
# ORION

## SERVICE DIGEST

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# ORION




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**FRONT AND BACK COVERS: PATRON 22,** having in its infancy witnessed the "day of infamy" at Pearl Harbor, has for the last quarter-century epitomized the determination of our Armed Forces to never see a recurrence of that day.

Known as VP-14, VB-102, and VPB-102 during W.W. II, (operating PBY's and, later, PB4-Y's) the itinerary of this squadron's operational bases follows the chronology of that war—Noumea/Santa Cruz/Espiritu Santo/Guadalcanal/Tinian/Iwo Jima. Squadron entries to the select society of Medal of Honor winners include Chief Ordnanceman John William Finn and the Skipper of VB-102, Lieutenant Commander Bruce A. Van Voorhis, who was awarded the citation posthumously.

In the immediate post-war years, the squadron continued island-hopping through Micronesia, in the course of which their designation changed to VP-102, VP-HL-2, and, in 1948, to VP-22. The next year, the squadron took up residence at its permanent home base, Barber's Point NAS, were re-equipped with P2V-4's in 1950, P2V-5's in 1952, and were the first to fly the Pacific with the jet-equipped P2V-5 in 1955.

VP-22 took full advantage of the enhanced tactical capabilities of their Neptunes and compiled a record for tactical excellence paralleled only by their safety records. During deployments to Alaska, Okinawa, Japan, Midway, etc. in the late 50's they were repeatedly commended for operational readiness — qualifying the first "ALPHA CREW" in the Pacific Fleet, winning the CNO Safety Award in 1957 and again in 1959; the Arliegh Burke Fleet Trophy for their achievements in Battle Efficiency Competition in 1963.

Selected as the first Hawaiian-area squadron to receive P-3's, the squadron calmly transitioned from SP-2E's while maintaining full operational capability, and at the close of their twelfth year of accident-free flying their total surpassed 95,000 hours. Then, while deployed to the Seventh Fleet, the squadron became first to have **all** crews "ALFA" qualified.

While fulfilling their assignments in connection with the recent "Market Time" operations in south-east Asia, VP-22 won the Battle Efficiency "E" Award, the Arnold J. Isbell Trophy for ASW excellence, and many VP-22 aircrewmen were decorated with the Air Medal.




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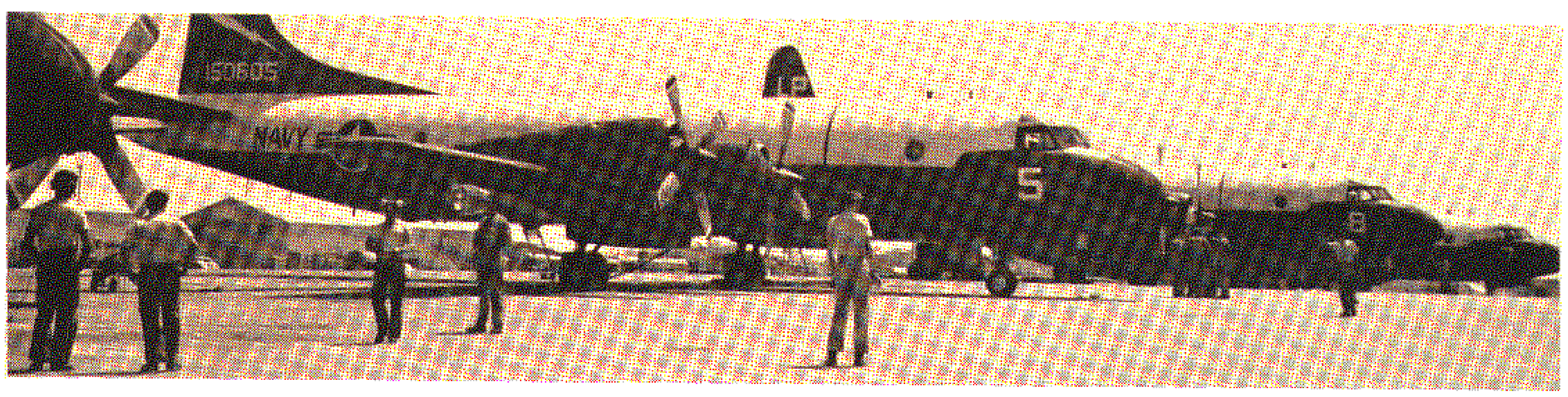
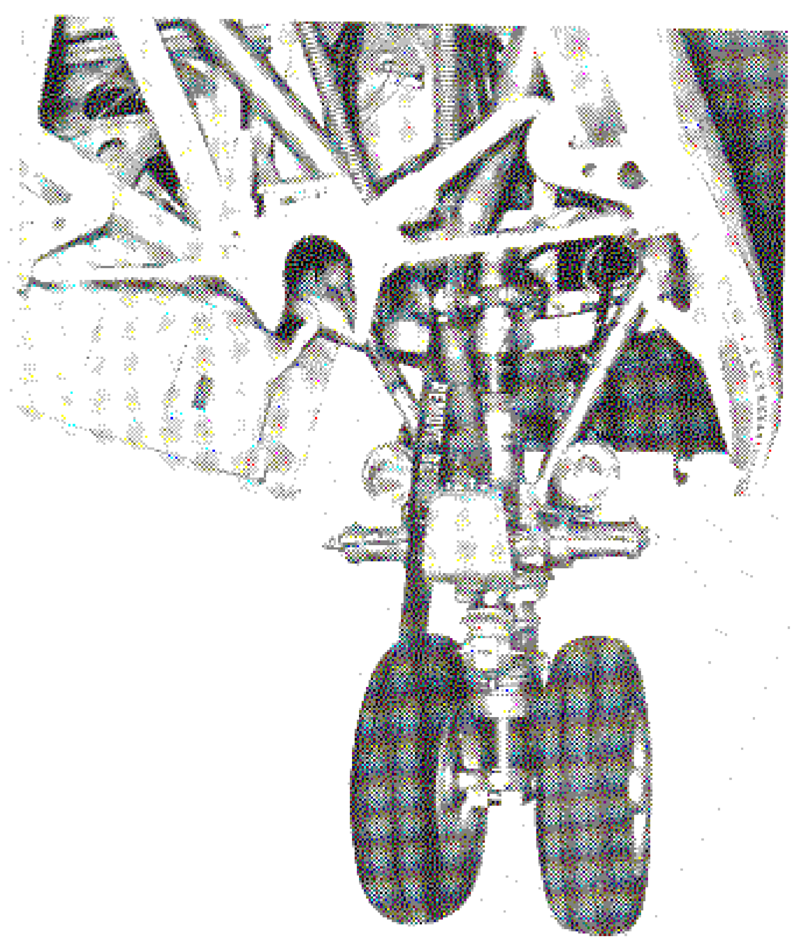




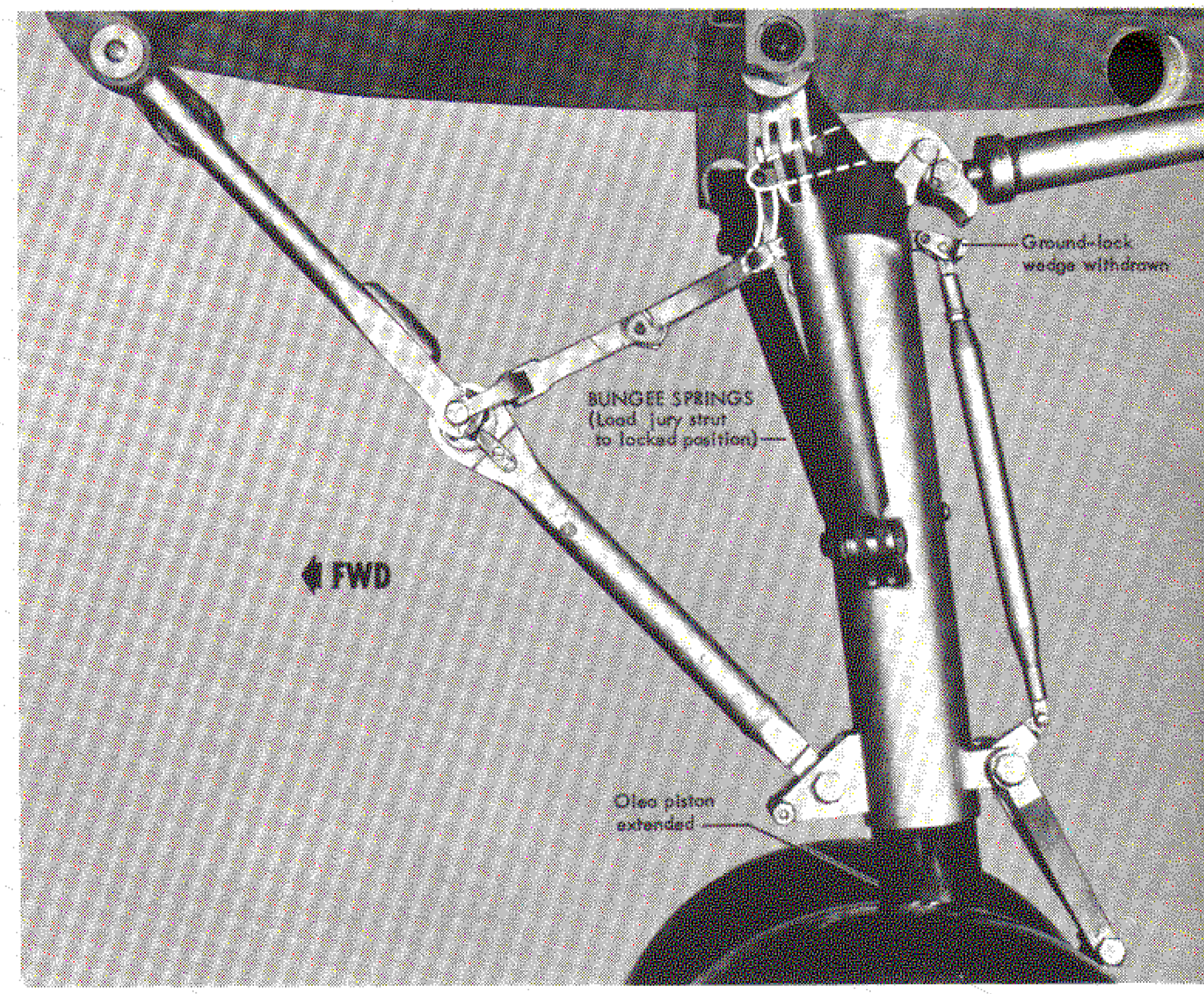
FOREWORD

This article, devoted to landing gear functions, is another in the continuing Digest series explaining the devices and subsystems that comprise the ASW weapons system designated P-3 Orion. Our subject systems are closely allied to those discussed previously in Digest Issue 7 (Hydraulic Power System), Issue 3 (Electric System), and, to a lesser degree, Issue 9 (Wing Flaps).

Since the landing gear systems during normal operation utilize electrically-generated hydraulic power, we have included the master Hydraulic Power System Schematic at the centerfold of this issue and an abbreviated schematic of Electrical Power Support at Figure 2. Readers are urged to refer to these illustrations frequently to acquaint themselves with those aspects bearing directly on our subjects.

Of course, schematics alone cannot entirely supplant the many pages of texts needed to explain them fully. It is suggested that readers who wish to obtain a more precise and broader view of these inter-related systems refer to the current NAVWEPS Manuals for recent modifications and changes, in addition to the Digest back issues for narrative explanations of a more general nature.

# P-3 Landing Gear Brakes and Steering




## LANDING GEAR DESIGN-GENERAL

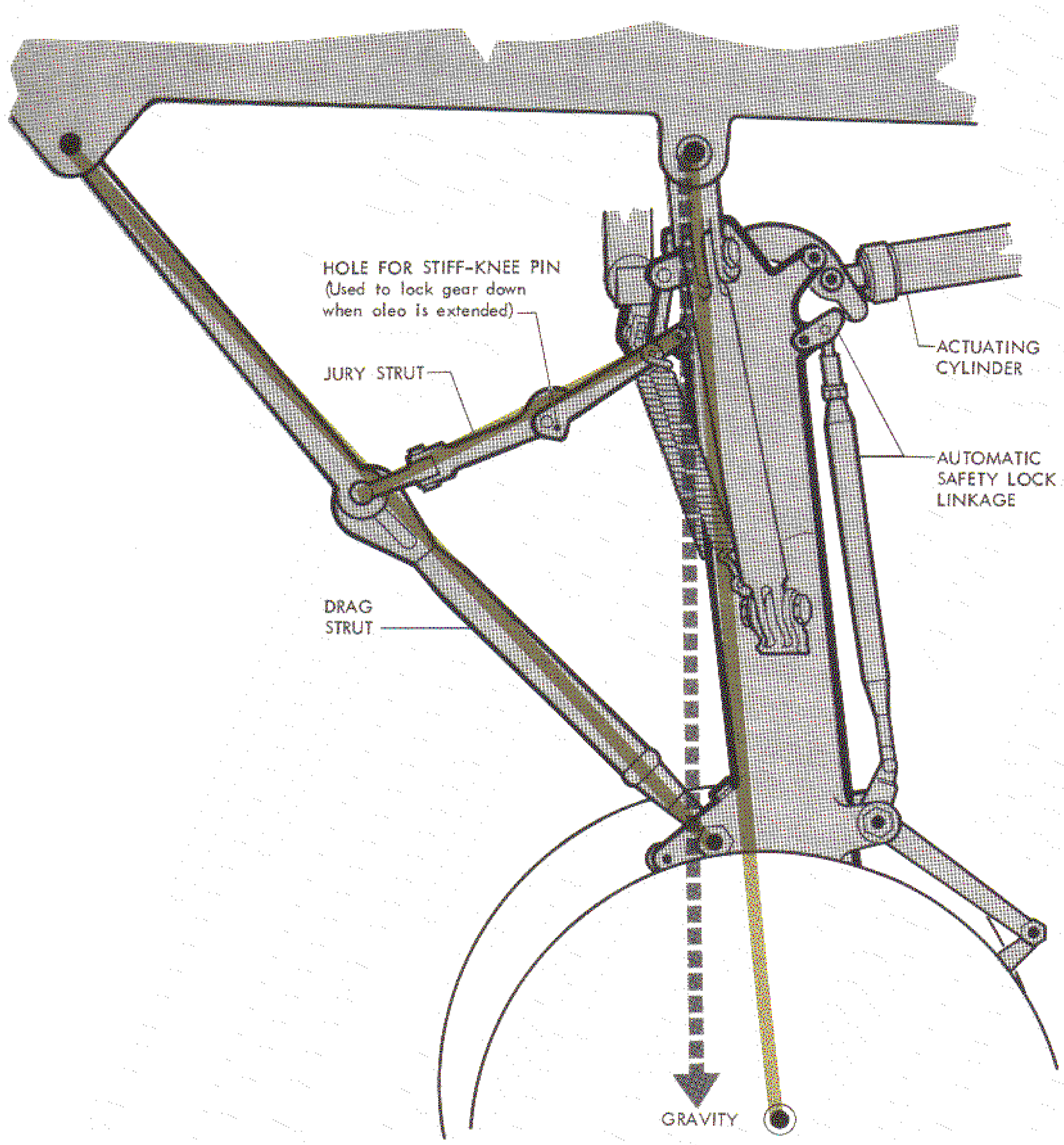



Figure 1a
Mechanical Locking Features of Orion Landing Gear in Ground Configuration

THE P-3 TRICYCLE LANDING GEAR assemblies are hydraulically retracted, hydraulically or manually extended. All three struts extend down and aft in an arc about their trunnion pivots, and with the impetus of in-flight airloads, they will free fall to "down-and-locked" when the uplocks are released.

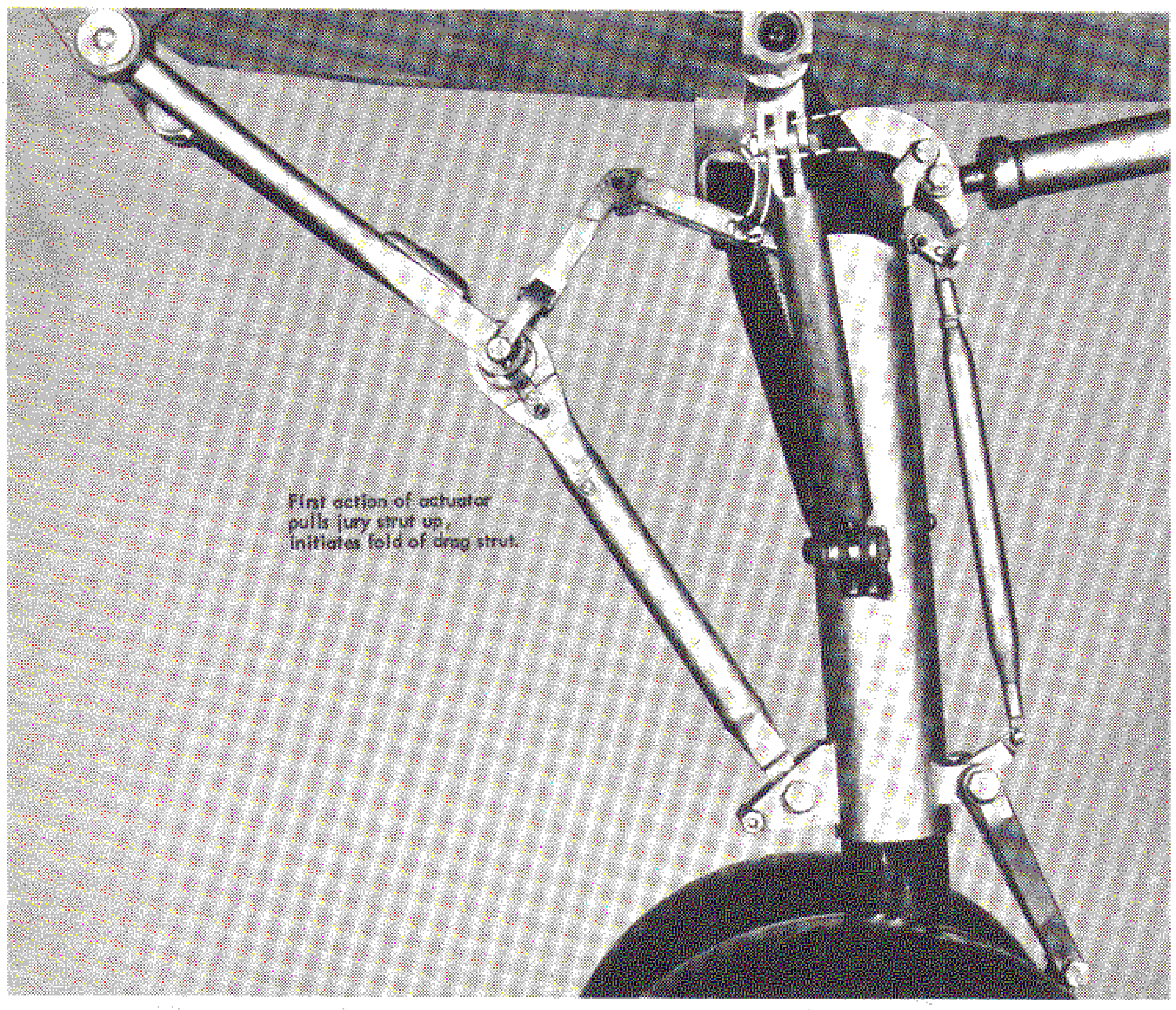
Dual wheels are fitted to both the main and the nose gear; the main gear only have hydraulic brakes of the segmented rotor-disc type. The brakes do not incorporate anti-skid provisions. For emergency braking, a separate pneumatic system is provided. The nose wheel has a hydraulic steering system. All hydraulic power for all landing gear functions is furnished by the No. 1 hydraulic system. Two large ac motor pumps power this system normally, and, when these are not operable, a small dc motor pump can be used to power the brake system only.

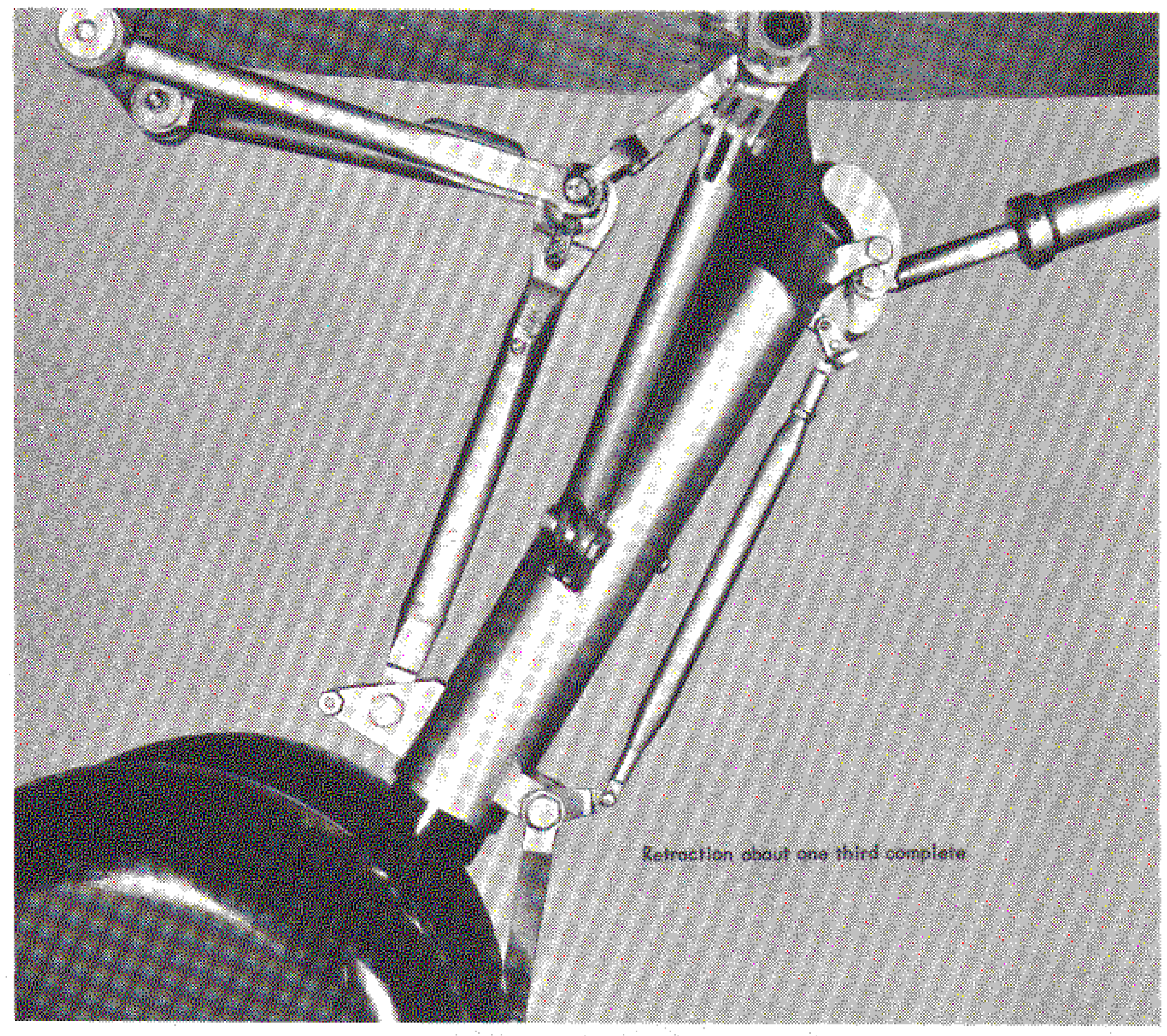
All major structural members of the landing gear are of high-strength steel. Main landing gear wheels are forged aluminum alloy, the NLG wheels are forged magnesium. All are of the split-rim type.

The shock struts are conventional oleo (air-oil) design, and each gear is extended and retracted by a single actuating cylinder mounted directly aft of the strut.

There is a close similarity between the design "plan" of the main and nose gear, and their uplock and down lock configurations too are essentially the same in plan if not in conformation. Full advantage is taken of the strut compression that occurs when aircraft weight is supported on the gear to make accidental gear retraction a physical impossibility. In this

Figure 1b Three Views of MLG Scale Model Showing Configuration After Lift-off, Initial Unlock of Struts, and Retraction in Progress




respect, the most positive insurance is furnished by a solid, purely mechanical locking device that closing of the scissors (torque arm) linkage inserts into the gear actuating linkage (see Figure 1). In addition to this, there are provisions for the conventional manually inserted down lock safety pins, but these are used primarily as a back-up for the automatic lock, or for use in maintenance checks requiring special control of gear actuation.

The design of all the gear mechanisms makes use of a simple geometric arrangement which may be likened to the arrangement nature has provided at the knees of man's landing gear—the over-center lock. For instance, when down-and-locked the struts themselves are canted aft with the axle slightly aft of the trunnion so that aircraft weight and braking tends to maintain their position. As shown in Figure 1, the drag-strut/jury-strut arrangement of each gear provides a down-lock that also features a knee joint arrangement, with springs which load the links in their over-center-lock position.

The uplocks, too, utilize the over-center-lock principle, although it is less obvious in their design. In view of the heavy loads they must support, the uplock mechanisms use remarkably light links and springs, but the light calibre of these components and the dispersion of loads inherent to the over-center-lock geometry is advantageous, for the unlocking loads are equally diminutive. Tiny hydraulic actuators are provided to unlock the mechanisms, and if hydraulic power is not available, a light pull on the emergency "down" cables will release the uplocks.

The nose wheel axles are aft of the strut center line so that they "caster," and the steering system incorporates a number of automatic safety features. The system depends on "gear down" pressure for power and therefore steering is de-activated automatically when "GEAR UP" is selected. When the nose wheel clears the ground and nitrogen gas pressure within the nose strut extends the strut piston fully, cams within the strut act automatically to center the nose wheels, ensuring against the strut being retracted with the nose wheel cocked. Further, for towing by the nose gear, a special tow bar must be used, and when the tow bar is locked in position it mechanically disengages the steering system. The tow bar cannot be removed without re-engaging the system.

The brake system too is inter-related with the landing gear actuating system. With GEAR DOWN selected, the brakes are operable in conventional fashion from the pilot's or co-pilot's rudder toe pedals. While the gears are in-transit after GEAR UP has been selected, normal brake power is blocked, but a special in-flight brake system is activated and a mild braking action is applied automatically to stop MLG wheel rotation before the wheels enter the wheel wells.

Wheel well doors are all of the clam shell type. As the gears retract, the aft MLG doors are closed by permanently attached mechanical linkage, while the forward MLG doors and the NLG doors are coordinated with the gear cycle through linkage that is engaged by strut components as the strut enters the well. The NLG door linkage is entirely mechanical. The forward MLG doors are triggered mechanically by the strut, but they close with pressure taken from the gear up pressure lines.

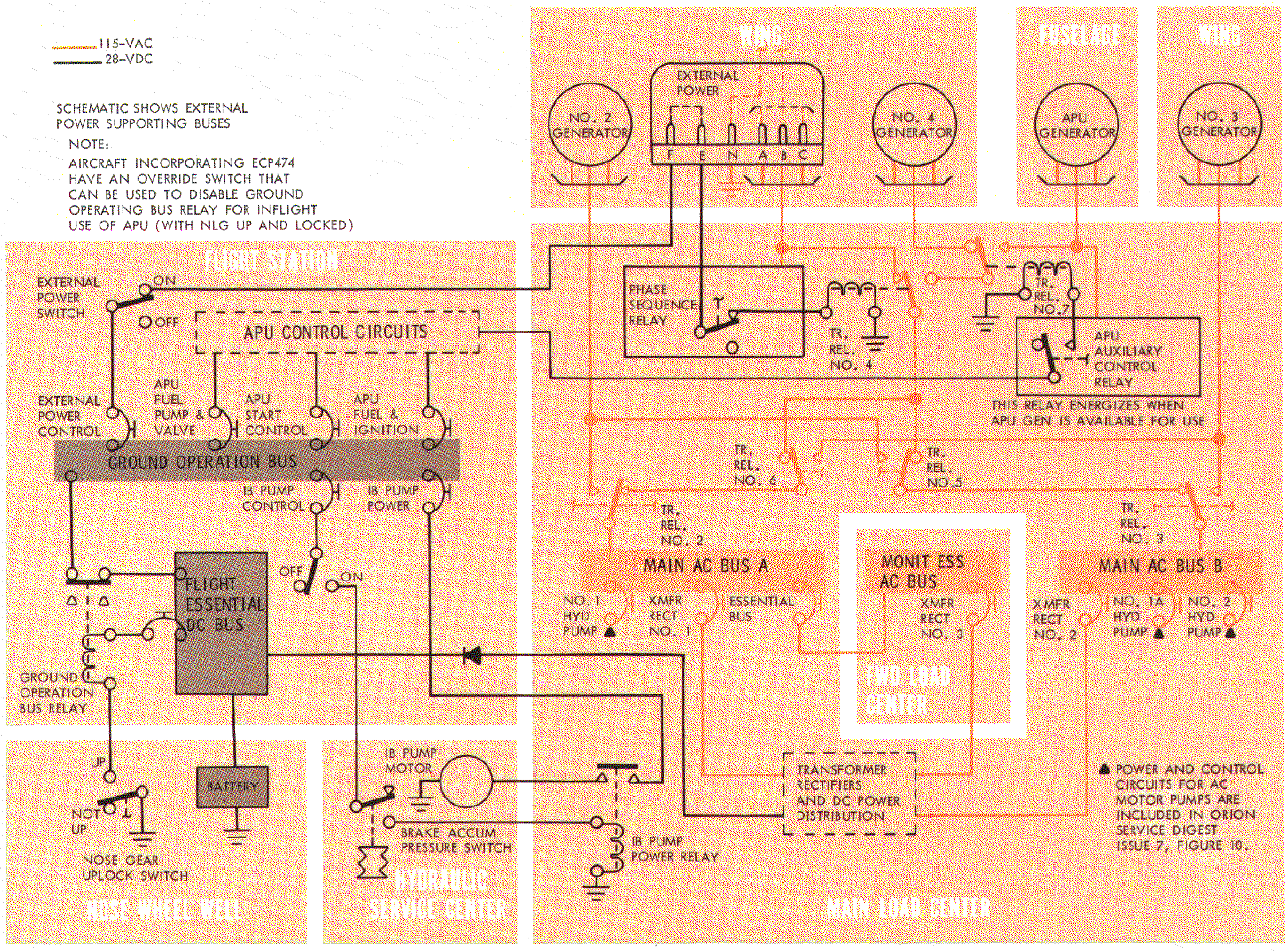



Figure 2 Electrical Support of Hydraulic Pumps. Note that External Power and APU energization of all buses is dependent on unlocked NLG uplock. If ECP 474 has been incorporated, this feature can be overridden.

**LANDING GEAR ACTUATION** The landing gear and its control components are closely integrated with many aircraft systems. The following discussion traces the order of events that occur from block-to-block during a flight and supplementary information of interest to line maintenance and operating personnel is interjected in the narrative.

**Hydraulic Power System Activation.** The two ac motor-pumps that power the No. 1 hydraulic system are supported by separate buses (as shown in Figure 2) both of which can draw power from any operating generator or from the Ground Power receptacle. It should be noted that if ground power only is available, the control circuit that connects power to the aircraft buses cannot function unless the nose gear uplock is in its unlocked position. This will normally be the case, of course, but not necessarily so, for it is possible to manually lock the gear uplocks, and if this has been done it will be necessary to either manually unlock the nose uplock or open the GROUND OPERATION BUS RELAY circuit breaker at the Flight Essential DC Bus* before ground power can be connected to the aircraft buses.

Once the buses are energized, turning ON the No. 1 system pumps with the gear handle in DOWN position will pressurize the gear down lines, and if the MLG uplocks have been inadvertently left in the locked position they will unlock automatically. Also, nose wheel steering and the normal brake system will be operational at this time.

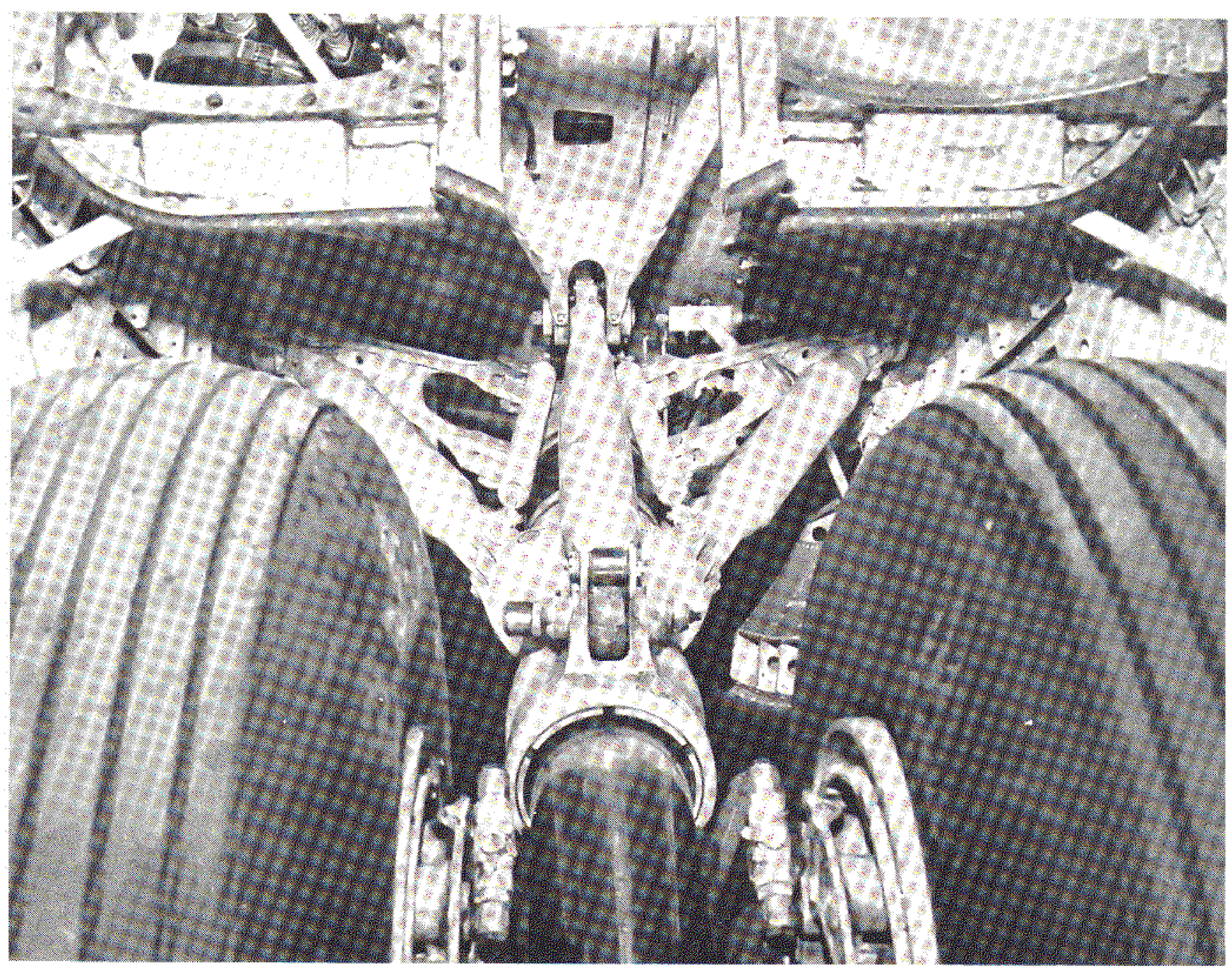
**Ground maintenance procedures entailing operation of the nose gear uplock invariably require that the GROUND OPERATION BUS RELAY circuit breaker be pulled. Otherwise, locking of the uplock will automatically de-energize aircraft buses.*

**Ground Configuration.** The landing gear configuration when parked, taxiing, and during the early part of the takeoff run is substantially as follows:

As long as the balance between aircraft weight and strut inflation keeps the MLG and NLG struts compressed more than 4 inches and 2 inches (respectively) from their fully extended position, the automatic safety lock will positively prevent landing gear retraction. (Also, even if the NLG strut is fully extended, its safety lock will be effective if the wheels are turned a few degrees off center.) This safety feature is predicated on the maintenance of proper strut inflation. The safety lock linkage is purposely made without adjustment facilities to preclude misadjustment, but there remains a possibility of a dangerous misadjustment in respect to strut inflation and we will digress briefly to discuss the principles involved.

It is generally thought that once a strut is properly serviced with oil and nitrogen, it will remain so indefinitely, but this is not the case. The inflation procedures placarded on the struts list a number of pressure versus volume coordinates (volume being gauged by measuring piston extension), and once a balance is achieved, the strut will function efficiently and safely for a time, but not necessarily forever. It should be noted that a rather delicate balance is achieved by this procedure. Once sufficient gas has been injected to lift the landing gear struts from their fully compressed position, very little pressure change is required to bring them to their fully extended position, although there is a considerable difference in the gas volume content. Since pressure varies but little, then, volume, which is to say strut extension, is closely allied to two variables, temperature and aircraft weight.

We wish to emphasize this for the reason that the perfect safety provided by the ground lock device under normal circumstances is quite apt to mislead personnel into a presumption of absolute, automatic safety when in some unusual circumstances one or all of the devices may be rendered inoperative. One obvious cause of such an occurrence would be a long cross-country flight from a frigid to a torrid climate. Struts, serviced in sub-zero weather to obtain a proper extension for a heavily-laden takeoff, will be considerably over-inflated by a temperature rise in excess of 100°F at termination of the flight, and it has happened that after a smooth landing with low aircraft weight the strut pistons remained at full extension. We recommend that all who work with the P-3 exercise routine vigilance to ensure that the automatic down lock wedges are in place, particularly before beginning maintenance work on landing gear, wheels, or brakes. The manually-inserted "stiff knee" pins should always be used if the down lock wedges are not in place, or if there is any likelihood that off-loading or temperature rise will over-inflate the struts.



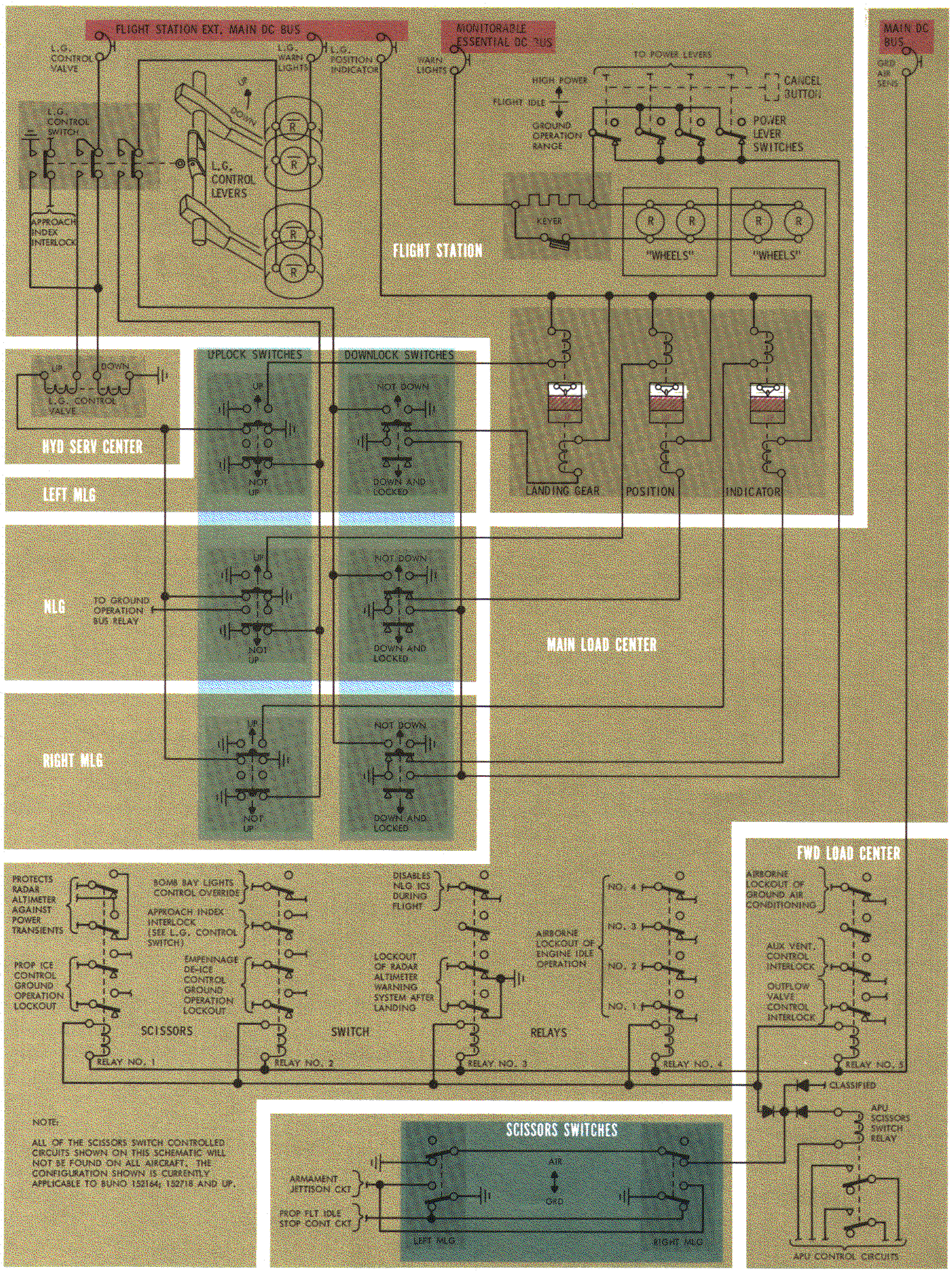


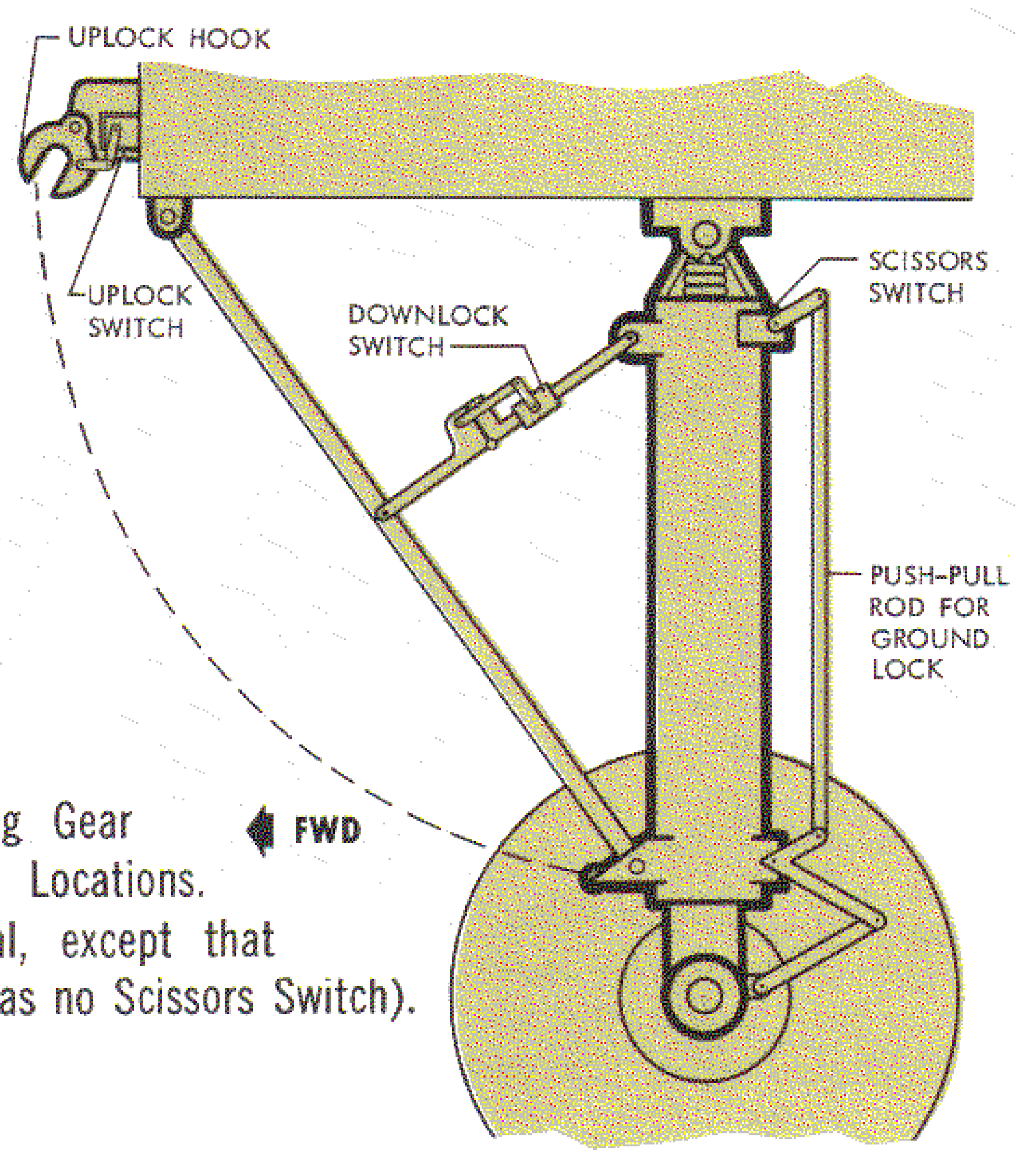

Figure 3 Landing Gear Control, Indication, and Warning Schematic

**Landing Gear Cycle—Electrical.** As the MLG are relieved of aircraft weight, the strut pistons extend, expanding the scissors (torque) links which control the ground lock linkage. At about 4" from full strut extension, the automatic down lock wedges are disengaged from the retracting mechanism; at less than ⅜" from full extension the down lock linkage will actuate the scissors switch mounted adjacent to each of the wedges.

These are 2-pole, 2-position switches. One pole of each switch is connected in parallel (enabling weight on either MLG to retract the prop control flight idle stops and to disarm the armament jettison circuit*); the other pole of each switch is connected in series (requiring weight on both MLG) to control the Scissors Switch Relays shown on Figure 3. It can be seen that the multitude of functions controlled by the Ground/Air Sensing circuits makes this a most important safety provision, deserving of study by both air and ground crewmen.

On the P-3, the pilot's and the co-pilot's landing gear control levers are interconnected, and their only function is to actuate 5 cam operated switches. The switch with which we are concerned is a 2-position, 3-pole switch (as shown in Figure 3, only two of the poles are directly related to landing gear actuation).

**Safety precautions must be observed before undertaking any ground maintenance procedure which could result in one or both scissors switches sensing that the aircraft is airborne. We recommend pulling all the circuit breakers listed in the "Jacking" procedure of the General Information and Servicing MIM in all such cases. It is sometimes more expedient to ground the scissors switch wires in the wheel well area, but note that if this is done, it will be necessary nevertheless to pull the ARMAMENT JETTISON circuit breaker. This is located near the bottom of the small Monitorable Essential DC Bus subsidiary at the right-rear of the Flight Engineer's seat.*



Landing Gear Switch Locations. (Typical, except that NLG has no Scissors Switch).

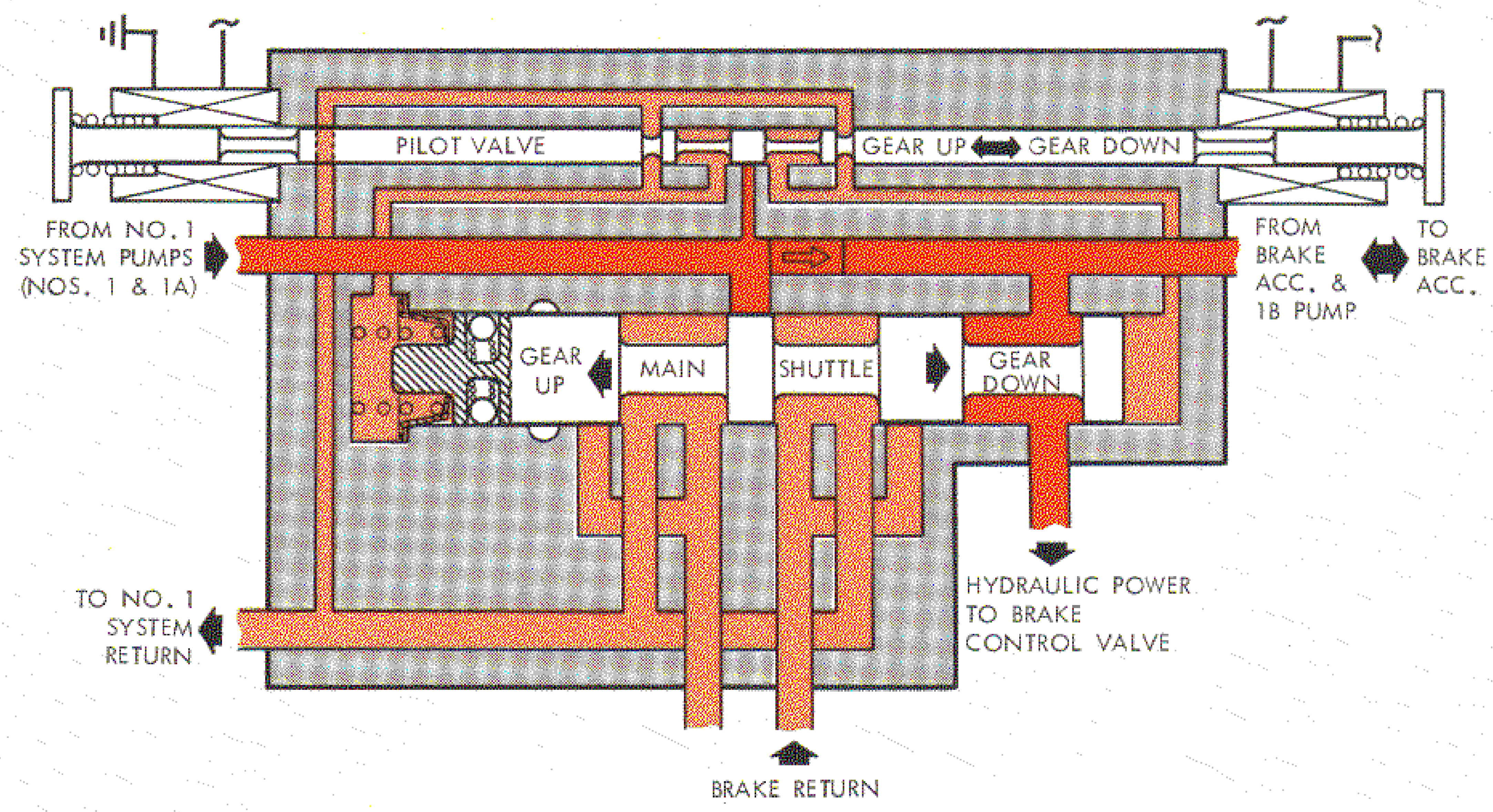
When GEAR UP is selected, power from the LG CONT VALVE circuit breaker on the Extension Main DC Bus is directed through the "up" solenoid of the landing gear selector valve and to the three landing gear uplock switches. The circuit will be completed to ground through the switch of any unlocked uplock.

The landing gear control selector valve is a servo operated valve. The servo (generally known as the pilot valve) is positioned by energizing the "up" solenoid, porting system pressure to actuate the selector shuttle valve. Movement of the shuttle to its "up" position ports pressure to the gear-up lines, return to the gear down lines, (thus deactivating the steering system) and also blocks the pressure line to the normal brake power valves and applies the in-flight brakes. The selector will only remain at gear up position until all three gears are up and locked, for locking of the uplocks opens the selector valve "up" solenoid circuit, and springs within the selector return both the pilot and the shuttle valve to "neutral." At neutral, all landing gear lines are connected to return, pressure is made available to the normal brake system, and in-flight brakes are released. The landing gear selector is located at the top of the hydraulic service center adjacent to the access hatch in the cabin floor, and it is possible to manipulate the pilot valve manually if it is necessary to do so. Note that this merely duplicates the electrical actuation—it offers no cure for hydraulic problems.

**Landing gear warning** is a three-part electrical system which operates a conventional "down-and-locked/in-transit/up-and-locked" indicator on the co-pilot's panel, a red light imbedded in both the pilot's and co-pilot's control lever handle, and a flashing red warning light bearing the word "WHEELS" at the top-center of the pilot's and co-pilot's instrument panels.

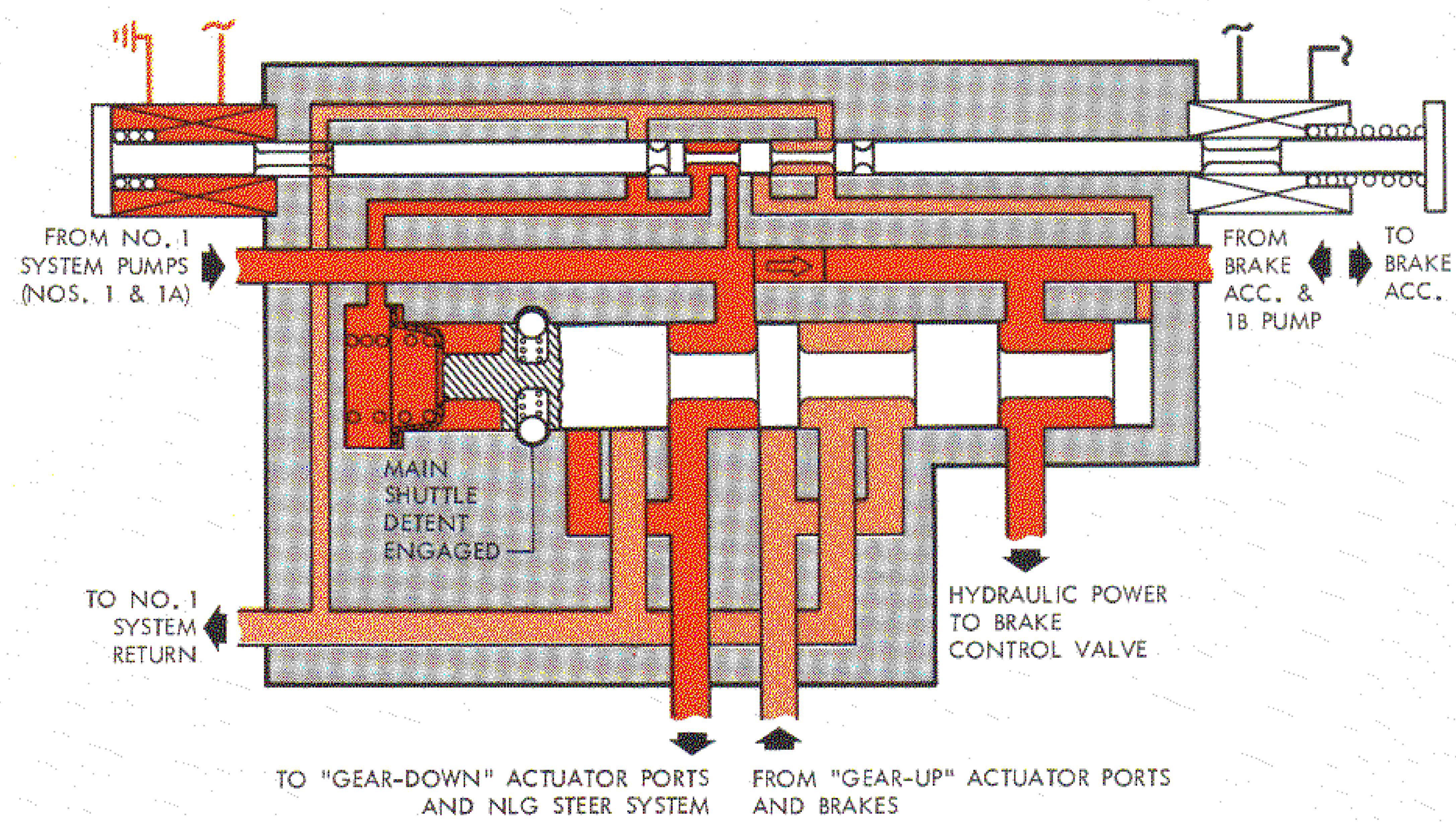
The indicator is a standard type, having three windows to view three solenoid-operated drums. Each downlock switch completes a circuit for the related drum "down" solenoid, and a pictorial symbol of an extended landing gear appears in the viewing window. When neither the uplock nor the down lock of a specific gear is locked, both the "up" and the "down" solenoids are de-energized, and a spring rotates the drum to expose a striped barber-pole pattern, indicating that the gear is in-transit. When the uplock switch actuates to locked, the up solenoid of the related drum causes the word "UP" to appear in the window.

The lights in the gear control lever handles are closely allied to the barber-pole warning provided by the indicator, but they do give some additional infor-

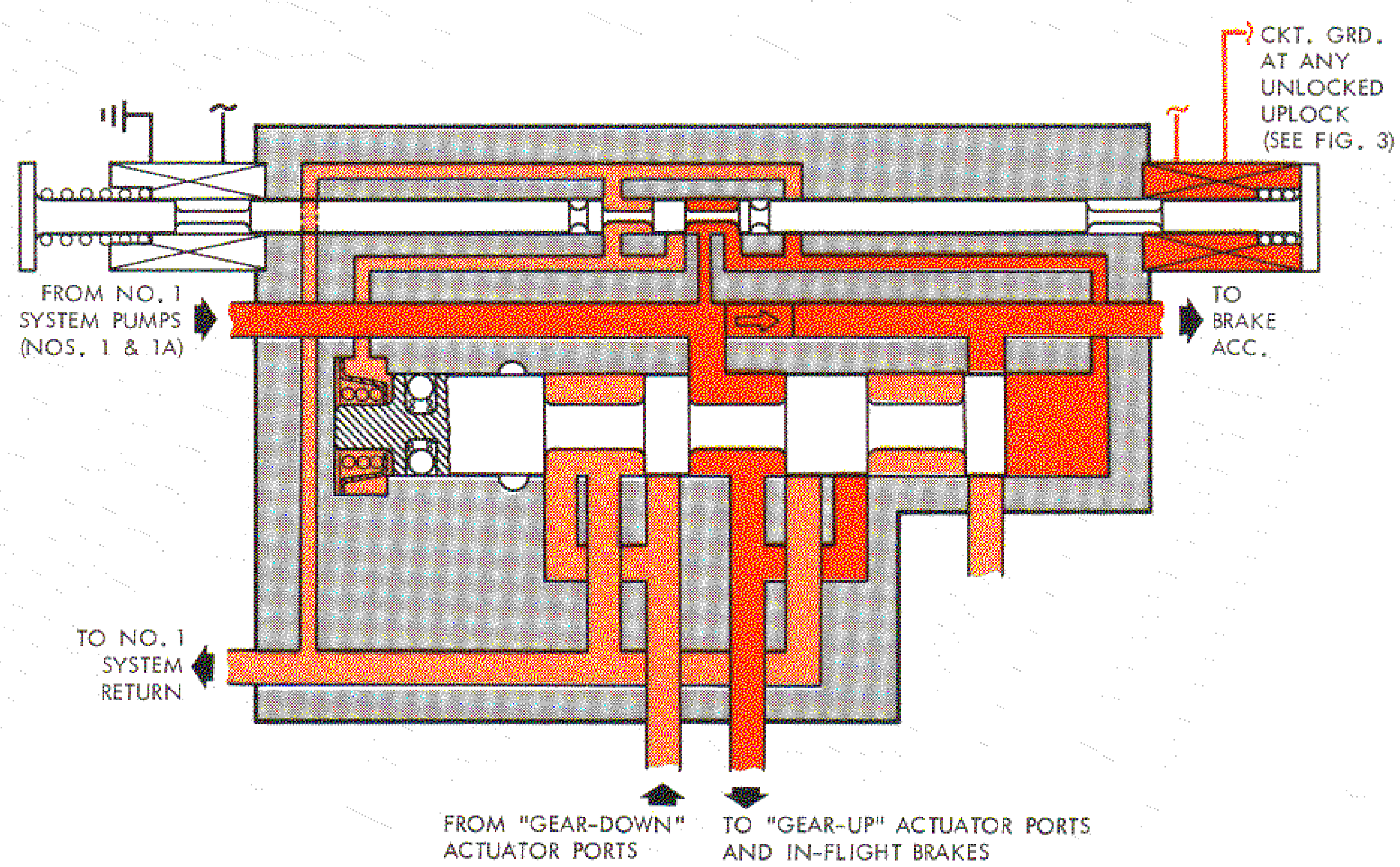



NEUTRAL CONFIGURATION - NORMAL TO FLIGHT (GEAR LOCKED UP)

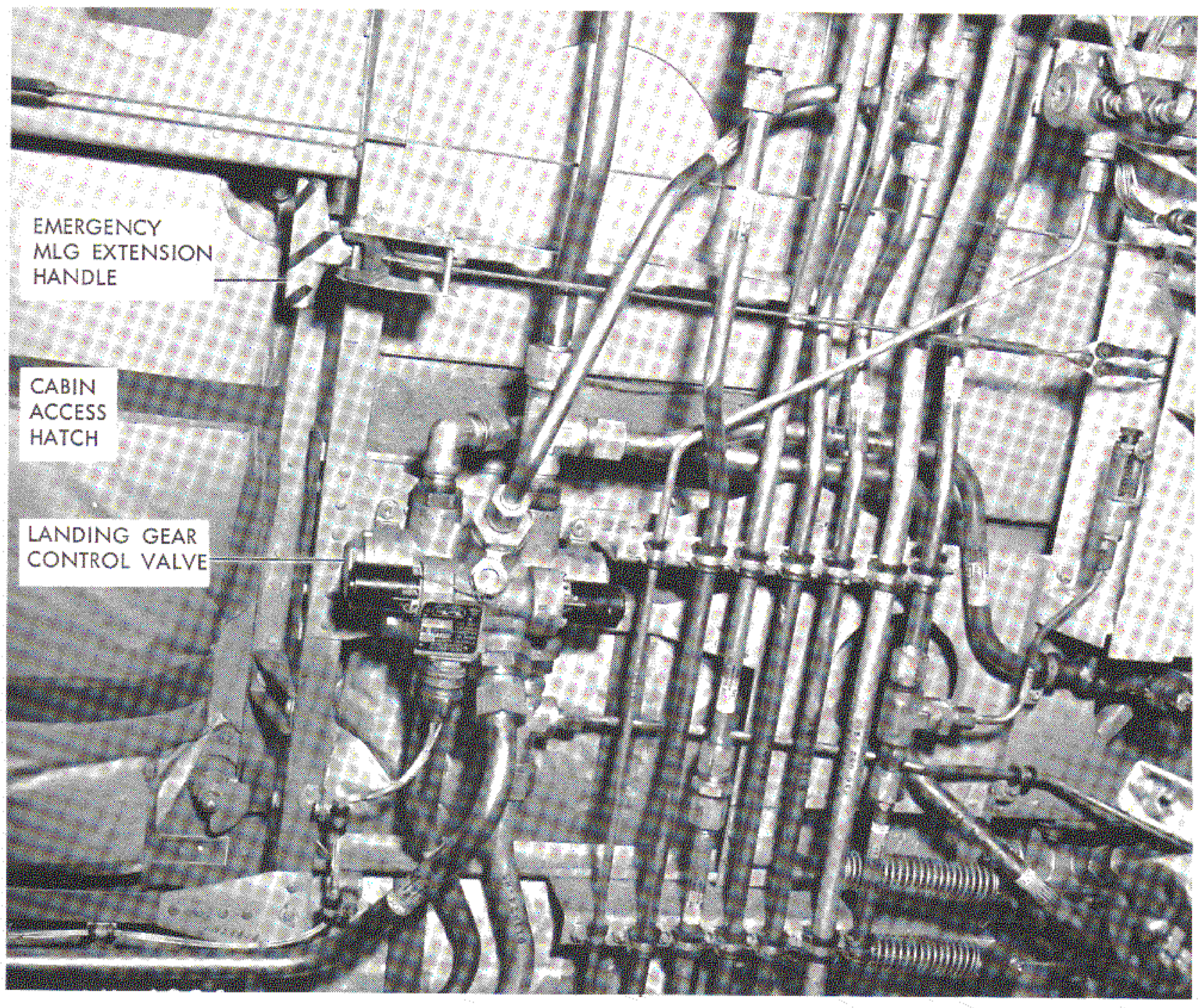
Figure 4
Landing Gear Control Valve Schematics Showing all Control Configurations




GEAR-DOWN CONFIGURATION - NORMAL TO APPROACH AND GROUND OPERATION




GEAR UP CONFIGURATION - NORMAL TO GEAR RETRACTION STROKE




View Looking up at Cabin Sub-floor in Hydraulic Service Center

mation in that their circuit is routed through the landing gear selector switch. Thus, these lights illuminate immediately when the landing gear selector switch is repositioned, (thus proving that the switch has actuated) and they continue to glow until all three landing gear switches sense that the gears are locked in the selected position.

The "WHEELS" lights on the instrument panels never illuminate in normal flight operation, for their circuit is not complete unless one or more power levers are retarded below minimum cruise while one or more landing gear are not down and locked. The circuit incorporates a "keyer" that flashes the red "WHEELS" light at the top-center of each pilot's instrument panel if the gear is not in landing configuration when the power levers are brought into a configuration that is normal only to approach and landing. The flashing light can be extinguished, by advancing power levers, extending gear, or by depressing an over-ride button on the co-pilot's side of the control pedestal. The over-ride button disarms the system, but it is re-armed automatically by advancing the power levers.

When the landing gear reach the up and locked position, one pole on each uplock switch closes the circuit from the related "up" solenoid of the position indicator, one pole of each switch opens one of the three parallel circuits from the "up" solenoid of the landing gear control valve, and, when all gear are locked up, the control valve is de-energized. Springs within the control valve will return the valve to neutral when the "up" solenoid is de-energized, and this connects the "gear up" actuating pressure lines to return, de-pressurizing the actuators entirely and de-activating the in-flight brake system.

When GEAR DOWN is selected at the landing gear control lever, the "down" solenoid of the selector valve is energized, and, unlike the "up" solenoid, the "down" solenoid remains energized after the gear is locked down. Also, due to a mechanical detent which engages the main shuttle within the selector valve (see Figure 4), the valve remains at its hydraulic gear down position until 1) the pilot valve is moved to its "up" position, either electrically or manually, while 2) No. 1 hydraulic system is pressurized.*

**There is a general misconception that a momentary manual operation of the pilot valve to UP without hydraulic pressure being available will result in repositioning the selector valve to "neutral." It should be noted that pilot valve actuation without hydraulic pressure will* not *disengage the main shuttle from the down detent, and if No. 1 system pressure is subsequently applied, all the actuators powered by the "gear down" pressure lines (steering, all uplock release, normal brake system, and all landing gear actuators) will be pressurized.*

**Landing Gear Cycle — Hydro-Mechanical.** Gear-up pressure from the selector valve pressurizes the in-flight brake line (described later) passes through a manually operated shutoff valve, branches into individual "up" lines for each gear and passes through flow regulating valves to the "up" port of each uplock release cylinder, the main gear door closing cylinders, and the landing gear actuators.

Pressure at the uplock release cylinder "up" port merely retracts the actuator piston rods so they will not interfere with the uplock actuation. Pressure at the MLG door actuating cylinders produces no immediate action, for the linkage to which they are attached is spring loaded in an over-center lock arrangement that prevents door actuation until the strut enters the wheel well.

Pressure will begin to extend the gear actuating cylinders, and the initial effect of each actuator is to depress the jury strut extension link to which it is attached. This "breaks" the jury strut up from its over-center locked position, and, through the forward jury strut link's attachment to the middle joint of the drag strut, the drag strut too is pulled up from its over-center-down-and-locked position. As the actuator continues to extend, its force is applied directly to the strut cylinder to swing the gear up and into the wheel well. The retraction cycles of the three gears are synchronized by flow control valves in each gear-up line which apportion 4.8 gpm to each main landing gear, 2.2 gpm to the nose landing gear.

"Up" pressure ported to the main landing gear door closing cylinders becomes effective as the struts enter the wheel-wells. At this point a roller lug attached to the outboard side of each main landing gear strut enters the mouth of a unique cam track hook, strikes on the forward jaw, forcing the hook to rotate, thus unlocking the linkage of the main landing gear door closing mechanism. The door actuators then work to close the doors, and the doors are kept in correct relationship to the strut by the passage of the strut roller through the cam track.

The nose landing gear doors are closed by a purely mechanical linkage arrangement wherein the strut piston engages a yoke and pulls the doors closed as the strut reaches the uplock. Since this closure is not aided by a hydraulic actuator, a higher pressure is developed in the "up" side of the nose landing gear actuator (maximum 2850 psi) than is required of the main landing gear actuators.

A roller lug mounted on the strut center line of each gear contacts the forward jaw of the uplock hook, causing it to rotate into its locked position. This is a purely mechanical latch that, when all three gears are up-and-locked (thus depressurizing the actuators), provides a single point support for the gear and gear doors.

The initial action of landing gear down pressure is to extend the piston rods of the small uplock release actuator at each uplock. The rod strikes a pawl, and rotation of the pawl axle unlocks the over-center-lock linkage of the uplock. The weight of the gear then forces the uplock open, and the gear falls free.

As the gears fall from the wells, the forward MLG doors are forced back to their locked-open position by the door linkage, which also mechanically extends the single-acting main landing gear door closing cylinders, expelling oil from their "up" pressure ports to return.

It is, of course, absolutely essential to snub the landing gear during the extension stroke, for if these heavy components were permitted to fall freely under the combined acceleration of gravity and airloads and stopped short by the drag link, the impact would inflict severe structural damage.

The necessary damping is provided by metering the flow of oil into each actuator and the flow of oil expelled from each actuator to return during the down stroke. By controlling the inlet flow with simple restrictor-check valves in the down pressure lines near the actuators, the actuator is prevented from accelerating the near-vertical fall of the landing gear from the uplock hooks. At the same time, the oil being expelled from the up ports to return is heavily restricted by restrictors mounted in the up port of each actuator, creating a high damping pressure (usually about 2000 psi) within the actuator to cushion the down-stroke against the accelerating force of gravity and airloads. The integral restrictors in the main landing gear actuators have a relief valve function which limits the amount of back pressure that unusually high g force or airloads can generate.

All six of these restrictor assemblies incorporate filters which prevent clogging of their orifices during "down" flow, and all of the restrictors allow free flow in the reverse direction during the gear up operation.

As the gear approach the full down position, the force of the actuator and/or airloads on the gear will nearly straighten the jury struts, at which point actuator force and/or the dual bungee springs attached to the jury struts will force them over-center to the fully locked position.

**Manual Shutoff and Thermal Relief Valves.** A manual shutoff valve is mounted in the "gear-up" pressure line adjacent to the selector valve. It is normally lockwired open, but it can be used during maintenance

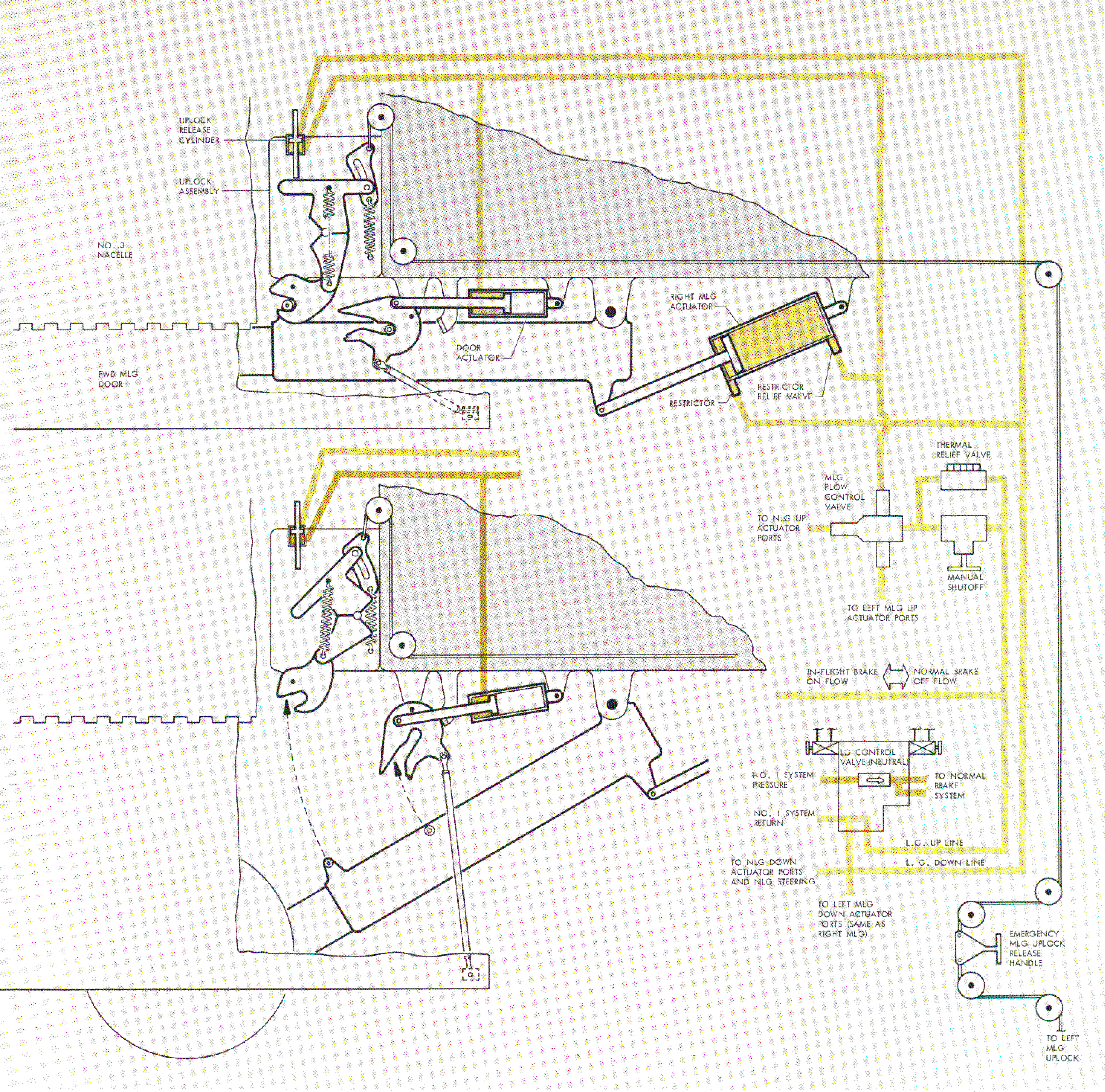



Figure 5 Simplified Hydraulic-Mechanical Schematic of Right MLG During Retraction and Up-and-Locked.

work to positively prevent gear-up flow from reaching the lines and components usually pressurized during gear retraction. It can also be used to meter gear up flow,* thereby slowing the retraction cycle. In the P-3 installation it does *not* provide a positive block of return oil for gear extension, and it should not be used for the purpose.

Note that a thermal relief valve is plumbed in parallel with the shutoff valve to relieve pressure build-up in excess of 1400 psi in the gear up lines due to thermal expansion of the fluid after the manual shutoff is closed. The relief valve will not pass fluid while gear-up pressure is applied, but *if a gear-down actuation is attempted with the manual shutoff closed, more than 1400 psi pressure will be generated in all the gear-up lines.* Inadvertently pressurizing the gear up lines in this way can have a variety of consequences, ranging from no damage through minor damage to major disaster, depending on the manner of actuation and the configuration of jacks, safety locks, and etc. at the time. The only safe course is to *always have the gear-up manual shutoff open before extending the landing gear.*

**Total throw from full on to full off is only 90° on this valve. The valve handle must be turned very cautiously to meter gear up flow.*

**Emergency Gear Operation.** There are no provisions for emergency gear retraction, except that it is possible to remedy an electrical fault in the selector valve control circuit by manually operating the solenoid on the selector. The selector is mounted at the top of the service center adjacent to the access hatch in the cabin floor, and by pushing and holding the "UP" solenoid button until all gear are locked-up, No. 1 system pressure will effect a normal gear retraction.

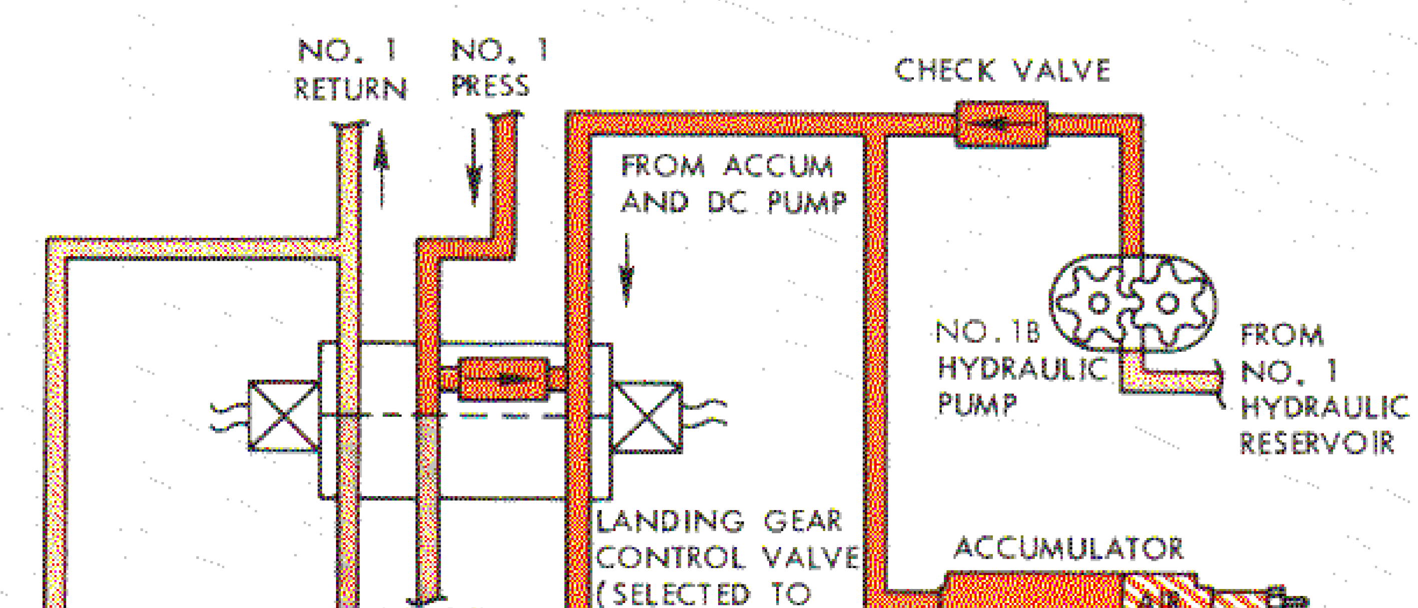
Similarly, if No. 1 hydraulic pressure is available, momentarily depressing the "DOWN" solenoid button will effect a normal gear extension, but generally a "free-fall" emergency gear extension will be made, using the manually operated cable system to mechanically unlock the main gear uplocks and the nose gear uplock. A striped "T" handle accessible from the cabin through the hydraulic service center access hatch unlocks the main gear uplocks; a similar handle, located under a cover at the rear of the pilots' control pedestal unlocks the nose gear uplock.

Once the uplocks are released in flight, the gear will free fall to the down and locked position, provided only that the landing gear selector valve is either at neutral or gear-down position. Even if the valve is in up position a successful free-fall can be made by following a special procedure described in the following discussion.

## BRAKES

**Brake Power Sources and Associated Hydraulic Functions.** Each main landing gear wheel is equipped with a brake of the segmented disc type. These have access to hydraulic power from all of the No. 1 System pumps, and hydraulic power is utilized for the normal, parking, and in-flight brake systems. In an emergency, a separate pneumatic system can be utilized to pressurize the brakes.

As can be seen in Figure 6, hydraulic power for the normal brake control valve is taken from a segment of the No. 1 hydraulic system that can receive pressure (and retain it in a 200-cubic inch accumulator) from either of the large No.



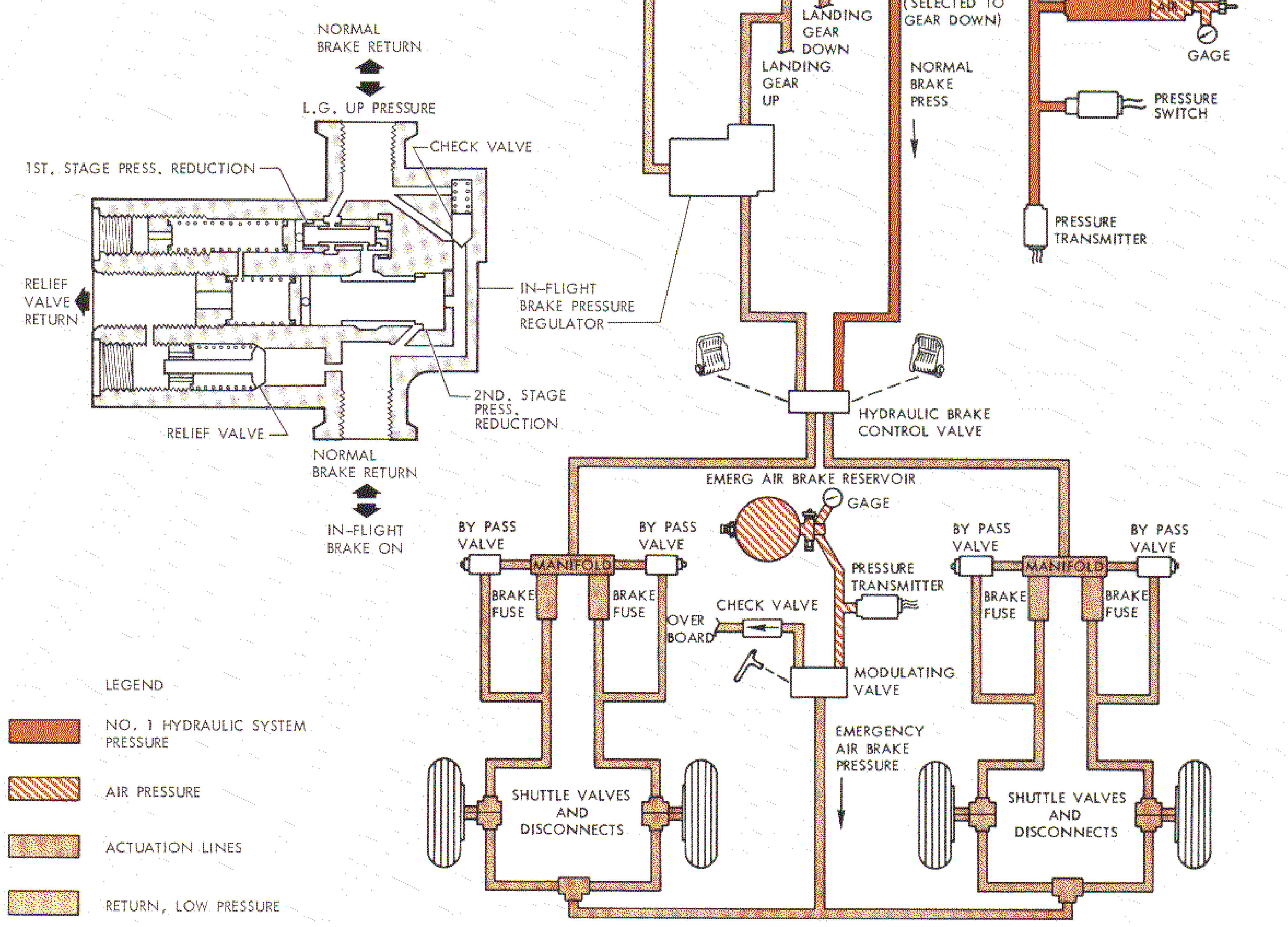
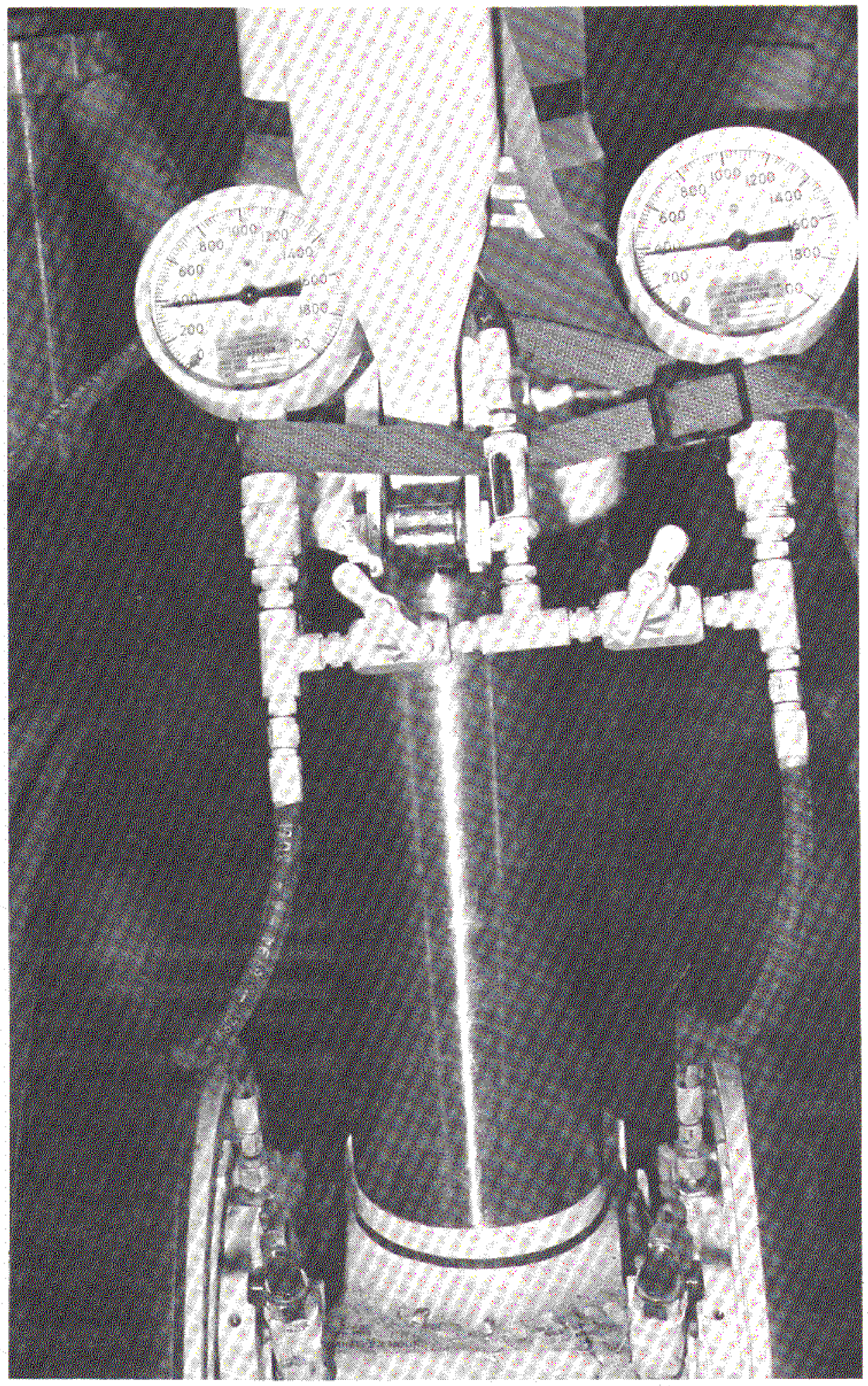
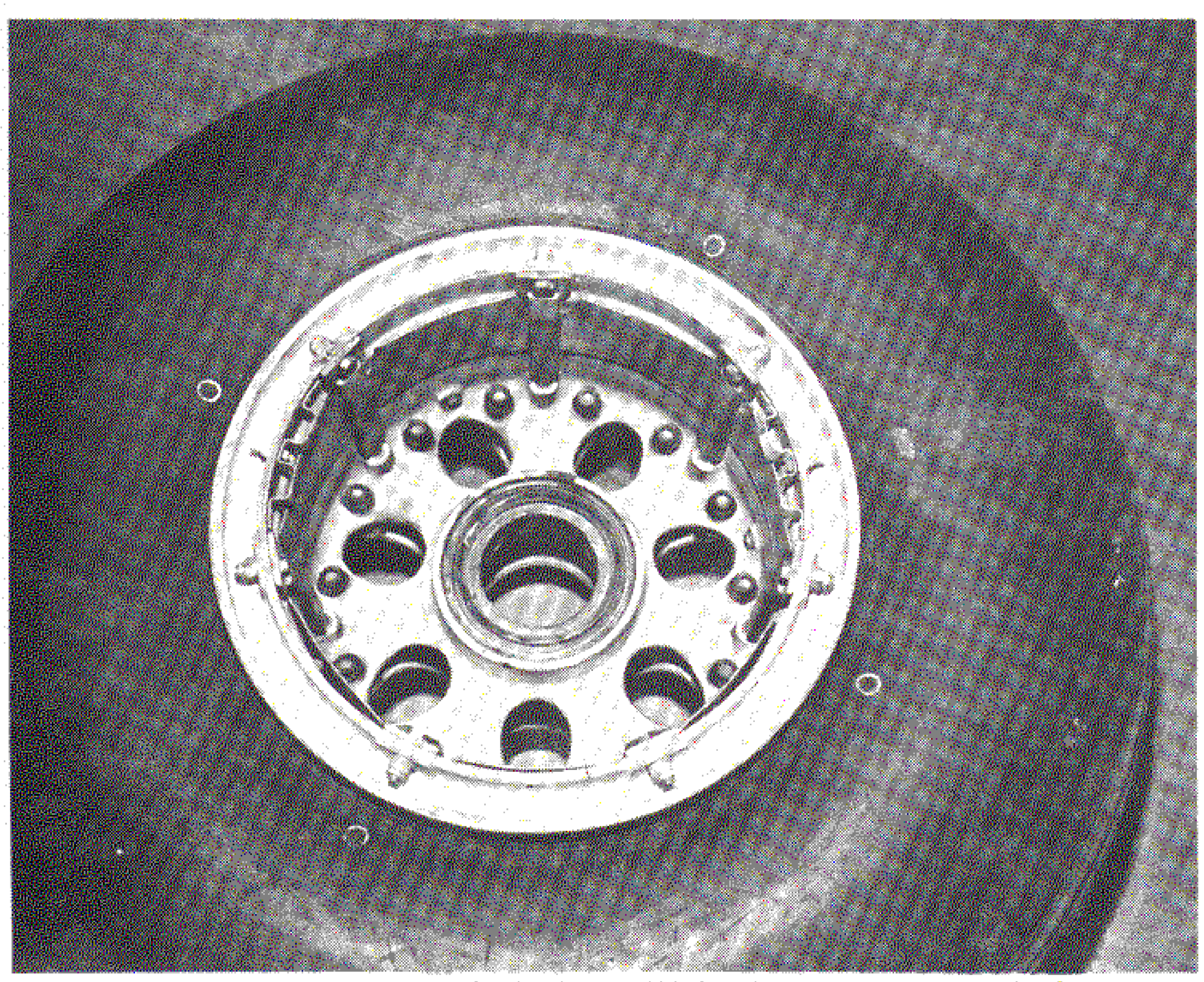
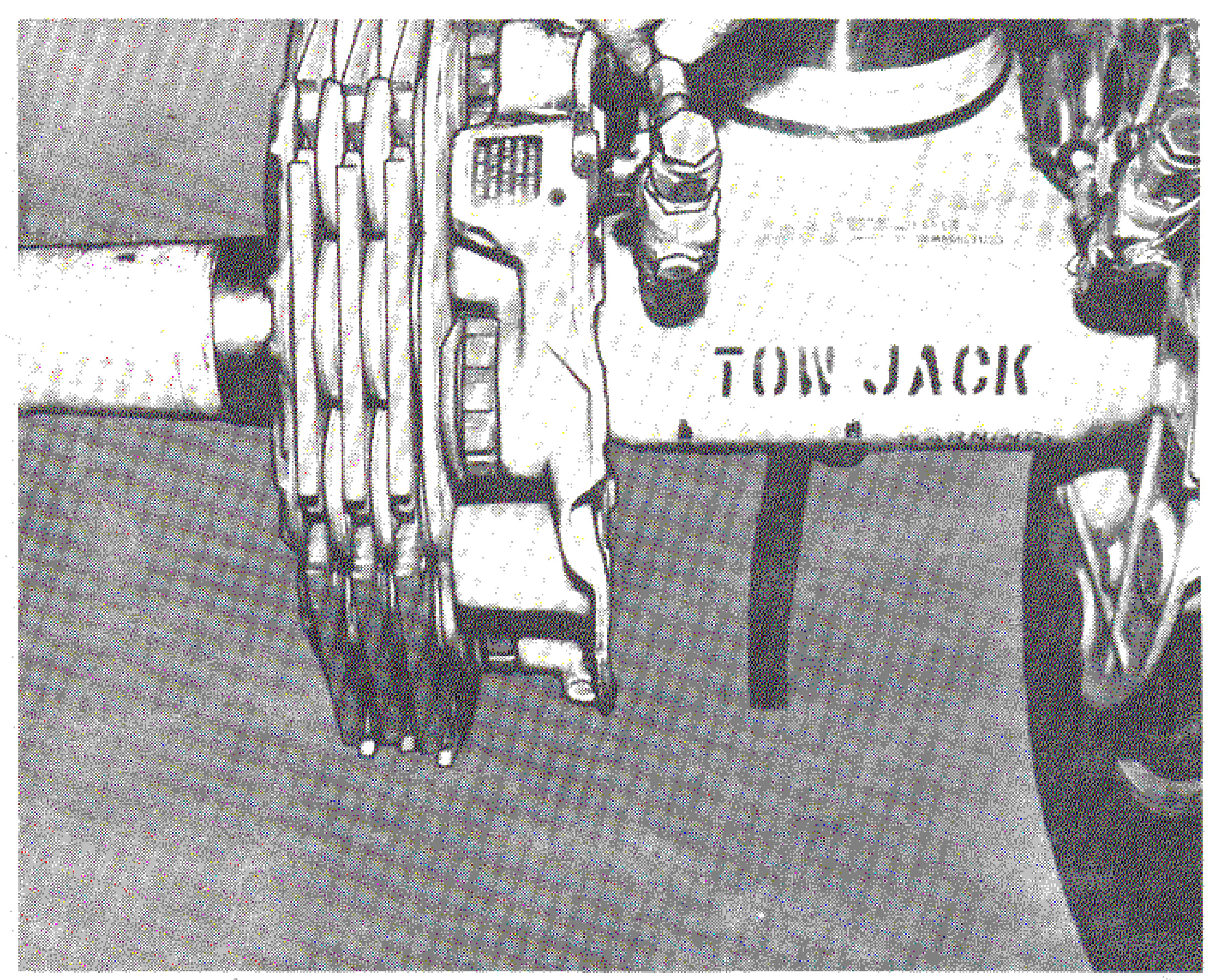




Figure 6 Inter-relation of P-3 Normal, In-Flight, and Emergency Brake Systems

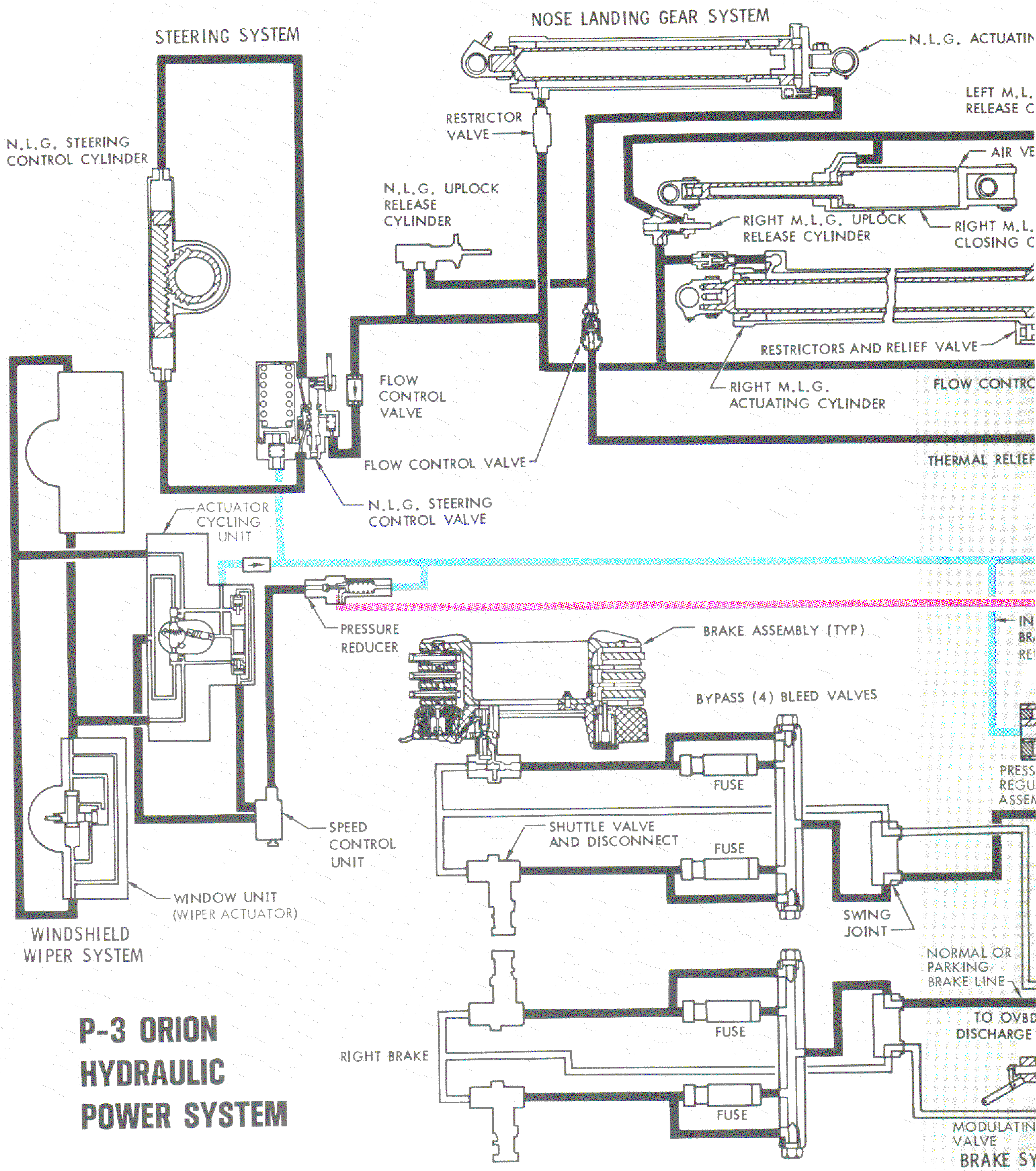


BRAKE
BLEEDER
KIT

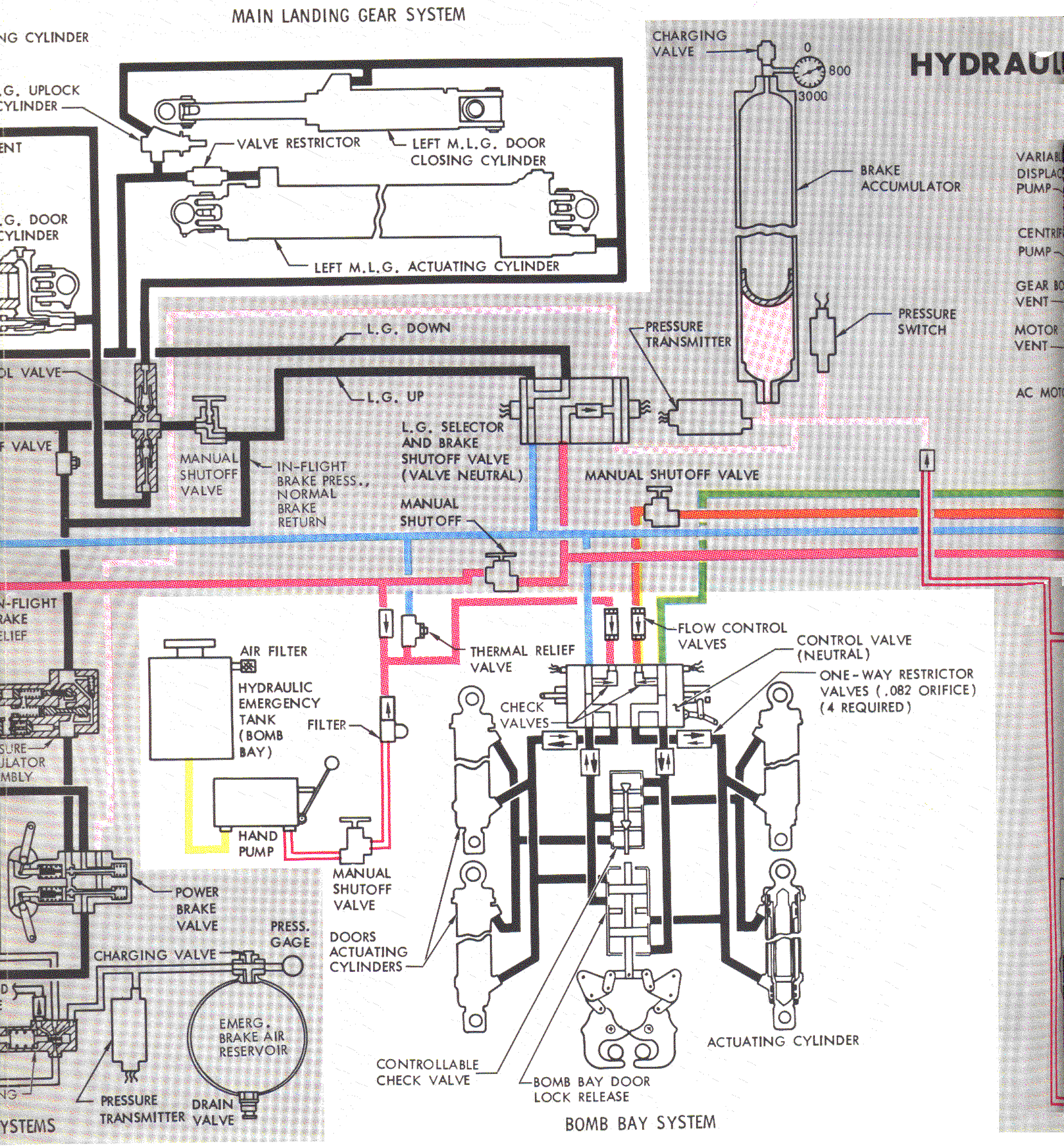


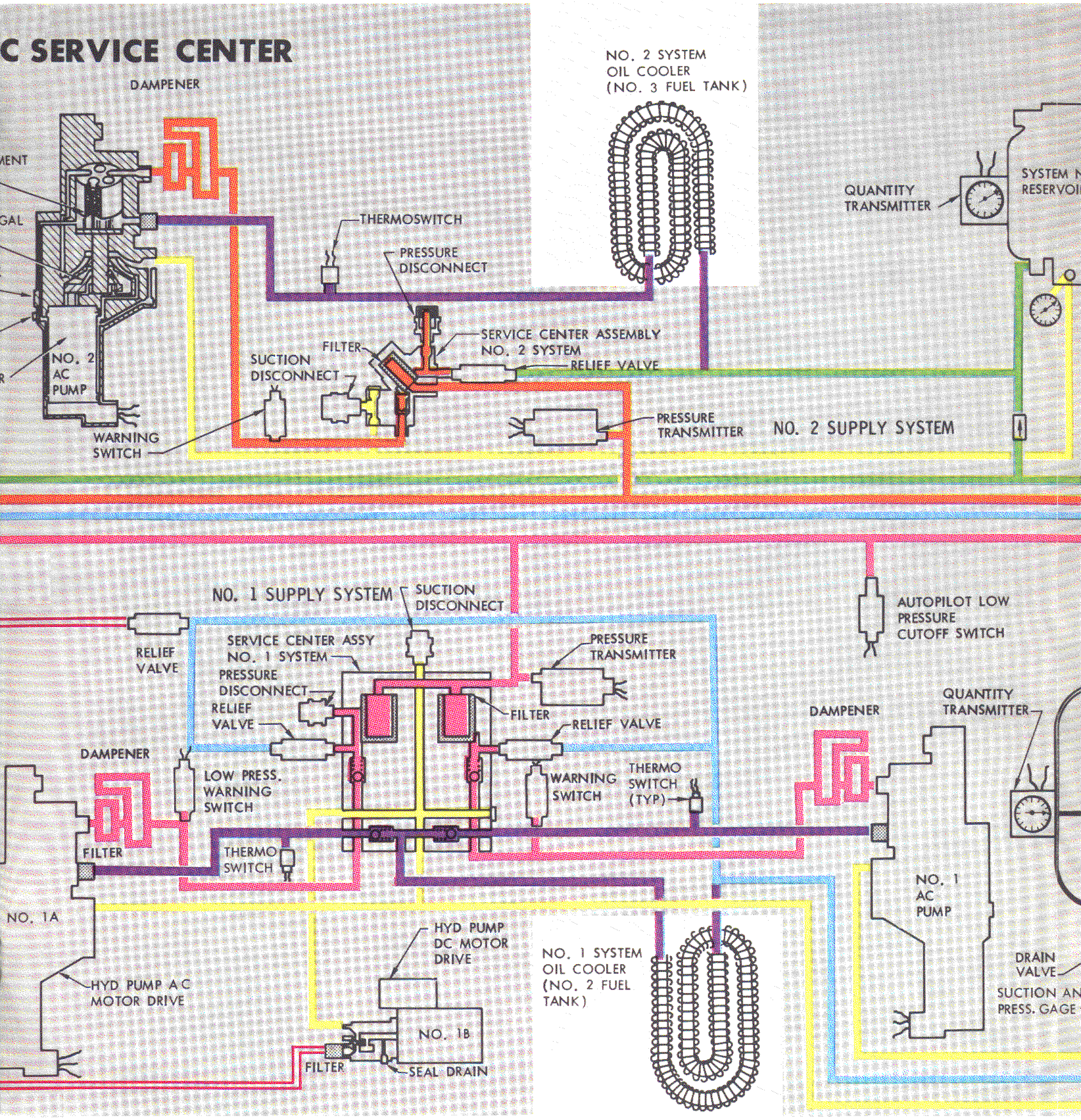


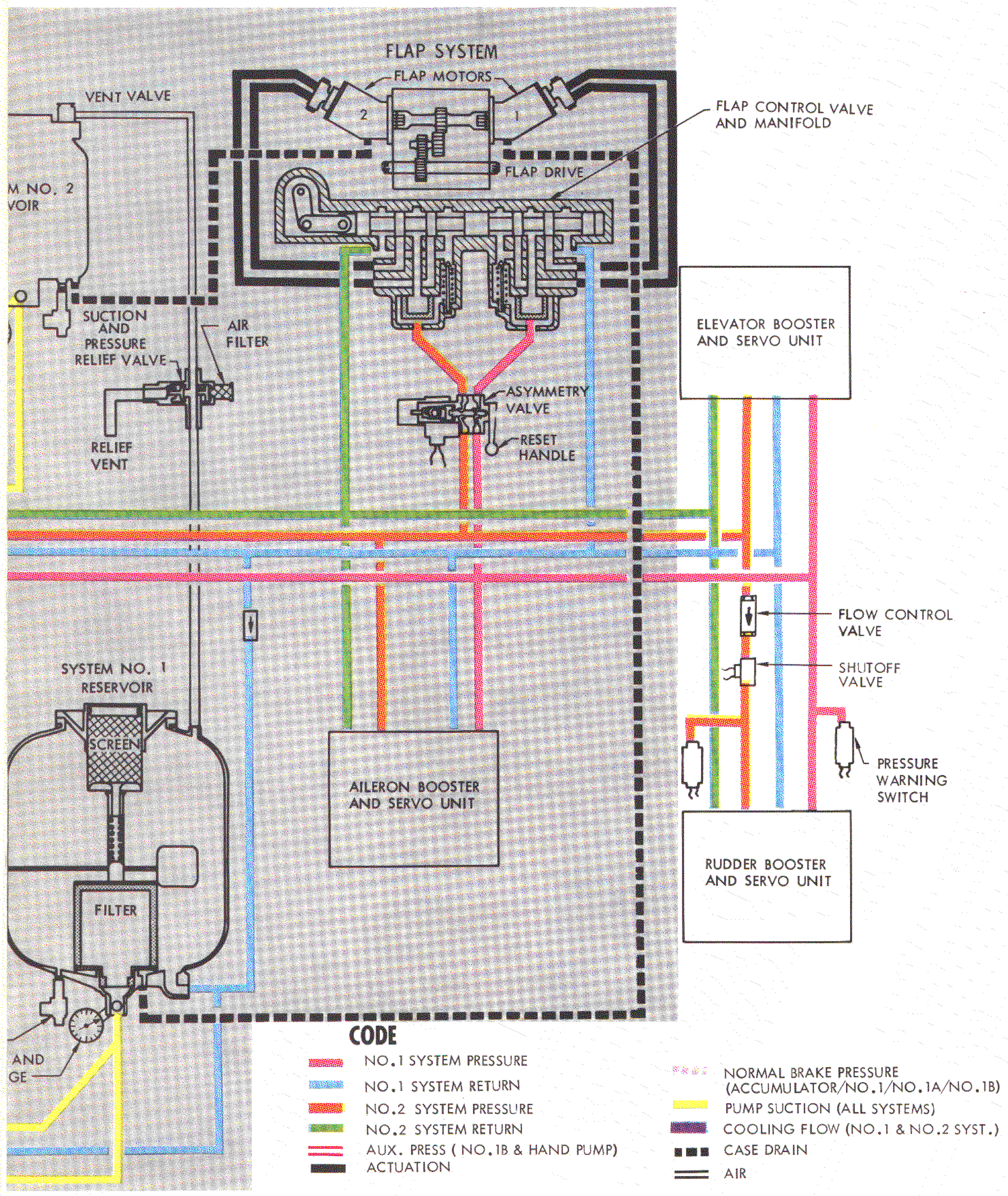

MLG WHEEL AND BRAKE SHUTTLE VALVE/QUICK DISCONNECT
DISMOUNTED FROM BRAKE ASSEMBLY




# P-3 ORION HYDRAULIC POWER SYSTEM


MAIN LANDING GEAR SYSTEM
VALVE RESTRICTOR
LEFT M.L.G. DOOR CLOSING CYLINDER
LEFT M.L.G. ACTUATING CYLINDER
L.G. DOWN
L.G. UP
MANUAL SHUTOFF VALVE
IN-FLIGHT BRAKE PRESS., NORMAL BRAKE RETURN
L.G. SELECTOR AND BRAKE SHUTOFF VALVE (VALVE NEUTRAL)
MANUAL SHUTOFF
CHARGING VALVE
0
800
3000
BRAKE ACCUMULATOR
PRESSURE TRANSMITTER
PRESSURE SWITCH
MANUAL SHUTOFF VALVE
AIR FILTER
HYDRAULIC EMERGENCY TANK (BOMB BAY)
FILTER
HAND PUMP
MANUAL SHUTOFF VALVE
THERMAL RELIEF VALVE
FLOW CONTROL VALVES
CONTROL VALVE (NEUTRAL)
ONE-WAY RESTRICTOR VALVES (.082 ORIFICE) (4 REQUIRED)
CHECK VALVES
POWER BRAKE VALVE
PRESS. GAGE
CHARGING VALVE
EMERG. BRAKE AIR RESERVOIR
PRESSURE TRANSMITTER
DRAIN VALVE
DOORS ACTUATING CYLINDERS
CONTROLLABLE CHECK VALVE
BOMB BAY DOOR LOCK RELEASE
ACTUATING CYLINDER
BOMB BAY SYSTEM


C SERVICE CENTER
DAMPENER
MENT
GAL
NO. 2 AC PUMP
WARNING SWITCH
THERMOSWITCH
PRESSURE DISCONNECT
FILTER
SUCTION DISCONNECT
SERVICE CENTER ASSEMBLY NO. 2 SYSTEM
RELIEF VALVE
PRESSURE TRANSMITTER
NO. 2 SYSTEM OIL COOLER (NO. 3 FUEL TANK)
QUANTITY TRANSMITTER
SYSTEM N RESERVOI
NO. 2 SUPPLY SYSTEM
NO. 1 SUPPLY SYSTEM
SUCTION DISCONNECT
AUTOPILOT LOW PRESSURE CUTOFF SWITCH
RELIEF VALVE
SERVICE CENTER ASSY NO. 1 SYSTEM
PRESSURE DISCONNECT
RELIEF VALVE
PRESSURE TRANSMITTER
FILTER
RELIEF VALVE
DAMPENER
QUANTITY TRANSMITTER
DAMPENER
LOW PRESS. WARNING SWITCH
WARNING SWITCH
THERMO SWITCH (TYP)
FILTER
THERMO SWITCH
NO. 1A
NO. 1 AC PUMP
HYD PUMP DC MOTOR DRIVE
NO. 1 SYSTEM OIL COOLER (NO. 2 FUEL TANK)
HYD PUMP A C MOTOR DRIVE
NO. 1B
FILTER
SEAL DRAIN
DRAIN VALVE
SUCTION AN PRESS. GAGE


FLAP SYSTEM
FLAP MOTORS
2
1
VENT VALVE
FLAP CONTROL VALVE
AND MANIFOLD
FLAP DRIVE
M NO. 2
VOIR
SUCTION
AND
PRESSURE
RELIEF VALVE
AIR
FILTER
RELIEF
VENT
ASYMMETRY
VALVE
RESET
HANDLE
ELEVATOR BOOSTER
AND SERVO UNIT
FLOW CONTROL
VALVE
SHUTOFF
VALVE
PRESSURE
WARNING
SWITCH
SYSTEM NO. 1
RESERVOIR
SCREEN
FILTER
AILERON BOOSTER
AND SERVO UNIT
RUDDER BOOSTER
AND SERVO UNIT
AND
GE
CODE
NO. 1 SYSTEM PRESSURE
NO. 1 SYSTEM RETURN
NO. 2 SYSTEM PRESSURE
NO. 2 SYSTEM RETURN
AUX. PRESS ( NO. 1B & HAND PUMP)
ACTUATION
NORMAL BRAKE PRESSURE
(ACCUMULATOR/NO. 1/NO. 1A/NO. 1B)
PUMP SUCTION (ALL SYSTEMS)
COOLING FLOW (NO. 1 & NO. 2 SYST.)
CASE DRAIN
AIR

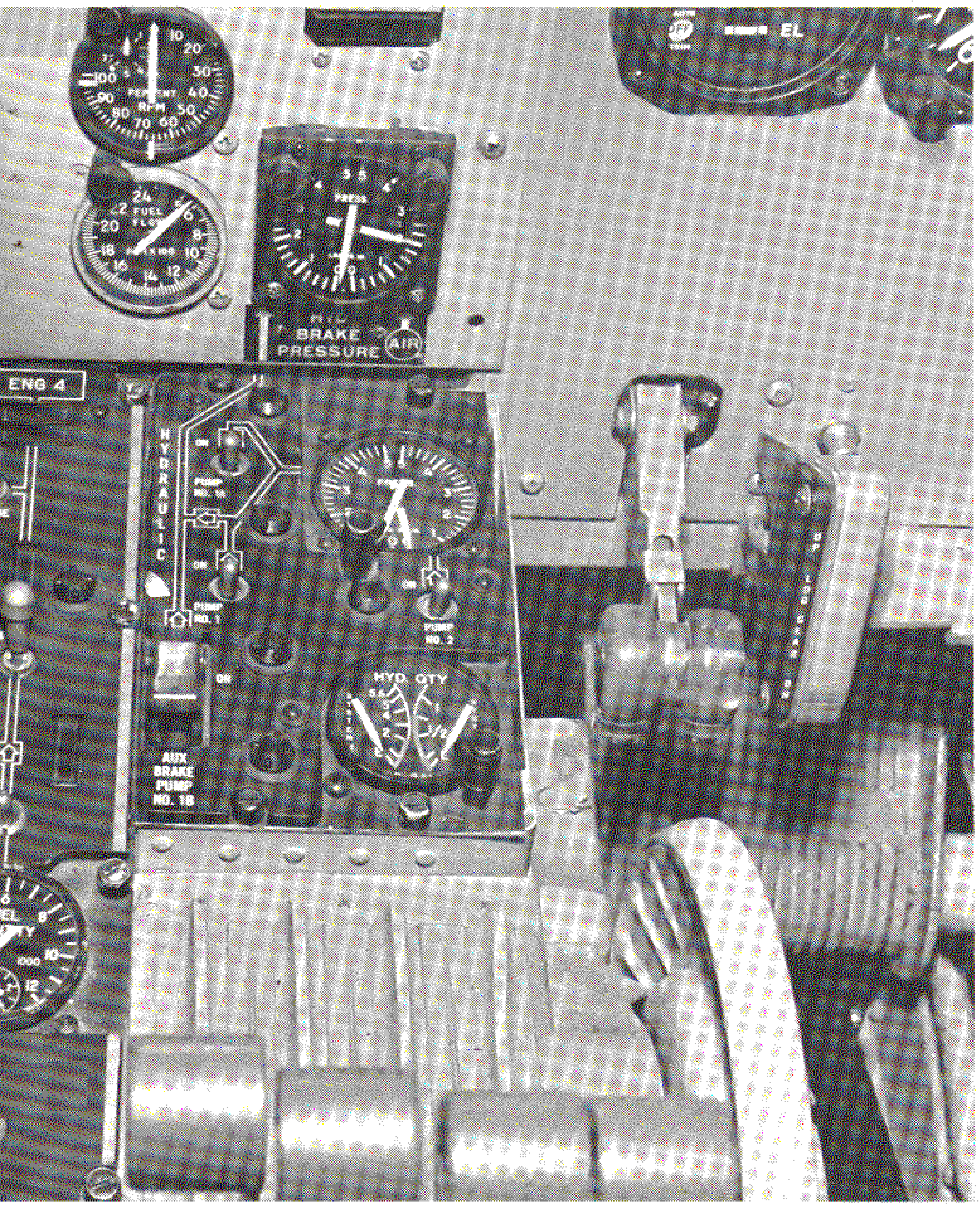



Figure 7 Hydraulic and Brake Systems Indicators and Co-pilots Landing Gear Control Lever

1 system ac motor pumps or from a small .2-gpm dc motor pump (No. 1B). The 1B pump operates on Ground Operation Bus power, and its control circuit is routed through a pressure switch that closes only when hydraulic pressure in the brake accumulator falls to less than 2200 psi and reopens when accumulator pressure rises to approximately 2900 psi. Thus, operation of the 1B pump is predicated on the circumstances common to its intended purpose—to maintain a power reserve for the normal brake system for ground-handling when the ac motor pumps are inoperable. As noted earlier, the Ground Operation Bus is energized only when the nose landing gear uplock is in its unlocked position (or when the Ground Operation Bus Relay circuit breaker is pulled), but when it is energized, it is supported by every source of dc power on the aircraft, including the battery.

Pressure transmitters in the hydraulic service center sense the reserve hydraulic and pneumatic brake pressure and operate the dual remote flight station indicator shown in Figure 7. The pressure indicating circuits are powered from the 26-VAC Instrument buses.*

When accumulator pressure reads 3000 psi, sufficient power is available for 6 to 9 applications of both brakes, and if the 1B pump is operating, it will supply sufficient oil to replenish the accumulator in about three minutes. Thus, the availability of power for the normal and parking brake systems is exceptionally sure, but note that the normal brake control valve is completely inoperative when the shuttle valve in the landing gear selector valve is at "gear-up" position.

The hydraulic power line to the normal brake control valve is routed through the landing gear selector valve shuttle to automatically de-activate the normal brakes while the landing gear are retracting after takeoff. The heavy main landing gear wheels, spinning at high speed, could inflict a damaging inertial "jolt" on actuating and structural members if full normal brake pressure was applied at this time.

The inter-relation between normal braking and the other landing gear hydraulic systems is an item of special interest to both maintenance and operating personnel. Some maintenance procedures require "gear-up" selection with No. 1 system pressurized, and every precaution should be taken to ensure that the loss of pressure to the normal and parking brake system does not entail unfortunate consequences.

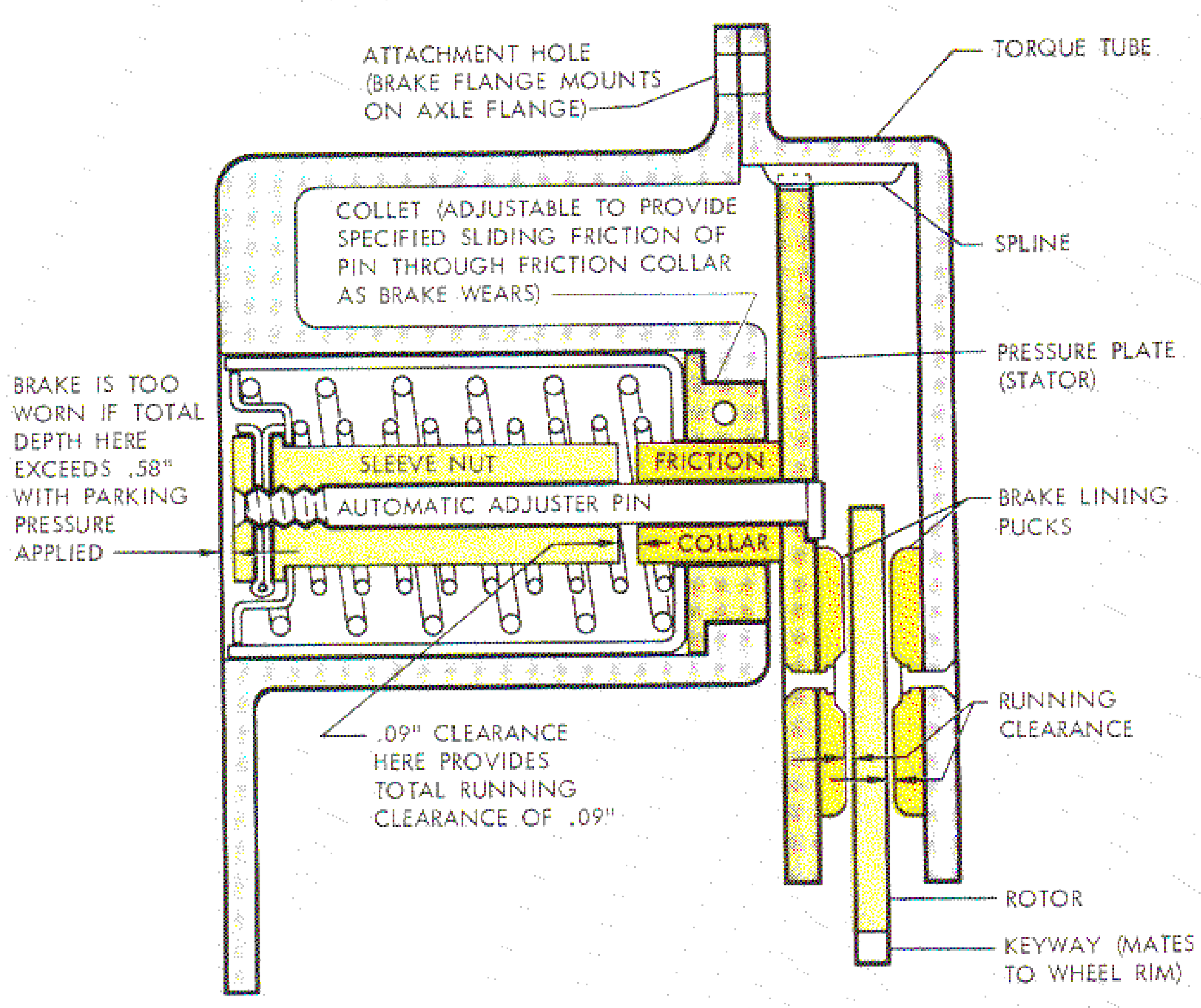
It is more difficult to enumerate specific examples of situations in which the inter-related system arrangement would bear directly on flight operation procedures, but in emergency situations involving landing gear and/or hydraulic power the aircrew may have a real need to ascertain the exact position of the landing gear selector shuttle valve. The following logic would apply in such a situation:

1) If the landing gear selector shuttle is at its up position, the rudder pedal brakes will not offer the usual back pressure when depressed. Thus, since the normal brake reaction will be evident regardless of the position of the landing gear if accumulator pressure is available and the shuttle is either at neutral or down position, a normal reaction of the pedals proves

**Since these circuits require ac power, they will not be operable during the towing operation, and may not be operable immediately prior to towing. In such a case, the emergency brake reserve can be ascertained by observing the direct-reading gauge on the pneumatic reservoir; the normal brake reserve can be approximated by subtracting accumulator pre-charge, 800 psi, from the direct reading gauge on the accumulator.*

that the shuttle will not interfere with landing gear free fall and that normal braking will be available on landing.

2) With the landing gear down, nose wheel steering should be operable if No. 1 system is pressurized and the selector shuttle is at down position. If steering is inoperable and brake reaction is normal, the shuttle is certainly at neutral. Both systems will operate only when the shuttle is at its down position and No. 1 system is pressurized.




The design of the landing gear selector and its control leaves very little chance that a malfunction could result in the selector shuttle being uncontrollably fixed in up position. But if it should occur, a successful free-fall gear extension can be made nonetheless after turning off No. 1 hydraulic system pumps, thus relieving the pressure in the landing gear actuators so the gear can drop free of the uplocks when the emergency extension handles are pulled. This will create back pressure in the up lines and the No. 1 hydraulic system when the leverage of gear weight attempts to move the landing gear actuator pistons against a hydraulic lock. The hydraulic lock can then be relieved by actuating the flaps. As the flap hydraulic motors run, oil from the up actuation lines will be transferred to the No. 1 system return lines. From here, the oil required to fill the "down" side of the landing gear actuators will be drawn into them and the excess will return to the No. 1 hydraulic system reservoir. (The mechanics and flow-paths involved in this technique can be visualized by examining the Master Hydraulic System Schematic at the centerfold of this issue.)

Of course, after the gear lock down, the No. 1 system pumps must be left off and windshield wipers, normal braking, and steering will be inoperable, but note that the No. 2 system remains operable and the flaps can be repositioned as necessary.

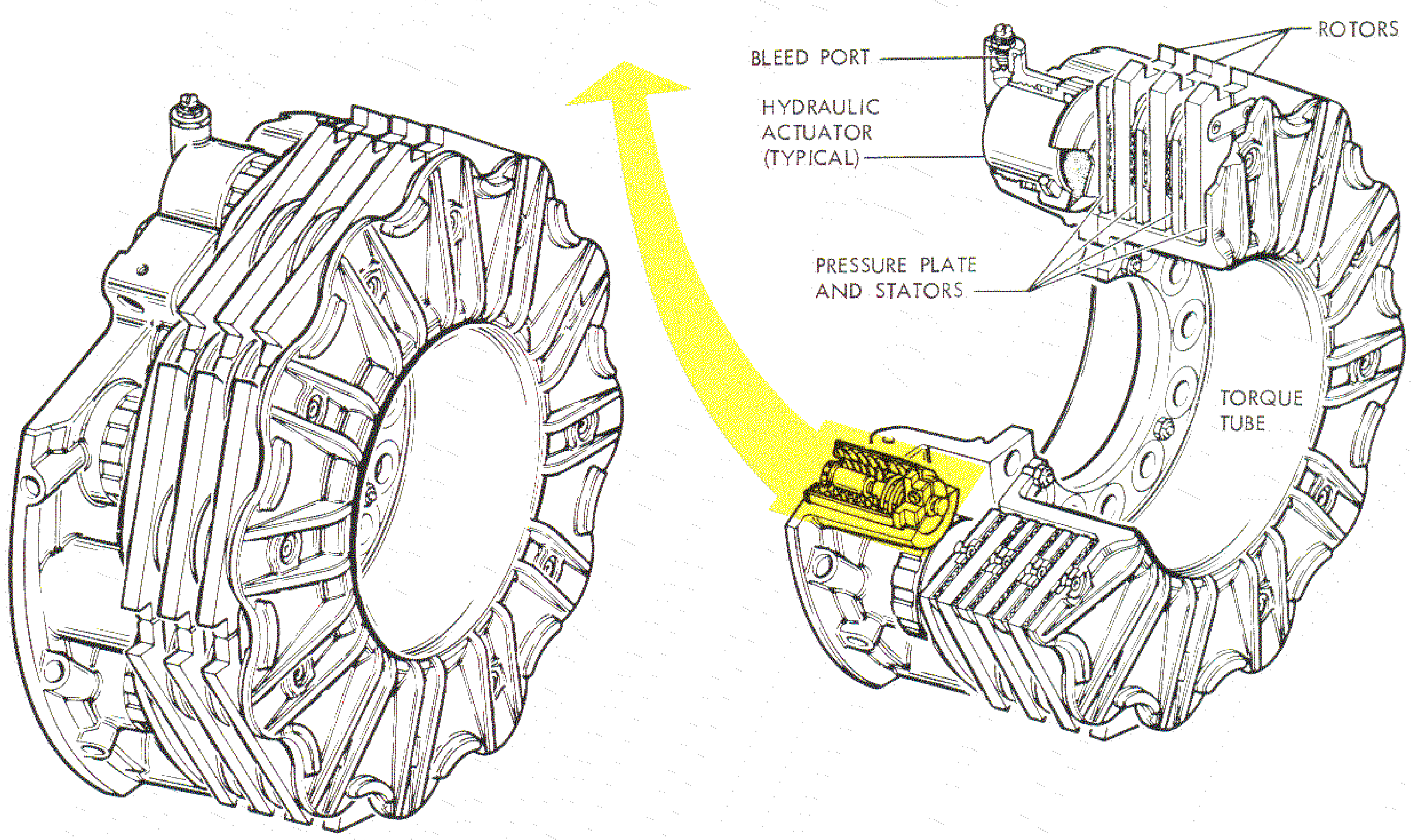
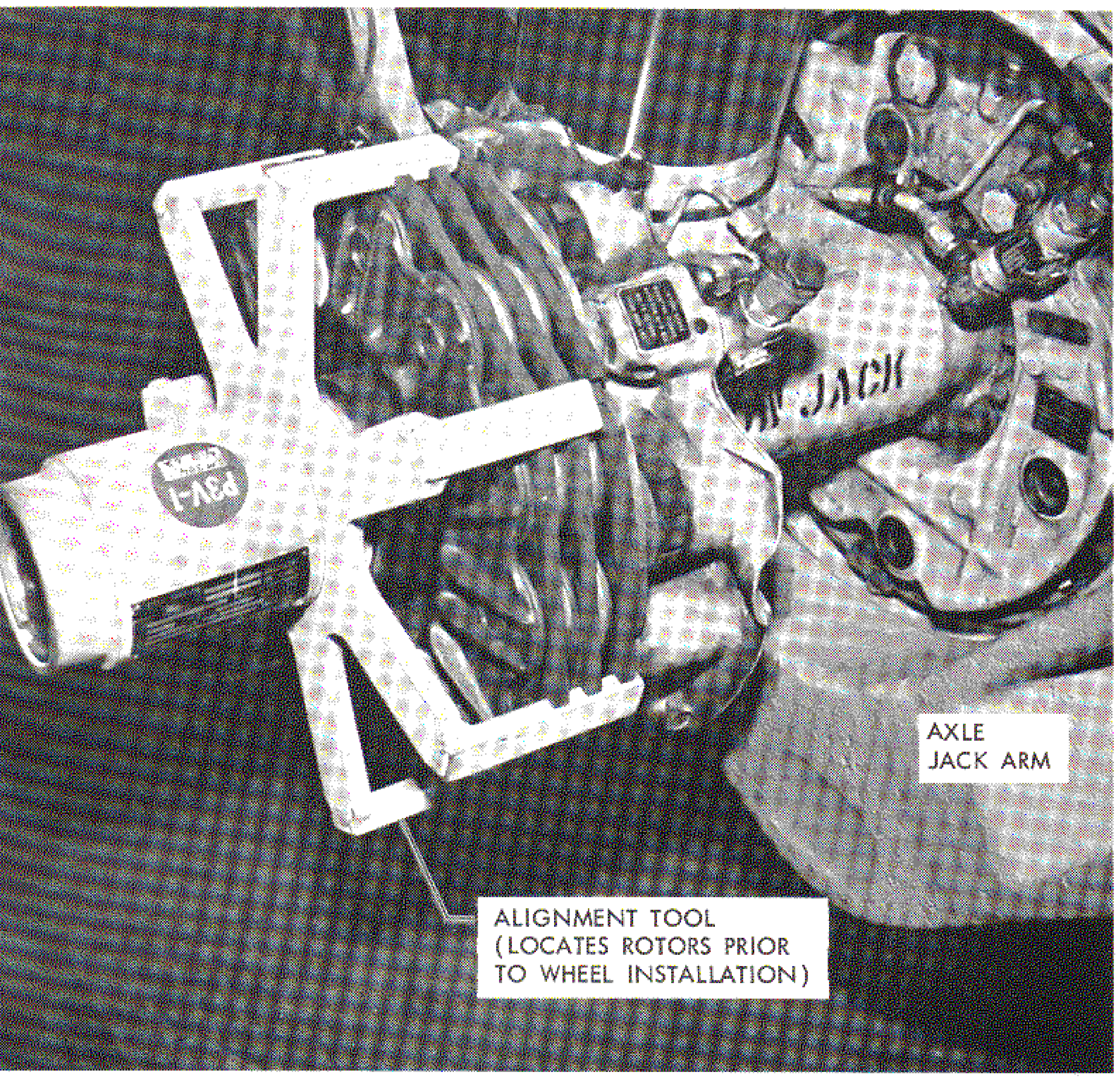



Figure 8 Bendix Segmented Rotor Type Brake. Inset, showing schematic detail of one retractor/adjuster assembly, does not show the entire pile of rotor and stator discs.




**Normal and Parking Brake Systems.** Depressing the pilot's or co-pilot's left or right rudder toe pedal operates a cable control which positions one half of a dual brake valve mounted in the hydraulic service center. The brake control valve is designed to provide a feed back "feel" to the pedals, enabling the operator to gauge the severity of brake application. Maximum deflection of a pedal will meter oil at about 1650 psi from the control valve through a swivel joint at the appropriate main landing gear trunnion and into a manifold mounted on the strut. Here the flow divides into separate branches for the two wheel brakes, each branch incorporating a fuse at the inlet, a flex line to accommodate the variable strut extension, a shuttle valve at the brake assembly to accommodate an alternate power input from the pneumatic Emergency brake system, and the flow terminates in a labyrinth of passageways in the brake frame which distributes pressure to six actuating cylinders. The actuating pistons are in constant contact with a spring loaded pressure plate that is splined to the brake frame, and has brake lining "pucks" on its outer face. When the pressure plate is forced outboard, away from the main landing gear strut, it compresses a pile of alternating rotor (splined to the wheel) and stator (splined to the brake frame) discs. As shown in Figure 8, the stators carry brake lining; the rotors are "sandwiched" between the stators so that both faces provide friction surface for the linings.

When the brake pedal force is removed, pressure in the brake assembly is relieved, and a path to return is provided. Six dual spring assemblies on each pressure plate retract the plate, thus retracting the brake pistons and completing the expulsion of oil from the brake assembly back into the actuating lines. This retraction supplies the necessary brake clearance, and it should be noted that the clearance is kept to a uniform value by an automatic adjustor pin in each retractor spring assembly which relieves the spring force when the pressure plate has retracted .09 inches.

The oil expelled from the brake assemblies flows backward through the fuse bodies (thereby resetting them) and to the brake control valve, where it is diverted to a "Return" port. Although "brake-off" flow does reach return through this port, it should be noted that the path to return is routed through the in-flight brake pressure regulator, the "LG UP" pressure line, and through the landing gear selector valve before it reaches the No. 1 system return. Thus, this segment of the hydraulic network serves also as an actuation line for landing gear up and in-flight brake pressure during gear retraction, and it is color-coded as actuation pressure on Figure 6 schematic.

**In-Flight Brake System.** As noted above, the in-flight brake system is activated automatically from the LG UP pressure line during gear retraction. Of course, it is also de-activated automatically when the three up-locks latch and de-energize the "UP" solenoid of the landing gear selector valve, allowing the main shuttle to return to its "neutral" position where all gear actuating lines are connected to return.

The device which applies the in-flight brakes, the Pressure Regulator Assembly shown on the Figure 6 schematic, is a two-stage pressure reducer. It will supply from 90 to 105 psi to the brakes (via the route of normal brake-off flow), which is sufficient to stop rotation of the main landing gear wheels before they are retracted into the wheel wells. The assembly incorporates a pressure relief valve which will by-pass oil to No. 1 system return if the pressure regulator malfunctions, and it will not permit in-flight brake pressure to exceed 115 (plus or minus 5) psi.

The system performs a valuable safety function, for if a blown out main landing gear tire or one with a loose tread were to be retracted into the wheel well while spinning at high speed, it could inflict severe damage on adjacent components.

**BRAKE FUSES** The purpose of the four hydraulic fuses is to ensure that an excessive amount of oil will not be lost through a ruptured seal or hydraulic line in the vicinity of the main landing gear wheels. Aside from the depletion of No. 1 system oil which might occur, a high pressure oil leak adjacent to the hot brake assemblies would constitute an appreciable fire hazard if there were no means of limiting the fluid loss.

Figure 9 schematic shows the operating principles of the fuse valve. Brake-on oil flow through the valve activates a volume measuring device which will positively block further flow after 30 cubic inches of oil has passed to the related brake assembly. Since the brake is self adjusting, this is many times the amount of oil needed to apply it. Of course, if a rupture does exist, the fuse will close and oil pressure in the brake assembly will drop to zero. Then, when the brake is released there will be no "brake-off" flow to return, and the design of the fuse valve is such that once it has closed it will remain closed until a reverse flow of oil is passed through it. The valve does not take accurate account of the quantity of reverse flow, but *some* appreciable reverse flow must occur to reset the fuse. Therefore, an increment of oil could be lost through a high pressure leak without affecting the related hydraulic fuse unless it resulted in 30 cubic inches of fluid passing through the valve on a single, sustained brake application.

Since considerably more than 30 cubic inches of oil may be required in the brake bleeding operation, a bypass provision is incorporated to expedite this task. At one point in the bleeding procedure the fuses will inevitably be locked out, and it is absolutely essential to carry out the remainder of the procedure in its entirety and in the exact sequence outlined in the Maintenance Manual to ensure that the fuses are reset. Note that the Brake Bleed Kit (01-902570-1-17H5) provides a separate gauge to read pressure in each brake assembly. These gauges offer the only positive visual means by which the maintenance crew can ascertain that full normal brake pressure can be applied to the brakes *after* the bleeding procedure has been completed.

In normal operation, it is possible to detect whether or not a fuse is locked out by observing the retract spring motion during two sequential brake applications. The retract springs should be compressed .09 inches or more on every application.

As mentioned previously, the fuses are intended as a safeguard against needless oil loss through a rupture in a section of the hydraulic system that is unavoidably exposed to damage from heat, flying objects, and etc. They are designed to automatically

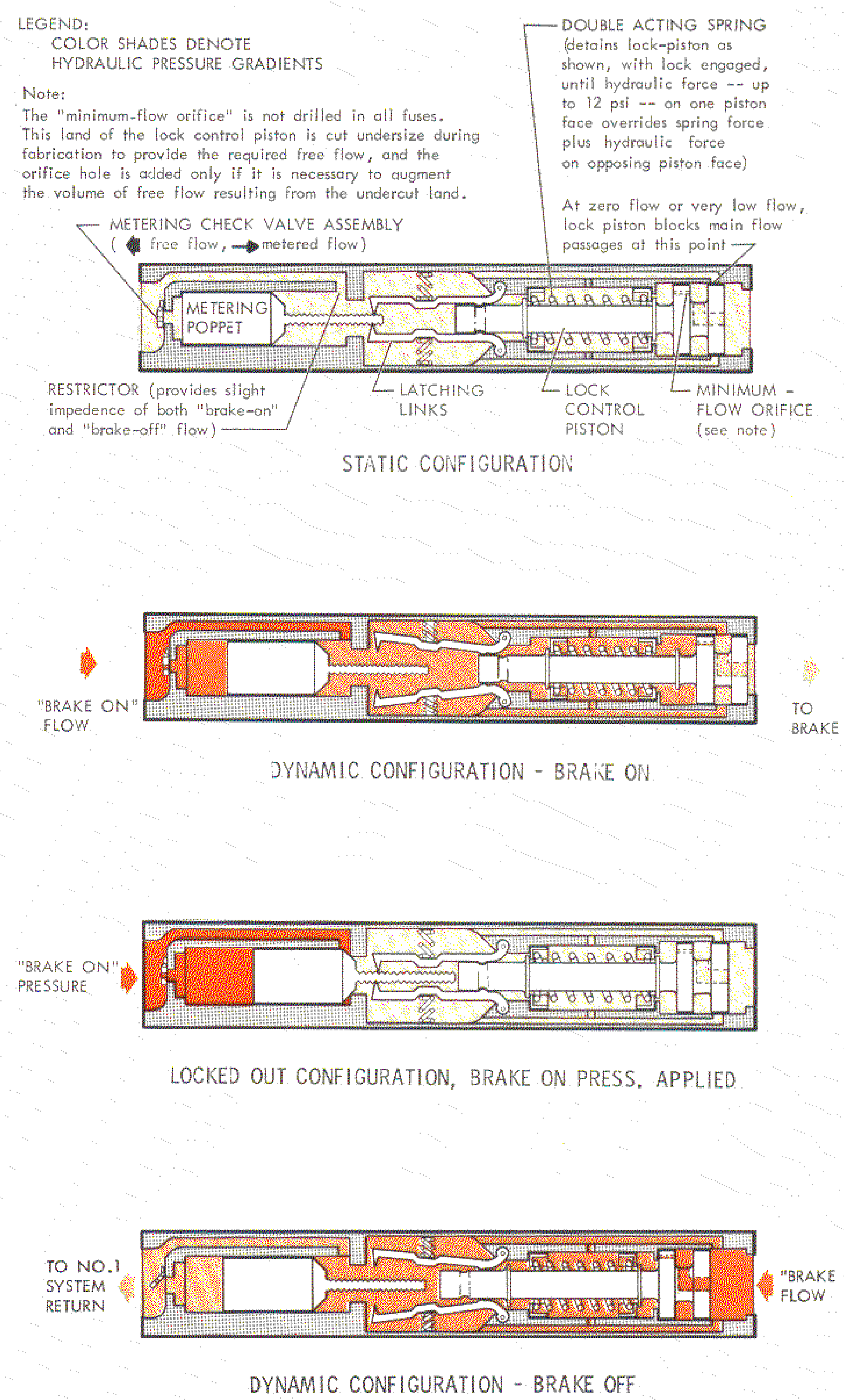
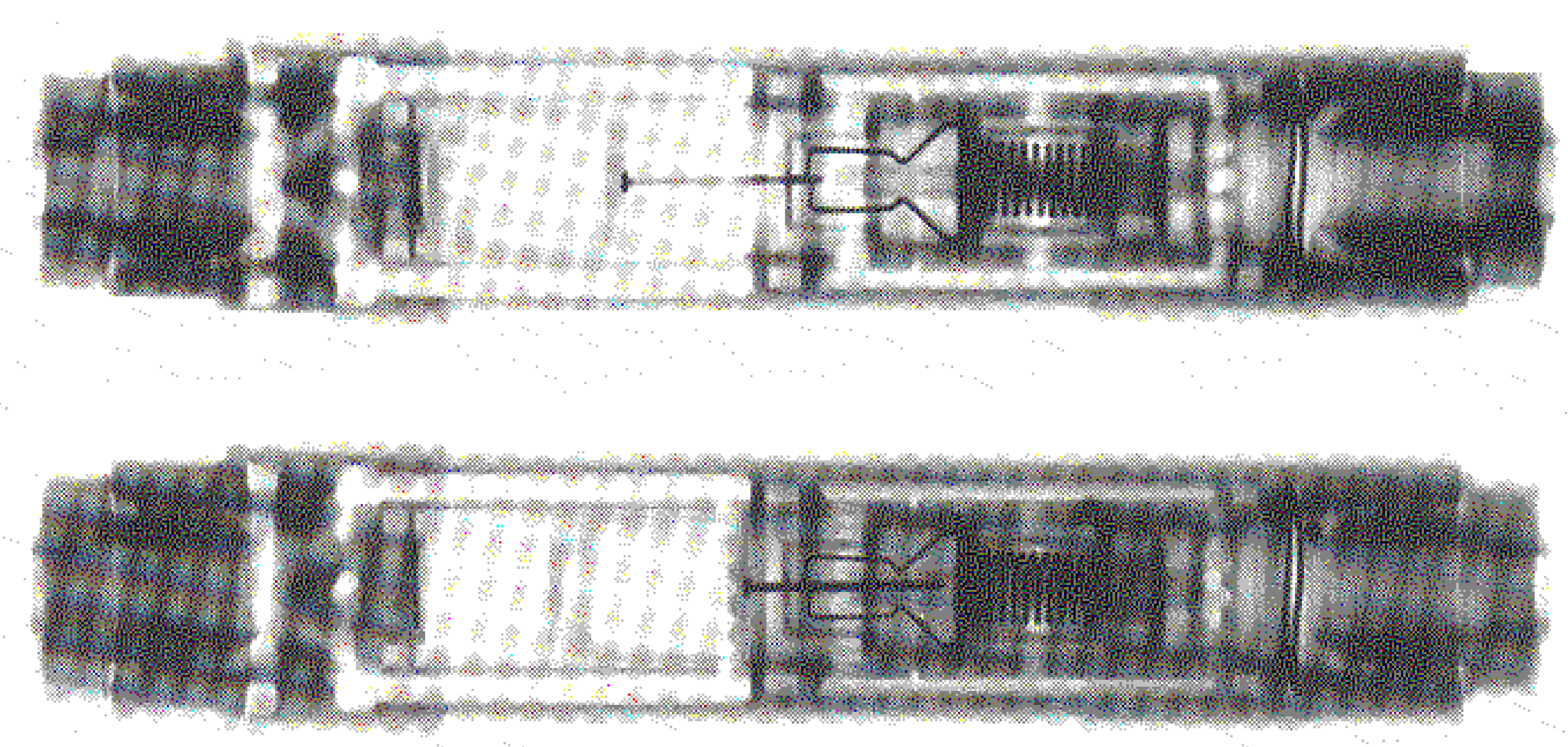



Figure 9 Brake Fuse Schematics.
One fuse per brake is mounted on MLG strut.



X-ray Photos of Fuse Fully Reset and Locked-out Configurations block hydraulic power to a brake assembly when it becomes obvious (as indicated by a lack of normal brake return flow following a normal brake application) that leakage has made the brake ineffective and a high-rate oil loss is being experienced.

The valve is flow-sensitive, but not perfectly so. To meet the requirement of the Military Specification which governs hydraulic fuse design (MIL-F-5508), the fuse must be sensitive to a flow of .1 gpm, but it must tolerate a lower flow—that is, it must *not* measure the type of slow leak that poses no immediate hazard in respect to oil loss. Most hydraulic actuators, such as the P-3 brakes, will be perfectly operable with a slight leak, but if the fuse persistently measured every drop of oil that passed through it, an insignificant leak would eventually cause the fuse to lock out, thereby rendering a brake inoperable for no good reason.

The "minimum flow orifice" shown on Figure 9 provides the necessary open passage for a limited free flow. The lock control piston will not release the metering poppet until the flow becomes great enough to create a small pressure differential (up to 12 psi) across the piston and therefore the poppet will neither "meter" brake-on flow nor "reset" back to full capacity unless a significant flow rate is developed.

It is for this reason (to provide a high-pressure high-rate return flow to reset the fuse) that the brake bleeding procedure specifies pumping the brake pedal repeatedly. Also, operating procedures specify application and release of the parking brake during preflight, and it is standard operating procedure to pump the brakes to check them prior to landing. Although, of course, the fuses are not the principal objective of either procedure, we wish to point out that these procedures do have a beneficial side effect which makes it additionally important to observe them.

**Parking Brake Provisions.** A simple latching device, operated by a T handle at the bottom of the pilot's instrument panel, is provided to permit the normal brake system to be permanently pressurized for parking. The brakes are parked by depressing the pilot's toe pedals, then pulling and holding the T handle while releasing the pedals. The general arrangement of this simple device is shown in Figure 10. Note that: the parking pawl design permits one brake being parked without parking the other; only one increment of braking is provided (supplying about two thirds of full pressure to the brakes); the parking pawl releases automatically when the parked brake pedal or pedals are depressed (but it is impossible to release the brakes on one strut without releasing the other); the interconnection between the pilot's and co-pilot's pedals (not shown) permits the parking brakes to be released from either station.

This arrangement makes it practically impossible to taxi with dragging brakes, and since the hazard is not present on the P-3 design there is no necessity for a warning system.

The parking brake facility is intended as a convenience for ground operations, and should not be regarded as a substitute for wheel chocks. When the pumps are not operating to replenish the accumulator, brake pressure will gradually deteriorate through small internal leakage, and since there is no way to accurately predict exactly how long the brakes will remain effective on a given aircraft, no airplane should be left unattended without wheel chocks in place.

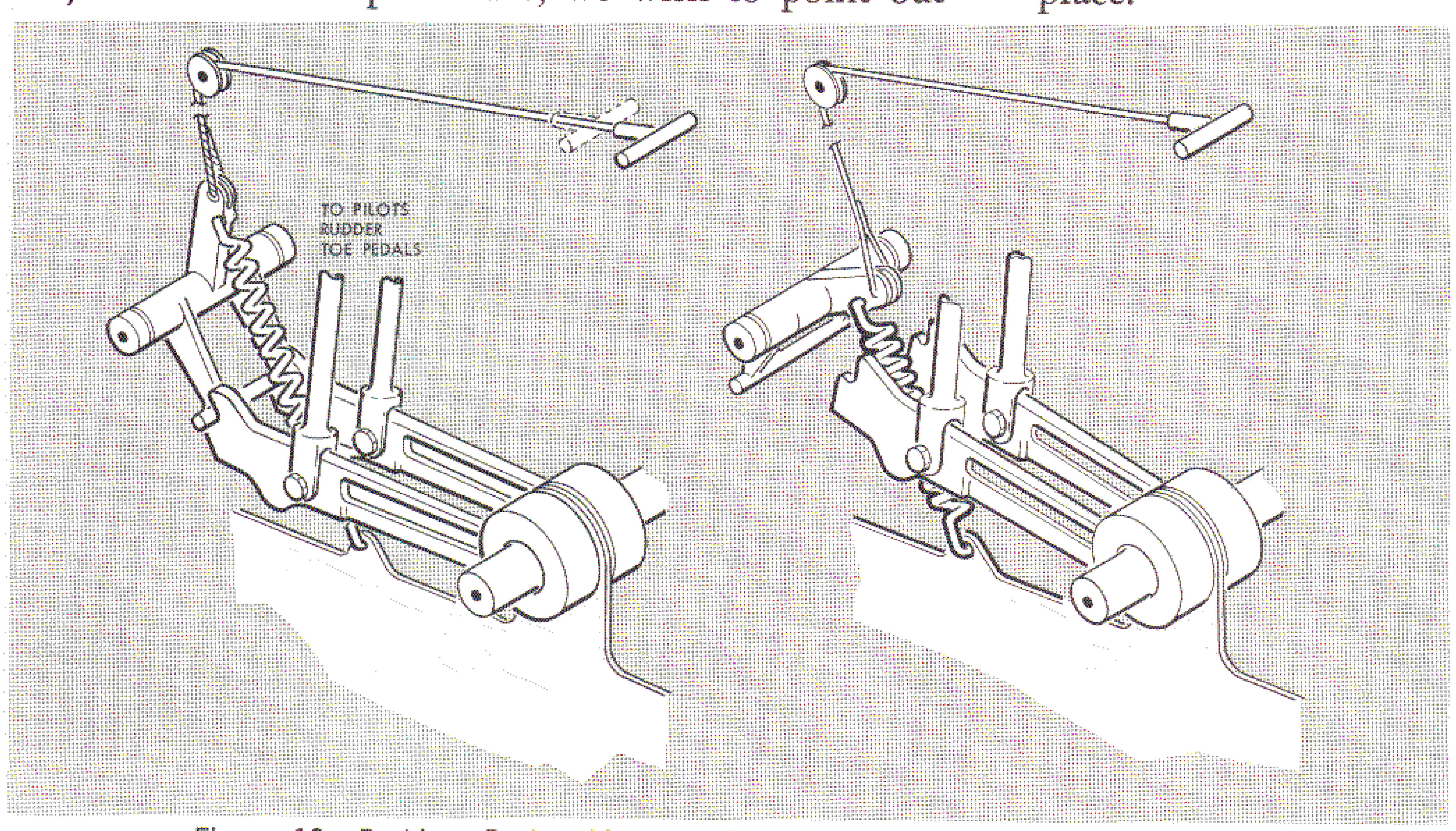



Figure 10 Parking Brake Linkage, Parked and Unparked Configurations

**Emergency Brake System.** A 200-cubic inch, 3000-psi spherical bottle mounted at the top of the hydraulic service center provides pneumatic power for the emergency brake system. A cable control, operated by a lever at either the pilot's or the co-pilot's station, positions a modulating valve which meters air to the emergency brake lines. Note that this is not a dual valve. When either control lever is pulled, equal pressure is applied to all brake assemblies. The air reservoir will supply from three to six brake applications. The modulating valve exerts a counter force on the cable control, permitting the operator to gauge the severity of a brake application. A single line to each strut terminates in a "T" fitting mounted on the main landing gear axle, with separate lines leading to a shuttle valve on each brake assembly (see Figure 6). The shuttle valve will port pressure from either the normal or emergency system to the brake assembly, and the poppet is detented to seal off the inlet from the inactive system, keeping the normal and emergency brake lines isolated from one another. The shuttle valve also incorporates a quick-disconnect provision which automatically seals off both the brake actuation line and the inlet to the brake assembly when the brake is removed from the axle.

The emergency brake lines from the modulating valve to the brake shuttle valves are kept completely filled with hydraulic fluid. This provides faster and smoother braking and substantially reduces the amount of air expended per brake application. When the brakes are applied, some air will be entrained in the emergency brake line oil. Then, when the brakes are released, the modulating valve ports both actuation lines to an overboard exhaust, and both air and oil will be exhausted. Therefore, an important part of the replenishment procedure after the emergency system has been used is devoted to bleeding and refilling the line through the modulating valve exhaust port to and through the brake assemblies.

**BRAKE AND WHEEL MAINTENANCE.** To determine the wear on the brake assembly, the brakes are applied and the position of the pressure plate is gauged by measuring the relationship between the face of the brake frame and the adjustment pin assembly (the central member of each pressure plate retractor spring assembly). If the pressure plate has drawn the adjustor .58 or more inches into the carrier frame, the brakes are too worn for further service.

Two aspects of wheel maintenance have been a problem on the P-3. The tie bolts which hold the wheel halves together have failed in service occasionally for diverse reasons, and damage to the wheel forgings, inflicted in service and in maintenance operations, has resulted in an unnecessarily high rejection rate.

The wheel halves and the tie bolts that hold them together carry tremendous forces from tire inflation and from landing impact and aircraft weight. There is little tolerance for error and damage where such heavily stressed members are concerned.

The tie bolts supplied by the MLG wheel manufacturer, and only those tie bolts, should be used (P/N 152167-3), and they should not be mixed with similar bolts when not assembled.* One standard bolt is very similar, but the special bolt has a slightly longer thread that is essential for this application. As many as four different types and sizes of bolts have been found in a single wheel that was removed from service and disassembled, and the danger in this situation is self evident. Also, special countersunk washers are used which should be installed under both the bolt head and nut with the countersink out and the flat surface bearing on the wheel. If these are installed backwards, the fillet area of the bolt head will be damaged and/or the wheel assembly will be damaged.

Bolts may be re-used, but only after they have passed a thorough visual and magnaflux examination. Also, if a tie bolt is found to have failed on an assembled wheel, we recommend that the tire be deflated immediately, that the two bolts on either

**The manufacturer will imprint a distinctive marking on their bolts in the future (see Figure 12).*

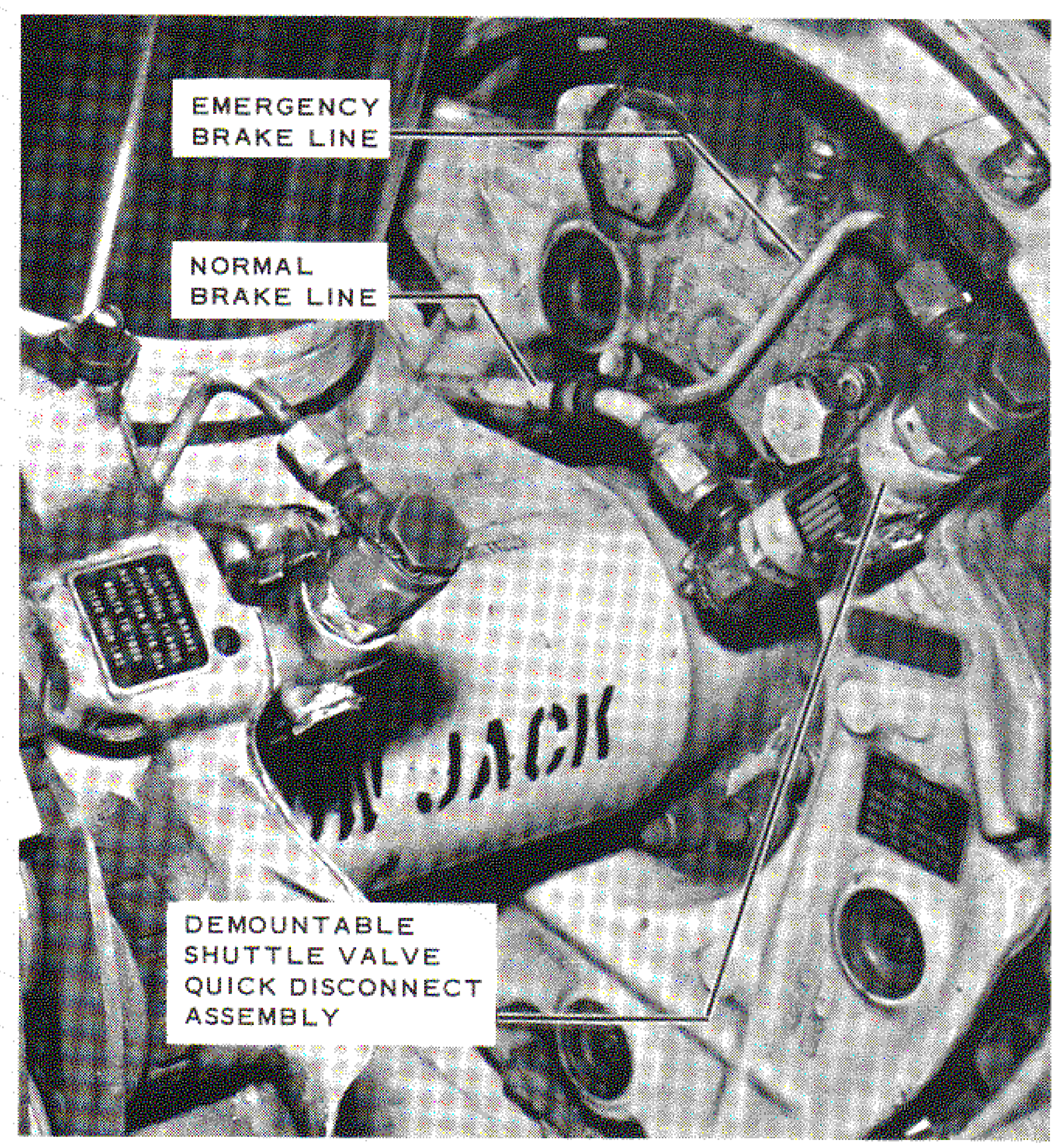



Figure 11 Shuttle Valve Installation

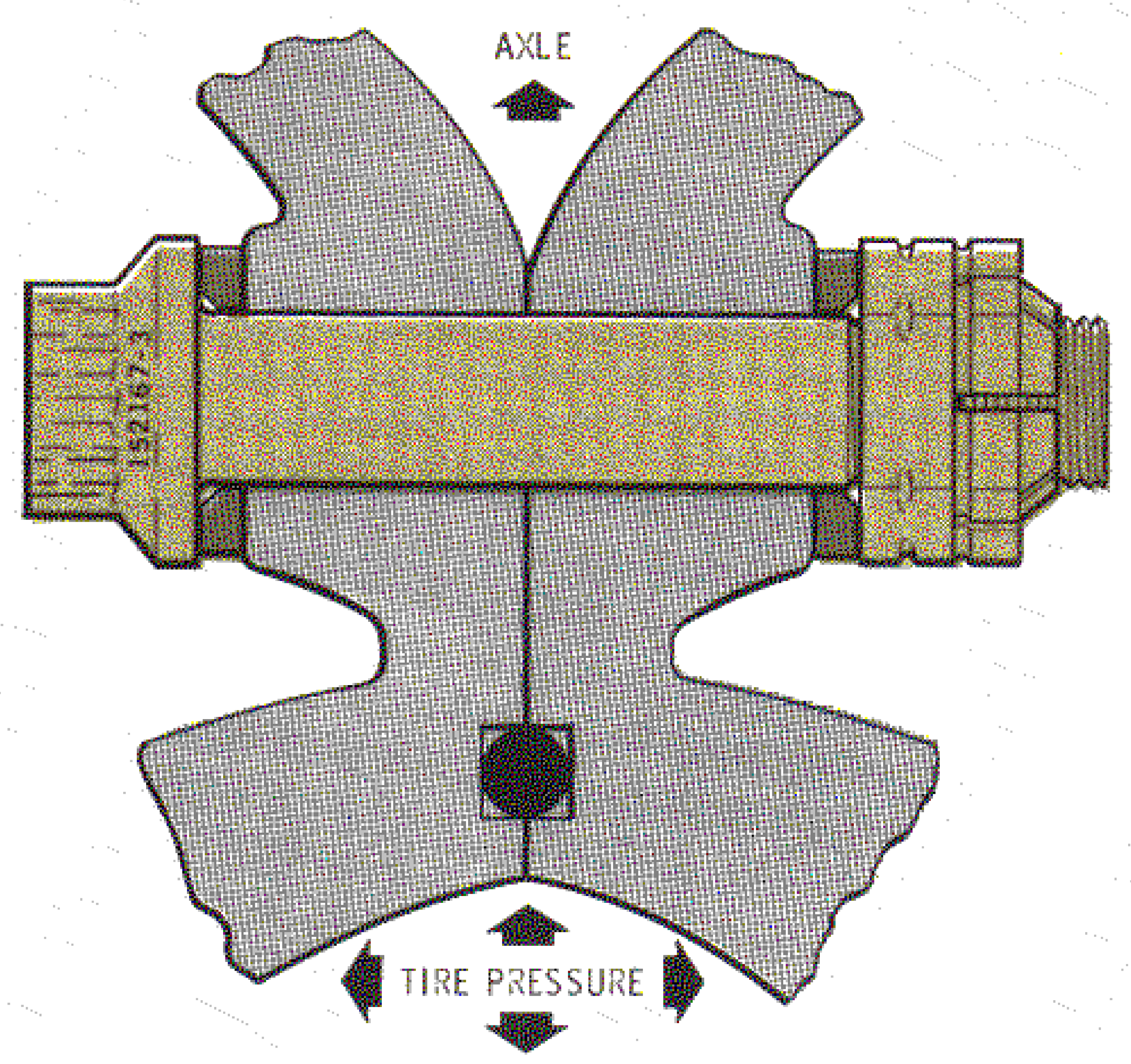



Figure 12 Split Rim MLG Wheel Cross Section Showing Correct Tie Bolt Installation and Bolt Identification

side be removed and discarded, and that all three be replaced. The neighboring bolts have certainly been exposed to unusual stress, and the safest course will be to discard them immediately even though no defects are apparent.

It is extremely important that the correct torque be applied to the tie bolt nuts at the time of installation. To obtain the closest tolerance of torque on the main landing gear nuts, the bolt hole, the bolt, and the washers should be coated with a special graphite grease, MIL-T-5544, before installation, and the nuts should be torqued to 1050 (plus or minus 50) inch-pounds. The use of this grease, generally known as Lubtork, substantially reduces the amount of torque which must be applied to obtain a proper pre-load on the bolt, and very accurate and uniform preloads are obtained.

Until recently, the Lubtork grease was also used on the nose landing gear wheel tie bolts, but when corrosion problems with the magnesium wheel were traced to the graphite in this grease, the specification for bolt lubricant was changed to MIL-G-25760, the same grease as is used in the wheel bearing/axle assembly. This grease is much less effective in relieving thread friction, and consequently it was necessary to increase the specified torque for the nose landing gear tie bolts almost 65% (to 280 plus or minus 10 inch-pounds) in order to obtain the proper preload using the less efficient grease.

*There is an obvious chance for a dangerous error to be made.* If nose landing gear wheel tie bolts are lubricated with Lubtork and assembled to the *new* torque value, the pre-load will be much too great. If the bolts do not fail immediately, they almost certainly will fail in service, possibly with grave consequences. On the other hand, if the *old* torque value is observed in installing nose landing gear tie bolts lubricated with MIL-G-25760, the preload will be much too light, the wheel halves will probably "fret," and the air-seal may be blown out.

Nose wheel components that have been used with Lubtork should *not* be re-assembled with MIL-G-25760 and the new high torque value until every trace of Lubtork has been removed by vapor degreasing. Any less effective cleaning method will not completely eliminate the thread lubricant, and the bolt preload will be too high.

Reports from the field indicate that the wheel design philosophy currently applied to heavy aircraft such as the P-3 is poorly understood, and it is hoped that the following brief discussion will help stem the tide of correspondence on this subject.

Although heavy aircraft could be fitted with wheels as immune to abuse and having the unlimited service life usually found on light aircraft and automobiles, it would be quite inefficient to do so. An aircraft so equipped would be perpetually burdened with a great weight of metal, totally contrary to flight efficiency, and the penalty in performance and operating costs for the life of the aircraft would be excessive. Instead, much design time is spent to ensure that every ounce of metal is employed efficiently, and light, strong metals are used.

Unfortunately, the wheels are of necessity cumbersome to handle. If a heavy wheel and tire assembly is dropped on its side on a steel or concrete object, or if metal tools are used indiscriminately on the wheel forging, there is every chance that the wheel material will be gouged. The structure is *not* permissive of such "stress risers" and when a sharp indentation of any appreciable depth is discovered, the wheel half should be scrapped.*

The other unavoidable debit of the "light wheel" design philosophy lies in the fact that fatigue cracks will probably begin to develop in the wheel eventually despite the fact that the wheel is forged, in preference to other types of fabrication, specifically because of the innate resistance to fatigue crack propagation forgings possess.

It is for this reason that the MIM requires a thorough dye-penetrant wheel inspection whenever the wheels are disassembled. Since the forces which wear-out tires are also instrumental in producing wheel fatigue, and since tire maintenance regularly requires wheel disassembly, there is very little chance that a crack will progress to dangerous size before it is detected. But when a crack *is* detected it gives ample proof that the service life of the wheel has expired, and in almost every instance the wheel segment must be rejected.

**Of course, there is some tolerance for minor corrosive erosion and minor dings such as stones may inflict on the rim. These are defined in the MIM, together with repair procedures.*

## NOSE WHEEL CONTROL

Aside from nose wheel steering, two directional control features are designed into the nose landing gear strut and function automatically: One, castering, is in effect during the ground phase of operation; the other, centering, when airborne. Either can be overridden by the hydraulic steering system.

**CASTERING** Castering action results from the strut design which locates the nose wheel axles aft of the axis about which they swivel. The castering action automatically serves to align the nose wheels with the direction of the aircraft's motion during all ground operations.

**CENTERING** When the airplane weight is removed from the nose strut, the shock strut piston is driven to full extension by gravity plus the internal nitrogen charge. When the piston approaches full extension, a two-lobe centering cam attached to the piston head will engage a similar cam keyed to the nose strut cylinder forging. These cams can be seen in Figure 13. If the nose wheels initially are not centered, as the strut extends the centering cams engage, converting the energy of the compressed gas into torque, and so turning the nose wheels towards center. At full piston extension the wheels will be no more than 2° from dead center. This 2° tolerance allows for machining tolerance and for turning friction of the strut.

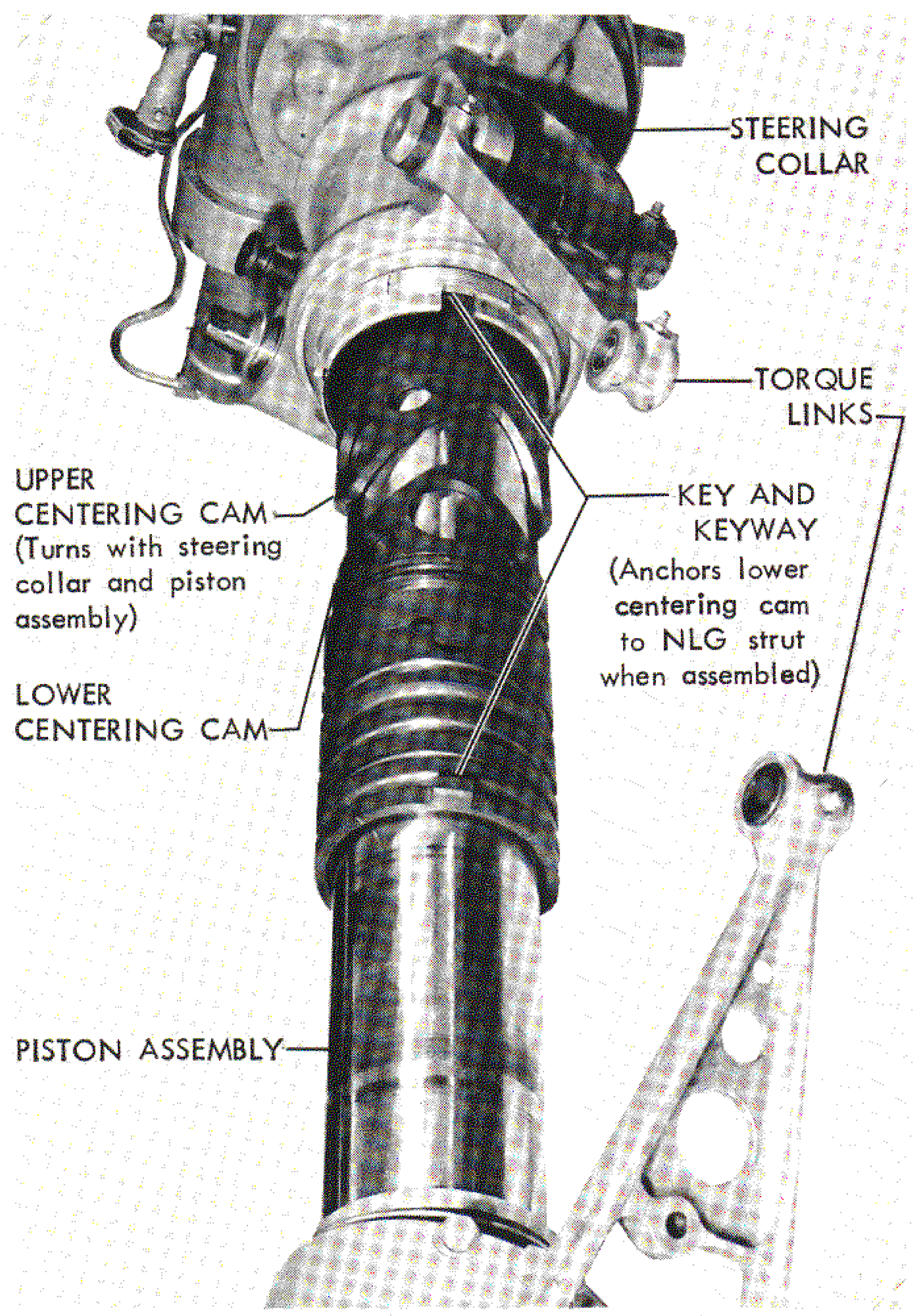



Figure 13 Dismantled NLG Strut

**HYDRAULIC STEERING SYSTEM** Pressure for steering is supplied to the steering control valve by the No. 1 hydraulic system ac pumps and is taken off the nose gear down line at a point downstream from the landing gear selector valve. As the landing gear control lever moves from the GEAR DOWN towards the UP position, landing gear down pressure (and consequently steering pressure) is blocked off at the landing gear selector valve. The system is, of course, designed this way so that the nose wheels cannot be turned when the nose gear is in or near the wheel well.

When hydraulic pressure is directed to the steering control valve, full hydraulic pressure will be directed to both the opposing, single-acting steering cylinders so long as the steering control valve spool is allowed to remain in its neutral (mid-travel) position, as shown in Figure 14.

The steering control valve is actuated by a closed cable control system which is anchored and routed so that torque applied to the steering wheel unbalances the tension in the two halves of the cable system. This tension differential will displace a rocker arm and, through linkage, the control valve spool will be moved from its neutral spring loaded position.

The displaced valve spool will continue to route full system pressure to the appropriate steering cylinder and at the same time route oil from the opposing steering cylinder to the steering system accumulator, through an 850-psi relief valve to return. The steering cylinder piston heads are connected by a rod which incorporates a rack whose teeth are meshed with a pinion gear segment on the steering collar. Differential hydraulic pressure moves the steering cylinder pistons; the rack turns the steering collar, and the torque is transmitted through the torque links to the nose strut piston and the nose wheels. As the steering collar turns, the attached cable will follow, tending to cancel the cable tension signal originated at the steering wheel.

**OPERATION AND MAINTENANCE** Items of importance to operating and maintenace personnel are:

1. Two of the functions of the nitrogen charge in the nose shock strut are to center the wheels prior to gear retraction and to keep them centered for touchdown. The nose landing gear will not lock in the "UP" position unless the shock strut piston is fully extended and the wheels are centered. Conversely, it is proven that the nose shock strut is centered and extended when it is up and locked.
2. The ratio of steering wheel rotation to nose wheel rotation is 7.5 to 1, with the rate of turn being limited by a flow control valve to 12.5° per second for the nose wheels. The stroke of the steering pistons limits nose wheel throw to 67.5° each side of center, but travel of the steering control valve permits the steering wheel to over-travel about 20° each direction. Therefore, the steering wheel's total throw will be almost exactly three turns from hard over in one direction to hard over in the opposite direction.
3. As shown in Figure 14, one spoke of the steering wheel has a distinctive shape, and the system is rigged with this index spoke pointing forward when the nose wheels are centered. At this point the steering wheel is at mid-travel.
4. During normal ground operation the landing gear control levers must be DOWN and No. 1 hydraulic system must be pressurized before the steering system can be operated. If necessary the airplane can be maneuvered without steering system pressure by castering the nose wheels with thrust and brake combinations, but in this case the operator must *not* hold the steering wheel or turn it in either direction in an effort to expedite castering. The reason for this can be explained as follows: When the wheels caster, the steering pistons must move, and they are free to do so if the steering control valve spool is allowed to remain in its neutral position so that oil can transfer through the control valve from one steering cylinder to the other. When steering system hydraulic pressure is not present, force applied to the steering wheel will move the control valve spool from neutral, block the transfer of oil, and the resulting hydraulic lock will defeat all attempts to caster the nose wheels.
5. In the normal course of taxiing, the rig of the steering system and the effectiveness of the steering system and castering can be checked by initiating a turn with the steering wheel alone and then releasing the wheel while the turn is in progress. The airplane should recover from the turn by castering action and when the airplane is re-established on a straight course the nose wheel index spoke will point forward if the steering system is rigged correctly.

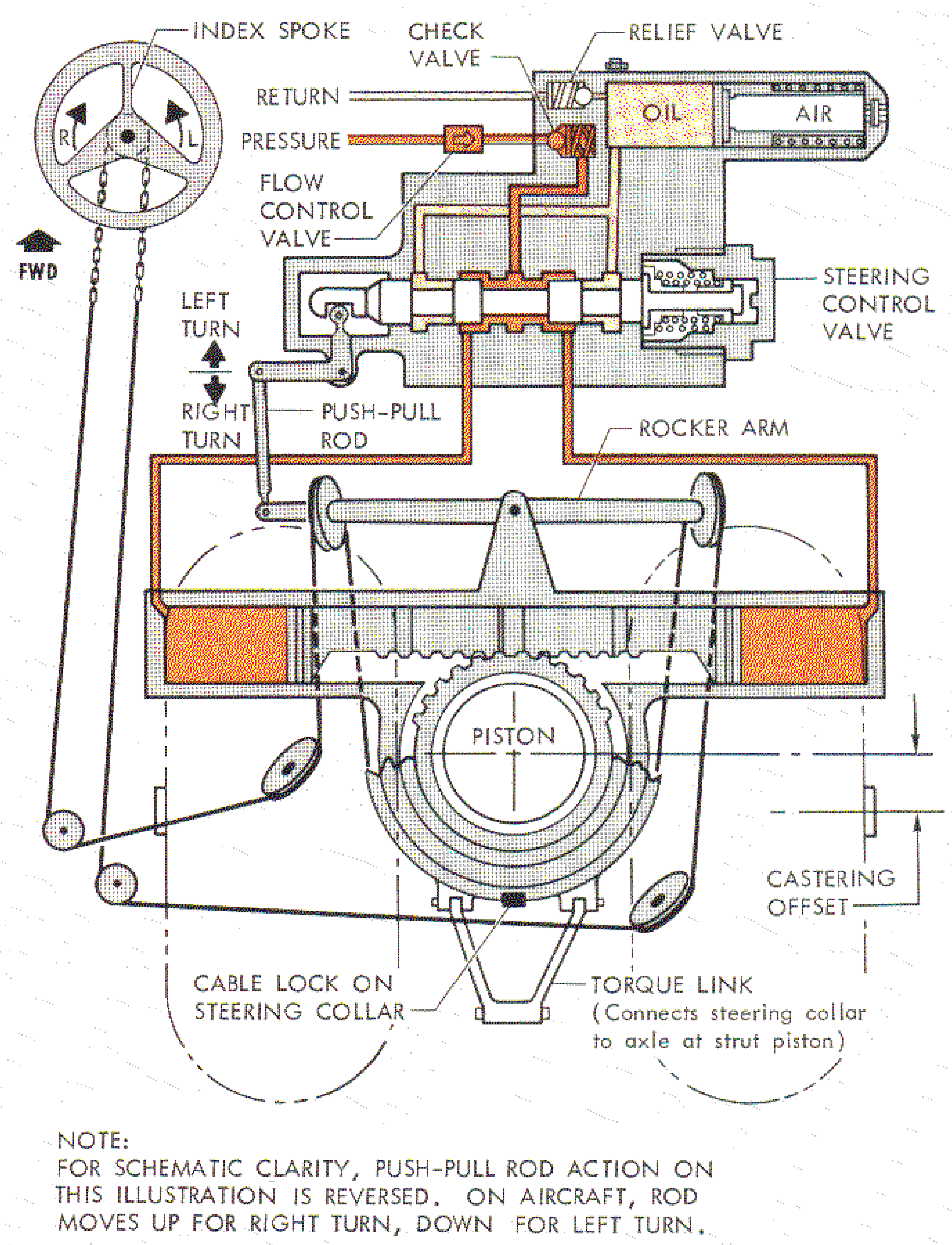



Figure 14 NLG Steering System Schematic

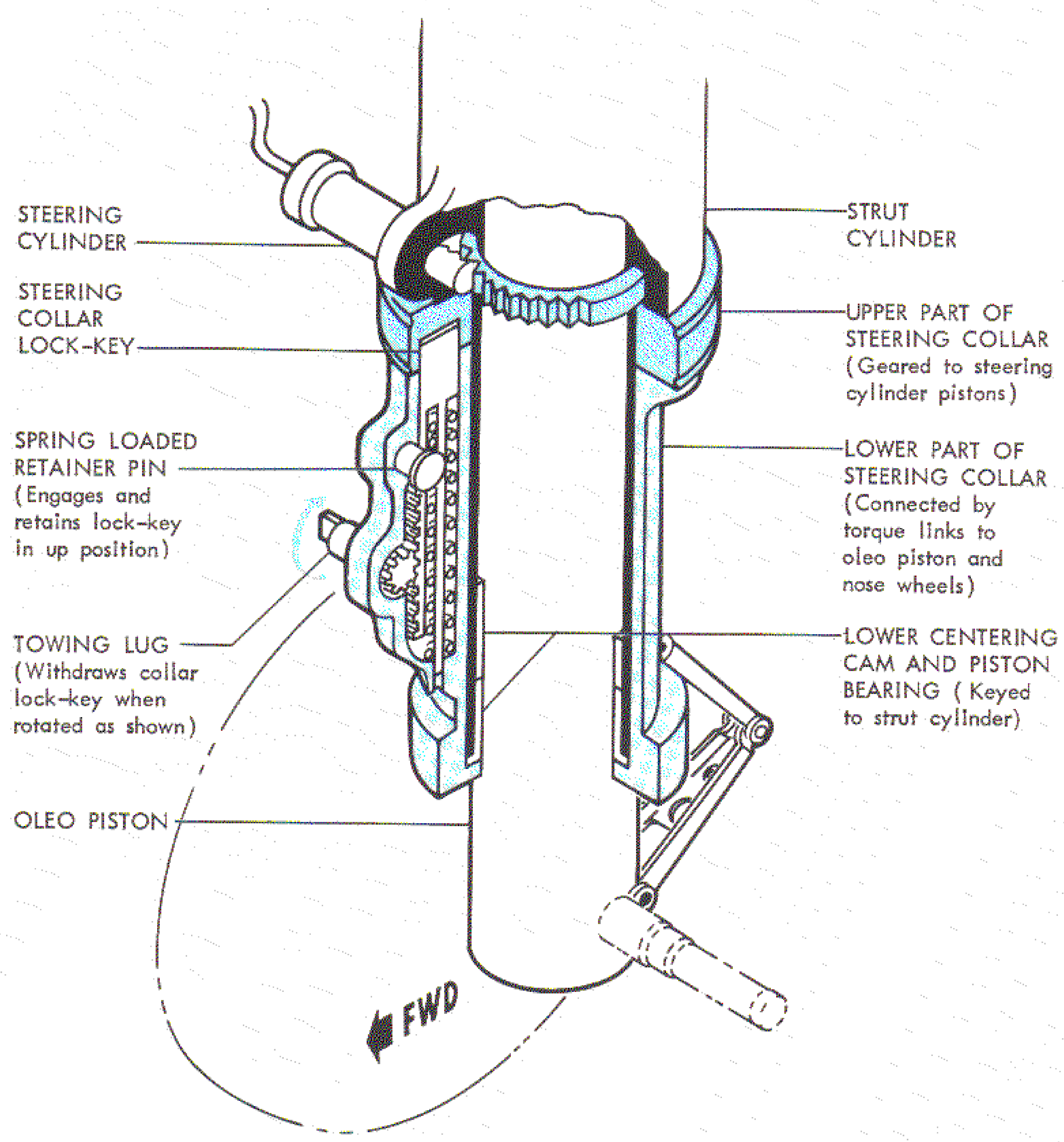



Figure 15 NLG Steering Disconnect Mechanism

6. It should be noted here that nose wheel centering can be checked visually through the wide-angle viewing window at the aft end of the bomb bay, but the index spoke on the steering wheel can be utilized for this purpose also. If for any reason the flight crew should want to make an additional in-flight check, the procedure is as follows:
   a. No. 1 hydraulic system pumps are ON.
   b. Landing gear DOWN.
   c. Turn steering wheel hard over one way (maximum travel). Verify that steering wheel returns one and one-half turns and comes to rest with the index (upstanding) spoke pointing forward (within 15°).

   The foregoing procedure assumes that the steering control system is rigged properly so that the index spoke points approximately dead ahead when the nose wheel is centered. Any doubt can be quickly resolved by turning the steering wheel maximum hard left and then three turns to hard right. Verify that the steering wheel returns one and one-half turns, indicating that the nose wheel is centered.
7. As with most four-engine craft, when sharp turns are executed from a standing start motive power for the turn must come from an engine or engines on the outside of the turn. If, for example, the nose wheels are turned hard right, thrust from engines on the left wing will accomplish the turn easily. But if all the thrust comes from the right hand engines the nose wheels will be side-loaded and no movement will occur at ordinary taxi power. If power is increased, the nose wheels will slide side-ways, and unless brakes are applied or power reduced, the airplane will pivot to the left. This may be disconcerting to the aircraft's operator who had intended to turn right; but aside from scuffing the nose wheel tires an incident of this type will not harm the airplane as long as it does not encounter obstacles during the unexpected maneuver.
8. When traveling at high speed on the ground (such as during landing roll), very little nose-wheel angle is necessary to cause a change in direction of the airplane. More than this is undesirable because of excessive scrubbing of the tires on the runway, and corresponding side loads on the gear and the fuselage. If the airplane CG happens to be fairly far aft or if speed is sufficiently high (with resultant low vertical loads on the nose gear), excessive turning of the nose gear tires may result in sideways "skipping" causing excessive wear on the tires and undesirable strain on the wheels and structure. Just as with an automobile, at high speeds it is neither necessary nor desirable to turn the nose wheels very far to change the aircraft's direction of travel.

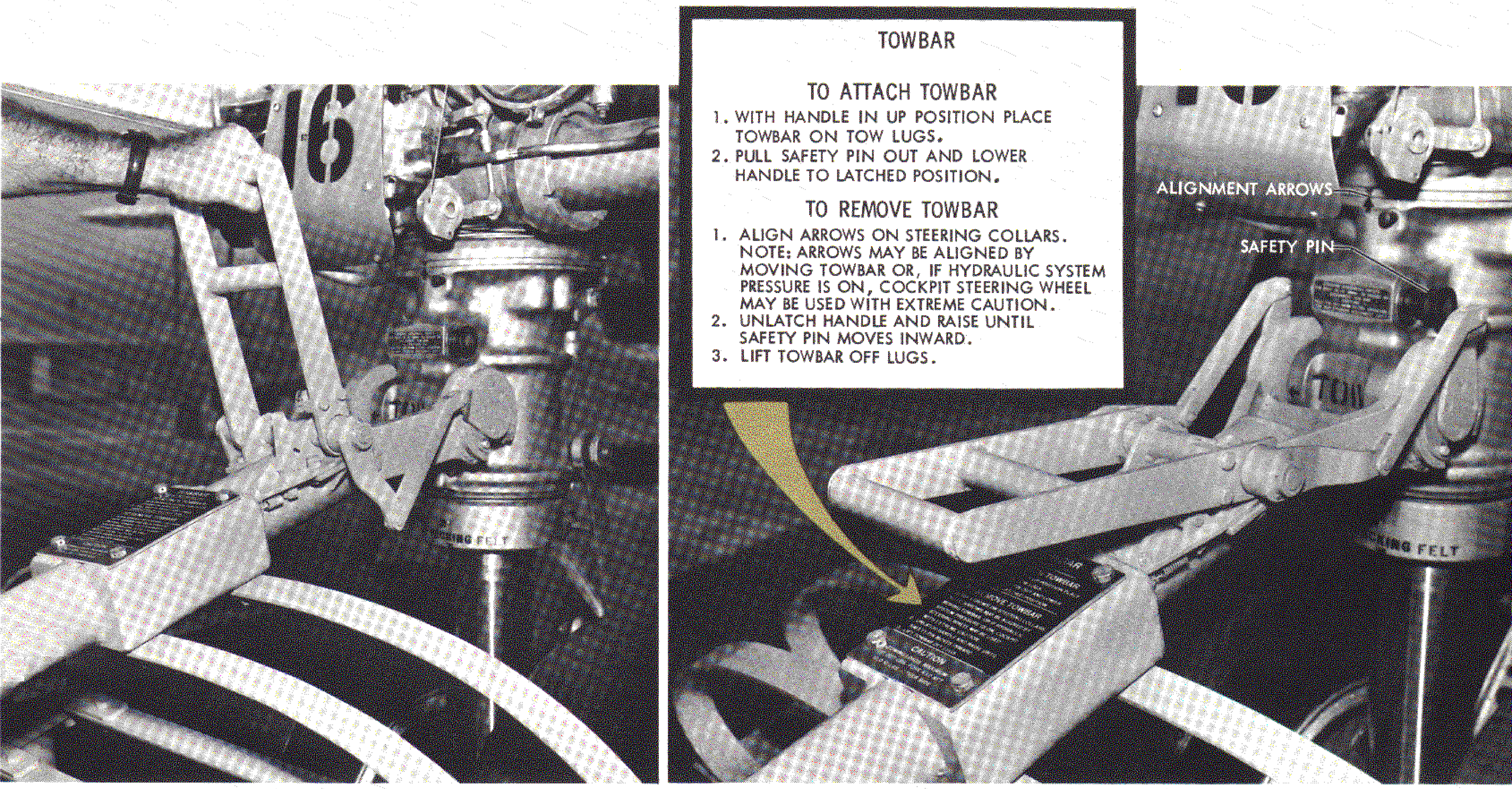



Figure 16 Tow-bar Connection to NLG

**TOWING** The NLG steering collar is divided into two parts as shown in Figure 15. The parts are normally keyed together so that the upper part (which is geared to the power steering mechanism), and the lower part (which is connected to the torque links), turn as a unit. This locking pin is actually the upper end of a spring loaded rack which is geared to the shaft of the pinion pin provided for tow bar attachment. The tow bar (LAC P/N 821255-5 shown in Figure 16) used for nose towing has dual locking end wrenches that fit wrench flats on the projecting ends of the pinion pin. The tow bar mechanism which locks the tow bar in place also turns the pinion pin, thereby withdrawing the rack's key from the upper part of the steering collar. The lower part of the steering collar (and the nose wheels and strut piston assembly which are attached to it by the torque links) will then be free to swivel full circle while the upper part of the steering collar and the steering mechanism remains stationary.

The tow bar cannot be detached until steering collar parts are re-aligned; the locking key will be re-inserted in the upper collar's keyway when the tow bar is unlocked from the pinion pin. A tow-bar (Regent Jack Mfg. Co. P/N 8025; LAC P/N 670871-101) just entering the FSN inventory can also be used with the Orion. This design incorporates a "break-away" mechanical fuse to prevent excessive loads being applied to the NLG structure. In the event the tow bar does separate during use, it can be immediately re-assembled and put back into service without replacing parts. The fuse is adjustable within certain limits, but it is not possible to increase the breakaway setting beyond the maximum allowable draw-bar load.

A towing attachment eye is provided on the bottom of each MLG strut between the wheel assemblies. This eye is accessible to tow cables from both fore and aft of the struts. Maintenance Manual ground handling instructions should be followed if it is necessary to use these attachments to tow the airplane. ▲▲

# Prop Static Operation Damage

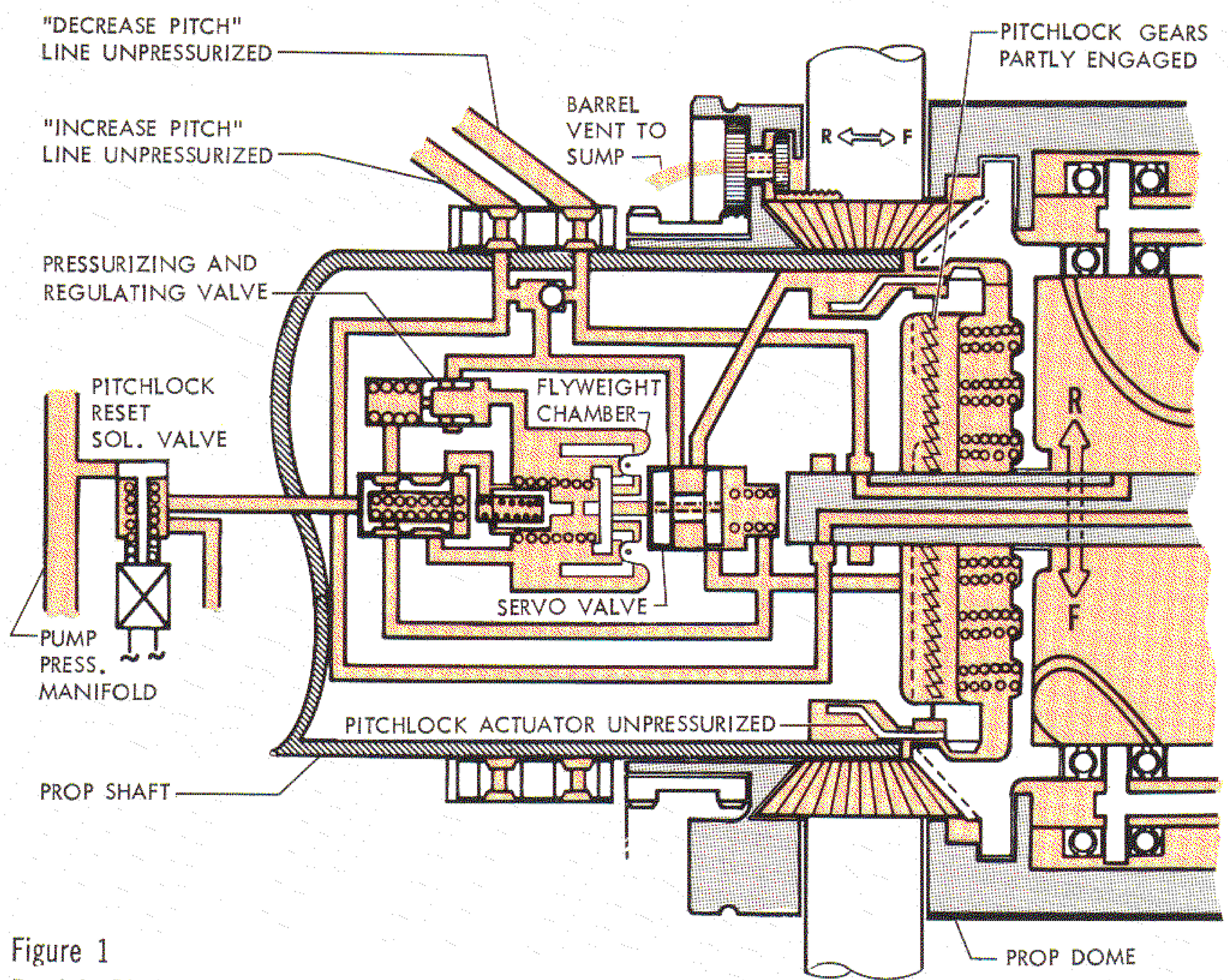



Figure 1
Partial Pitch-lock Engagement Due to De-energizing Auxiliary Pump with Prop Static and at Normal Flight Blade Angle

IN RECENT INCIDENTS propellers have suffered internal damage during static operation which could have been avoided if the operator had used a different technique. A specific set of circumstances is necessary before such damage *can* occur, and even then there is no certainty that it *will* occur, but the possibility of damage exists and every one who has occasion to operate propellers would do well to adopt a technique that will prevent such needless damage.

The incidents occur during maintenance or check-out work when the propeller is let to stand idle for even a brief period of time while in flight range, and is then operated directly towards low pitch. During the pause when no pressure is being developed, the spring load on the pitch-lock ratchets will bring the two halves of the ratchet into contact, although they probably will not engage fully as they would if pressure were lost in normal operation. (As explained in Orion Service Digest Issue 11, when the engine is operating, the prop blade's "twisting moment" tends to turn the rotatable ratchet towards low pitch and seat the raked ratchet teeth in a positive-lock engagement.)

Then when the Feather Button is pulled to "UN-FEATHER," the full system pressure is exerted to 1) turn the rotatable ratchet to low pitch and 2) disengage the pitch-lock ratchets. With only the crowns of the ratchet teeth engaged, the decrease pitch force may be sufficient to break the teeth before the actuator can disengage them.

The damage cannot occur if the propeller is cycled to full feather before decreasing blade angle. When the prop is to be exercised the safest course is to always assume the pitch-lock is engaged unless there is a sure indication that the pitch-lock is cammed out. An illuminated "BETA" light furnishes one such indication, for the pitch-lock ratchets cannot engage while the propeller is in ground operating range. The only other proof convenient to the flight station is an indication that the prop is in its feather-position cam out range, i.e., feather button at "FEATHER" with the button light not illuminated.

The rule to follow to reduce blade angle without danger of abrading the pitchlock is simply to increase pitch before decreasing it. Reduced to its simplest terms: *If the BETA light is not illuminated, always feather the propeller before reducing the blade angle.* ▲▲

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