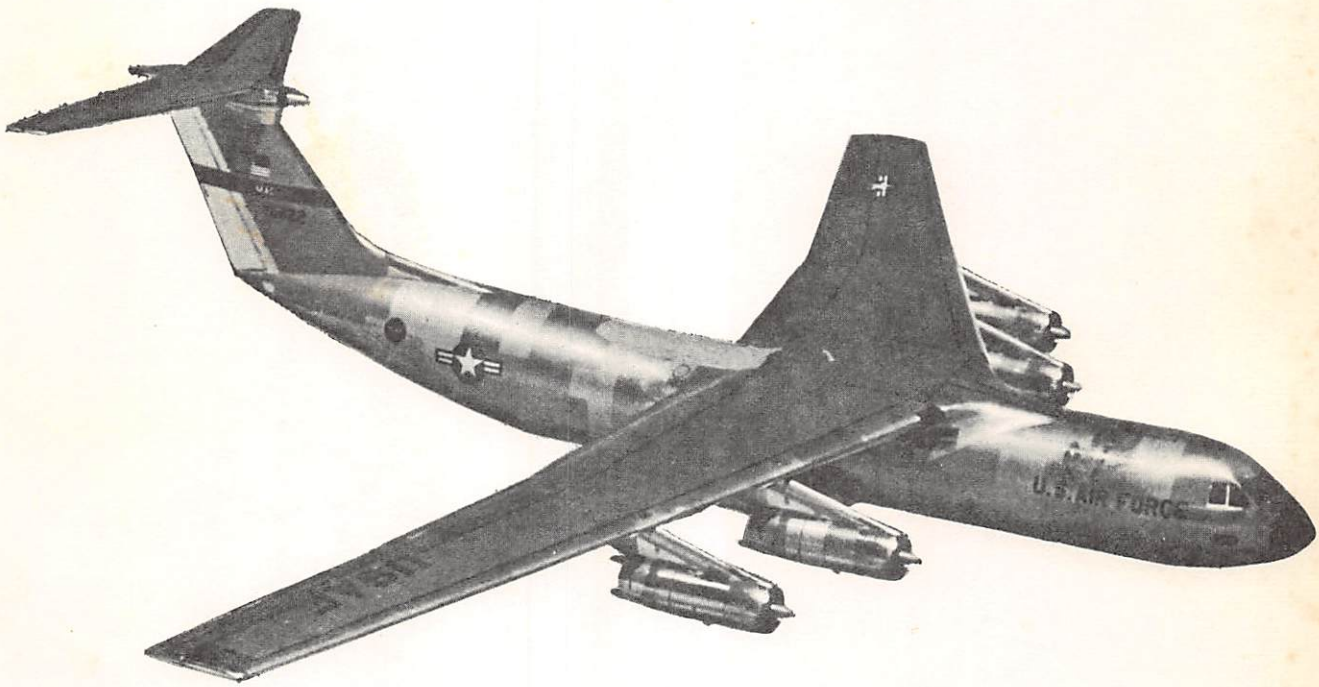
SEEGER

C-141A

MACH TRIM COMPENSATOR
NOT USED

PITCH TRIM SYSTEM



read 23 OCT 72

443d TECHNICAL TRAINING SQUADRON

443d MILITARY AIRLIFT WING, TNG (MAC)

ALTUS AIR FORCE BASE, OKLAHOMA

FOR TRAINING PURPOSES ONLY

NOT NECESSARILY CURRENT AFTER DISTRIBUTION

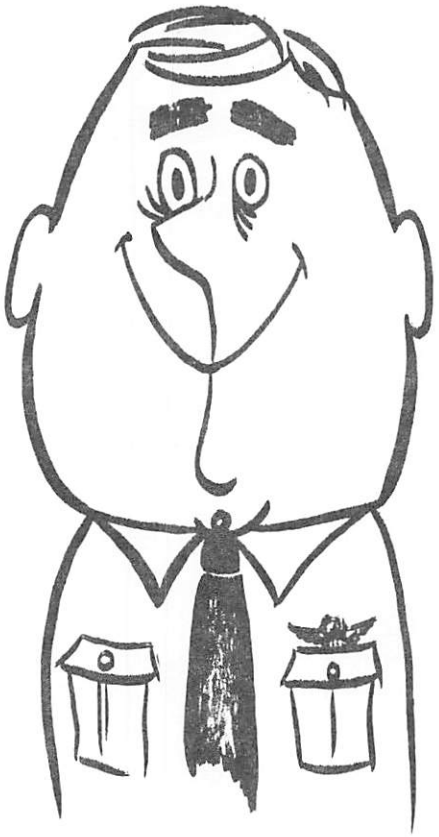
This book is not arranged like an ordinary study guide. Even though the pages are numbered in order, the text does not follow in that order. There will be directions on each page directing you to the correct page.

For example; TURN to Page C.

This is Page B! If you were reading a common, ordinary, every day book this would be the right page, but remember we said that in this book the text would not follow in order. Each page will have directions telling you the correct page to turn to.

Now RETURN to Page A and follow the directions at the bottom of the page.

OK, you got the idea and shouldn't have trouble following the text of this program.



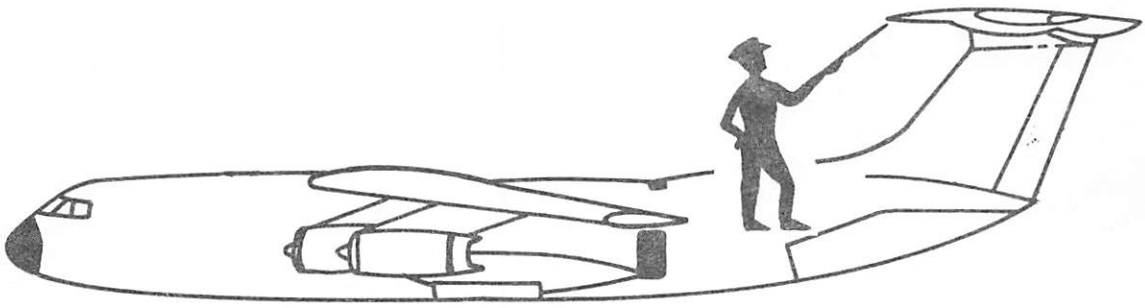
OBJECTIVES

When you have completed this program, you should be able to:

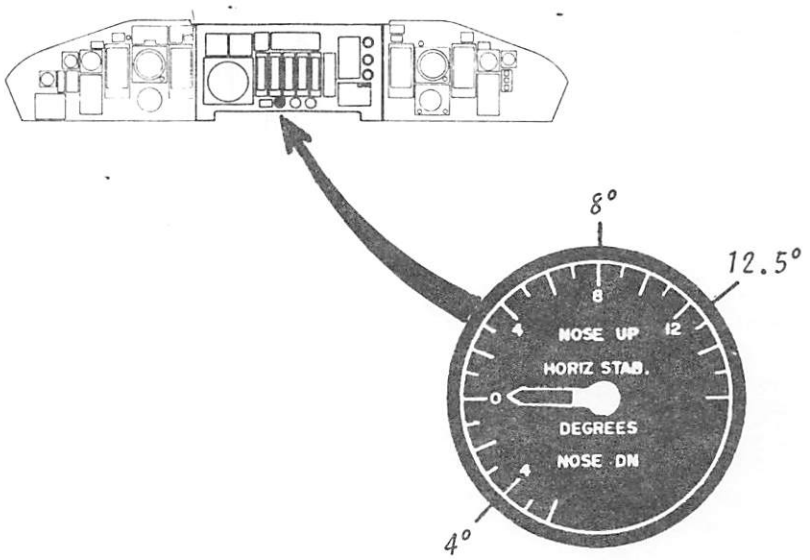
1. List the two types of motors that drive the pitch trim system.
2. Identify the power source of each pitch trim motor.
3. List the pitch trim limits.
4. Identify the pitch trim controls and list the function of each.
5. List the two automatic modes of operation and identify the function of each.

Now TURN to Page 1.

On conventional, relatively slow speed aircraft, elevator trim tabs are normally used to make adjustments for nose up or nose down attitude. Not so on the C-141. The entire HORIZONTAL STABILIZER is moved up or down to accomplish these adjustments.



The Pitch Trim Position Indicator located on the pilots' center instrument panel indicates degrees of aircraft trim.



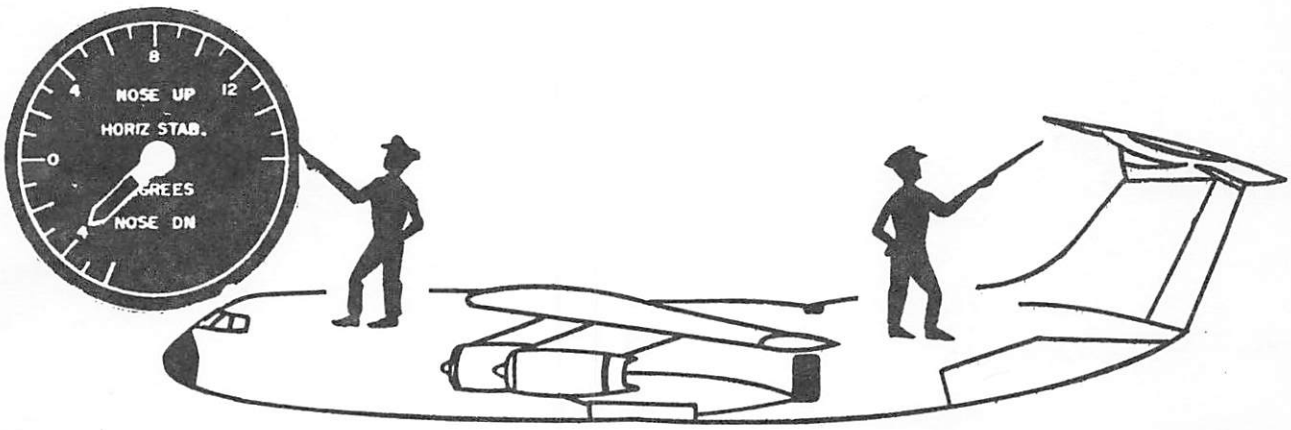
The pitch trim limits are:

4° aircraft nose DOWN.

8° aircraft nose UP with flaps fully retracted. (CLEAN)

12.5° aircraft nose UP with flaps NOT fully retracted.

TURN to Page 2.



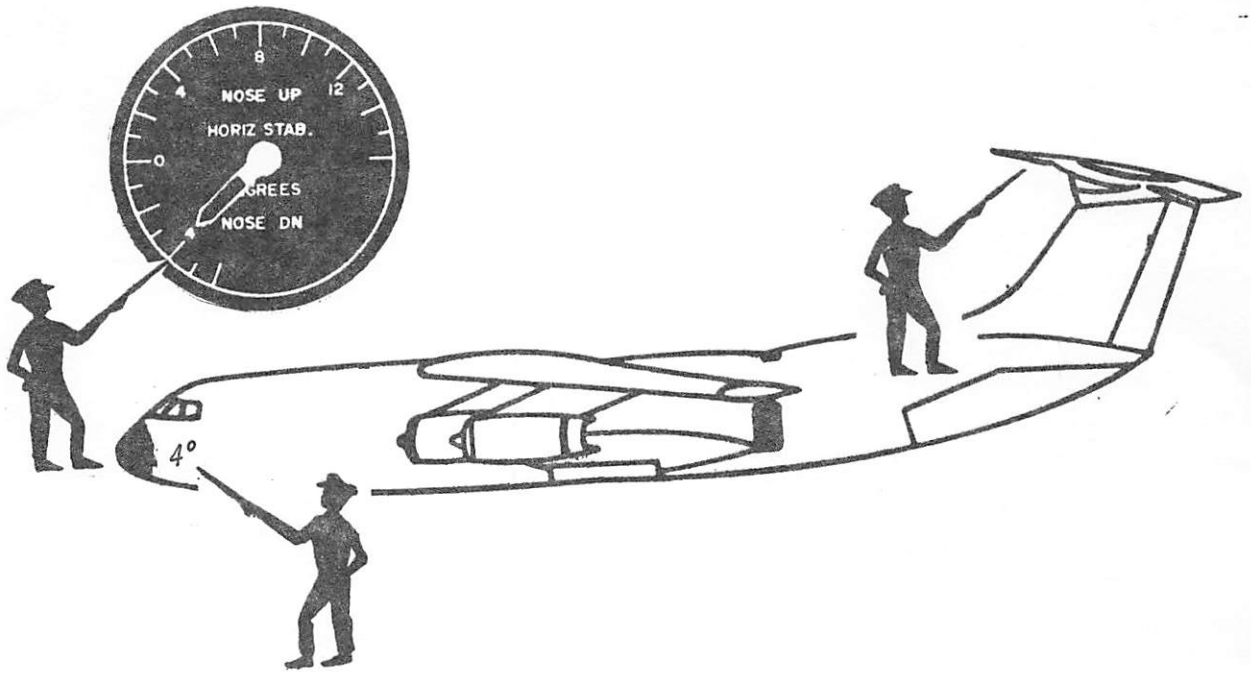
Study the illustration and note the relationship between the stabilizer angle and the Pitch Trim Indicator.

With the Pitch Trim Indicator indicating 4° nose down, it indicates:

a. stabilizer nose down. TURN to Page 3.

b. aircraft nose down. TURN to Page 4.

Somehow you missed something. Look at the illustration below and compare the relationship of the stabilizer leading edge with aircraft attitude and pitch trim indicator.

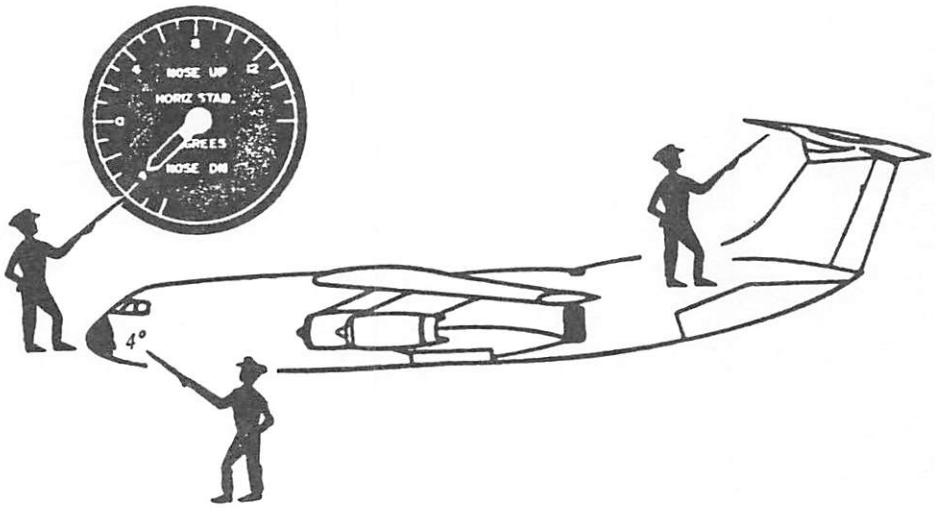


Is the pitch trim indicator indicating the limit of 4° aircraft nose DOWN?

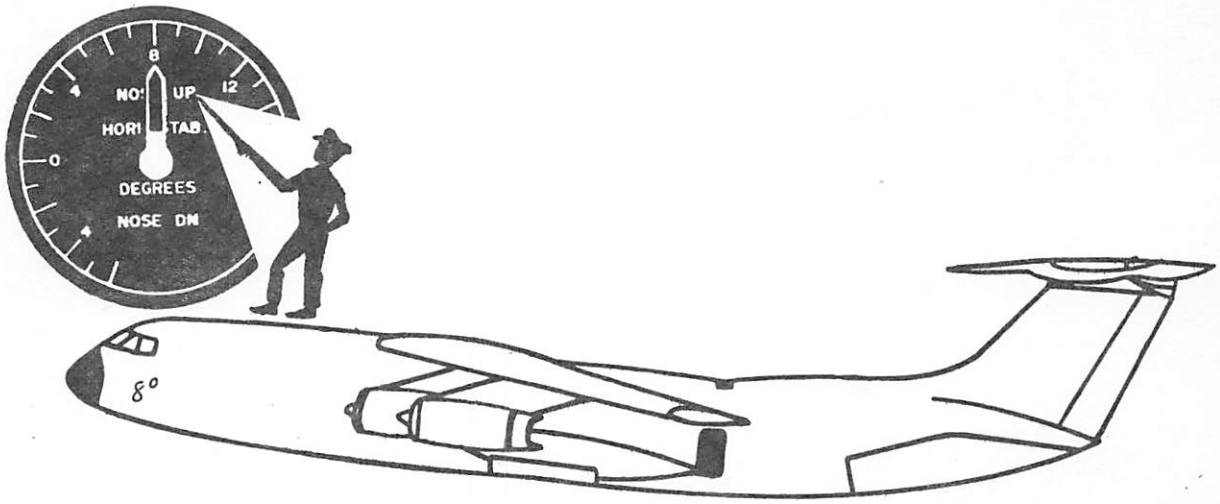
Yes TURN to Page 4.

No Look at it until it does.

Sure, the position indicator is indicating the limit of 4° aircraft nose DOWN.



Now that you have the idea, let's take a look at this illustration and complete the statement.



The indicator is indicating 8° nose up. This is the limit for:

a. stabilizer nose UP with flaps fully retracted. TURN to Page 5.

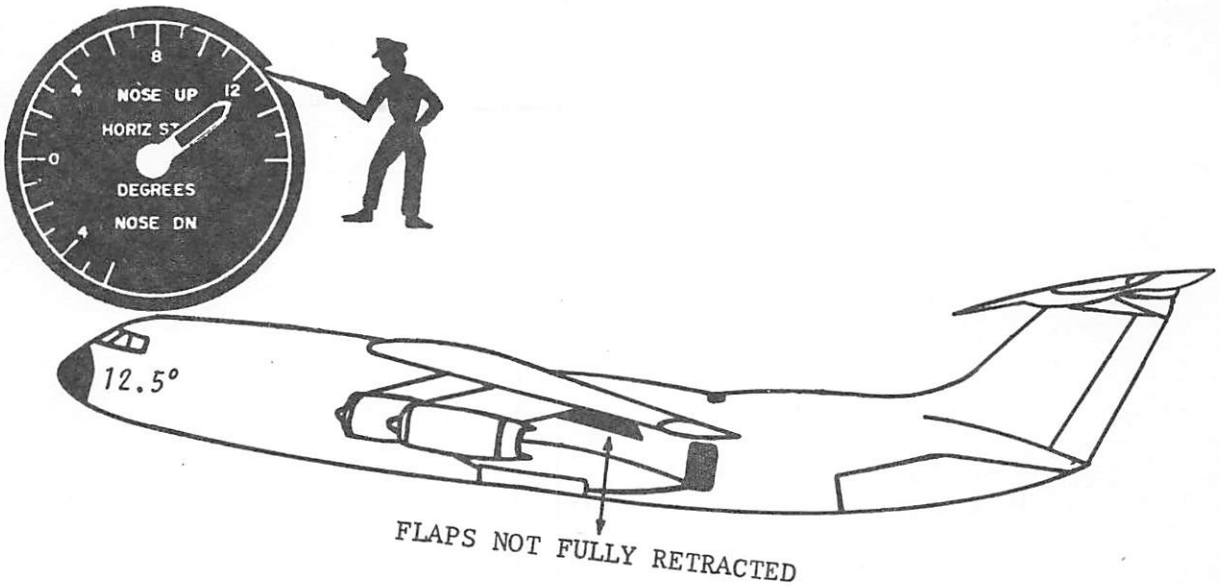
b. aircraft nose UP with flaps fully retracted. TURN to Page 6.

You are partially right, the indicator is indicating the limit of 8° nose UP, but it reflects AIRCRAFT TRIM and NOT stabilizer trim. Remember on Page 1 we stated that the indicator is calibrated in degrees of stabilizer movement from the neutral position, but REFLECTS AIRCRAFT TRIM.

Please PROCEED to Page 6.

Right, this indicator is indicating 8 degrees nose up, which is the limit for nose UP with flaps fully retracted.

Study the illustration below and complete the statement.



The indicator is indicating 12.5° nose up, which is the limit for:

a. aircraft nose UP with flaps fully retracted. TURN to Page 7.

b. aircraft nose UP with flaps NOT fully retracted. TURN to Page 8.

Oops! Why are you here? The indicator is reading 12.5° aircraft NOSE UP, which is the limitation when the FLAPS ARE NOT FULLY RETRACTED!

TURN to Page 8.

You're right, the indicator is indicating the limitation for aircraft nose UP, with the flaps NOT fully retracted.

List the correct limitations for the following conditions:

Max Aircraft nose DOWN _____

Max Aircraft nose UP with flaps fully retracted _____

Max Aircraft nose UP with flaps NOT fully retracted _____

Please TURN to Page 9 and check your answers.

Max Aircraft nose DOWN	4°
Max Aircraft nose UP with flaps fully retracted	8°
Max Aircraft nose UP with flaps NOT fully retracted	12.5°

Is pitch trim accomplished by moving the ENTIRE HORIZONTAL STABILIZER.

Yes TURN to Page 11.

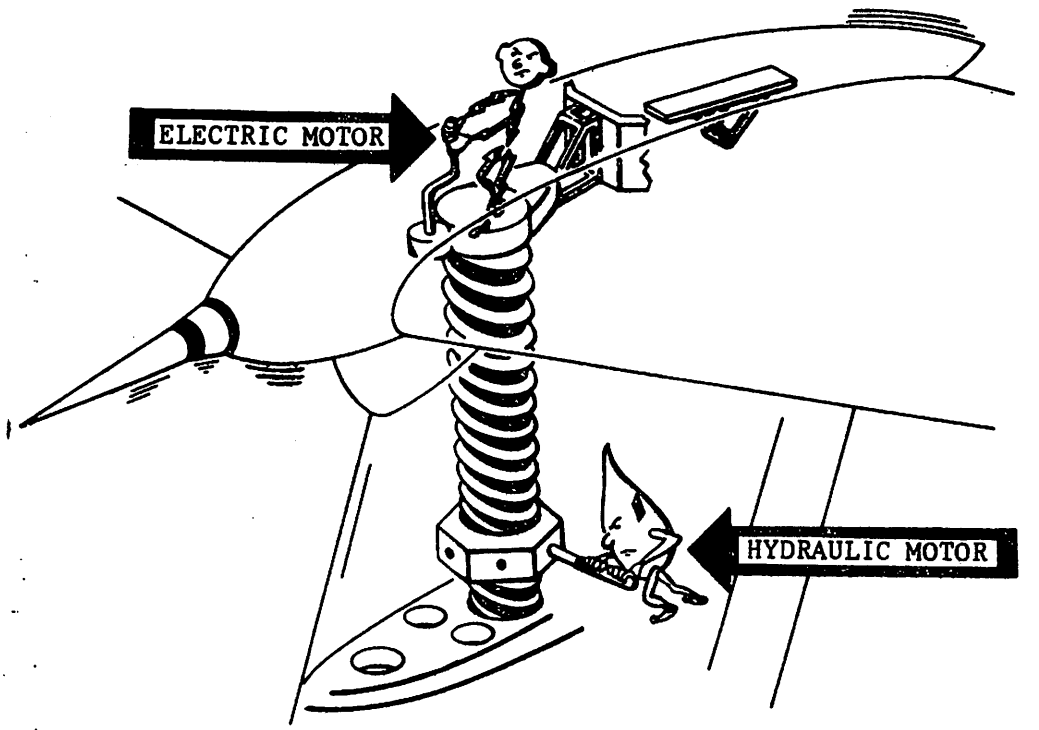
No TURN to Page 10.

NOooo?? You gotta be kidding. I thought we already agreed that pitch trim IS accomplished by moving the entire Horizontal Stabilizer. We did, didn't we? Sure we did.

Please TURN to Page 11.

Yes, pitch trim IS accomplished by moving the entire Horizontal Stabilizer.

The Horizontal Stabilizer actuator is driven by a ~~HYDRAULIC MOTOR~~ or an ELECTRIC MOTOR. The HYDRAULIC MOTOR is powered by Hydraulic System Nr 2 and may be controlled either electrically or mechanically. The ELECTRIC MOTOR is powered from Essential AC Bus Nr 2 and may be controlled electrically or automatically.



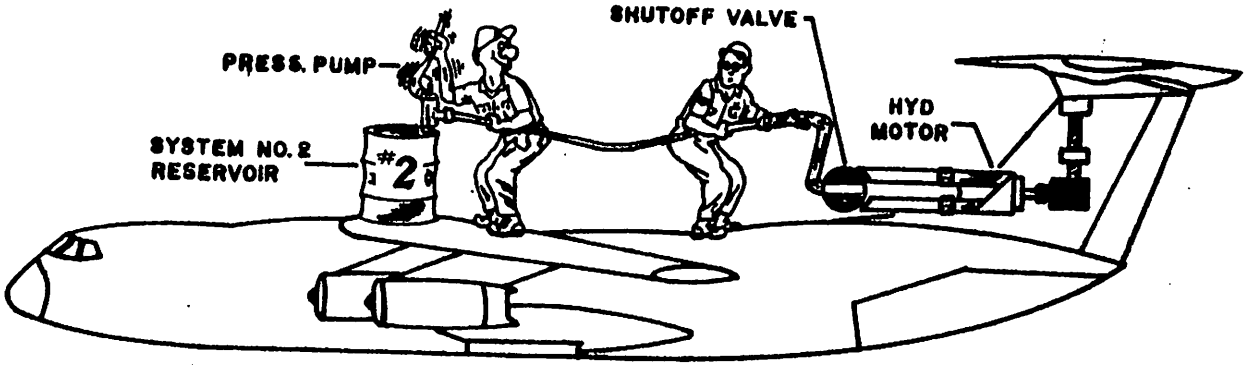
Is this statement true? The actuator may be driven by either motor.

No TURN to Page 12.

Yes TURN to Page 13.

No? Why not? GO to Page 13 and find out why.

Yes, the actuator may be driven by either motor. The hydraulic motor rate of pitch trim change is five times faster than the electric motor.



Which HYDRAULIC system powers the HYDRAULIC motor?

System Nr 1 TURN to Page 14.

System Nr 2 TURN to Page 15.

System Nr 3 TURN to Page 16.

You selected Hydraulic System Nr 1???? Perhaps you were thinking of another system. HYDRAULIC SYSTEM Nr 2 is the power source for hydraulic motor operation.

Please TURN to Page 15.

That's right, HYDRAULIC SYSTEM Nr 2 powers the hydraulic motor. Now, let's discuss controlling the hydraulic motor. Can the hydraulic motor be controlled either electrically or mechanically?

No	TURN to Page 17.
Yes	TURN to Page 18.

Oh come now, who said anything about Hydraulic System Nr 3? Surely you remember that HYDRAULIC SYSTEM Nr 2 is the power source for hydraulic motor operation.

Please TURN to Page 15.

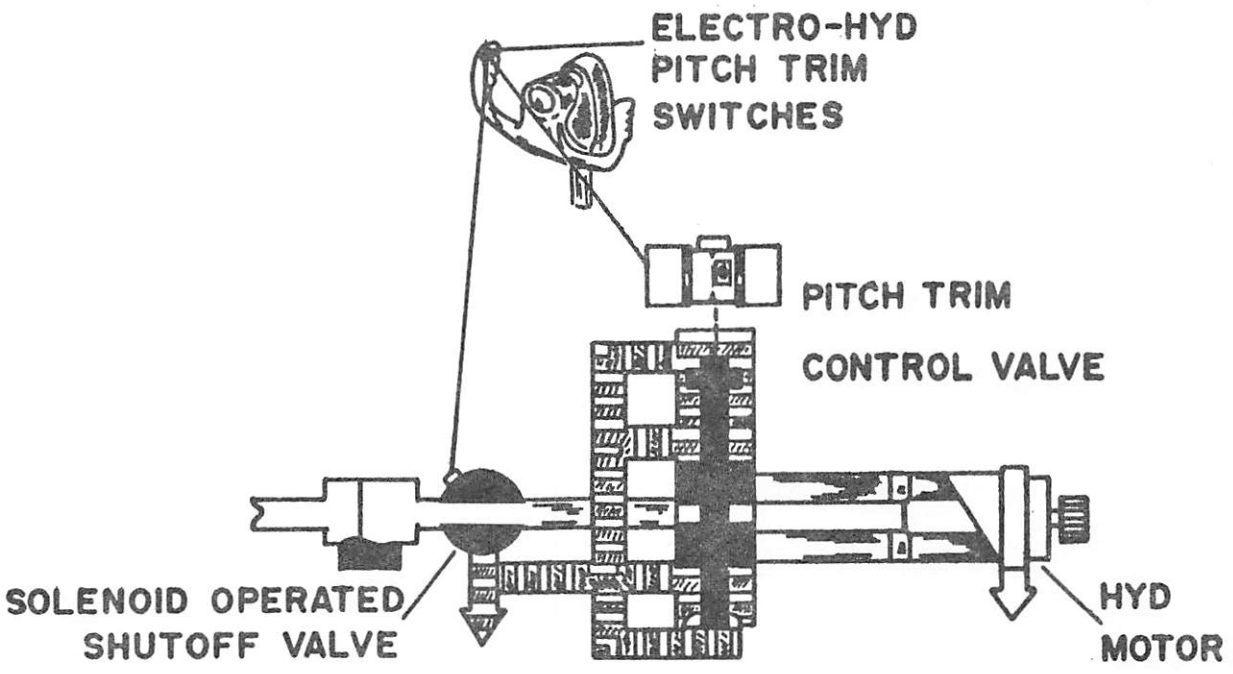
No? Remember on Page 11 we said the hydraulic motor may be controlled either ELECTRICALLY or MECHANICALLY.

With this in mind, please TURN to Page 18.

From Page 16

Sure, hydraulic motor operation is controlled either ELECTRICALLY or MECHANICALLY. Now let's discuss these methods of control. First, the ELECTRICAL METHOD, commonly referred to as ELECTRO-HYDRAULIC.

ELECTRO-HYDRAULIC? What does that mean? It simply means that you are controlling hydraulic pressure electrically. There is a hydraulic shutoff valve to control Hydraulic System Nr 2 pressure to the motor and a control valve to control the direction of motor operation. The shutoff valve is spring loaded open and electrically closed. Actuating the Electro-Hydraulic Pitch Trim Switches electrically positions the control valve and interrupts the electrical power permitting the shutoff valve to open.

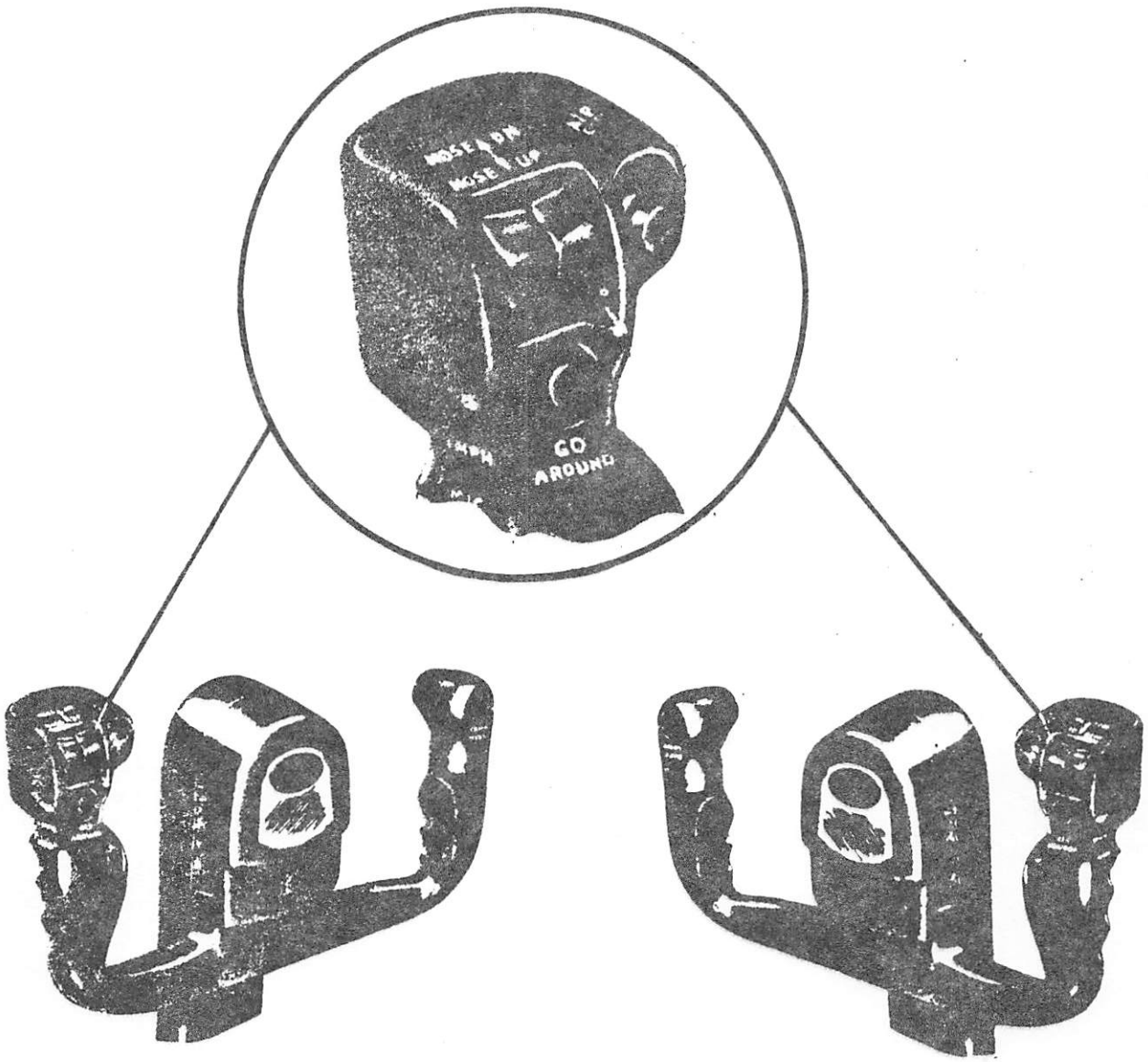


Does Electro-Hydraulic identify electrical control of hydraulic motor operation?

Yes TURN to Page 19.

No TURN to Page 20.

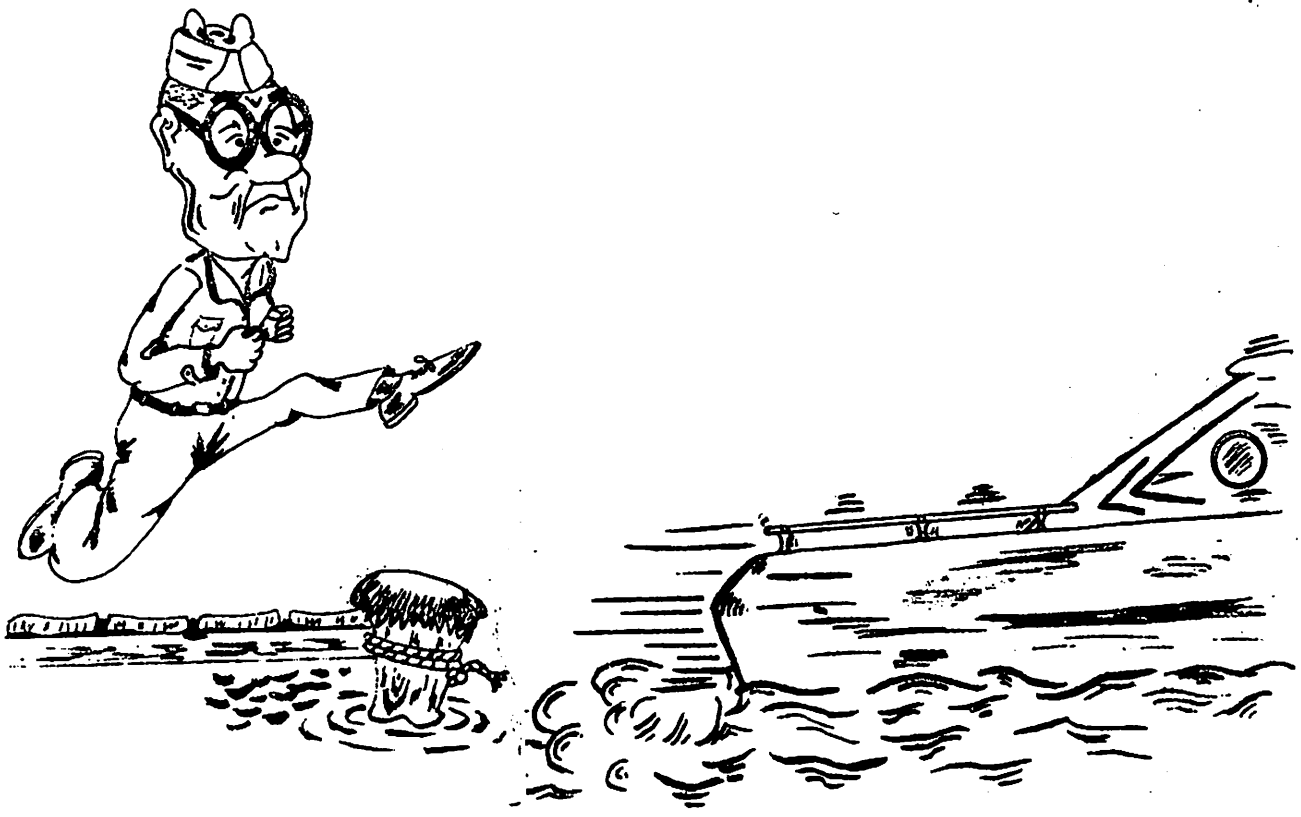
You are absolutely right. Electro-Hydraulic identifies ELECTRICAL control of hydraulic pitch trim operation. Let's see where the ELECTRO-HYDRAULIC PITCH TRIM SWITCHES are located.



Which grip of each control wheel contains the two ELECTRO-HYDRAULIC PITCH TRIM SWITCHES?

INBOARD	TURN to Page 21.
OUTBOARD	TURN to Page 22.

No?? You've completely missed the boat!

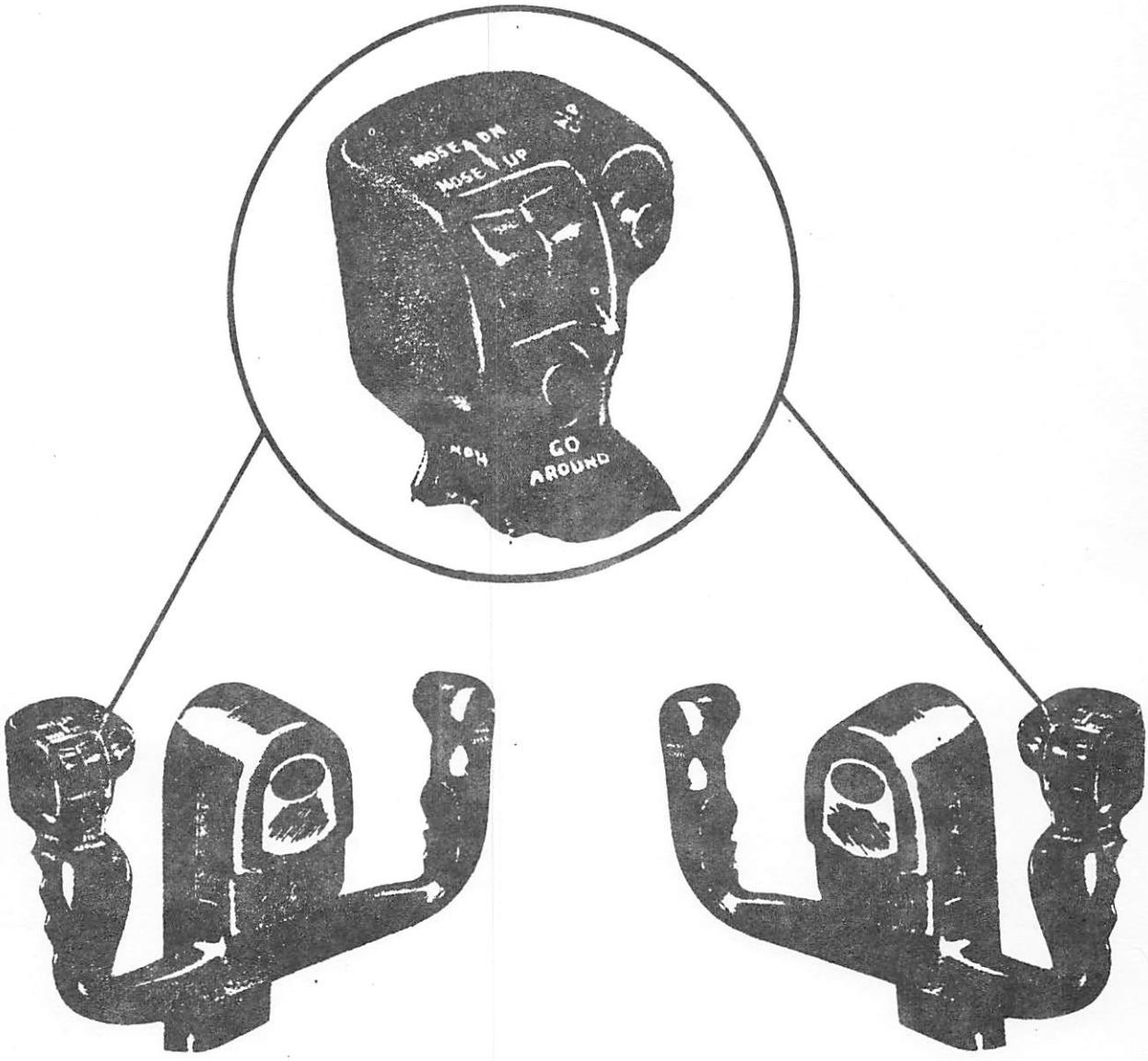


GO BACK to Page 18 and take another look at the explanation.

Inboard! You know better than that.

GO BACK to Page 19 and take another look.

No sweat! The Electro-Hydraulic Pitch Trim Switches are located on the OUTBOARD GRIP of each control wheel. They are normally used to ELECTRICALLY control Hydraulic Pitch Trim operation. These switches are recessed into the control wheel grip to guard against inadvertent operation.



What is the function of the Electro-Hydraulic Pitch Trim Switches?

a. Electrically control electrical operation. TURN to Page 23.

b. Electrically control hydraulic operation. TURN to Page 24.

The Electro-Hydraulic Pitch Trim Switches electrically control HYDRAULIC operation rather than electric operation.

Okay, now that you remember (you do, don't you) please TURN to Page 24.

Sure, Electro-Hydraulic Pitch Trim Switches are used to electrically control hydraulic pitch trim operation.

They are dual fail safe switches. Dual, in that one switch provides electrical power and the other switch provides the ground. BOTH need to be actuated at the same time for the ELECTRO-HYDRAULIC operation.

Fail safe, in that they are spring loaded to the center (OFF) position.

Will actuation of only one switch initiate electro-hydraulic operation?

Yes TURN to Page 25.

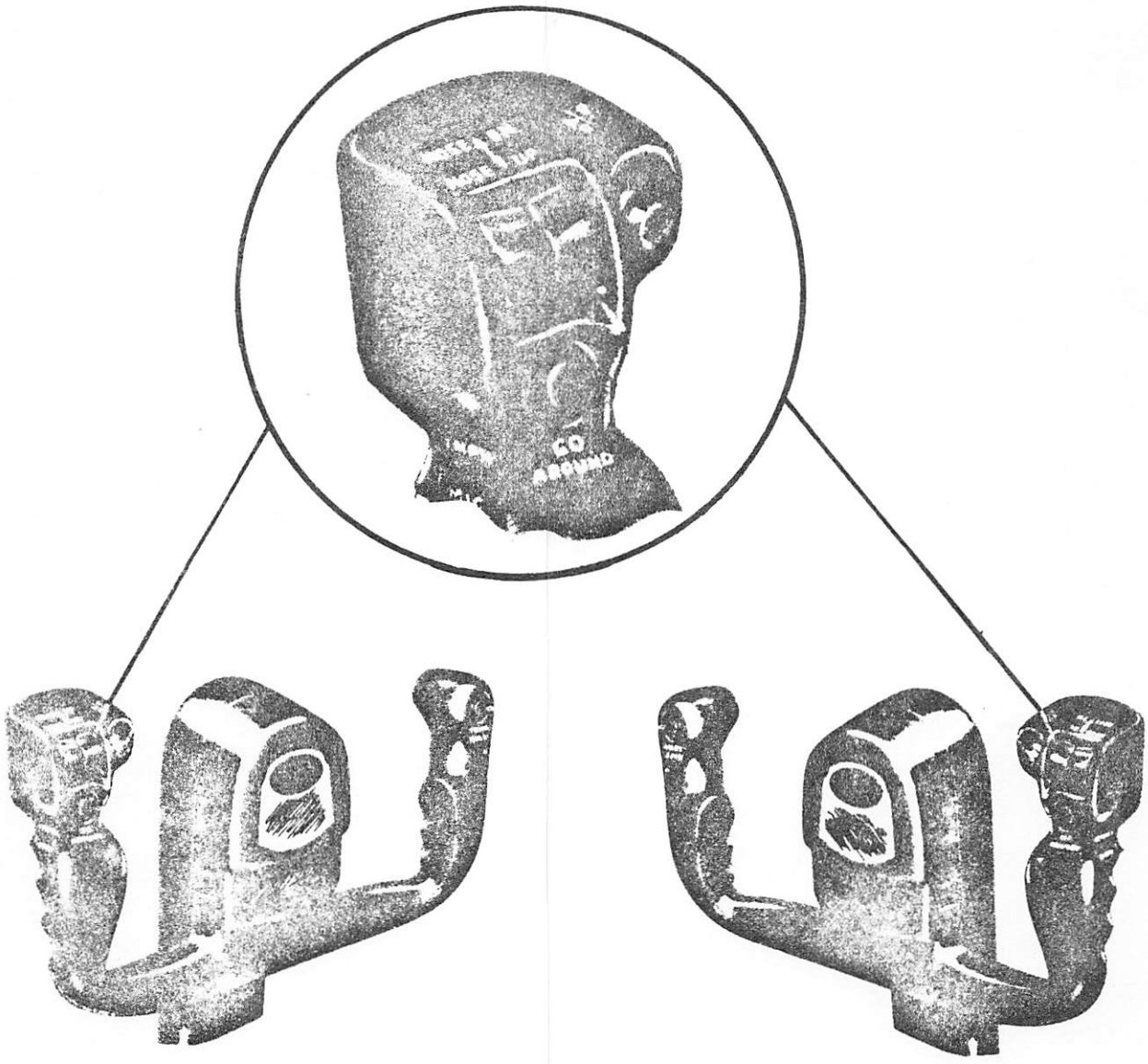
No TURN to Page 26.

Oops! Think again, both power and ground are required to complete an electrical circuit. Remember, one switch provides power, the other switch provides ground. So, to complete the circuit BOTH SWITCHES MUST BE ACTIVATED.

Please TURN to Page 26.

This is 100% correct. BOTH switches on either control wheel MUST be actuated to initiate electro-hydraulic operation.

Let's take another look at these switches.



Pushing either set of these switches upward will initiate Nose UP/Nose DOWN trim.

a. Nose DOWN. TURN to Page 27.

b. Nose UP. TURN to Page 28.

Yes, pushing the switches UPWARD initiates NOSE DOWN trim.

There is NO PRIORITY between the pilot and copilot switches. If the pilot and copilot switches are pushed in opposite directions at the same time, the opposing signals will CANCEL EACH OTHER OUT, and there will be NO pitch trim change.

Okay, let's try this one.

Are Electro-Hydraulic Pitch Trim Switches spring loaded to the center (OFF) position?

Yes TURN to Page 29.

No TURN to Page 30.

Apparently you didn't observe the switches too closely. GO BACK to Page 26 and take a close look at the switch position markings.

Yes, this is an accurate observation. The switches are spring loaded to the center (OFF) position.

There is one more important point to remember about the Electro-Hydraulic Pitch Trim Switches. This applies ONLY if the autopilot is in operation. Actuating the Electro-Hydraulic Pitch Trim Switches will automatically disconnect the autopilot.

What will be the result if the pilot's switches are pushed up, at the same time the copilot's are pushed down?

a. NOSE DN trim. TURN to Page 31.

b. NOSE UP trim. TURN to Page 32.

c. No trim change. TURN to Page 33.

You said no. This is NOT surprising, since the center (OFF) position is not actually marked as such. REMEMBER they must be held in the selected position for trim change. When released they will return to the center (OFF) position.

Please TURN back to Page 29.

You say, NOSE DN? This is NOT correct. Remember we said that if the pilot's and the copilot's switches are pushed in opposite directions at the same time, the opposing signals will cancel each other, resulting in NO PITCH TRIM CHANGE.

Now that you remember, please TURN to Page 33.

You picked NOSE UP, which is not correct. We said that if the pilot's and the copilot's switches are pushed in opposite directions at the same time, the opposing signals will cancel each other, resulting in NO PITCH TRIM CHANGE!

Now that you remember, please TURN to Page 33.

You're right. Pushing the pilot's and copilot's switches in the opposite directions at the same time will result in NO PITCH TRIM CHANGE. However, the system remains operational because this feature merely protects the control circuitry. How's that for a safety feature.

Now that we have the Electro-Hydraulic method of control pretty well in mind, let's move to the second method of control. In this method of control, we will mechanically control the hydraulic pressure.

Should this method be called:

a. Mechanical. TURN to Page 34.

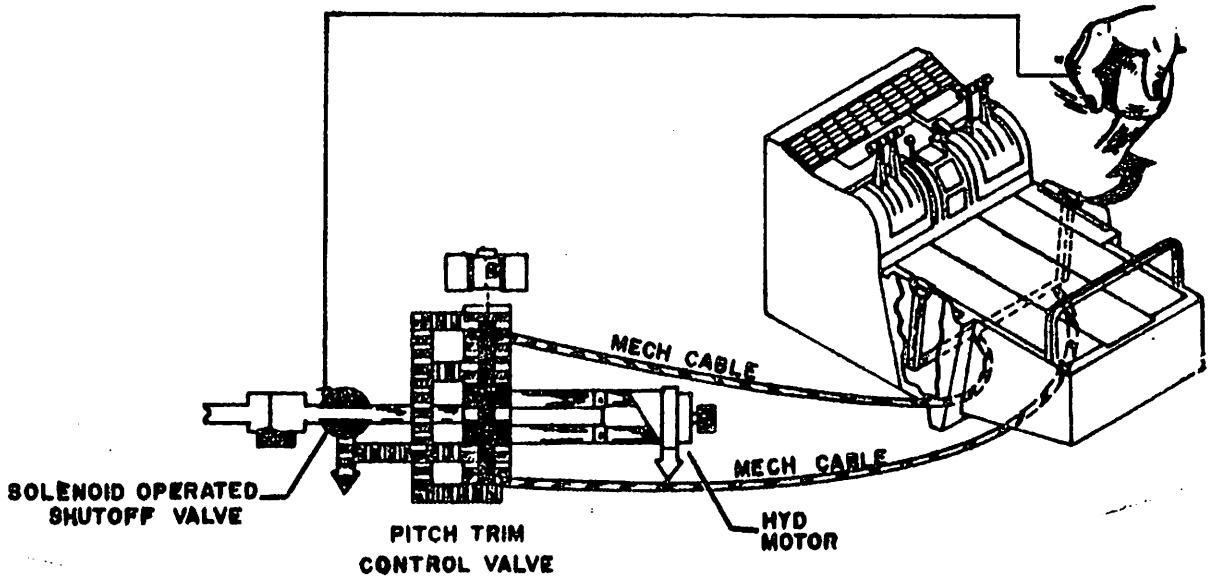
b. Hydro-Mechanical. TURN to Page 35.

Mechanical? That's a logical assumption all right but since controlling pitch trim by this method requires both mechanical and hydraulic power, it is referred to as HYDRO-MECHANICAL.

Please TURN to Page 35.

Yep, the second method is called HYDRO-MECHANICAL. Why? Because Hydraulic Motor operation is mechanically controlled. Remember, we previously discussed electro-hydraulic control and how the electro-hydraulic pitch trim switches are used to electrically control the hydraulic shutoff valve and the control valve.

Okay! The HYDRAULIC PITCH TRIM LEVERS mechanically control the same two valves for hydro-mechanical operation.



Notice there are two levers, one on each side of the center control pedestal. They are interconnected so both levers move together. The levers are also spring loaded to the center (OFF) position.

Are these levers identified as hydraulic pitch trim levers?

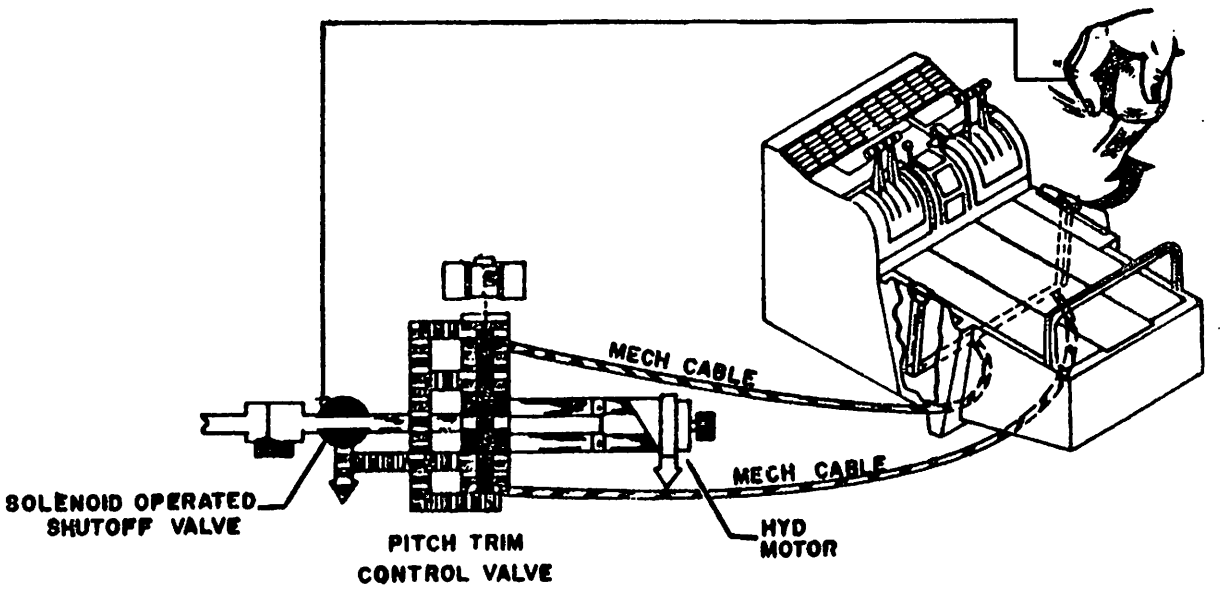
Yes TURN to Page 37.

No TURN to Page 36.

No???? Better GO BACK to Page 35 and read the large print.

Yep! Wouldn't be called anything else but Hydraulic Pitch Trim Levers even though they mechanically control the Hydraulic Shutoff Valve and Control Valve.

When the button on either of the Hydraulic Pitch Trim Levers is depressed, it will interrupt an electric circuit allowing the shutoff valve to open. Now moving the lever will position the control valve to give the desired pitch trim change.



Squeezing the button of either lever and pushing the lever forward will give:

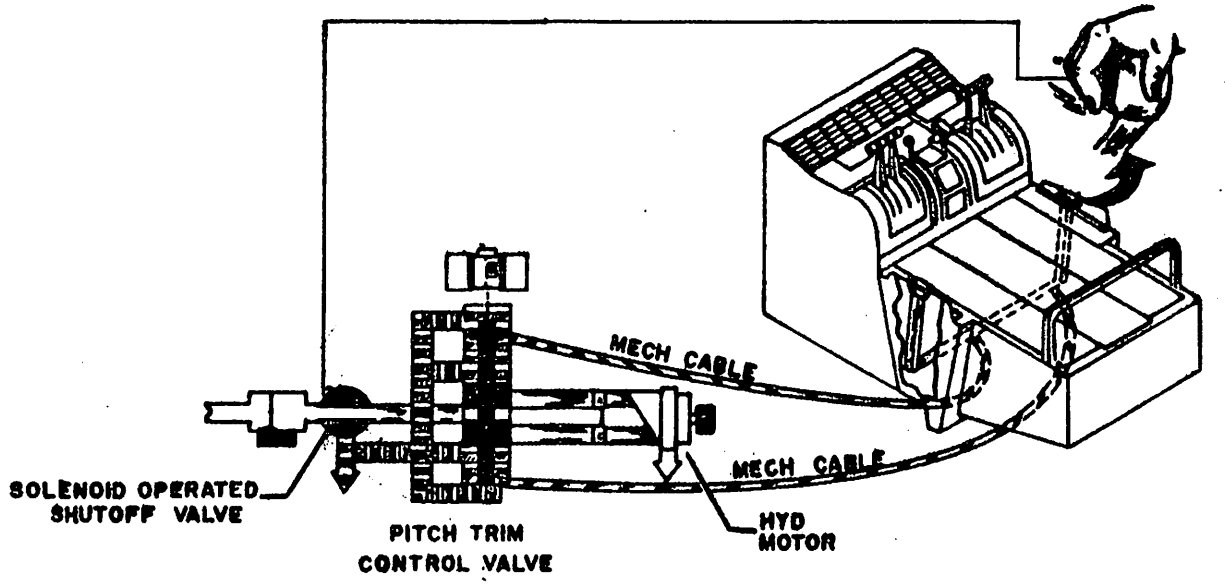
a. Aircraft nose UP trim. TURN to Page 38.

b. Aircraft nose DOWN trim. TURN to Page 39.

Aircraft nose UP trim??? No!! Pushing forward on either lever will initiate aircraft nose DOWN trim.

Please TURN to Page 39.

Right, squeezing the button and moving the pitch trim lever forward will initiate nose DOWN trim. Squeezing the button on the lever merely interrupts electrical power to the Hydraulic Shutoff Valve allowing it to open. This is a safety feature to guard against pitch trim change due to unintentional movement of the Hydraulic Pitch Trim Levers.



Will the Hydraulic Pitch Trim Levers be operational without electrical power?

No TURN to Page 40.

Yes TURN to Page 41.

Sorry, you have picked the wrong selection. Remember, the Hydraulic Shutoff Valve is held SPRING LOADED OPEN and ELECTRICALLY CLOSED. The hydraulic motor control valve is mechanically positioned by the Hydraulic Pitch Trim Levers. Therefore, if we lost electrical power only, we would still have pitch trim.

Please TURN to Page 41.

Certainly. The Hydraulic Pitch Trim Levers will be operational without electrical power, because the hydraulic shutoff valve is spring loaded open and the hydraulic motor control valve is mechanically positioned by the Hydraulic Pitch Trim Levers. Therefore, anytime Hydraulic System Nr 2 is pressurized, the Hydraulic Pitch Trim Levers are OPERATIONAL. Pretty good safety feature, right?

Now let's briefly review what we have covered this far.

Please TURN to Page 42.

1. Pitch trim is accomplished by movement of the entire Horizontal _____ by either an _____ motor or a _____ motor.

2. Electro-Hydraulic operation of the pitch trim is controlled by Electro-Hydraulic Pitch Trim Switches located on the pilot's and copilot's _____ _____.

3. The Electro-Hydraulic Pitch Trim Switches are spring loaded to the _____ position.

4. Pushing the Electro-Hydraulic Pitch Trim switches upward would give aircraft nose _____ trim.

5. If the pilot was pushing UP and the copilot was pushing DOWN on the Electro-Hydraulic Pitch Trim Switches, the result would be _____ _____ in pitch trim.

6. The Hydraulic Pitch Trim Levers on the center control pedestal are (independent)/(interconnected) and spring loaded to the _____ position.

7. Pushing the Hydraulic Pitch Trim Levers forward would initiate aircraft nose _____ trim.

8. The maximum nose DOWN trim is _____ degrees.

9. With the flaps NOT fully retracted, the maximum nose UP trim is _____ degrees.

10. With the flaps full retracted, the maximum nose UP trim is _____ degrees.

Please TURN to Page 43, check your answers, correct any errors, and then follow the instructions.

1. Stabilizer electric hydraulic
2. control wheels
3. center (OFF)
4. down
5. no change
6. interconnected center (OFF)
7. down
8. 4^{o}
9. 12.5^{o}
10. 8^{o}

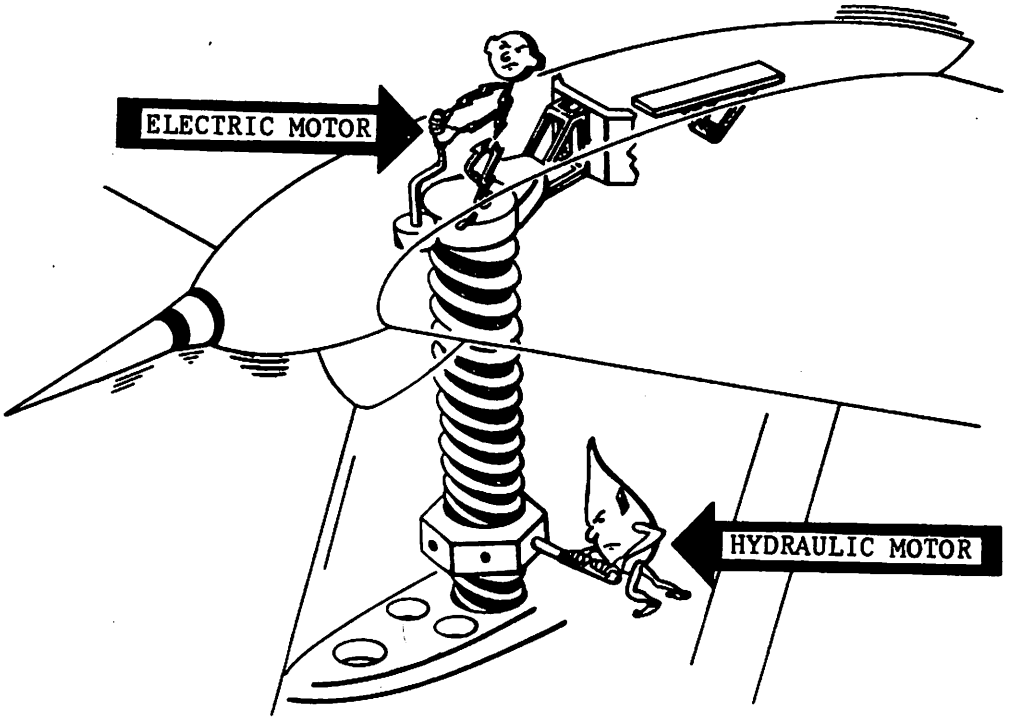
Now that we have hydraulic operation of pitch trim pretty well in mind, let's move on to ELECTRICAL OPERATION.

Please TURN to Page 44.

From Page 43

The pitch trim changes when made by the electric motor are slower than those made by the hydraulic motor, meaning that more precise pitch trim changes can be made with the electric motor.

Remember we said the power source for the Electric Pitch Trim Motor is the Essential AC Bus Nr 2.



If the Essential AC Bus Nr 2 was lost, how could you operate pitch trim?

a. With the Electro-Hydraulic Pitch Trim Switches only. TURN to Page 45.

b. With the Hydraulic Pitch Trim Levers only. TURN to Page 46.

c. With either the Electro-Hydraulic Pitch Trim Switches or the Hydraulic Pitch Trim Levers. TURN to Page 47.

You selected "Electro-Hydraulic Pitch Trim Switches only." What's wrong with using the Hydraulic Pitch Trim Levers? If we lose the Essential AC Bus Nr 2, we lose only the electrical pitch trim. We can still operate pitch trim by using <u>either</u> the Electro-Hydraulic Pitch Trim Switches <u>or</u> the Hydraulic Pitch Trim Levers.

Please TURN to Page 47.

From Page 44

You selected "Hydraulic Pitch Trim Levers only." What's wrong with using the Electro-Hydraulic Pitch Trim Switches? If we lose the Essential AC Bus Nr 2, we lose only the electrical pitch trim. We can still operate pitch trim by using either the Hydraulic Pitch Trim Levers or the Electro-Hydraulic Pitch Trim Switches.

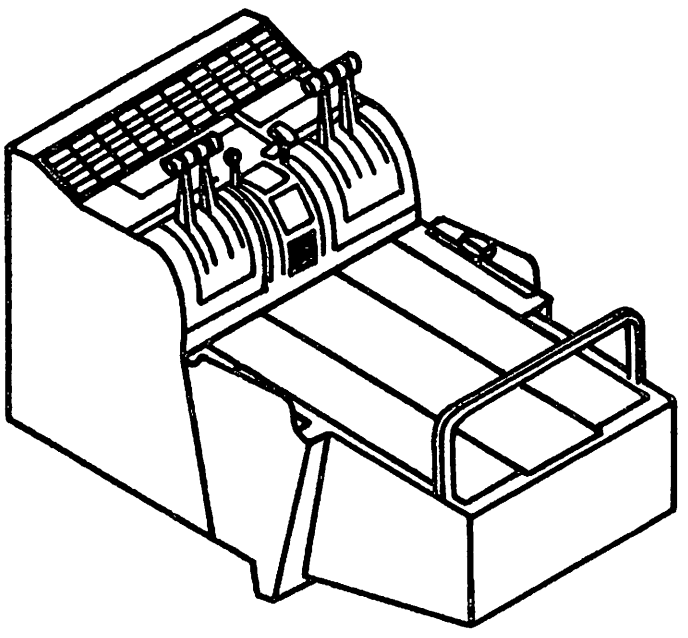
Please TURN to Page 47.

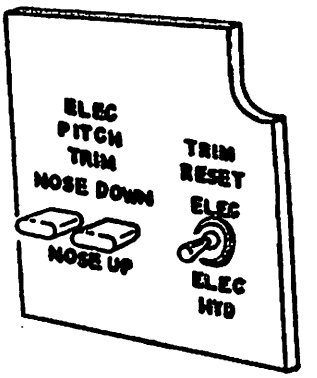
From Page 44

This is correct. If we lose the Essential AC Bus Nr 2, we lose only the electrical pitch trim. We can still operate pitch trim by using either the Electro-Hydraulic Pitch Trim Switches or the Hydraulic Pitch Trim Levers.

The electric pitch trim motor may be controlled either electrically or automatically. First, we will discuss the electrical method.

There are two ELEC PITCH TRIM SWITCHES located on the center control pedestal. One switch provides power, the other ground. Both switches, just like the electro-hydraulic switches, must be actuated at the same time for completion of the control circuit. They are spring loaded to the center (OFF) position.





Pushing both Elec Pitch Trim Switches UPWARD will result in:

a. No pitch trim change. TURN to Page 48.

b. Aircraft nose DOWN trim. TURN to Page 49.

c. Aircraft nose UP trim. TURN to Page 50.

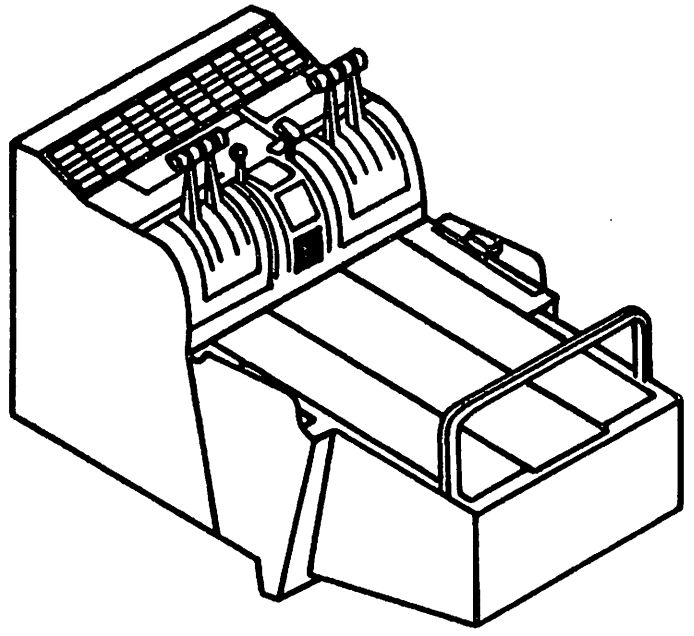
Your selection was no pitch trim change. Perhaps you were thinking of some other system? Pushing both switches upward initiates aircraft nose DOWN trim.

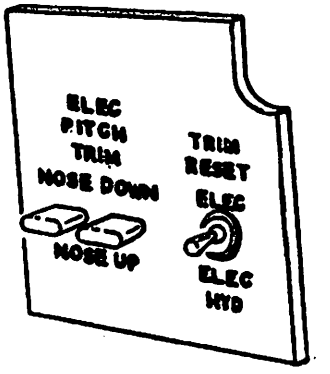
Please TURN to Page 49.

Right. Pushing both Elec Pitch Trim Switches upward initiates nose DOWN trim.

Next, let's discuss AUTOMATIC control of the Electric Pitch Trim Motor. Automatic control of this motor is accomplished by the AUTOPILOT or the MACH TRIM COMPENSATOR.

Whenever the Autopilot is ENGAGED, it controls the Electric Pitch Trim Motor to keep the aircraft in trim. At this time, the ELEC PITCH TRIM SWITCHES are INOPERATIVE.





Are the Elec Pitch Trim Switches inoperative while the Autopilot is engaged?

Yes TURN to Page 51.

No TURN to Page 52.

Sorry, nose UP is wrong.

Please TURN back to Page 47, for another look.

Sure, the Elec Pitch Trim Switches are INOPERATIVE while the Autopilot is engaged.

The second method of automatic control is accomplished by the MACH TRIM COMPENSATOR.

This system is used to provide automatic control at high speeds when the Autopilot is disengaged.

When the speed of the aircraft approaches its critical Mach number, the nose of the aircraft will tend to tuck under. (The T.O. 1C-141A-1 refers to this as the "tuck" region of operation.) In order to counteract this tendency, the Mach Trim Compensator sends nose up trim signals to the pitch trim system.

Is the Mach Trim Compensator automatically disengaged when the Autopilot is engaged?

Yes TURN to Page 54.

No TURN to Page 53.

No???? How come?? Perhaps you missed something.

Please TURN back to Page 49 and take another look.

No! You missed something. We stated that the Mach Trim Compensator was used at high speeds when the Autopilot was disengaged. Therefore, engaging the Autopilot will disengage the Mach Trim Compensator.

TURN to Page 54 and continue on.

From Page 51

Sure, the Mach Trim Compensator is automatically disengaged when the Autopilot is engaged.

During Autopilot operation, if the Electro-Hydraulic Pitch Trim Switches or the Hydraulic Pitch Trim Levers are actuated, they will automatically disengage the Autopilot and the pilot can then control the pitch trim system by using any of the pitch trim controls.

Will the Electro-Hydraulic Pitch Trim Switches and the Hydraulic Pitch Trim Levers be operational after either of them automatically disengages the Autopilot?

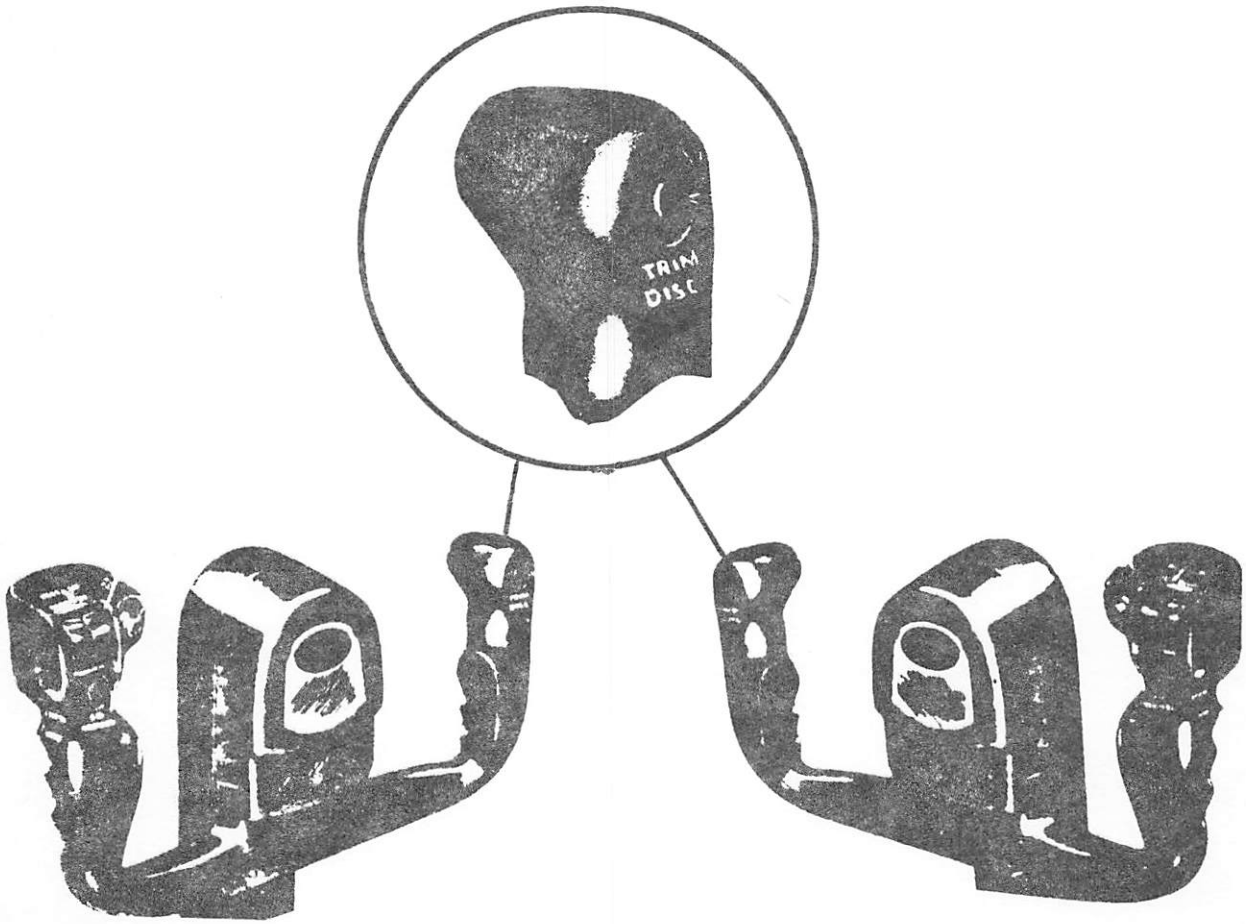
Yes — TURN to Page 55.

No — TURN to Page 56.

From Page 54

Yes, the Electro-Hydraulic Pitch Trim Switches and the Hydraulic Pitch Trim Levers BOTH remain operational after the Autopilot is automatically disengaged and the Autopilot may be reset when the pitch trim change is completed.

Next, let's take a look at the PITCH TRIM DISCONNECT BUTTONS. They are located on the inboard grip of each control wheel. Pushing either TRIM DISC button disengages all ELECTRICAL CONTROL for both the ELECTRIC MOTOR and the HYDRAULIC MOTOR. However, the Hydraulic Pitch Trim Levers remain operational.



The Pitch Trim Disconnect Buttons are located on which grip of each control wheel?

INBOARD — TURN to Page 57.

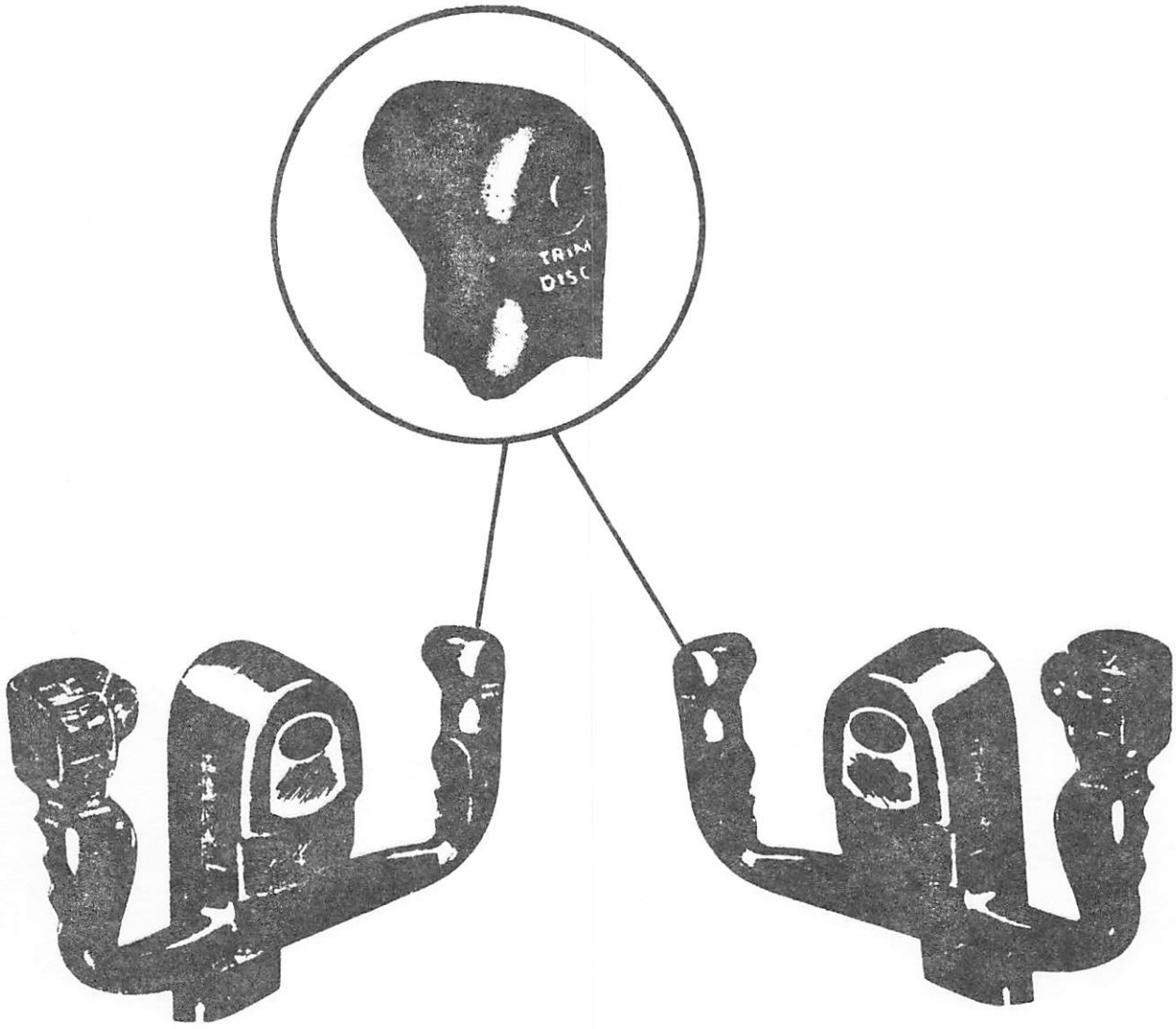
OUTBOARD — TURN to Page 58.

No??? Why not? Both the Electro-Hydraulic Pitch Trim Switches or the Hydraulic Pitch Trim Levers disengage the Autopilot, so it will not interfere with their control of pitch trim.

TURN back to Page 55 and continue on.

From Page 54

Right. The Trim Disconnect Buttons are located on the INBOARD grip of each control wheel.



Which pitch trim control remains operational after depressing a TRIM DISC button?

a. Electro-Hydraulic Pitch Trim Switches. TURN to Page 59.

b. Electrical Pitch Trim Switches. TURN to Page 60.

c. Hydraulic Pitch Trim Levers. TURN to Page 61.

Oops! Please GO BACK to Page 55 for another peek, then change your selection.

Sorry about that!

Once a TRIM DISC button has been depressed, all electrical operation is disconnected.

Please TURN to Page 61.

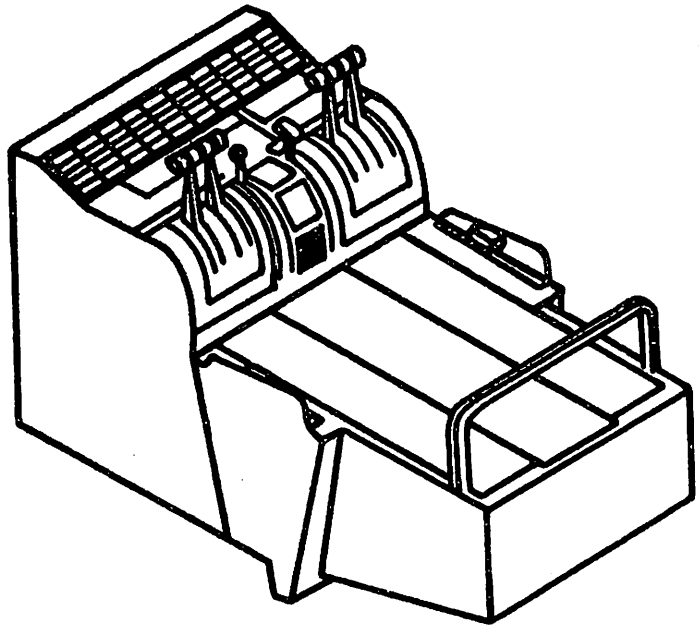
Electrical Pitch Trim Switches! You gotta be kidding.

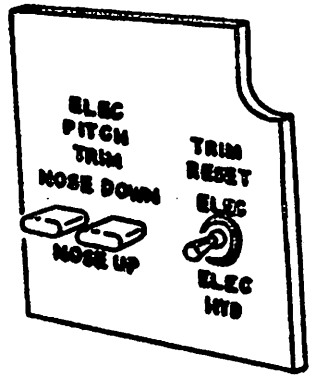
Please TURN back to Page 57 and make another selection.

From Page 57

Right. Hydraulic Pitch Trim Levers will remain operational after depressing the TRIM DISC button, because hydraulic motor operation can be mechanically controlled by the Hydraulic Pitch Trim Levers even though all electrical control has been disconnected.

Electrical control may be restored by use of a TRIM RESET SWITCH on the center control pedestal. The Trim Reset Switch is spring loaded to the center (OFF) position and has two reset positions. One position (ELEC) resets electrical control and the other position (ELEC HYD) resets the electro-hydraulic control.





In order to reset all electrical control, what must be accomplished with the Trim Reset Switch?

a. Place Trim Reset Switch momentarily to the ELEC HYD position. TURN to Page 62.

b. Place Trim Reset Switch to the ELEC and then to the ELEC HYD position. TURN to Page 63.

You selected "place Trim Reset Switch to the ELECT HYD position." Well, this would be true IF we wanted hydraulic pitch trim only.

In order to reset all electrical control, both the ELEC and ELEC HYD positions must be used.

TURN to Page 63.

From Page 61

This is correct. In order to reset all electrical control, the Trim Reset Switch must be placed to the ELEC position and then to the ELEC HYD position.

This completes the electrical pitch trim operation.

Please TURN to Page 64 for a review.

As a short review, write the correct answers in the blank spaces.

1. When the Elec Pitch Trim Switches are actuated, the trim change operation is performed by the _____ motor.

2. List the two methods of pitch trim operation that will automatically disengage the Autopilot.

3. Which pitch trim control system remains operational after depressing a TRIM DISC button?

4. Which pitch trim switches are inoperative when the Autopilot is engaged?

5. While the Autopilot is engaged, is the Mach Trim Compensator signal interrupted?

   Yes

   No

Please TURN to Page 65, check your answers, and correct any you missed.

Correct answers to items on Page 64.

1. Electric
2. Electro-Hydraulic Switches Hydraulic Pitch Trim Levers
3. Hydraulic Pitch Trim Levers
4. Elec Pitch Trim Switches
5. Yes

Correct any wrong answers on Page 60.

This completes the discussion of pitch trim. We hope it has been helpful to you in understanding how it operates.

If you would like to review any part of the system, the subjects start on following pages: