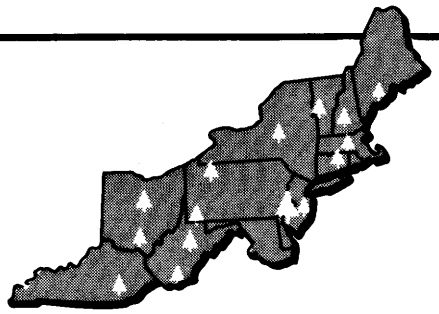
USDA FOREST SERVICE RESEARCH NOTE NE-214
1975

Northeastern Forest Experiment Station



FOREST SERVICE, U.S. DEPT. OF AGRICULTURE, 6816 MARKET STREET, UPPER DARBY, PA. 19082



# AN IMPROVED APPARATUS FOR PRESSURE-INJECTING FLUID INTO TREES

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*Abstract.*—Our original tree-injection apparatus was modified to be more convenient and efficient. The fluid reservoir consists of high-pressure plastic plumbing components. Quick couplers are used for all hose connections. Most important, the injector heads were modified for a faster and more convenient and secure attachment with double-headed nails.

The desirability of injecting fluids into trees for correction of mineral deficiency, therapy of diseases, prevention of disease, and attack by insect pests has been recognized for some time *(1, 2, 3, 4, 5, 6, 7, 8)*. Furthermore, injection of chemicals into trees should be environmentally more acceptable than spray or soil applications because a minimum amount of chemical is used, and it is confined within the treated tree.

Until recently, most tree-injection units were of the gravity-feed type. The current trend is to inject under pressure (20 to 400 psi). Pressure injection saves time and labor and makes it possible to treat trees that otherwise would take up fluid very slowly.

Our original injection apparatus *(4)* had a low-volume iron reservoir attached to the nitrogen pressure cylinder. This unit was heavy and difficult to move.

Also, the pipe connections and hose connections to the injector heads were made of pipe unions. The injector heads were attached to the trees with belts and forced against the tree with a hydraulic jack to make a pressure-tight seal.

Our improved device has a much higher volume reservoir, but is made of plastic so it is not so heavy. All connections are made by means of quick couplers, and the injector heads have been modified so they can be nailed onto the trees with double-headed

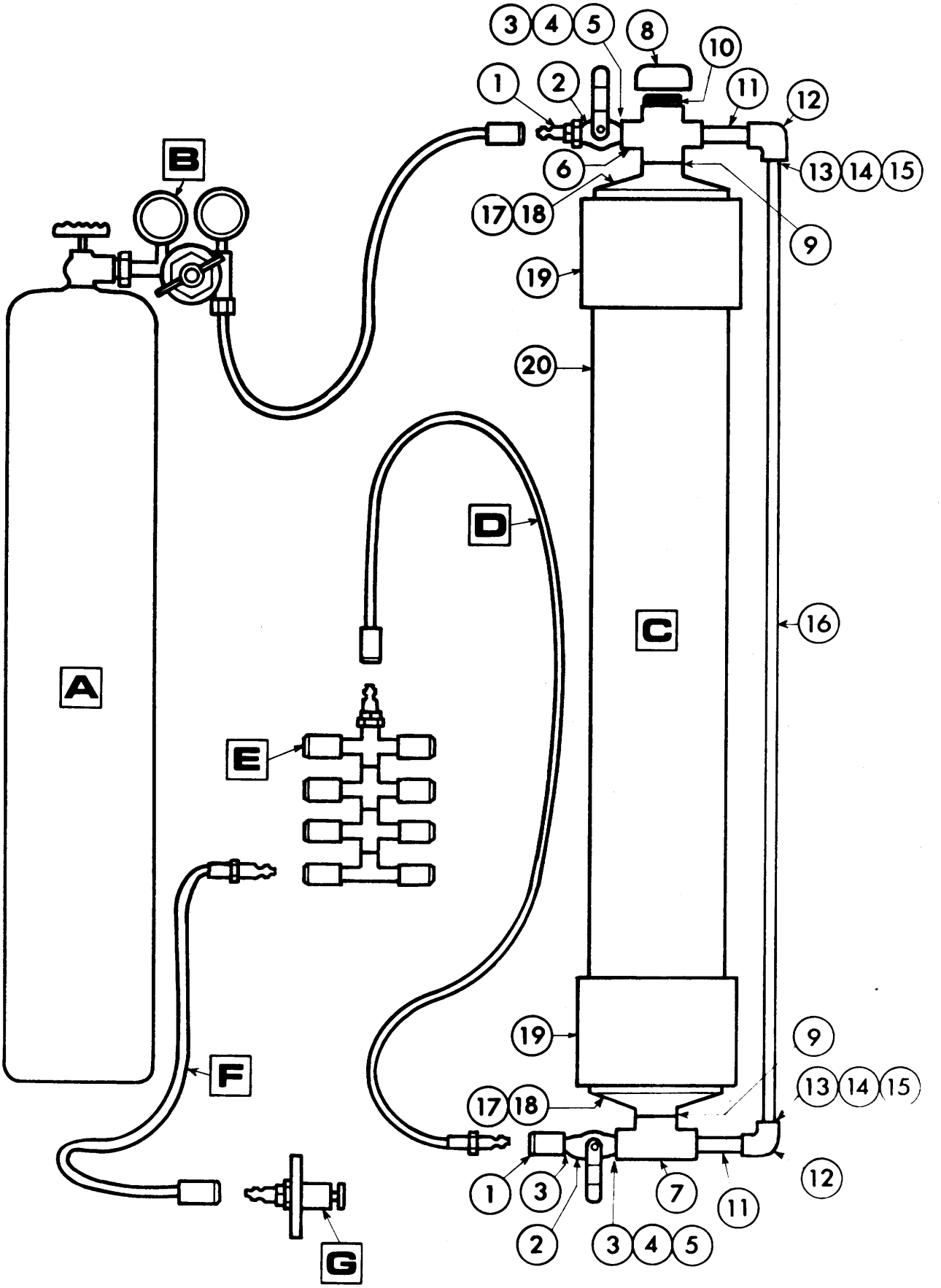
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Figure 1.—Schematic drawing of the improved injection apparatus.

A, Gas pressure cylinder containing water-pumped nitrogen at 2,200 psi (Matheson Gas Products 1A cylinder or equivalent contains 227 cubic feet of gas at atmospheric pressure, enough to inject approximately 50 elms 24 inches in diameter).[1]

B, Gas pressure regulator with a range of 0 to 200 psi (National Cylinder Gas No. 1608 or equivalent). Reinforced PVC 3/8-inch i.d. hose (225 psi working capacity) attached to regulator and connected to a female portion of a quick coupler (1 X 919, 1/4-inch coupler assemblies consisting of female body and male coupler), by means of a 1/4 X 3/8-inch brass pipe-hose connector. Hose is approximately 6 feet long.

C, Fluid reservoir with gage consisting of:

1. One 1/4-inch quick coupler (male top, female bottom).
2. Two brass ball valves (1 at top, 1 at bottom).
3. Three galvanized iron all-thread 1/4-inch pipe nipples (1 at top, 2 at bottom).
4. Two 1/4-inch x 1/2-inch galvanized iron threaded bushings (1 at top, 1 at bottom).
5. Two 1/2-inch x 1-inch PVC thread-socket bushings (1 at top, 1 at bottom).
6. One 1-inch PVC 4-socket cross connection (top).
7. One 1-inch PVC 3-socket tee connection (bottom).
8. One 1-inch PVC cap, threaded (neoprene gasket cut to fit).
9. Two 1-inch PVC pipes, unthreaded, 2 1/4 inches long (1 at top, 1 at bottom).
10. One 1-inch PVC pipe nipple 2 1/2 inches long, threaded one end (top).
11. Two 1-inch PVC pipe nipples 3 inches long, unthreaded (1 at top, 1 at bottom).
12. Two 1-inch PVC 2-socket elbows (1 at top, 1 at bottom).
13. Two 1/2-inch x 1-inch PVC thread-socket bushings (1 at top, 1 at bottom).
14. Two 1/4-inch x 1/2-inch galvanized iron bushings, threaded (1 at top, 1 at bottom).
15. Two 1/4-inch x 3/8-inch brass pipe thread-hose connectors (1 at top, 1 at bottom).
16. One 3/8-inch PVC nylon reinforced hose (225 psi working pressure) approximately 5 feet long (cut to fit).
17. Two 1-inch x 3-inch PVC 2-socket bushings (1 at top, 1 at bottom).
18. Two 3-inch x 6-inch PVC 2-socket bushings (1 at top, 1 at bottom).
19. Two 6-inch PVC 2-socket pipe couplers (1 at top, 1 at bottom).
20. One 6-inch PVC pipe approximately 4 feet long (unthreaded).

D, Fluid delivery hose. These can be made conveniently in 25-foot lengths and connected for longer distances. PVC nylon reinforced hose, at one end of the hose a 1/4-inch x 3/8-inch brass pipe hose connector, a 1/4-inch pipe coupling, and a male portion of a quick coupler; at the other end of the hose a 1/4-inch x 3/8-inch brass pipe-hose connector and a female portion of a quick coupler.

E, Manifold. One male portion of a quick coupler connected into a 1/4-inch galvanized iron cross which is in turn connected to two or more 1/4-inch similar crosses and ultimately to a 1/4-inch tee by means of 1/4-inch galvanized iron all-thread pipe nipples. All eight arms are then connected to female portions of quick couplers by means of 1/4-inch galvanized iron all-thread pipe nipples. At least two manifolds are supplied with the injection apparatus.

F, Injector hoses. Similar to D except 4-foot long; 16 are supplied per injection apparatus.

G, Injector head. See figure 2 for details.

Note: Schedule 80 PVC pipe and fittings should be used throughout, but are especially important to a capacity for high working pressures in sizes above 1 inch. All threaded joints are sealed with pipe thread compound. All unthreaded joints are connected by first coating the surfaces to be joined by brushing them with PVC primer, followed by a liberal application of PVC solvent cement; then the fittings are pushed firmly together. The hose ends are secured to pipe-hose connectors with stainless steel hose clamps.

[1] Mention of commercial products is for information only and should not be considered an endorsement by the Department of Agriculture or the Forest Service.

nails. The result is that less time and labor are required to attach and detach this model; and in addition, it is safer and more convenient to use.

## Construction of the Injection Apparatus

The injection apparatus (fig. 1) consists of seven components: (A) a gas pressure cylinder, (B) a gas pressure regulator, (C) a fluid reservoir, (D) a fluid delivery hose, (E) a manifold, (F) injector hoses, and (G) injector heads.

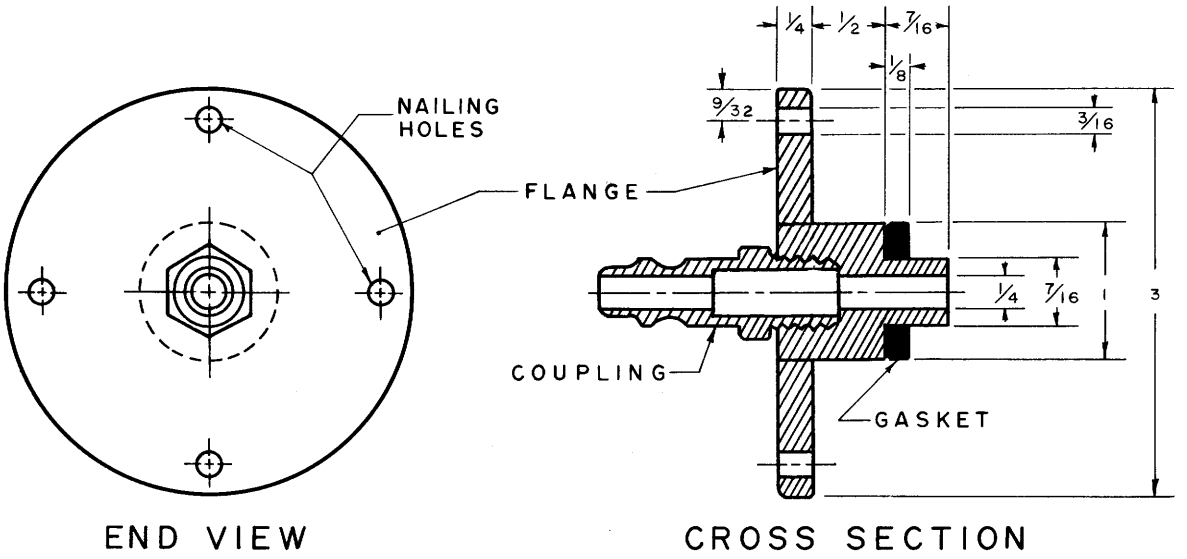
The assembly of the injection apparatus is shown in figures 1 and 2. We provide pressure for the system from a cylinder of compressed nitrogen gas. Though this is convenient, an air compressor could be used.

The clear PVC hose alongside the fluid reservoir provides a gage so that fluid level in the reservoir and rate of fluid uptake during operation can be observed. The neoprene-gasketed 1-inch cap at the top of the fluid reservoir makes a gas-tight seal, but it is easily removed or replaced by hand.

The 1-inch brass ball valves at the pressure inlet at the top and the fluid outlet at the bottom are important, especially the top one, which is necessary for maintaining pressure when not connected to a pressure cylinder and for slowly releasing pressure when injection is completed.

The manifold accommodates eight injector heads; however, it can be made with more outlets by adding more ¼-inch crosses and female quick-coupler parts. But we found it more convenient to connect two or more manifolds with the short injector hoses when treating especially large trees.

Figure 2.—Details of injector head.




Fabrication details: A 1-inch diameter iron rod 2-3/16 inches long is turned down to ⅞-inch diameter for ¼ inch at one end and to 7/16-inch diameter for 7/16 inch at the other end. A ¼-inch centered hole is drilled through the length of the rod and tapped for ¼-inch pipe threads at the ⅞-inch end so as to accept the male part of a quick coupler.

A 15/16-inch centered hole is drilled through a 3-inch diameter by ¼-inch-thick iron flange. The ⅞-inch end of the rod is inserted in the flange and welded on the flush side, and the weld is ground smooth. Four 3/16-inch holes are drilled in the flange, 90° apart and 9/32 inch from the edge. These are used for nailing the injector head to the tree. On the 7/16-inch portion of the injector are placed one or two ⅛-inch neoprene gaskets (outside diameter 1 inch and inside diameter 7/16 inch) to seal the injector head to the tree.

## Operation of the Injection Apparatus

Before preparing a tree for injection, it is generally desirable to determine the volume and concentration of injection fluid and the number of injector heads to be used. This is frequently determined on the basis of diameter at breast height of the tree. In our work on Dutch elm disease therapy and prophylaxis, we are injecting 675 ml per diameter inch. We use one injector per 8 inches of circumference based on dbh. Injector heads are attached as near the ground as possible or on the roots if they are exposed.

The injection sites are prepared with a brace and a $\frac{7}{16}$-inch wood auger with a 1-inch counterbore, adjusted so that when the 1-inch counterbore has cut almost to the inner bark, the wood auger has drilled through the outer two or three annual growth rings. An injector head is then inserted into each prepared injection site and is secured by four 8- or 10-penny duplex nails.

The injector heads are connected to the fluid reservoir by means of injector hoses, manifold, and the fluid delivery hose (fig. 1).

A trace of azosulfamide solution is added to the injection fluid so that injection may be followed visually. The injection fluid is put in the fluid reservoir, the hose from the pressure cylinder is connected to the fluid reservoir, and the gas pressure valve is opened. The gas pressure is adjusted by means of the pressure regulator. Air can be bled from the hoses ahead of the fluid by disconnecting an injector hose at the injector head and inserting an extra male part of a quick coupler into the end of the hose; however, we have found that bleeding the system is seldom necessary.

When injection is complete, the injector hoses are uncoupled from the injector heads, the valve at the top of fluid reservoir is closed, and the gas-pressure supply hose is uncoupled from it. The ball valve is then partially opened to release the pressure slowly. The injector heads are removed

Figure 3.—The tree injection apparatus in operation.

easily by pulling the duplex nails with a claw hammer.

## Results and Discussion

This improved tree-injection apparatus saves time and labor, particularly in attaching and detaching the injector heads. Nailed-on injector heads can be attached quickly and securely.

For a 24-inch American elm tree, about 10 minutes are required for attaching the injectors, 5 to 15 minutes for making the injection, and 5 minutes to detach the injectors.

The fluid reservoir is filled easily and rapidly. Although the fluid reservoir is light and can easily be moved to a tree, we usually leave it fastened in a vertical position on the tailgate of a sedan-delivery automobile (fig. 3). The pressure cylinder contains enough gas for 4 to 5 days of injecting and is secured in the vehicle during transport and use.

The gain in safety and time and labor saved are not at the expense of proficient functioning. The injection site, like that prepared for the original injector, channels the injection fluid into the vessels of the outer two or three annual growth rings (fig. 4). This injection site seems advantageous for injecting most types of injection fluids; for example, trace elements, systemic insecticides or fungicides, and herbicides. This apparatus or smaller models of it, in fact, have been used experimentally for injection of systemic insecticide, soluble fertilizer, herbicide, and systemic fungicide.

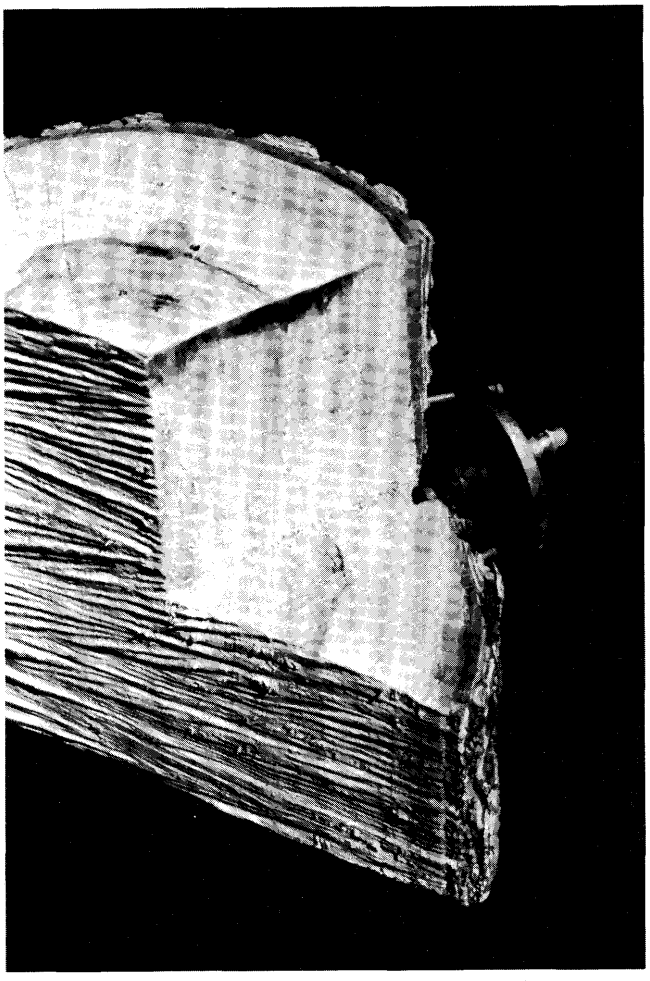


Figure 4.—Attachment of injector head. The injector head protrudes into the xylem through a hole that extends about 3 annual rings deep. The neoprene gasket is seated on bark that has been cut smooth by a 1-inch counterbore. The injector head is nailed in place with 8-penny duplex nails.

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MANUSCRIPT RECEIVED FOR PUBLICATION 10 MARCH 1975