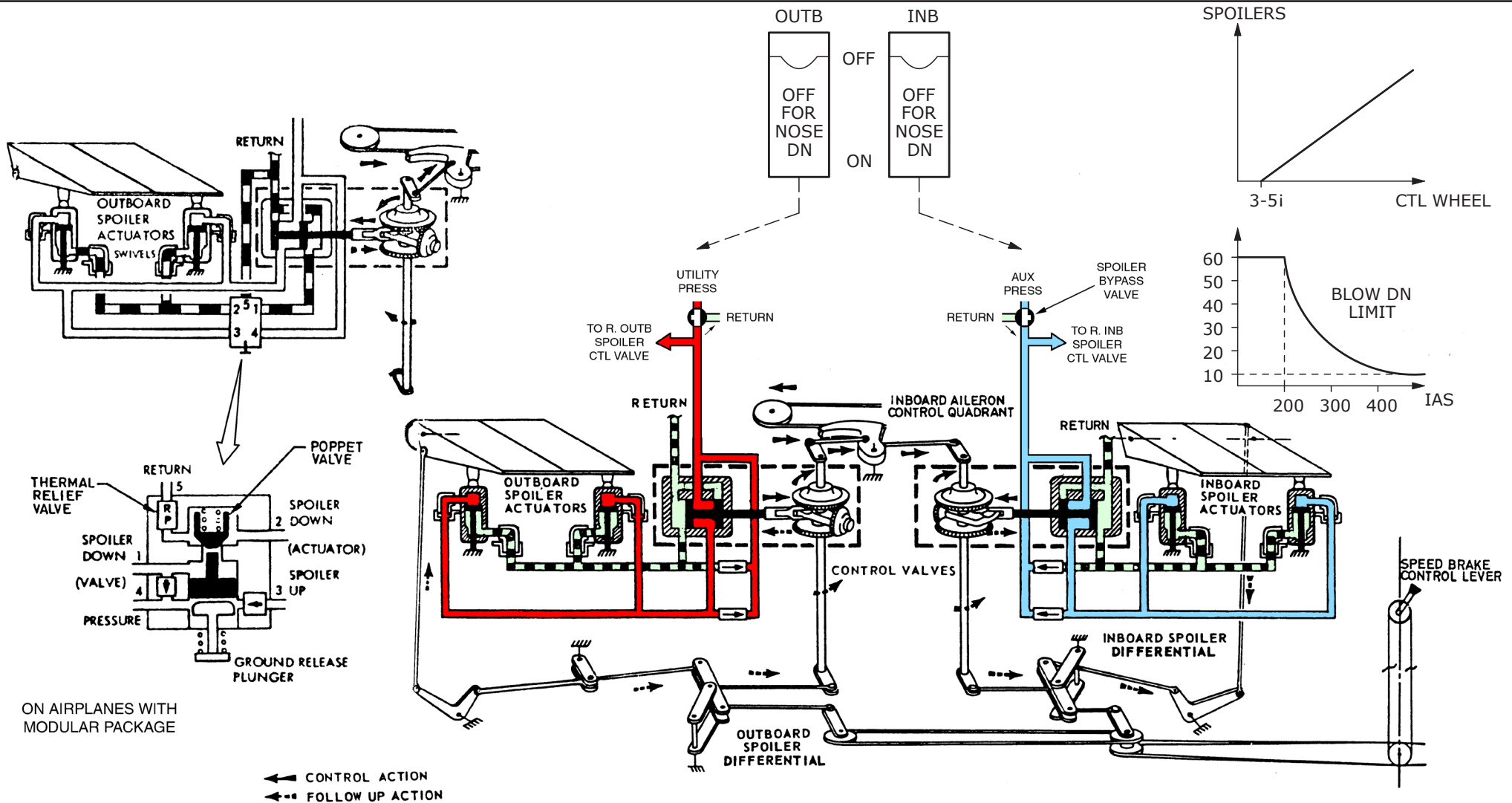
At low speed ailerons and spoilers efficiency is limited. Outboard ailerons compensate for low inboard aileron efficiency. As speeds increase, inboard aileron and spoilers pick up effectiveness and outboard ailerons deflect less as flaps are retracted. Spoilers deflection available decreases due to aerodynamic blow down. At high speed inboard ailerons develop adequate roll control capability.

With speed brakes down, turning the control wheels brings up only the spoilers on the wing in the direction of the desired roll. When speed brakes are extended symmetrically turning the control wheel affects spoilers differentially. Spoilers of the wing in the direction of roll extend and the opposite spoilers move down. This increases spoiler efficiency and roll rate.

Flap position affects roll control capability two ways. First, flap position controls the outboard aileron lock out mechanism.

Second flap extension angle affects control surface effectivity, particularly spoilers, by changing the lift distribution along the wing chord.

Two check valves are incorporated in each modular package to control fluid flow in one direction. When the pressure in the hydraulic lines to the actuators exceeds the input pressure of 3000 psi, fluid will flow through the check valves into the pressure line and so be governed by the main system relief valves. The utility and auxiliary relief valves open at ± 3500 psi and close at no less than 3150 psi. Such pressures can develop when high airloads act upon the spoilers.



SPOILER SYSTEM

3. COMPONENT DESCRIPTION

3.1. Speed brake Handle.

The SPEED BRAKE control lever can be moved from 0° to 60° with a lock detent at 0° and a feel detent at 30°. An adjacent scale shows the position of the lever. The scale is marked in 10° increments between 0° and 60°.

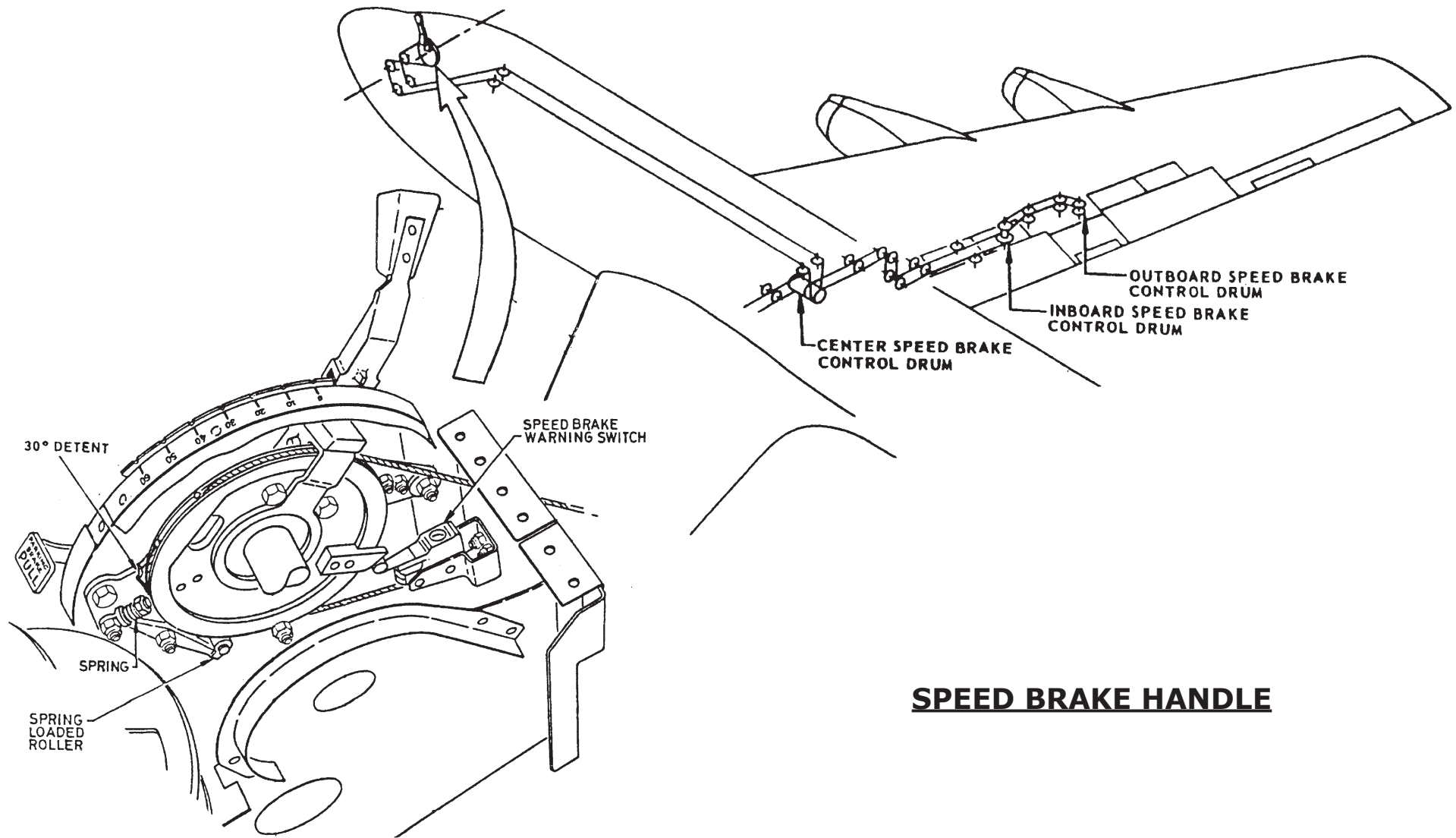
A cable system from the lever controls the spoiler follow up linkages.

This action meters hydraulic fluid to raise all spoilers to the selected angle, unless limited by airspeed or modified by control wheel movement.

Full speed brake extension (60°) is obtained only at speeds below approximately 200 KIAS.

For higher roll rates at airspeeds above 310 KIAS, use the 30° detent position. Airplane roll rates are higher when control wheel is deflected and spoilers are raised less than 60° (spoiler blow down or SPEED BRAKE control lever set to less than 60°). Full roll input on control wheel gives 40° difference between spoiler positions. If the spoilers are not at 60°, one set is raised to 60° and one set is lowered to 20°, increasing roll rate. Refer to ROLL CONTROL.

The takeoff warning horn is actuated if the SPEED BRAKE control lever is more than 2 to 5° out of the 0° detent and No. 3 throttle is advanced while the airplane is on the ground. Refer to TAKEOFF WARNING SYSTEM.



SPEED BRAKE HANDLE

3.2. Spoiler Bypass Valve.

One bypass valve controls both outboard spoiler pairs. A single bypass valve is installed in the pressure line that supplies both inboard spoiler pairs.

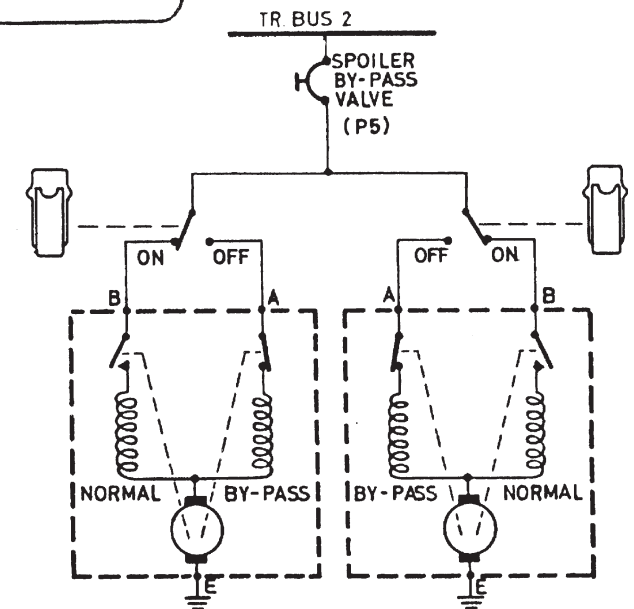
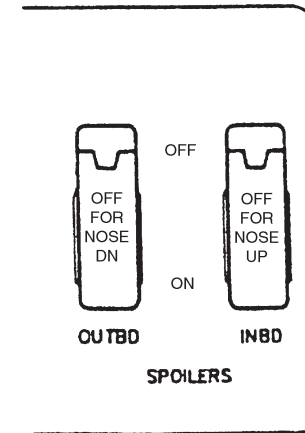
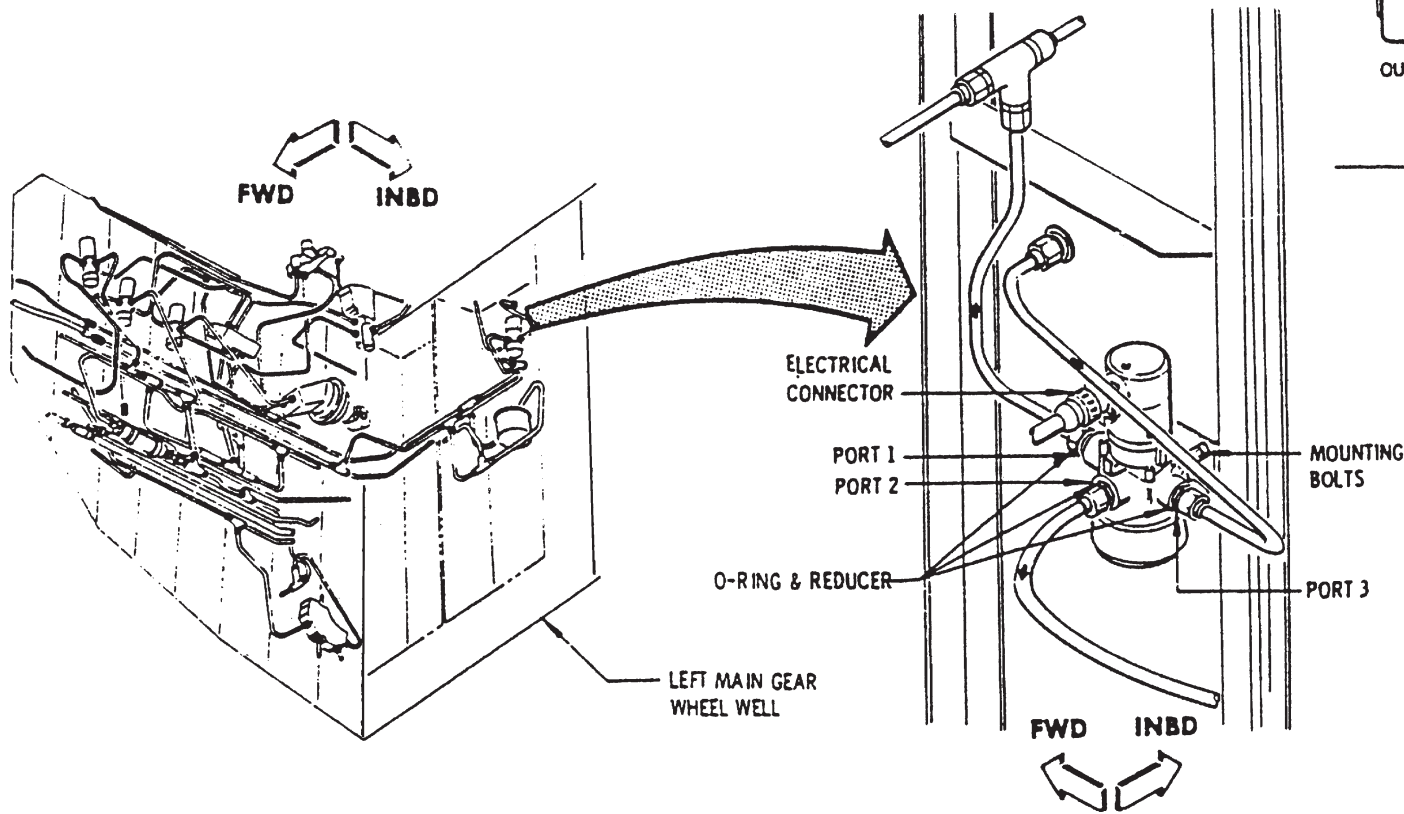
In the event of malfunction, either the outboard or the inboard spoilers can be removed from the system by actuation of the appropriate valve switches. Two switches on the pilot's overhead panel actuate the bypass valves for inboard and outboard spoilers. The switches are placarded "NOSE UP" and "NOSE DOWN" so the connected set of spoilers may be selected for making pitch corrections to the airplane in the event of a jammed stabilizer. Activation of the inboard spoilers only will provide airplane nose down trim. Activation of the outboard spoilers only will provide airplane nose up trim.

The spoiler bypass valves isolate the spoilers from the lateral control system in the event of spoiler control system malfunction, or hydraulic fluid leaks.

The bypass valve consists of an electric motor-operated, three-warp two-position bypass valve. Three external hydraulic fittings are located on the valve body. A manual override handle is provided on the valve for operating -the valve on the ground without electrical power.

There is one bypass valve for both outboard spoiler pairs in the utility pressure line, and one bypass valve for both inboard spoiler pairs in the auxiliary pressure line. The inboard valve is located near the forward bulkhead in the right main gear wheel well. The outboard valve is located near the forward bulkhead in the left main gear wheel well.

SPOILER BYPASS VALVE



SPOILER BY-PASS VALVES
(MOTOR-DRIVEN VALVES)

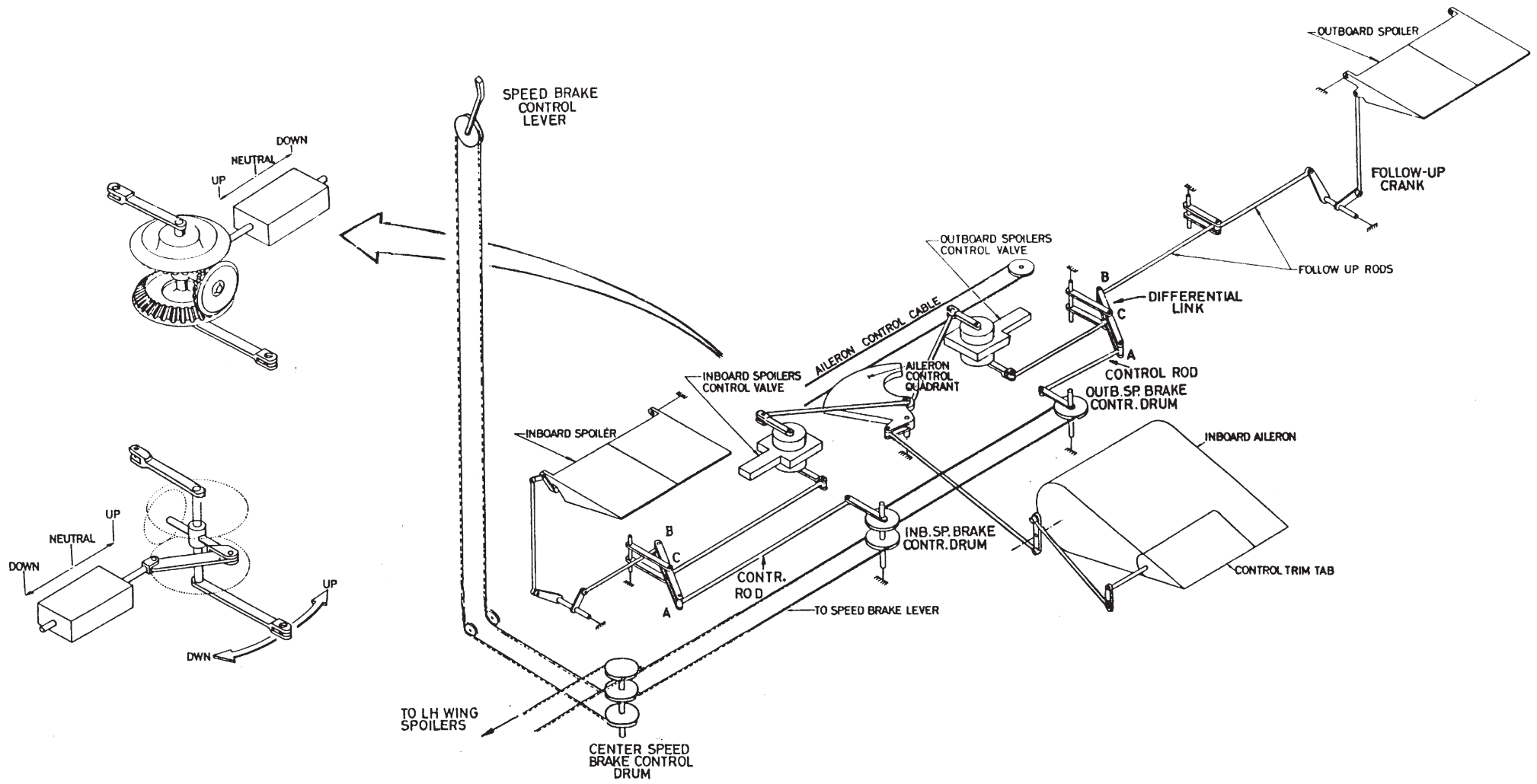
3.3. Spoiler Control Valve Linkage.

The control valve linkage starts at the inboard aileron control quadrant, from which motion is carried to the input shafts of the spoiler control valves. This linkage causes the spoilers to operate with the ailerons.

The inboard control valve linkage consists of two pushrods, an idler, a pushrod control crank, a connecting rod and a valve crank. The outboard control valve linkage consists of a pushrod, a pushrod control crank, a connecting rod and a valve crank.

Failsafe protection is provided by shear rivets which attach the valve cranks to the input shafts of the control valves. If jamming occurs within the system, increased pressure at the aileron control wheel will shear the rivets and allow continued normal aileron operation.

The inboard control valve linkage is located aft of the wing rear spar and is accessible through the inboard cove lip doors. The outboard control valve linkage is located forward of the inboard aileron balance panel chamber, and is accessible through the wing lower access panels.



CONTROL VALVE LINKAGE

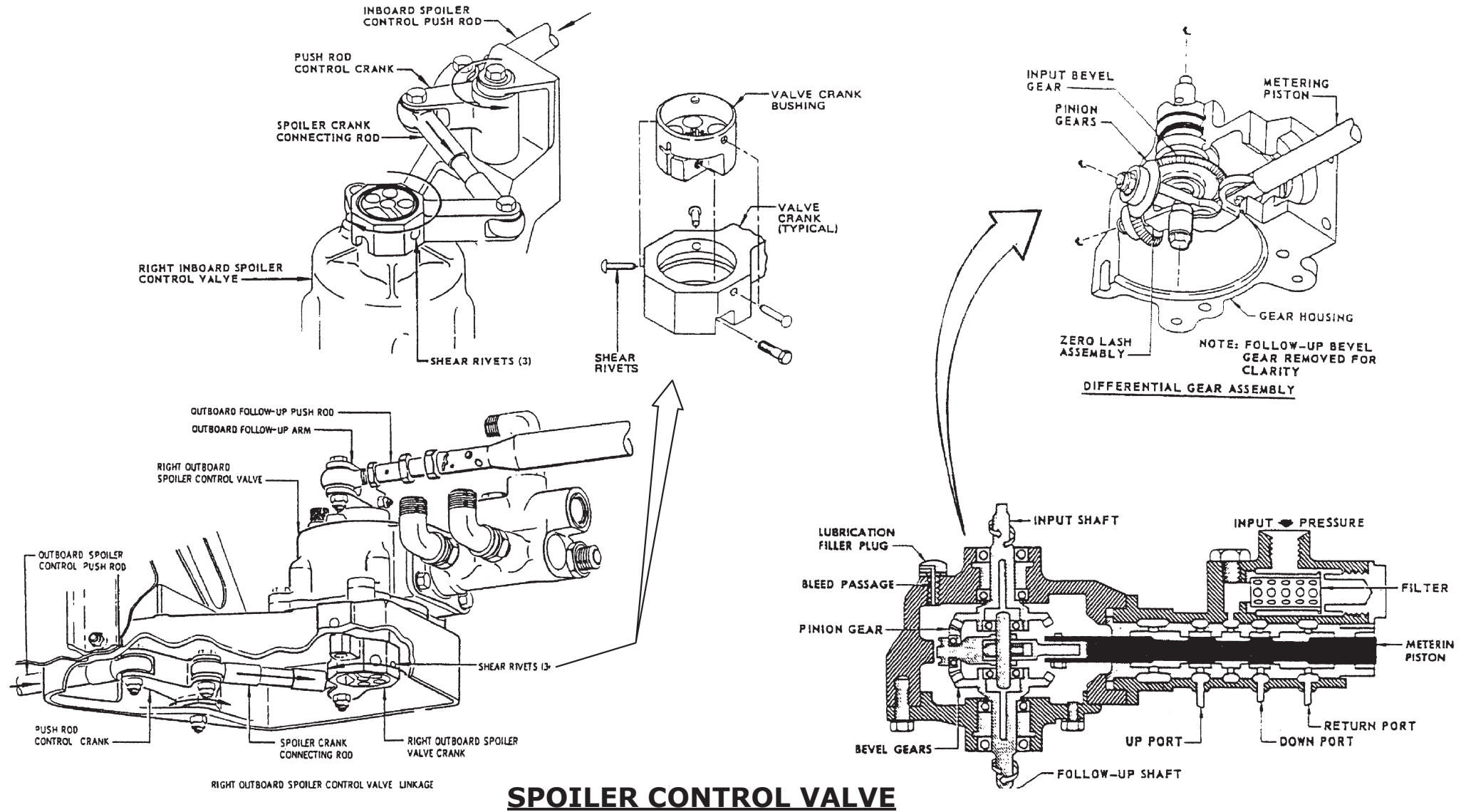
3.4. Spoiler Control Valves.

There is one spoiler control valve for each pair of spoiler actuators.

The valve consists of two main sections, the gear housing and the valve body. The housing contains two bevel gears and two pinion gears, which together constitute a differential gear assembly. The bevel gears rotate with the input and follow-up shafts. The pinion gears are connected, via a crank and link to the metering piston in the valve body. One of the pinion gears is mounted to a spring loaded swinging arm to eliminate back lash in the gear train, thus ensuring rapid response. The axes of the pinion gears converge upon, and rotate about, the axis of the bevel gears. The valve body contains a filter at the fluid inlet port, a metering piston, and a sleeve. Ports are provided in the valve body for fluid passage to and from the spoiler actuators.

The metering piston has three basic positions, extreme in, extreme out, and neutral. When a signal is received at the input shaft, the bevel gear will rotate the pinion gear assembly because the follow-up bevel gear is held stationary by the spoiler. As soon as the input signal has terminated, the input bevel gear becomes the stationary member of the differential, leaving the spoiler controlled follow-up bevel gear free to rotate the pinion gear assembly in the opposite direction. When the pinion gear assembly has moved the metering piston an equal but opposite amount to its original travel, it assumes the neutral position and prevents fluid flow through the control valve.

The inboard spoiler control valves are located aft of the wing rear spar and are accessible through the inboard cove lip doors. The outboard control valves are located forward of the inboard aileron balance panel chambers, and are accessible through the wing lower access panels.



3.5. Spoiler Actuators.

One spoiler actuator is used for each spoiler, the rod end being attached to the wing structure and the cylinder end to the spoiler.

Actuators are accessible when the spoilers are extended.

The actuator includes a cylinder, piston and rod assembly, poppet valve, slide assembly, relief valve, ground release plunger, restrictor and transfer tube. To extend this actuator, fluid at 3000 psi enters port "A" and is fed to the piston face, via the transfer tube; also, fluid acts upon the slide assembly which forces open the poppet valve, allowing fluid at the rod side of the piston to flow out through port "B". To retract the actuator, pressurized fluid enters port "B", forces open the poppet valve and acts upon the rod side of the piston. Fluid from the piston face side flows out of port "A" via the transfer tube. If, during retraction or when the spoilers are down, the fluid pressure exceeds 3300 psi, the relief valve opens to allow fluid to pass out through the restrictor and port "A". The ground release plunger permits manual extension of the spoilers without hydraulic power. Depressing the plunger moves the slide assembly to force open the poppet valve, thus allowing fluid from the rod side of the piston to flow out through port "B".

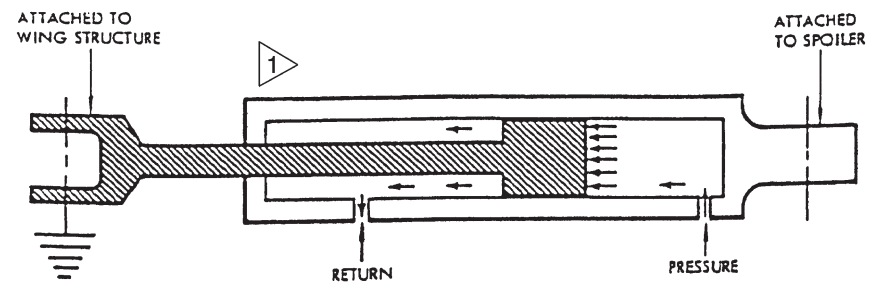
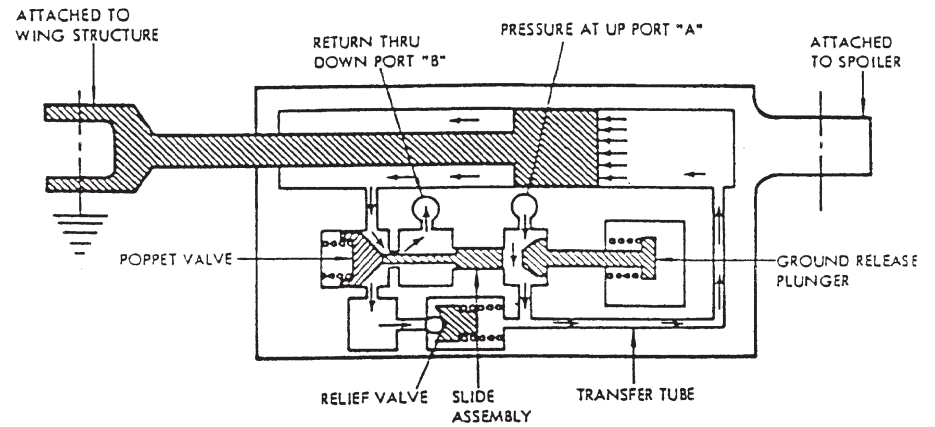
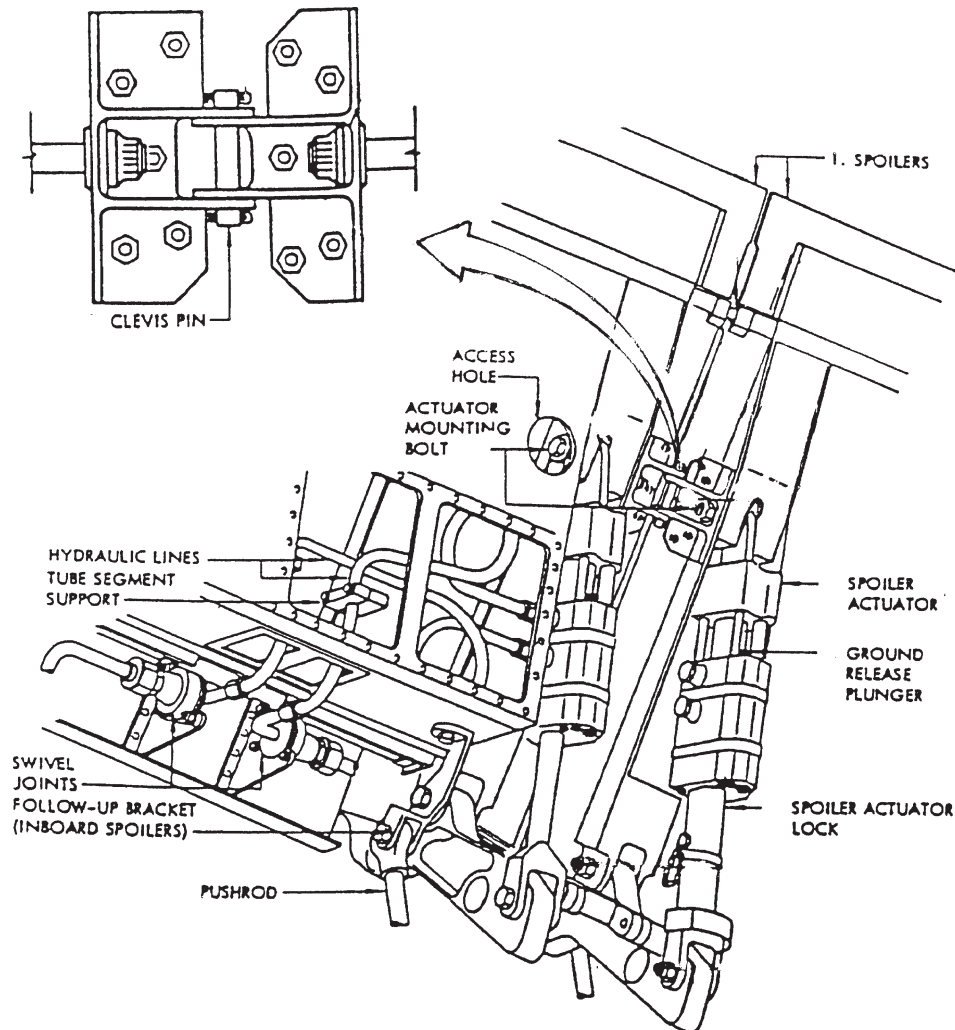
On Some Aircrafts.

The actuator includes a cylinder and a piston and rod assembly. The other components required for spoiler operation are located in a spoiler modular package. These components are shared by adjacent spoiler actuators.

Spoiler Swivel Joints.

Swivel joints in the spoiler control system hydraulic lines allow segments of lines to rotate with the spoilers. The swivel joints have hydraulic fittings at each end and internal seals to prevent fluid leakage. Each spoiler has two swivel joints in the hydraulic lines leading to the actuators. These swivel joints are located on the spoiler hinge lines and are mounted to wing structure.

The swivel joints are accessible when spoilers are extended.



1 ON SOME AIRCRAFTS (WITH MODULAR PACKAGE)

SPOILER ACTUATOR

3.6. Spoiler Modular Package (If installed).

Four identical spoiler modular packages are installed on each airplane, one for each pair of spoiler actuators. Each modular package hydraulically interconnects the pair of spoiler actuators to provide pressure relief, antfloat and manual release functions. The modular packages are bracket mounted at the wing rear spar.

The modular package is a housing which contains a relief valve, two check valves, and a pressure operated valve. The pressure-operated valve contains a poppet valve, a slide assembly, and a ground release plunger. The housing has five ports for hydraulic system pressure and return lines, spoiler actuator up and down lines, and a spoiler control valve down line.

Hydraulic system pressure enters the modular package at port 4 and moves the slide to open the poppet valve connecting ports 1 and 2 of the modular package. This connects the spoiler control valve down line to the spoiler actuators. Spoiler up pressure from the control valve is directed to the face of both spoiler actuator pistons and to port 3 of the modular package.

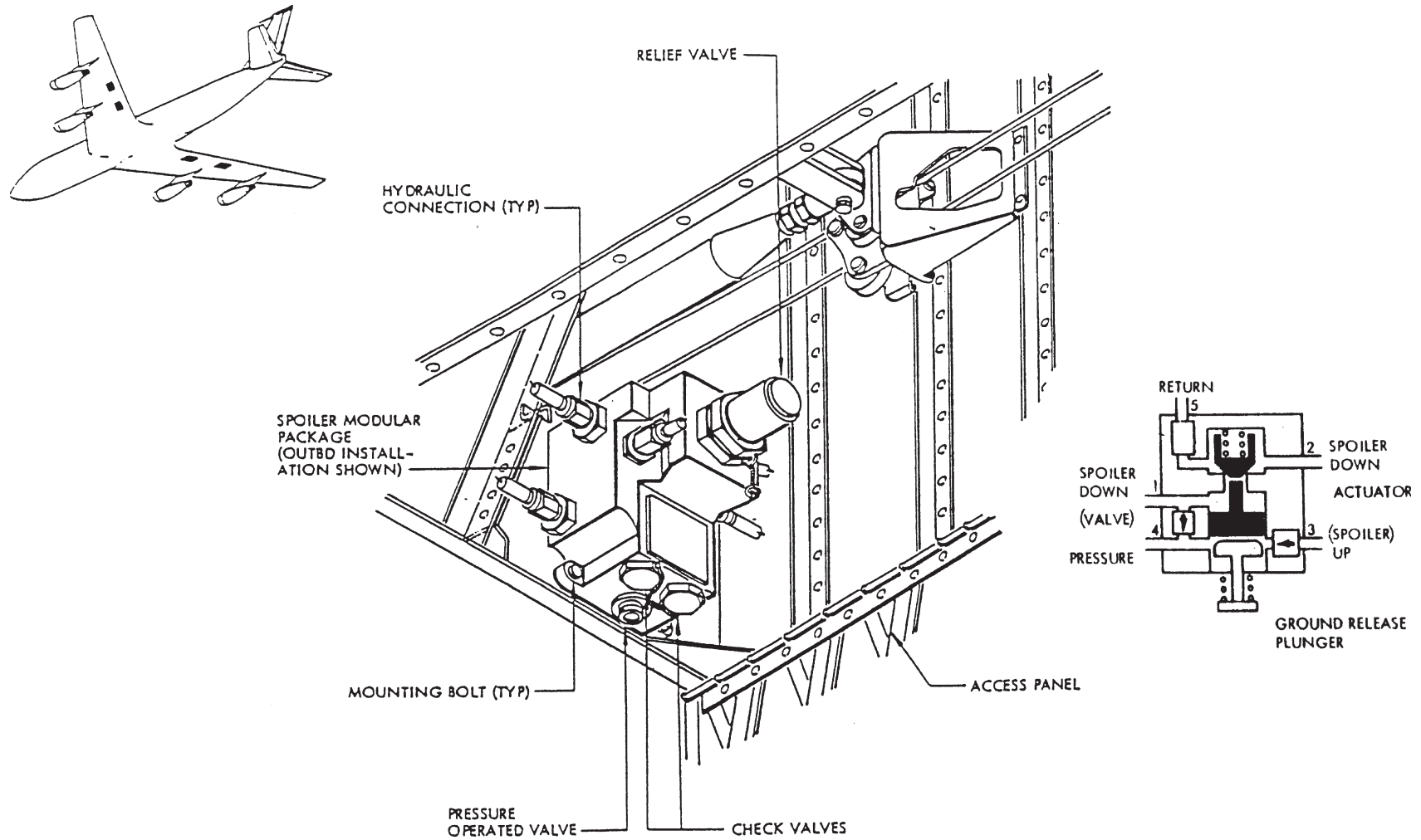
If the pressure at port 3 exceeds system pressure due to excessive airloads on the spoiler panels, fluid will flow through the check valve and out port 4.

This will allow excessive airloads to blow the spoilers down. When the spoilers are moving up, the fluid at the rod side of both actuator pistons is routed from port 2 of modular package through the poppet valve to port 1.

The fluid is then routed through the control valve to hydraulic system return. During spoiler down travel, the hydraulic fluid flow through the modular package is reversed. If the pressure at port 2 exceeds system pressure, due to flap loads on the spoilers, fluid will flow through the poppet and check valves and out port 4. This will allow the spoilers to move up, preventing structural damage to the spoilers and the flaps.

When hydraulic pressure is off, the poppet valve is closed, blocking hydraulic flow at port 2. This action retains the fluid on the rod side of the spoiler actuators preventing spoiler float. If the pressure at port 2 exceeds 3350 psi, due to thermal expansion, the relief valve will allow fluid to flow out port 5 to hydraulic system return.

With hydraulic power off, the spoilers may be raised manually by using the manual release button. Depressing the manual release button will open the poppet valve allowing hydraulic fluid to flow from port 2 to port 1. Manually lifting the spoiler panels will cause fluid to flow from the rod side of the actuator through the modular package and spoiler control valves into the system pressure lines. Hydraulic fluid from the system return lines will flow through the control valve to the other side of the actuators.



SPOILER MODULAR PACKAGE (IF INSTALLED)

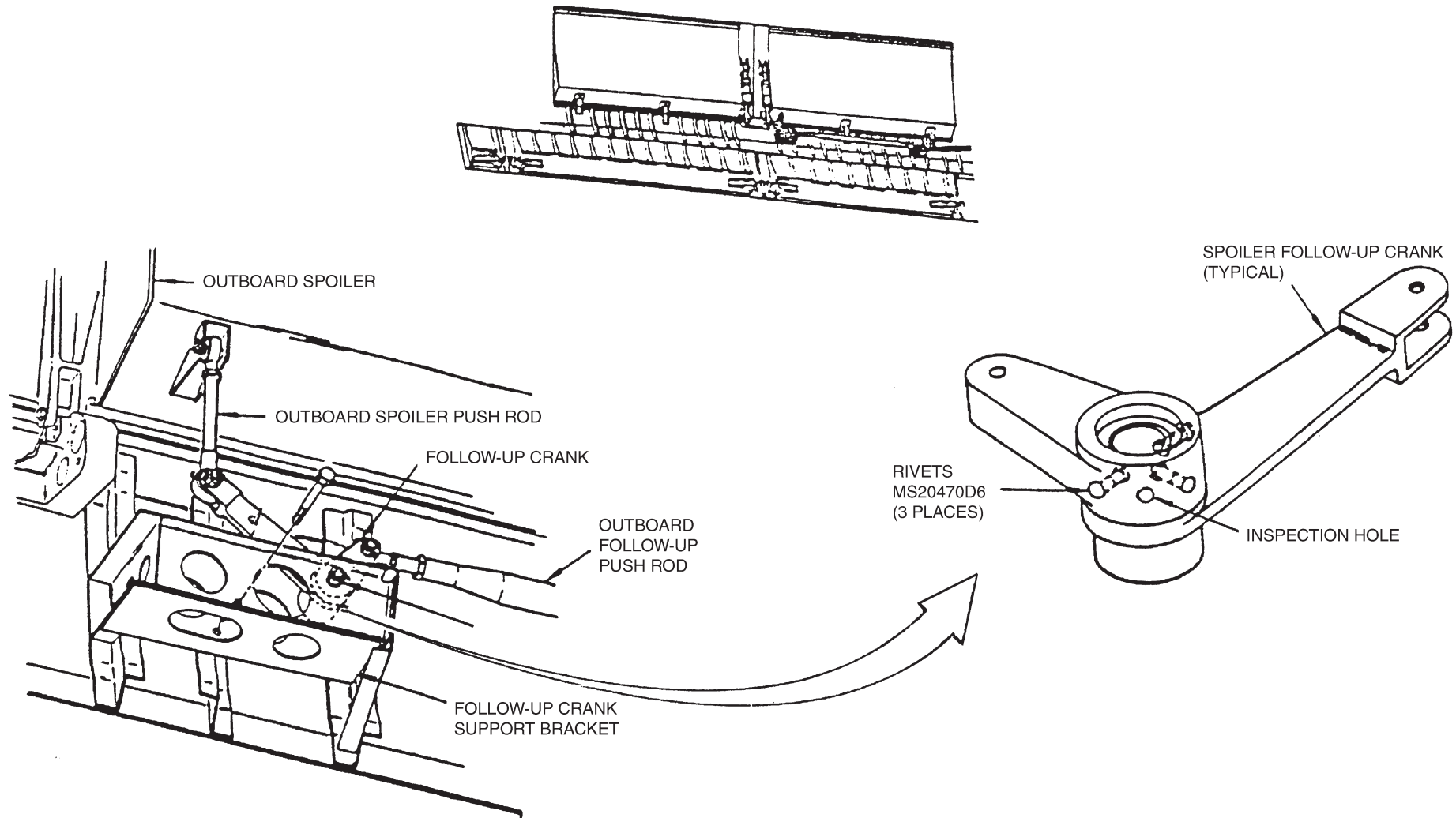
3.7. Spoiler Follow-Up Linkage.

The follow-up linkage extends from the spoilers to the differential link assembly, and transmits the position of the spoiler to the control valve.

The inboard follow-up linkage consists of two pushrods and a follow-up crank, and the outboard consists of three pushrods, a follow-up crank, and an idler arm. The shear feature is eliminated and shear rivets are replaced by structural rivets in each follow-up crank.

Spoiler Differential Linkage.

The differential linkage extends from the speed brake control drum and the follow-up linkage, to the spoiler control valve. The differential system permits motion from both the follow-up linkage and the speed brake control lever to be induced into the follow-up shaft of the control valve, via a single pushrod. Each linkage consists of two pushrods, a differential link and a pivoted support arm.



SPOILER FOLLOW-UP

4. SPEED BRAKE POSITION WARNING SYSTEM.

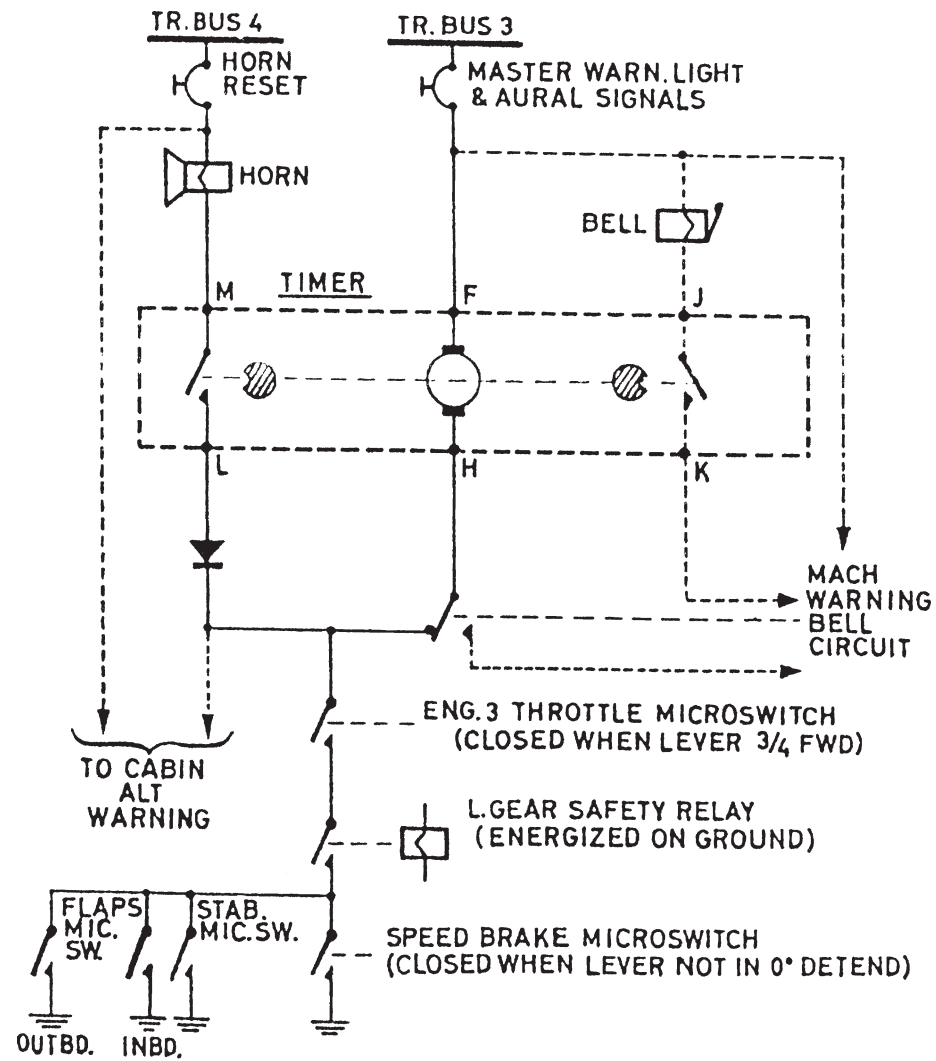
A warning horn is actuated by the speed brake position warning system when an unsafe condition for take-off exists.

The speed brake warning switch (single pole, single throw) is operated from cam motion produced by a phenolic actuator attached to the cable drum of the speed brake control lever. The switch is mounted in the left forward portion of the control stand, forward of the speed brake control lever.

It is accessible by removing the left lower side panel on the control stand.

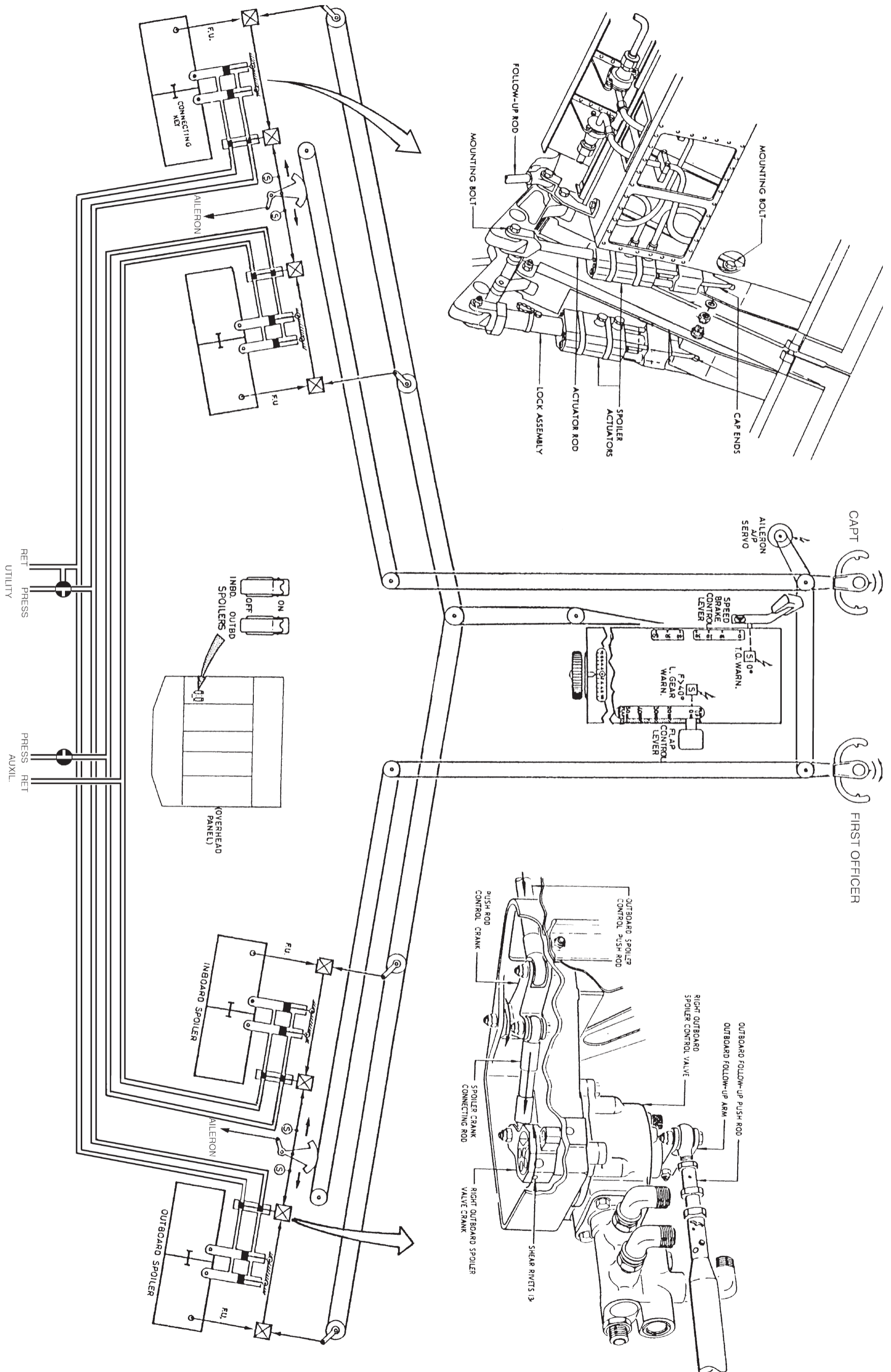
The speed brake warning switch completes a circuit to the ground safety relay. When the speed brake control lever is in any raised positions, No. 3 thrust lever at 75% (or 50% on some A/C), and the airplane on the ground, the warning horn will sound. A flasher unit in the J4 relay panel operates to give intermittent horn soundings. The horn out-out switch does not eliminate a sounding horn from the system with a speed brake warning signal.

Moving the speed brake control lever to the lockout (off) position opens the speed brake warning switch, interrupting current to the horn.



SPEED BRAKE WARNING

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SPOILERS

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