CHAPTER 14
REVISION LIST

The following list of revisions will allow you to update the Lancair ES construction manual chapter listed above.

Under the "Action" column, "R&R" directs you to remove and replace the pages affect by the revision. "Add" directs you to insert the pages shown and "R" to remove the pages.

Page(s) affected	Current Rev.#	Action	Description
14-1 thru 14-9	0		
14-10	6	R&R	Modified figure 14-3, added fig. 14-3a
14-11	6	R&R	Modified figure 14-4a
14-11a	6	Add	New style power pack
14-12 thru 14-34			
14-35 thru 14-36a	5	R&R	Rewrote section, changed figures
14-37 thru 14-44	0		

CHAPTER 14:
LANDING GEAR

FINAL
ELECTRICAL & HYDRAULIC
INSTALLATIONS

REVISIONS

From time to time, revisions to this assembly manual may be deemed necessary. When such revisions are made, you should immediately replace all outdated pages with the revised pages. Discard the out dated pages. Note that on the lower right corner of each page is a "revision date". Initial printings will have the number "0" printed and the printing date. All subsequent revisions will have the revision number followed by the date of that revision. When such revisions are made, a "table of revisions" page will also be issued. This page (or pages) should be inserted in front of the opening page (this page) of each affected chapter. A new "table of revisions" page will accompany any revision made to a chapter.

Arrows

Most drawings will have arrows to show which direction the parts are facing, unless the drawing itself makes that very obvious. "A/C UP" refers to the direction that would be up if the part were installed in a plane sitting in the upright position. In most cases the part shown will be oriented in the same position as the part itself will be placed during that particular assembly step. However, time goes on and changes are made, so careful attention should be paid to the orientation arrows. That old cartoon of the guy agonizing over the plans for his canoe, built one end up, one end down, should not happen in real life. Especially to you.

CONTENTS

1. INTRODUCTION

Refer back to chapter 5, page 5-50, "Gear hydraulics", which began a section that primarily addressed the installation of the cylinders themselves. This section will address the hydraulic and electrical connections that will make it all operate correctly. Note that there will be some beginning duplication used here which might help get you back to the right train of thought.

The landing gear itself should now be fully installed, with the completion of this chapter, you'll be able to make it go up and down by itself. The electro-hydraulic system that actuates the landing gear, although perhaps appearing to be complex at first glance, is actually very simple and straight forward in its design. As with all systems, they can be designed in a variety of ways. The choices for the Lancair have all placed a strong emphasis on simplicity and reliability.

There are essentially two sides to the system, the UP side and the DOWN side. Another way of describing them is via pressures, i.e., high pressure (UP) and low pressure (DOWN). The pressures are achieved via an electric motor and small gear pump. This is a self-contained unit that combines the motor, pump and reservoir in one compact 6 lb package.

HIGH PRESSURE SIDE: The high pressure lines will always attach to the retract cylinder port that is nearest to the shaft of that cylinder. All cylinders on the Lancair "retract" their shafts into the cylinder body when the gear is retracted or the gear doors are closed. This side of the system will operate at pressures of about 1,200 psi.

LOW PRESSURE SIDE: The low pressure lines will always attach to the cylinder port that is farthest away from the shaft of the cylinder. This side of the system will push the gear down & locked and open the appropriate gear doors. There is less operating pressure used for gear down functions, about 550 psi.

SAFETY BACKUP: There is a built in safety backup system in the event of a hydraulic or electrical system failure - it is the FREE FALL ability. The landing gear will usually free fall down and locked faster than it can be pumped down since the hydraulics tend to act as a restrictor as the gear extends down and locked.

The high pressure and low pressure sides of the system will never be mixed or connected except at the free-fall valve. This valve will normally remain closed. If electrical power is lost for any reason, the free-fall valve can be opened and the gear will automatically drop down & lock. All gear legs are spring loaded to the down & locked position.

When this free-fall valve is opened, it essentially allows fluid from the high pressure side to flow across to the low pressure side thus allowing the gear to drop down and the spring loads lock it down.

2. DRAWING LIST

3. EQUIPMENT REQUIRED - SPECIAL PARTS, TOOLS & SUPPLIES

A. Parts

- Hydraulic power pack
- Pressure switch (high)
- Pressure switch)low)
- Starter relay (2)
- A/C master relay
- 50 Amp circuit breaker
- Attach plate
- Gear free-fall valve
- Gear switch
- Gear "quadrant"
- Gear micro switches (3)

B. Tools

- Sharp utility knife
- Bench vise
- drill motor
- drill bits: 7/16"
- 9/16" wrench (2)
- Pencil
- Flaring tool, **37°**

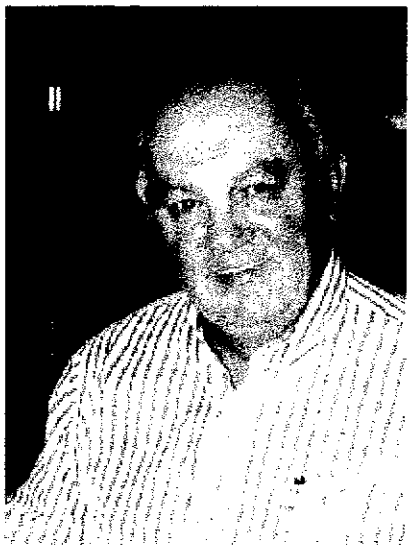
C. Materials & supplies

- epoxy
- flox
- BID cloth
- micro
- sandpaper, assorted grit
- Duct tape or release tape
- MC or acetone for cleaning
- 1/4" 5052-0 rigid line aluminum tubing
- HR 303 flexible hose

Builders' Corner

Lancair Oildyne Hydraulic Power Units

I had an opportunity to visit Oildyne who manufactures the hydraulic power pack for the Lancair family of aircraft. We are fortunate in these days of product liability that Oildyne still will



Don Plooster of Oildyne

produce the units for aircraft use largely thanks to Don Plooster a long time Oildyne executive, aviation enthusiast and Mooney 201 driver. Oildyne's series 108 pumps are mostly used in OMC's inboard/outboard stern drives and are nearly identical to the units that we are using in the Lancair. With over one million marine units sold, they have proven to be extremely reliable to which I can verify having owned several boats with the Series 108 power unit.

The motors on all our units are intended for intermittent use only and are reversible. The older Lancair two place electrical motor units were manufactured by Eaton and can be identified by the two heavy gauge wires and a lighter gauge black wire. This black wire is not the ground wire but instead a wire electrically connected to a thermostatically controlled normally closed switch within the motor housing. This unit must be grounded through its case and not the black wire. The blue/white wire when connected to a 14V power supply spins the motor in a direction to provide high pressure at the high pressure/up port. The green/white wire when connected to a positive 12V power supply spins the motor in a direction which will provide pressure to the low/down pressure port.

All the newer Lancairs using a Roby electrical motor (the same electrical power rating as the Eaton) also have three wires but can be identified by the fact that they are all the same size and also by the plastic case. On these units the black wire is the ground wire and the case need not be grounded. These units are about a pound heavier but also have a higher capacity pump (almost one gallon per minute as opposed to 1/2 gallon per minute) and thus draw more amperes at 14V. They are also available in 28V variety cutting the amperes in half. For the Lancair IV, the motor runs in one direction requiring that only the Blue/White and the black wire be hooked up.

All the units have built in pressure relief valves. When the motor is run in the high pressure direction, there is a high pressure relief valve that limits the internal pump pressure to a maximum of 1,400 psi. When the motor is run in the low pressure direction, there is a pressure relief valve that limits the internal pressure to about 750 psi. Now remember that we add external pressure switches whose functions are to turn the motor pump on when the pressure is low. It is extremely important that these switches be adjusted at least 200 psi below their respective internal pressure relief valve pressure setting. Otherwise the pump will run continuously and that is a bad thing to do. A continuously running pump could burn out the electrical motor or heat the hydraulic fluid up so hot that it melts the hydraulic reservoir. The two place Lancairs have two external pressure switches because they are run in both directions and the IV's have only one external pressure switch.

The newer Oildyne units used on two place Lancairs also have an internal back pressure valve. This valve operates when the landing gear is being retracted. For every ounce of fluid going into the shaft side of the cylinders, there is about 1.125 ounces of fluid coming out of the piston side of the cylinders (a function of cylinder diameter and shaft diameter).

The back pressure valve is set for a low 150 psi relieving the piston side (down port) of the hydraulic system when the gear is being retracted resulting in an efficient and uniform gear speed. If it were not for this back pressure valve during the gear retract cycle, not only would the hydraulic power pack have to overcome gravity, the down lock mechanisms and friction, it would also have to overcome the pressure created within the down side of the system resulting from more fluid coming out of the cylinders than is going into the cylinders. In addition, the pressure on the down side of the system after a gear retraction would be at the down internal pressure relief limit of about 750 psi which is well above the 550 psi external pressure switch.

If you are having to use the dump valve in order to get the pressure

NOTE: It is hopefully obvious, and already settled upon, as to the choice regarding the optional hydraulic gear door system for the main gear. The basic hydraulic installations are essentially the same with some additions used with the hydraulic gear door option.

4. PROCEDURE

A. Power pack & pressure switch installations

1. Review pages 5-~~59~~ 62 and 5-~~60~~ 63 in chapter 5, "Hydraulic power pack installation". Per figure 14-3, this attach plate is highly recommended as a very convenient means of assembling all the elements as shown in figure 14-4.

2. The power pack, as discussed above, is a self contained unit comprised of three elements: electric motor, gear pump and reservoir. This pack is attached to the aft face of the baggage bulkhead. The pressure switches will also be located there as will the two starter relays that operate it.

3. It is also recommended that you install the MASTER RELAY for the aircraft's full electrical system at this same location. See figure 14-4.

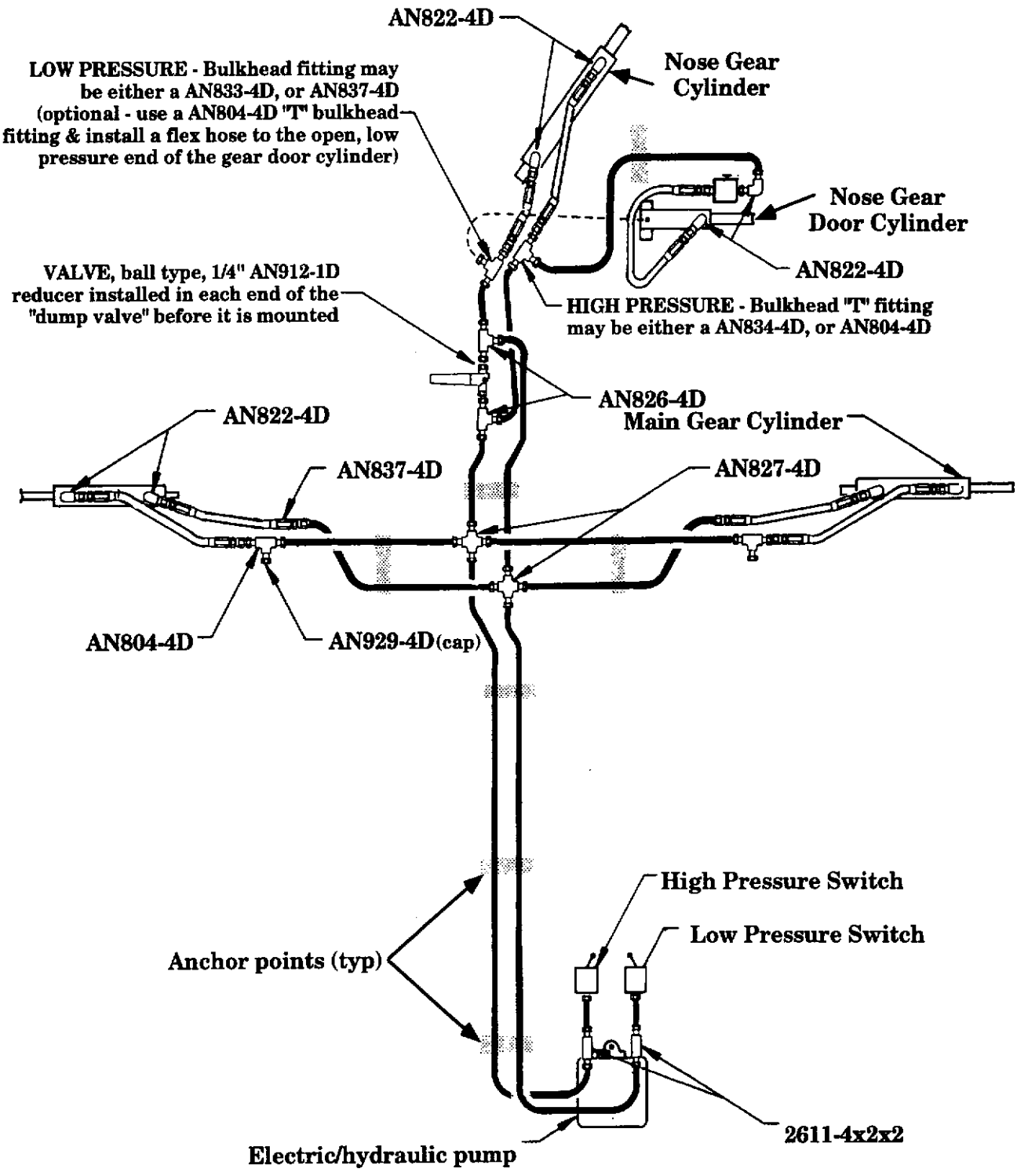
4. A 50 amp circuit breaker must also be used with this system and, per figure 14-4, the location is best suited near the power pack. This will place the circuit breaker in the baggage bulkhead.

5. Now go back to the power pack and install the two short lines from the AN826-4D fittings that are screwed into the power pack ports. These lines will extend vertically and attach the pressure switches.

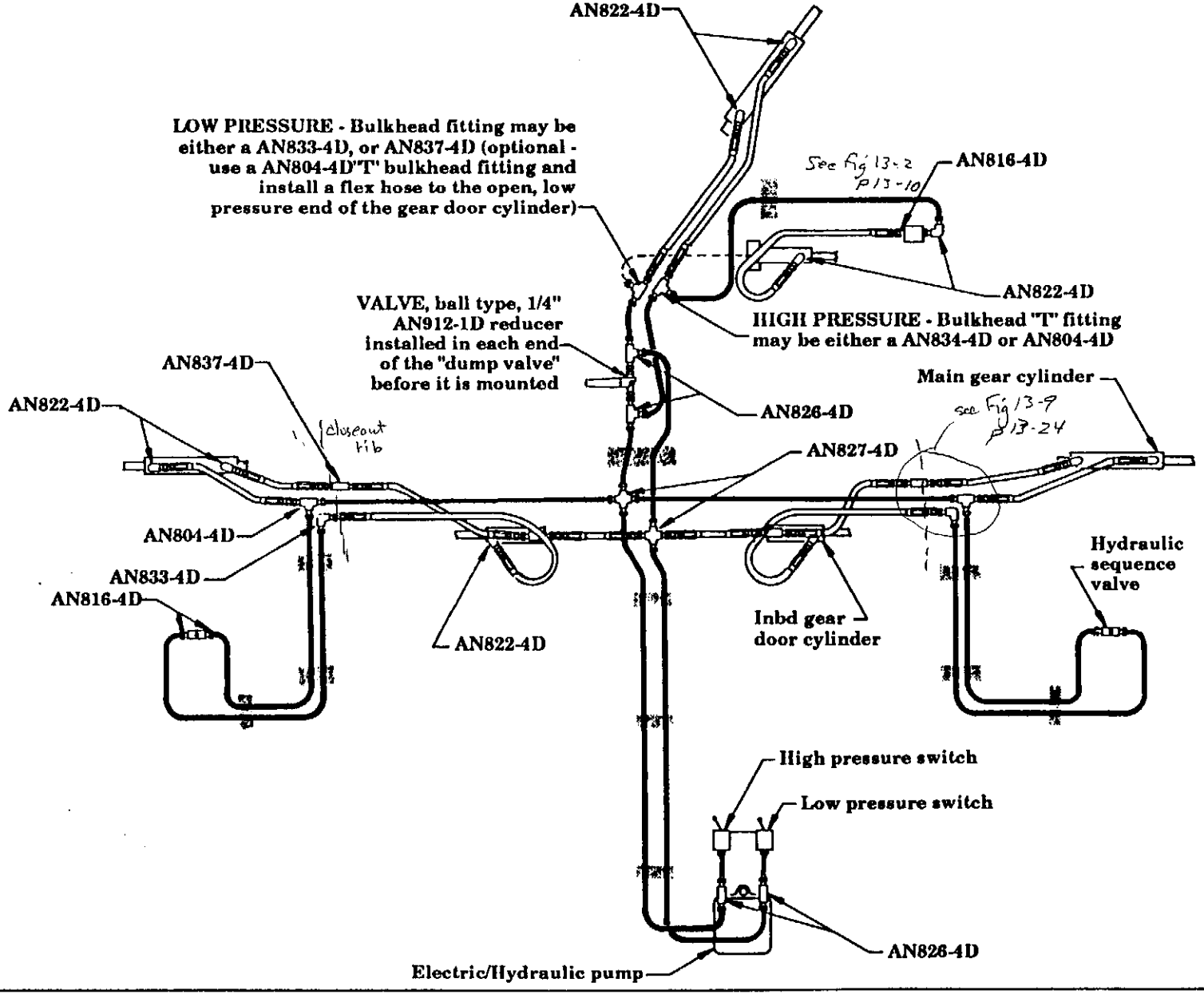
6. Attach the pressure switches to the above lines.

WARNING: Be very careful in marking the pressure switches for "high" and "low" since once you remove the switches from their marked packets, they will look the same. Put a marking system onto them immediately as you remove them from their packets. If you mix the order, the system will not operate.

SCHEMATIC - LANDING GEAR HYDRAULICS
STD. - MECH. INBD GEAR DOOR
FIGURE 14-1

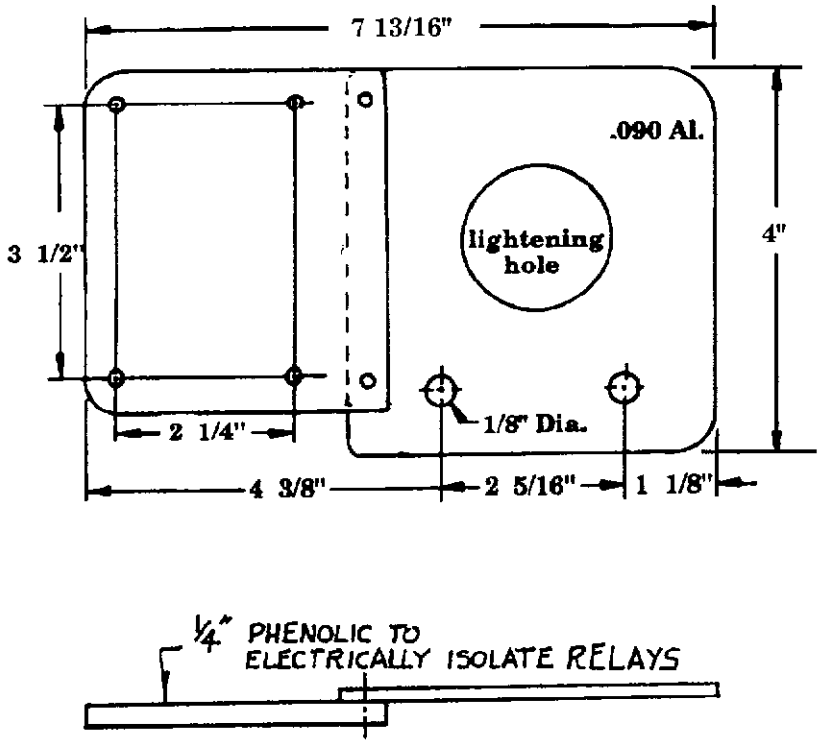


SCHEMATIC - LANDING GEAR HYDRAULICS
OPTIONAL - HYDRAULIC INBD GEAR DOOR
Figure 14-2



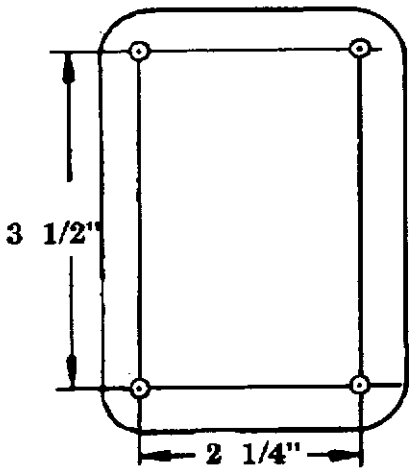
Old style with small black wire

(Hydraulic power pack assembly)
Figure 14-3



New style with large black wire

Figure 14-3a

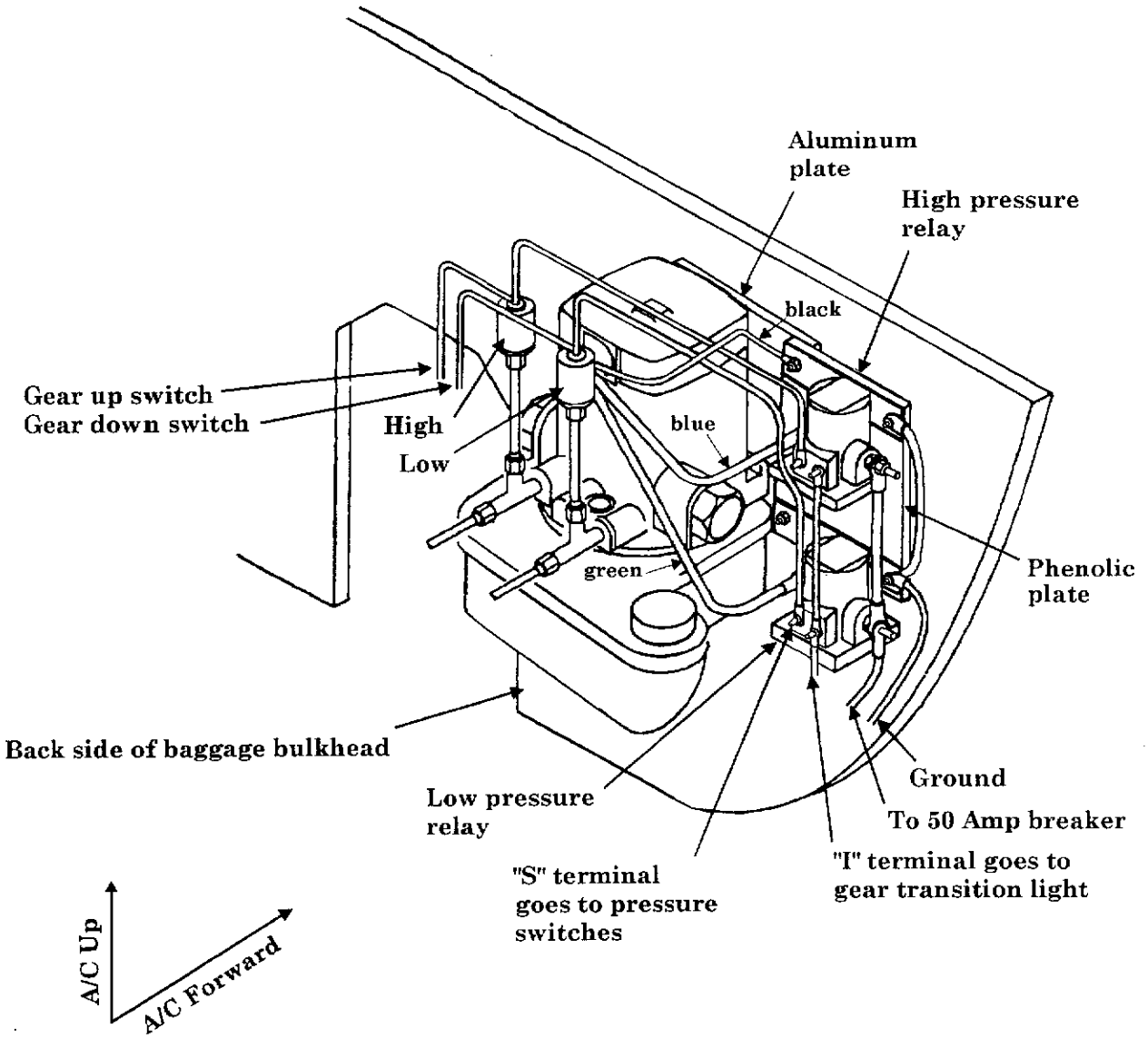


Note: No metal plate is needed under pump.

Hydraulic Power Pack Installation

Old Style

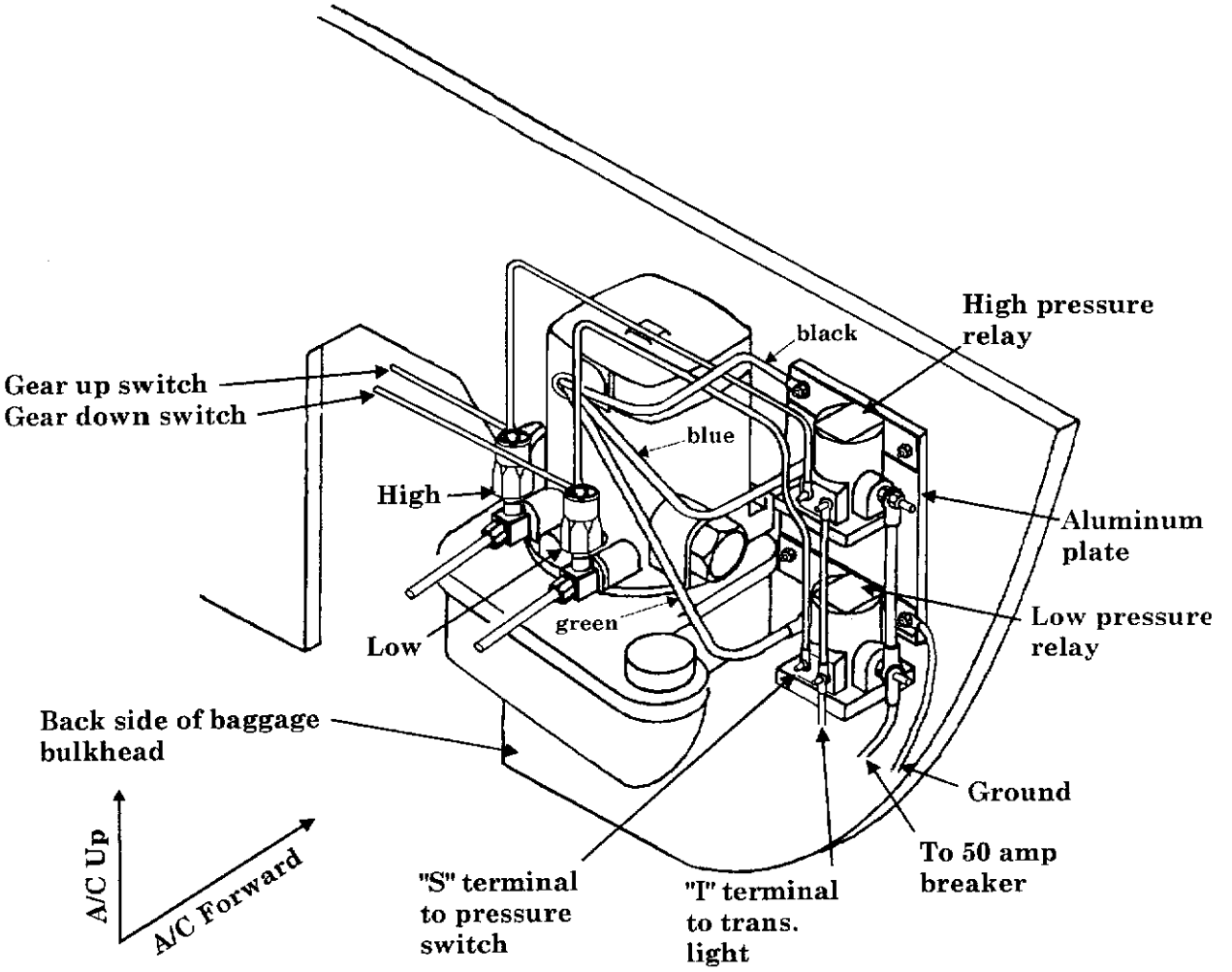
Figure 14-4a



Hydraulic Power Pack Installation

New Style

Figure 14-4b



B. Gear free-fall valve installation

The Free-Fall valve must be located in a position that affords relative ease of reach. The ability of free falling the gear should be checked regularly in flight, the proper test procedure will be detailed at the end of this chapter.

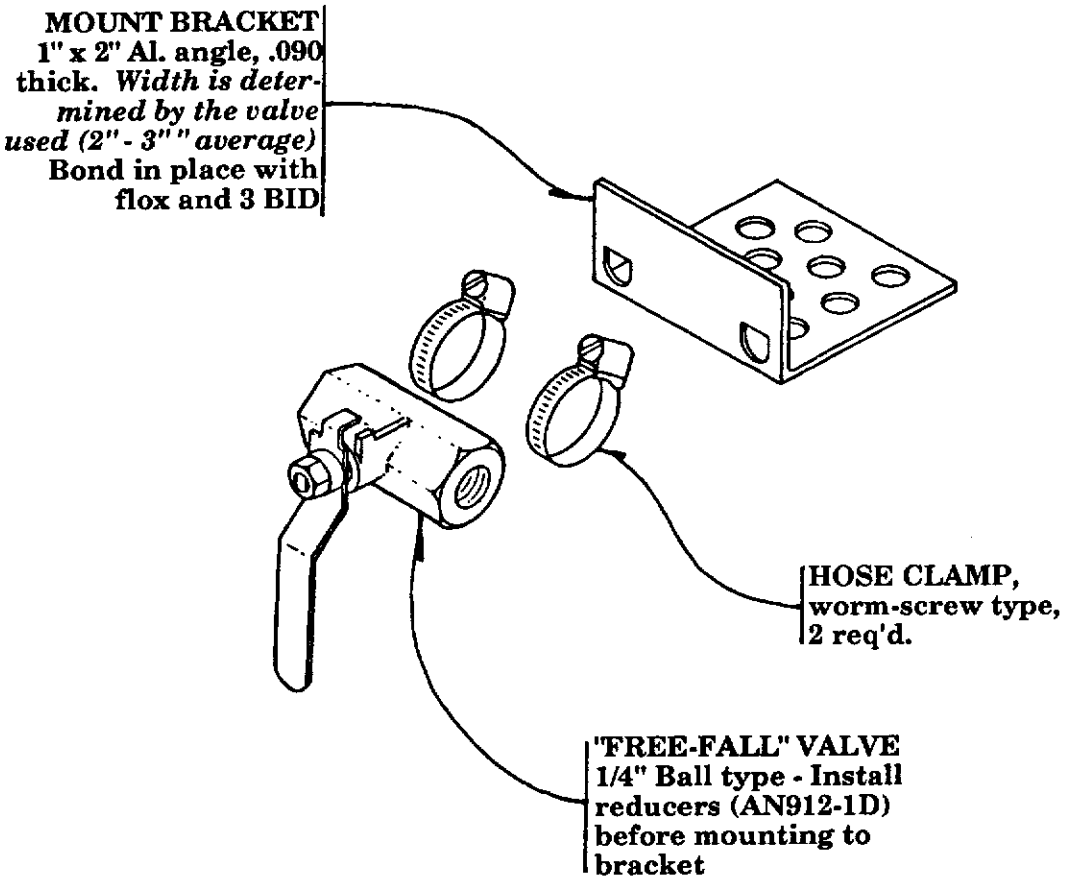
1. See figure 14-5 for a method of securing the valve in position. This valve should be located at a position that can be reached with relative ease by the pilot. It is generally positioned just fwd of the instrument panel center console area and up on top of the nose gear tunnel.

2. Generally, the Free-Fall valve is desired at a position that flushes with the left side of the nose gear tunnel, to avoid interference with the pilots right leg, see figure 14-6. The valve can then be positioned behind an upholstery panel which has a hole nicely cut in it for access. This makes for a good looking finished detail.

NOTE that the Free-fall valve has the two AN912-1D reducers installed into it so that it can attach to the AN825-4D fittings spliced into the lines.

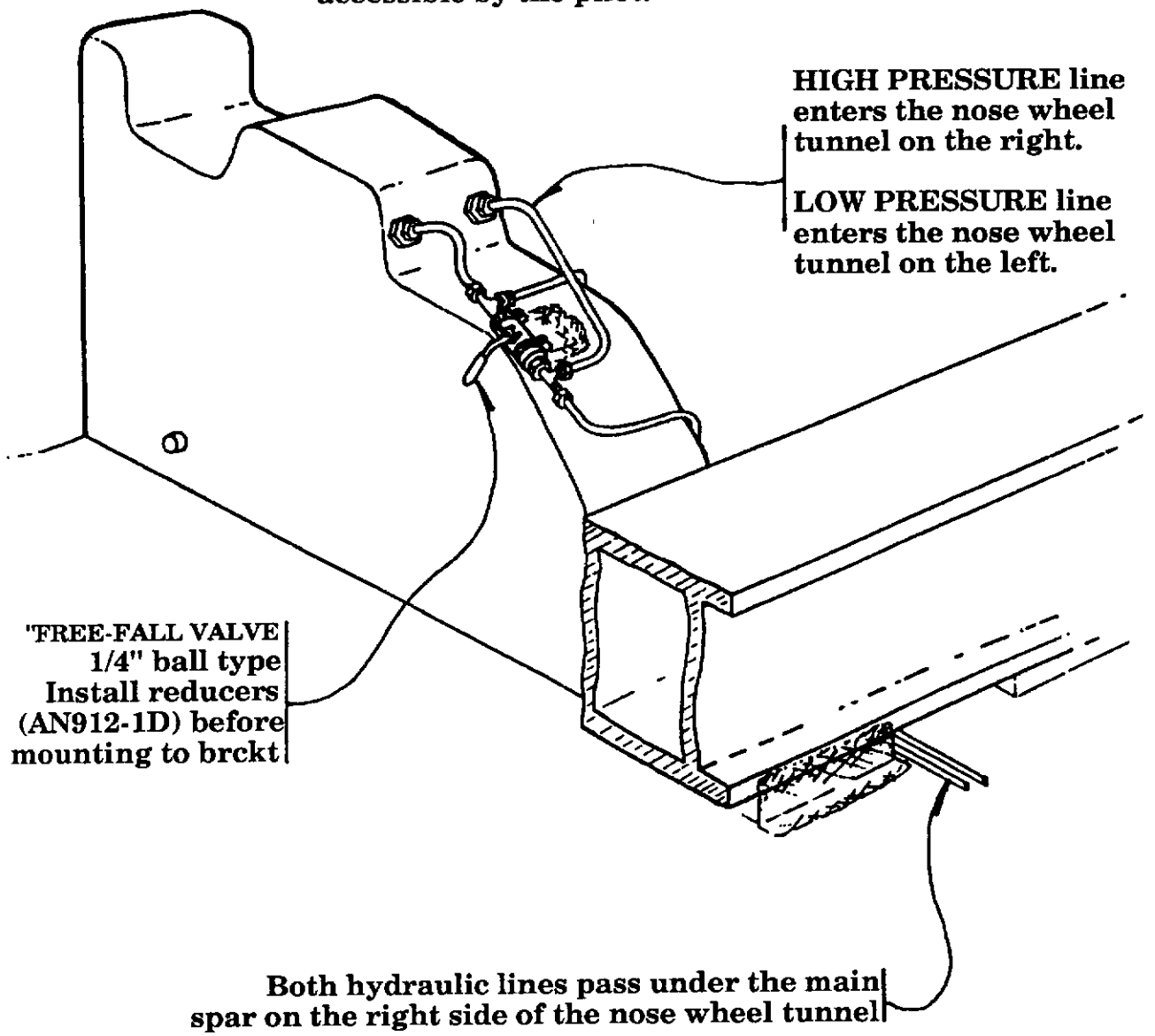
Gear Free-fall valve mount bracket & assembly

Figure 14-5



Gear Free-fall valve placement

Figure 14-6



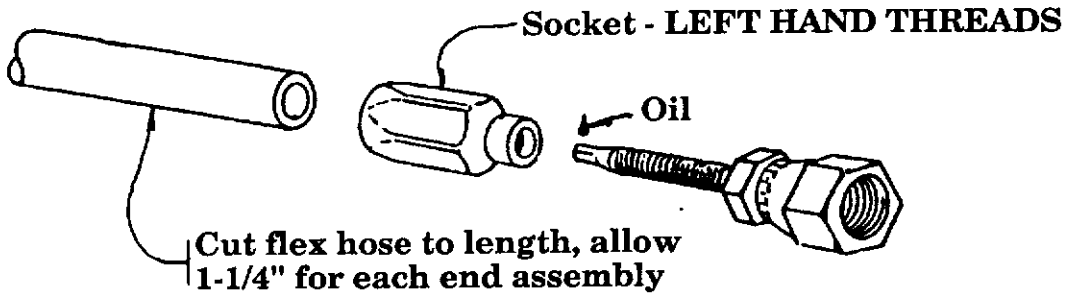
C. Basic hydraulic line fabrication techniques

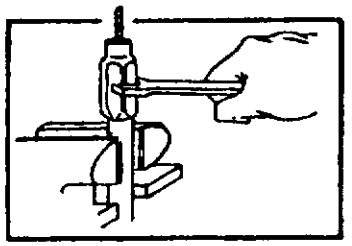
There are two types of hydraulic lines you will be installing, rigid aluminum lines which connect between non-moving items (such as pump motor and bulkhead ftgs.) and flexible lines which connect between moving items (such as retract cylinders etc.).

Naturally the assembly of each type is completely different. It is acceptable to install a flex line between stationary items but it is NOT acceptable to install rigid lines between moving parts. The aluminum line would work harden and fail if it were installed in any location that saw movement during operations.

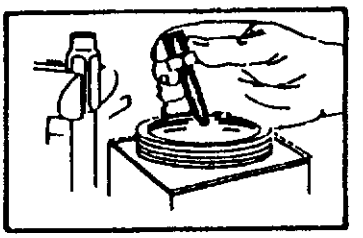
Flexible hydraulic line fabrication

Figure 14-7

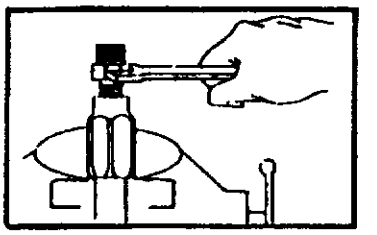




Place hose in vise with center mandril inserted. Thread socket counterclockwise onto hose until hose bottoms, back off 1/2 turn.



Oil nipple threads and inside of hose with Hoze-Oil or heavy oil. Caution: DO NOT oil hose cover.



Thread nipple clockwise into socket until nipple hex shoulders against socket

D. Flexible hydraulic line fabrication

We now use R 703 hose for all Lancair flex line applications. The fittings are two part assemblies consisting of a "socket" and a "nipple". The socket fits over the hose and the nipple threads into the socket. The end fittings can be easily installed provided you follow a couple of simple instructions. See figure 14-7.

1. When sizing the line lengths, don't forget to calculate the length of each fitting on that line. **The fittings will add 1-1/4" each to the line assemblies overall length.** Thus the flex hose itself must be cut 2-1/2" shorter than the *overall* hose assembly length to compensate for the length of the two fittings.

2. A mandrel is required. This need only be a simple steel rod of proper diameter. We use a drill bit #11) which slips through the threaded nipple portion of the fitting (it should not be a snug fit, or you may not be able to remove it once the socket is tight).

3. Make a clean cut with a sharp utility knife on the first end of the flex line.

4. Next slip the mandrel (drill bit) about 2" into the hose end (the bit should however be sticking out of the hose by 1-1/4" minimum). Place the hose into a vise, vertically, with 3/4" extending above the jaws. Then snug up the vise on the hose, not too tight, just enough to hold it firmly. You won't crush the hose since the drill bit is inside of it (something that works well here is a piece of wood with a hole drilled through it the size of the hose diameter, then sawn through the center of the hole - you can put the hose in the hole in the wood and chuck up the wood in the vise. The saw blade width now missing from the wood usually gives you just the right amount of gripping force when clamped into the vise).

5. Now use a 9/16" end wrench to screw the socket portion of the fitting onto the hose. THESE ARE LEFT HANDED THREADS, IT WILL SCREW ON WITH WHAT WOULD BE CONSIDERED A BACKWARDS ROTATION. Once you start threading the socket on, try to keep a steady, progressive movement going. You will be generating heat from the friction and if you stop in the middle, the going will be tougher when you resume. So don't stop until the socket is screwed fully onto the hose (.650" hose penetration). Note the small "tick" marks on the barrel of the socket, that's where the hose should screw up to. Thus with .75" of hose sticking out of the vise, you will basically continue until the socket screws just short of the vise jaws.

   NOTE: You will generally have to push against the end of the socket as you twist *counter clockwise* in order to get it started on to the hose. Once the threads are engaged, you can simply twist.

6. Next remove the hose from the vise and place the socket into it (the hose). Then thread the nipple into the socket. These are standard, right hand threads. Oil threads with Hoze oil or 30 wt. motor oil. Slip the nipple over the mandrel and push as you twist to engage the threads. This nipple should be tightened up until just snug against the socket. This requires a 9/16" wrench as well. That's it except for the visual check.

WARNING: It is very important to make a visual check to verify that the nipple entered the hose correctly and did not create a blockage due to misalignment. When finished with the fitting installations, check by looking through the end of the completed hose piece. This is actually quite easy to do. Simply have a bright light at one end and sight through the other end. Pull and slowly rotate the hose until it is straight enough to see through it. You'll be able to view the opposite end fitting quite clearly. There must be absolutely no obstructions in the line. Sometimes, if the nipple mis-enters, it will cut a slice of hose lining out and push it to the end of the nipple. This could cause disastrous effects and failure at some point in time during operation. So check carefully.

Another test is to blow through the hose first from one end, then from the other, and make sure that there isn't a bit of torn hose anywhere in between acting as a one-way, or "flapper" valve. If this is the case, you may feel a different resistance or hear a different sound as you blow first from one end, then the other.

E. Aluminum hydraulic line fabrication

The Lancair uses all 1/4", 5052-0 rigid line. This requires AN818-4D nuts and AN819-4D sleeves for end fittings. The only flare angle acceptable is 37°.

WARNING: DO NOT USE AUTOMOTIVE FLARING TOOLS, THEY ARE 45° AND TOTALLY UNACCEPTABLE. *FITTING FAILURE WOULD RESULT.* Only aircraft type, 37° flaring tools can be used.

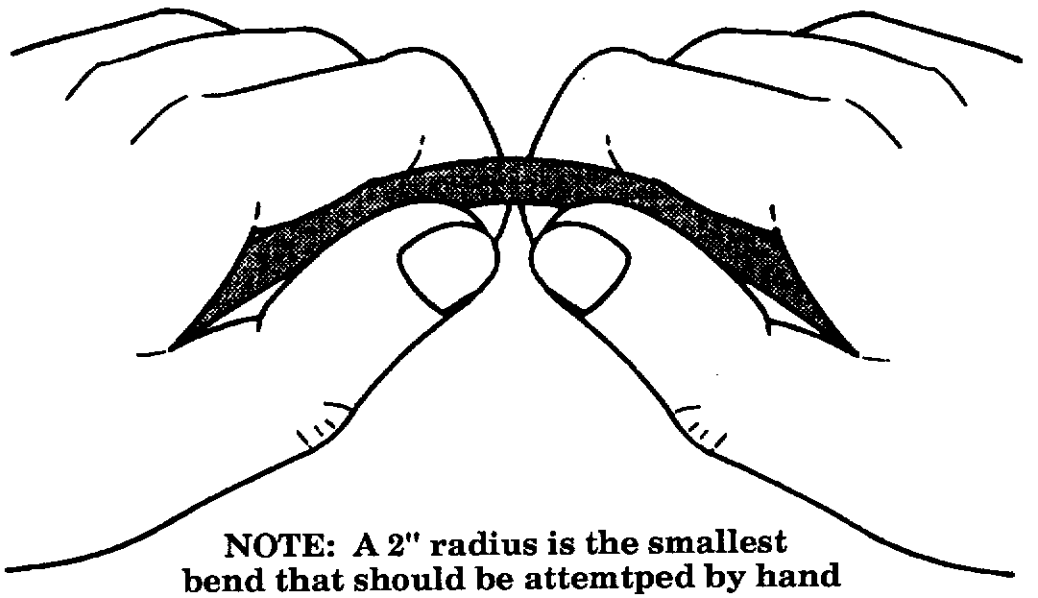
1. Use tubing cutter to cut the end of the aluminum tube. It should be a good, perpendicular straight cut. After that, use a flat file to dress the end of the tube so that it is squared off nicely with no ragged saw cut marks. You'll notice a slight "burr" which often results along the edges of the tube end. These burrs should be removed. You can use a pointed knife to carefully remove JUST the burr from the inside of the tube and a file to carefully remove JUST the burr from the outside perimeter. Remove only the burr and no more. Blow out the line with compressed air.

2. Now slip the nut assembly over the tube in the proper order. First the AN818-4D nut (small dia. end goes on first) and then add the AN819-4D sleeve (facing the proper direction - narrow end goes on first). You *will surely forget this more than once and be forced to cut the flared end of the tube off again since you've make the flare without first putting the nut assembly on. You can get away with that on the first end, but not on the last end.*

3. Now you're ready for the 37° flare. There are many types of flaring tools available from cheap to pretty expensive. We use a $50.00 unit that performs very well. Single flares are acceptable. Consult your flare tool instruction book for specific instructions on use of the tool.

   In general though, the flare should be just wide enough to cover the sleeve that mates to it. If the flare gets too wide, the end will start to break down and crack due to excessive stretch. This could cause a failure either right away or at some distant point in time. If your flare looks too big, don't guess about its integrity, just saw it off and make another. The aluminum line is not very expensive and leaking hydraulic systems are a real nuisance.

Hand bending aluminum hydraulic line
Figure 14-8



4. Bending the aluminum hydraulic line:
The supplied aluminum line is 5052-0 which is not particularly difficult to bend. The primary requirement is to avoid any "kinks" that would close up the inner diameter and consequently restrict the flow. There are many types of hand operated tube benders, you do not need an expensive, highly sophisticated bender. In fact, if you are very careful, you can produce excellent bends by use of just your thumb and fingers to very gently make the bend. Try to keep the radius as generous as possible with a 1" radius being about the smallest advisable. The smaller the radius, the greater care required to produce it correctly. See figure 14-8.

F. Installing the gear high and low pressure lines

With the power pack installed onto the aft face of the baggage bulkhead, the lines can be installed. We will start at the pump and work our way forward. This is a very straight forward installation and is very simple. The primary initial concern is to be very certain NOT to mix up the high pressure vs. low pressure lines. And that's easier to mix up than you might expect. It's even a good idea to mark the ends of the lines with colored tape as you go - green for down (low pressure lines) and red for up (high pressure lines).

It is generally best to first attach all the aluminum lines, then come back and attach all the flexible lines. This keeps you working with the same sets of tools instead of jumping back and forth and getting slowed down in the process.

1. From the power pack, two aluminum lines will be routed forward. One will be for high pressure, one for low pressure. Review figures 14-1 and 14-2 thoroughly before proceeding. Note that two installations are shown, the system used with the optional hydraulic main gear door closure (figure 14-2) will obviously have additional lines for them. You should have made up your mind about this option before continuing (the hydraulic gear door option is however, retrofitable at any time, it's just less work if you figure it out now).

2. Locate the position on the cockpit floor where the AN827-4D "Cross" fittings will be installed. There must be adequate clearances around these fittings so that the lines can be easily routed to them without rubbing on anything.

3. Use a measuring tape or a piece of string to trace out the length of these first lines (from power pack to "Cross" fittings). Refer to figure 14-1 for orientation. You will likely be installing and removing these lines several times each before the "final" installation. This first sizing is only to get the piece of tubing cut to approximate size (remember that it can be a little long, but it cannot be a little short!).

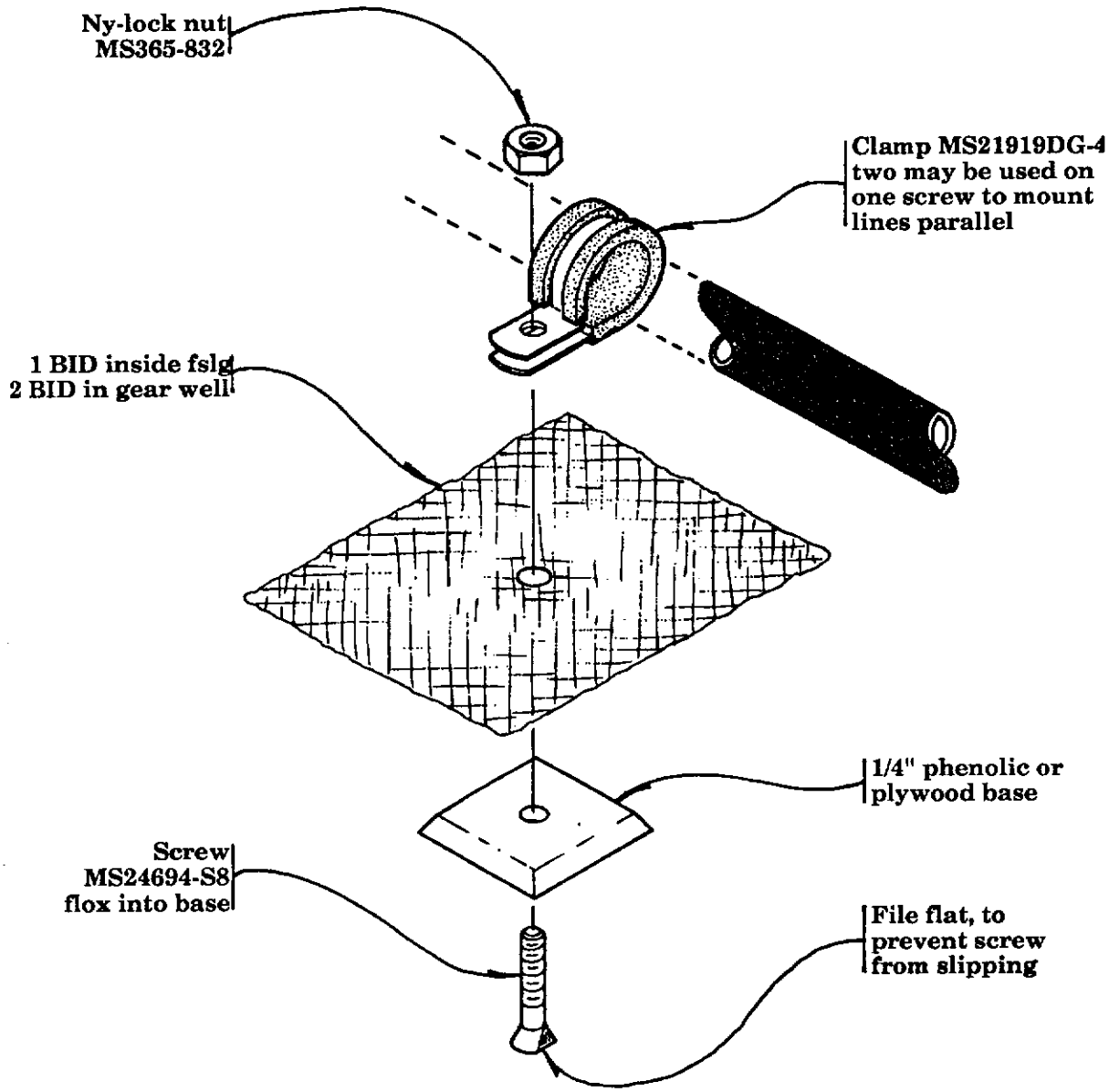
4. It is generally best to measure the approximate tube lengths *between* bends and make those bends prior to inserting the tube into the fuselage. These first two tubes will extend under the aft spar and should be kept well to the sides of the center "tunnel area thus clearing the elevator push rod and idler arm assembly which should be already installed behind the aft spar.

5. When the fit is close, attach the ends of these first tubes to the power pack as shown in figure 14-1. Finger tight is OK for now. Now it will be easy to locate the exact trim point for the other end of the lines so as to attach nicely to the "Cross" fittings.

6. Check the tubing's overall alignment, adjust as necessary and attach the other ends to the "Cross" fittings. These lines can lay loose on the floor for now. Later, the lines should be anchored at periodic points to secure. See figure 14-9 for a suitable means of securing lines to stationary objects (like fslg floor, nose gear tunnel sides, etc.).

Once all the lines are positioned, both rigid and flexible, the assembly will begin to nearly hold itself in position by virtue of their rigidity once attached to bulkhead fittings, etc. However, these lines should still be anchored at a few points which are shown in figure 14-1 (or 14-2).

ANCHOR POINTS for ALUMINUM HYDRAULIC LINE
Figure 14-9

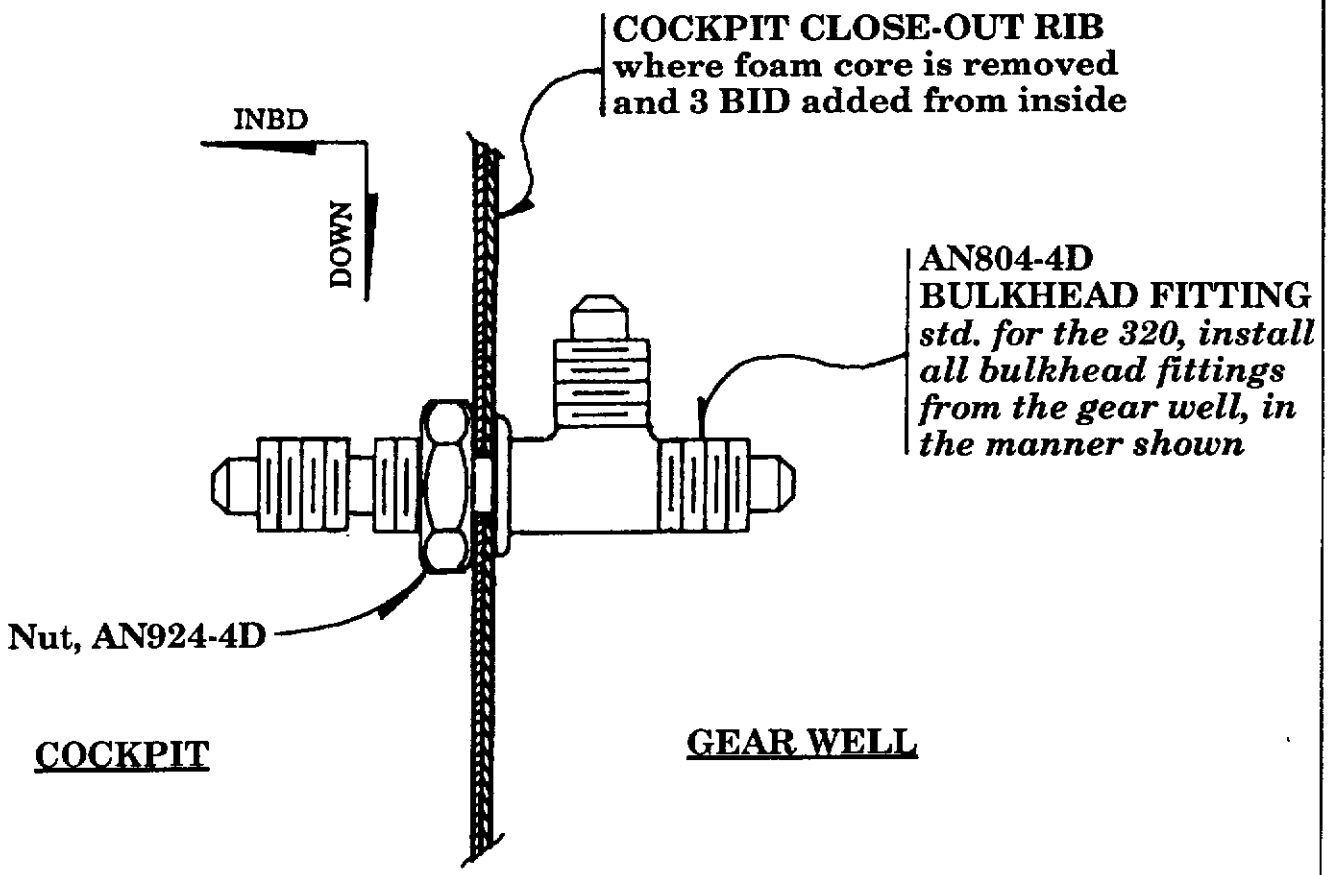


7. Install the bulkhead fittings, that attach to the cockpit closeout ribs, from gear well side of the rib. Use a 7/16" drill bit to drill through the area that has the core material removed and reinforced with 3 BID from the inside. Refer to blueprint "K" for these bulkhead fitting locations, and see figure 14-10. These will be the next connection points for line installations.

NOTE: If you drill a good clean hole for the bulkhead fittings, the fittings will seat nicely into the hole. If the hole is a little ragged then the small end of the bulkhead fitting will not seat properly since its shoulder is only 0.065" wide. If this should occur, simply slip an AN960-716 washer over the fitting first, then insert it into the hole and tighten up with the AN924-4D bulkhead nut.

Note that there are three bulkhead fittings for each side when using the optional hydraulic gear door closure system. For the mechanical system, there will only be two fittings installed per side and the AN804-4D fitting will have an AN926-4D cap attached to seal off that extra unused port.

Bulkhead fitting installation for hydraulic lines
Figure 14-10



8. Make and attach the lines that run from the "Crosses" to the AN804-4D fittings next. See figure 14-2. If you have the standard mechanical gear door (figure 14-1), then route the low pressure lines from the bulkhead fitting to the low pressure "Cross" fitting next.

9. Next continue the aluminum lines forward, under the main spar to the position just aft of the nose gear tunnel where the Free-fall valve is located. See figure 14-6. The Free-fall valve will have the two AN912-1D reducers installed onto it so that it can attach to the AN825-4D fittings spliced into the lines.

10. Next you will install the bulkhead fittings into the nose gear tunnel. Before drilling the holes, retract the gear by hand and verify that you will have adequate clearances for the fittings. See figure 14-6 for location. Drill the 7/16" holes and install the bulkhead fittings in the same manner used for the close out rib, refer to figure 14-10.

11. Install the lines from the Free-fall valve to the above bulkhead fittings on the nose gear tunnel.

12. This will complete all the aluminum line installation inside of the fslg. The aluminum lines still must be installed into the nose gear well from below (one line to the sequence valve). If you have the optional hydraulic gear door system for the main gear, then there are two additional aluminum lines in the main gear wells yet to install.

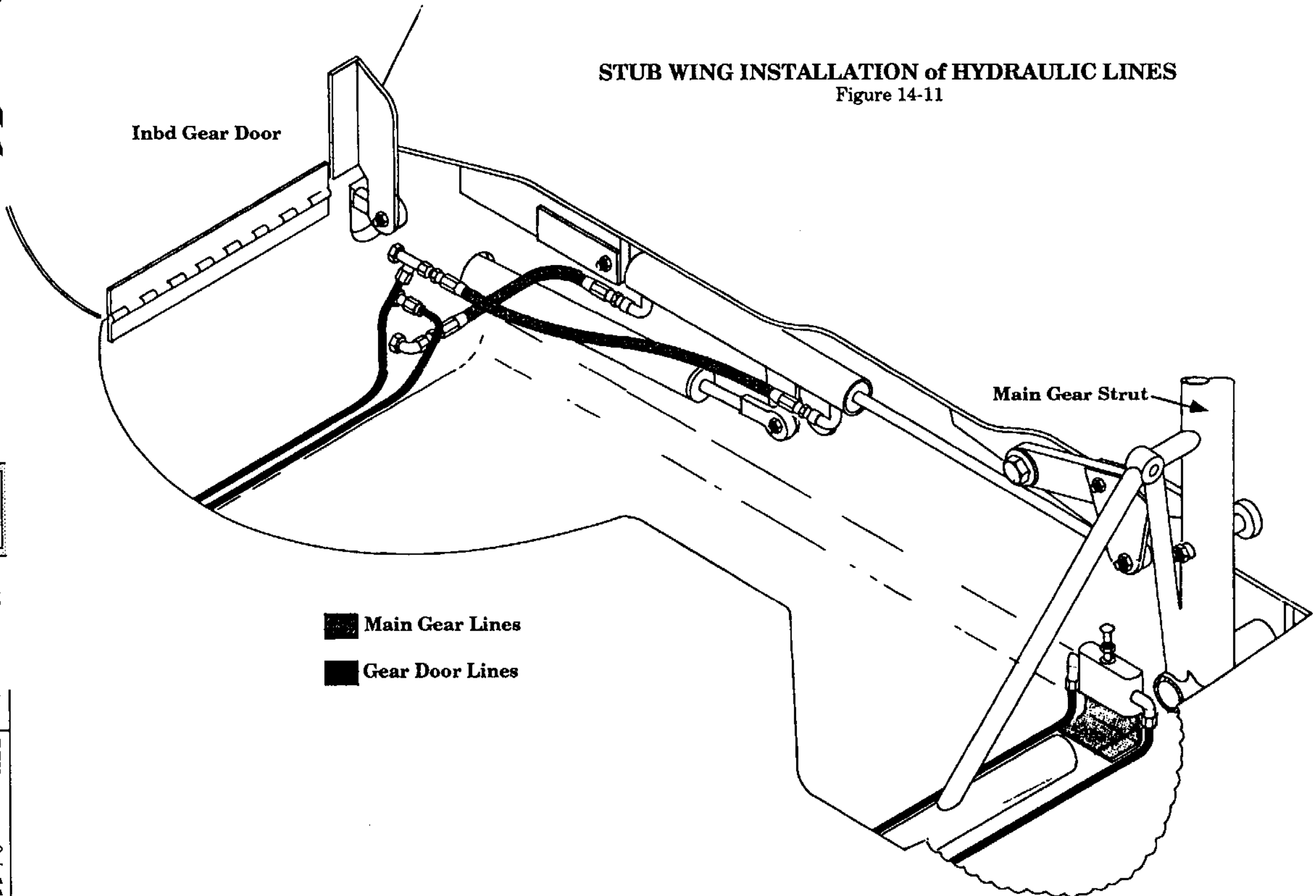
13. For the optional hydraulic main gear doors, refer to blueprint "K". Before you can install these two lines, the sequence valve must be located. During line installation, check by cycling the gear up by hand, that proper clearance is maintained from all moving parts. The two aluminum lines should route up high into the "fillet" area formed where the upper skin rolls up and meets the fslg. See figure 14-11. These lines will route through the partial rib in the stub wing, use either a short length of rubber type hose as an insulator or use grommets. You can simply drill through the partial rib and install the lines. No reinforcement is required. Anchor the lines in the gear well since air turbulence is one added factor in the gear wells. See figure 14-9 for recommendations.

14. Install the one and only aluminum line into the nose gear tunnel, see figure 14-12. This line runs from the AN834-4D bulkhead "T" to the "IN" port of the sequence valve. This line must also be secured and carefully clearanced away from all moving parts in the nose gear well.

THIS WILL COMPLETE ALL ALUMINUM LINE INSTALLATIONS

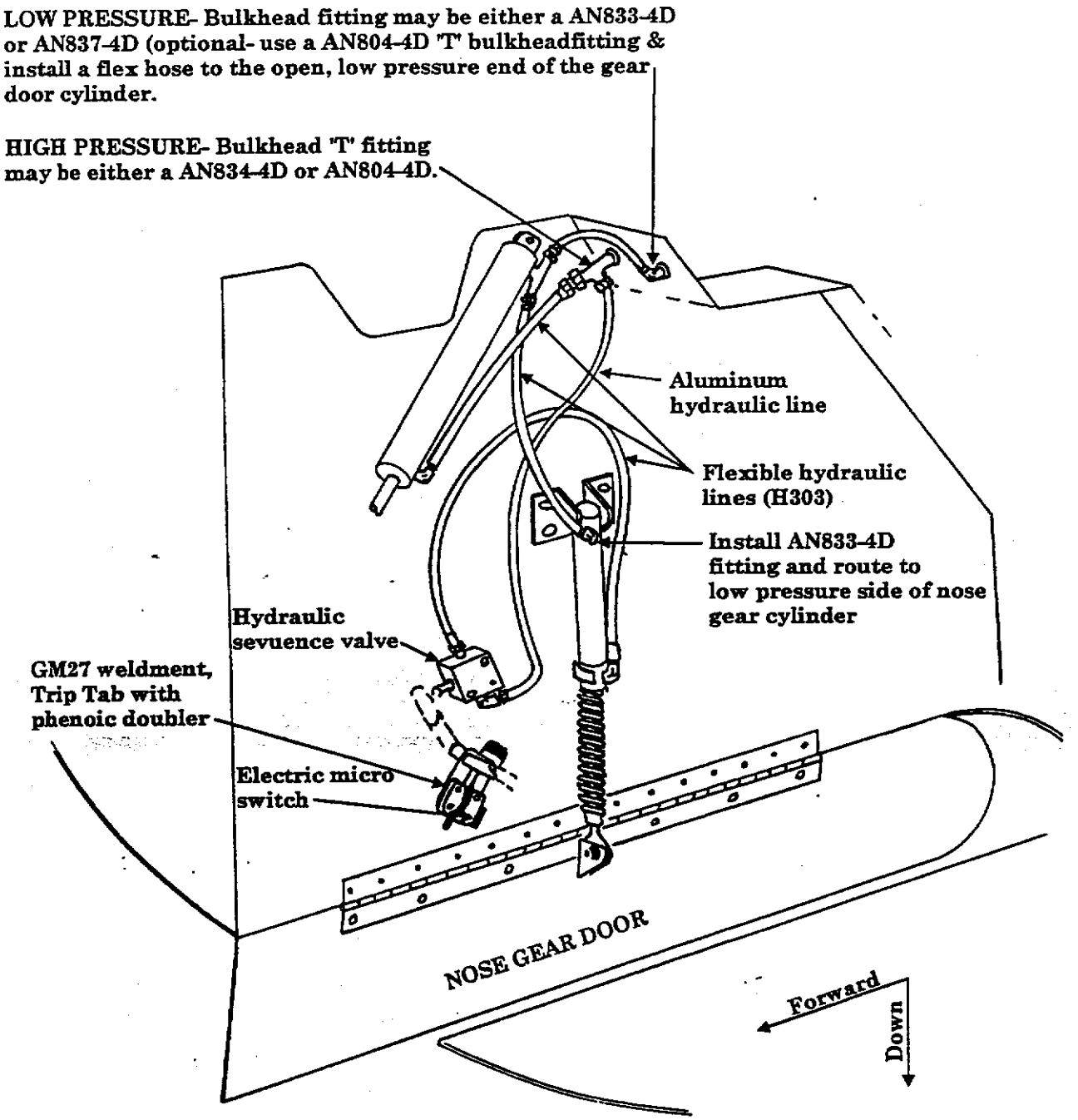
STUB WING INSTALLATION of HYDRAULIC LINES

Figure 14-11



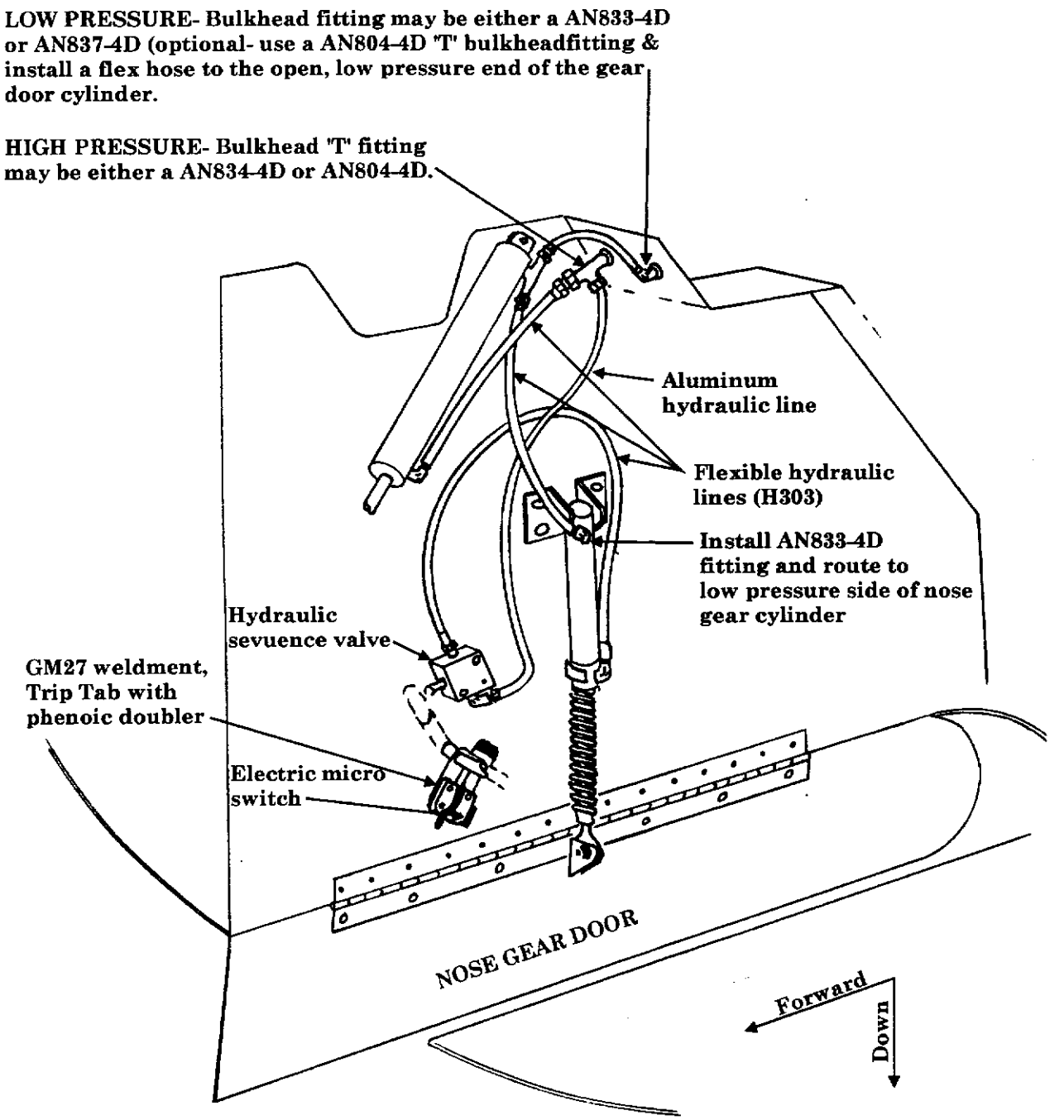
Hydraulic line routing inside the nose wheel tunnel

Figure 14-12



Hydraulic line routing inside the nose wheel tunnel

Figure 14-12



G. Flexible line installations

With the aluminum lines all installed, it is a relatively easy matter to install the hydraulic flexible lines.

1. Start in the main gear wells and fit the high pressure lines (for gear retraction) first. See figures 14-1 and 14-11.

2. Next fit and install the low pressure lines to the main gear cylinders (for gear down. These lines are a bit more critical in installation since their length must be just right to not kink or be stretched.

3. Cycle the gear up and down by hand to verify the installation and clearances. These lines must be kept away from all moving parts that could generate a "rub". Also check that they clear the tire as it passes by during retraction. The nylon type wire ties work very well for securing the flex lines.

4. Next fit and install the three flex lines in the nose gear tunnel. See figure 14-12.. These lines must, like all the others, be verified as clearing all moving parts. When the assembly is completed, run the nose gear up by hand and verify clearances.
   This will complete the flexible line installations and thus completes all gear hydraulic line installations.

Gear electrical installations:
The gear electrical installations, although described in this chapter, should not be made until basically all glass work is completed on the airframe. The one exception is regarding the power pack assembly with pressure switches and relays. This assembly can be wired at most any time.

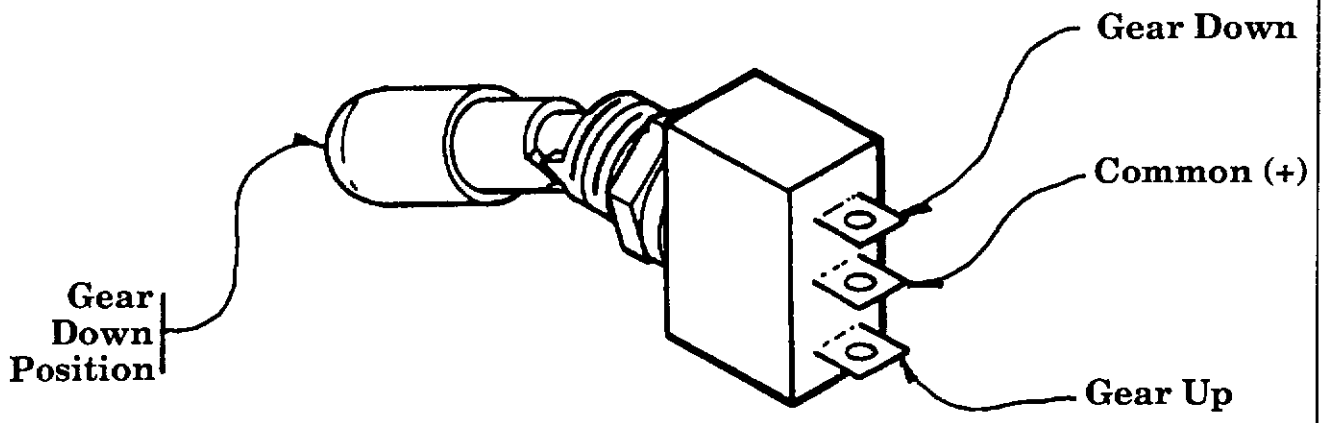
H. Gear switch

1. The standard gear switch is a locking switch, as shown in figure 14-13. It takes up little room on the instrument panel. The switch is a SPDT meaning that it "pulls" voltage from a single source and can "throw" that voltage in either of two directions. The switch is in addition positive locking and must be gently pulled out of its detents before it can be shifted to the opposite position. As with all electrical parts, it should be handled with care and kept clean.

2. The center contact of the gear switch will have the primary "hot" lead from the battery soldered to it. The other two contacts will connect to either of the pressure switches. The wire on the pressure switch that connects to the gear switch can be either the red or the blue lead (the white lead is not used at all). See figure 14-13, and refer back to chapter 5, pages 5-59 and 5-60.

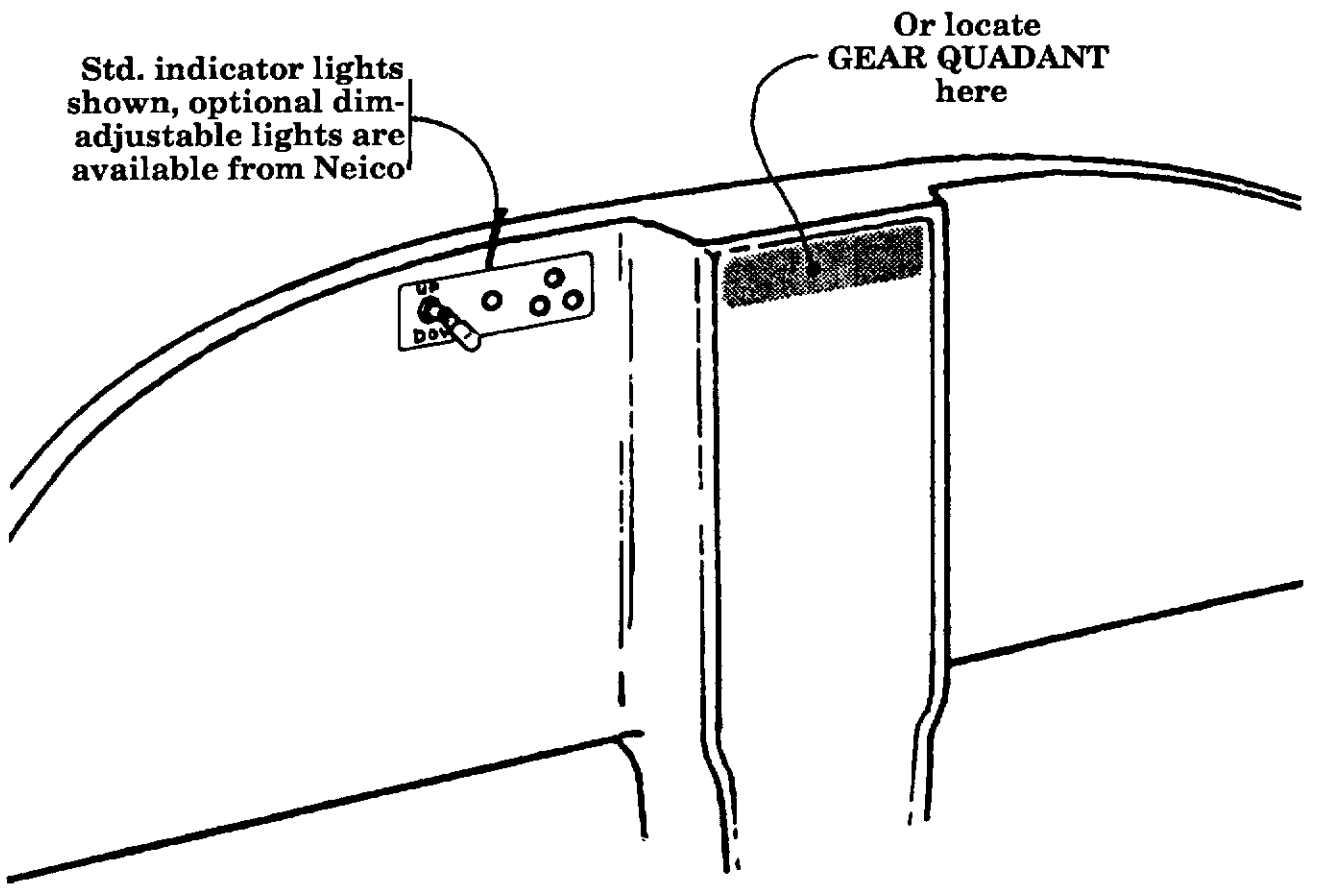
NOTE: It should be pointed out that the alignment between gear switch handle position and the back contacts is perhaps opposite to what you might think is correct, i.e., if the gear switch handle is "UP" then the contact on the "bottom" is activated, and vice versa. This will obviously become important when you wire it. See figure 14-14 for a suggested location of the gear "quadrant".

Wiring - landing gear switch
Figure 14-13



Gear "quadrant" location

Figure 14-14



I. Gear down lights

The standard gear lights are AMP type lights and are non-dimmable. For night flight, you will want to install an adjustable "pot" to be able to dim the lights at night. Optional gear lights with push to test and dim features are now available from Neico.

1. These lights will be illuminated by voltage that is interrupted by the gear micro switches. Thus the micro switches must be "CLOSED" in order for voltage to pass by and reach the gear lights. This "closed" position is only achieved when the gear is down and locked. See figure 14-16 and the wiring diagram, figure 14-17. Generally, the gear down (green) lights are arranged visually so that the center green light is for the nose gear and the left is for the left main, etc.

J. Gear transition light

A gear "transition" light (amber or yellow) is provided. This light allows you to monitor exactly when and how long the gear motor runs. It is an excellent safety feature in that it can indicate problems that you might not otherwise be aware of.

Example: If you have a small hydraulic leak, the gear transition light will warn you of the condition since you will see this transition light blinking on and off repeatedly during cruise. This will alert you to start looking for leaks as soon as you next land. That's much better than running the system out of fluid unexpectedly. Also, if for any reason the pump motor does not shut off within 20-30 seconds, you will be alerted and you should then immediately pull the relay breaker on the instrument panel to shut down the system. Otherwise you would run the risk of burning up the pump motor.

The gear transition light is generally placed just to the left of the three green gear down lights, near the gear switch. These units together comprise the "gear quadrant".

K. Gear micro switches - main gear

Gear micro switch installation & adjustments

Each of the landing gear will require a micro switch to indicate a "down and locked" condition. This is a simple installation but extreme care should be taken with the micro switches themselves and with the wiring that connects them. If a wire were to fall off because, for example, you did not adequately secure the wires on the gear bay, the net result would be some very high anxiety when you realized that the gear down light was not on. Of course in that case, the landing would be uneventful but there is no point in stressing your anxiety levels due to loose wires or improperly adjusted micro switches.

1. The main gear micro switches will attach to predrilled holes in the GM4 alignment brackets. These are the small (4-40 screw size) hole and slot in the inboard ends of these GM4 brackets.

2. First simply place the micro switch in relative position and check to see of the chrome trigger arm requires any trimming. Some may require trimming for clearance from the welded boss on the GM4. If so, snip with a pair of wire snips. The trigger arm must fully clear the GM4 boss.

3. Position the micro switch an insert the inbd 4-40 screw with AN365-440 lock nut. See figure 14-15.

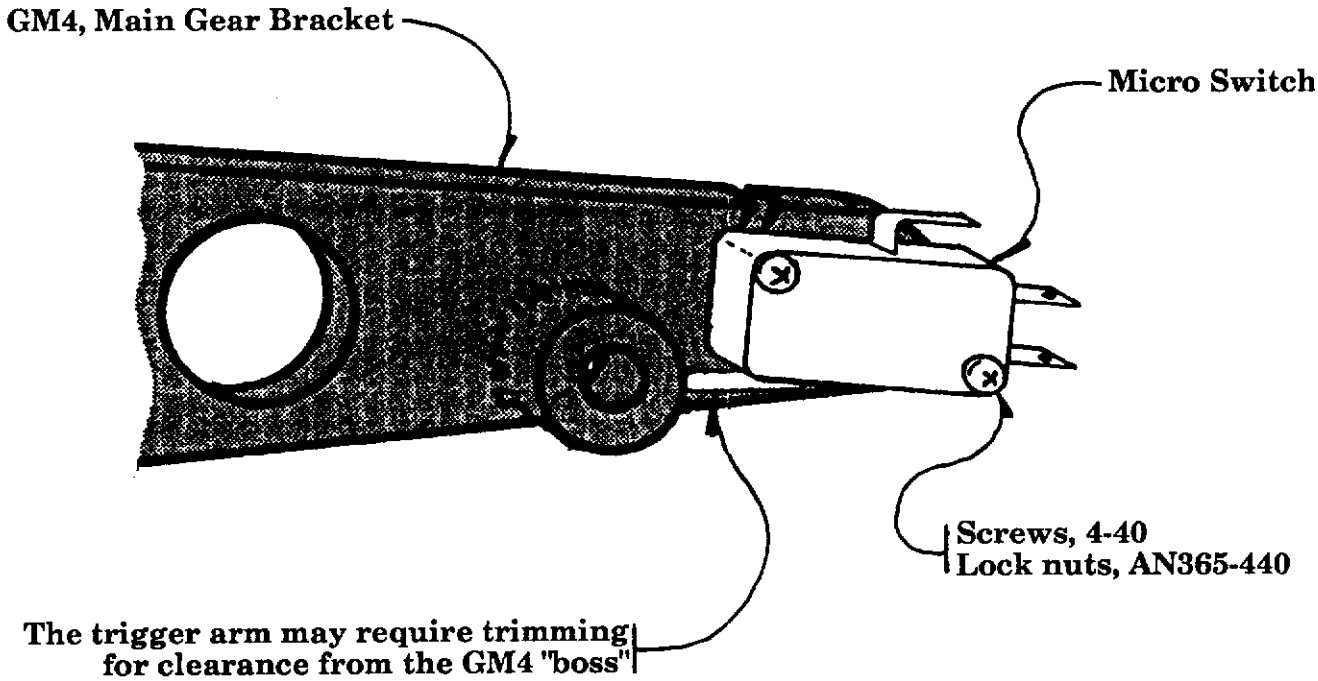
   WARNING: Do not overtighten the micro switch mounting screws. They should be snug only. Overtightening could cause the switch case to crack. If the case becomes cracked, the switch should be discarded and replaced.

4. The outbd micro switch mounting screw will fit into a slot in the GM4, thus allowing adjustment range. Insert this screw and tighten it up just a little so as to still allow hand rotational adjustment of the switch, i.e., it should have a little friction but still be movable.

5. With the gear in the fully adjusted, down and locked position, rotate the micro switch until it strikes the roll pin that extends out of the fwd face of the GM3 (over center link assembly). When you hear the switch "click" then the contact will be made. You'll notice that you will still have additional rotational adjustment remaining. Some of this additional depression of the trigger is advisable. The proper adjustment is achieved when nearly all of the available trigger movement is taken up but the trigger should not be tightly "jammed" against the switch case. There should be about 0.010" clearance remaining.

6. When the micro switch is adjusted correctly, then very carefully snug down the two 4-40 screws and nuts that secure the switch to the GM4. Check with your fingers that you can no longer move the micro switch by hand.

Micro switch installation, main gear
Figure 14-15



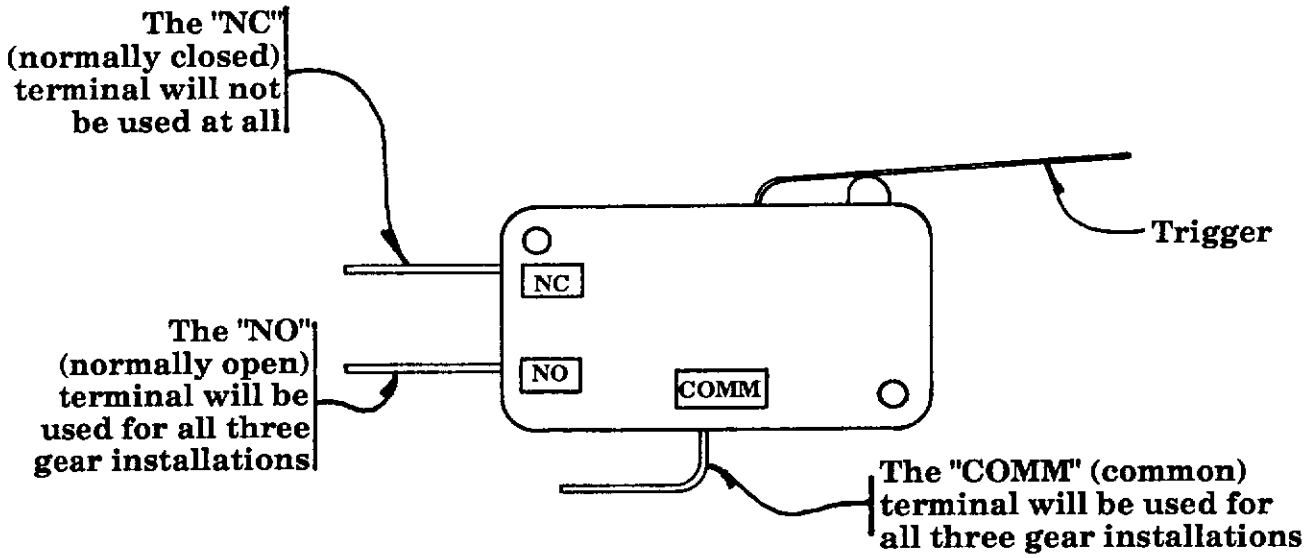
L. Nose gear micro switch

The nose gear micro switch is a different type of installation. Refer to pages 5-47 to 5-50, "nose gear gas strut installation", and to figure 13-5, "Positioning the nose gear sequence valve & micro switch). This assembly should be adjusted in a similar manner as that used with the main gear micro switches. The switch will be rigidly mounted to the aluminum attach plate and all adjustments will be made by positioning of that created assembly as it rotates on the two MS24694-S8 screws.

M. Gear micro switch wiring

The wiring for the micro switches is quite simple. The stock switches are built such that they can be used as NO (normally open) or NC (normally closed). We will only use the NO (normally open) circuit and thus one spade connector will not be used on the switch. If you look closely you will see the markings on the switch case, see figure 14-16. These are 3/16" wide spade terminals as are the terminals on the gear lights.

Micro switch wiring connections
Figure 14-16



1. The micro switch wires should be tied securely in the gear wells since considerable air turbulence will be encountered. Use the nylon type wire ties. Also, it is important to use the insulated type of terminal connectors to prevent water, etc., from making a contact and giving a false reading.

2. We generally use the (-) side of the electrical system to route through the micro switches and wire the (+) side directly to the gear lights. See chapter 18.

   The wiring can be 18 or 22 gauge. Two wires are needed for each micro switch which must be routed to the back central area of the instrument panel. This wiring can enter the cockpit area through the cockpit closeout rib. A good location is between the spar closeout web and the aft phenolic attachment for the retract cylinder. See figure 14-11.

3. From there, route under the main spar (at the central console area) and up behind the instrument panel. The nose gear switch wiring can simply travel up the side of the tunnel and punch through the radius where the side of the tunnel rolls into the top portion. See figure 14-12.

N. Gear pressure switch wiring

1. This is again very simple. Refer to page 5-50. There are two spades exiting the pressure switches.

2. The high pressure switch which operates the "gear up" cycling is located above the left port on the power pack. One wire on that switch will connect to the relay that operates the pump (high pressure side). The other wire on the pressure switch will connect directly to the lower solder terminal on the gear switch (remember that the lower terminal makes electrical contact when the switch handle is up).

3. The low pressure switch will connect in a similar manner to its respective contacts.

   Also see section "P" of this chapter for possible adjustments of the pressure switches.

O. Gear wiring schematic

1. See figure 14-17. This is a very straight forward schematic and should be easy to follow. As mentioned already, the 50A circuit breaker is generally located on the face of the baggage bulkhead. This will save weight and make for a nice compact installation.

2. The gear pump will draw about 30-40 amps and therefore must run through the two relays. This pump motor will spin in both directions thus generating a gear up and gear down movement of the hydraulic fluid.

3. Note that the secondary terminals on the relays will be jumped together and will operate the "Gear Transition Light".

4. From the power pack itself, you will have to run three wires up to the instrument panel. One for the gear up relay to the gear switch, one from the gear down relay to the gear switch, and one from the relays to the "Gear Transition Light".

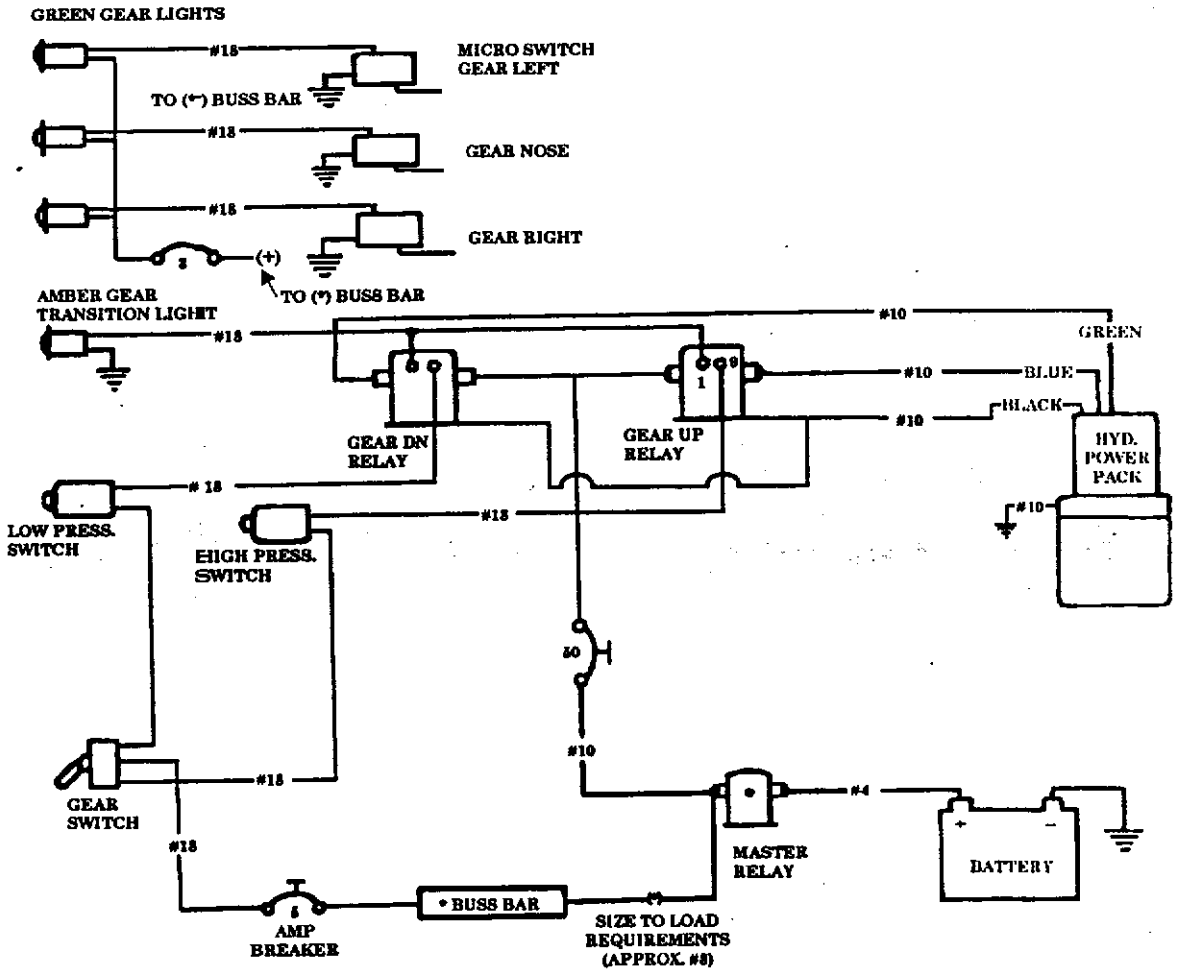
Note: Differences Between Old and New Style 235/320/360 Landing Electro/ Hydraulic Power Packs.

Old power pack for all 235's and many 320/360's
- Motor has 3 wires
  - Large blue and green
  - Small black

New current power pack
- Motor has 3 wires
  - Large blue, green, and black

Note: The old power pack has an internal temperature sensitive switch which is normally closed at lower motor temperatures, and opens when the motor overheats. The small black wire is connected to this thermo switch and opens along with the switch. When wiring this unit, the blue and green wires are connected to the high (up) and low (down) solenoids, respectively. The black wire is used to provide the only ground for the solenoids. If the motor overheats, the black wire opens, the solenoids lose their ground and they open, which stops the power pack motor. The motor ground is connected to the motor housing with a seperate wire.

Old Style Schematic
Landing gear system
Figure 14-17

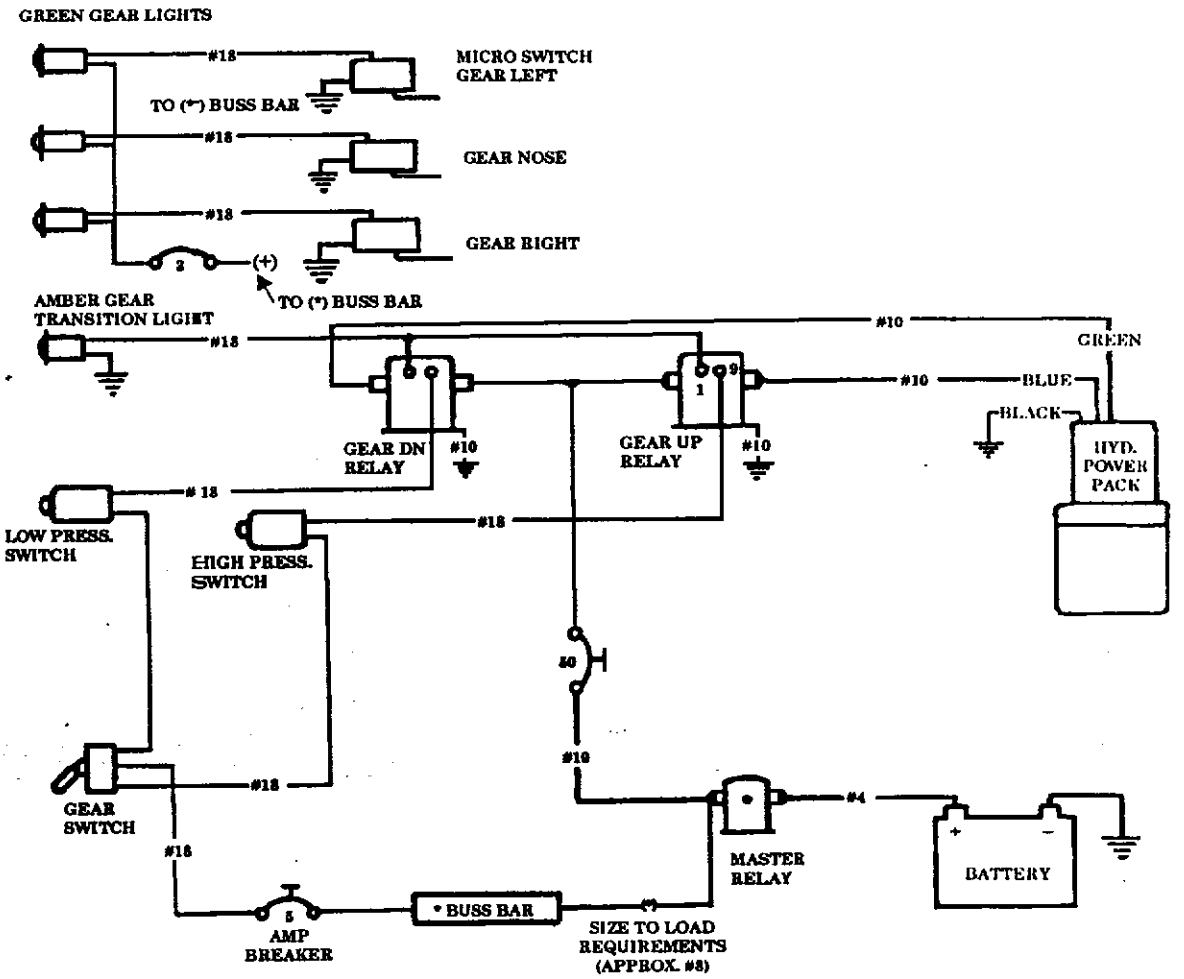


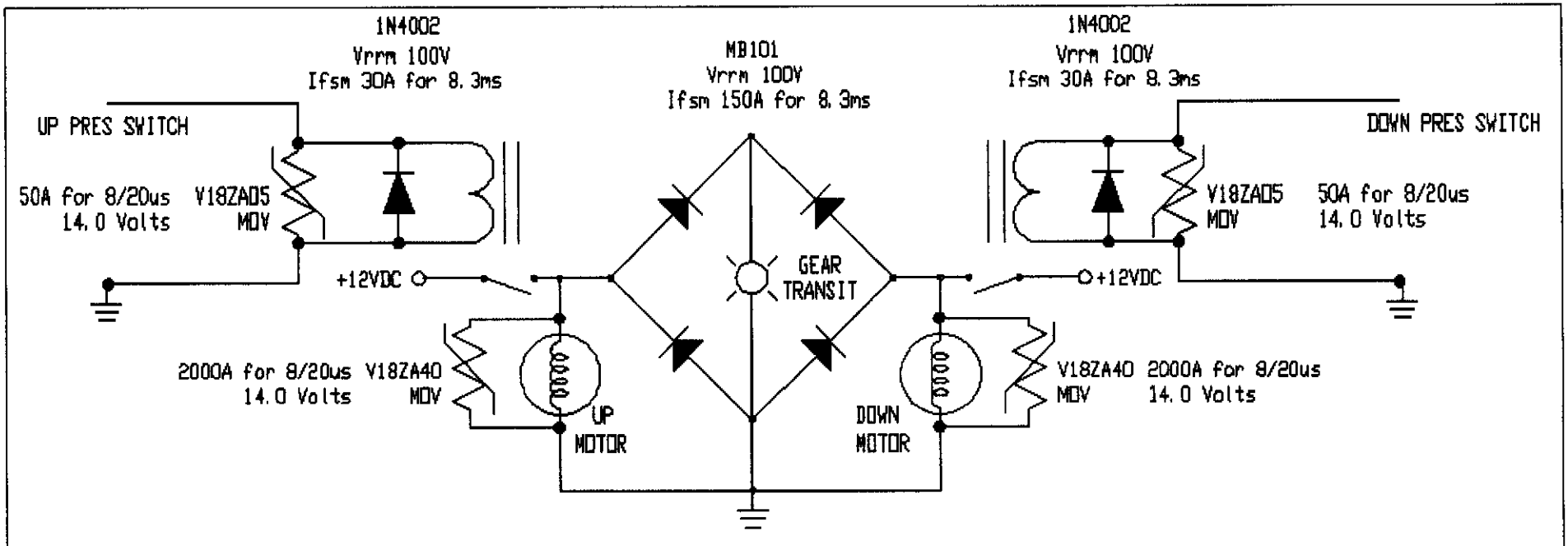
Note: The new power pack has an internal load and temperature switch which stops the motor when either condition goes over the limit. The black wire is used for the motor ground.

New Style Schematic

Landing Gear System

Figure 14-17A





MOVs, Metal Oxide Varistors. Commonly called Varistors when searching in catalog indexes.

V18Z series starts to conduct at 14Volts. The min spec is 1mA at 14.4 volts. If your electrical system's voltage goes higher than 14.4 volts, use the V22Z series. This starts conducting at 18 volts.

8/20us means a pulse that starts at zero, rises to it's peak in 8 micro seconds, then decays to zero again in 20 micro seconds. this kind of pulse is what you typically see as spikes and noise in electrical systems.

The V18ZA05 is a small radial leaded disk only 5mm in diameter

The V18ZA40 is also a small radial leaded disk only 20mm (0.78") in diameter. I chose this one for the energy rating of 80 Joules. Joules is Voltage * Current * time. We have 14V * 50Amps * however long it takes for the motor coils to discharge. say 10ms this would be 7 joules. The next size lower is only 3.5 joules that is why I chose this larger size.

These MOVs are manufactured by Harris Semiconductor. Available from Newark Electronics. 1800-463-9275 use the Harris part number.

The diodes and Bridge Rectifier are Motorola, they are also Available from Newark Electronics and many others.

LNC2 Hydraulic Pump Circuit --- from Ed Armstrong

P. Gear system start up / test operations: Adding hydraulic fluid

Fluid type: Petroleum based
MIL-H-5606-Red
You'll need about 1 qt. minimum therefore you should get 2 qts.
This fluid is the same as used for the brake system.

1. Remove the filler cap and fill with fluid. A piece of 1/4" vinyl tubing works well as a siphon tube from a 1 qt can of fluid. Pinch off the tube when the reservoir is full.

   NOTE: Before starting the system up for the first time, go around and check each and every fitting to insure that it is tight. The odds are very high that no matter how many times you "thought" you checked that fitting, it will still be loose and that will cause a mess. Also, have many rags around and have a very quiet room when you first start up. A quiet room will allow you to hear the "fissss" of a leaky fitting that's under pressure.

2. The reservoir will hold about a pint of fluid which will be emptied as the gear is first run and the empty lines are filled. This will then require refilling of the reservoir. The reservoir will usually require about three or even four fillings until all is working well and the reservoir is again full.

   NOTE: The gear system will self bleed but this will take many back and forth cycles which is OK but time consuming so don't expect the cycle time to be particularly fast in the beginning. You will encounter many small "burps" of the pump motor once the gear is fully retracted because the air in the lines is compressing and the motor therefore comes on for only an instant to re-establish the operating pressures dictated by the pressure switches.

Q. Start up of hydraulic gear

When the gear is all installed, and known to operate by hand without any binds or interferences, and the pump is filled ... its time for the real thing. This, for most builders, is considered to be a monumental event and a major milestone. There is great joy in watching all that gear tuck up into the airframe and totally disappear - all by itself. Of course the odds are about 25% that you'll have some sort of a small problem to correct before it all tucks away neatly but in a short time all will be working well and the excitement of the event will still be real.

1. The airframe will have to be supported for this testing and there are two good ways to do that. One is to simply use the jack pads for the main gear if you put them into the fslg. Jack the airframe up only enough to clear the main tires off the ground and then weight the tail down or pull it down so as to lift the nose gear off the ground. The other means is to simply use a portable jack and lift the engine by the normal engine hook that temporarily bolts to the upper case bolts of the engine and slide a rigid support under the fwd baggage area of the fslg. The fslg is strong enough to be supported from such a point. (Don't ever try that with a sheet metal plane though.) We've used a small stool with a good thick foam pad on it to disperse the loads over an area of about 1 sq. ft. You'll then have to steady the wing tips. Which ever approach you use to elevate the airframe, check to verify that it is indeed stable before retracting the gear.

   WARNING: Don't ever assume that you have wired everything correctly prior to this first start up. You must assume that you have wired everything WRONG and that the gear switch, although placed in a down position, might actually cycle the gear up as soon as power is put through it. Thus don't put power to the system until the plane is supported and can thus tolerate those kinds of surprises!

2. If you prefer, with the help of a friend, undo a line as far down stream as possible. Place a piece of hose on the line and place the other end in a clean container. One guy watches the hose while the other works the gear and master switch. Bump the system on and off until fluid and no air is coming out of the hose. Reconnect the hydraulic hose or aluminum line. Do this in a couple of locations and your system will take fewer cycles to come on line.

3. Install a battery temporarily into the system and establish the following:
   a. Plane supported off the ground, steady and secure.
   b. Gear switch is in the down position.
   c. Gear itself is down and locked.
   d. Free-fall valve is closed.
   e. Nose gear is straight.
   f. Cycle each gear leg up by hand to verify that there are no obstructions or interferences, etc.

   Now connect the power (12V DC)
   The motor will produce a good deal of noise and will run for several seconds beyond the normal 6-7 seconds for cycling since there is no fluid in the lines at this time.

   WARNING: The motor must not be allowed to run more than 20 seconds continuously. Running beyond that length of time could generate too much heat and damage the motor.

4. If the motor runs more than the 20 seconds allowed, remove the power thus shutting the motor off. The motor is not designed for continuous operation and must be allowed to cool down somewhat before operation can continue. Give it just a few minutes (5 min. should be sufficient) to cool down before continuing.

5. Check all fittings for leaks and correct as required.

6. Check the reservoir to see if all the fluid has been pumped out, refill and continue to pump in the down direction. If three runnings like this do not shut the pump off automatically then stop and continue with the next step. Thus don't worry about it for the moment.

7. Check again that the nose gear is straight.

8. Flip the gear switch to the up position and observe as it starts to retract. The order of retraction is unimportant as that is strictly a function of which system gets the fluid first.

9. As the gear retracts, generally the mains will retract first and the nose will follow last. Once all the gear is up, assuming it all goes up on the first try here, the motor should run for just two or three seconds only and automatically shut down.

WARNING: If the motor has adequate amounts of fluid available, you will hear a distinctive tone change as the pump reaches its higher PSI loads. It will slow down and sound as if it is working harder. This is when the heat can really build up fast in the motor as it can pull over 40 amps so do not let it run more than two or three seconds in this condition.

10. If the gear comes up and the motor bogs down without shutting down automatically, then the pressure switch will require adjustment. This rarely will happen though.

If the gear comes up most of the way and the motor continues to run with little or no tone change, then you are again out of fluid in the reservoir. Shut the system down, free-fall the gear down and locked and crawl back in to refill the reservoir.

11. Cycling the gear up and down several times will work to bleed the air out of the system and you'll notice that the cycle times will become shorter. Once the system is fully charged and free of air, the cycle time should be about 7 seconds.

12. When the gear retracts, the motor will shut off due to the pressure switch being tripped which cuts the current to the "UP" relay. If, as mentioned in step 9, the pump does not shut off automatically, then the pressure switch will need adjusting (or you've got a basic wiring problem that's having the effect of bypassing the high pressure switch). See wiring diagram and the section following this one, "Pressure switch adjustment".

NOTE: As the nose gear retracts into the well, if it is allowed to hit the GM27 weldment, a pretty loud "clunk" may result. This should be avoided by attaching a rubber strip around the weldment to serve as a cushion. A couple of nylon wire ties will adequately secure it in place.

13. It is common for the motor to cycle on for a couple of periodic "burps" when the gear retracts. This is the system "tightening" up on itself as air is compressed and slowly forced out of the loop as cycling continues.

If you get repeated, continuous bursts of the pump motor, then there is a leak some place so shut it down and go hunting.

14. At some point it is a good idea to run the gear up with some of the gear doors removed so that you can inspect the condition of everything up in the wells. Look for any interferences, binds or rubs. These must be corrected immediately. Verify that the retract cylinders are indeed bottomed out on themselves, this is critical. Make any adjustments necessary.

R. Pressure switch adjustment

1. The two pressure switches control the power to the pump motor through the relays and thus the power to the motor itself. These switches are preset but they are also easily adjustable. They are wired in the NC (normally closed) configuration. When the pressure setting is reached, they will open thus cutting current flow to the motor, opening the relay and shutting the system down.

   Sometimes the pressure switches will require a little adjustment to achieve proper operation of the gear system. Here are two possible problems:

2. **SYMPTOM 1:** The gear in the retract mode runs in short, on and off bursts until the gear is fully retracted.

   CAUSE 1: The high pressure switch is most likely prematurely shutting off current to the relay and as the backside pressure drops, the switch closes again thus providing current.

   CURE 1: The UP side pressure switch will require a higher setting.
   a. There is small slotted screw in the top of the pressure switch. Turn this screw 1/4 turn to the right. Turning to the right increases pressure and to the left decreases pressure.
   b. Test the gear again and tighten additionally if required.

3. **SYMPTOM 2:** The gear retracts up but the motor does not shut off at all, it merely bogs down and continues running (As previously mentioned, this is dangerous to the life of the motor and should therefore be disconnected immediately if this symptom occurs.

   CAUSE 2: The high pressure switch is set too high and although the power pack has reached full pressure, the motor can not shut off since the pressure switch has not reached its higher pressure setting. NOTE: The power pack has internal bypass valves that are factory set. The pressure switch must be set lower than the internal bypass valve setting.

   CURE 2: Lower the pressure of the high pressure switch, see "cure 1" above. The procedure is similar except you will be backing off the internal screw 1/4 turn at a time.

4. It is also possible that similar circumstances could occur involving the low pressure side of the system. History has however indicated that usually no problem is found or if there is a problem, it will be with the high pressure system.

S. Free-Fall test

The ability for the gear to successfully free fall to the down and locked position is critical. Flight can not be made if this condition is not achievable. In addition, you should make it a practice to check it on a regular basis (monthly) during operation so you will not be caught off-guard by a broken spring or deflated pressure strut.

1. While still in your ground testing setup, run the gear up and disconnect the power.

2. Open the free-fall valve by making the 90° rotation of the handle in one smooth, quick movement.

   A bit of "clang" will result and the gear will start coming down. The nose gear will usually be the first down and locked due to the 100 lb gas spring up front.

3. The main gear will usually fall about half way very quickly and the remaining half could be a slow struggle for the springs. This is OK. In fact it is OK if they never do lock down by themselves but you must measure the pressure against the sides of the tires that is required to bring them down and locked.

4. If the main gear does not lock down, take a scale and press against the inside of the tire bottoms. The force required to lock the gear down should not exceed about 5-8 lbs. This force is easily achieved by simply kicking a little rudder left to create a side slip which will lock the left main then right rudder to lock the right main. If more force is required, then you have a "bind" condition somewhere in the linkage or the springs are stretched out of shape. You'll have to correct the condition before flight.

T. In-flight free fall testing

This must be conducted on a regular basis to insure safety on the event of either a hydraulic loss or an electrical loss.

CAUTION: This Free-fall check should be made monthly during normal operations. It's easy and only takes a couple of quick steps.

1. Start with the A/C in a normal gear up, cruise mode at a speed of 140 m.p.h. or less.

2. Pull the circuit breaker (or fuse) that operates the gear relays.

WARNING: Do not pull *only* the 50A gear pump circuit breaker, this would appropriately disconnect the pump but it would not disconnect the relays. This would then allow the relays, which are for intermittent use *only*, to close. Possible damage could result to the relays if left on for too long. Thus you should pull the circuit breaker *for the relays* when shutting down for this test.

3. With the electrical system disconnected, place the gear switch into the down position. Of course, nothing will happen.

4. Open the Free-fall valve with a fast smooth 90° rotational movement.
The gear will now drop down and lock in place, the three green gear down lights should illuminate. There is no particular locking sequence between the three gear. Sometimes the nose will lock first and we've seen cases where the nose gear is last to lock down. And you ask, "what if they don't lock down?"

If the main gear does not lock down: If, after one minute, the mains do not lock down (no green light appears) then try kicking in a little rudder to cause a slip in the direction of the non-locking gear leg, i.e., left rudder to lock the left main, etc. This additional air load on the gear door and gear itself, will provide the extra force to cause the gear to lock. The main gear should easily lock down with no more than half rudder applied at 140 m.p.h. indicated. If this is not successful, then you have a problem of either too much friction or too little spring pull. Ground adjustments must be made before your next flight.

If the nose gear does not lock down: If the nose gear does not lock down, first try slowing up to reduce the air loads acting against the gas strut that is trying to push the gear out into the air stream. Slow up by 10 m.p.h. increments, wait at least 1 minute between speed changes and note the speed at which the nose gear does lock down, keep this for reference to determine whether or not the nose gear is requiring more and more help as the flight hours build.

If at 85 m.p.h. indicated, you still can not lock the nose gear down, then you have a problem, do not go slower in attempting to lock it down. Increase speed back to about 110 m.p.h. and try pulling about 2 g's. If after two or three attempts at this, you still can not lock the nose gear down, then you have a problem and ground adjustments must be made before your next flight.

5. With the test completed, either all the gear will be down and locked or the stubborn ones will not be locked down. At this point, there is a three step procedure to follow when reactivating the hydraulic power system.

   1. Close the Free-fall valve by rotating it 90° back to the closed position.
   2. Check to make sure the gear switch is still in the "down" position.
   3. Push in the *gear relay* circuit breaker to reactivate power to the pump. The gear will now recharge and establish a down and locked position under hydraulic pressure.

   WARNING: If there is ever a test which results in the inability to free fall the gear down and locked, pump the gear down, land and do not resume flight until the problem has been identified and corrected.

6. If you had Free-fall trouble with any of the gear, then ground inspection and adjustment MUST be made prior to your next flight. Repeat the ground cycling procedure until all the gear is free-falling well. Then go back up and repeat this test procedure. Normal flight can not be made until this free-fall test is successful.
   (As a final note, it should be mentioned that the free fall test has an extremely high percentage of first flight test successes.

This concludes the chapter on the landing gear hydraulic systems.