

Building a Hydraulic Ram

by Don Marier

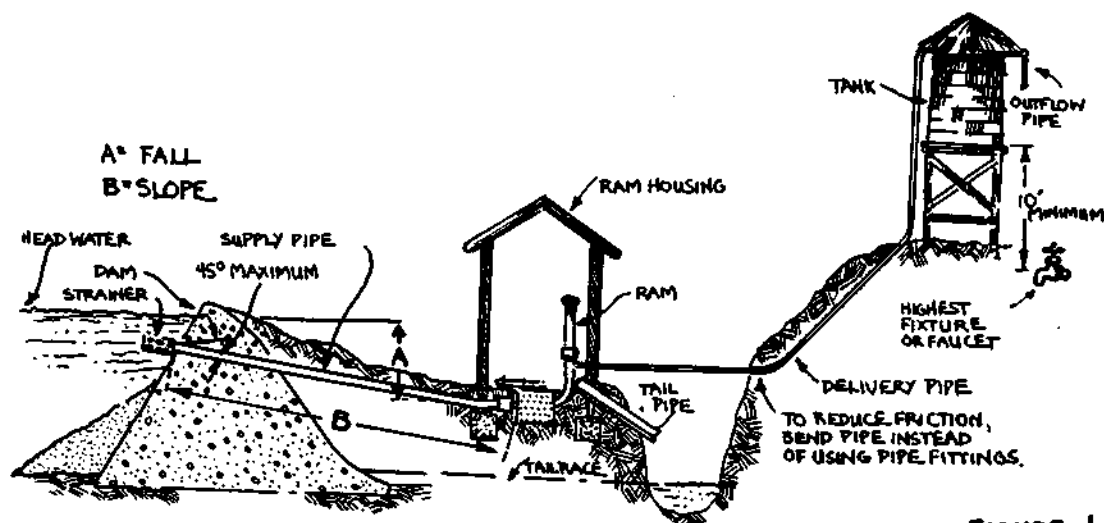


FIGURE 1

I'm always interested in getting something for nothing, so I find hydraulic rams intriguing. They pump water using water — no gas, oil, or electricity is needed. You do need a stream, artesian well, or a spring as a source, though, so not everyone can use one.

The hydraulic ram was invented about 150 years ago and was fairly well widespread in use, until electricity came to the countryside. There are still a few of them around and you may be lucky enough to find one, on an old farm.

I first saw a ram in 1970, when I noticed one in my father-in-law's toolshed in northern Wisconsin. It looked like some type of pump with an octopus- or bulb-shaped chamber on top. My father-in-law still had copies of the sales information on the ram (see references 1 and 2 at end). I was able to get the ram working by reading this information. It's too bad they don't explain how things work anymore.

I took the ram apart, expecting to find a series of chambers and valves inside the bulb, but all I found was one simple leather valve. The leather had lost its zip after 25 years, so I replaced it. With this simple repair done, I installed the ram near a pond with a two-foot dam on it. The ram was irrigating the garden within a few hours.

The ram looked so simple that I began to think of ways to build one out of regular plumbing parts. Two weeks later, I found out that the people at VITA had just put out a manual — *A Hydraulic Ram for Village Use* — on how to do just that (page 52). Since then, I also found a *Popular Science* article on building a ram (page 57). As a future project, I'd like to combine the best of both designs.

I built a ram according to VITA's plans and I'm satisfied with the results. It cost me about \$18 worth of parts but that's only about one-tenth the cost of buying a factory-made ram. The parts list calls for regular plumbing parts such as tees, couplings, and bushings. A two-foot section of three-inch pipe with a cap on it serves as the air chamber. The plans are detailed and the parts list is complete.

I made one major modification in VITA's plans that I wouldn't recommend. I used plastic sewer pipe rather than galvanized pipe. I did this because I didn't have the facilities for some of the machining operations called for in the plans and plastic is easier to work with. I got by with this variation, as it turns out, because the ram was operated at very low pressure. If it had operated at higher pressures, chances are it wouldn't have worked. I don't see why plastic water pipe wouldn't work, though.

I also modified VITA's plans by using a leather valve from a hand pump rather than the homemade one called for in the plans.

A diagram of a typical ram is shown in Fig. 1. Here's how it works. Water rushes down the drive pipe and escapes out the waste valve until enough pressure is built up to close the waste valve. The amount of this pressure increases as the fall increases. The fall is the vertical distance from the water to the ram.

When the waste valve closes, water is forced through the check valve and into the air chamber. The rushing water compresses the air in the chamber and the compressed air pushes back like a piston. This action closes the check valve and forces water up the delivery pipe to a storage tank.

When the check valve closes, the water in the drive pipe rebounds for a moment. This action created a partial vacuum which allows the waste valve to drop open again. When the waste valve opens, the excess water which was not forced up the delivery pipe flows out of the waste valve. The partial vacuum also draws a small amount of air into the ram through the air valve or "snifter" which is just below the air chamber. This air will be forced into the air chamber when the water starts slowing down the drive pipe again. The air is needed to replenish the air supply in the chamber because some is mixed with the water during each cycle. A small amount of water is lost through the air valve during each cycle but it is very small and it serves to keep the valve clean.

The cycle just described is repeated about 25 to 100 times a minute. How fast it is repeated depends on how much tension is put on the waste valve spring by means of adjusting screws. The slower the ram pumps, the more water it will pump, so the waste valve tension is adjusted for the minimum number of strokes per minute at which the ram will still operate. I had to build the waste valve spring a couple of times so that it lined up properly and had the correct tension. Otherwise, the pressure would not build up properly and the ram would not work.

How much water the ram will pump can be calculated from the following formula:

$$D = \frac{S \times F}{L} \times \frac{2}{3}$$

Where:

D is the amount of water delivered in gal./min.

S is the amount of water supplied to the ram in gal./min.

F is the fall, or the vertical difference in height between the ram and the storage tank

L is the lift, or the vertical distance the water is lifted from the ram to the storage tank

The $\frac{2}{3}$ represents the efficiency of the ram. Older rams had efficiencies of about 40%

The minimum fall a ram will work with is 18" and this is the fall I had to work with. I measured the supply flow to be 10 gallons per minute by catching the water in a pail and timing how long it took to fill. The lift I used was 10'. Thus the amount of water I should have expected to be delivered was:

$$D = \frac{10 \text{ gal./min.} \times 1\frac{1}{2}'}{10 \text{ ft.}} \times 2 = 1 \text{ gal./min.}$$

I actually measured about .5 gallons per minute.

It sounds "inefficient" to use 10 gallons of water to pump one gallon, but if you figured it out, one gallon per minute adds up to 1440 gallons per day, since the ram pumps constantly, unlike a windmill. Besides, that nine gallons which went out the waste valve isn't really wasted since it can be returned to the stream or can be used for any convenient purpose.

You can't pump the water to an indefinite height since pipe friction slows the water down. Friction is kept to a minimum by using sufficiently large pipe and by keeping connections and bends to a minimum. It is much better to bend a long piece of pipe at a gradual angle than to use

sections of pipe which are connected together at a sharp angle. The VITA ram calls for a 1½" drive pipe with a 1" delivery pipe. Garden hose is out of the question because all the bends would produce too much friction.

The drive pipe should be between five and ten times the height of the fall and should not be more than 30 degrees from the horizontal. Audel's book on water supply has a good chapter on hydraulic rams. According to Audel, the delivery pipe should not be more than 20 times the lift height in length. Also, according to Audel, if a storage tank is used, it should be at least 20' from the highest plumbing outlet. This is to guarantee a minimum of eight pounds of pressure. Storage tanks must be insulated from freezing in cold climates so a better solution might be to use a pressure tank like those used with electric pumps.

Other precautions are to put a small house around the ram to keep it from freezing and to put a piece of screen over the supply pipe intake to prevent leaves from clogging the ram.

The only company I know of that still makes hydraulic rams is the Rife Company. Their rams cost about \$180 and up. This is more than the cost of a regular pump but then there are no electricity costs and, with only two moving parts, a ram should last a lifetime. Rife also sells double-acting rams which allow you to pump pure spring water using water from a nearby stream.

My next project is to build another ram based on the VITA and Popular Science designs. My objective is to use only parts that can be bought in a hardware store and to limit machining operations to drilling a couple of holes.

References

1. **Gould's Hydraulic Rams**, Gould Pumps, Inc., Seneca Falls, N.Y. (about 1945). No longer available.
2. **Montgomery Ward Hydraulic Rams for Running Water Without Power**, Montgomery Ward Co., Chicago (about 1945). No longer available.
3. **A Hydraulic Ram for Village Use** by Ersal W. Kindel, Volunteers for International Technical Assistance (VITA), 3706 Rhode Island Ave., Mt. Rainier, MD 20822.
4. "Hydraulic Ram Forces Water to Pump Itself", **Popular Science**, by A. W. Kaufmann, October 1948, pp 231-233.
5. **Domestic Water Supply and Sewage Disposal Guide**, by Edwin P. Anderson. Theodore Audel & Co., New York, 1967. (Chapt. 10 is on hydraulic rams.)
6. **Manual of Information: Rife Hydraulic Water Rams**, Rife Hydraulic Engine Mfg. Co., Box 367, Millburn, NJ 07041. 1968.

A Village Ram

by Ersal Kindel

A hydraulic ram is a simple device, invented about 150 years ago. It uses the power from falling water to force a small portion of the water to a height greater than the source. Water can be forced about as far horizontally as you desire, but greater distances require larger pipe, due to friction. There is no external power needed and the ram has only two working parts. The only maintenance needed is to keep leaves and trash cleaned away from the strainer on the intake and to replace the clack and non-return or delivery valve rubbers if they get worn. The original cost is almost the only cost.

Two things are needed to make the ram work: (a) enough water to run the ram and (b) enough height for water to fall through the drive pipe to work the ram. A small amount of water with plenty of fall will pump as much water as a greater amount of water with only a little fall. The greater the height to which the water must be raised, the less water will be pumped, under a given set of circumstances.

Water may come from a spring on a hillside or from a river. It must be led into a position from which it can pass through a relatively short supply pipe to the ram, at a fairly steep angle (about 30 degrees from the horizontal is good). Often a catch basin or cistern is used as the source for the drive pipe, but an open ditch such as that which supplies a water posho mill could be used. Be sure to put a strainer on the top of the drive pipe to keep trash out of the pipe and ram.

The water starts to run down through the drive pipe, going faster and faster till it forces the automatic valve or clack to close suddenly. The weight of the moving water, suddenly stopped, creates very high pressure and forces some of the water past the non-return or delivery valve and into the air chamber, compressing the air more and more till the energy of the moving water is spent. This compressed air acts as a spring and forces the water up the delivery pipe to the storage tank in a steady stream. It takes a lot of falling water to pump a little water up a hill. Often about one part in ten is delivered to the storage tank at the top of the delivery pipe. The snifter hole wastes a bit of water but takes in a bubble of air with each stroke. This is necessary to keep air in the air dome and it must not get plugged or the air dome will get filled with water and the ram will stop. The small ram works best at about 75 to 90 strokes per minute, depending on the amount of drive water available. The slower it goes, the more water it uses but the more it pumps.

Any working fall from 18" to 100' can be used to work a ram, but in general, the more working fall you obtain, the less the ram will cost and the less drive water it will require to raise a given amount of water. If there is plenty of water, a fall of four feet could be made to raise water 800' but this would be an expensive installation.

Our ram at Kaimosi farm is a very small one and has a small amount of water to run it, but there is plenty of fall and not very much lift.

Head 20', lift 44' uses 8.4 gal./min.

Drive pipe 85', run 690', delivers 1-2/3 gal./min.
= 100 gal./hr. or 2400 gal. in 24 hr.

Unless you have practically unlimited water available, measure it exactly by making a temporary dam and putting a large pipe or two through it. Then catch and measure the water for, say, 15 minutes. Next sight along a carpenter's level to the top of a 10 ft. pole set on the ground down the hill at a lower level. Then move the level to the pole's position and sight again to the top of the pole, finding how many levels or fractions you have, and this will give you when added together, the amount of fall for the drive pipe. Do the same for the height to which the water must be raised. This height is measured from the ram level. For a more elaborate method of measuring fall, refer to **Cloudburst 1**, page 43.

A factory-built ram is more efficient but costs more. This small ram you can make up yourself from pipe fittings and you only have to buy or build the clack and delivery valve assemblies.

Building the Ram

Start by building the clack valve. If you do not have a metal lathe, a machine shop will do the work for a small price. Chuck a 3" x 1" pipe bushing in the lathe and turn the inside smooth, where the clack strikes. Turn out the threads and eliminate any sharp edges. Drill two 1/4" holes near the end of a piece of strap iron 1/4" x 1 1/2" x 2" and, using it as a template, drill and tap holes in the top of the pipe bushing. Grind off the galvanizing, then bolt the clack spring support solidly to the bushing and braze it also. Bend a 36" iron strap, 1 1/2" x 1/8", around a 2" pipe to make the clack spring. Drill two 1/2" holes through the end and also through both the support and two short pieces to make up the pad as shown in the drawing. Cut pieces of rubber inner tube and assemble the sandwich. This is to keep vibration from breaking the support off the pipe bushing. A brace can be added for additional support but is not absolutely necessary.

The clack valve itself is made up of a rubber disc and metal washer 3/8" smaller than the inside of your bushing and assembled on a 3/8" x 4 1/2" bolt. The best rubber I have found is from an old tractor tire — it shows no wear at all after 8 months' use. I cut it on a band saw and sanded it flat and even on a disc sander with coarse paper. A similar one is used for the check valve. Slip a washer over the bolt and a short length of thin wall steel tube (3/4" o.d. conduit) with the ends filed exactly square. Then put it through a hole in the clack spring. Adjust by bending so the rubber clack strikes true and doesn't rub on the sides of the bushing.

Drill a hole for a carriage bolt to adjust the stroke of the spring; also a pair of holes about three inches from the round end of the spring for a tension bolt. If the bottom hole is filed square to fit the under side of the bolt, it will not turn when adjustments are made.

The check valve is similar in construction but a 1/2" x 2" galvanized bolt is used. Machine the lip true where the valve rests but do not cut it down farther than necessary. This gives

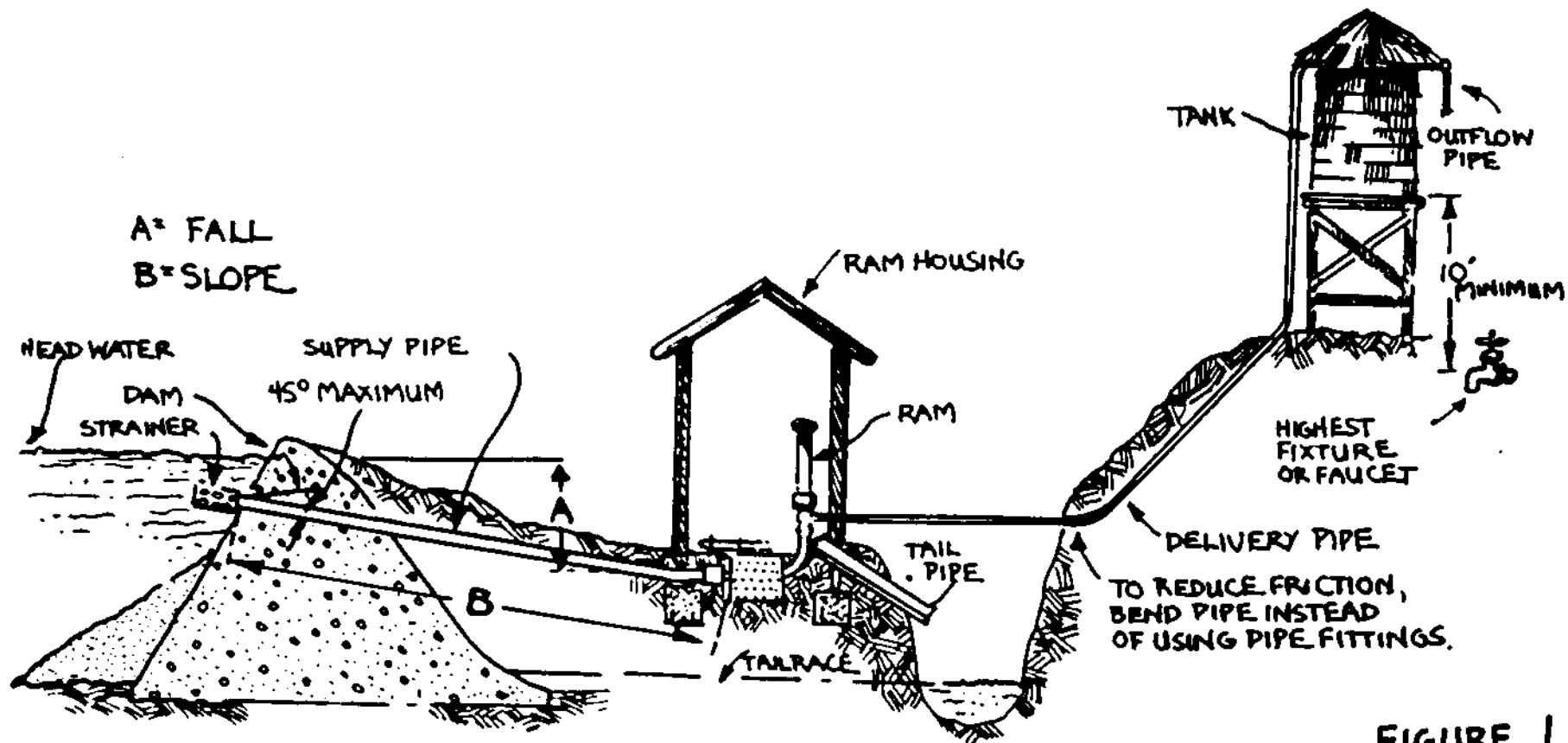
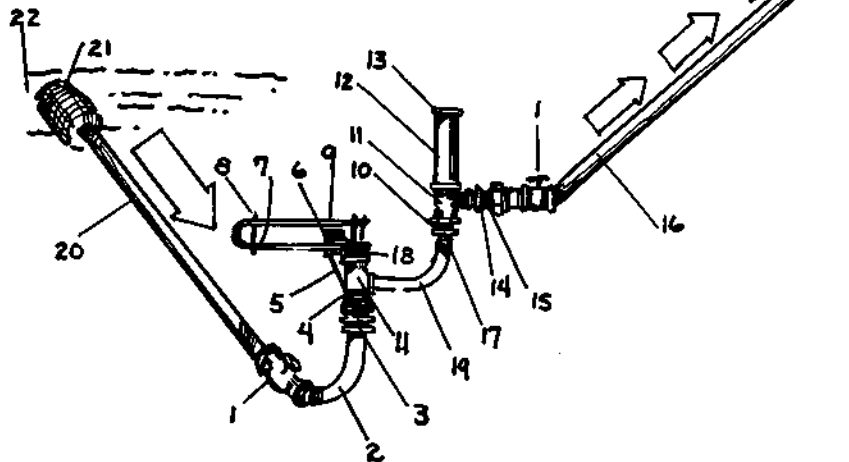


FIGURE 1

HYDRAULIC RAM IN OPERATION

1. GATE VALVES
2. 1½" STREET BEND
3. 1½" x 3" BUSHING
4. BRACE CLAMP
5. BRACE

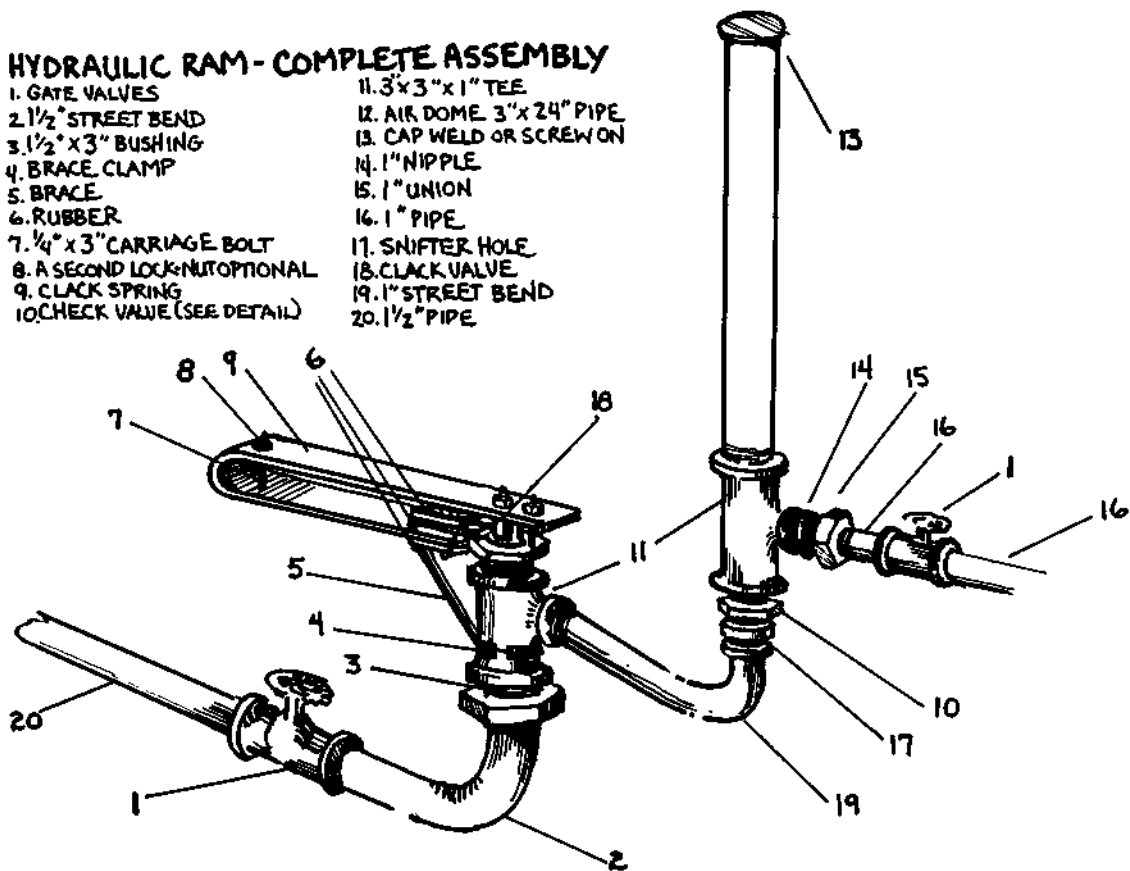
6. RUBBER
7. ¼" x 3" CARRIAGE BOLT
8. A SECOND LOCK NUT IS OPTIONAL
9. CLACK SPRING
10. CHECK VALVE

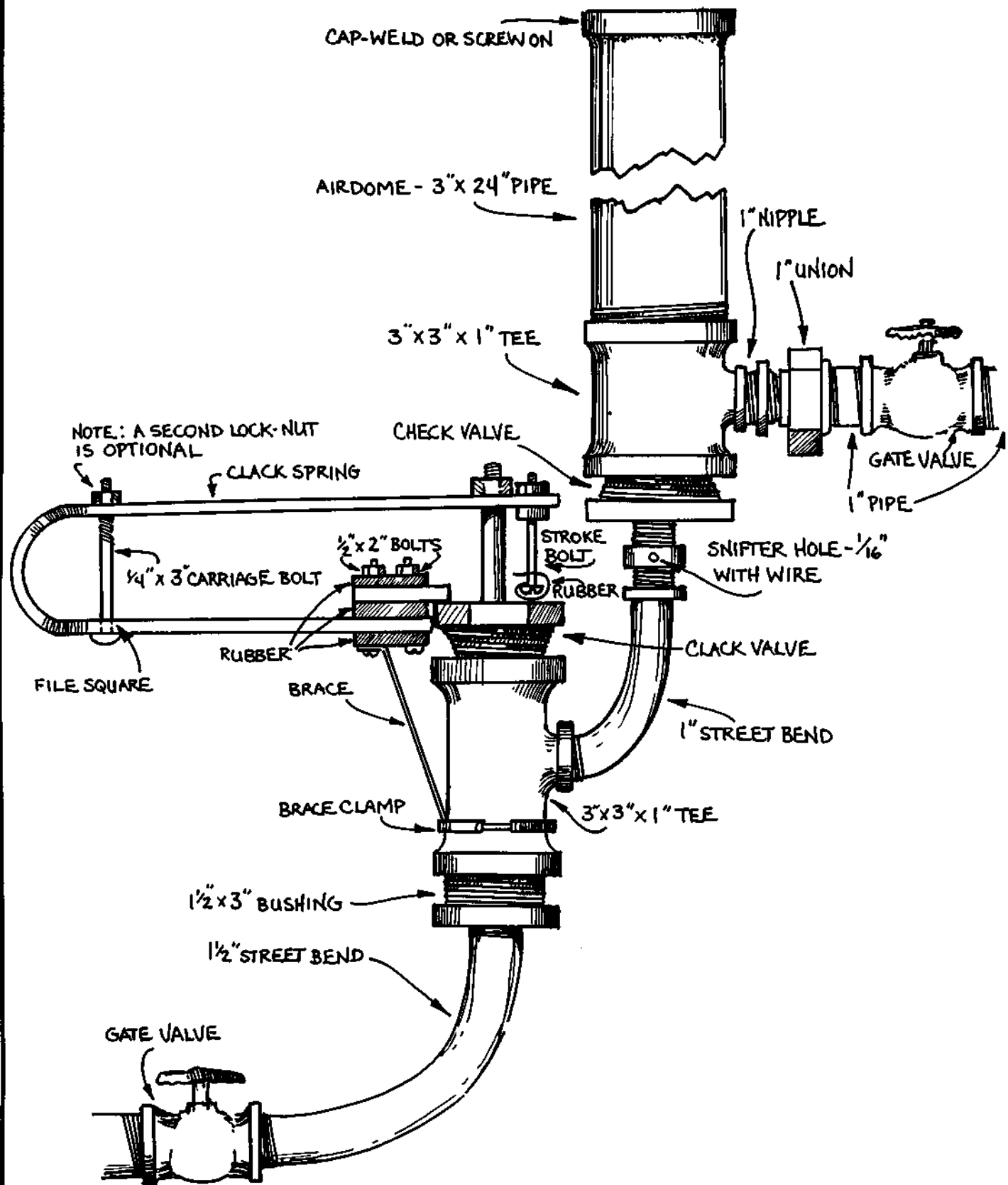


11. 3 x 3 x 1" TEE
12. AIR DOME 3 x 24" PIPE
13. CAP WELD OR SCREW ON
14. 1" NIPPLE
15. 1" UNION
16. 1" PIPE
17. SNIFFER HOLE - ¼" WITH WIRE
18. CLACK VALVE
19. 1" STREET BEND
20. 1½" PIPE
21. STRAINER
22. SOURCE
23. STORAGE TANK

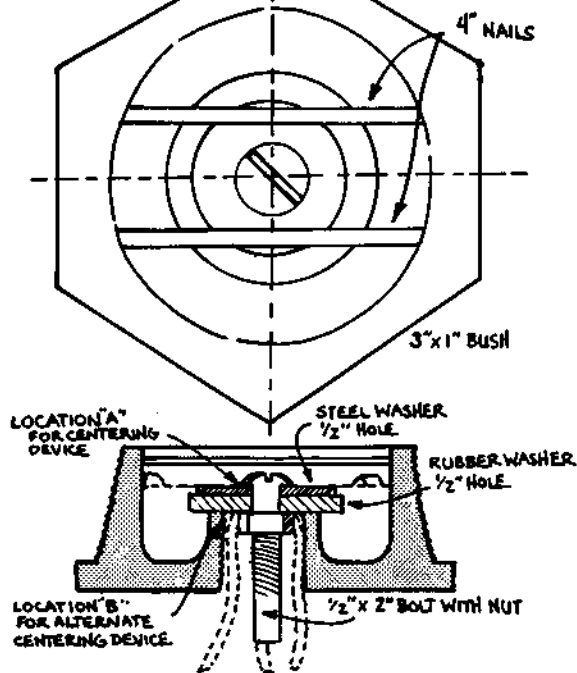
HYDRAULIC RAM - COMPLETE ASSEMBLY

- | | |
|---------------------------------|--------------------------|
| 1. GATE VALVES | 11. 3"x3"x1" TEE |
| 2. 1/2" STREET BEND | 12. AIR DOME 3"x24" PIPE |
| 3. 1/2"x3" BUSHING | 13. CAP WELD OR SCREW ON |
| 4. BRACE CLAMP | 14. 1" NIPPLE |
| 5. BRACE | 15. 1" UNION |
| 6. RUBBER | 16. 1" PIPE |
| 7. 1/4"x3" CARRIAGE BOLT | 17. SNIFFER HOLE |
| 8. A SECOND LOCK & NUT OPTIONAL | 18. CLACK VALVE |
| 9. CLACK SPRING | 19. 1" STREET BEND |
| 10. CHECK VALVE (SEE DETAIL) | 20. 1/2" PIPE |



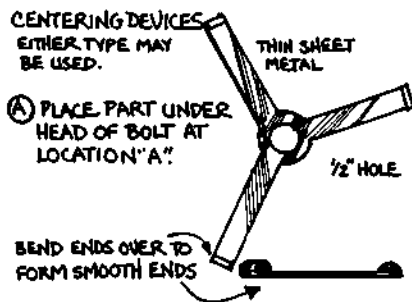


CHECK VALVE ASSEMBLY



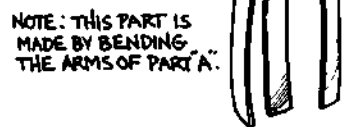
PURPOSE OF CENTERING DEVICES.

THE CENTERING DEVICE PREVENTS THE MOVING ASSEMBLY FROM SLIPPING TO THE SIDE (OFF CENTER).



B BEND ENDS OVER TO FORM SMOOTH ENDS

B PLACE PART ABOVE NUT AT LOCATION \"B\"



a bit of clearance for the water to pass. Drill two holes on each side of the middle for a 4" common nail to pass just above the valve metal washer, to keep it in place. Leave enough clearance so the valve can open just about 1/16". Spread the bolt with a centre punch just below the nut, so the nut can't work loose. Cut the nails off and file threads across their ends so the bushing will screw into the tee above it.

Just one other small job before assembly: Drill a 1/16" hole in the centre of the 1" nipple just below the check valve and bend a piece of copper wire to the shape of a cotter pin and insert it from the inside of the nipple with long nosed pliers. Spread the outside ends. This copper wire restricts the jet of water coming out, yet moves enough to keep the hole clean, most always.

The air dome can be a 2' length of 3" pipe, threaded on both ends with a cap on the top end, or the top end can have a plate welded over it. It must be airtight at great pressure. I coated the inside of the pipe with asphalt paint to protect it from rust and to seal any small leaks in the weld. Let it dry in the sun while assembling the rest of the ram.

Assembly

Use plenty of good grade pipe joint compound, both on inside and outside threads. Screw things together firmly but not excessively tight, and leave them in the correct position for your installation. Set the ram reasonably level but nothing is demanding in this respect. The snifter hole must be immediately below the air dome so the bubbles will go up into the dome. Clack and check valves must be free from binding and touch evenly all around. The old tractor tire rubber with some fabric on the back seems to be just the right toughness and resiliency to last a long time – much longer than either gasket rubber or live rubber.

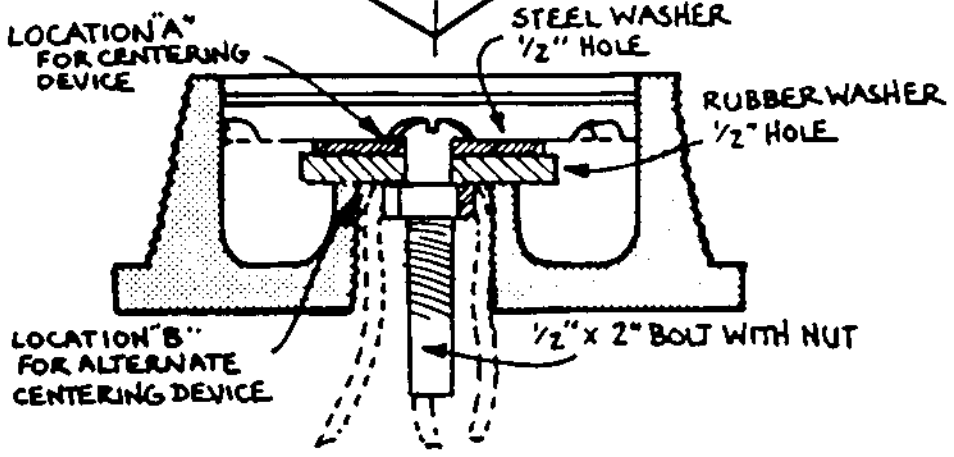
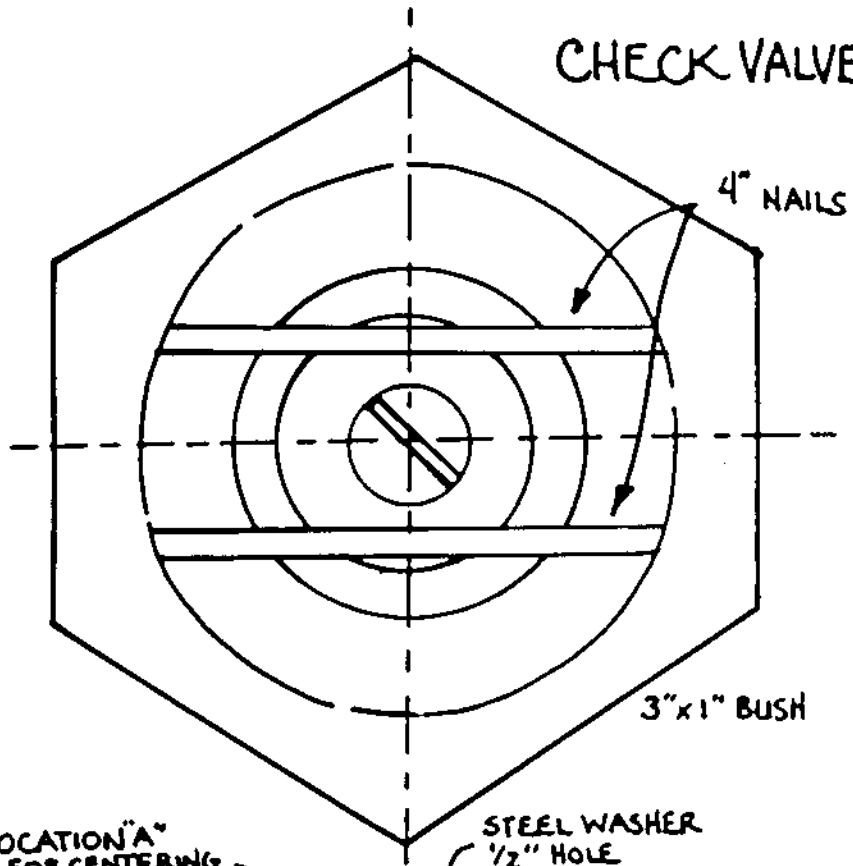
I find no reason at all to mount the ram in concrete as has been suggested – in fact it is a convenience to be able to shut off the two valves, loosen the unions, and take the ram to the shop for cleaning and painting. Painting of course doesn't help its working but it does make it look better when visitors go to see it. The cost of a home built ram is about a tenth the manufactured cost and it works on at no cost at all. A bit of rubber stretched over the head of the stroke bolt quiets the ram but isn't essential. Adjust the spring tension bolt and stroke bolt together to get the best period for your particular ram. Support the drive and delivery pipes so they don't bounce and vibrate.

This is a small ram but larger ones can be built – we have built two with 3" drive pipe and correspondingly larger ram parts. One lifts water about 150' and drives it through 3600' of pipe.

Installation & Adjustments

The drive pipe should have a strainer on the top made of 1/2" coffee tray wire, hardware cloth or anything suitable. This keeps out trash, frogs and leaves, any of which will stop the ram if they get inside. The drive pipe should be 1 1/2" or larger (we use 2" pipe) and, if possible, new, solidly put together, straight, and well supported through its length. A gate valve on the drive pipe about 4' from the ram is a great convenience but not necessary. Another gate valve on the delivery pipe is almost a necessity to avoid draining the entire delivery pipe whenever the ram is cleaned. The ram should be connected to the delivery and drive pipes by unions so it can be removed for cleaning. If it is desirable to use two rams, they must have separate drive pipes, but the delivery pipes can be joined, provided the pipe is large enough to carry the water.

CHECK VALVE ASSEMBLY



PURPOSE OF CENTERING DEVICES.

THE CENTERING DEVICE PREVENTS THE MOVING ASSEMBLY FROM SLIPPING TO THE SIDE (OFF CENTER).

CENTERING DEVICES

EITHER TYPE MAY BE USED.

- (A) PLACE PART UNDER HEAD OF BOLT AT LOCATION "A".

BEND ENDS OVER TO FORM SMOOTH ENDS

THIN SHEET METAL

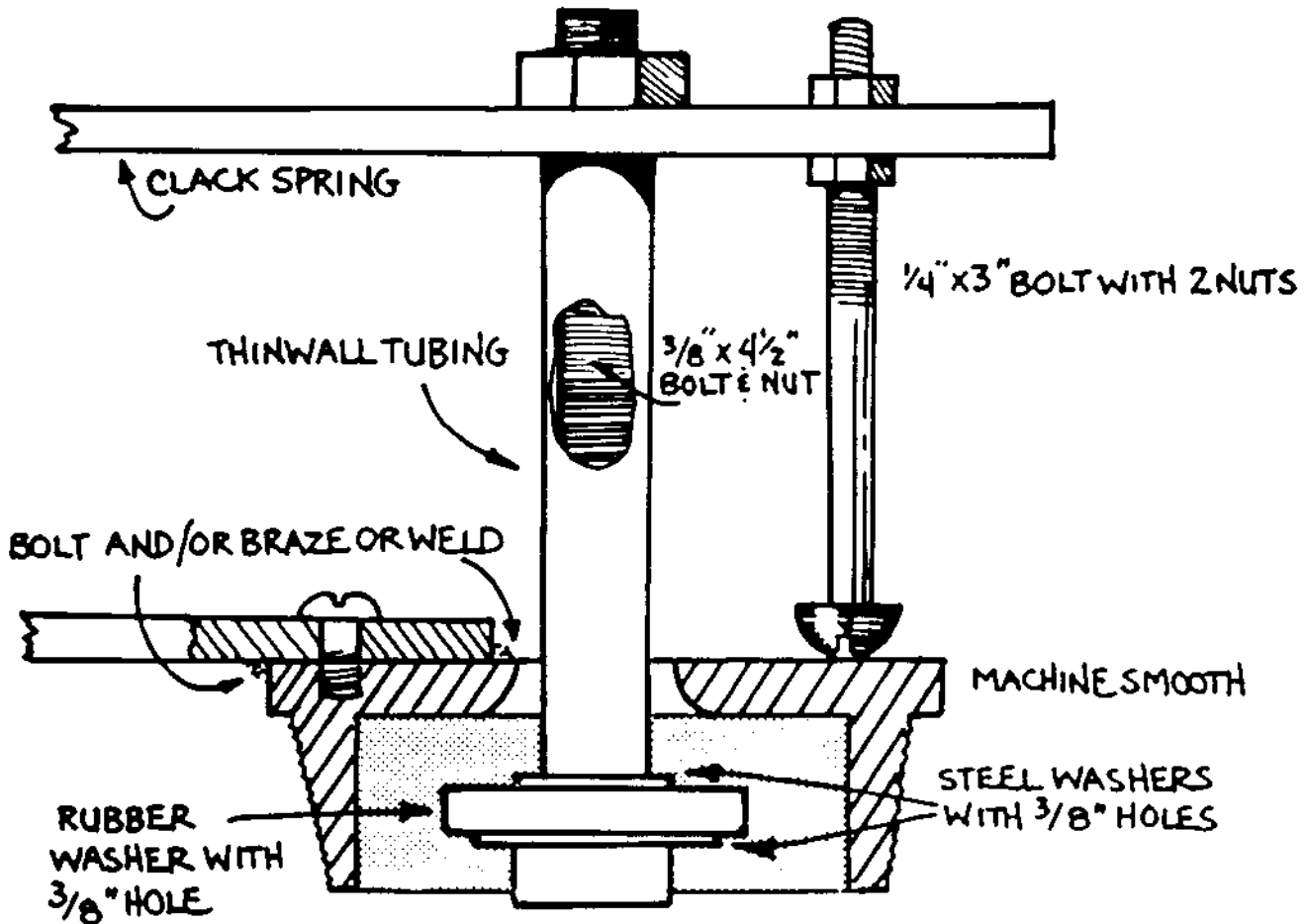
1/2" HOLE

- (B) PLACE PART ABOVE NUT AT LOCATION "B".

NOTE: THIS PART IS MADE BY BENDING THE ARMS OF PART "A".



CLACK VALVE ASSEMBLY



The delivery pipe should start from the ram with about two lengths of 1" galvanized iron pipe. From there ¾" plastic pipe can be used. The iron pipe will give the ram better support, but plastic pipe is smoother inside and can be a size smaller than the iron pipe. Also, plastic pipe is cheaper, but it must be protected from mechanical injury and sunlight. Do not take any branches off the supply line at less than three times the working fall, or when the tap is turned on the ram will stop. (A float valve might be an exception.) Best results will be obtained by putting all the water from the ram directly into a storage tank and using it from there. Use the overflow to irrigate the pasture.

The small bolt at the end of the clack spring controls the length of the stroke of the clack spring. Experiment for the best length of stroke and tension for your set of conditions. Adjust the length of stroke first, then the spring tension. The greater the tension and length of stroke, the slower the ram will work and the more water it will pump, but it will take more water to keep it working.

If Action is Faulty

See that the clack valve closes squarely, evenly and completely. If it does not, the clack spring may have been bent somehow, and it will have to be straightened.

See that the clack valve does not rub on the front, side or back of the valve body.

Check for trash in the ram or delivery valve or snifter hole.

Check to see that the air dome is not filled with water. It must not be full of water or the ram will knock loudly and may break something. The snifter lets in a bit of air between each of the strokes and this keeps the dome full of compressed air.

Check rubber clack and delivery valve for wear or looseness.

If drive water is in small supply, speed up the stroke by loosening spring tension and shorten the stroke by lowering the stroke adjusting bolt. More water is delivered by a faster stroke and continuous running than a slower stroke

that stops every day.

Check for leaks in the drive pipe. If air bubbles come out of the drive pipe after it has been stopped for a while, air is leaking into the drive pipe and the ram action is spoiled.

Clean the ram once in a while. It deserves it after working without rest day and night for weeks and months on end. Protect it from outside injury and inquisitive children.

When the ram runs out of water, it will usually stop, remaining open and losing all the water available until it is closed again. You can listen at the storage tank to hear if it is still running and, if it isn't, go to the ram and close the drive pipe until water has accumulated in the cistern.

Long delivery distances require larger pipe to reduce friction.

A cistern is a good thing to have at the top of the drive pipe to let dirt settle out of the water. The outlet from the cistern to the ram should be a foot or so above the bottom to allow room for dirt to settle out. A cleaning drain in the bottom is good.

Parts List

Quan.	Part		
1	1½" valve	2	4" nails
1	1½" street bend	1	¼" x 3" bolt with 2 nuts
1	1½" x 3" bushing	1	3/8" x 4½" bolt with nut
1	Brace	1	¾" dia. x about 4" long
1	Brace clamp		thinwall tubing
2	3" x 3" x 1" tees	1	Rubber washer, 1¼" dia., 3/8" hole
1	¼" x 3" carriage bolt & nut (2 nuts optional for lock-nut)	1	Steel washer, about ¾" dia., 3/8" hole
1	Clack spring	1	Steel washer, about 1¼" dia., 3/8" hole
3	Rectangular pieces of rubber	1	1" valve
2	½" x 2" bolts with nuts	1	1" union
1	3" x 24" pipe	2	1" nipples
1	Cap for air dome	1	Small piece of rubber for stroke bolt
2	3" x 1" bushings		1" street bend
1	Sheet metal disc about 2¼" in diameter	1	Short piece of 3/32" wire for snifter hole
1	½" x 2" bolt with nut		Steel washer, ½" hole
1	Rubber washer, 1¼" dia., ½" hole	1	