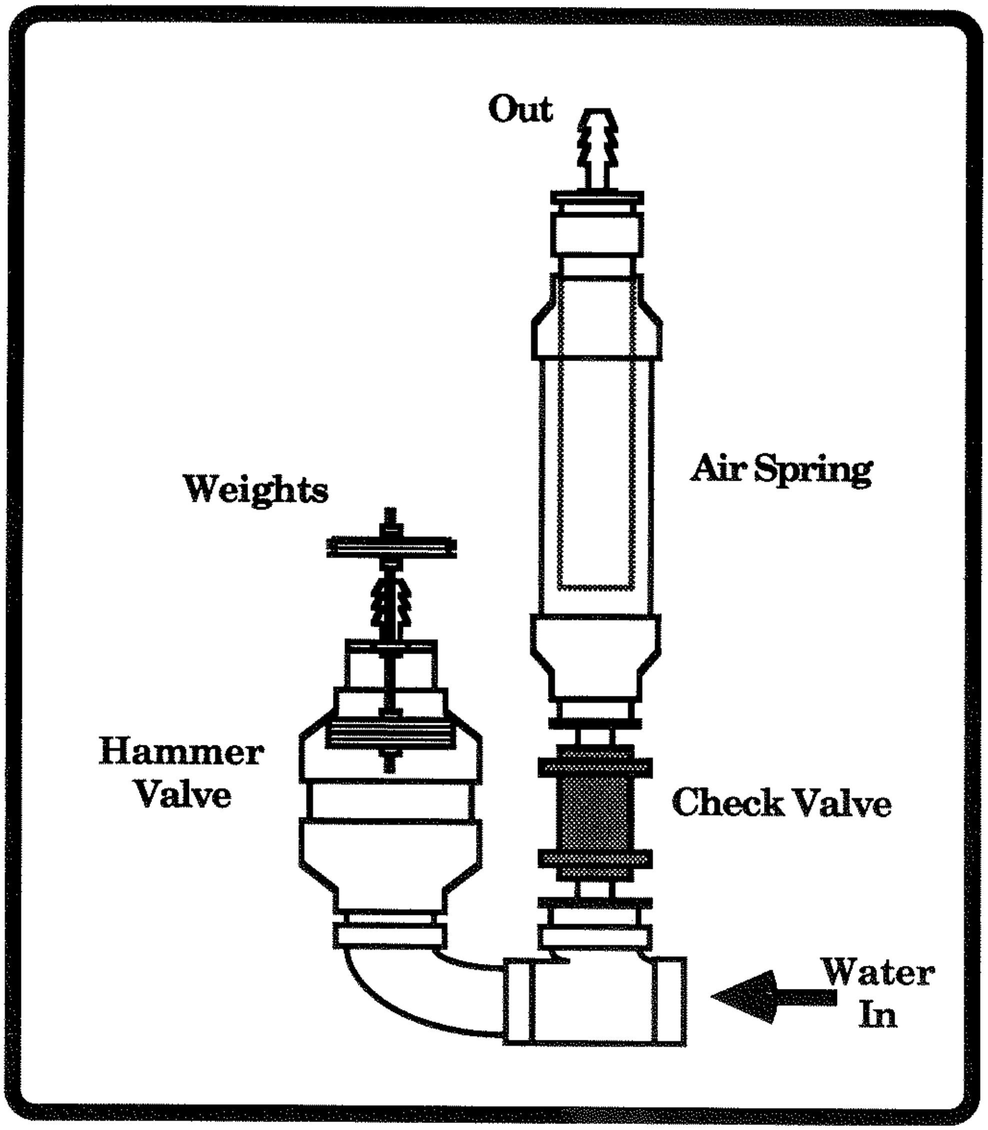
# The Hydraulic Ram




MTM Technical Press

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## Introduction

The Hydraulic Ram is a water pump which uses the power of falling water to deliver a portion of the flow to a point higher than the original source. A Hydraulic Ram does not produce power from nowhere. The source of power is provided by the energy in the falling water. Only a portion of the total water flow is lifted to a location higher than the original source. The rest of the water continues its journey along the original path. The distance that the water source falls is called the head and the height to which the water is pumped is called the lift. A well designed pump can easily produce a lift five times greater than the head. A Hydraulic Ram requires no other sources of power to operate, making it ideal for remote and economical operation. Once in operation, a Hydraulic Ram will continue to pump water indefinitely without interruption.

## History

The Hydraulic Ram is definitely not a new invention. It was originally invented by a person named Montgolfier in the 18th century. (The same person who invented the Hot Air Balloon!) The Hydraulic Ram was particularily useful then, because electricity was not readily available to run electric motors for pumps, and the internal combustion engine was not invented yet. A town or village could dam a local stream to create a head of water and use a Hydraulic Ram to send a portion of the flow up to where it was needed by the citizens. Likewise, a farmer could use a Hydraulic Ram to send water up to his barn for the livestock, or to replenish a stagnant farm pond. Later, Railroad's used Hydraulic Rams on occasion to send water up to the storage tanks used by their steam locomotives. At one time there were many companies in the business of building and selling Hydraulic Rams for purposes like these. Eventually though, the ready availability of electricity to power pumps and the introduction of the gasoline engine eclipsed the industry and sent it into decline. Not helping the matter was the price tag of the pumps. Hydraulic pumps were never inexpensive because they used rather elaborate castings and forgings in their construction.

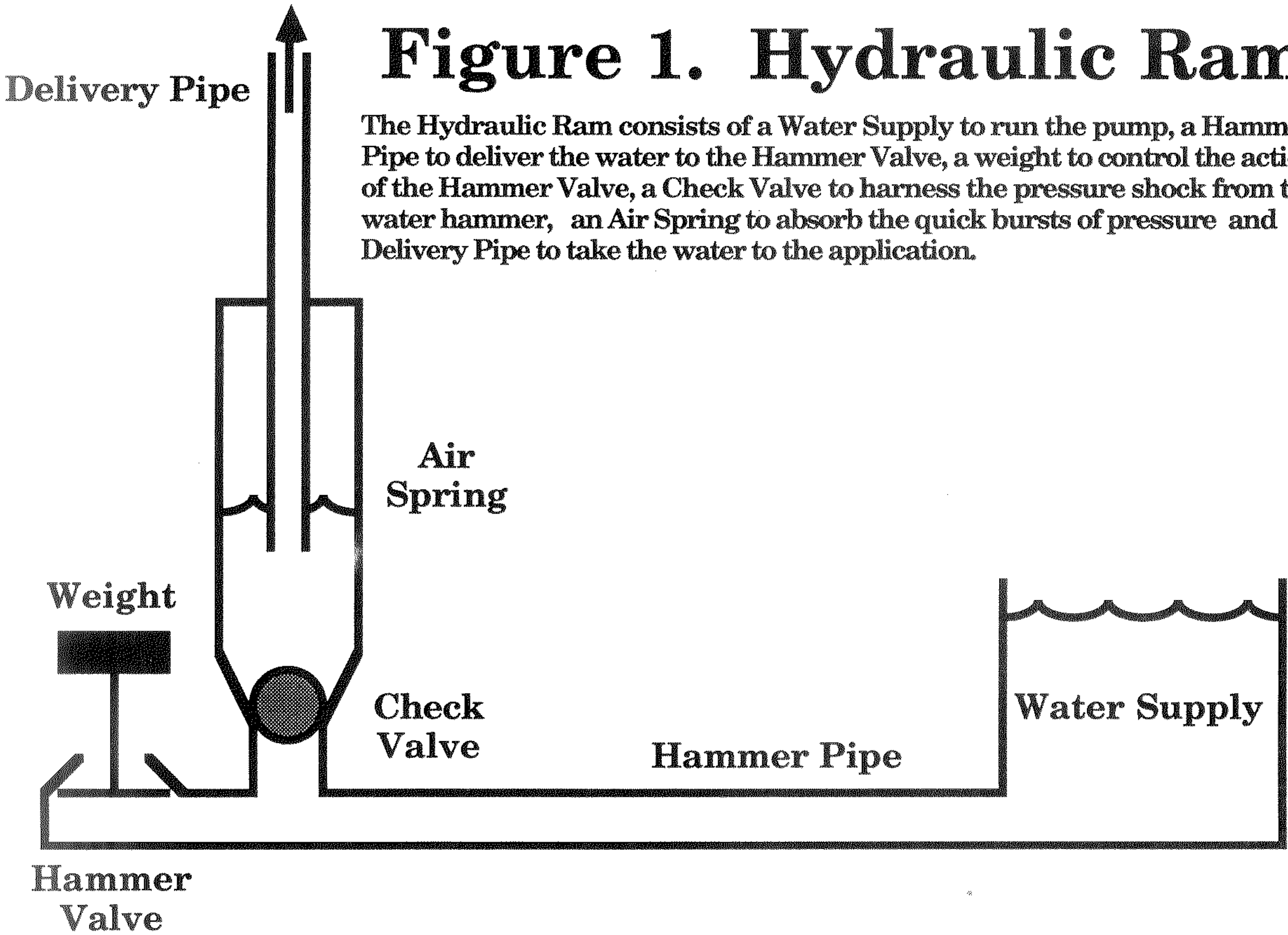
Today a fresh look is being taken at the Hydraulic Ram. The primary reason is the remarkable developments in the production of very low cost plumbing components made from PVC (Poly Vinyl Chloride). PVC technology makes it possible to build a high capacity Hydraulic Ram very economically, and in some ways better, than the old models.

## Principles of Operation

The Hydraulic Ram is a device that converts energy from one form into another to do useful work. A schematic outline of a simple Hydraulic Ram installation is shown in Figure 1. The Ram is supplied with water from a source capable of delivering a working head, such as a dam

# Figure 1. Hydraulic Ram

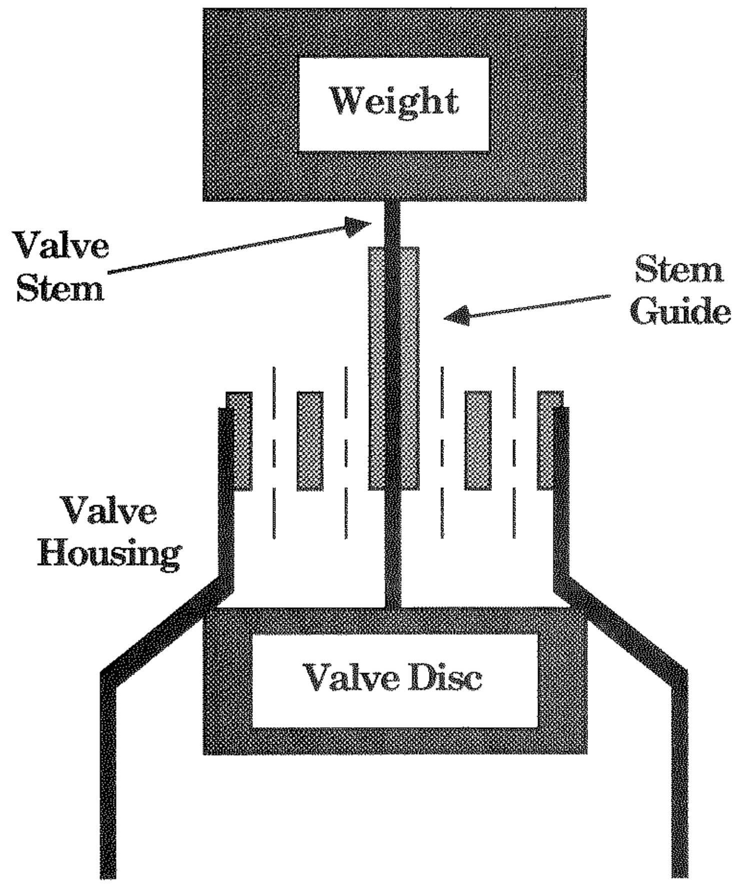
The Hydraulic Ram consists of a Water Supply to run the pump, a Hammer Pipe to deliver the water to the Hammer Valve, a weight to control the action of the Hammer Valve, a Check Valve to harness the pressure shock from the water hammer, an Air Spring to absorb the quick bursts of pressure and a Delivery Pipe to take the water to the application.



across a stream or a tank filled by a spring. A long pipe carries the water from the source to the Ram. The Ram has a valve, called the Hammer Valve, that opens and shuts fairly quickly under its own power. The alternate opening and shutting of the Hammer Valve creates large pressure surges in the pipe. The pressure surges are large enough to force water through the Check Valve into the Air Spring chamber. The Check Valve prevents backflow after each pressure surge, and with nowhere else to go, the pressurized water heads up the delivery pipe to the application.

The pressure surge that makes the Hydraulic Ram work may seem a little mysterious at first. The pressure surge is created when the rapidly moving water in the supply pipe is suddenly stopped by the closure of the Hammer Valve. The moving water contains energy of motion, called kinetic energy. When the moving water is suddenly stopped the kinetic energy is transformed into pressure energy inside the pipe. The pressure surge that results is a real effect that can even burst steel pipes under the right circumstances. Engineers refer to the pressure surge created by stopping water suddenly as water hammer. The Hydraulic Ram takes advantage of water hammer to send a portion of the flowing water to a point higher than the original source.

The Hammer Valve opens and shuts under its own power to create the pressure surges called water hammer. A closeup view of a Hammer Valve is shown in Figure 2. The Hammer Valve is able to move up and down. In the "up" position it makes a tight seal and in the "down"




# Figure 2. Hammer Valve

**The Hammer Valve opens and closes quickly to produce the pressure pulses called Water Hammer. The Weight tends to hold the valve open, but water rushing past the Valve Disc tends to shut it again. This process repeats itself indefinitely.**

position it allows water to flow out. The weights on the valve are heavy enough to make the valve open when the water is not flowing. However, when the valve does open under the weight, water rushes through and applies an upward force that snaps the valve shut again. This process of opening and closing repeats itself indefinitely, and every time the water is suddenly stopped a pressure surge is created because of the water hammer effect.

The Check Valve, shown in Figure 1, opens during the pressure surges created by the water hammer. The open Check Valve provides an alternate path for the flowing water when the Hammer Valve snaps shut. After the momentary pressure surge is over, the Check Valve closes again to prevent backflow. The opening and closing of the Check Valve happens every time the Hammer Valve goes through a cycle.

The Air Spring, also shown in Figure 1, is a trapped volume of air that can respond quickly to the short powerful surges of pressure coming in through the Check Valve. The Air Spring behaves like a shock absorber. It stores the brief but powerful surges of pressure by compressing the trapped air. Air Springs are an essential component in the successful operation of Hydraulic Rams. An Air Spring can respond much more rapidly to the changing pressure conditions than if only a solid column of water were present.

**Factors Affecting Performance**

Several factors have a big influence on the performance of a Hydraulic

Ram and the success of an installation. The height of the Water Supply above the Hammer Valve, or "head", is certainly one of the more important factors. With a higher head the water rushes out the Hammer Valve faster and creates a larger pressure spike when it is suddenly stopped by the valve snapping shut. The size of the pressure spike determines how high the water can be lifted. Unfortunately, the available head is probably the least easily controlled factor affecting performance. A sturdy dam across a small stream can become expensive if large amounts of water must be retained. Generally, a head of at least 18" is required for a Hydraulic Ram to operate properly.

Another factor that has a big influence on performance is the flow rate available from the Water Supply. A Hydraulic Ram discharges much more water through the Hammer Valve than it lifts. In general, the Ram requires about 10 gallons per minute of flow from the Water Supply to lift 1 gallon per minute to the user. Therefore the stream or spring providing the Water Supply should be sized adequately for even the driest summer months, if the pump is to continue operating.

The tuning of the Hammer Valve is another factor that can have a big affect on performance. Two things "tune" the Hammer Valve: the Stroke and the Weight. The Stroke is the amount of up and down motion the valve stem can travel per cycle. If the Stroke is too large the Hammer Valve will not snap shut from the flowing water. If the Stroke is too short the Valve will close early, before a good flow of water is developed. The Weight on the Hammer Valve affects performance the same way. Too much weight holds the valve open and too little weight makes the valve close prematurely. Surprisingly, *the optimum weight is often less than the full amount needed to open the valve from a dead start.* With an undersized weight the Hammer Valve must be started by tapping the valve stem to "get it going", but then it will continue on indefinitely. Tuning the Hammer Valve, by adjusting the Stroke and Weight, can greatly affect performance and should be done carefully for any new installation.

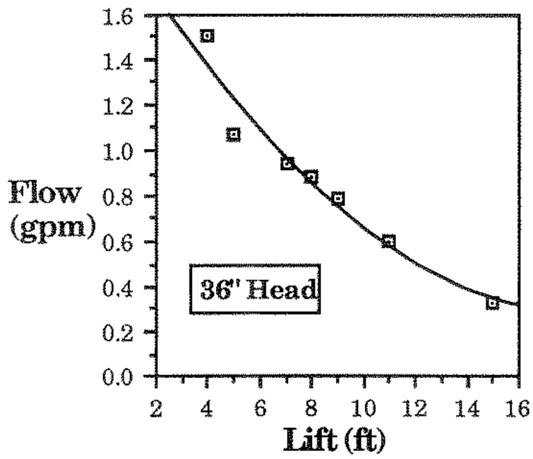
## Typical Performance Data

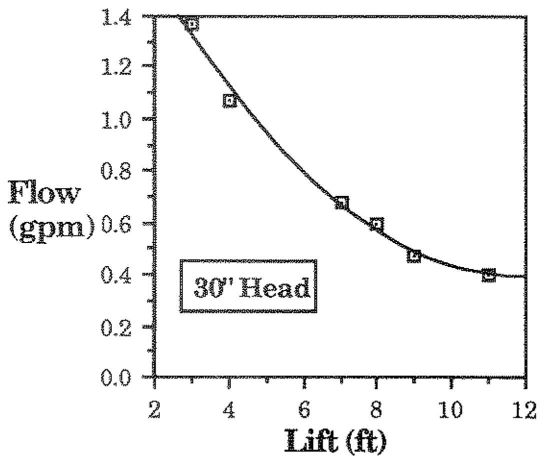
The performance data of a Hydraulic Ram manufactured by MTM Technical is shown in Figure 3. The performance data shows how the output flow decreases as the lifting height increases. The MTM Ram requires a minimum water head of 18" to operate, with which it can pump .25 gallons per minute (gpm) to a height of 10 feet. Increasing the head to 36" allows the pump to deliver .60 gpm to the same height. The pump requires approximately 10 gpm from the Water Supply to operate. The performance with different heads and lifts, along with a description of the exact test conditions, also appears in Figure 3. Plans for building the MTM Ram appear on the last page of this booklet.

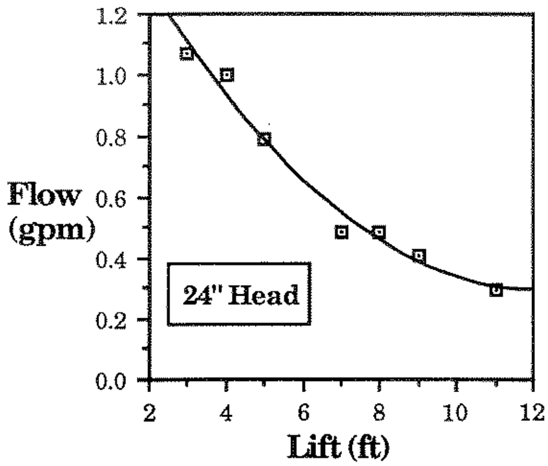
## Ideas, Suggestions and Things to Try

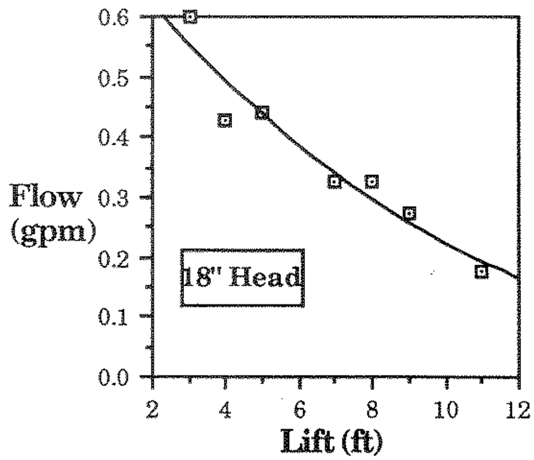
There is alot of room for experimenting with different configurations of the Hydraulic Ram. Fortunately, the ready availability of economical

# Performance Curves
# MTM Technical's Hydraulic Ram Kit




**The output flow of our Hydraulic Ram Kit, in gallons per minute (gpm), decreases as the lifting height increases. Output flow begins with an 18" head (minimum required) and steadily increases up to a 36" head (maximum recommended). The pump requires approximately 10 gpm from the source to operate. Although higher lifts are possible, output flows become much smaller.**

### Test Conditions

Water was supplied to the pump via a 10' length of 2" Diameter PVC pipe. Both the Head and Lift were measured with respect to the discharge elevation of the Hammer Valve. Stroke was held constant at .290" during the test, and no effort was made to tune the stroke for optimum performance for the various conditions. Weight on the Hammer Valve was 1.1 lbs, which was also not optimized for the various conditions.

PVC Pipe fittings makes it easy to try different things. During the experimental phase it is possible to push the PVC fittings together by hand and secure them with one or two screws, allowing for possible disassembly later. CAUTION! The pressure surges created by the Water Hammer effect are very real. Unsecured fittings will come apart, usually at the worst possible moment!

A Water Supply, for experimenting with, can easily be simulated by using a piece of 3" diameter pipe, in an upright position, filled from a garden hose. The upright pipe can be lengthened or shortened to provide whatever "head" you desire. Remember too, that the working head of the Water Supply is measured with respect to the discharge elevation of the Hammer Valve.

There are many different modifications that can be made to the Hammer Valve. One of the most obvious would be to replace the Weight with a spring. Another modification might use some sort of "flapper" configuration for the valve, like a toilet tank has. The Hammer Valve must snap shut quickly and hard to work right. Avoid valve configurations that are slow or spongy when they operate. Whenever you are experimenting, don't forget to "tune" the Ram by adjusting the Stroke and Weight for maximum performance.

The Check Valve can be homemade or boughten. Ball check valves are generally the most expensive, but they also offer superior performance in this application. Less expensive check valves usually use some sort of flapper arrangement, and don't work as well. If you are serious about getting good Ram performance a quality ball check valve is definitely worth the investment.

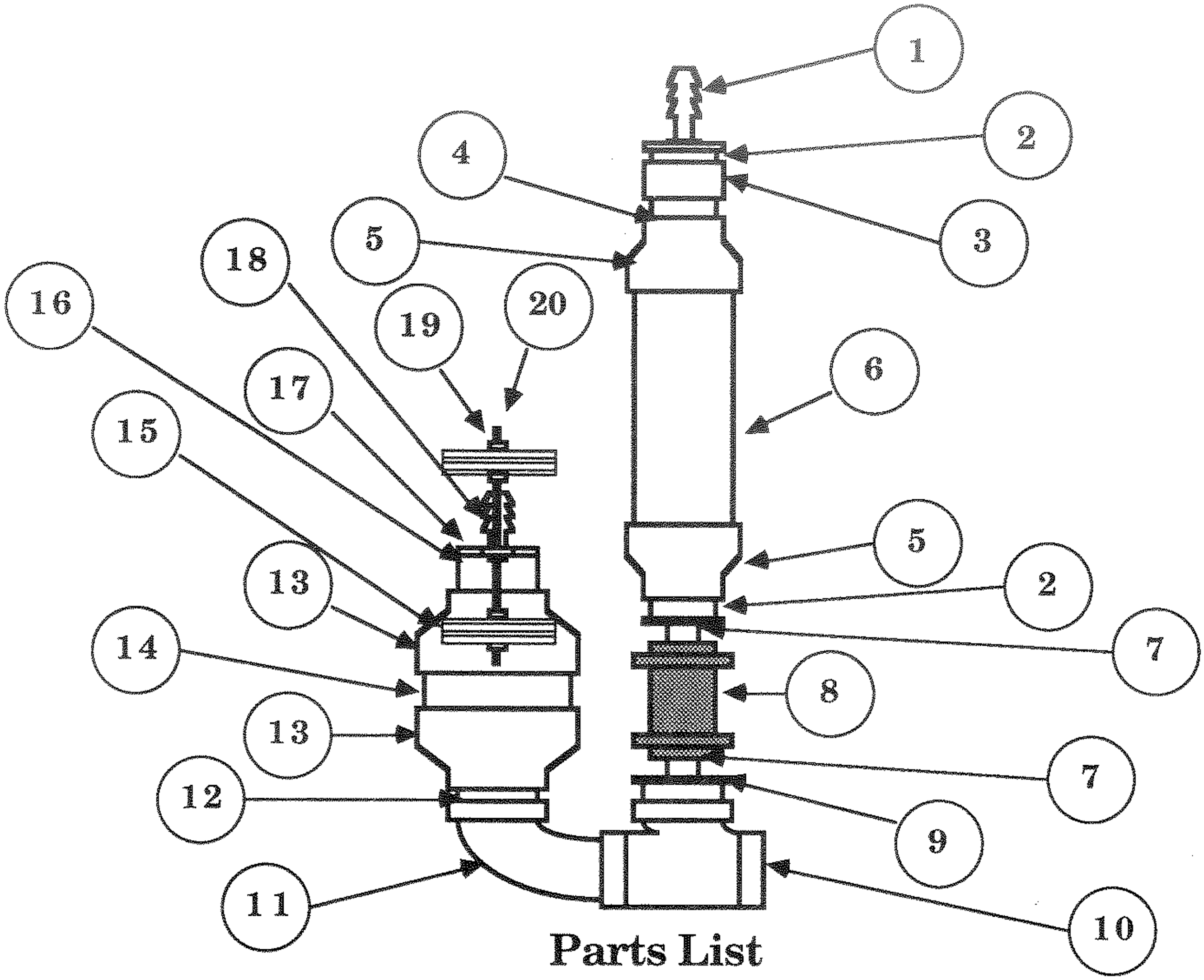
The Air Spring can also be made from PVC pipe fittings. A Hydraulic Ram will not work without an Air Spring! It is very important that the air chamber be leak tight, otherwise water will eventually displace the air and the Ram will stop working. Also, if you are the least bit suspicious that the air spring might have filled with water ( from laying on its side for example) drain it dry and start over.

The Hydraulic Ram is an interesting device that is fun to experiment with. It is also a machine with a purpose. Whatever motivates your interest....Happy Experimenting and Good Luck!

**References**

Handbook of Homemade Power, published by Bantam Books in New York for the Mother Earth News in 1974, pp. 110-115. (Interesting description of two Ram installations.)

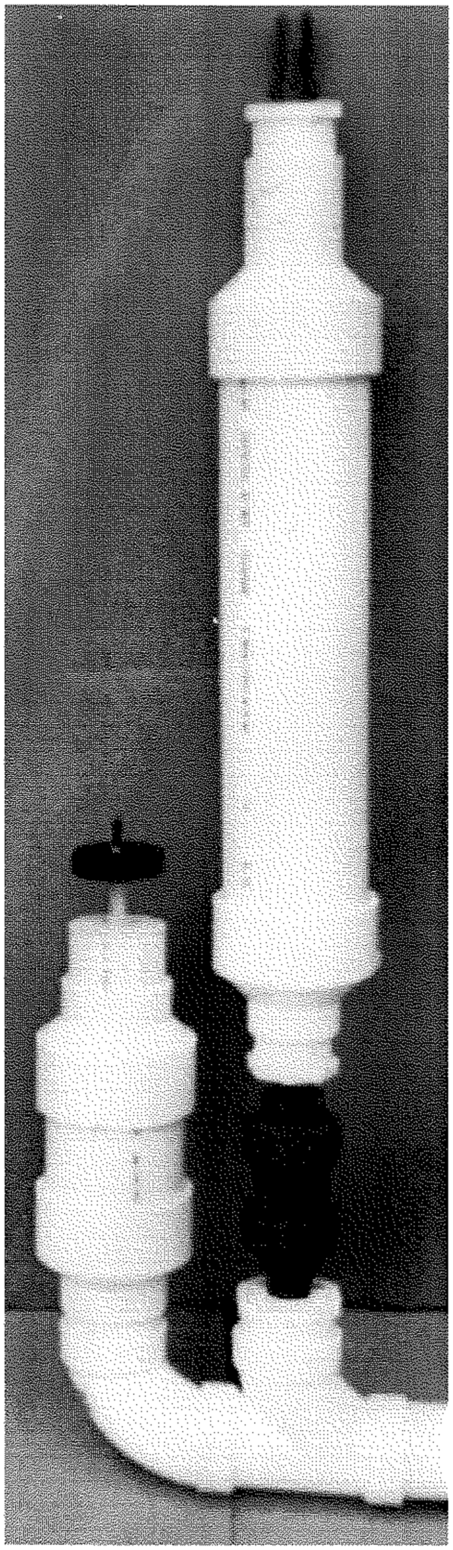
New Low-Cost Sources of Energy for the Home, by P. Clegg and published by Garden Way Publishing in Charlotte, Vermont in 1975, pp. 141-161. (Contains a good section on Dam Building, plus Performance Data on an antique Hydraulic Ram.)




# Parts List

1 Hose Barb with 3/4" Male NPT end
2 PVC Adapter, 1.5" Pipe to 3/4" Female NPT
3 PVC Coupling for 1.5" Pipe
4 PVC Pipe, 1.5" Diameter X 18" Long
5 PVC Pipe Adapter, 3" to 1.5" (Modify top one to allow 1.5" pipe to pass through)
6 PVC Pipe, 3" Diameter X 15" Long
7 Plastic Close Nipple, 3/4" NPT
8 NIBCO 3/4" Ball Check Valve
9 PVC Adapter, 2" Pipe to 3/4" NPT
10 PVC Tee, 2" Diameter
11 PVC Street Elbow, 2" Diameter
12 PVC Pipe, 2" Diameter X 2" Long
13 PVC Pipe Adapter, 3" to 2"
14 PVC Pipe, 3" Diameter X 4" Long
15 Washers, .25" ID by 2" OD
16 PVC Pipe, 2" Diameter X 3" Long
17 PVC "Snap In" Drain Fitting for 2" Pipe, (Drilled and Tapped for 1/4" NPT)
18 Nylon Hose Barb with 1/4" Male NPT end
19 1/4-20 Nuts, 4 Places to hold on washers
20 Brass Toilet Float Rod, 1/4" Diameter X 8" Long

Construction Notes: Modify top item 5 to allow the 1.5" pipe to pass through leak tight. Item 17 is drilled and tapped for item 18 (Which forms the valve stem guide.) Adjust initial stroke to approximately .25". Initial weight of washers should total about 1.25 lbs. Tune to suit.



Hydraulic Ram Water Pump

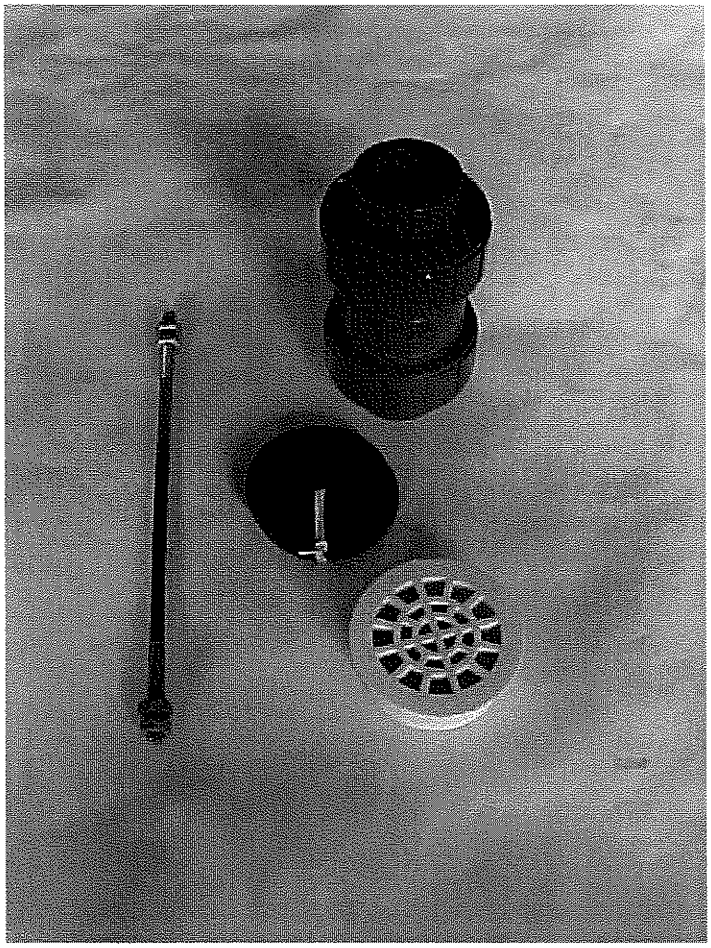


Photo showing Float Rod, Washers, Check Valve and Drain Fitting

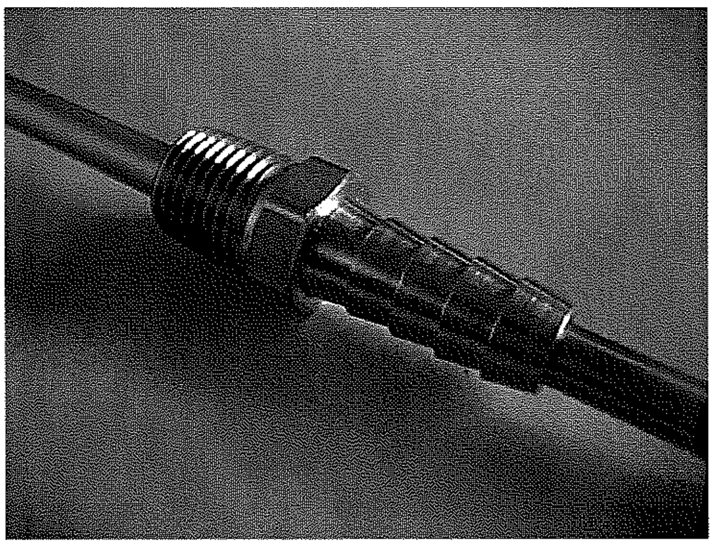


Photo showing Float Rod passing through Hose Barb

# Building a Water Ram: Additional Information

We hope you have enjoyed reading our Water Ram Booklet! If you plan on building a Water Ram, we would like to pass along some useful tips and comments about the Project.

1. Part #8, the NIBCO Ball Check Valve, is available from U. S. Plastics Corporation (1390 Neubrecht Rd., Lima, Ohio 45801). It is their Catalog #18292, and costs about $25. Their phone number is (800) 537-9724.

2. Large diameter washers are listed as part #15. They are used for two purposes in the Hammer Valve: as the valve disc and as tuning weights. Although the parts list specifies 2" diameter, we have found that 2.25" is usually required. (Depending on the size of the hole in part #13). Watch for large diameter washers at Farm Supply Stores, they are used for attaching lawn mower blades. Incidentally, our first ram used a round plastic "floor protector" as the valve disc, and some ordinary fender washers on top for tuning weights.

3. Part #17 is a "Snap-In" drain fitting for 2 inch pipe. It is manufactured by Plastic Oddities, Inc. in Shelby, NC. It is their part #PPK-304. They do not accept small mail orders because they are a wholesaler. A good hardware store or plumbing supply shop should have this item, if not they may be able to order it for you.

4. Part #20 is a brass toilet float rod. These can usually be found in the pre-packaged parts section of the plumbing department. The exact length is not critical because the length of part #14 can be adjusted to fit.

5. Part #5 must be modified so the plastic pipe will pass through it leak tight. This is most easily done on a small lathe by turning down the inside ridge. The pipe is then glued in with ordinary PVC cement to make the seal. It is also possible to file down the ridge instead, but it must be done carefully.

MTM Technical Inc.