Eccentric Engineer

Nathan 4000C “Non-Lifting” Injector

In 1.5” Scale

Installation, Maintenance, and Operation Manual

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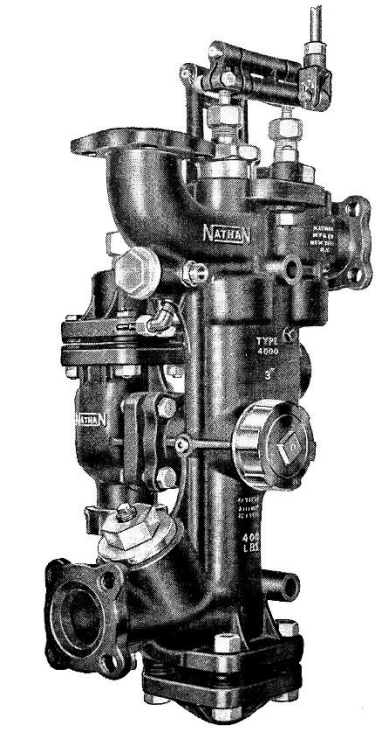
Introduction



This Nathan Type 4000 Injector meets every requirement for heavy duty locomotive service

The prototype 4000C Injector: advertising illustration.

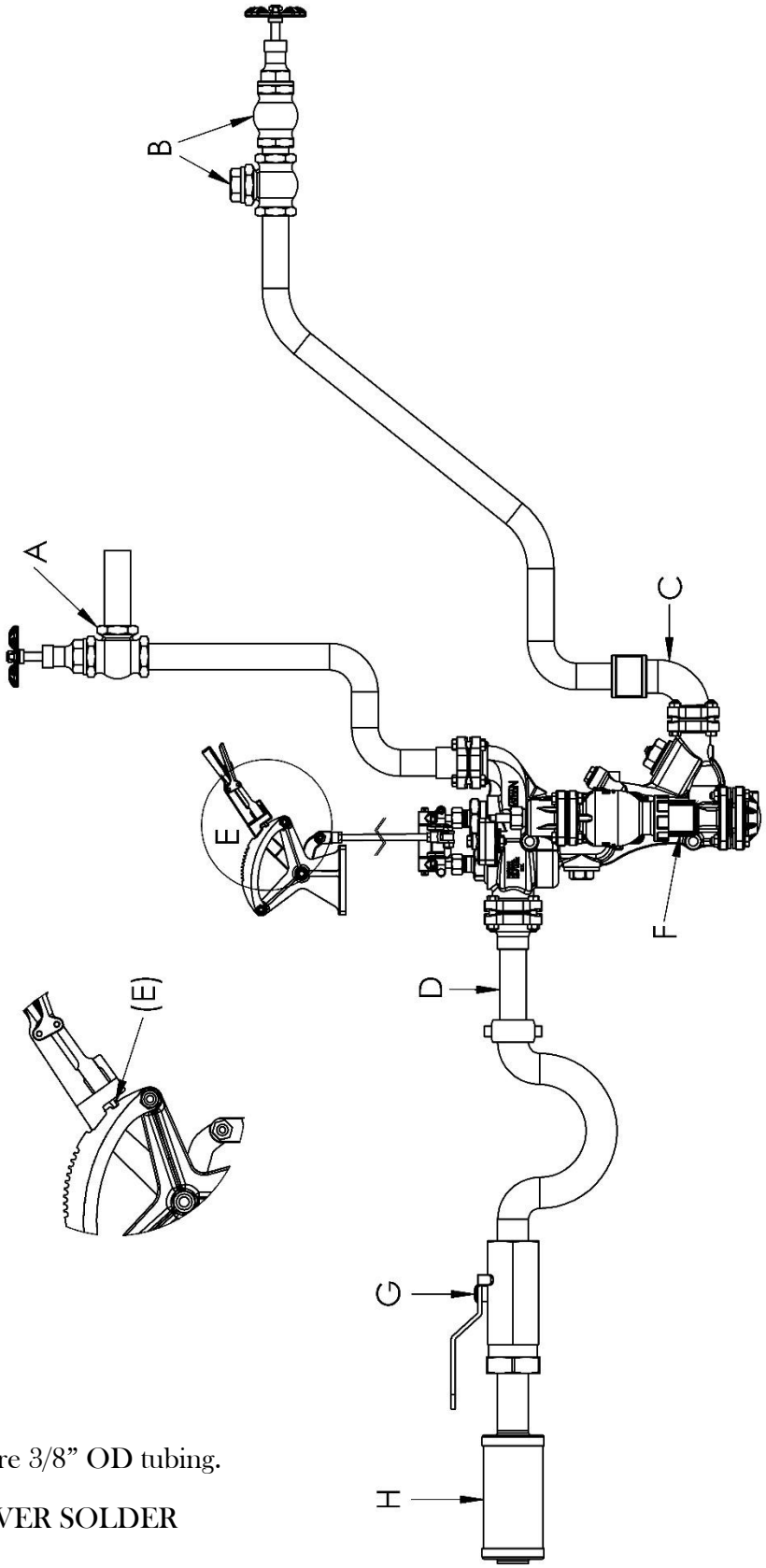
From the 1941 Locomotive Cyclopedia

Congratulations on your new 1.5” scale Nathan 4000C injector! Eccentric Engineer has recreated these injectors in miniature as accurately as possible from original Nathan blueprints.

Nathan Manufacturing Co. was founded in 1862 just 3 years after the earliest attempts to manufacture injectors. Focusing initially on items like lubricators and water gauges, they did not introduce their first injector until 1880. Their injectors quickly gained popularity, and towards the end of the steam era, the 4000C was required to keep up with the heavy demands of modern superpower locomotives.

With any injector, the quality of the installation is the greatest factor to its successful operation. In this manual, we will discuss the best practices for installation, operation, maintenance, and how to troubleshoot if the injector is not working correctly.

Installation



All connections are 3/8" OD tubing.

ONLY USE SILVER SOLDER

Fig A, Steam Shutoff Valve

Although the 4000C has a built-in steam valve, it is still strongly recommended to have a shutoff valve to isolate the injector for hydrostatic boiler testing, or in the event of a solder joint failure while in steam service. It can also then be used to control the injector if the quadrant is difficult to reach.

Fig. B, Boiler Shutoff & Check Valve

As a bare minimum, a 5/16" MTP (1/16" NPT) check valve should be used. Check valves from PM Research and SuperScale have proven reliable for this injector's capacity. If your check valve does not have a built-in shutoff, it is strongly recommended to have a shutoff valve between the boiler and check valve. This allows the check valve to be safely maintained under pressure.

Fig. C, Delivery Connection

Supplied with your injector is a cast 90° elbow for tight clearances between the injector and engine cradle casting. This elbow may be necessary depending on your installation requirements. A straight solder connection is also included if the elbow is not necessary.

Fig. D, Water Suction Line

The water suction line must be completely airtight between the injector and your shutoff/control valve (G). Avoid compression fittings and use as few fittings as possible.

Fig. E, Setting the Quadrant

The notches on the operating quadrant are very precisely placed to correspond with the valve positions inside the injector body. To ensure your quadrant works properly, set the latch as close as possible to the center of the "closed" notch with the 4000C valve fully closed. The position of the handle can be adjusted by screwing or unscrewing one of the clevis ends of the control rod.

Fig. F, Overflow

Since the 4000C is to be installed below the cab, the overflow is already ideally positioned near the ground, so an extension should not be necessary. However, many prototype installations had a simple extension so the overflow could be more readily visible from the cab. Diffusers from SuperScale or Keim Steam Pump make a nice addition to your injector's overflow!

Fig. G, Tender Shutoff Valve

Although the 4000C has a built-in water valve, it is still recommended to have a shutoff valve on the tender. This allows the engine and tender to be disconnected in the event of an emergency without draining the tender. The shutoff valve can also be used as a water control valve and can give more flexibility to the injector's operation, which will be discussed more in Operation.

Fig. H, Water Filter

The 4000C has filters built-in around the internal valves, however EE still strongly recommends a water filter to ensure you can enjoy a maintenance-free injector. Dorman "Help!" glass fuel filters work very well if your tender does not have a filter inside the tank. They are readily available from O'Reilly Auto Parts and are serviceable.

Working With Flanges

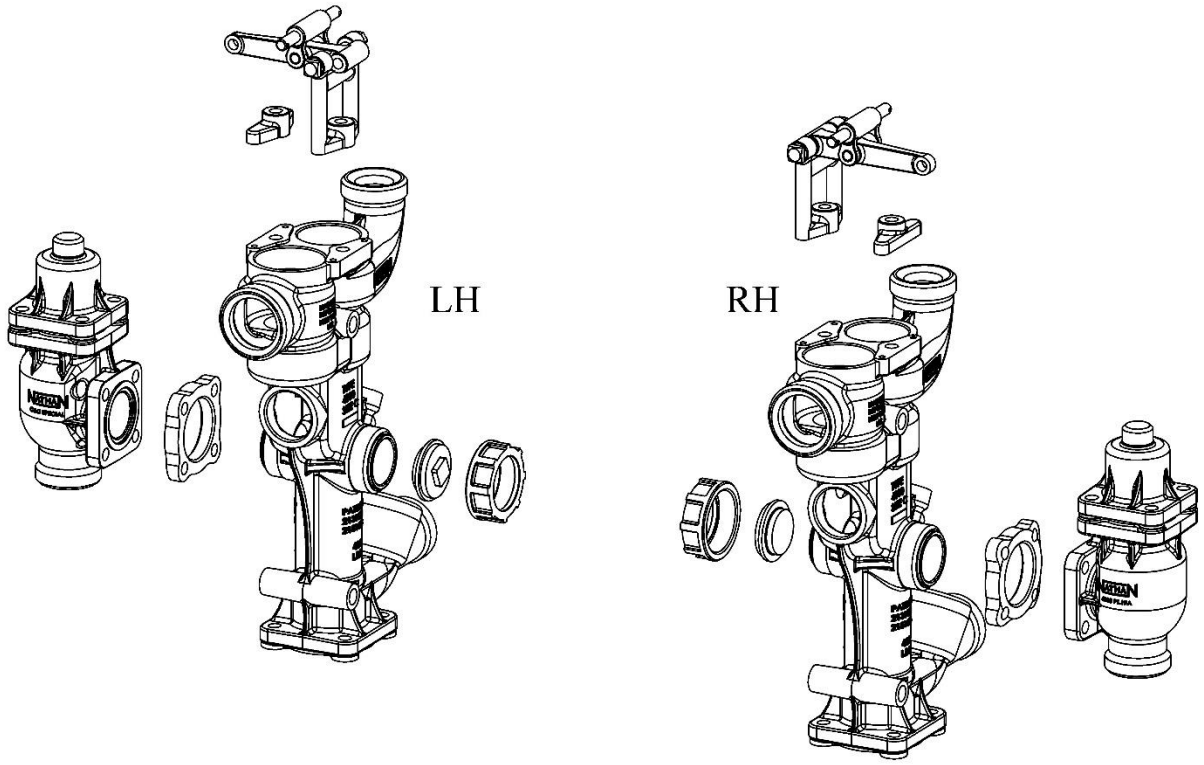
Having flanges like the prototype really make this injector stand out, but there are some things to keep in mind when working with them.

Most importantly, do not forget to put the smooth flange (opposed to threaded) on your tubing before soldering the union!

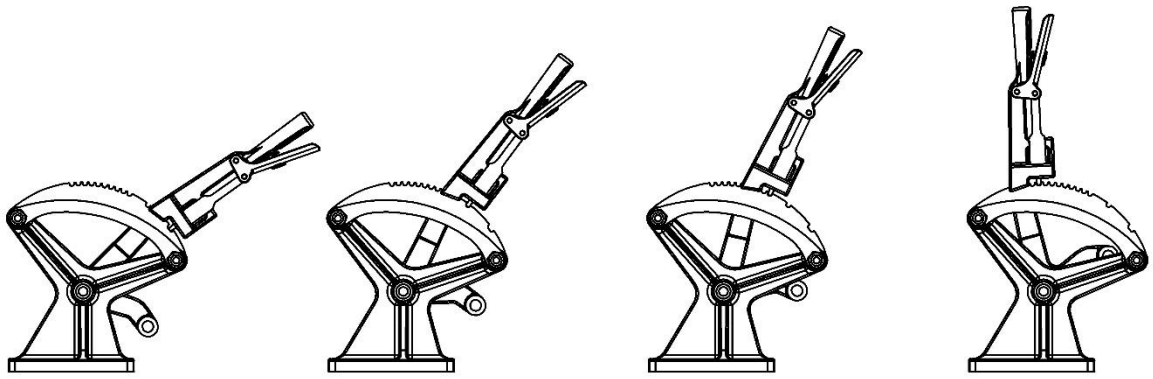
Generally, it doesn't matter whether the bolts are installed on the injector side or the union side, however EE recommends as a rule of thumb that the bolts should be installed on the injector side. When disassembling the flanges, this generally makes the bolt stay in place, and only the nuts will come loose. One exception to this is the steam inlet flange. The bolts should be on the union side so gravity keeps them in place. Have a cup handy to capture the nuts if they escape!

Switching Sides

These injectors were most commonly installed on the righthand side (engineer's side) of the locomotive, however there were most certainly exceptions to the rule. If you need to switch your injector from right hand to left hand (or visa versa), below is a diagram of the effected parts that need to be switched:



Operation



1) Closed 2) Prime 3) Wide Open 4) Minimum Capacity

Like the prototype, the 1.5" scale 4000C features "one step" operation. You have full control over a wide range of operating conditions with a simple pull of the quadrant handle.

1) Closed – first notch

When closed, the internal water and steam valves are both shut off, eliminating the proverbial problem of forgetting to shut the water valve and accidentally draining your tender.

2) Prime – second notch

In the priming position, the water valve is wide open and the steam valve is just barely cracked. If the injector or feedwater is overheated, this is the best position to leave it in for it to eventually draw in water. At low pressures, the quadrant will need to be opened wider to prime.

3) Wide Open – third notch

In the wide open position, the water and steam valve are both fully open. Depending on your installation and operating pressure, you may need to pull the quadrant back another notch or two for the injector to start.

4) Minimum Capacity – "fining down" the injector

All notches passed the third notch will begin to restrict the water valve while keeping the steam valve fully open. This trims back, or "fines down" the amount of water the injector is delivering. Bringing the handle further back will be necessary when operating below full operating pressure. At the lowest operating pressure (45 and below), the quadrant must be pulled back fully.

Operating Without the Quadrant

Depending on your locomotive, the quadrant may be difficult to reach. In this case, set the quadrant to where the injector picks up at your maximum operating pressure. Leave the quadrant in that position, and operate the injector using your steam turret valve and tender water valve.

Maintenance

Preventative Measures for a Maintenance-Free Injector

The 4000C is designed to be as maintenance free as possible, and with a proper installation it should truly be maintenance free. Here are the steps you can take to ensure you never have reason to disassemble your injector.

1) Water Filter

The Nathan 4000C has a strainer which shrouds the water valve, but it could still eventually become clogged by coal, dirt, and other debris from the tender. A fine water filter prior to the injector (as described in Installation, Fig. H) is the ultimate preventative defense to keep your injector functioning properly.

2) Scale buildup

Another common problem is scale buildup in the nozzles. This occurs after the locomotive has been shut down and water sits inside the injector. As it sits and very slowly dries out, minerals are deposited on the nozzles. This slowly reduces the injector's performance and causes the check washer to freeze up on the delivery cone. The best way to prevent this is to thoroughly blow the injector out with air after a run, preferably through the steam line. If that is not possible, then blowing it out through the tender water line will work as well. Be sure the quadrant is in the "wide open" position and your steam turret valve is open while performing this step. Be cautious of using too much boiler treatment as well. This can easily leave a thick coating on the nozzles.

3) New Boilers and Installations

When steaming up for the first time with a new boiler, it is recommended to steam up and blow down multiple times to remove all rust, scale, and metal shavings from inside the boiler before trying your injector. They WILL make their way inside!

With a new installation or new boiler, it is recommended to disconnect the steam line to the injector and blow it out with steam before trying the injector. This ensures any debris from manufacturing (chips, flux, etc..) are completely removed from the line before putting steam to your injector. Rinsing your tubing thoroughly with water and blowing with compressed air will suffice as well.

The 1.5” 4000C is assembled just like its full-sized companion, so it is not a simple procedure to remove the internal components. But, if you prescribe to the forementioned preventative steps, you should never have to take the injector apart.

Disassembling the 4000C

If the injector does need to be disassembled for cleaning, follow these steps to take apart the injector without damaging any of the internal components.

1) Remove the four #3-48 nuts and bolts that secure the bottom cap.

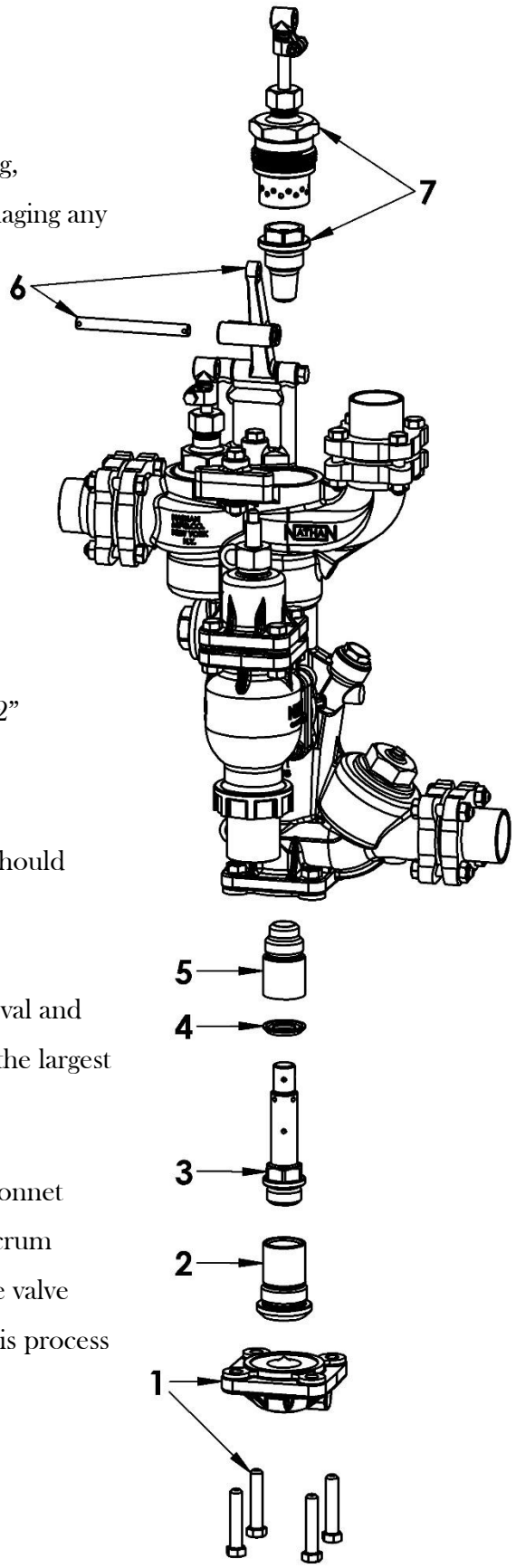
2) The nozzle spacer has a 7/32” internal hex for easy removal with an Allen key. The delivery cone and washer will come out along with the spacer.

3) The delivery cone is threaded into the spacer. Use the internal hex on the spacer and the external 9/32” hex on the delivery cone to remove the nozzle.

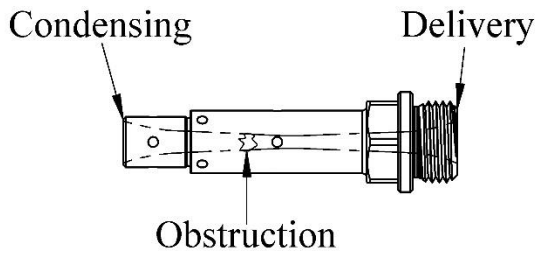
4) The washer sits on the top of the delivery cone and should move freely. The chamfered side faces down.

5) The combining cone requires a special tool for removal and should not be removed unless it is being replaced. It is the largest nozzle and is the least prone to build up or wear.

6) Before removing the steam nozzle, the steam valve bonnet assembly must be removed. To do this, remove the fulcrum pin which goes through the knuckles that directly lift the valve stems. This pin is held in place with .02” brass wire. This process may be easier with the lifting clevis removed.



7) With the lifting bracket now out of the way, unscrew the steam bonnet. It features a 1/2" hex. The whole assembly pictured will come out as one unit. Then remove the steam nozzle with a 3/8" socket or nut driver. This may be easier with the water bonnet removed as well.



Unclogging Your Injector

If your injector was working fine and suddenly stops, a clogged nozzle is the most likely culprit. With the built-in filters in addition to all the proper precautions, hopefully this will never happen. If it does, refer to these instructions for the safest and most effective way to unclog your nozzles.

99 times out of 100, obstructions occur in the delivery cone. Luckily, it is the easiest to get to. The delivery cone is technically two separate nozzles that meet in the middle. On the left (which is the top of the cone when installed) is the condensing nozzle. The right (bottom when installed) is the delivery nozzle. When something gets stuck, it is inevitably in the condensing side of the delivery cone, otherwise it would have passed through the delivery cone and traveled to your boiler.

Contrary to traditional advice, the best way to unclog an obstruction is with a properly sized steel gauge pin. Digging it out with something softer can do just as much damage as scraping the cone walls with metal, and you can end up breaking off the end of your toothpick or copper wire inside the cone. A .050" - .053" steel gauge pin will push out the obstruction with ease, and if it is done correctly, there is absolutely no risk of damaging the nozzle.

So how to do it correctly? The pin must be inserted from the delivery end. If inserted from the condensing end, you WILL push it in tighter. No matter what. When inserting the pin in through the delivery end, move it in slowly without applying pressure against the cone walls. Once it hits the obstruction you will feel the pin stop. At this point is safe to apply some pressure to push out the obstruction. The pin will now be held in place by the small straight diameter in the middle of the nozzle and will not scrape the tapered walls of the cone.

Troubleshooting

Once the quadrant is placed in a suitable position relative to your operating pressure, the 4000C injector should draw in water and promptly begin injecting without overflowing water or steam. Any variance from this described operation indicates there may be a problem with the installation or the injector.

Symptoms:

1. All steam and no water while in the prime position – B, H, I
2. Water flows freely but injector won't pick up – A, C, E, G, H, K
3. Injects, but overflow will not run dry – A, B, D, H, J, K
4. Overflow sputters water and steam while injecting – A, B, H, I
5. Water drips from overflow while injecting – A, B, D, H, J, K, M
6. Steam coming from overflow while injector is not in operation – L
7. Steam blowing back to tender – C
8. High starting pressure - A

Potential problems:

A. Leak in water suction pipe
B. Obstruction in suction pipe or clogged water filter
C. Clogged delivery nozzle
D. Restricted delivery line
E. Check valve shutoff closed
F. Check valve leaking / stuck open
G. Wet steam into injector
H. Feed water too warm
I. Water tank empty
J. Worn out nozzles
K. Water valve and/or quadrant improperly adjusted
L. Leaky steam valve
M. Boiler pressure too high

Solutions

A. Leak in Water Suction Pipe

When using the quadrant, the effects of a leaky water joint between the injector and tender are negligible. If you're using a tender water valve as your primary water adjustment, make sure all joints and fittings are completely air-tight. The smallest air leak will impact your injectors performance. This is the cause of nearly all injector troubles.

B. Obstruction in Suction Pipe or Clogged Water Filter

If the suction pipe is clogged, either in the line or in the filter, this can act the same as having the water valve closed too far or shut entirely. If possible, first clean out the water filter to rule out that potential issue. Blow out the water lines with steam or air and be sure water is flowing freely out of the tender with the lines disconnected.

C. Clogged Delivery Nozzle

This is the most common issue that plagues injector owners, and it will cause the injector to simply not work. A filter is your best defense against anything getting in your injector. Refer to the steps outlined on page 10 to safely remove, inspect, and clear your delivery nozzle.

D. Restricted delivery line

If water flows from the overflow no matter how the injector water valve is adjusted, then it is possible that the delivery line is too restrictive. This could be due to restrictive fittings, pipe with too small of an I.D., a check valve that is too small, or a shut off valve with excessively small passageways. Be sure that all fittings and pipes in the delivery system have a minimum I.D. of 1/4" to ensure optimal performance.

E. Check Valve Shutoff Closed

Make sure the shutoff to the boiler check valve is open.

F. Check Valve Leaking or Stuck Open

If possible, close the check valve shutoff and maintain the check valve. The injector should be able to operate normally if the leak is not severe, however if it is so severe that the injector will not operate, or boiler water loss is significant and there is no secondary injector, follow this procedure:

Close the shutoff to the check valve. Start the injector as normal and set the quadrant to its normal operating position. Its delivery will discharge out the overflow with the check valve shut. Slowly open the check shutoff until the injectors overflow runs dry. When the water level is satisfactory, close the check valve and shut off the injector. If the leak was due to debris, this may fix the leak. If there is a more serious problem with the check valve, this procedure will keep your boiler full until you can safely shut down your locomotive.

G. Wet Steam into Injector

If the steam line taken from the boiler is not from a dry pipe, water can be sucked into the steam line. Move the line to a point where it can only receive dry steam. If the boiler water is too high, or contaminants are causing foaming, this can cause priming as well.

H. Feed Water Too Warm

For optimal performance, the feedwater temperature should be 60-80 degrees Fahrenheit. The injector will work with warmer feedwater temperatures, but efficiency and performance will decline. If the feedwater tank is too warm, top off the tank to bring the temperature down. If the tank is full and still too warm, partially drain the tank before adding cool water. Adding ice to the tender will get you by, too!

I. Water Tank Empty

Be sure to check water tank level frequently to avoid a low water emergency.

J. Worn Out Nozzles

If overall performance has declined, it may be time to replace the nozzles. However, with the frequency the typical hobbyist runs, it should be many decades before the stainless nozzles wear out. Eccentric Engineer keeps extra sets in stock should you wish to replace them!

K. Water Valve or Quadrant Improperly Adjusted

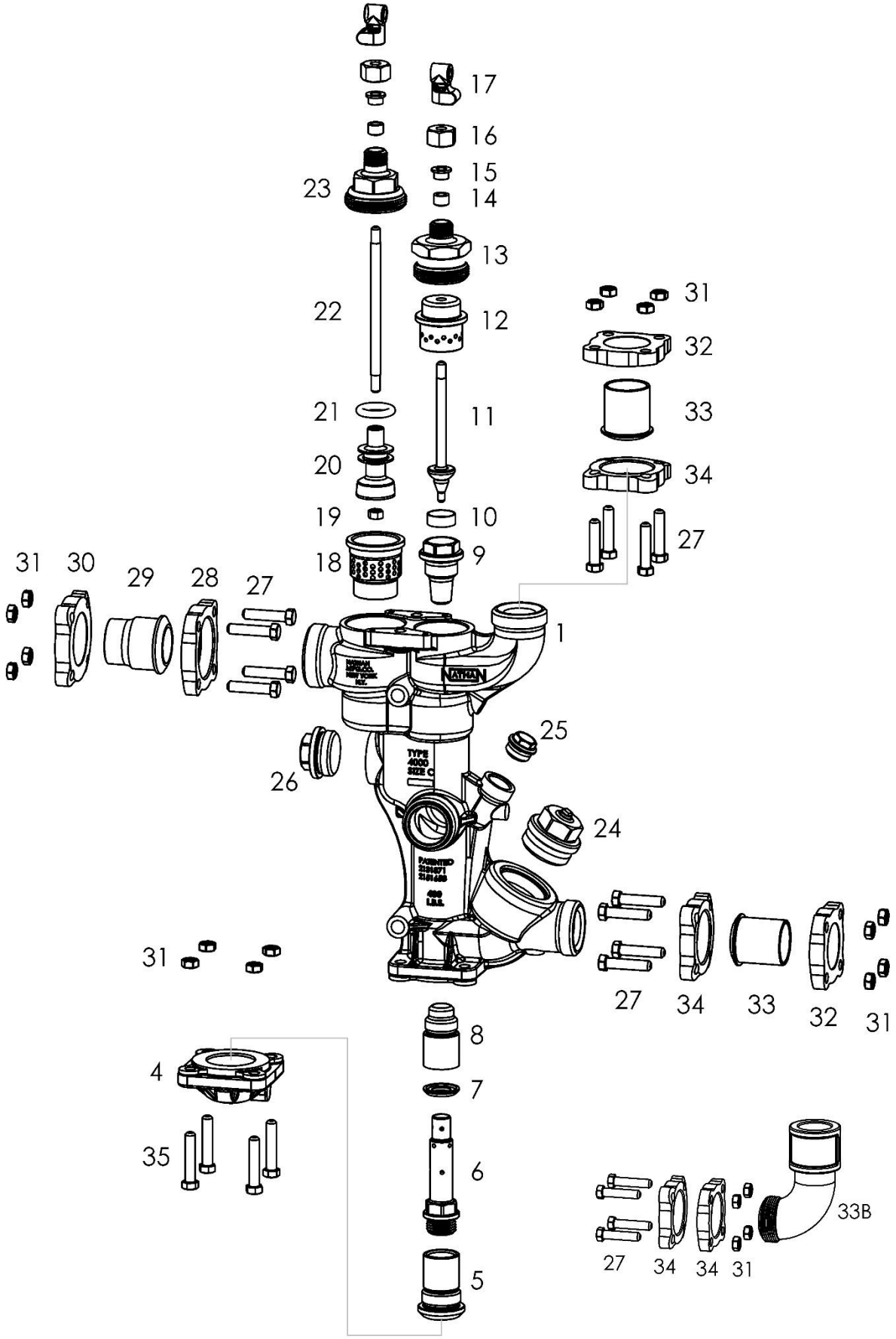
If water is pouring from the overflow during operation, the first thing to try is slowly close the water valve, or slowly pull back the operating quadrant. If the overflow does not dry up, and instead goes from pouring water to sputtering steam, then there is another issue that needs to be addressed. See A, C, G or H.

L. Leaky Steam Valve

The 4000C injectors feature a replaceable Teflon seat which should provide a very forgiving seal on your steam valve. If a steam leak occurs, it's possible that debris is holding the valve open, or has become embedded in the Teflon. A replacement seat may be required. Also check to make sure the packing glands are not too tight and preventing the valve from closing properly.

M. Boiler Pressure Too High

The 4000C injectors are guaranteed to work between 40psi and 150psi. With ideal conditions they may operate from 30-160psi. Above this, the injector will likely begin to waste water out the overflow. It will still inject water, but with noticeable loss.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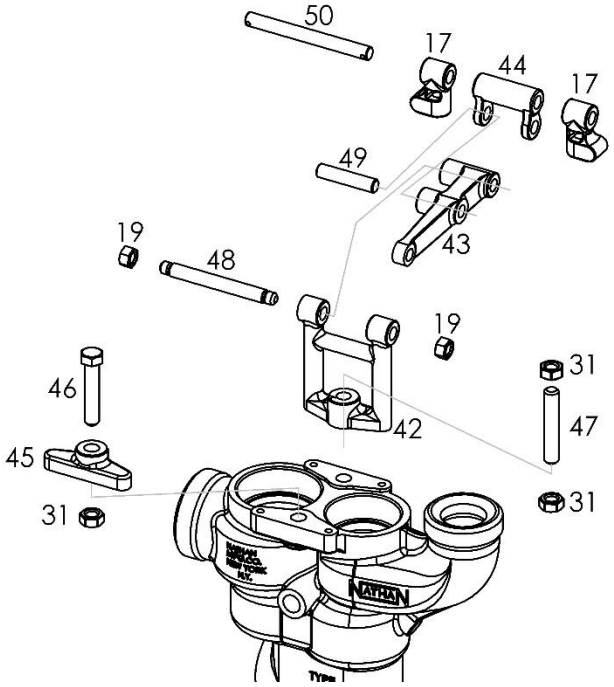
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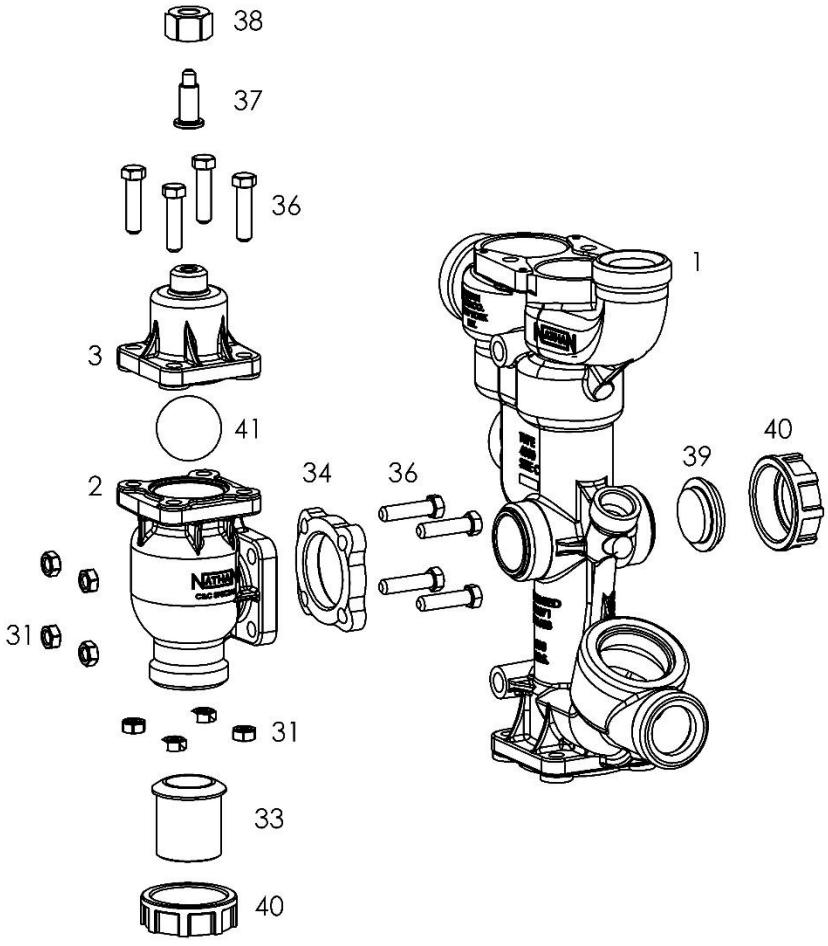
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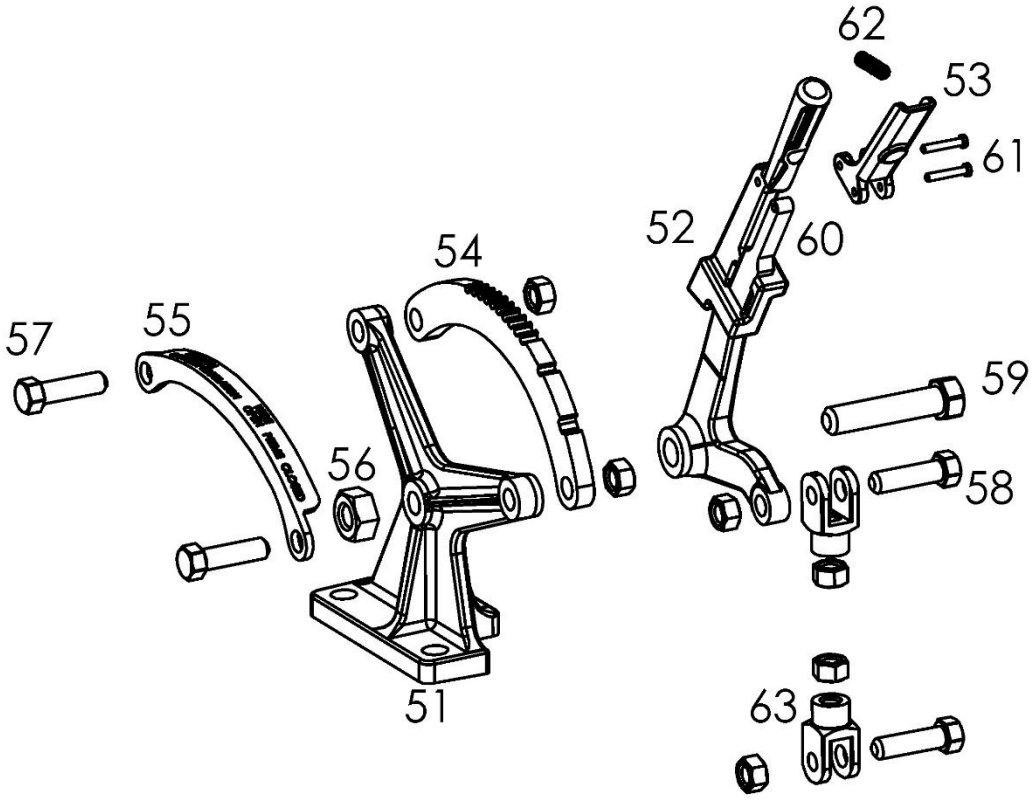
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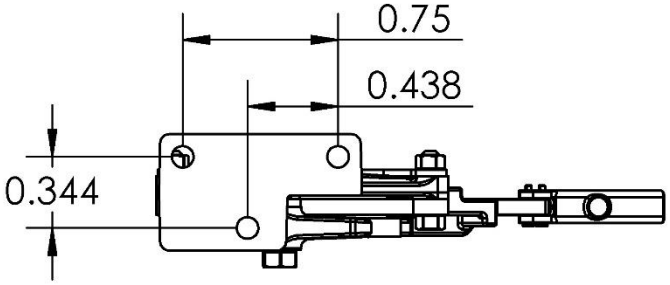
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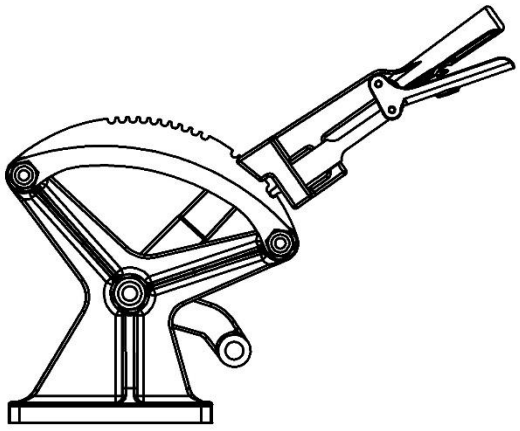

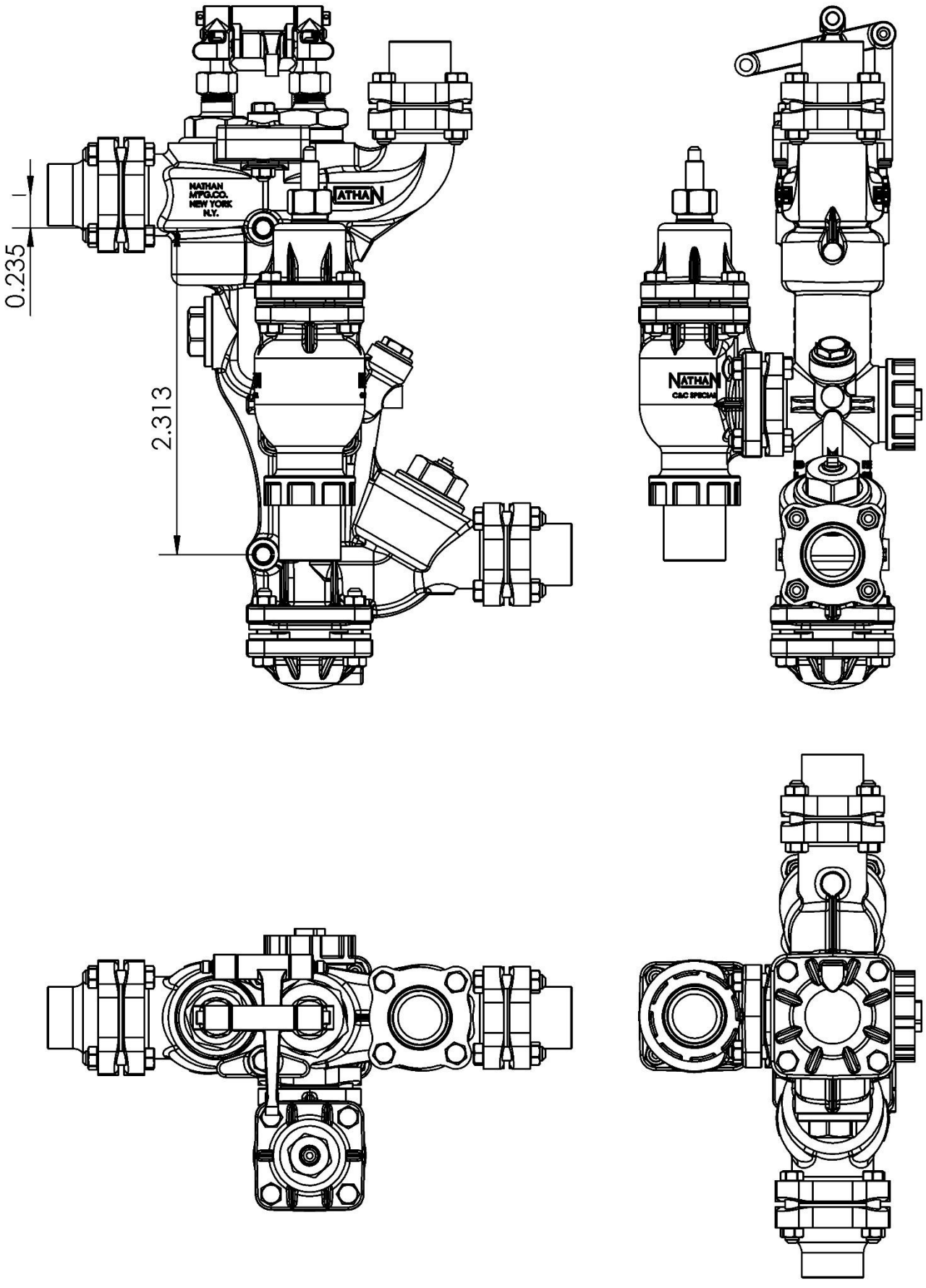
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NATHAN
MFG.CO.
NEW YORK
N.Y.
NATHAN
C&C SPECIAL

Nathan 4000C Parts List

1 - Body
2 – Overflow Body
3 – Overflow Valve Cap
4 – Body Bottom Cap
5 – Nozzle Spacer
6 – Delivery Nozzle
7 – Nozzle Washer
8 – Combining Nozzle
9 – Steam Nozzle
10 – Teflon Valve Seat
11 – Steam Valve Stem
12 – Steam Valve Cage
13 – Steam Valve Bonnet
14 – Teflon Valve Packing
15 – Packing Follower
16 – Valve Packing Nut
17 – Valve Stem Lifting Knuckle
18 – Water Valve Cage
19 – #2-56 Nut
20 – Water Valve Poppet
21 – 3/8" OD Viton O-Ring
22 – Water Valve Stem
23 – Water Valve Bonnet
24 – Delivery Check Cap
25 – Control Cylinder Cap
26 – Inlet Valve CAp
27 – #3-48 x .425" Bolt
28 – Water Flange (Threaded)
29 – Water Solder Connection
30 – Water Flange (Clearance)
31 – #3-48 Nut
32 – Steam Flange (Clearance)
33 – Steam Solder Connection
33b – Cast Delivery Elbow
34 – Steam Flange (Threaded)
35 – #3-48 x .468" Bolt
36 – #3-48 x .375" Bolt
37 – Overflow Valve Stem
38 – Overflow Packing Nut
39 – Overflow Body Cap
40 – Overflow Spanner Nut
41 – 7/16" Viton Ball
42 – Fulcrum Bracket
43 – Lifting Lever
44 – Lifting Link
45 – Fulcrum Bracket Cover
46 – #3-48 x .5" Bolt
47 – #3-48 x .56" Stud
48 – Lifting Lever Pin
49 – Lifting Link Pin
50 – Valve Lifting Pin
51 – Cab Stand Bracket
52 – Hand Lever
53 – Latch Handle
54 – Quadrant
55 – Position Name Plate
56 – #4-40 Nut
57 – #2-56 Bolt
58 – #2-56 Clevis Pin
59 – Handle Fulcrum Pin
60 – Latch Plunger
61 – Latch Handle Pins
62 – Latch Spring
63 – Lifting Rod Clevis

Eccentric Engineer

Anthony Duarte

607 N Poplar St, Orange, CA 92868

anthony@duarte.com • (650) 450 - 1422