FORCE™ Boom

Operator's Manual

10637903 (10/04)

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Dear Owner,

Thank you for purchasing a HARDI® product and welcome to the ever-increasing family of HARDI® sprayer owners.

Our sprayers and accessories are rapidly becoming a familiar sight on North American farms. We believe that this results from growers becoming increasingly conscious of crop protection input costs and the vital need for cost effective application equipment.

Please take the time to thoroughly read the Operator's Manual before using your equipment. You will find many helpful hints as well as important safety and operation information.

Some of the features on your FORCE™ boom were suggested by growers. There is no substitute for "on farm" experience and we invite your comments and suggestions. If any portion of this instruction book remains unclear after reading it, contact your HARDI® dealer or service personnel for further explanation before using the equipment.

For Product, Service or Warranty Information:
- Please contact your local HARDI® dealer.

To contact HARDI® directly:
- Please use the HARDI® Customer Service number: 1-866-770-7063
- Or send your email to CUSTSERV@hardi-us.com

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Sincerely,

Tom L. Kinzenbaw
President

1.0 INTRODUCTION

Fig. 1

HARDI® FORCE™ Boom (110' shown)

The HARDI® FORCE™ boom is constructed from a 3-dimensional design offering exceptional strength, stability and low maintenance. 80', 88' and 90' FORCE™ booms have Bi-fold wings (also 110' prior to 2002), while 100', 120' and 132' FORCE™ booms have Tri-fold wings. The trapeze and link arms make the FORCE™ boom friction free with less service and wear on the parts.

The FORCE™ boom is offered with an HZ type of hydraulic system that features simultaneous inner wing fold and outer wing fold as well as individual wing tilt. For "closed center" tractor hydraulics systems, an optional "DH" (Direct acting Hydraulics) control box is available. Both systems require one single acting and one double acting hydraulic outlet on the tractor and a 12V-power supply for the in-cab mounted controls.

The FORCE™ boom is fitted with triplet nozzle bodies that can be set up for a variety of spraying applications.

2.0 SAFETY INFORMATION

WARNING

ALWAYS READ OPERATOR'S MANUAL BEFORE USING EQUIPMENT

DO NOT REMOVE ANY SAFETY DEVICES OR SHIELDS. NEVER SERVICE, CLEAN OR REPAIR A MACHINE WHILE IT IS OPERATING

WARNING

ALWAYS WATCH FOR THIS SYMBOL TO POINT OUT IMPORTANT SAFETY PRECAUTIONS

IT MEANS ATTENTION! BECOME ALERT! YOUR SAFETY IS INVOLVED!

RECOGNIZE SAFETY INFORMATION

This is the Safety-alert symbol. When you see this symbol on your machine or in this manual, be alert to the potential for personal injury.

Follow recommended precautions and safe operating practices.

2.1 Follow Safety Instructions

- Carefully read all the safety messages in this manual and the safety labels fitted to the machine. Keep safety labels in good condition. Replace missing or damaged safety labels. Be sure that new equipment components include any current safety labels. Replacement safety labels are available from your authorized HARDI® dealer.

- Learn how to operate the spray boom and controls properly. Do not let anyone operate the machine without proper instructions.

- Keep your FORCE™ boom in proper working condition. Unauthorized modifications or use may impair the function and or safety and affect the spray boom's life.

- If you do not understand any part of this manual and need assistance, please contact your authorized HARDI® dealer.

2.2 Operating The FORCE™ Boom Safely

1. Read the complete manual carefully and become familiar with the operation of the equipment before initial operation of each spraying season. Failure to do so may result in possible over or under application of spray solution which may drastically affect crop production or lead to personal injury.

2. Before starting the engine on the tractor unit, be sure all operating controls are in the off or neutral position, including (but not limited to) the P.T.O. shaft and or spray controls. Be sure the tractor power train is disengaged.

3. Operate spray and boom functions only when seated in the operator's seat.

4. One of the most frequent causes of personal injury or death results from persons falling off or being run over. Do not permit others to ride on or in. Only one person - the operator - should be on the machine when in operation.

5. Before leaving the tractor seat, stop the engine, put all controls in neutral, and put the transmission control lever in the park position or neutral with the brakes locked. Read the tractor operation manual for added safety precautions.
6. P.T.O. driven equipment can cause serious injury. Before working on or near the P.T.O. shaft, servicing or cleaning the equipment, put P.T.O. lever in the DISENGAGE position and stop the engine.
7. Do not fold or unfold boom near overhead wires. Serious injury or death could result if contact is made with electric wires.
8. Keep hands, feet & clothing away from moving parts.
9. Wear relatively tight and belted clothing to prevent from being caught on some part of the machine.
10. Slow down when turning, especially with boom extended.
11. Always keep children away from your sprayer and/or tractor unit.
12. Before transporting the sprayer ensure that the boom is fully folded and fully locked into transport rests and stops. Ensure all locking devices are fully engaged whether hydraulic or mechanical.
13. Slow moving tractors and spray equipment can create a hazard when on public roads. Avoid personal injury or death resulting from any accidents by using flashing lights. Local regulations may require installation of flashing warning lights.
14. Avoid injuries from high pressure fluids penetrating the skin by relieving system pressure before disconnecting hydraulics or other lines. Ensure all fittings are tight before applying pressure to the system.
15. Understand service procedures before undertaking any maintenance. Never lubricate, service, or adjust the spray boom while its operating. Securely support any components before working on them.
16. Keep all parts in good condition and properly installed. Fix damaged parts immediately. Replace worn or broken parts. Remove excessive buildup of grease, oil, or debris.

2.3 Handling Chemical Products Safely

1. Direct exposure to hazardous chemicals can cause serious injury. These chemicals can include lubricants, coolants, paints, adhesives and agricultural chemicals. Material Safety Data Sheets (M.S.D.S.) are available for all hazardous chemicals which inform the user of specific details including, physical and health hazards, safety procedures, and emergency response techniques.
2. Protective clothing such as rubber gloves, goggles, coveralls and respirator must be worn during operation. All protective clothing should be kept in excellent condition and cleaned regularly or discarded.
3. If chemicals come in contact with any exposed skin areas, wash immediately with clean water and detergent. Never place nozzle tips or any other components that have been exposed to chemicals to mouth to blow out obstructions. Use a soft brush to clean spray nozzles.
4. Dedicate an area to fill, flush, calibrate and decontaminate sprayer where chemicals will not drift or run off to contaminate people, animals, vegetation, water supply, etc. Locate this area where there is virtually no chance of children being in contact with this residue.
5. Decontaminate equipment used in mixing, transferring, and applying chemicals after use. Follow the instructions on the chemical label for the correct procedure required. Wash spray residue from outside of the sprayer to prevent corrosion.
6. Extreme care should be taken in measuring spray products. Powders should be used in suitable sized packages or weighed accurately. Liquids should be poured into a suitable graduated container. Keep chemical containers low when pouring. Wear a filtered respirator and let the wind blow away from you to avoid dust and/or splashes contacting the skin or hair.
7. Store chemicals in a separate, plainly marked locked building. Keep the chemical in its original container with the label intact.
8. Dispose all empty containers after rinsing in accordance with local regulations & by-laws. Dispose of all unused chemicals and left over fertilizer in an approved manner.
9. Keep a first aid kit and fire extinguisher available at all times when handling chemicals.

2.4 Local Poison Information Center

If you live anywhere in the United States, the following toll free number will connect you to your Local Poison Information Center.

PHONE NO. 1 - 8 0 0 - 2 2 2 - 1 2 2 2

If you live outside the United States, find the number for the poison control center in your phone book and write it in the space below:

PHONE NO. _____ -_____ - _____

Keep a list in the space provided below, of all the chemicals that you have in use.

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

3.0 GLOSSARY

1.) ***RIGHT HAND & LEFT HAND SIDES-*** Are determined by facing forward in the direction of travel.

2.) ***HZ MODEL-*** A FORCE™ boom with advanced hydraulics. This boom can raise and lower, fold inner or outer wings simultaneously, and tilt each wing individually.

3.) ***FOLDED BOOM-*** Refers to the boom in transport position.

4.) ***UNFOLDED BOOM-*** Refers to the boom in spraying position.

5.) ***WING-*** Refers to the folding portion of the boom.

6.) ***LIFT FRAME-*** Mounts to the upper and lower parallelogram arms, also called the Paralift™.

7.) ***CENTER SECTION-*** Refers to the portion of the boom that the wings attach to. The wings move up and down with the center.

8.) ***LINK ARMS-*** Attaches the Center Section to the Lift Frame, together with the trapeze arms.

9.) ***INNER WING-*** Refers to the inner portion of the wing.

10.) ***INTERMEDIATE WING-*** Refers to the intermediate portion of the wing (only on tri-fold configurations - 100', 120' & 132').

11.) ***OUTER WING-*** Refers to the outer portion of the wing.

12.) ***BREAKAWAY-*** Refers to the part of the wing that allows movement in the event of striking an object.

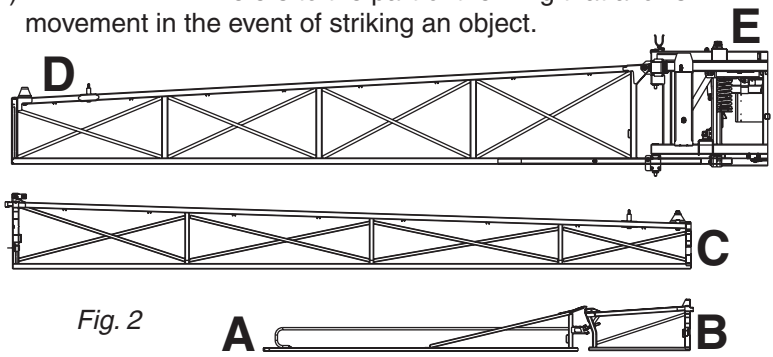


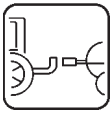
Fig. 2

A - Breakaway Section
B - Outer Wing Section
C - Intermediate Wing Section (tri-fold 100', 120' & 132' only)
D - Inner Wing Section
E - Center Frame

4.0 PREPARATION

The FORCE™ booms need one single outlet for the lift function of the spray boom and one double outlet for the folding and the tilt function. Note that the booms hydraulic system requires an oil capacity of approximately 1.5 GPM (5.7 liters/min.) and a minimum pressure of 2,100 PSI (145 bar).

5.0 HYDRAULIC HOOK-UP



WARNING:

- **BE SURE TO HOOK UP HYDRAULIC LINES PROPERLY!**
- **MAKE SURE THE HYDRAULIC LINES HAVE NOT BEEN DAMAGED DURING SHIPPING.**
- **ESCAPING HYDRAULIC FLUID UNDER PRESSURE CAN PENETRATE THE SKIN CAUSING SERIOUS INJURY. AVOID THIS HAZARD BY RELIEVING PRESSURE BEFORE DISCONNECTING HYDRAULIC LINES.**
- **ENSURE ALL CONNECTIONS ARE TIGHT BEFORE APPLYING PRESSURE. SEARCH FOR LEAKS WITH A PIECE OF CARDBOARD, NOT YOUR HANDS!**
- **IMPROPER HOOK-UP CAN CAUSE DANGEROUS BOOM MOVEMENTS AND/OR DAMAGE TO THE SPRAYER HYDRAULICS.**
- **DO NOT ALLOW ANYONE NEAR A HYDRAULIC BOOM IN OPERATION.**
- **ALWAYS SHUT TRACTOR OFF WHEN CONNECTING, SERVICING OR ADJUSTING BOOM.**

IMPORTANT: ***Due to the wide variations in tractor hydraulic systems and capacities, care should be exercised when initially operating the sprayer hydraulic cylinders. It is advisable to adjust the hydraulic flow control down to the minimum rate before operating the system. Adjust/increase the flow control after the system is bled of any air, if necessary.***

1. Attach the larger (3/8“) hydraulic hose to the tractor's single acting outlet.
2. Attach the smaller (1/4“) hydraulic hose to the tractor's double acting outlet.

5.1 HZ Hydraulics Joystick Controls

Switch **A** operates: Left hand fold cylinder
Switch **B** operates: Right hand fold cylinder
Switch **C** operates: Left hand tilt cylinder
Switch **D** operates: Right hand tilt cylinder

Installation Of Handle

1. Attach the control handle to the hydraulic lever that operates the double acting outlet you intend to use (Fig. 3). The universal mounting bracket (**E**)(Fig. 3) is very flexible and a number of different mounting positions can be used.

2. Connect plug (**F**)(Fig. 3) to the tractor's 12V power system. Try to hook up the handle as close as possible to the battery or the starter for a better power supply. HARDI® recommends using electric distribution box #817925 to insure a good power supply to various 12V attachments.

Note: Check with your dealer or tractor operator's manual for the best location to hook up the 12V system.

NOTE POLARITY:
BROWN WIRE = POS (**+**)
BLUE WIRE = NEG (**-**)

3. Connect electric plug (**H**)(Fig. 3) from sprayer hydraulics to plug (**G**)(Fig. 3) on handle.

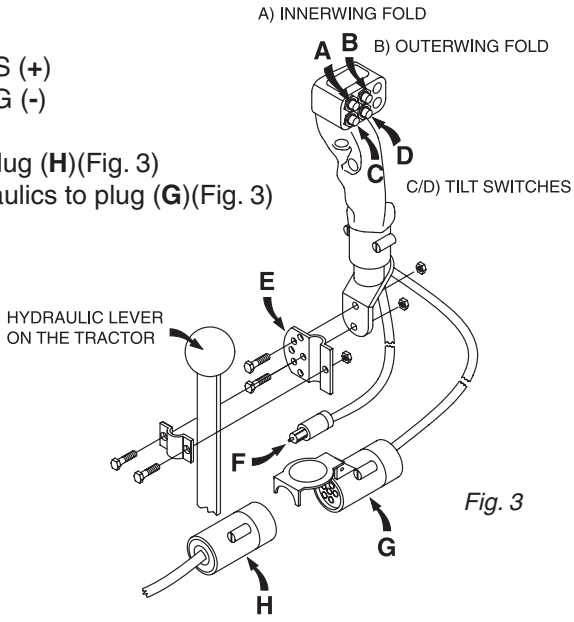


Fig. 3

5.2 'DH' Hydraulics (Optional)

Note: This kit can only be used on tractors with 'closed center' hydraulic systems.

Switch **A** operates: Left hand fold cylinder
Switch **B** operates: Right hand fold cylinder
Switch **C** operates: Left hand tilt cylinder
Switch **D** operates: Right hand tilt cylinder

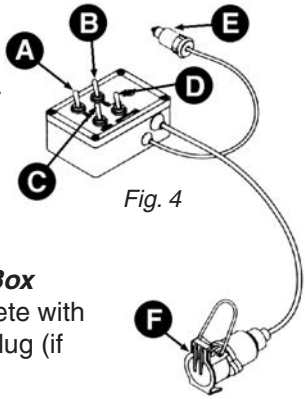


Fig. 4

Installation Of The 'DH' Hydraulic Switch Box

1. Remove the joystick control handle complete with bayonet style 12V plug and 7 pin female plug (if previously fitted).
2. Route the cable, with the 7 pins, from the hydraulic mount plate to the tractor.
3. Mount the 'DH' hydraulic switch box in a suitable location in the tractor cab.
4. Connect the bayonet plug (**E**)(Fig. 4) from the switch box to a 12V power supply. HARDI® recommends using electronic distribution box #817925 to ensure a good power supply to various 12V attachments.

NOTE POLARITY: BROWN WIRE **=** POSITIVE (+)
BLUE WIRE **=** NEGATIVE (-)

5. Connect the female 7 pin plug (**F**)(Fig. 4) from the switch box to the 7 pin male plug from the hydraulic mount plate on the sprayer.

6.0 OPERATING THE HYDRAULIC FORCE™ BOOM

WARNING: **USE EXTREME CAUTION THE FIRST SEVERAL TIMES YOU OPERATE THE BOOM AS THE AIR IS BLED OUT.**

- **AIR MAY STILL BE TRAPPED IN THE HYDRAULICS SYSTEM. THE BOOM CAN MAKE SUDDEN AND UNEXPECTED MOVEMENTS!**
- **ALWAYS OPERATE BOOM ON LEVEL GROUND.**
- **BEFORE UNFOLDING THE BOOM, ENSURE THAT THE SPRAYER IS HITCHED TO THE TRACTOR UNIT.**
- **ENSURE THAT THERE ARE NO OBSTRUCTIONS OR PERSONS IN THE PATH OF TRAVEL BEFORE FOLDING OR UNFOLDING THE BOOM.**
- **NEVER FOLD/UNFOLD THE INTERMEDIATE OR OUTER WINGS WITH THE INNER WINGS TILTED.**
- **NEVER DRIVE AND FOLD/UNFOLD THE BOOM AT THE SAME TIME.**

6.1 Releasing The FORCE™ Boom From Transport Supports

WARNING: **ALWAYS FOLD/UNFOLD BOOM ON LEVEL GROUND WITH A MINIMUM GROUND CLEARANCE OF 6 FEET, AND A MINIMUM REAR CLEARANCE OF 22 FEET!**

1. Start tractor and bring engine to operating RPM.
2. Activate the single acting outlet to lift the boom out of the sprayer's transport support.

Note: When raising the boom from the transport supports, two hooks will also be disengaged from the two Paralift™ cylinders. (As shown in Fig. 5).

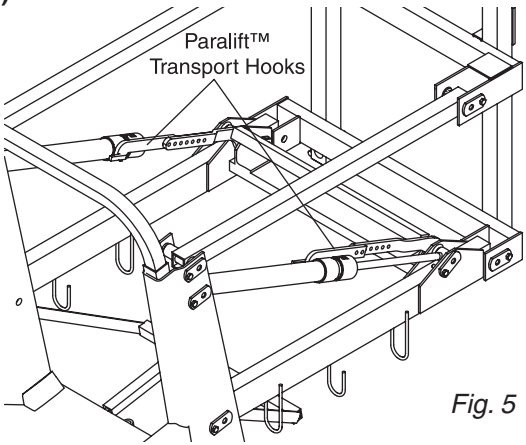


Fig. 5

6.2 Unfolding And Folding The Boom

A) Hydraulic Joystick Controls

TO UNFOLD BOOM

1. Raise the boom to the highest point to release the transport hooks and transport supports (Section 6.1).
2. Depress switch (**A**)(Fig. 6) and move the joystick forward or rearward to unfold the inner wing sections of the boom. Switch position of the hoses in the double acting remote outlet if you do not like the direction required to activate the boom.

Note: When unfolding the inner wings, the transport hooks on the two Paralift™ cylinders will disengage

3. With the boom still at the highest point, depress switch (**B**)(Fig. 6) to unfold the outer wing sections (unless spraying half folded). For tri-fold booms (100', 120' or 132') depressing switch (**B**)(Fig. 6) will unfold the intermediate wing sections first, followed by the outer wing sections. Lower boom to desired spray height.

TO FOLD BOOM

1. Raise the boom to the highest point.
2. Depress switch (**B**)(Fig. 6) and move joystick in opposite direction as unfold to fold in the outer wing sections. For tri-fold booms (100', 120' of 132'), depressing switch (**B**)(Fig. 6) will fold in the outer wing sections first, followed by the intermediate wing sections.

Note: Be sure that the boom is raised when folding, or damage can occur when the transport hooks are engaged.

3. Tilt wings up approx. 15° (Section 6.3).
4. Depress switch (**A**)(Fig. 6) to fold in the inner wing sections allowing the bottom profile of the wing to come in contact with the vertical part of the front transport bracket.
5. Lower boom down, activating the Paralift™ lift cylinders. Make sure that the transport hooks are engaged on the cylinders. Then lower the tilt cylinders (switches **C** and **D**)(Fig. 6) until the wings are resting on the front transport supports.
6. Relieve all oil out of the system by activating the tractor levers without any switches pushed.

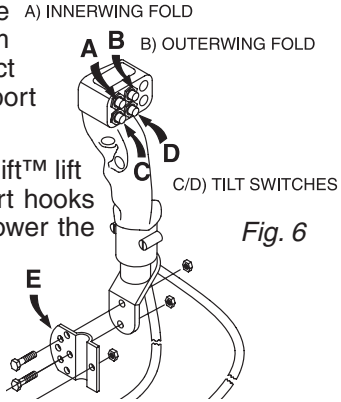


Fig. 6

B) "DH" Hydraulics Control Box (Optional)

TO UNFOLD BOOM

1. Raise the boom to the highest point to release it from the transport supports and hooks (Section 6.1).
2. Engage the tractor's double acting remote outlet lever and lock it in the engaged position.
3. Activate switch (**A**)(Fig. 7) upwards and hold to unfold the inner wing sections.

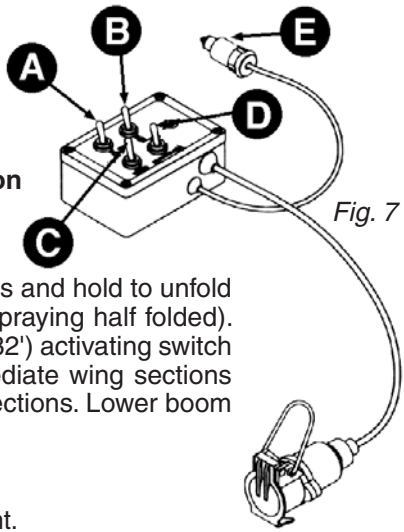


Fig. 7

Note: When unfolding the inner wings, the transport hooks on the two Paralift™ cylinders will disengage.

4. Activate switch (**B**)(Fig. 7) upwards and hold to unfold the outer wing sections (unless spraying half folded). For tri-fold booms (100', 120' or 132') activating switch (**B**)(Fig. 7) will unfold the intermediate wing sections first, followed by the outer wing sections. Lower boom to desired spray height.

TO FOLD BOOM

1. Raise the boom to the highest point.
2. With the double acting remote outlet lever engaged, activate switch (**B**)(Fig. 7) downwards and hold to fold in the outer wing sections. For tri-fold booms (100', 120' of 132'), activating switch (**B**)(Fig. 7) will fold in the outer wing sections first, followed by the intermediate wing sections.

Note: Be sure that the boom is raised when folding, or damage can occur when the transport hooks are engaged.

3. Tilt wings up approx. 15° (Section 6.3).
4. Depress switch (**A**)(Fig. 7) to fold in the inner wing sections allowing the bottom profile of the wing to come in contact with the vertical part of the front transport bracket.
5. Lower boom down, activating the Paralift™ lift cylinders. Make sure that the transport hooks are engaged on the cylinders. Then lower the tilt cylinders (switches **C** and **D**)(Fig. 7) until the wings are resting on the front transport supports.
6. Relieve all oil out of the system by activating the tractor levers without any switches pushed.

6.3 Tilting Boom

WARNING: **NEVER ATTEMPT TO WORK ON OR AROUND BOOM WHEN TILTED UP.**

A) Hydraulic Joystick Controls

1. Activate switch (**C**)(Fig. 8) and move hydraulic handle forward or rearward to tilt left hand boom up. To tilt the right hand boom, activate switch (**D**)(Fig. 8). Switch positions of the hoses in the double acting outlet if you do not like the direction required to activate the boom.

B) 'DH' Hydraulic Control Box (Optional)

1. Engage the tractor's double acting remote outlet lever and lock it in the engaged position.
2. Activate switch (**C**)(Fig. 8) upwards and hold to tilt left hand boom up. (Holding the switch in the down position will tilt the boom down.) To tilt the right-hand boom activate switch (**D**)(Fig. 8).

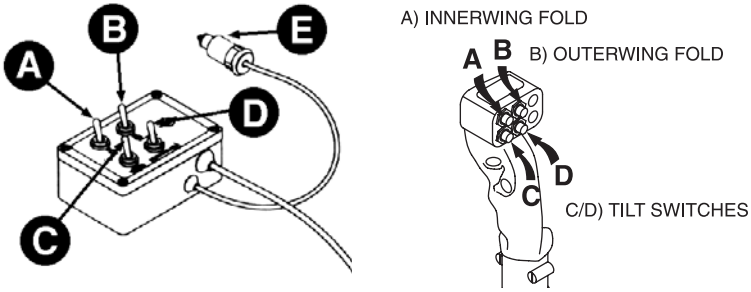


Fig. 8

7.0 ADJUSTMENTS

WARNING:
- **HARDI® CANNOT ASSUME RESPONSIBILITY OR BE HELD LIABLE FOR ANY LOSS OR DAMAGE THAT OCCURS DUE TO LACK OF ADJUSTMENTS OR MAINTENANCE.**
- **WE URGE YOU TO FOLLOW THE ADJUSTMENT AND MAINTENANCE RECOMMENDATIONS FOR EVERYONE'S SAFETY.**
- **MAKE IT A DAILY HABIT TO INSPECT YOUR BOOM FOR NEED OF ADJUSTMENT OR MAINTENANCE.**
- **IMMEDIATELY REPLACE ANY PARTS ON THE BOOM THAT ARE WORN OR BROKEN.**
- **ALWAYS CLEAN YOUR BOOM BEFORE ADJUSTING IT TO AVOID UNNECESSARY CONTACT WITH CHEMICALS**.

Your new HARDI® FORCE™ boom was hydraulically charged and adjusted at time of assembly (This applies to booms sold with sprayers as complete units only.) Fold and unfold the boom several times before making adjustments to remove all air from the hydraulic circuit. It is important that the hydraulic cylinders remain extended during adjustments with the boom open.

The FORCE™ boom will require additional adjustments shortly after being put into use and at regular intervals thereafter. It is important to perform the adjustment procedures in the same sequence as they are written in this manual.

To further ensure proper performance, the FORCE™ boom also has to be maintained on a regular basis. Please follow the suggested maintenance intervals (Section 8.0).

7.1 Adjustment And Maintenance Intervals

IMPORTANT: ***To maximize boom life and performance, retighten all boom fasteners and inspect boom for proper adjustment after the first 10 hours of use. Thereafter adjust the boom at least once a year and check all fasteners at 50 hr. intervals. Lubrication of the boom should be done daily to ensure maximum performance and life. (Section 8.0)***

7.2 Boom Adjustments and Alignments

A. Adjustment of Center Section

Suspension spring tension

1. With the boom unfolded (in spraying position), the trapeze suspension arms should be level/horizontal (Fig. 9). To adjust, loosen the 3 jam nuts (**A**)(Fig. 9) on both sides and adjust the tension of the vertical springs by tightening or loosening the bolts (**B**)(Fig. 9) to suit the boom weight.

Note: Adjust all 3 bolts (B)(Fig. 9) evenly on each spring. Also make sure both springs are adjusted equally.

2. Tighten the jam nuts (**A**)(Fig. 9) when correctly adjusted.

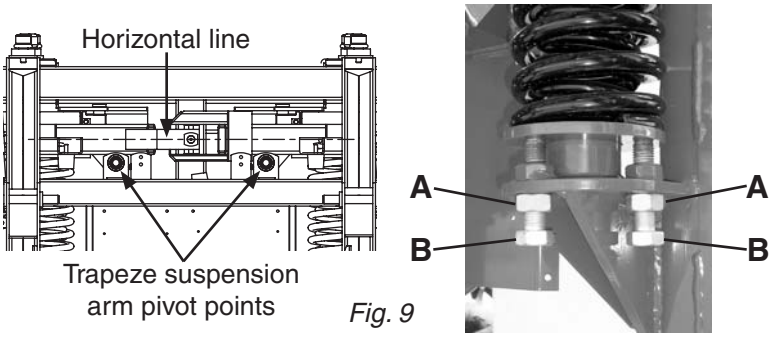


Fig. 9

Link Arms Length Adjustment

1. The link arm length should not normally need adjustment. If the suspension has been dismantled, the length must be checked or adjusted if necessary.
2. Loosen the jam nuts (**C**)(Fig. 10) on both sides of the link arms.
3. Adjust the length of all 4 of the arms (Fig. 10, Fig. 11) to initially measure 19-5/16" (490mm) from center of eyebolt to center of eyebolt.

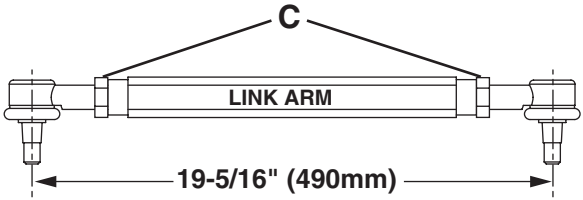


Fig. 10

4. The trapeze arms (**D**)(Fig. 11) must hang freely. Re-adjust the length of the link arms if necessary.
5. Tighten the jam nuts (**C**)(Fig. 10).

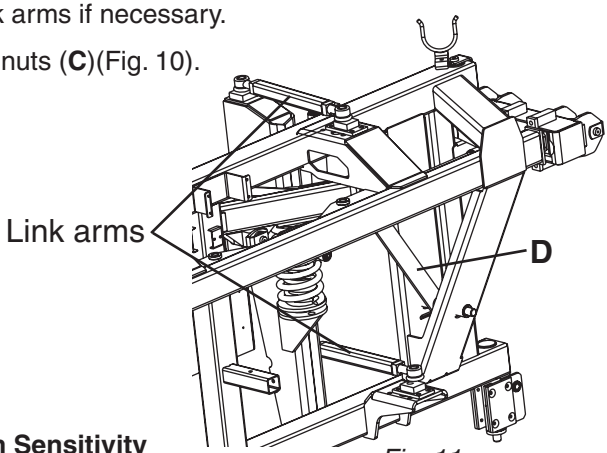


Fig. 11

Boom Suspension Sensitivity

The factory setting of the boom suspension should normally suit most conditions and will not require any adjustment. The suspension will keep the boom parallel to the ground and compensate for uneven ground.

However, special conditions or situations may require adjusting the suspension to react faster or slower. Fine tuning can be done by adjusting the inclination of the link arms.

When the RH and LH Link arm rods are parallel to each other (factory setting), the boom suspension will react immediately, but dampened. If the boom needs to follow the movements of the trailer more relaxed (less dampened), the link arms may be adjusted inwards at the rear.

80', 90', 100', 120', 132' Suspension Sensitivity Adjustment

Remove the 4 bolts (**E**)(Fig. 12) holding the link arm to the center section and move the rear of the link arm to one of the available set of holes.

Note: There are 3 possible positions for attaching the rear of each link arm to the center section. Make sure all 4 link arms are adjusted to the same position (outside, middle or inside).

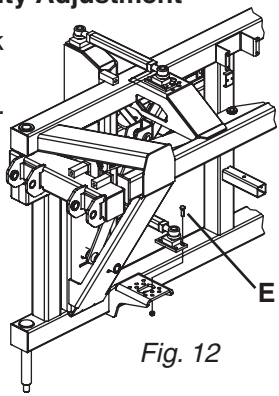


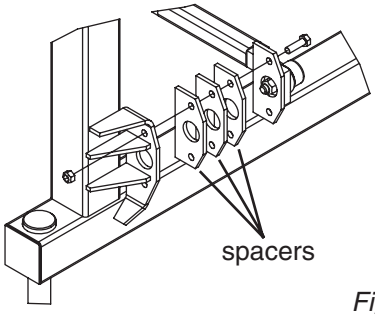
Fig. 12

WARNING: **WHEN MAKING ADJUSTMENTS TO THE CENTER SECTION, MAKE SURE THERE ARE SAFETY SUPPORTS (JACK STANDS) UNDER THE BOOM, IN CASE THE BOOM SHOULD FALL.**

110' Suspension Sensitivity Adjustment (Pre 2002)

Add 1-4 pcs. (#173388) of 8mm spacers as shown in (Fig. 13) at each rod until the desired dampening characteristics are reached.

For less aggressive "centering" (looser boom reaction) move the lower part of the trapeze arms from the outer position (**F**)(Fig. 13) to the inner position (**G**)(Fig. 13).



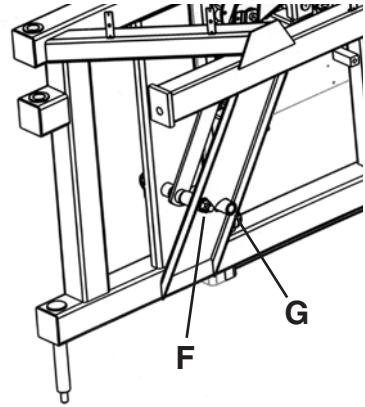


Fig. 13

B. Alignment of Inner Wing Sections

1. With the boom unfolded (in spraying position), check alignment of the inner wing section with the center frame.
2. With fold cylinder pressurized, determine if the inner wing section needs to be adjusted to the front or rear to come into alignment with center frame.

The boom tip must point slightly forward. If necessary, adjust the intermediate wing section as follows:

1. Depressurize the folding cylinders.
2. Loosen jam nut (**A**)(Fig. 14).
3. Adjust stop screw (**B**)(Fig. 14) until the correct setting is reached.
4. Tighten jam nut again.

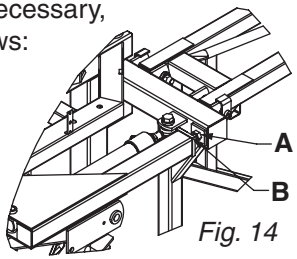


Fig. 14

Inner Wing Section

C. Intermediate and Outer Wing Level Adjustment (Tri-fold 100', 120' & 132' booms only)

The outer wing section needs to be level with the inner wing section. If necessary, adjust as follows:

1. To level the outer wing to the inner wing, loosen nut (**A**)(Fig. 15).
2. Adjust nut (**B**)(Fig. 15) towards nut (**A**)(Fig. 15) to raise the outer wing.
3. Adjust nut (**B**)(Fig. 15) away from nut (**A**)(Fig. 15) to lower the outer wing.
4. Tighten nut (**A**)(Fig. 15) after adjustment.

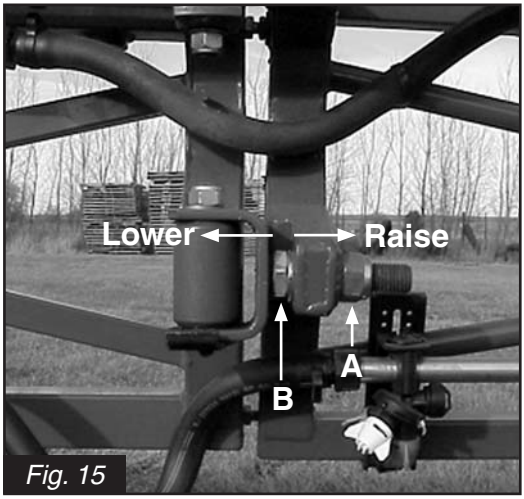


Fig. 15

D. Alignment of Intermediate and Outer Wing Sections

The outer sections must be aligned with the intermediate wing sections. Adjustment of the outer wing sections should be performed by two people as follows:

1. Depressurize the folding cylinder, disconnect both ends and set aside (leave hydraulics hooked up).
2. Loosen jam nuts (**A** and **C**)(Fig. 16).
3. Loosen the screws (**B**)(Fig. 16).
4. With one person holding the outer wing, adjust the stop screws (**B**)(Fig. 16) until the inner section is aligned with the outer section and both stop screws are contacting the outer section.
5. Tighten jam nuts (**A**)(Fig. 16).
6. Have one person adjust the rigging screw (**D**)(Fig. 16) until the outer wing section "snaps" into alignment and stays when the second person folds the outer section in a few feet and then back out against stop screws.
7. Tighten jam nut (**D**)(Fig. 16) and check the alignment. If needed, repeat the adjustment above.
8. Reconnect both ends of the folding cylinder.

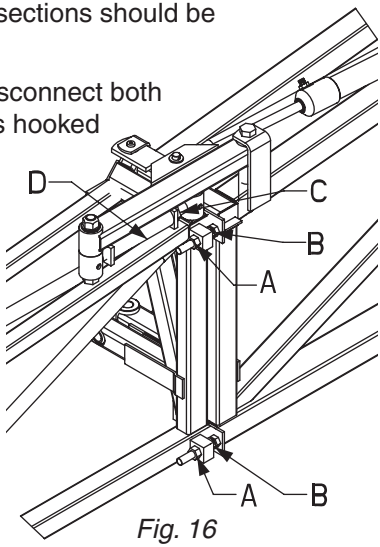


Fig. 16
Outer Section

Note: For tri-fold booms, repeat the above procedure for the outer fold section as well as the inner fold section.

E. Wing Tilt Adjustment

The horizontal alignment of the wings is done by adjusting the retracted tilt cylinder (Fig. 17). The boom tip must point slightly upward. If necessary, adjust the wing as follows:

1. Tilt wing approximately 15° up.
2. Loosen jam nut (**A**)(Fig. 17).

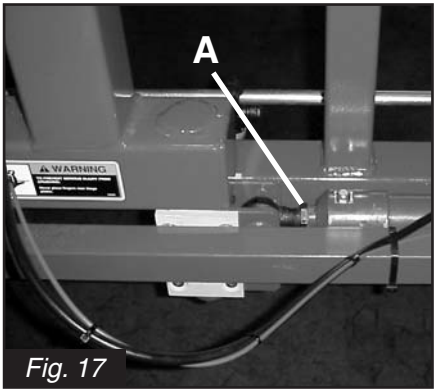


Fig. 17

3. With a wrench (use the two flattened spots on end of the ram), adjust the cylinder ram inwards or outwards to get the desired wing level.
4. Repeat steps for other side.

F. Alignment of Breakaway Section

WARNING: **NEVER PLACE FINGERS INTO OPEN BREAKAWAY CLUTCH OR YOU MAY BE INJURED SHOULD CLUTCH SNAP CLOSED! DO NOT TIGHTEN THE BREAKAWAY CLUTCH MORE THAN WHAT IS NECESSARY! OVER-TIGHTENING CAN CAUSE DAMAGE TO THE BOOM!**

The breakaway section must release when a force of approximately 35 lbs (150 N) is applied to the extremity of the breakaway section. If necessary, the release force is adjusted as follows:

1. Make sure the claw coupling is correctly lubricated.
2. Loosen the jam nut (**A**)(Fig. 18).
3. Adjust the nut (**B**)(Fig. 18) until the breakaway will release as desired.
4. Tighten the jam nut again.
5. Make sure the breakaway is level with the outer wing. If necessary, adjust by loosening locknut (**C**)(Fig. 18) and adjusting nut (**D**) (Fig. 18) until the breakaway is level. Tighten locknut (**C**)(Fig. 18) again.

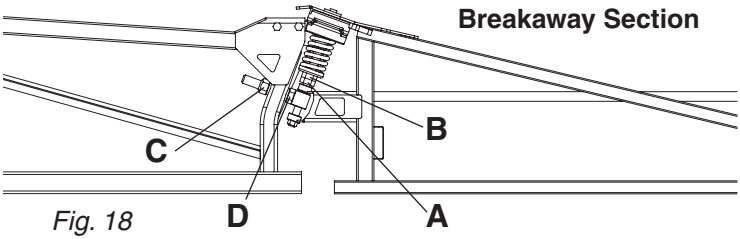


Fig. 18

G. Adjustment of Transport Stops

Adjustment of transport stops 100', 120' and 132'
Fold outer wing in and adjust boom stop for the breakaway (Fig. 19).

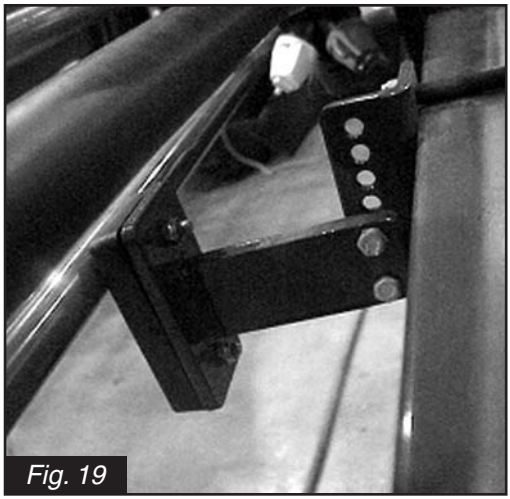


Fig. 19

Fold the intermediate wing in and adjust the other two boom stops to match the intermediate wings (Fig. 20) and (Fig. 21). The wing size will determine the placement of the boom stops (132' shown).

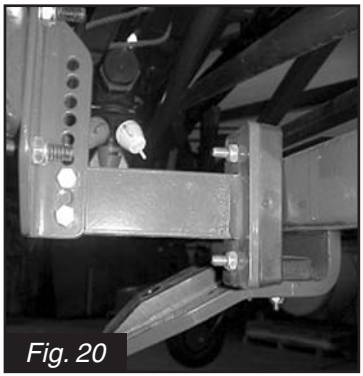


Fig. 20

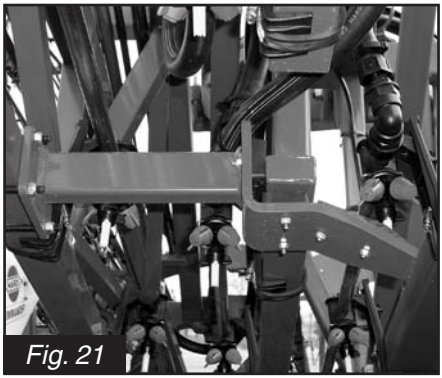


Fig. 21

Adjustment of transport stops 120' and 132'

Open the intermediate wing just enough to let the boom rest (**A**)(Fig. 22) move off the tube mount (**B**)(Fig. 23). In order to get maximum engagement when completely folded, loosen the U-bolts on the tube mount (**B**)(Fig. 23) and move it up until it makes contact with the pad on boom rest (**A**)(Fig. 22). Test the engagement by completely opening and then closing the wings. Re-adjust if necessary.

Fig. 22

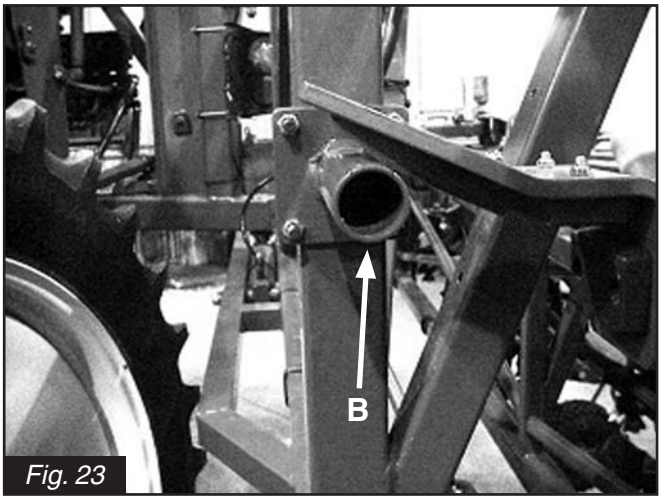


Fig. 23

7.3 Boom Transport Adjustments

Adjustment of Folded Wings

With the center section level (parallel) to the trailer, the boom wings should fold in to 1/2" from the vertical pads on the transport brackets (Fig. 24). If necessary, adjust as follows:

1. Position the wings in transport so that the inner wings are resting against the front transport bracket.

Note: Make sure that the wings are safely strapped and secured to the front transport bracket.

Fig. 24

2. Loosen jam nut (**A**)(Fig. 25) on the cylinder eye.
3. Remove bolt (**B**)(Fig. 25).
4. With the hydraulic controls, make sure that the fold cylinder rams are extended out to the maximum.
5. Adjust the cylinder eye inward or outward until bolt (**B**)(Fig. 25) can be replaced without force.
6. After proper adjustment, install bolt (**B**)(Fig. 25) and tighten jam nut (**A**)(Fig. 25) on the cylinder eye.
7. Repeat steps on the opposite side.

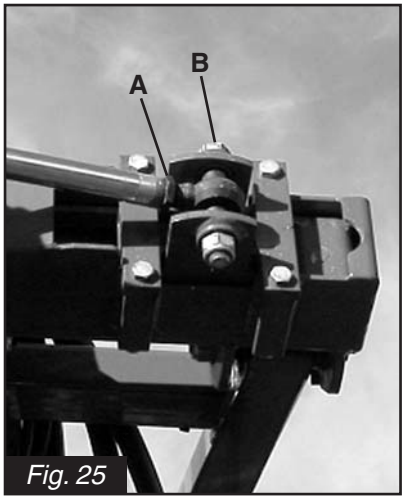


Fig. 25

Transport Brackets, Height Settings

The front transport brackets can be set in different positions to have different transport heights for suitable clearance above various tractor cabins.

Adjusting Rear Transport Hooks

The rear transport hooks (Fig. 26) should be adjusted so there is not only clearance for the tires (Fig. 27), but also clearance for the tractor cab (Fig. 28) at a full turn.

Note: Transport hook positions are not set at the factory for tractor or tire clearance. This adjustment needs to be made after connecting the sprayer to the tractor for the first time.

WARNING: **WHEN MAKING ADJUSTMENTS TO TRANSPORT HOOKS, MAKE SURE THERE ARE SAFETY SUPPORTS (JACK STANDS) UNDER THE BOOM, IN CASE THE BOOM SHOULD FALL.**

1. Raise the boom all the way up.
2. Fold the boom in and lower until it first touches the Transport Brackets.
3. Measure the distance from the rear of the boom to the ground and then lower the boom to fully rest into the Transport Brackets.

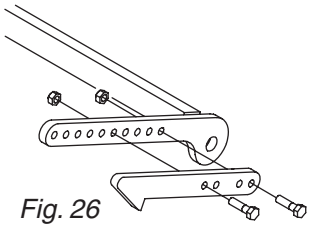


Fig. 26

4. Re-measure the distance from the rear of the boom to the ground. If the difference between the two measurements is greater than 2", then the transport hooks need to be re-adjusted.
5. Shorten the overall hook length (Fig. 26) by moving both sides in one hole.
6. Repeat steps 1-5 until the difference is less than 2".

Note: It may be necessary to raise the front transport brackets and repeat steps 1-5 if there is not enough tire clearance (Fig. 27) or tractor cab clearance (Fig. 28).

Fig. 27

Fig. 28

7.4 Boom Wheel Position

Boom wheel in transport position
(If traveling on roads where max. transport width of 12 ft. or greater is enforced)

1. Remove locking pin (**A**)(Fig. 29).
2. Move wheel position bar (**B**)(Fig. 29) to upper position (**C**)(Fig. 29), and insert locking pin.

Boom wheel in spray position

For boom wheel in spraying position, perform the above procedure in reverse so that the wheel is in the lower position.

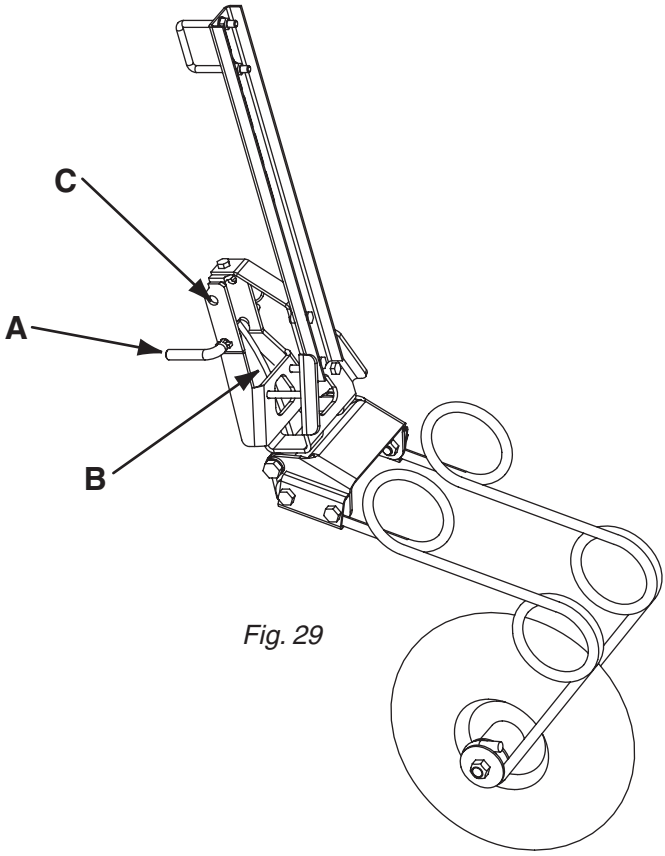


Fig. 29

7.5 Boom Hydraulic Adjustments

A. Fold Cylinder Activation Switches (Tri-fold 100', 120' & 132' booms only)

Tri-fold wings are equipped with hydraulic cylinder activation switches to operate the sequence of intermediate fold, then outer wing fold.

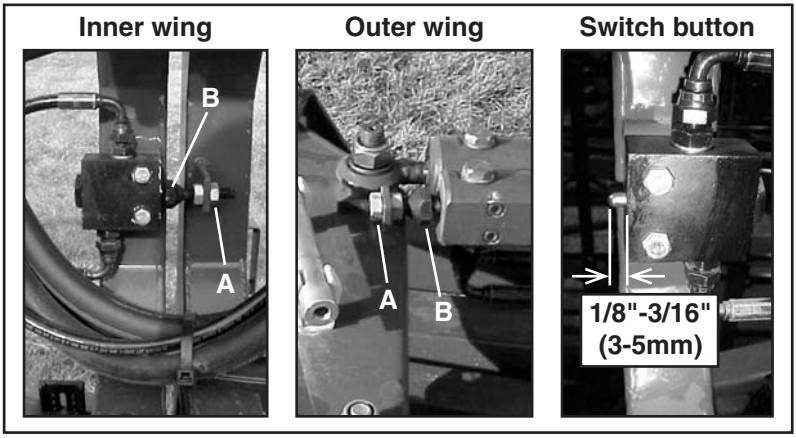


Fig. 30

If adjustment is needed, loosen jam nut (**A**)(Fig. 30) and adjust bolt (**B**)(Fig. 30) so it pushes the button on the switch 1/8" - 3/16" (3-5mm).

B. Fold Cylinder Flow Dividers

Force™ booms are equipped with two flow dividers that regulate simultaneous folding of inner and intermediate/outer wings. Flow dividers are factory set and should not need adjustment. If serviced or replaced, proper adjustment is necessary.

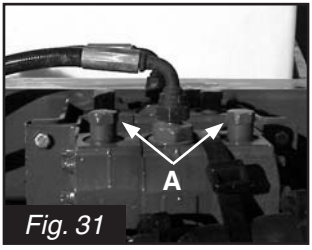


Fig. 31

1. Remove the caps (**A**)(Fig. 31).
2. With a 4mm hex wrench, close the set screws (**B**)(Fig. 32) completely. Then open 1 full turn each.
3. Replace caps (**A**)(Fig. 31) and tighten.

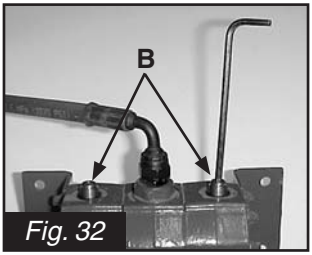


Fig. 32

C. Flow Control Valves (Tri-fold 100', 120' & 132' booms only)

Flow control valves on the outer wings are factory set (opened 1/3 turn) and should not need adjustment. If desired, the folding speed of the outer wings may be increased or decreased as follows:

1. Depressurize the fold cylinders and loosen the hydraulic hose fitting.

WARNING: **ESCAPING HYDRAULIC FLUID UNDER PRESSURE CAN PENETRATE THE SKIN, CAUSING SERIOUS INJURY. MAKE SURE THE PRESSURE IS RELIEVED BEFORE LOOSENING HYDRAULIC HOSE!**

2. Loosen jam nut (**B**)(Fig. 34) and adjust valve (**A**)(Fig. 34) to desired setting.
3. Tighten jam nut (**B**)(Fig. 34) and tighten hydraulic hose fitting.
4. Repeat same amount of adjustment on opposite wing.

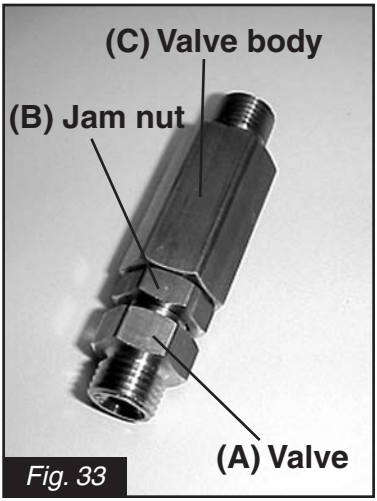


Fig. 33

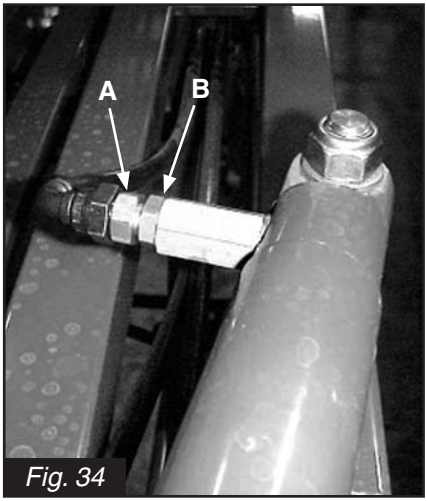


Fig. 34

8.0 MAINTENANCE

WARNING: **ALWAYS CLEAN YOUR BOOM AT THE END OF THE WORK DAY OR BEFORE SERVICING IS DONE TO AVOID UNNECESSARY CONTACT WITH CHEMICALS!**

Lubrication of the boom daily will ensure maximum performance and life. This lubrication includes Paralift™, center frame, suspension, wings and breakaway clutches.

8.1 Greasing the Paralift™

Every 8 hours (daily) new grease should be applied (Fig. 35).

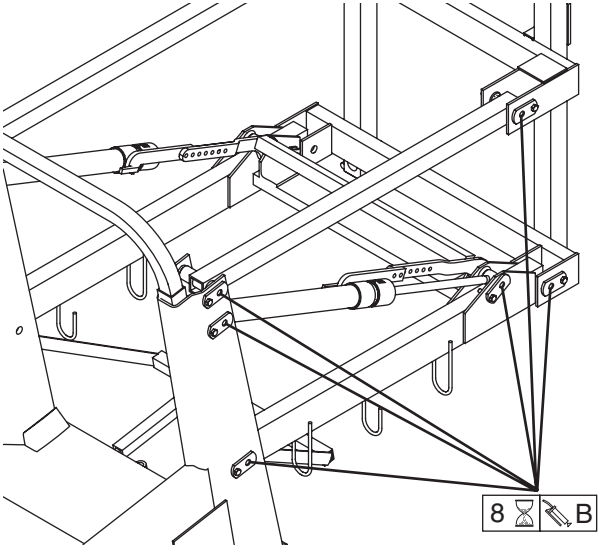


Fig. 35

8.2 Lubrication of the Lift Frame

Every 8 hours (daily) as indicated (Fig. 36).

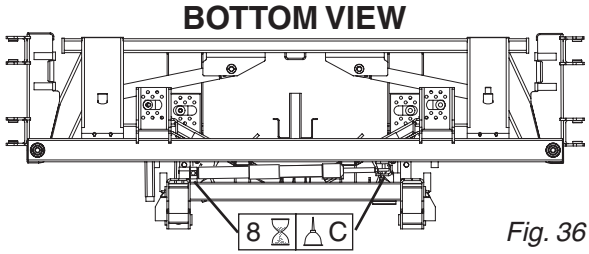
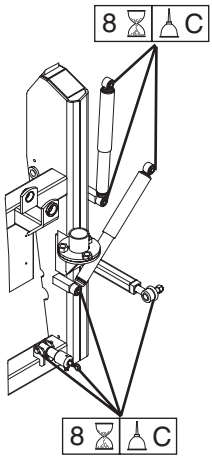


Fig. 36



8.3 Greasing the Center Frame

Every 8 hours new grease should be applied (Fig. 37).

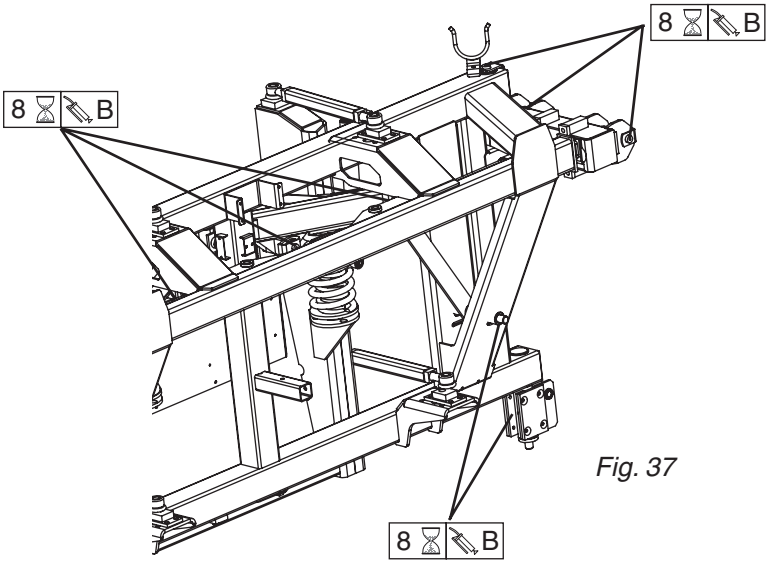


Fig. 37

8.4 Greasing the Boom

Every 8 hours new grease should be applied (Fig. 38).

Note: For tri-fold booms, grease the outer fold section as well as the inner fold section as shown below.

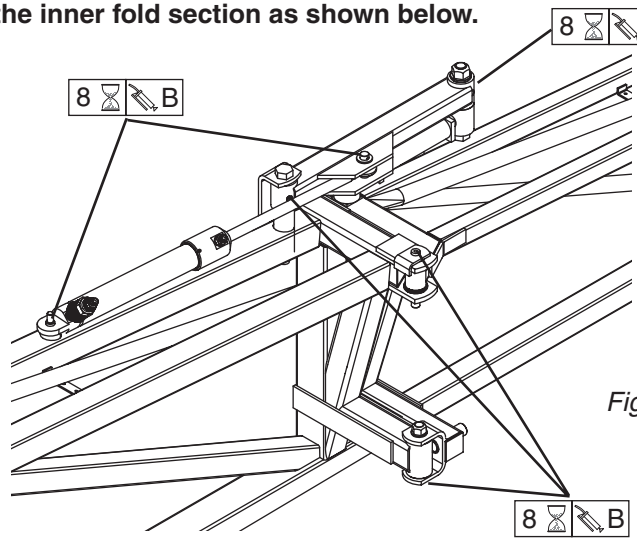


Fig. 38

8.5 Greasing The Breakaway Clutch

WARNING: **NEVER PLACE FINGERS INTO OPEN BREAKAWAY CLUTCH OR YOU MAY BE INJURED SHOULD CLUTCH SNAP CLOSED!**

1. Unfold the boom into operating (spraying) position.
2. Standing in front of the outer wing, snap the breakaway open by quickly pushing the boom away from you.
3. With the two clutches opened up, stick the nozzle of a grease gun into the clutch and apply a generous amount of grease (Fig. 39). This should be done every 8 hours.
4. Grease the zerk at the lower pivot point until new grease becomes visible. This should be done every 8 hours.

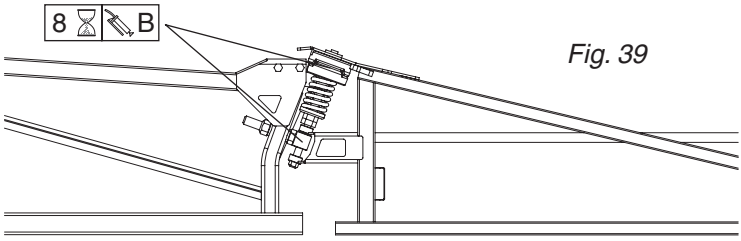


Fig. 39

8.6 Maintenance of Boom Wheel

1. Oil positions shown in (Fig. 40) every 8 hours to prevent rust and corrosion.
2. Maintain approx. 30 psi in tire.

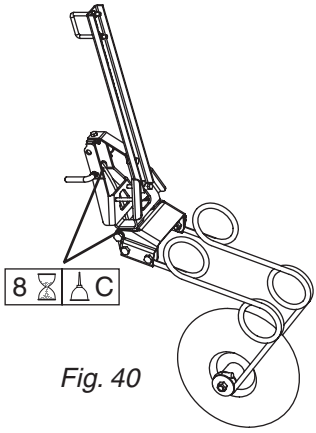


Fig. 40

WARNING: **DO NOT EXCEED MANUFACTURER'S MAX. 71 PSI IN TIRE OR SERIOUS INJURY COULD OCCUR IF THE TIRE SHOULD EXPLODE.**

8.7 Dampening Cylinder

The dampening cylinder on the FORCE™ boom is set at the factory to "dampen the oscillation" from the boom suspension and normally needs no adjustment. If adjustment is desired, use the following procedure.

1. Loosen the jam nut (**A**)(Fig.41).
2. Screw the adjustment screw (**B**)(Fig. 41) in all the way. Then back the adjustment screw out 2 turns.
3. If further adjustment is needed, turn adjustment screw "**IN**" to increase dampening, or "**OUT**" to decrease dampening.
4. When desired adjustment is reached, tighten jam nut (**A**)(Fig. 41).

Note: The adjustment screw must be at least 1/4 turn out (from all the way in) or seal damage may occur.

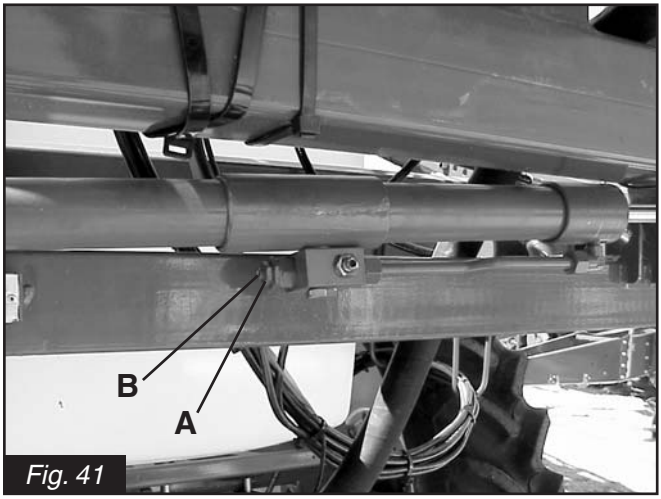


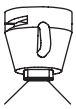
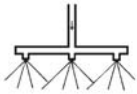
Fig. 41

8.8 Nozzle Filters

Each nozzle assembly is equipped with a 50 mesh filter screen as standard on units equipped with a 20 GPA Red ISO Color Tips™. Properly maintained suction filter and self cleaning filter will eliminate the plugging of screens and nozzles.

8.9 In-Line Filters (Optional)

If in-line filters are fitted, they should be cleaned every 8 hours (daily). Unscrew the bowl to remove sediment.

ISO Nozzle Size 	Nozzle Screen 	Inline Filters (optional) 
Pink (075) Orange (01) Green (015) Yellow (02)	100	100
Lilac (025) Blue (03)	80	80
Red (04) & Larger	50*	50*

***** Standard mesh

8.10 Nozzle Tubes And Fittings

Poor seals are usually caused by:

- Missing O-rings or gaskets
- Damaged or incorrectly seated O-rings
- Dry or deformed O-rings or gaskets
- Foreign materials

Therefore, in case of leaks; **DO NOT** overtighten any fittings. Disassemble, check the condition and position of the O-ring or gasket, clean, lubricate and then reassemble. For **radial** seals (O-ring) only hand tighten the fittings. Do not use pliers or wrenches.

The O-rings (**A**)(Fig. 42) need to be lubricated **ALL THE WAY AROUND** before mounting fittings on to the stainless steel nozzle and feed tubes.

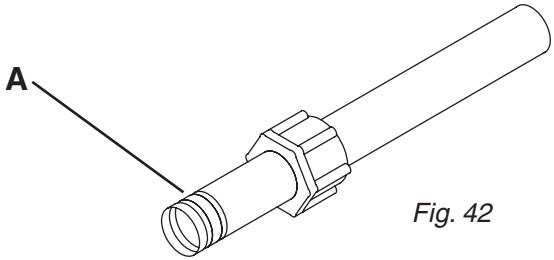


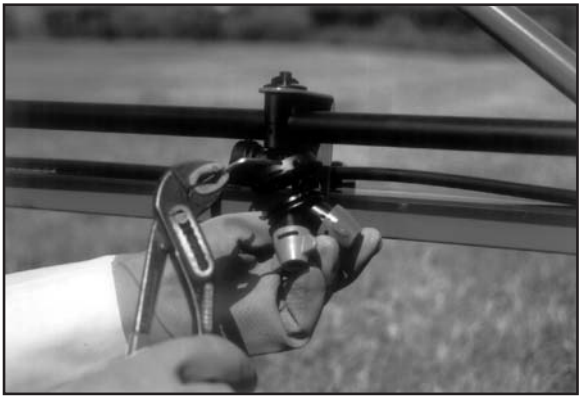
Fig. 42

HARDI® recommends using a vegetable based oil to prolong the life of the O-ring.

8.11 Maintenance Of Triplets

Every 50 hours the triplets should be disassembled and cleaned. This is done by pulling out the stainless clip on the side of the triplet assembly. Clean the bottom part as well as the top part thoroughly. Coat the O-ring with a light film of vegetable oil if the sprayer is to be stored for a long period of time.

If the triplets are not cleaned regularly, they will not rotate readily and possible damage to them may occur.



WARNING: **NEVER SERVICE YOUR CONTAMINATED NOZZLES WITHOUT WEARING CHEMICAL RESISTANT GLOVES AND SAFETY GOGGLES.**

8.12 Outer Wing Shear Pin

Force™ 100', 120' and 132' tri-fold booms that have a shear pin on the outer fold will need the shear pin replaced if the boom has a severe ground strike or hits an obstruction.

To replace the shear pin, depressurize the fold cylinder, remove the cotter pin (**B**)(Fig. 44) and discard remaining shear pin pieces. Align the fold mechanism bushing with the wing bushings and install the spare shear pin (**A**)(Fig. 43). Align the hole in the shear pin with the hole in the upper wing bushing and replace the cotter pin (**B**)(Fig. 44). Order a new shear pin (#14012300) as soon as possible.

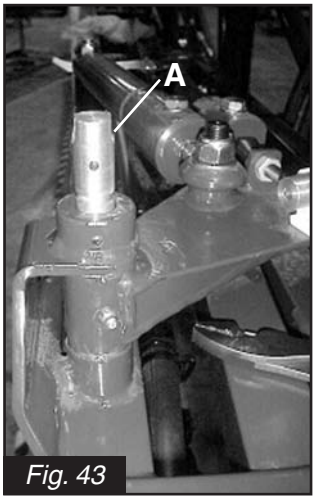


Fig. 43

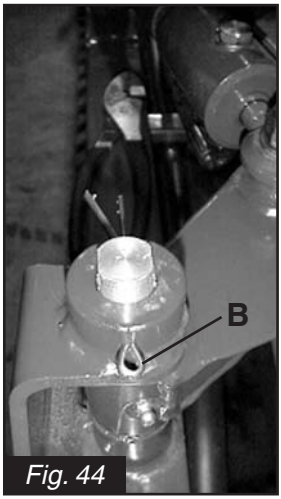


Fig. 44

9.0 TRANSPORTATION AND STORAGE

9.1 Follow Safe Transport And Towing Procedures

WARNING: **KEEP AWAY FROM OVERHEAD POWER LINES TO AVOID SERIOUS INJURY OR DEATH TO YOURSELF OR SOMEONE ELSE. KNOW THE TRANSPORT HEIGHT OF YOUR MACHINE.**

- Keep all persons away from machine when folding boom.
- When transporting sprayers equipped the with FORCE™ booms, only transport if Paralift™ hooks are engaged and the boom is folded and resting on the front transport brackets.
- Ensure rear transport hook on Paralift™ is engaged properly.
- Maximum transport speed is 15 mph (24 km/h).
- Have warning lights flashing when transporting or towing sprayer.

HARDI® FORCE™ Boom (110' shown)

9.2 Winter Storage

When the spraying season is over you should devote some extra time to cleaning and preparing the sprayer for storage.

Hoses

Check that none of the hoses are caught or have sharp bends. A leaky hose can give an annoying delay in the middle of the spraying job. Therefore check all the hoses and change them if there is any doubt about the physical condition.

Paint

Some chemicals are very hard on paints. It is therefore recommended to remove rust, if any, and then touch up the paint.

Anti-freeze Precaution

If the FORCE™ boom is not stored in a frost-free place, you should take the following precautions:

1. Drain as much water as possible from sprayer.
2. Pour in a mixture of ethylene glycol base anti-freeze and water at the ratio for the desired temperature protection (Volume of mixture should be about 1% of tank volume).
3. Run the sprayer and circulate the anti-freeze in the pump, controls and boom lines. The anti-freeze solution prevents the O-rings and gaskets from drying out.

WARNING: **NEVER USE OIL OR DIESEL FUEL IN A SPRAYER.**

Remove nozzles and screens. Clean and store in a safe, dry location away from children and animals. Remove pressure gauges and store upright in a warm dry location.

10.0 TROUBLESHOOTING

10.1 Hydraulic Systems

Problem	*Solution*
1. The boom moves too quickly when unfolding/folding.	A. Adjust the hydraulic flow control on the tractor. B. Check for restrictor (0.7mm) in return side of cylinder. C. Bleed air from hydraulic system. D. Adjust flow dividers.
2. Hydraulic system fold/tilt functions will not operate.	A. Check for proper 12V power supply.
3. One function (fold or tilt) will not operate.	A. Check for defective switch(es). B. Check continuity of cables. C. Check for operation of applicable solenoid (coil not activating or plunger stuck). D. Check for short circuit in wiring junction box at rear of sprayer. E. Dirt in the restrictor port of the cylinder.
4. Multiple hydraulic functions with one switch activated.	A. Check for correct solenoid electric/hydraulic hook-up. B. Check for short circuit in wiring in the junction box at rear of sprayer.
5. One side of boom moves faster when folding.	A. Adjust the flow divider. B. Dirt in restrictor port on the solenoid block.

'DH' Hydraulics

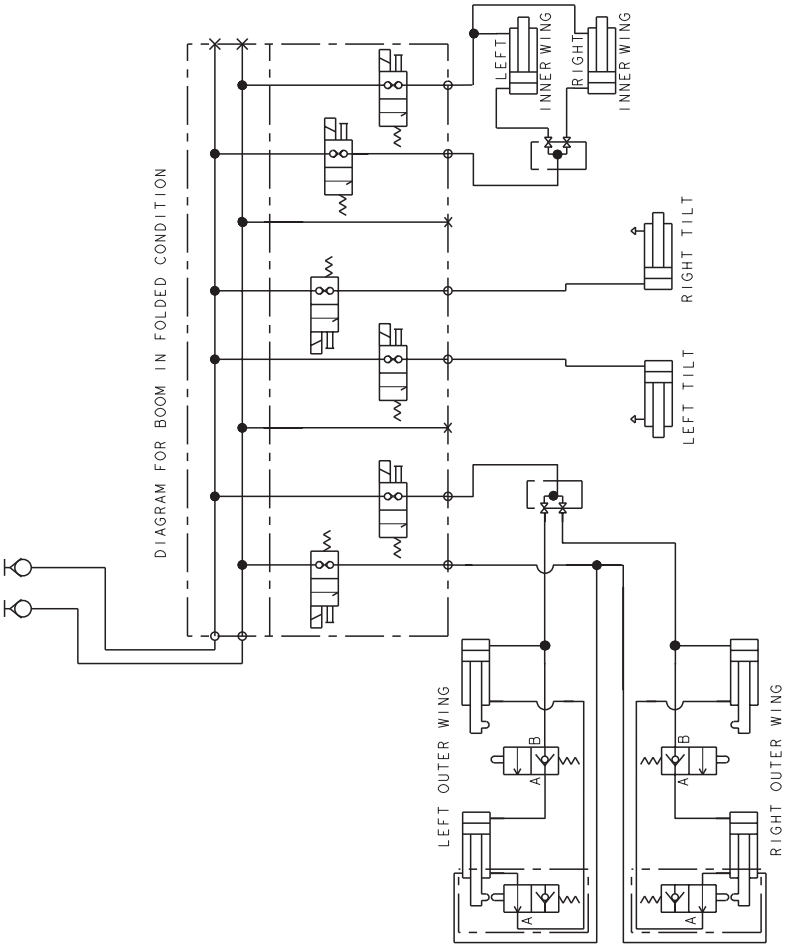
Problem	*Solution*
1. Hydraulic cylinder only moves one way.	A. Check for electrical operation of Directional Solenoid Valve. B. Check hook-up of hydraulic hoses on Directional Solenoid Valve block. **P** = Pressure from tractor **T** = Return to tractor **A**,**B** = Supply/return to solenoid block on spray boom.
2. One hydraulic function will not operate.	A. Check for electronic operation of directional solenoid valve. B. Check for electronic continuity through multi-pin plugs.

10.2 Mechanical Problems

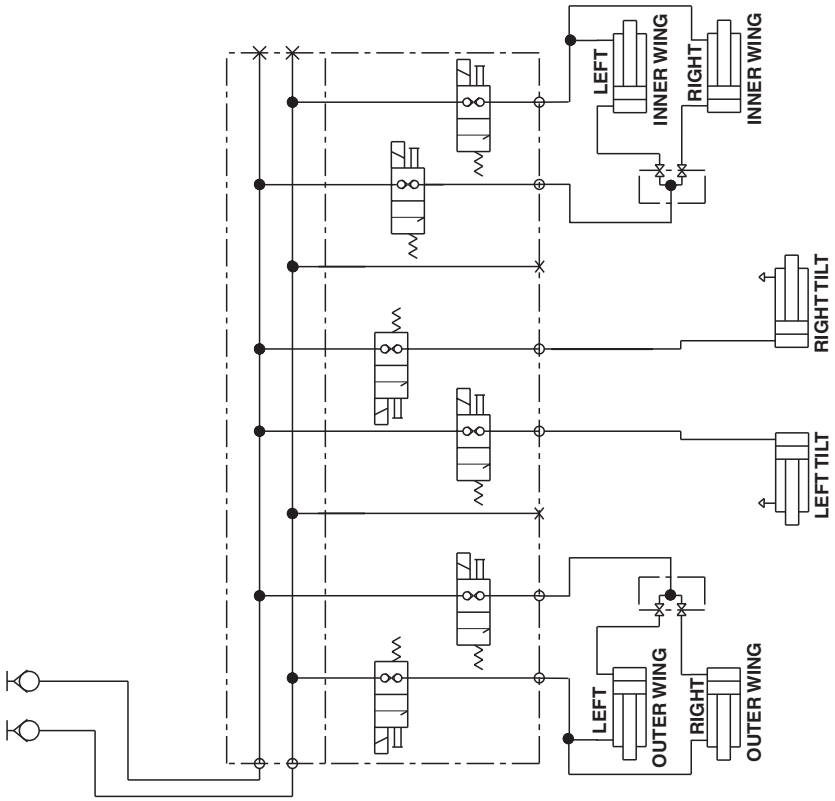
Problem	*Solution*
1. Boom will not completely fold in or out.	A. Adjust the fold cylinder. (Section 7.2B,D & 7.5) B. Adjust stop bolt (Sec 7.2B,D)
2. Boom not in alignment.	A. Check for hydraulic leak through solenoid block. B. Check for a solenoid that is stuck open. C. Re-adjust boom section (Sec 7.2)
3. Boom won't stay in spray position.	A. Recharge cylinders by completely folding in the boom and unfolding the boom. B. Check for hydraulic leak through solenoid block. C. Check for a solenoid that is stuck open.
4. Breakaway won't hold outer wing stable.	A. Adjust breakaway (Section 7.2F), replace clutches if worn.

10.3 Hydraulic Schematics

HZ Schematic CM1200 100' - 132' FORCE™



HZ Schematic CM1200 80', 90' AND 110' (Pre 2002) FORCE™



11.0 WARRANTY POLICY AND CONDITIONS

HARDI® INC. , 1500 West 76th Street, Davenport, Iowa, USA; 8550 W. Roosevelt Avenue, Visalia, California, USA and 290 Sovereign Road, London, Ontario, Canada hereinafter called "HARDI®", offers the following limited warranty in accordance with the provisions below to each original retail purchaser of HARDI® new equipment of its own manufacturer, from an authorized HARDI® dealer, that such equipment is at the time of delivery to such purchaser, free from defects in material and workmanship and that such equipment will be warranted for a period of one year from the date of delivery to the end user providing the machine is used and serviced in accordance with the recommendations in the Operator's Manual and is operated under normal farm conditions.

1. This limited warranty is subject to the following exceptions:

   a) Parts of the machine not manufactured by HARDI®, (i.e. engines, tires, tubes, electronic controls, and other components or trade accessories, etc.) are not covered by this warranty but are subject to the warranty of the original manufacturer. Any claim falling into this category will be taken up with the manufacturer concerned.

   b) This warranty will be withdrawn if any equipment has been used for purposes other than for which it was intended or if it has been misused, neglected, or damaged by accident, let out on hire or furnished by a rental agency. Nor can claims be accepted if parts other than those manufactured by HARDI® have been incorporated in any of our equipment. Further, HARDI® shall not be responsible for damage in transit or handling by any common carrier and under no circumstances within or without the warranty period will HARDI® be liable for damages of loss of use, or damages resulting from delay or any consequential damage.

2. We cannot be held responsible for loss of livestock, loss of crops, loss because of delays in harvesting or any expense or loss incurred for labor, supplies, substitute machinery, rental for any other reason, or for injuries either to the owner or to a third party, nor can we be called upon to be responsible for labor charges, other than originally agreed, incurred in the removal or replacement of components.

3. The customer will be responsible for and bear the costs of:

   a) Normal maintenance such as greasing, maintenance of oil levels, minor adjustments, etc.

   b) Transportation of any HARDI® product to and from where the warranty work is performed.

   c) Dealer travel time to and from the machine or to deliver and return the machine from the service workshop for repair.

   d) Dealer traveling costs.

4. Parts defined as normal wearing items, (i.e. tires and V-belts) are not in any way covered under this warranty.

5. This warranty will not apply to any product which is altered or modified without the express written permission of HARDI® and/or repaired by anyone other than an Authorized Service Dealer.

6. Warranty is dependent upon the strict observance by the purchaser of the following provisions:

   a) That this warranty may not be assigned or transferred to anyone.

   b) That the Warranty Registration Certificate has been correctly completed by dealer and purchaser with their names and addresses, dated, signed and returned to the appropriate address as given on the Warranty Registration Certificate.

   c) That all safety instructions in the operator's manual shall be followed and all safety guards regularly inspected and replaced where necessary.

7. No warranty is given on second-hand products and none is to be implied.

8. Subject to the following terms, conditions and contributions, HARDI® extends the warranty on polyethylene tanks (excluding fittings, lids and gaskets) to FIVE YEARS. To qualify for this extended warranty, the tank must be drained and flushed with fresh water after each day of use. HARDI®'s liability is limited to replacement of the tank, FOB our plant at no cost to the purchaser during the first twelve months; at 20% of the then current price during the second year ; at 40% during the third year ; at 60% during the fourth year ; and at 80% during the fifth year. This five year extended warranty is subject, in each instance, to the tank being inspected and approved for replacement or repair by HARDI® personnel before HARDI® will accept any liability hereunder.

9. Subject to the following terms, conditions, contributions, HARDI® extends the warranty on HARDI® diaphragm pumps (excluding wearing parts such as diaphragms, valves, etc.) to FIVE YEARS. To qualify for this extended warranty, the pump must be drained and flushed with fresh water after each day of use. Hardi®'s liability is limited to replacement of defective parts, FOB our plant at no cost to the purchaser during the first twelve months after date of purchase, at 20% of the then current retail price during the second year ; at 40% during the third year ; at 60% during the fourth year ; and at 80% during the fifth year. This five year extended warranty is subject, in each instance, to the pump being inspected and approved for replacement or repair by HARDI® personnel before HARDI® will accept any liability hereunder.

10. HARDI® reserves the right to incorporate any change in design in its products without obligation to make such changes on units previously manufactured.

11. The judgement of HARDI® in all cases of claims under this warranty shall be final and conclusive and the purchaser agrees to accept its decisions on all questions as to defect and to the exchange of any part or parts.

12. No employee or representative is authorized to change this warranty in any way or grant any other warranty unless such change is made in writing and signed by an officer of HARDI® at it's head office.

13. Any warranty work performed which will exceed $400.00 MUST be approved IN ADVANCE by the Service Manager.

14. Any pump replacement must be approved in advance by the Service Manager.

15. Claims under this policy must be filed with HARDI® within thirty (30) days of work performed or warranty shall be void.

16. Parts requested must be returned prepaid within thirty (30) days for warranty settlement.

17. Warranty claims must be COMPLETELY filled out properly or will be returned.

DISCLAIMER OF FURTHER WARRANTY

THERE ARE NO WARRANTIES, EXPRESSED OR IMPLIED, EXCEPT AS SET FORTH ABOVE. THERE ARE NO WARRANTIES WHICH EXTEND BEYOND THE DESCRIPTION OF THE PRODUCT CONTAINED HEREIN. IN NO EVENT SHALL THE COMPANY BE LIABLE FOR INDIRECT, SPECIAL OR CONSEQUENTIAL DAMAGES (SUCH AS LOSS OF ANTICIPATED PROFITS) IN CONNECTION WITH THE RETAIL PURCHASER'S USE OF THE PRODUCT.

12.0 NOTES

NOTES