EXCERPTS SELECTED BY JGH FROM

PRACTICE AND THEORY

OF THE

INJECTOR.

BY

STRICKLAND L. KNEASS, C.E.,

MEMBER OF THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, FRANKLIN INSTITUTE, ENGINEERS' CLUB OF PHILADELPHIA.

SECOND EDITION.

REVISED AND ENLARGED.

FIRST THOUSAND.

NEW YORK:

JOHN WILEY & SONS.

LONDON: CHAPMAN & HALL, LIMITED.

1898.

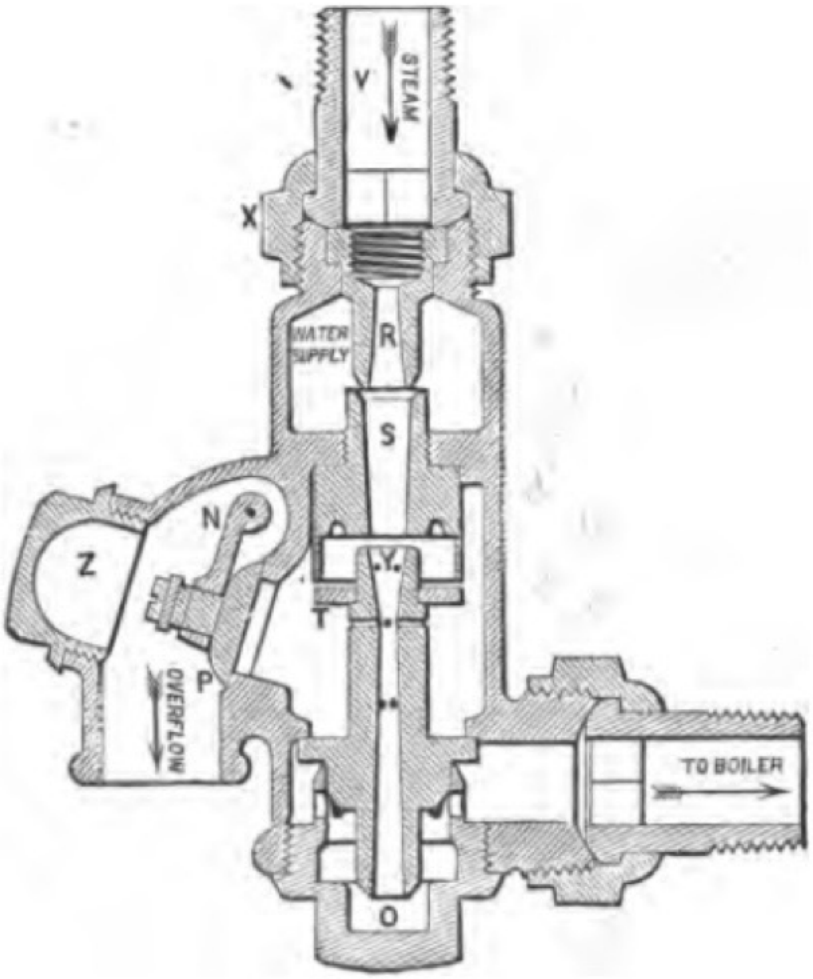
An Injector is an apparatus in which a gaseous jet impinges and is condensed by a fluid mass whose final kinetic energy exceeds that of a jet of similar form and density discharging under the initial pressure of the motive jet.

THE PENBERTHY INJECTOR,

which is shown in Fig. 36, also belongs to the re-starting class, as it is arranged with an overflow near the steam nozzle, which is closed when the injector is in action by the loose washer *T* sliding upon the outside of the combining tube *Y*. Steam discharges from the nozzle *R*, flows through the larger opening at the mouth of the suction tube *S*, and raises the water to the feed chamber, the inlet branch being at the side of the body facing the observer, and therefore not appearing in the drawing; the partial vacuum caused by the condensation of the steam raises the washer *T* to its seat in the same manner as the combining tube in the Gresham Injector, so that the two overflows are separated and no air

can enter, even if the waste valve *P* should leak; this valve is made large enough to permit free discharge for the steam without producing any back pressure in the overflow chamber, as this would interfere with the lifting power of the

FIG. 36. "PENBERTHY."



steam jet. The following tests of an injector of this pattern have been furnished by the manufacturers, but were made by disinterested experts—height of lift = 3 feet:

Limiting feed temperature at 65 lbs. steam,					128°,	delivery	200°
"	"	"	75	"	121°	"	196°
"	"	"	85	"	117°	"	200°
"	back pressure without overflow at 65 lbs., 92 lbs.						
"	"	"	"	75	" 103	"	
"	"	"	"	85	" 112	"	

In conclusion it may be said that the construction of the injector is exceedingly simple, as starting is effected by opening the globe valves placed on the steam and feed pipes.

FIG. 36 "PENBERTHY" DRAWING MODIFIED BY J. G. HOOK TO INCREASE THE CLARITY OF THE VARIOUS PASSAGEWAYS WITHIN THE INJECTOR

INJECTOR ILLUSTRATED NOT OPERATING WITH STEAM AND WATER SUPPLIES SHUT OFF

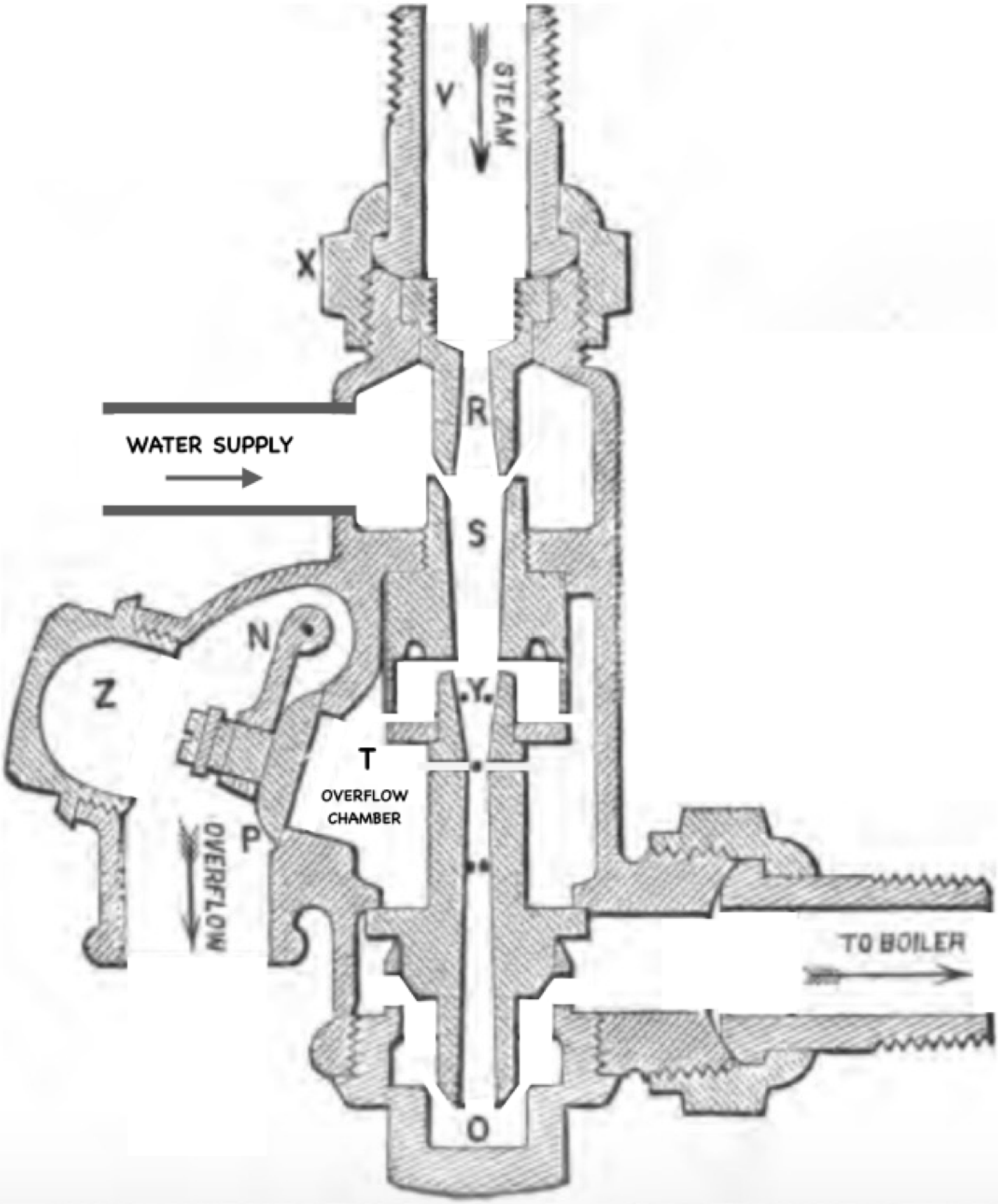


FIG. 36 "PENBERTHY" DRAWING MODIFIED BY J. G. HOOK TO INCREASE THE CLARITY OF THE VARIOUS PASSAGEWAYS WITHIN THE INJECTOR

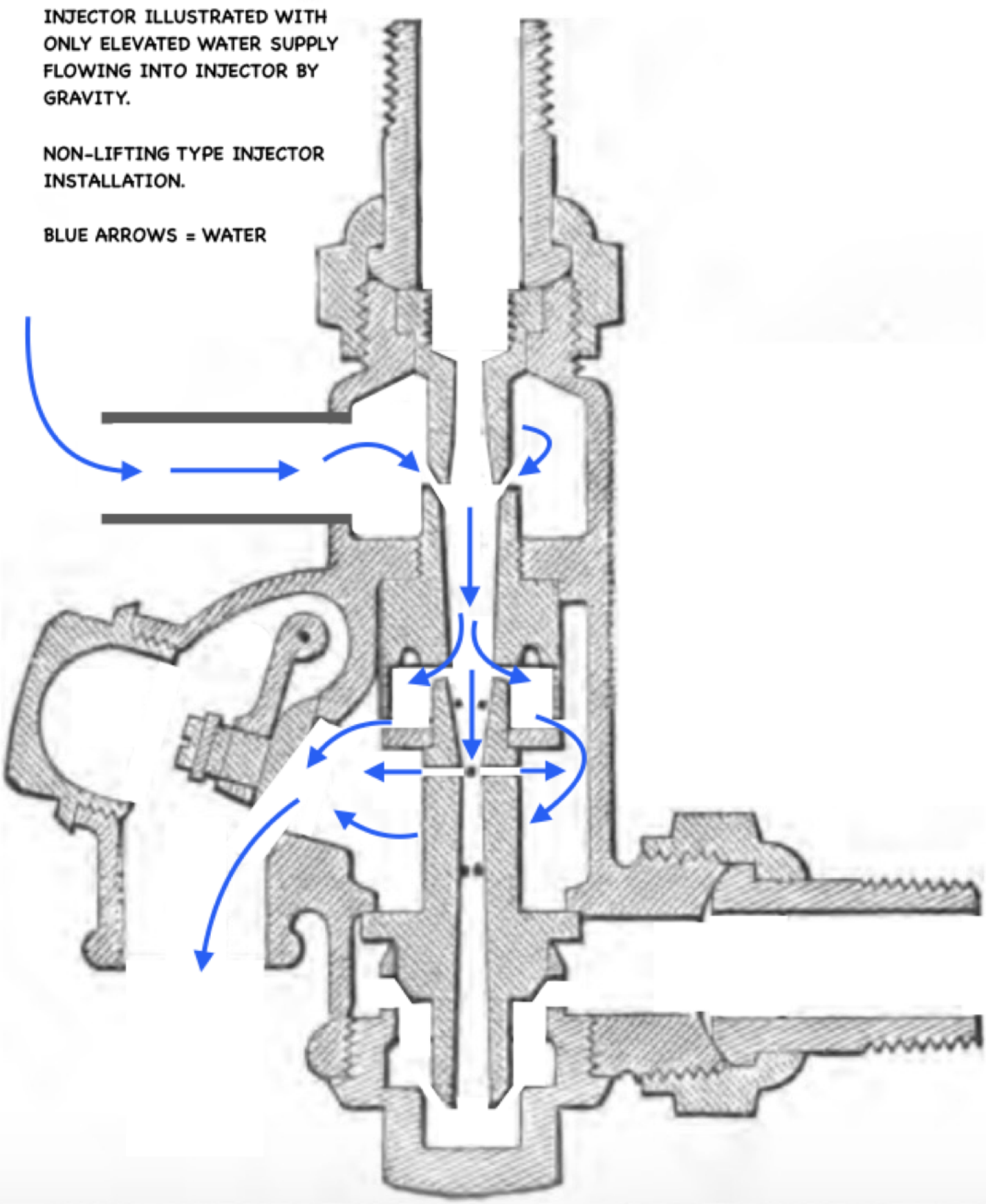


FIG. 36 "PENBERTHY" DRAWING MODIFIED BY J. G. HOOK TO INCREASE THE CLARITY OF THE VARIOUS PASSAGEWAYS WITHIN THE INJECTOR

INJECTOR ILLUSTRATED WITH ELEVATED WATER SUPPLY FLOWING INTO INJECTOR BY GRAVITY AND STEAM AT BOILER PRESSURE FLOWING INTO INJECTOR AND BEFORE THE WATER SUPPLY HAS SUFFICIENTLY CONDENSED THE STEAM JET ISSUING FROM THE STEAM NOZZLE.

NON-LIFTING TYPE INJECTOR INSTALLATION.

BLUE ARROWS = WATER
MAGENTA ARROW = STEAM
ORANGE ARROWS = MIXTURE OF STEAM AND WATER

THE DRAFT RELEIF WASHER CHECK VALVE BEING IN ITS LOWER OPEN POSITION ALLOWS FOR THE STEAM NOT CONDENSED TO ESCAPE OUT THE OVERFLOW OPENING, THUS THE WATER SUPPLY INTO THE INJECTOR IS NOT DISRUPTED DURING THE PERIOD OF TIME WHEN THE STEAM JET IS NOT YET COMPLETELY CONDESCENDED BY THE WATER SUPPLY.

THE AFORESAID DRAFT RELEIF FEATURE IS ESPECIALLY IMPORTANT WHEN THE INJECTOR IS INSTALLED IN A LIFTING TYPE INSTALLATION WHERE THE INITIAL FLOW OF THE STEAM JET IS RELIED UPON TO FORM A VACUUM IN THE WATER SUPPLY CHAMBER THAT WILL IN TURN RESULT IN THE WATER SUPPLY BEING DRAWN UPWARD FROM A WATER SUPPLY TANK LOCATED BELOW THE ELEVATION OF THE INJECTOR WATER SUPPLY INLET.

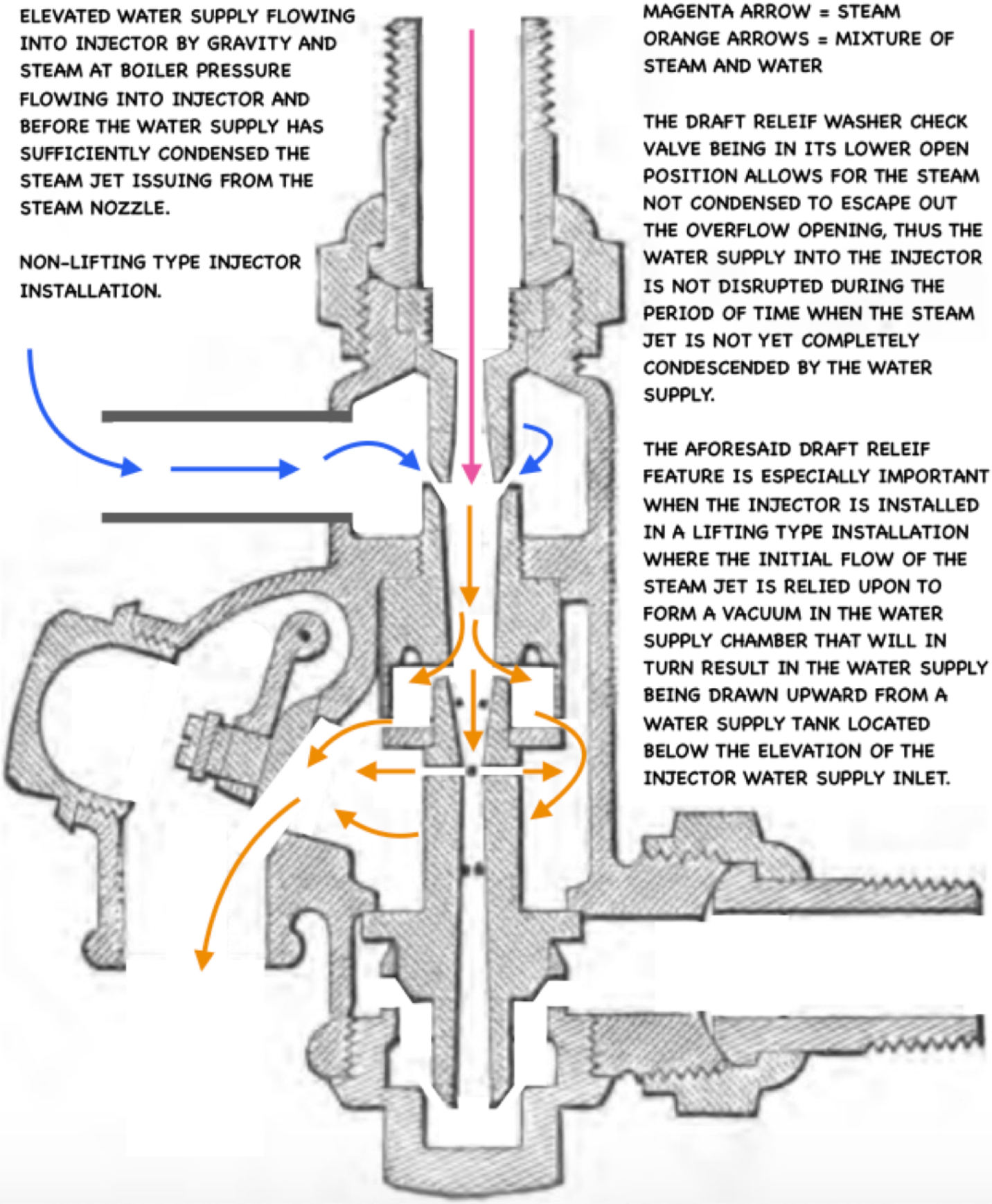
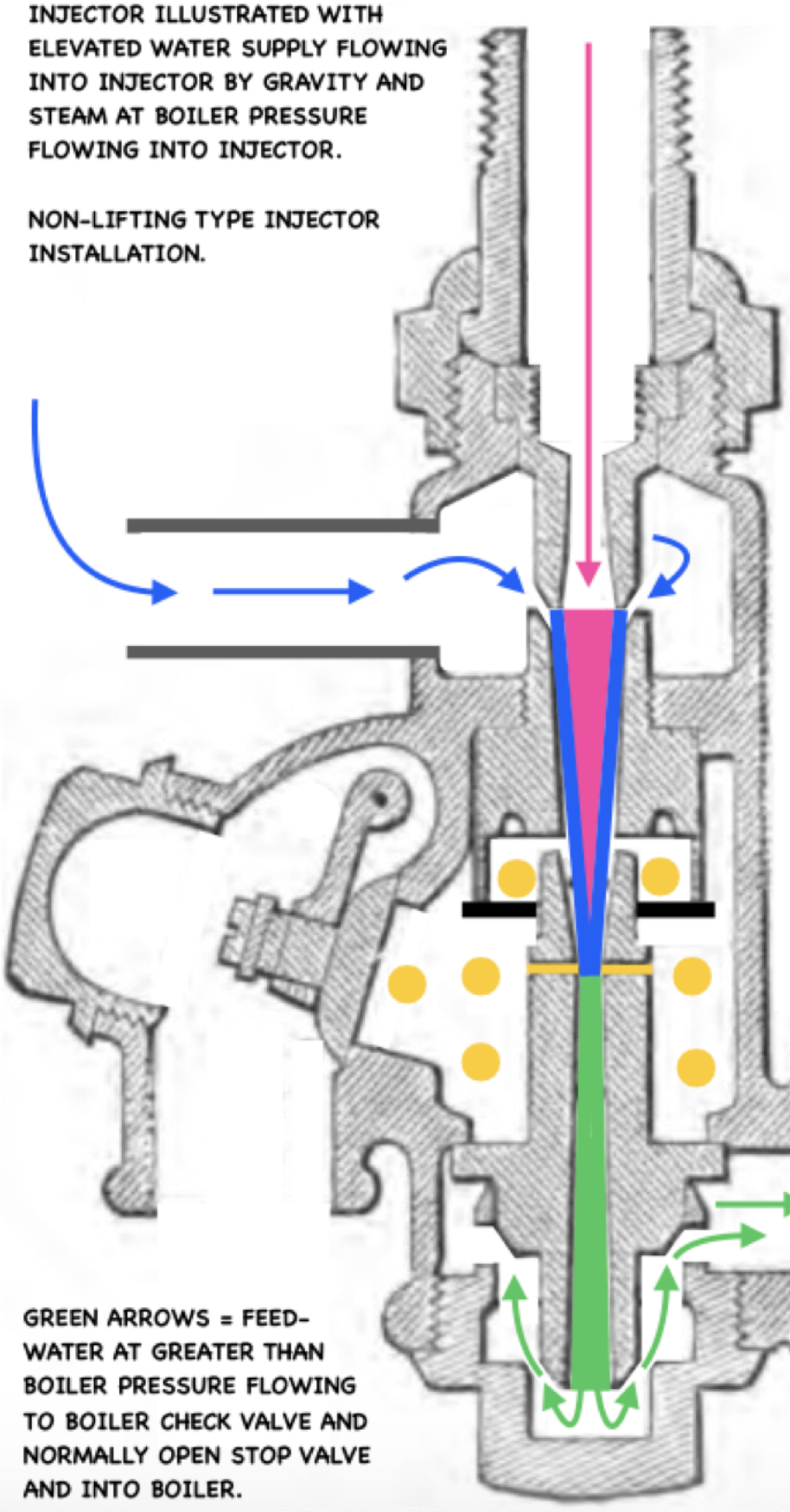


FIG. 36 "PENBERTHY" DRAWING MODIFIED BY J. G. HOOK TO INCREASE THE CLARITY OF THE VARIOUS PASSAGEWAYS WITHIN THE INJECTOR

INJECTOR ILLUSTRATED WITH ELEVATED WATER SUPPLY FLOWING INTO INJECTOR BY GRAVITY AND STEAM AT BOILER PRESSURE FLOWING INTO INJECTOR.

NON-LIFTING TYPE INJECTOR INSTALLATION.



BLUE ARROWS = WATER
MAGENTA ARROW = STEAM

MAGENTA TRIANGLE = HIGH VELOCITY STEAM JET ISSUING FROM STEAM NOZZLE BEING CONTINUOUSLY AND GRADUALLY COMPLETELY CONDENSED BY SUPPLY WATER.

BLUE TRIANGLES = SUPPLY WATER INCREASING IN VELOCITY DUE TO COMING INTO CONTACT WITH THE STEAM JET AS THE STEAM JET IS COMPLETELY CONDENSED BY THE SUPPLY WATER.

YELLOW DOTS AND LINES = AREA AT LESS THAN ATMOSPHERIC PRESSURE THAT RESULTS IN DRAFT RELEIF WASHER CHECK VALVE RAISING TO ITS CLOSED POSITION AND OVERFLOW CHECK VALVE BEING CLOSED AGAINST ITS VALVE SEAT.

GREEN TRIANGLE = HIGH VELOCITY WATER JET PRODUCED BY SUPPLY WATER COMPLETELY CONDENSING THE STEAM JET ENTERS THE DELIVERY TUBE AND GRADUALLY

GREEN ARROWS = FEEDWATER AT GREATER THAN BOILER PRESSURE FLOWING TO BOILER CHECK VALVE AND NORMALLY OPEN STOP VALVE AND INTO BOILER.

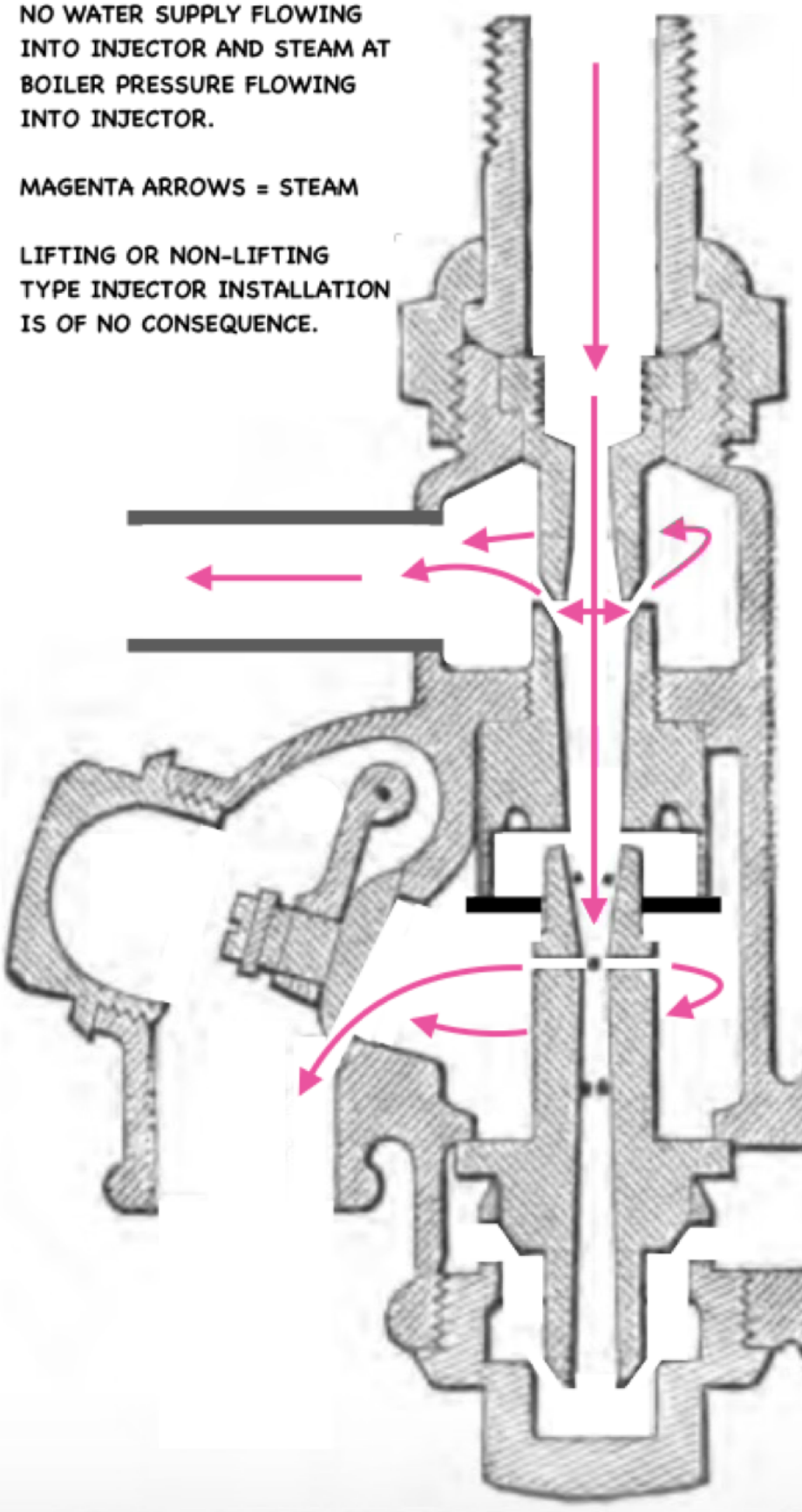
LOOSES VELOCITY AND SIMULTANEOUSLY BECOMES GREATER THAN BOILER PRESSURE.

FIG. 36 "PENBERTHY" DRAWING MODIFIED BY J. G. HOOK TO INCREASE THE CLARITY OF THE VARIOUS PASSAGEWAYS WITHIN THE INJECTOR

INJECTOR ILLUSTRATED WITH NO WATER SUPPLY FLOWING INTO INJECTOR AND STEAM AT BOILER PRESSURE FLOWING INTO INJECTOR.

MAGENTA ARROWS = STEAM

LIFTING OR NON-LIFTING TYPE INJECTOR INSTALLATION IS OF NO CONSEQUENCE.

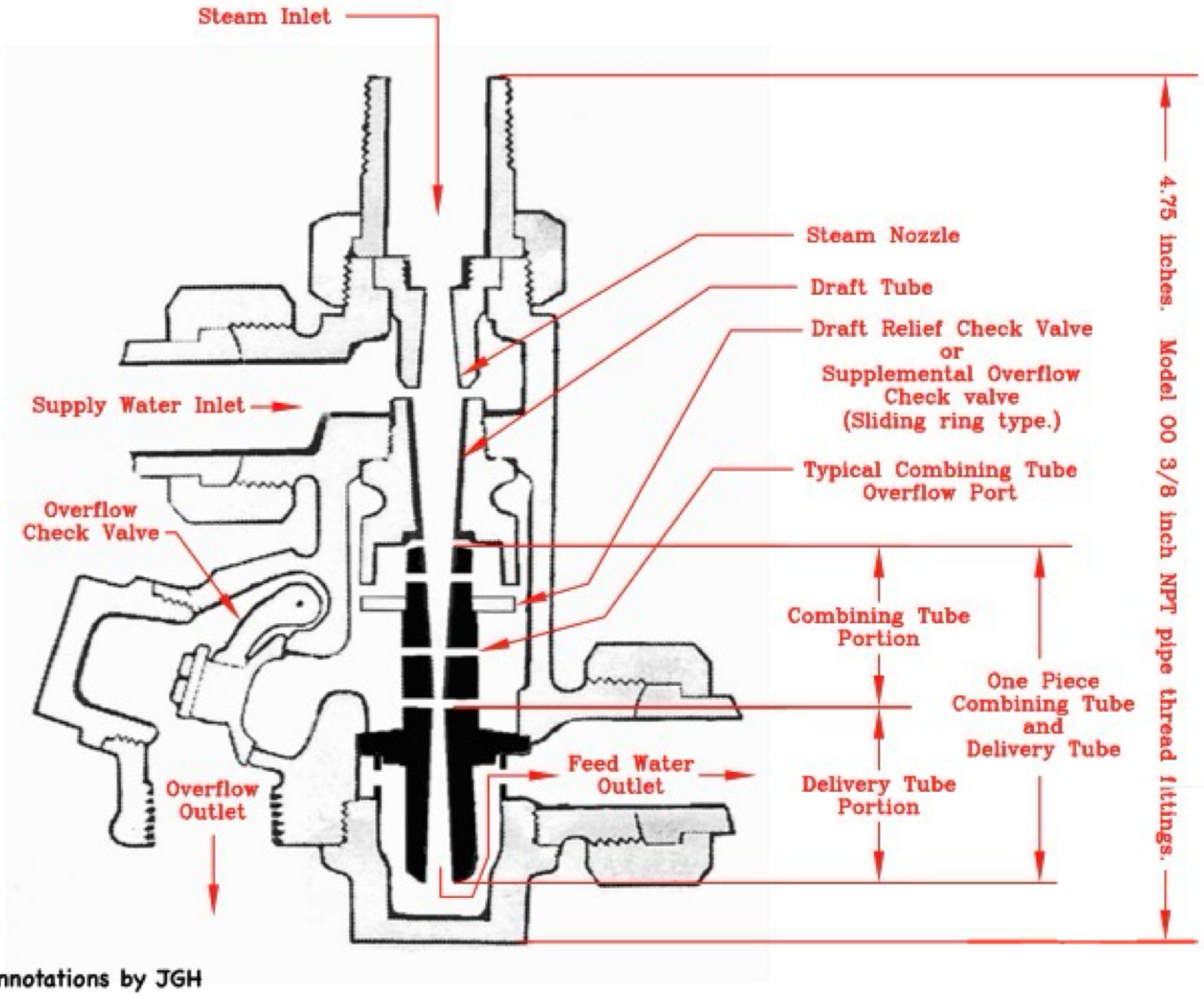


IF THE DRAFT RELEIF WASHER CHECK VALVE WAS INTENTIONALLY CLOSED (AFFECTIVELY DISABLING THE DRAFT RELIEF FEATURE) THE ENTIRE VOLUME OF THE HIGH VELOCITY STEAM JET ISSUING FROM THE STEAM NOZZLE WIIL NOT BE ABLE TO ESCAPE SOLELY THROUGH THE COMBINED AREA PROVIDED BY THE OVERFLOW OUTLET PORTS THAT ARE CROSS DRILLED INTO THE WALL OF THE COMBINING TUBE SECTION. THE EXCESS VOLUME OF STEAM WILL COLLECT IN THE SUPPLY WATER CHAMBER AND IN TURN WILL FORCE ITS WAY OUTWARD THROUGH THE SUPPLY WATER INLET, THUS PREVENTING SUPPLY WATER FROM ENTERING THE INJECTOR.

THIS INJECTOR IS CLASSIFIED AS A RE-STARTING TYPE. IT SHOULD BE BORNE IN MIND THAT ANY TIME THE SUPPLY WATER FLOW IS DISRUPTED, WHETHER INTENTIONALLY STOPPED FOR A LONG PERIOD OF TIME OR UNINTENTIONALLY STOPPED FOR A SHORT PERIOD OF TIME, THE RE-STARTING FEATURE IS REQUIRED TO BE PUT TO USE.

Drawing –E–

Illustration of typical full scale practice "Penberthy" injector
rated for lifting or non–lifiting service.
Model scale practice "Ohlenkamp" 5/16 inch injector is a reduced scale replica.
Model scale practice "Super Scale Economy" 5/16 inch injector is similar in form and function.



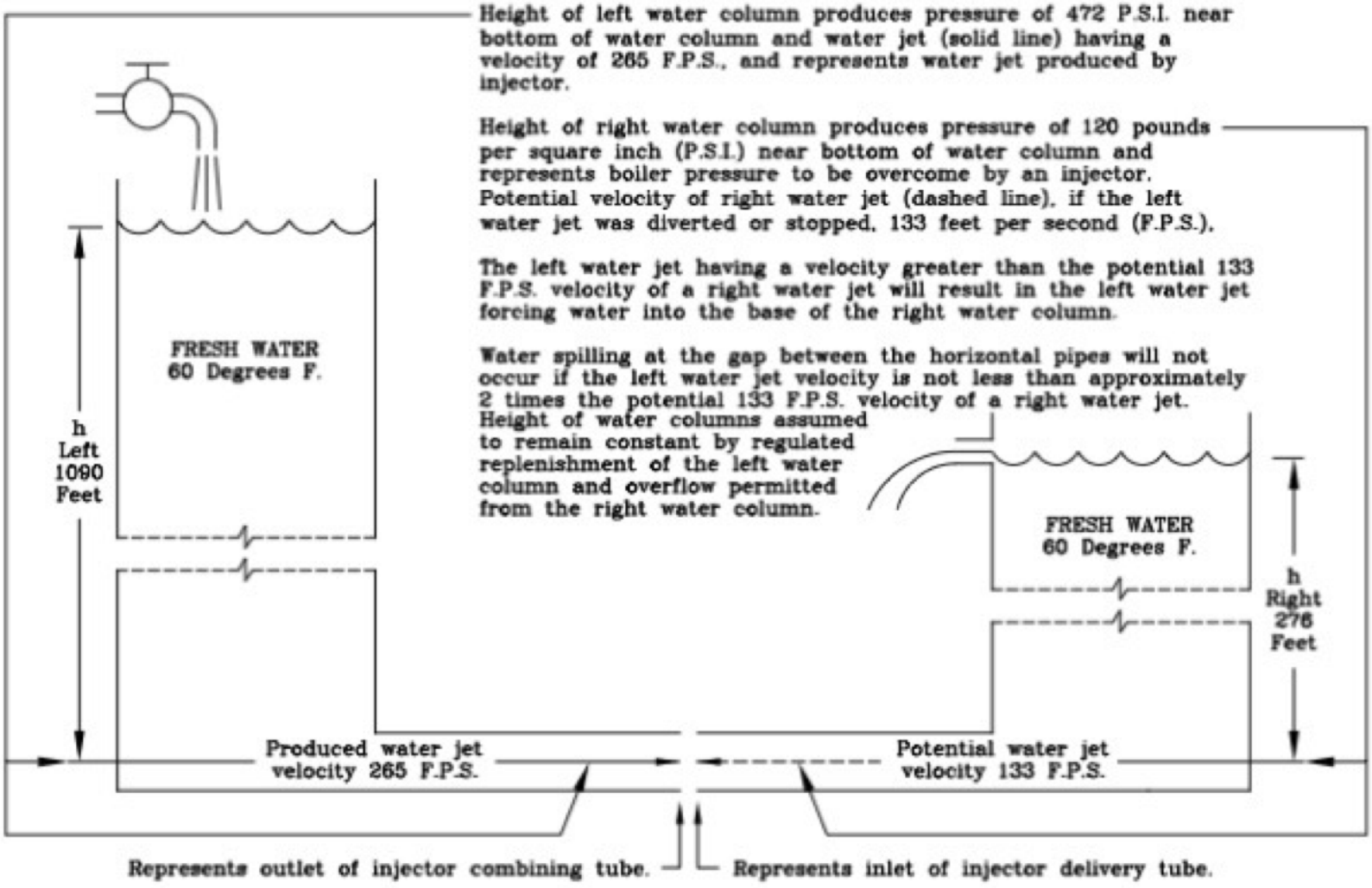
Annotations by JGH

Excerpt from PRINCIPLES OF INJECTOR OPERATION

By Jeffrey G. Hook July 4, 1996 Revised May 29. 2016

Drawing –A–

Illustration of pressure and potential water jet velocity produced by given height, or head, of water column.



Formula –1–

$$P = wh/144$$

where:

P = Pressure at bottom of water column in pounds per square inch.
w = Weight of water* taken as 62.4 lbs. per cubic foot.
h = Height of water column in feet.

Formula –2–

$$V = \sqrt{2gh}$$

where:

V = Velocity of water* jet in feet per second.
g = Acceleration due to gravity taken as 32.2 feet per second per second.
h = Height of water column in feet.

* Fresh water at 60 degrees Fahrenheit.