A Field Perspective on Pneumatic Control and Actuation Systems

Introduction

Presented By:
David Sellers
Senior Engineer, Facility Dynamics Engineering

Connecting to David Sellers Poll Everywhere Account

We may be using Poll Everywhere during the class to foster interaction. Please take a few minutes ahead of the class or during the introduction to get yourself set up to use Poll Everywhere with my account.

Get Connected with My Poll Everywhere

Via text messaging

Step 1

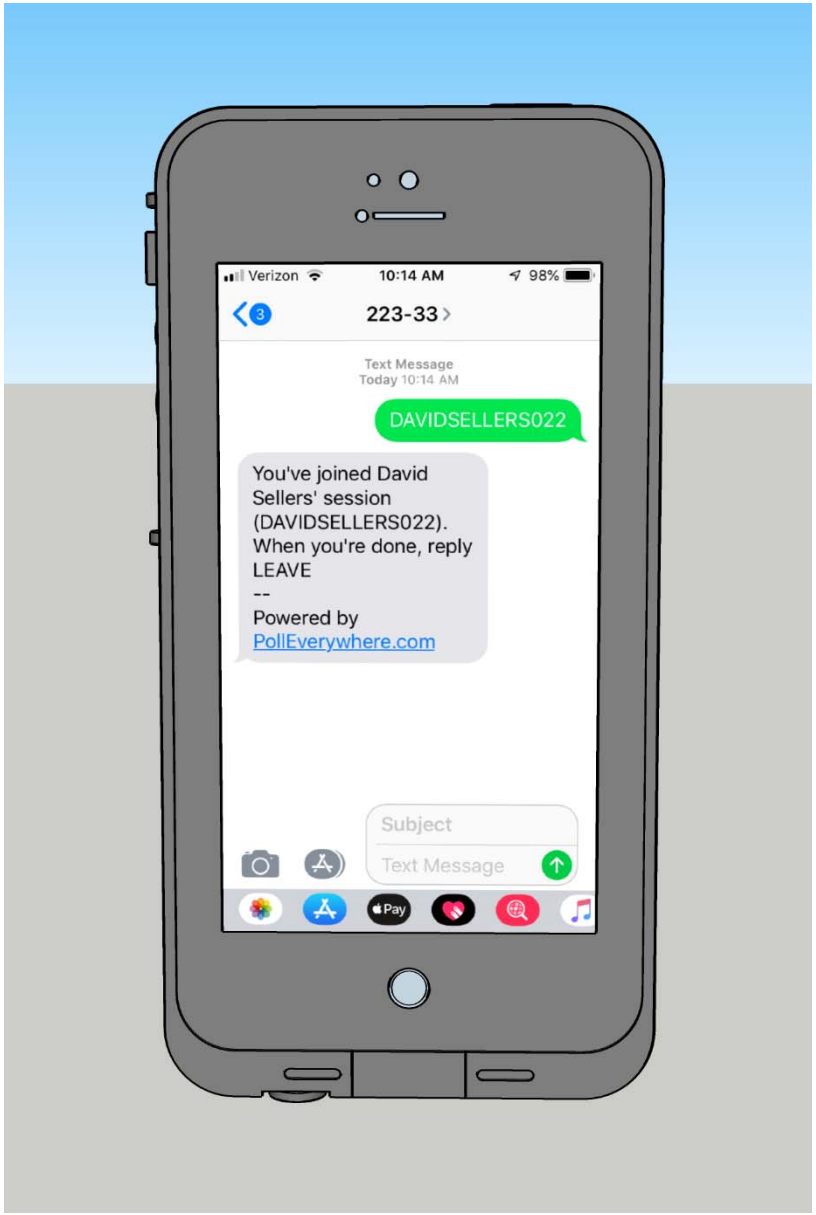
Text DAVIDSELLERS022 to 22333 (the hyphen gets inserted automatically on some phones)

Get Connected with My Poll Everywhere

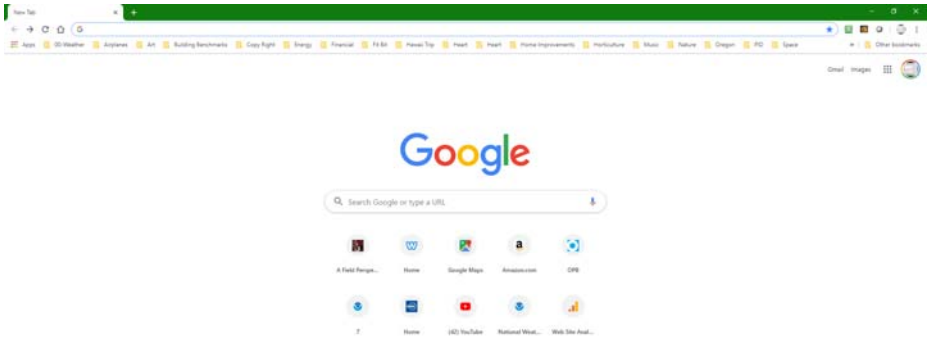
Via text messaging

Step 2

Receive confirmation that you have joined the session



Get Connected with My Poll Everywhere

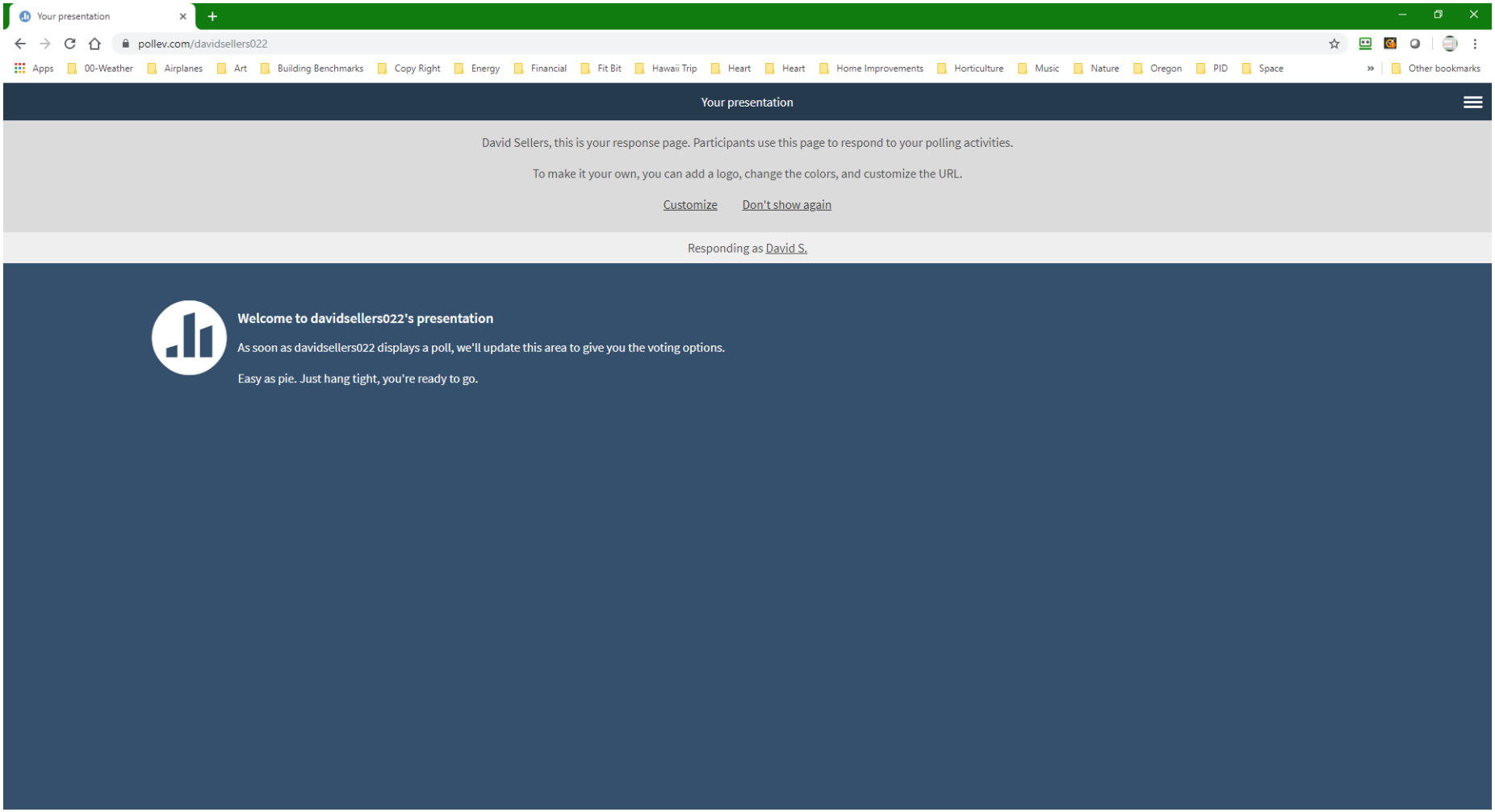


Via web browser

Step 1

Go to pollev.com/davidsellers022

Get Connected with My Poll Everywhere



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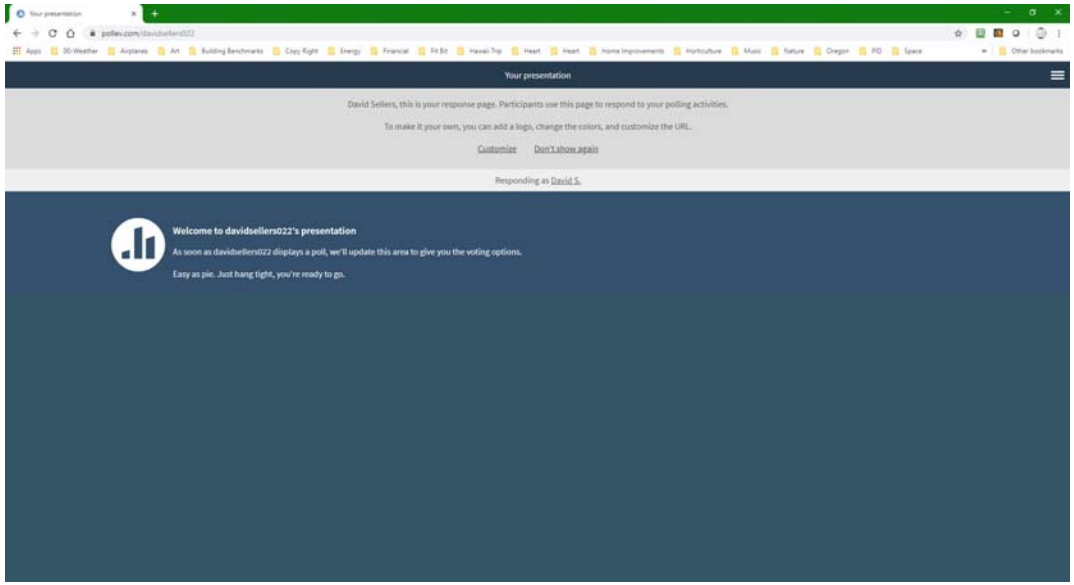
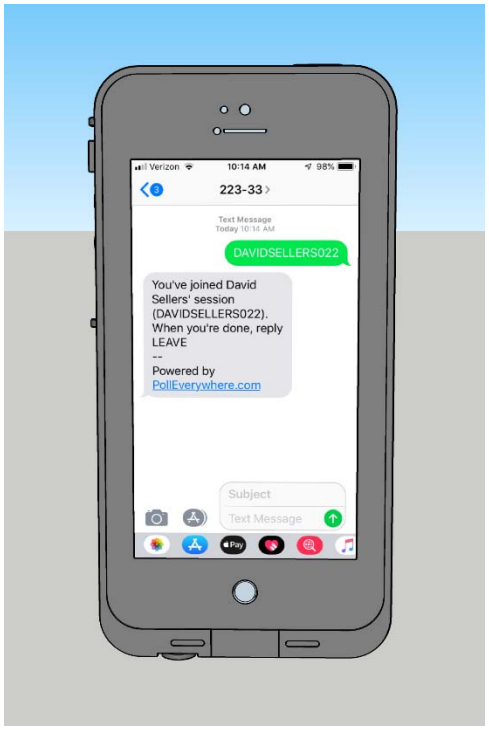




Via web browser or text messaging

Step 3

Wait for a poll question to come up

How many of you work with pneumatic controls on a regular basis?

Yes I do

No I don't

What are the primary reason(s) you are interested in learning about pneumatic controls? (Check all that apply)

I have them in my building.	**A**
I run into them in the course of my commissioning projects.	**B**
I am new to controls and heard that learning pneumatics was a good way to learn control theory.	**C**
I wanted to gain a general understanding of controls and this seemed like an option.	**D**

A Bit About Me

A Bit About Me

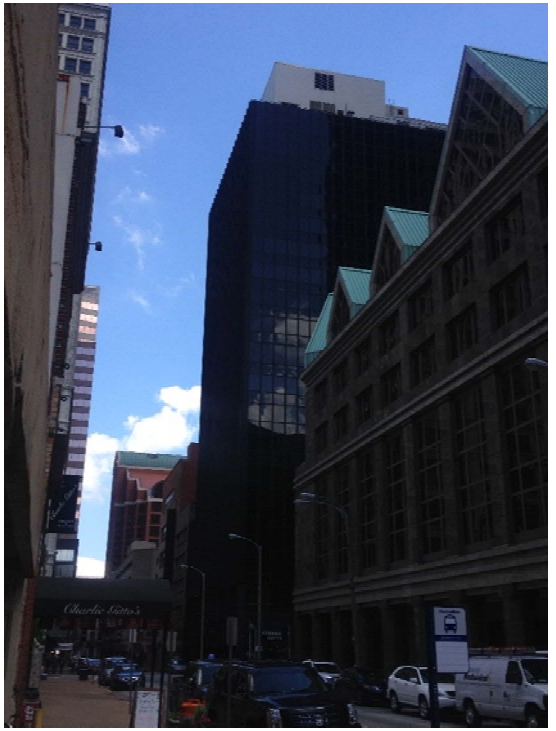
I intended to be an aircraft maintenance engineer

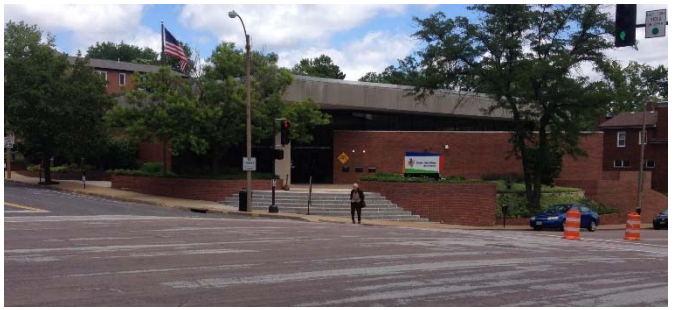
How many of you are doing what you went to school to learn to do?

Yes I am	**A**
No, I'm doing something different	**B**

I’m Doing Something Totally Different

I’m Doing Something Totally Different …

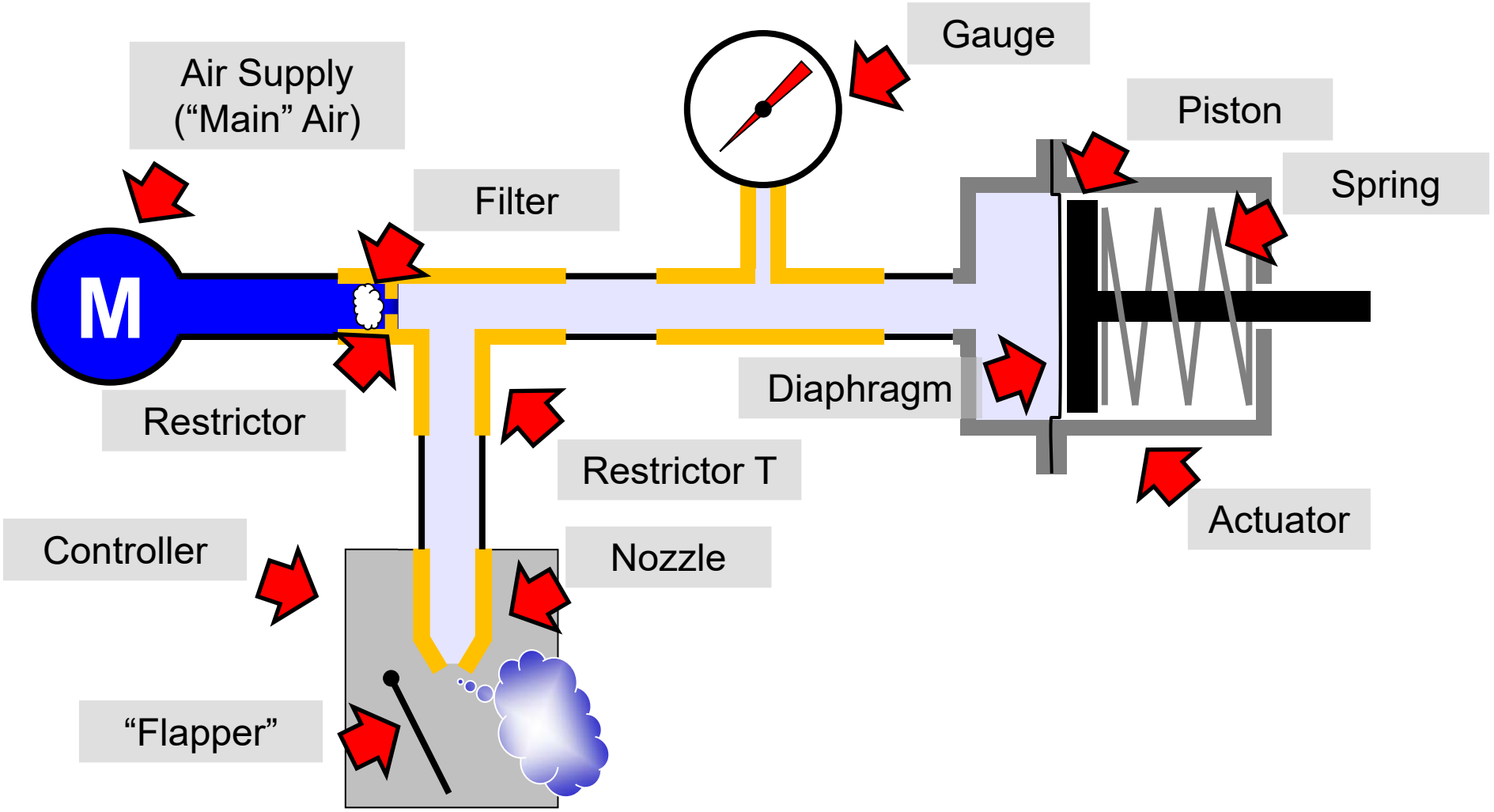




… And Encountered Pneumatics Very Early-on

One Pipe Pneumatic Controls

A Typical One Pipe Pneumatic Control System



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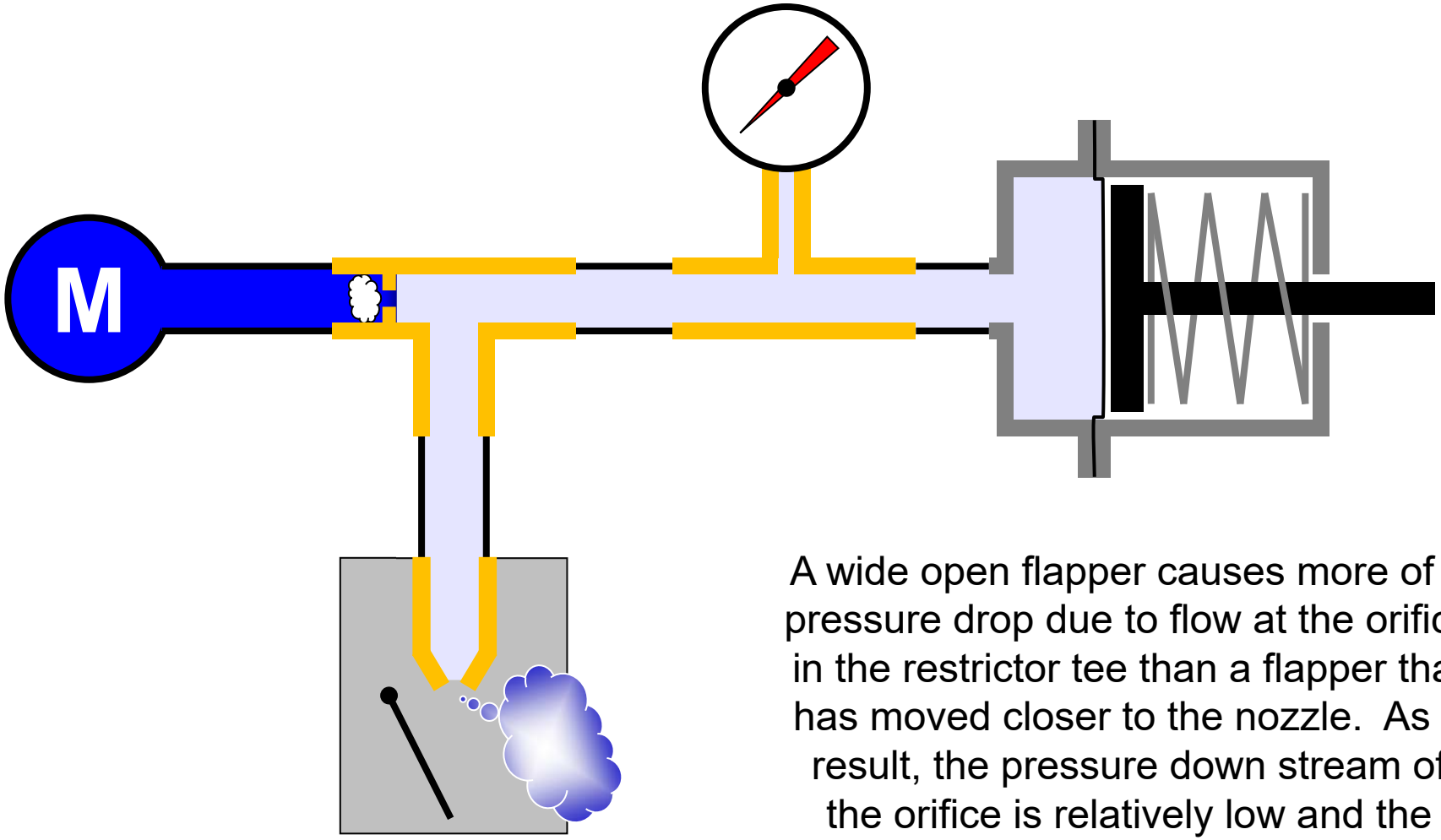

A wide open flapper causes more of a pressure drop due to flow at the orifice in the restrictor tee than a flapper that has moved closer to the nozzle. As a result, the pressure down stream of the orifice is relatively low and the actuator retracts

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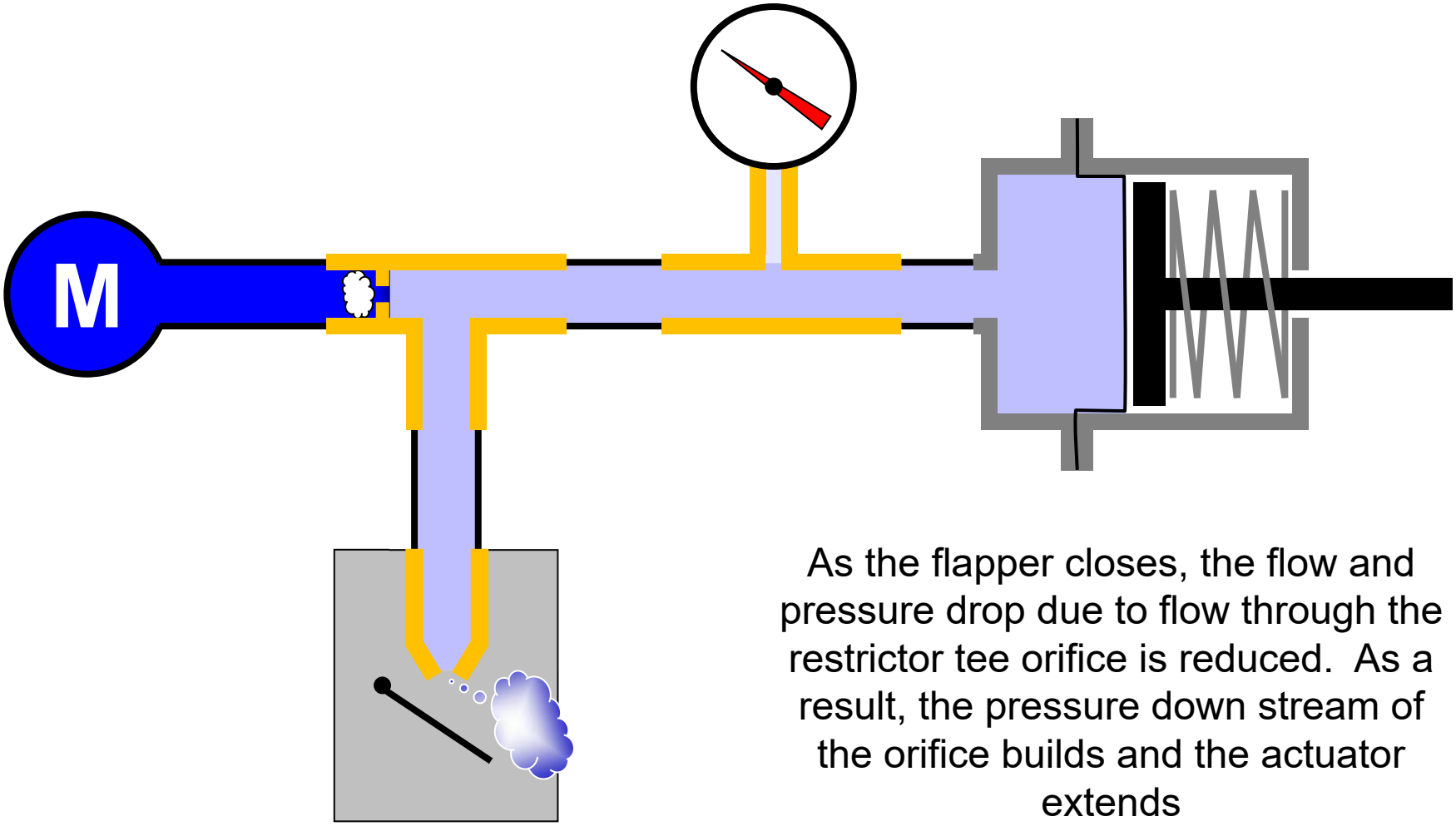

As the flapper closes, the flow and pressure drop due to flow through the restrictor tee orifice is reduced. As a result, the pressure down stream of the orifice builds and the actuator extends

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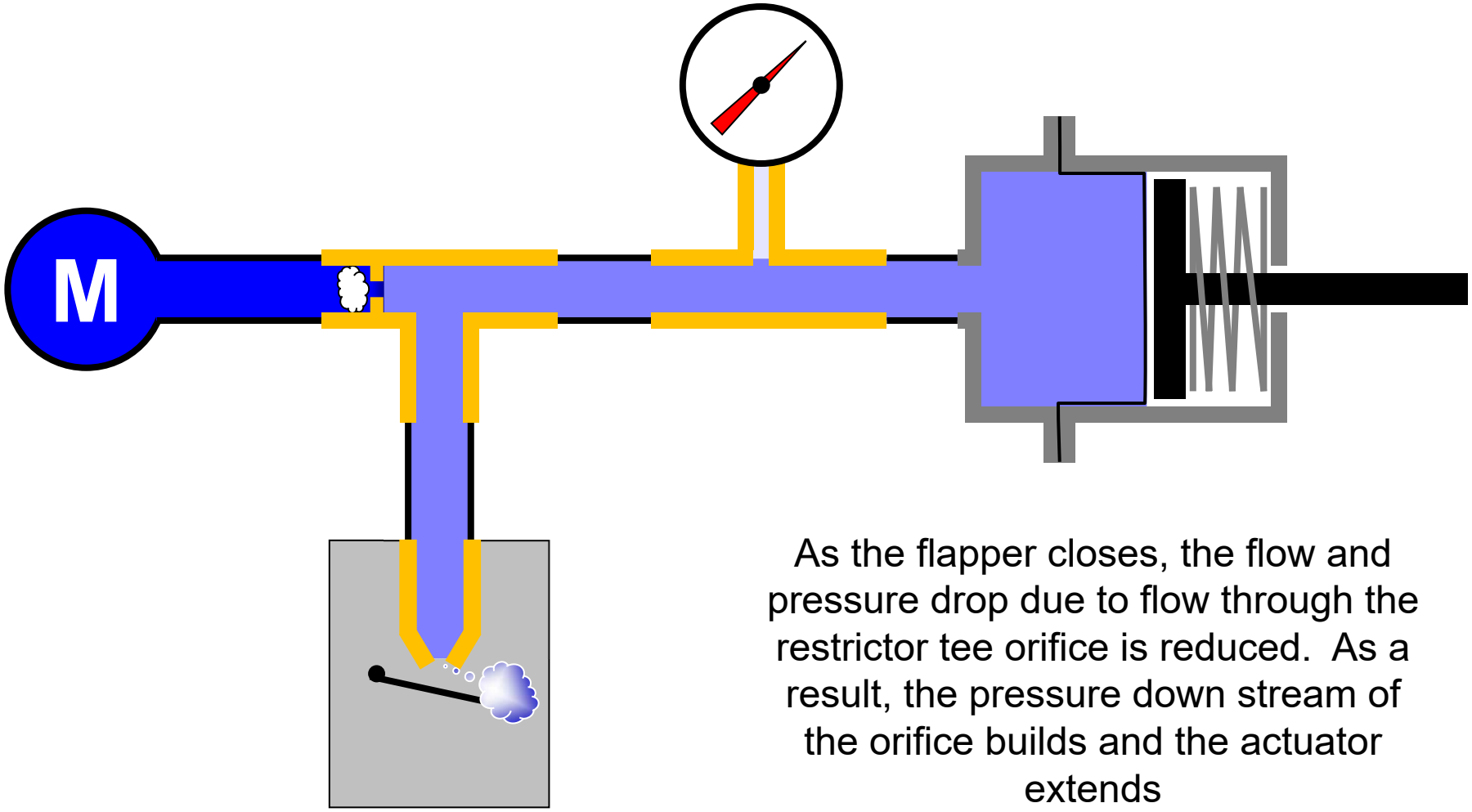

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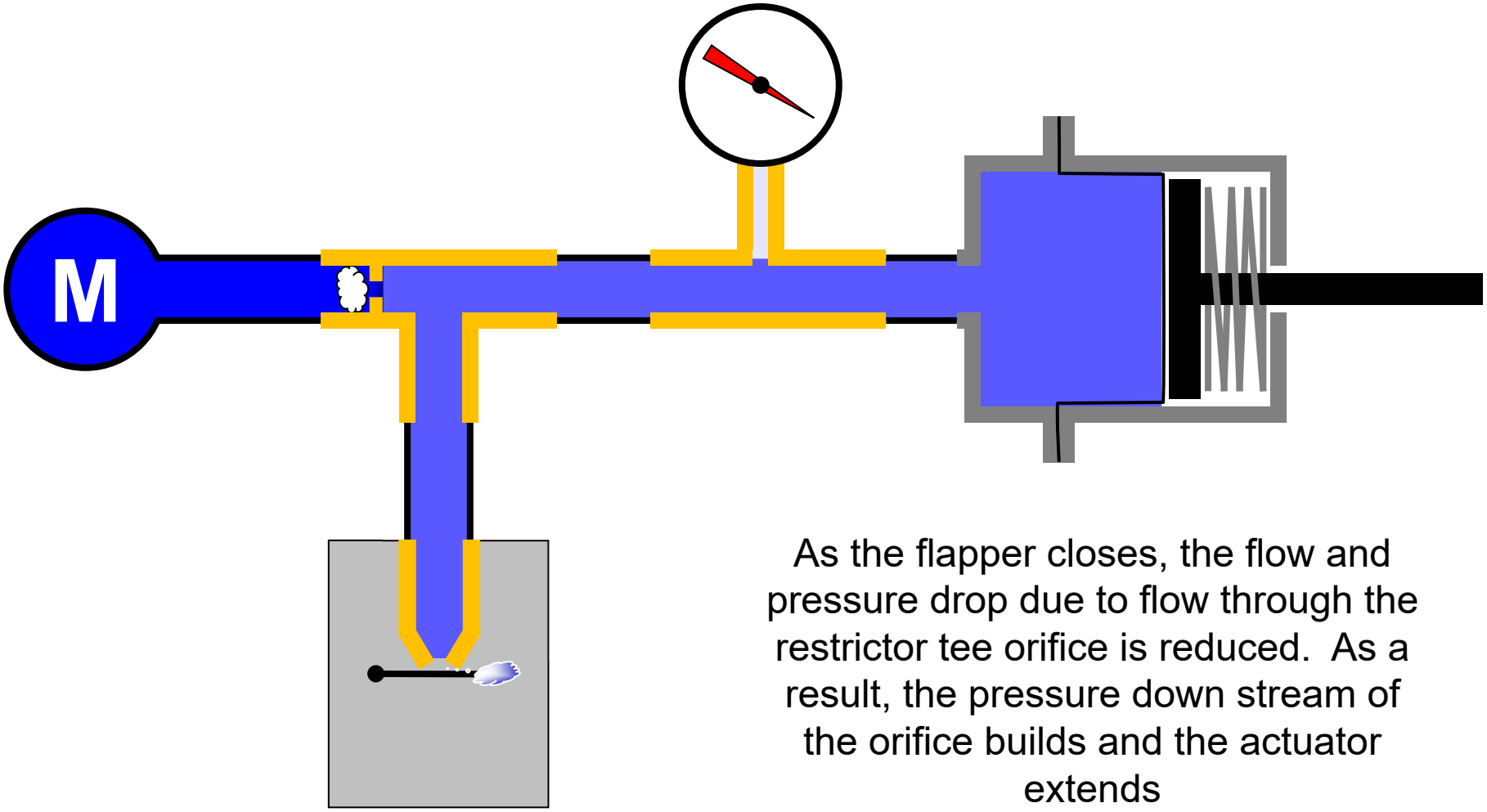

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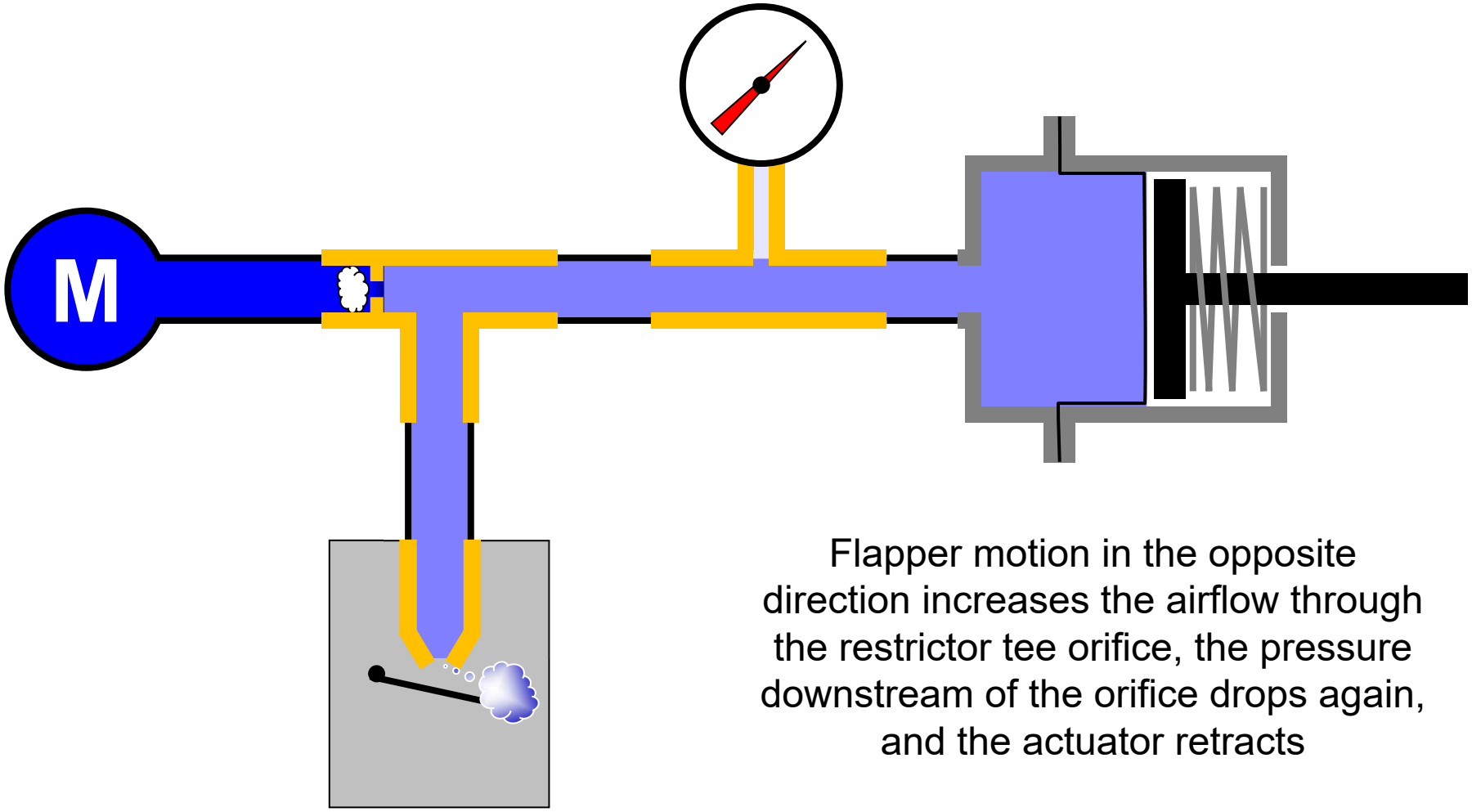

Flapper motion in the opposite direction increases the airflow through the restrictor tee orifice, the pressure downstream of the orifice drops again, and the actuator retracts

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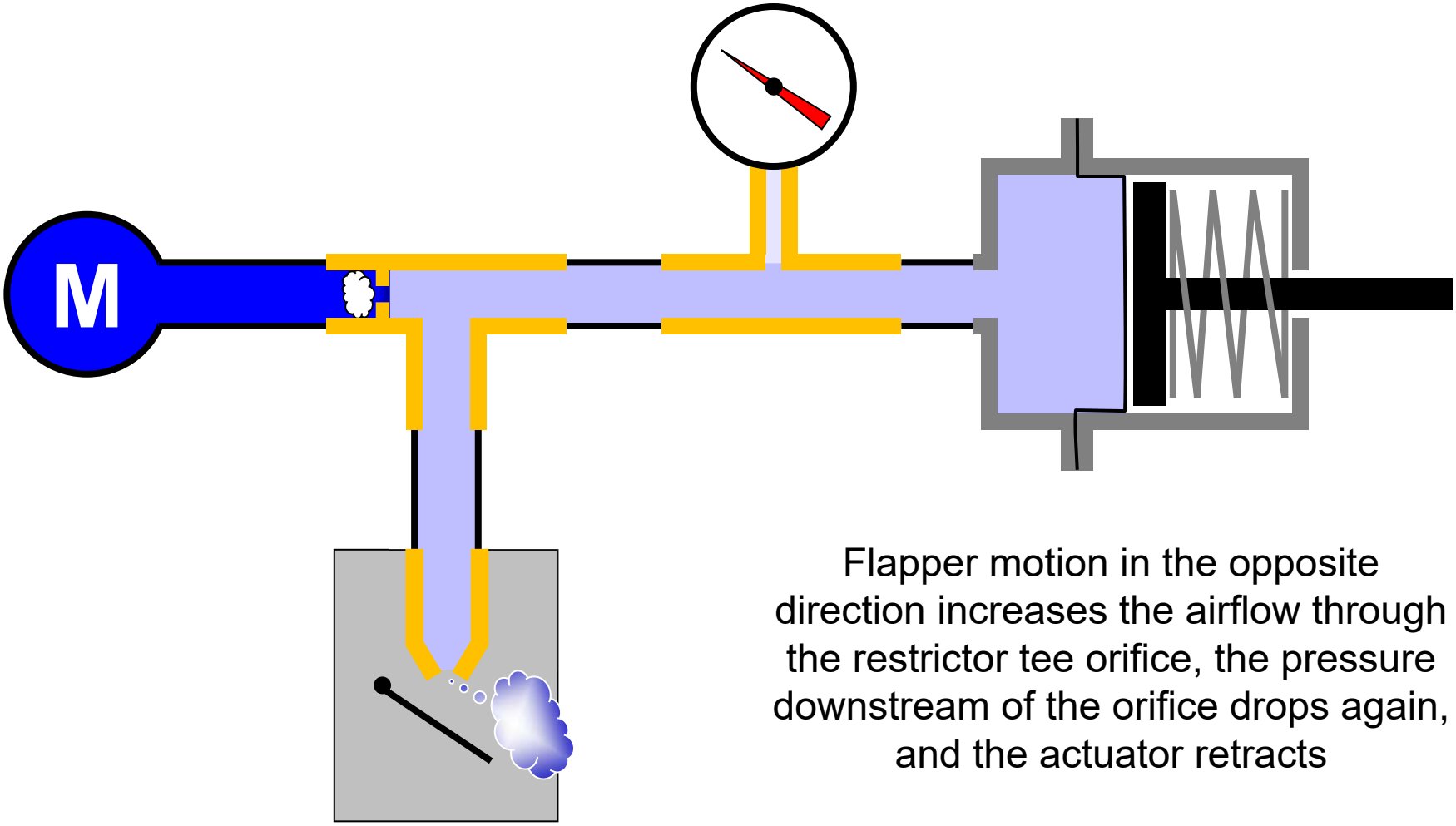

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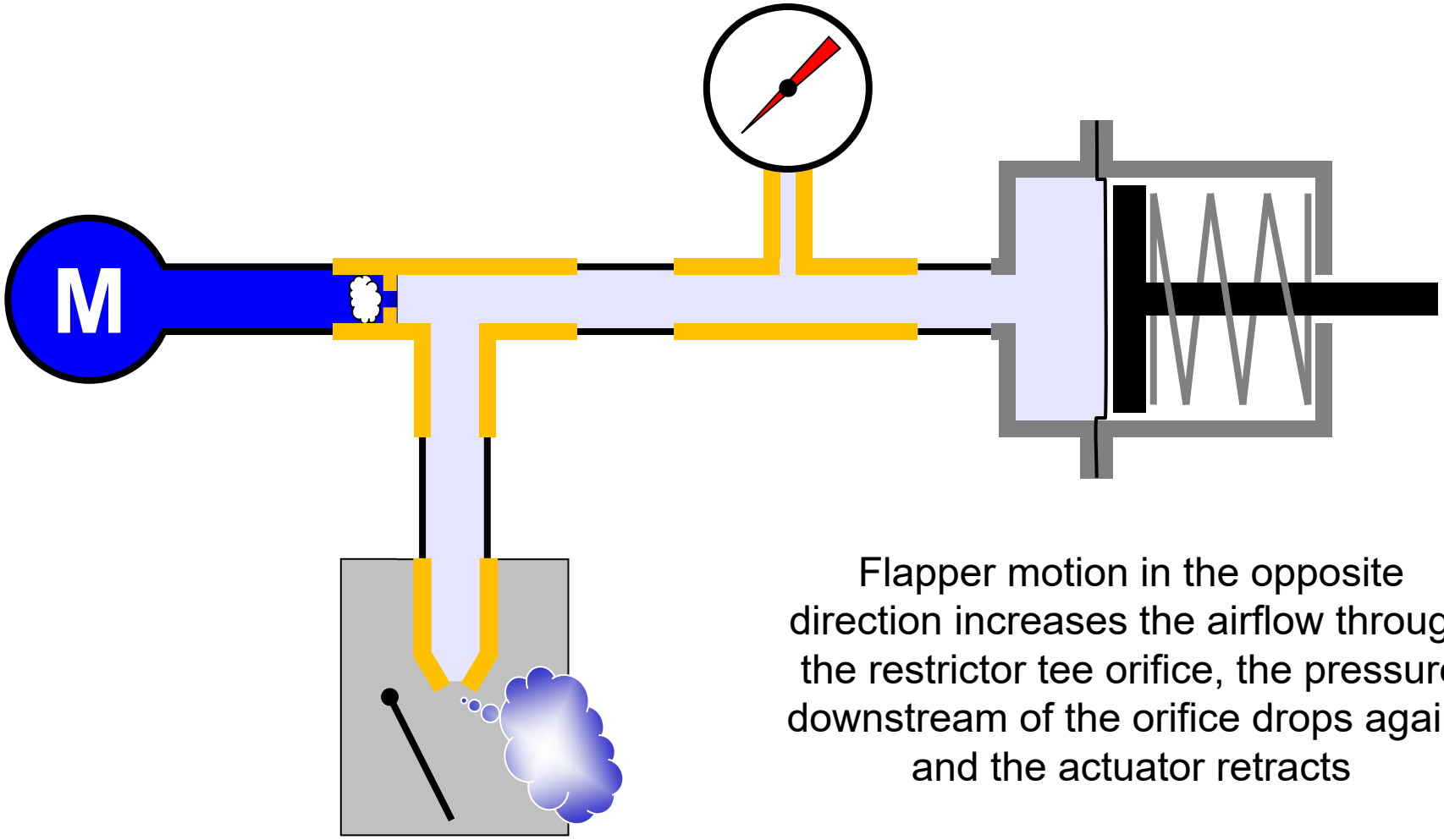

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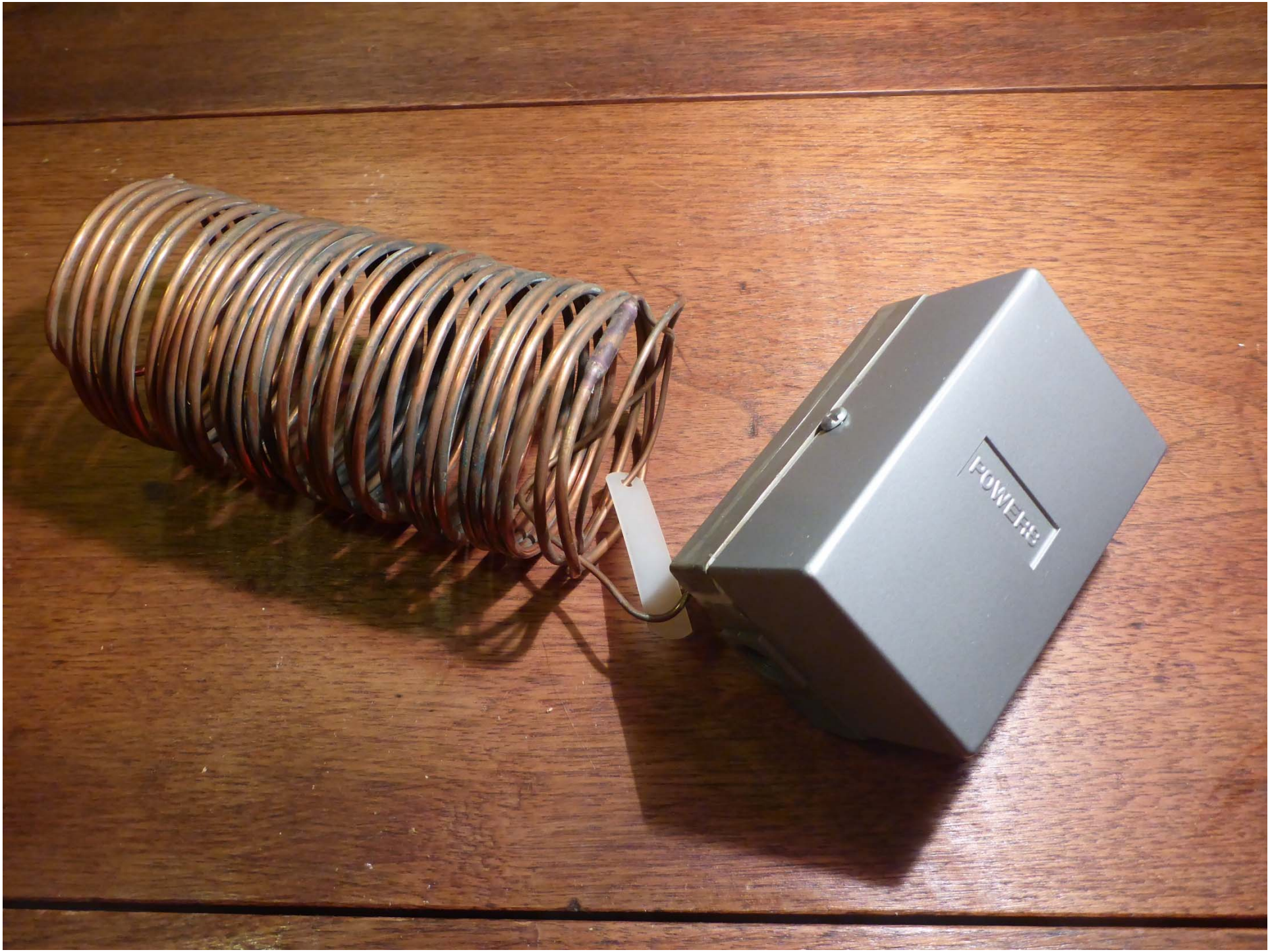
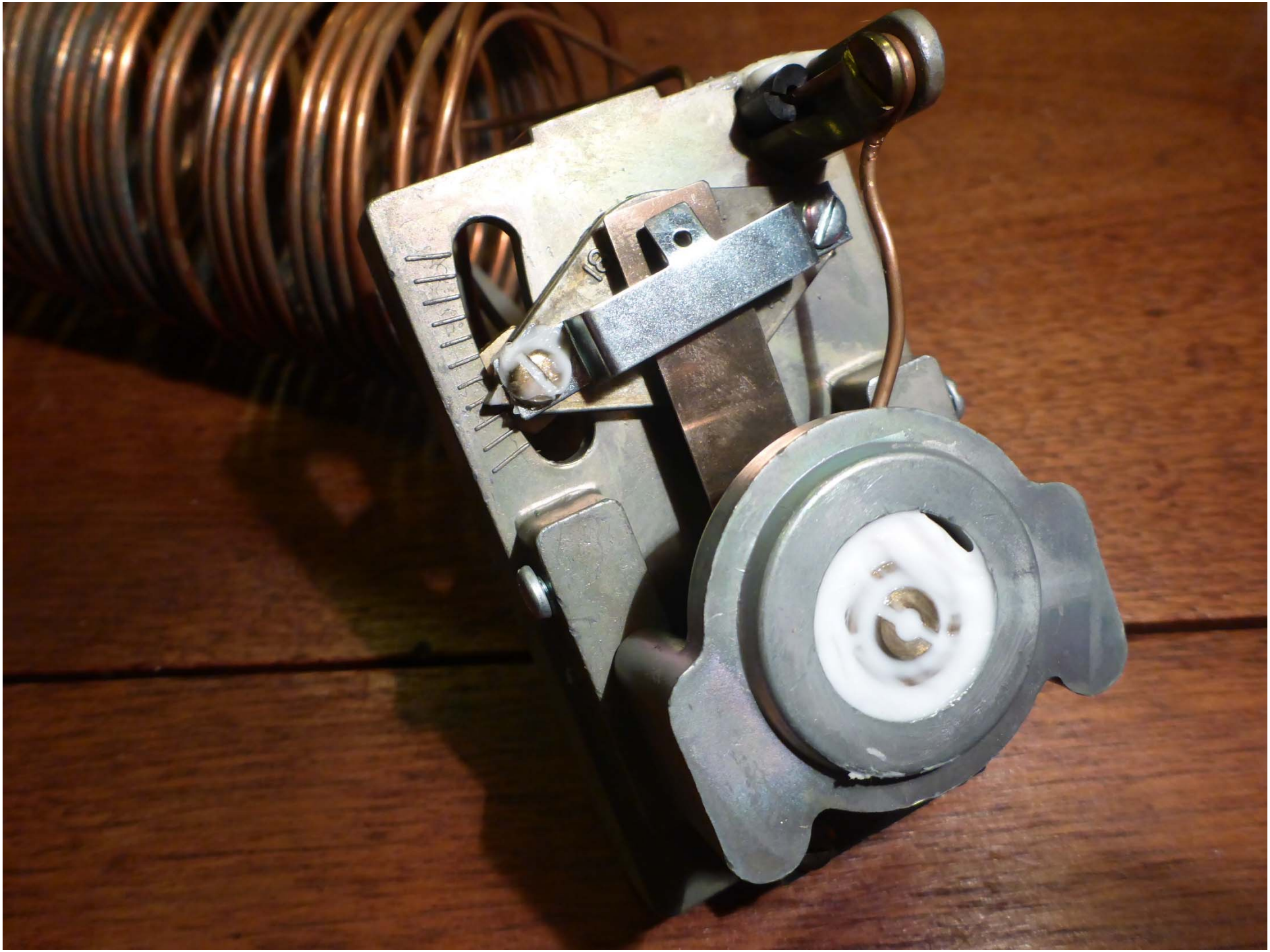
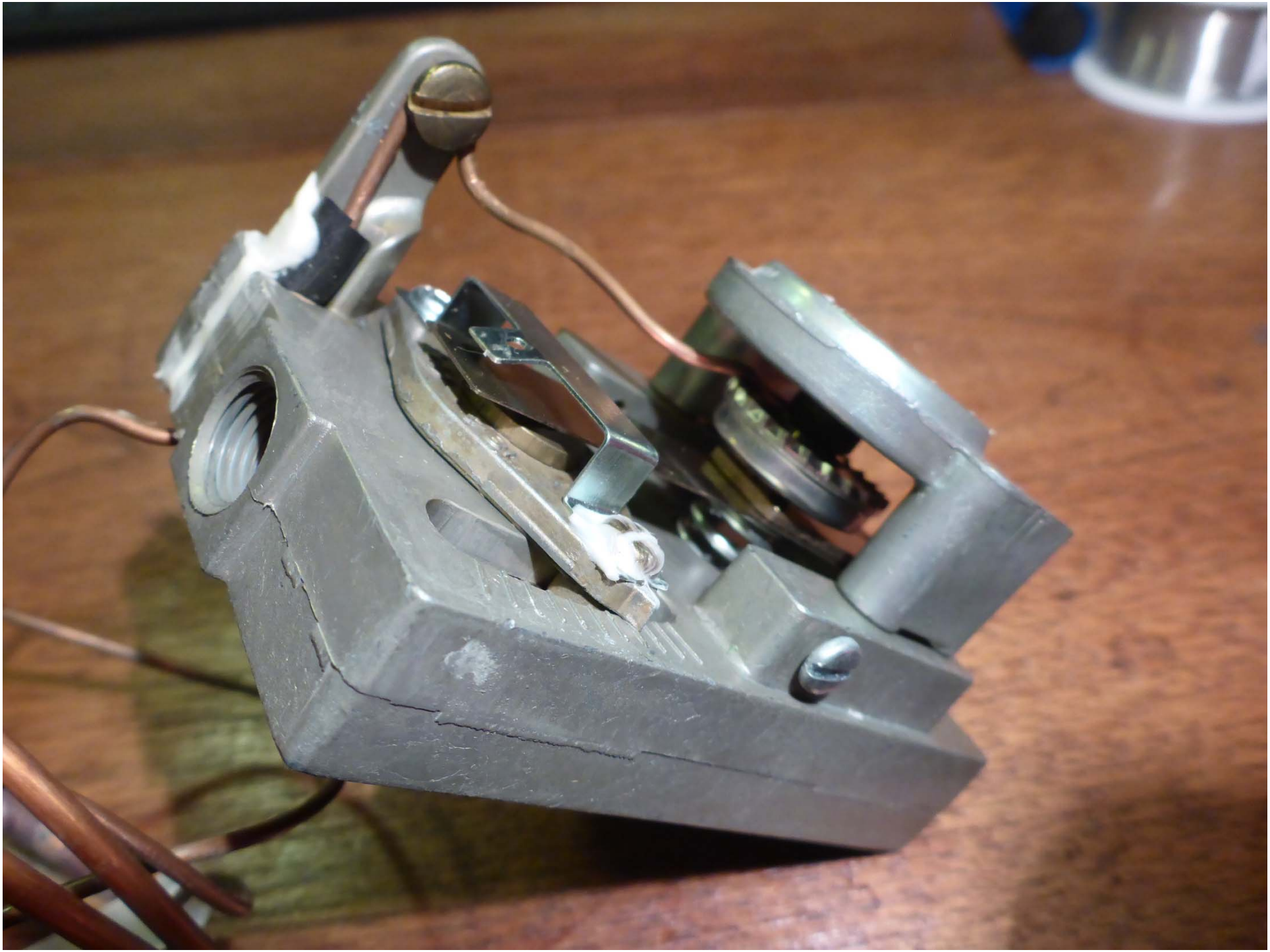

POWER





Tees; Restrictor and Not

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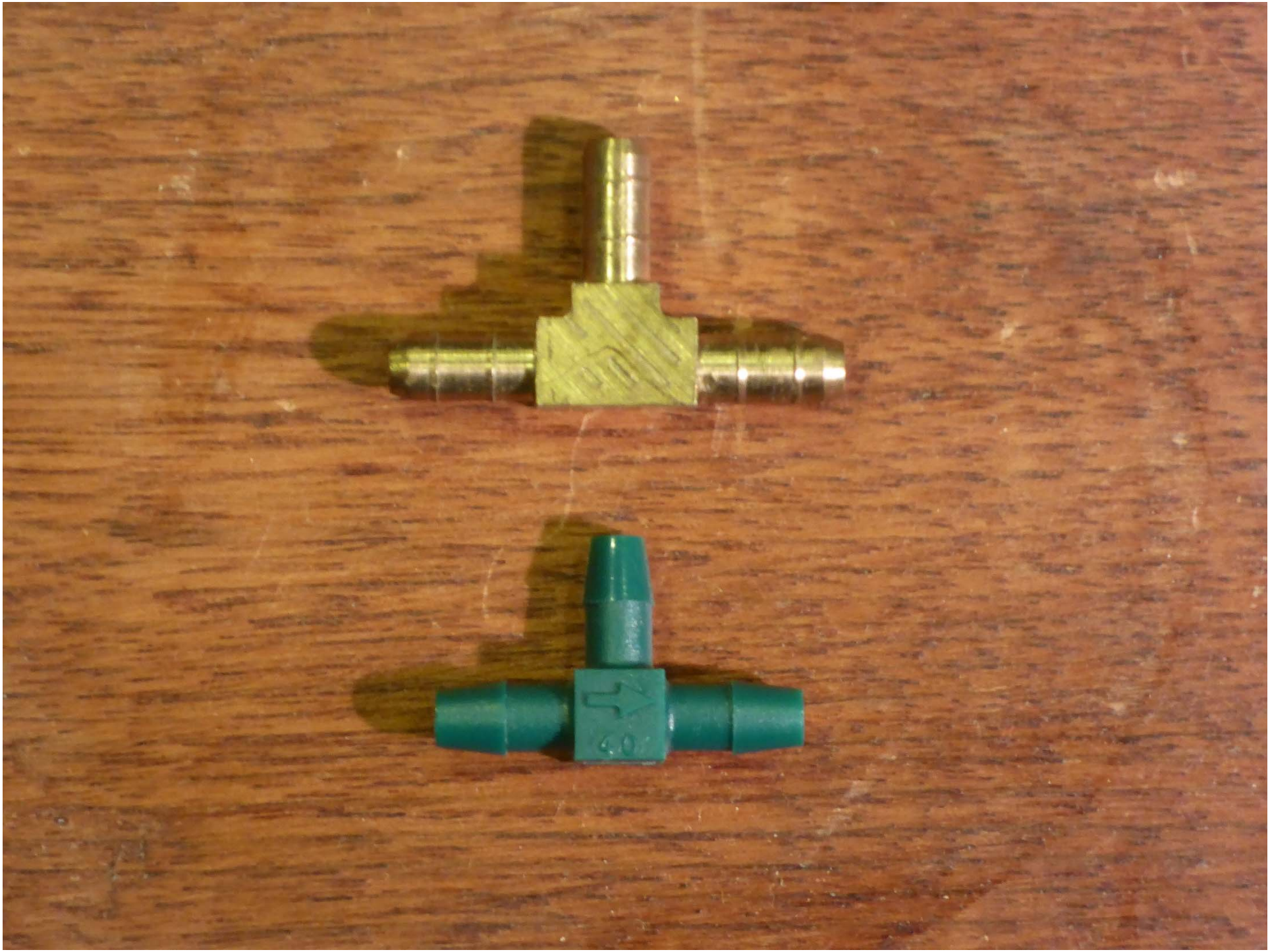
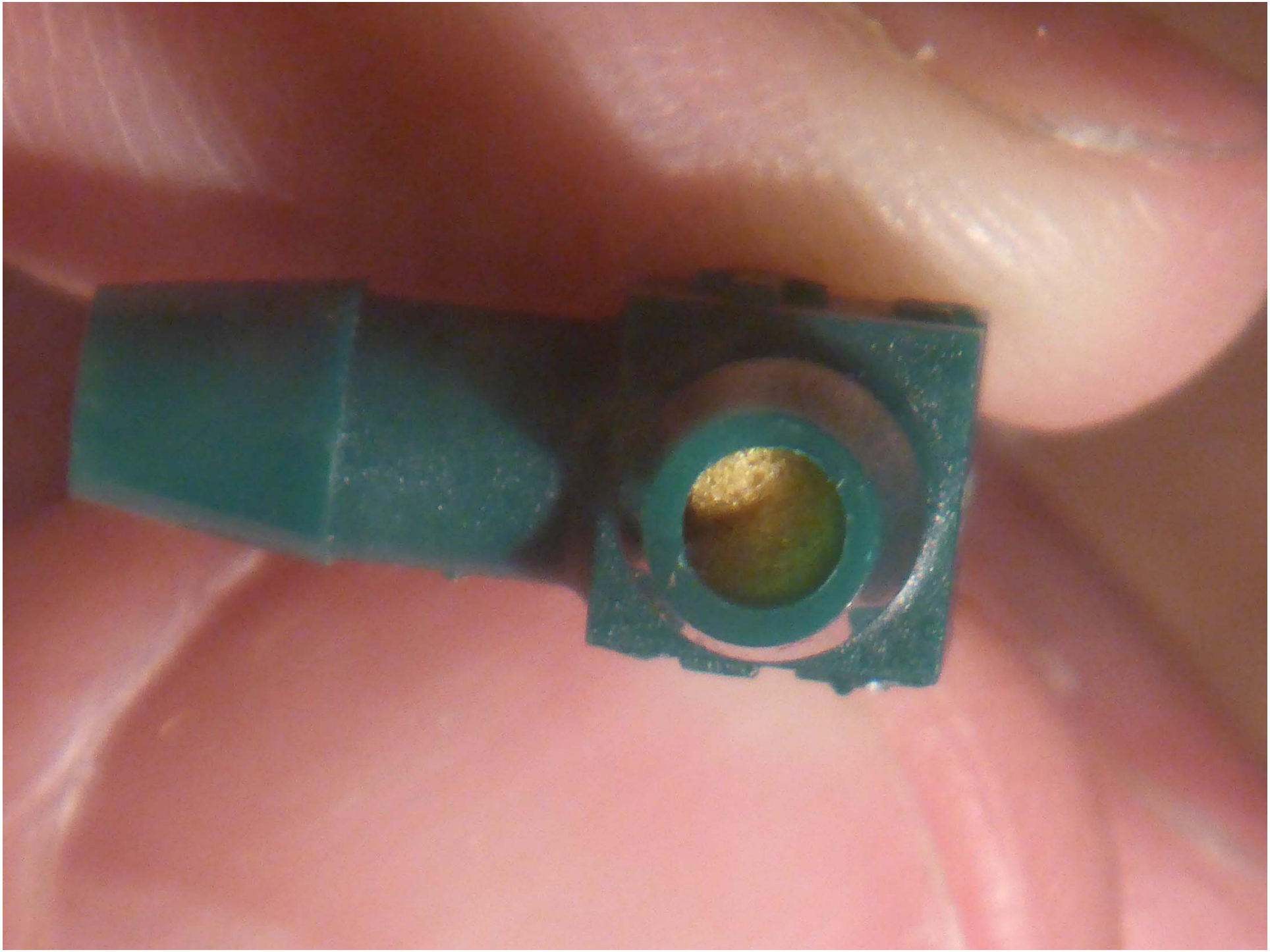
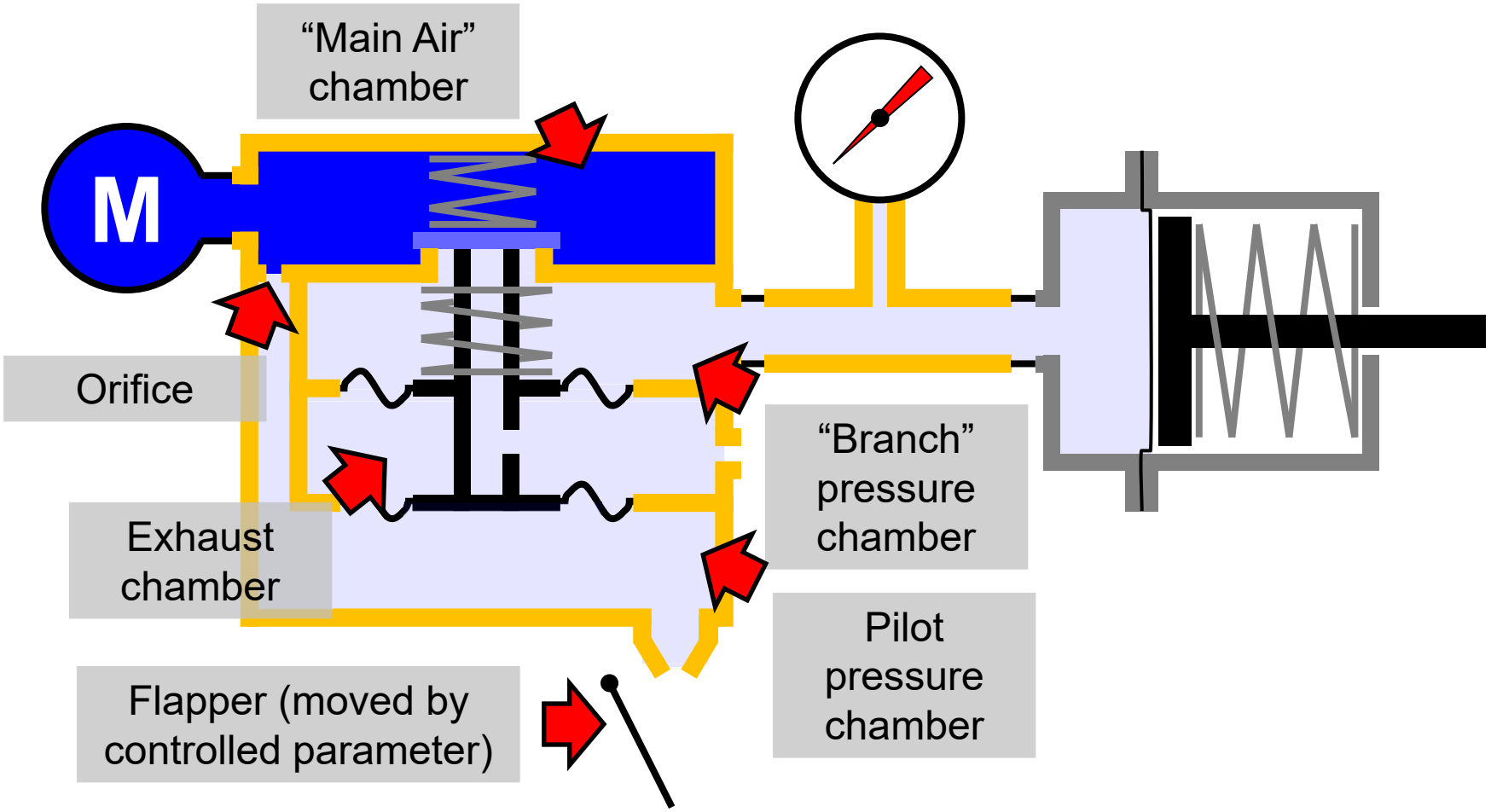




Two Pipe Pneumatic Controls

Optional subtitle

A Typical Two Pipe Pneumatic Control System



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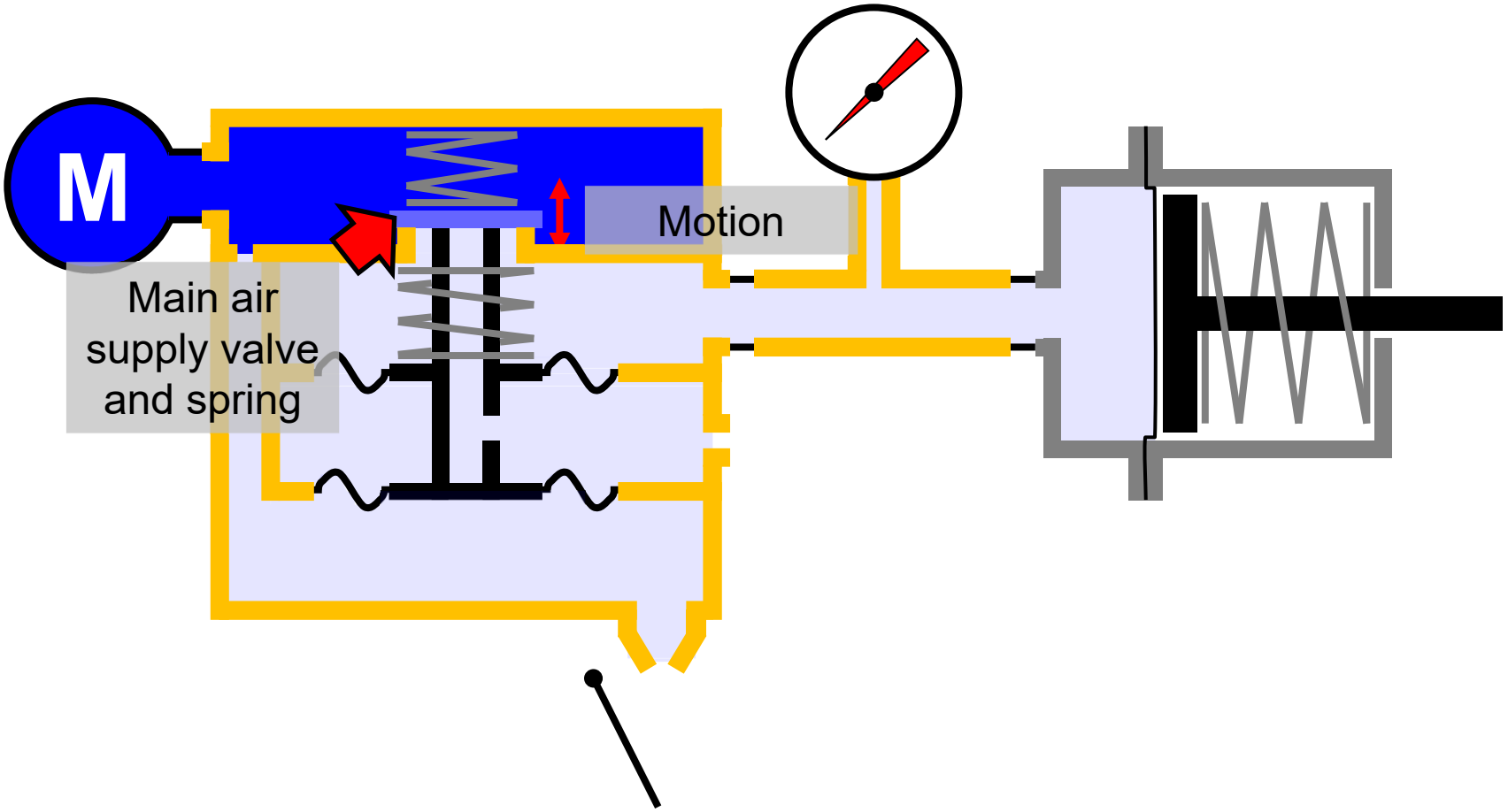

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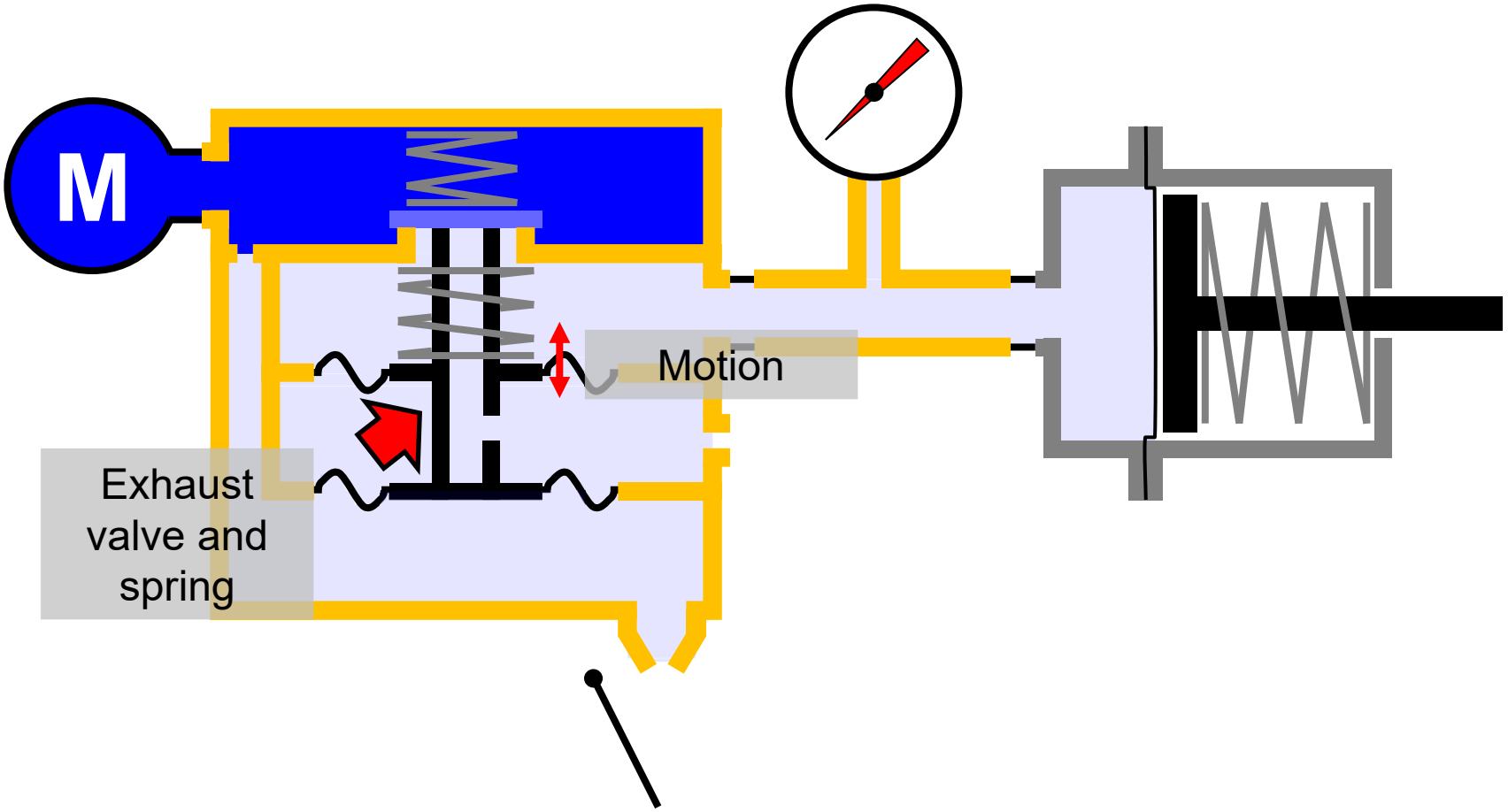

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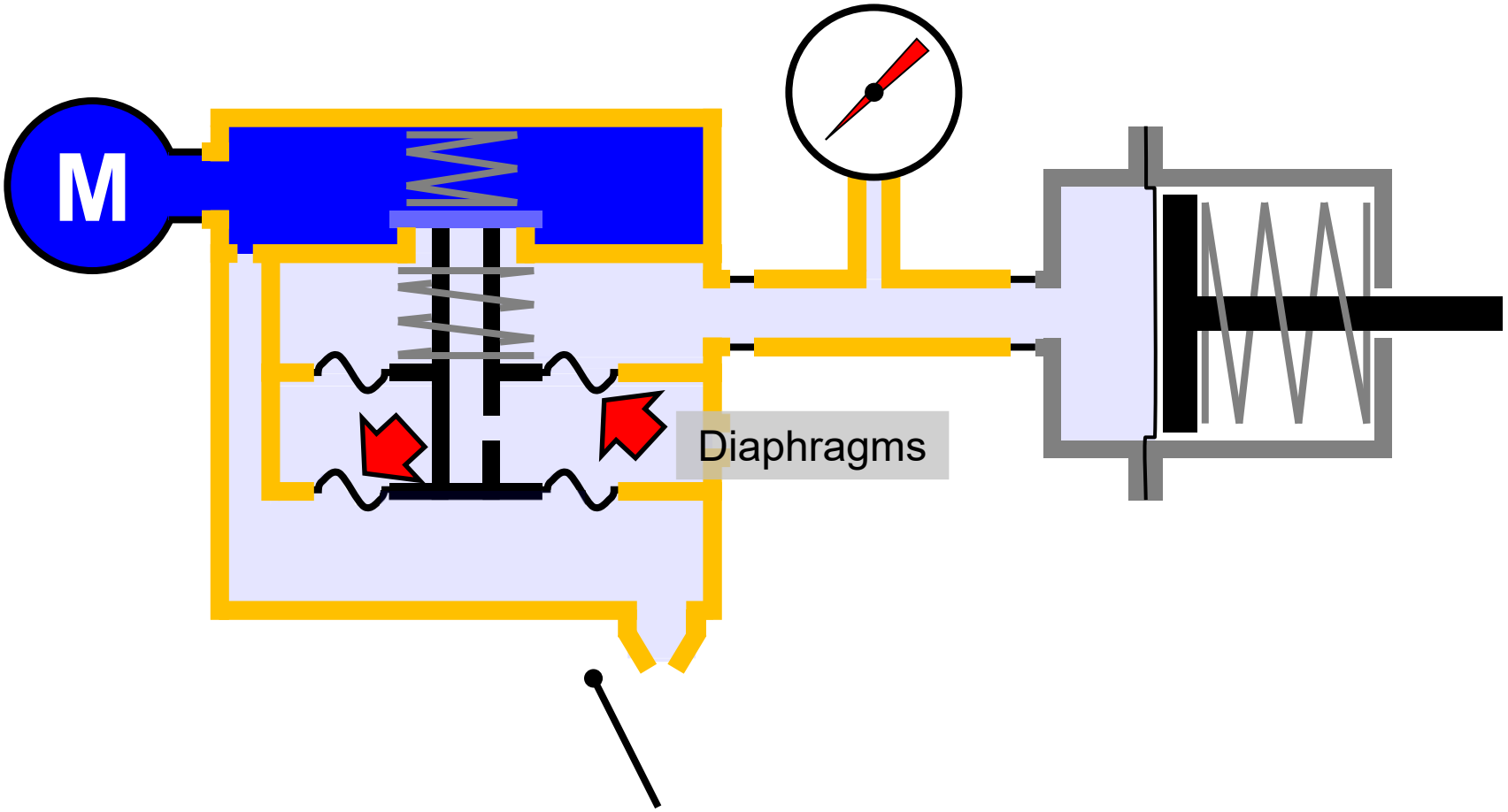

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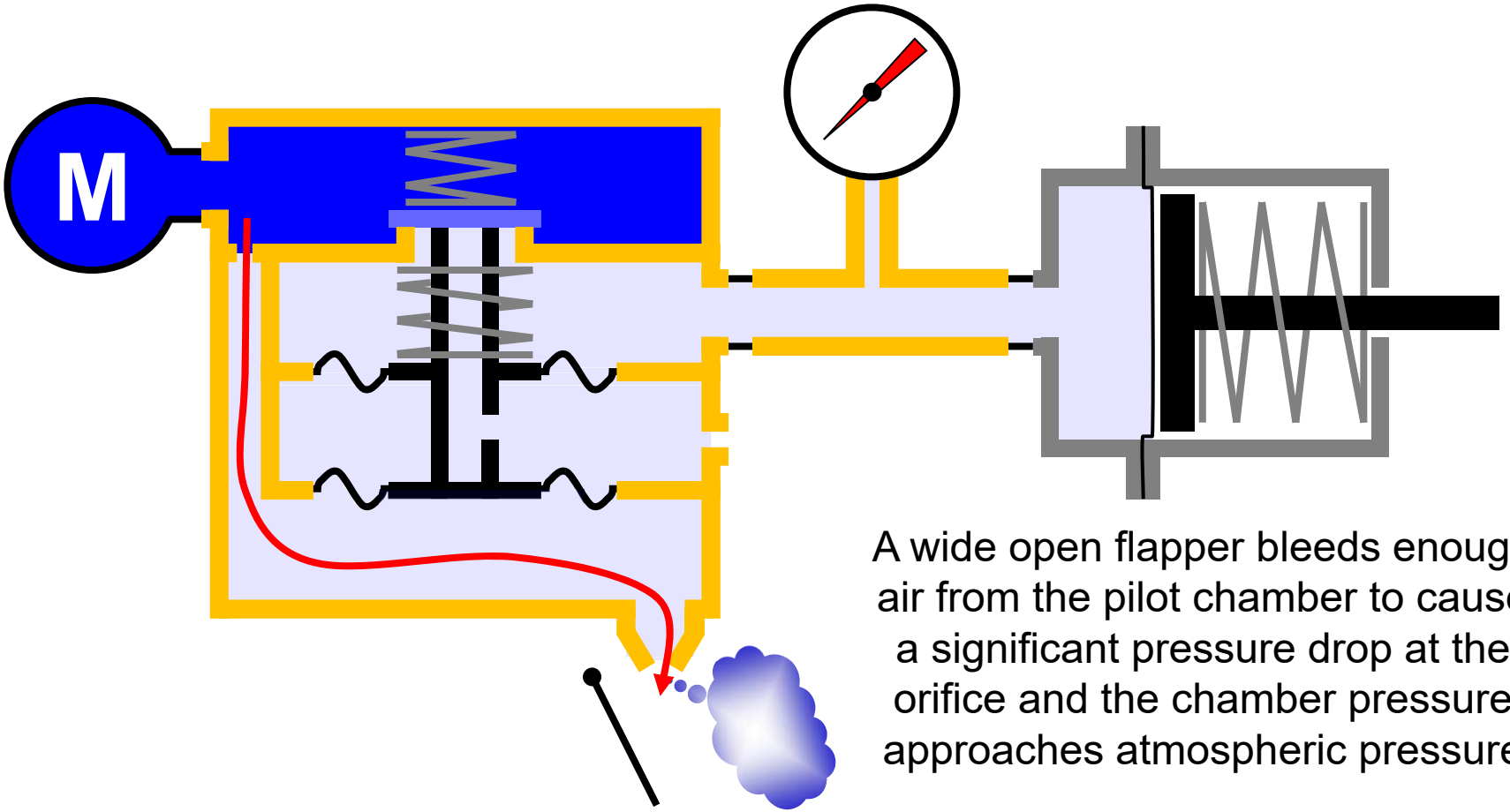
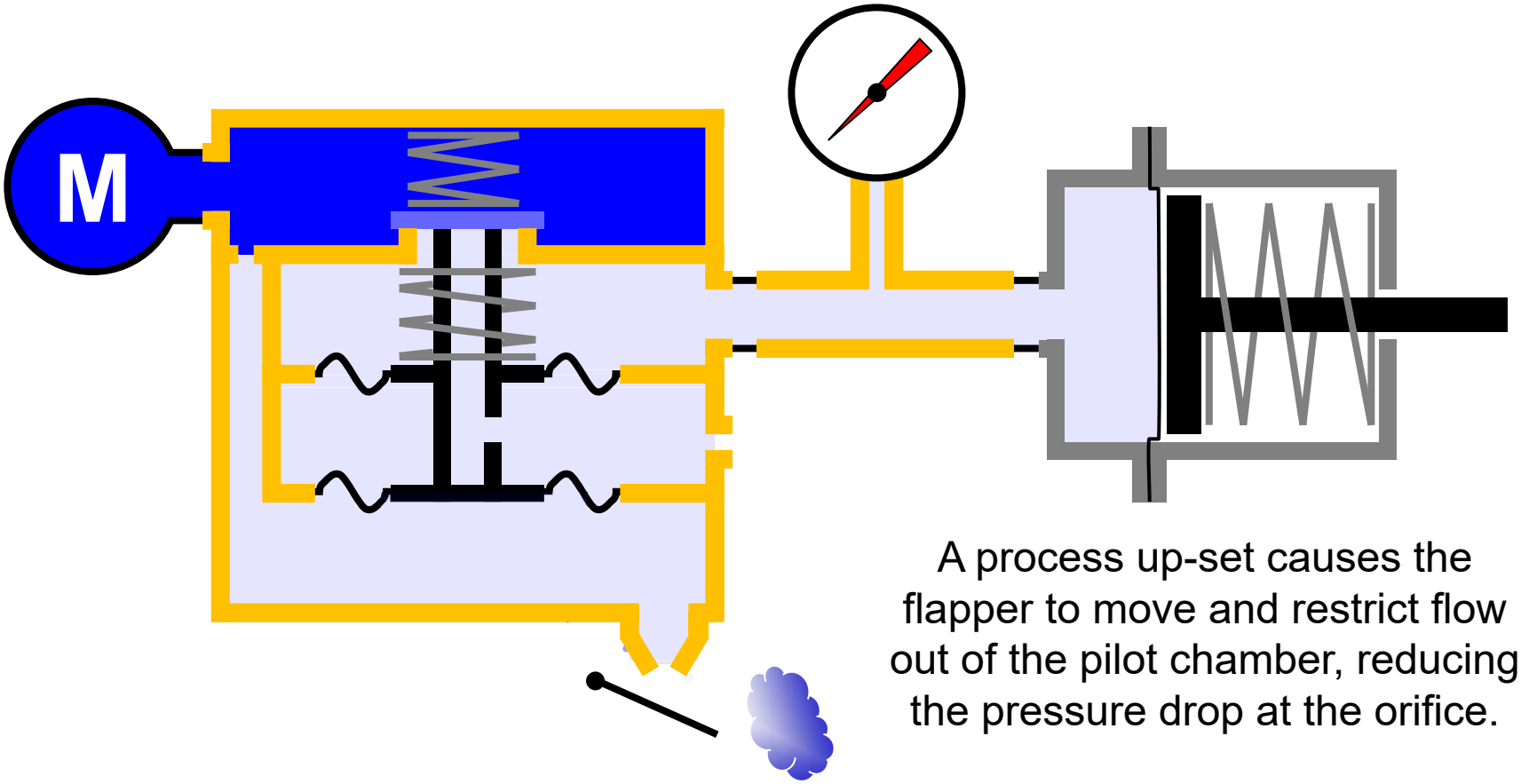


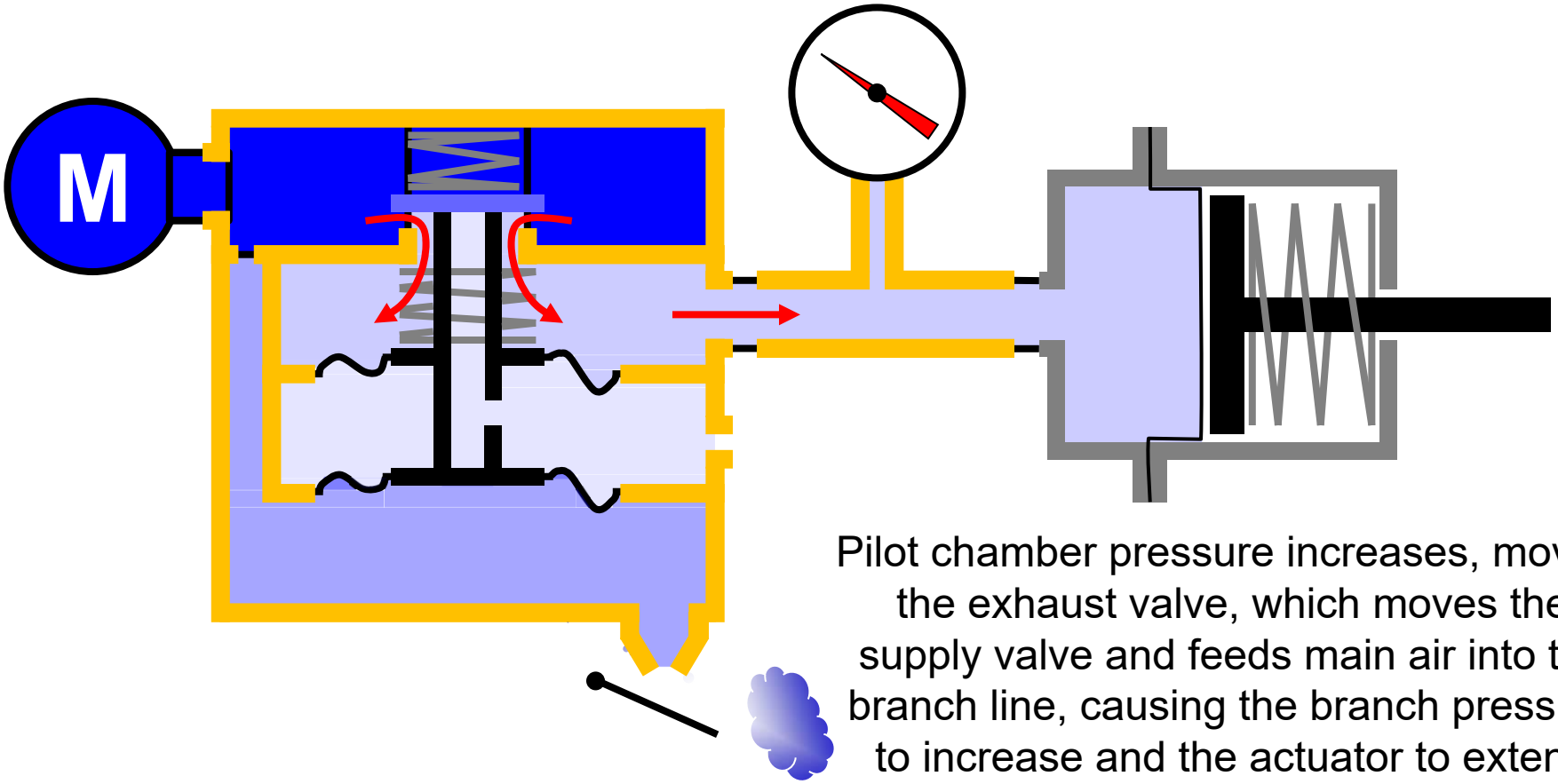
A wide open flapper bleeds enough air from the pilot chamber to cause a significant pressure drop at the orifice and the chamber pressure approaches atmospheric pressure

A Typical Two Pipe Pneumatic Control System



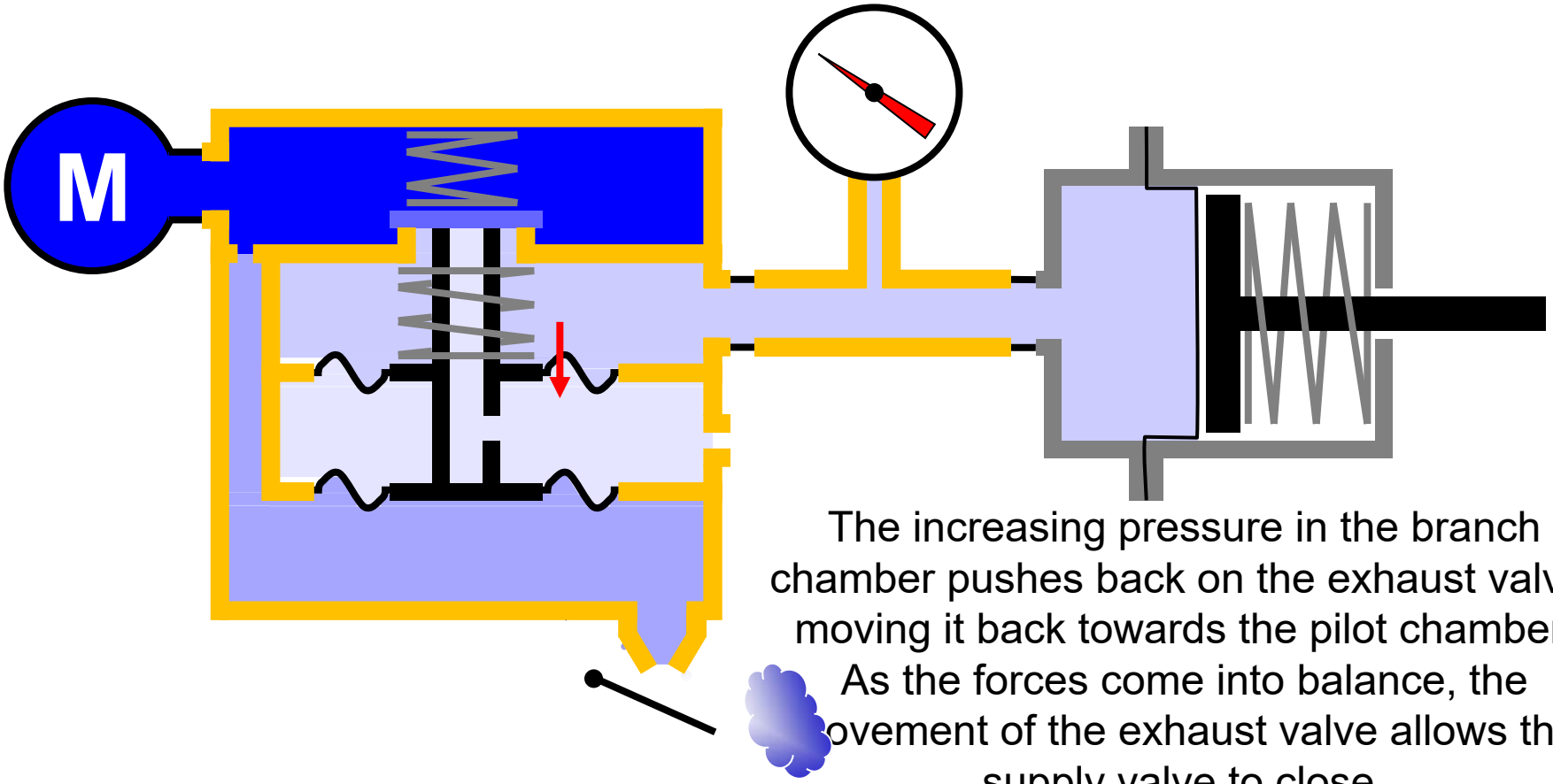
A process up-set causes the flapper to move and restrict flow out of the pilot chamber, reducing the pressure drop at the orifice.

A Typical Two Pipe Pneumatic Control System



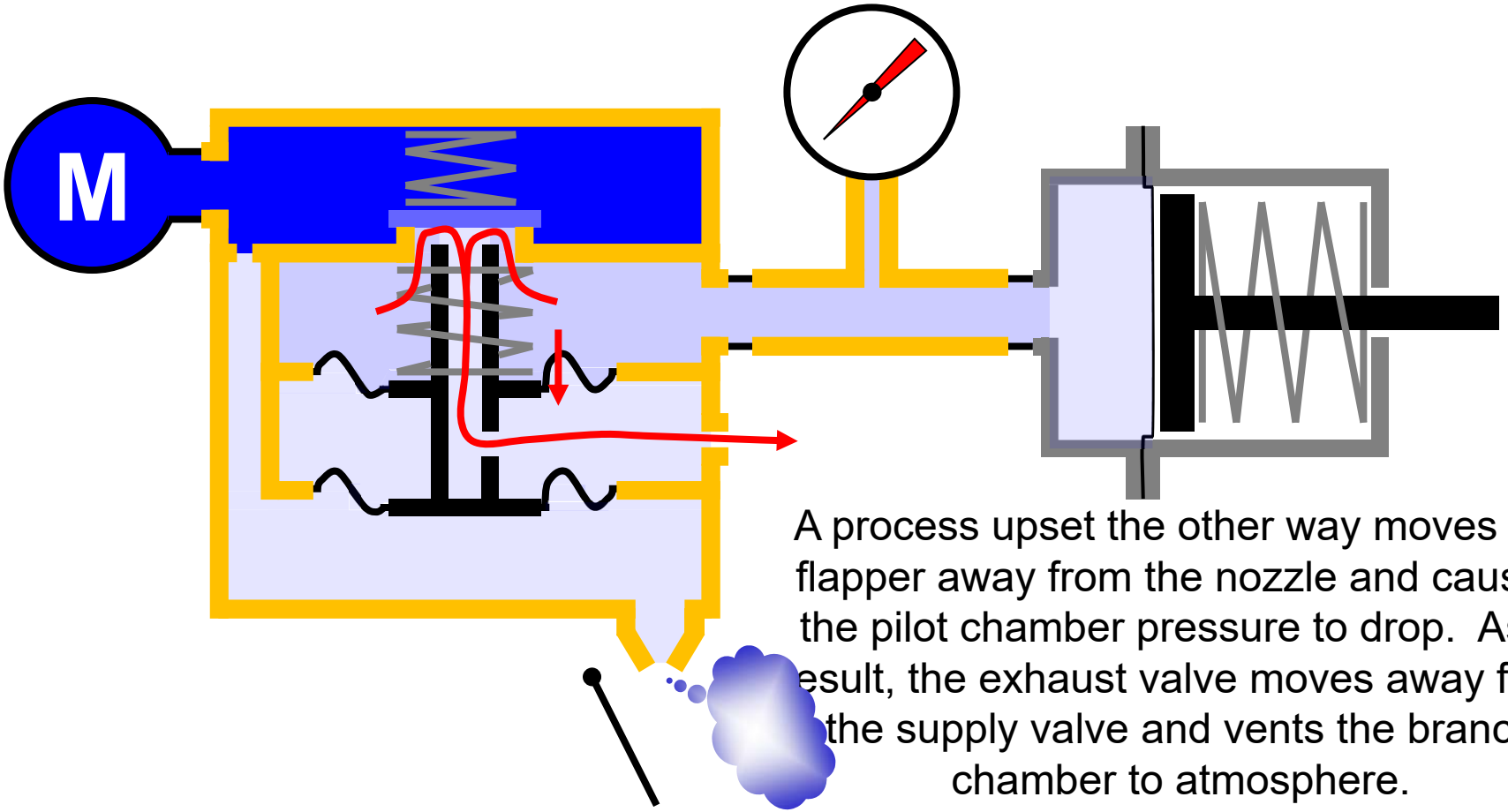
Pilot chamber pressure increases, moving the exhaust valve, which moves the supply valve and feeds main air into the branch line, causing the branch pressure to increase and the actuator to extend

A Typical Two Pipe Pneumatic Control System



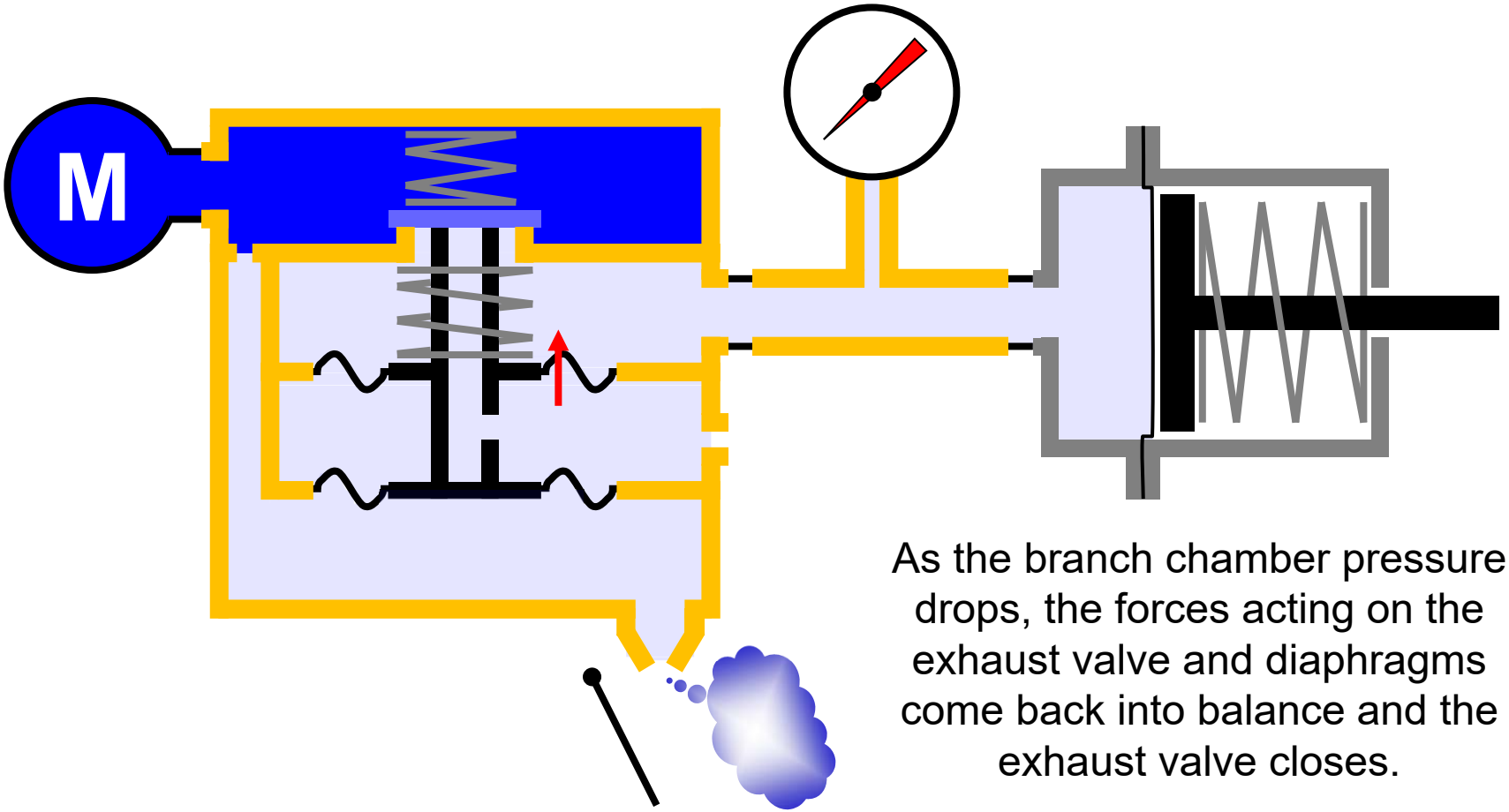
The increasing pressure in the branch chamber pushes back on the exhaust valve, moving it back towards the pilot chamber. As the forces come into balance, the movement of the exhaust valve allows the supply valve to close.

A Typical Two Pipe Pneumatic Control System



A process upset the other way moves the flapper away from the nozzle and causes the pilot chamber pressure to drop. As a result, the exhaust valve moves away from the supply valve and vents the branch chamber to atmosphere.

A Typical Two Pipe Pneumatic Control System



As the branch chamber pressure drops, the forces acting on the exhaust valve and diaphragms come back into balance and the exhaust valve closes.


HAKKO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Date Code
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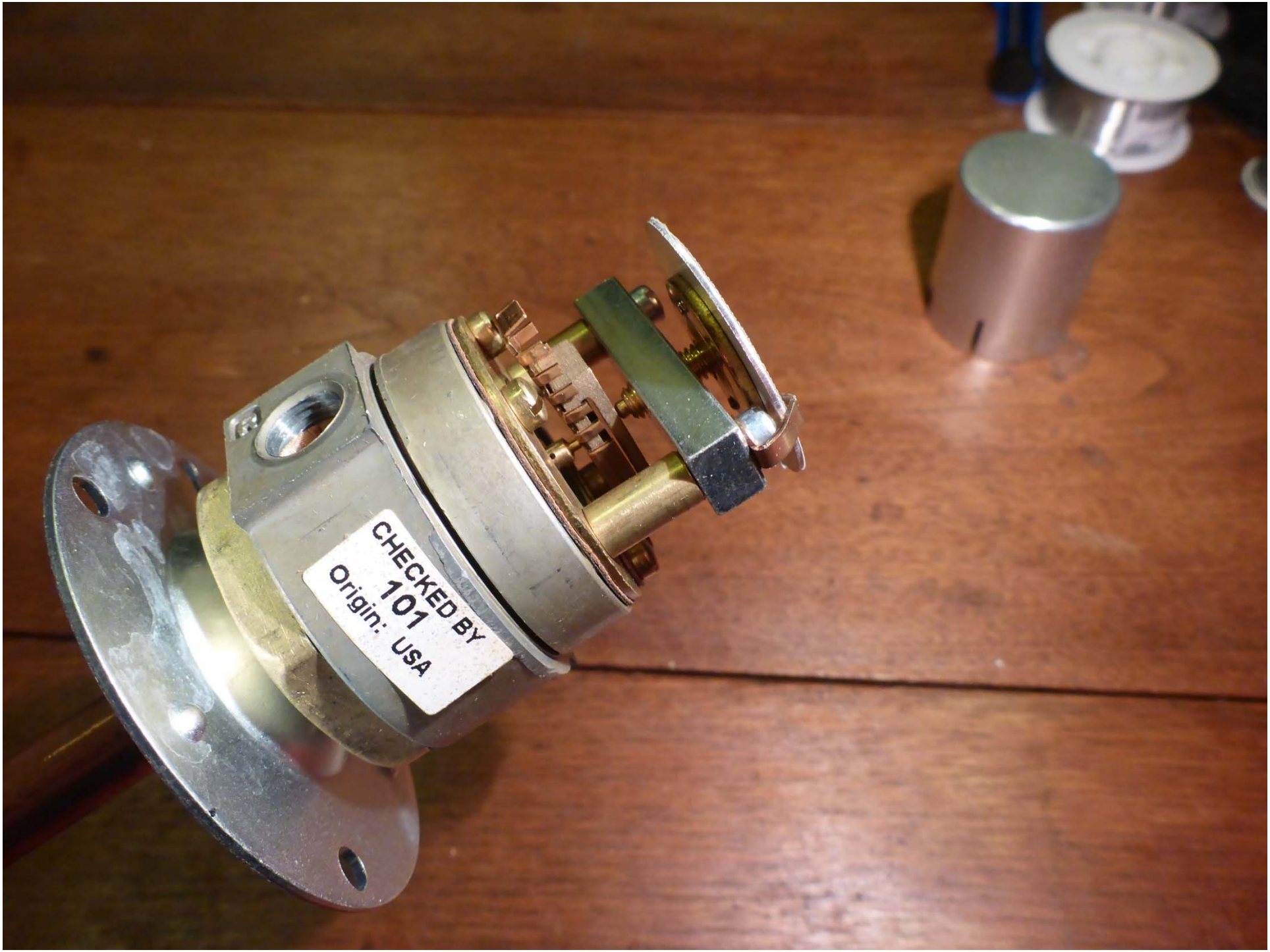
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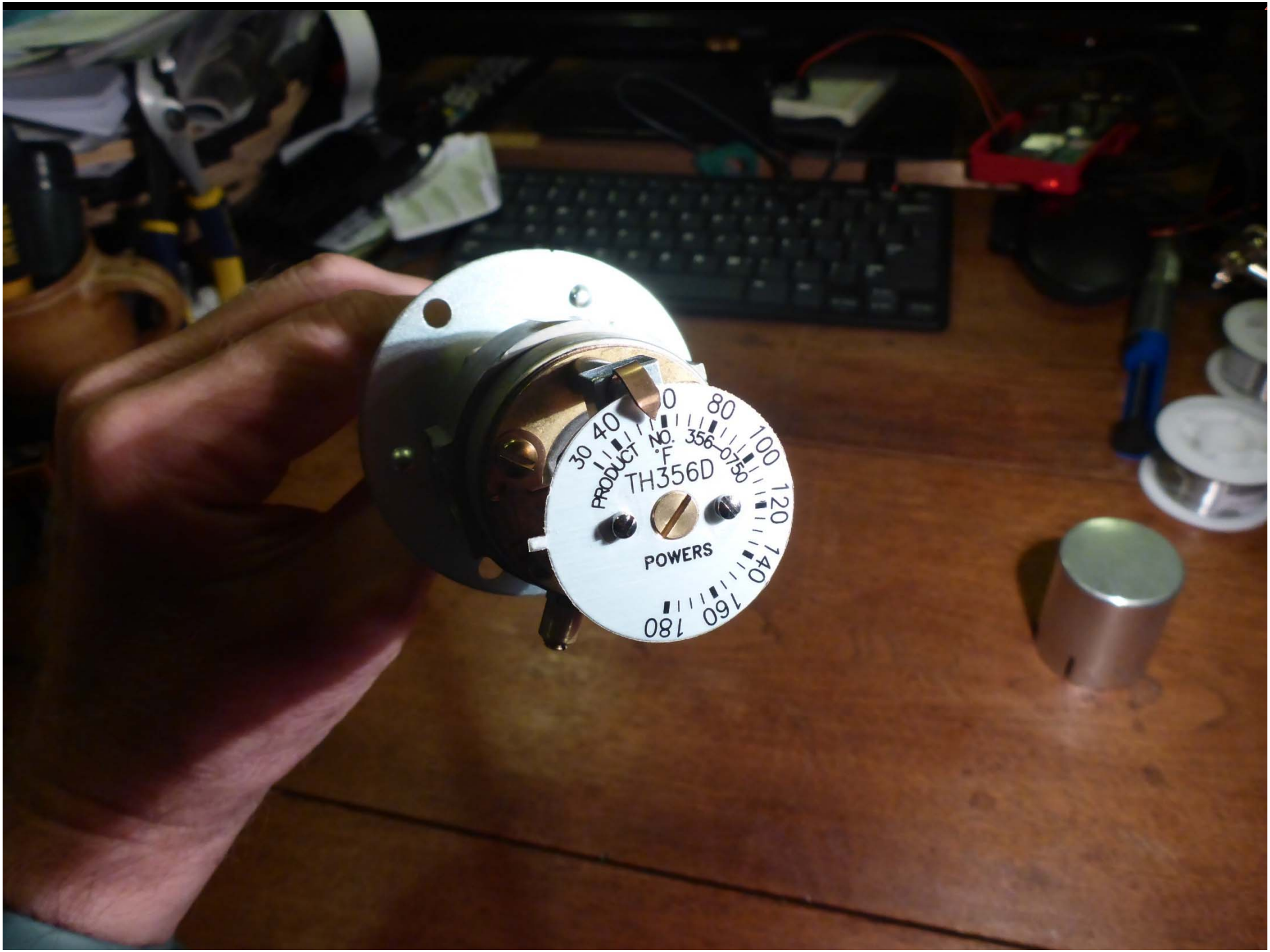
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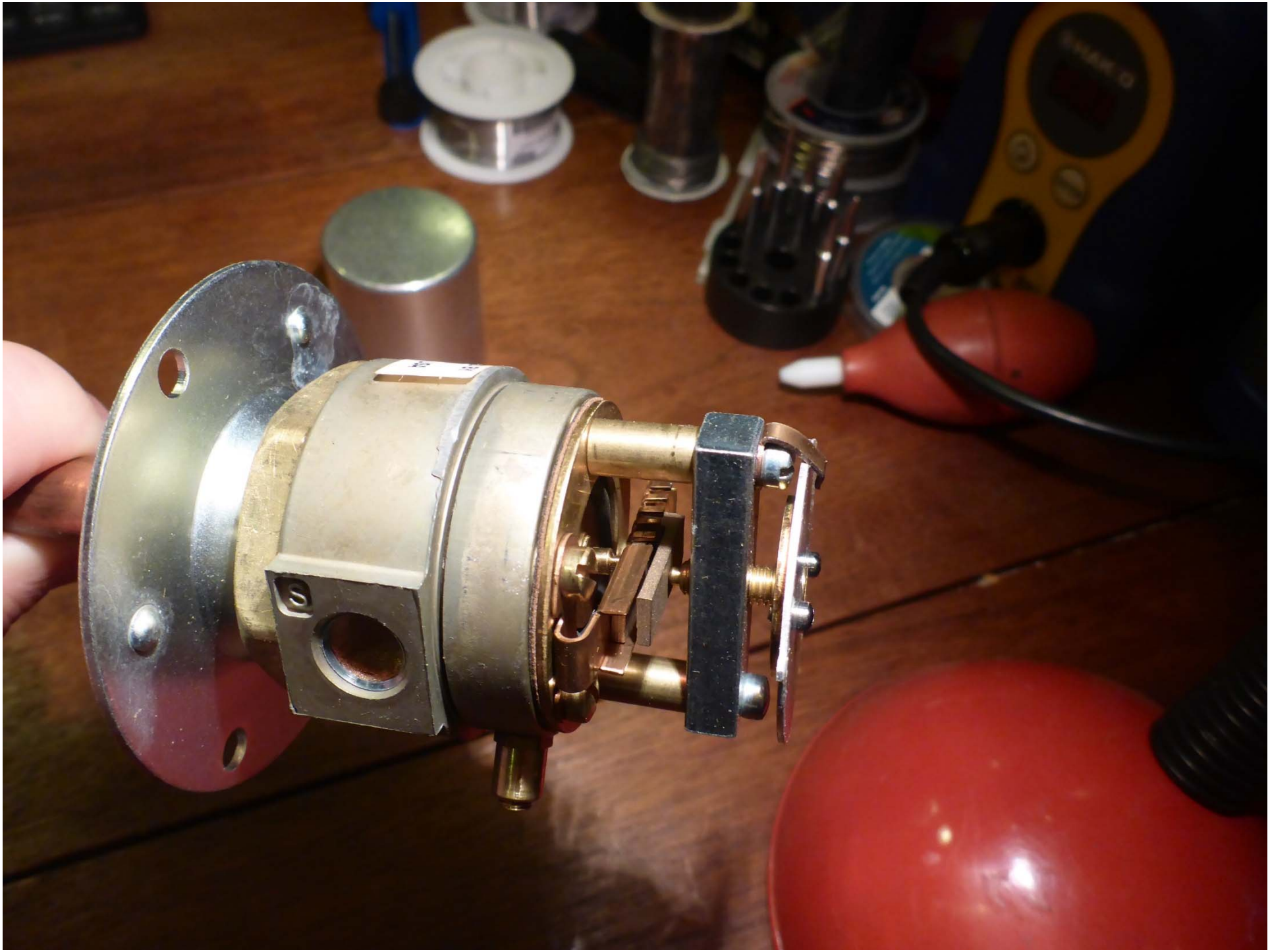


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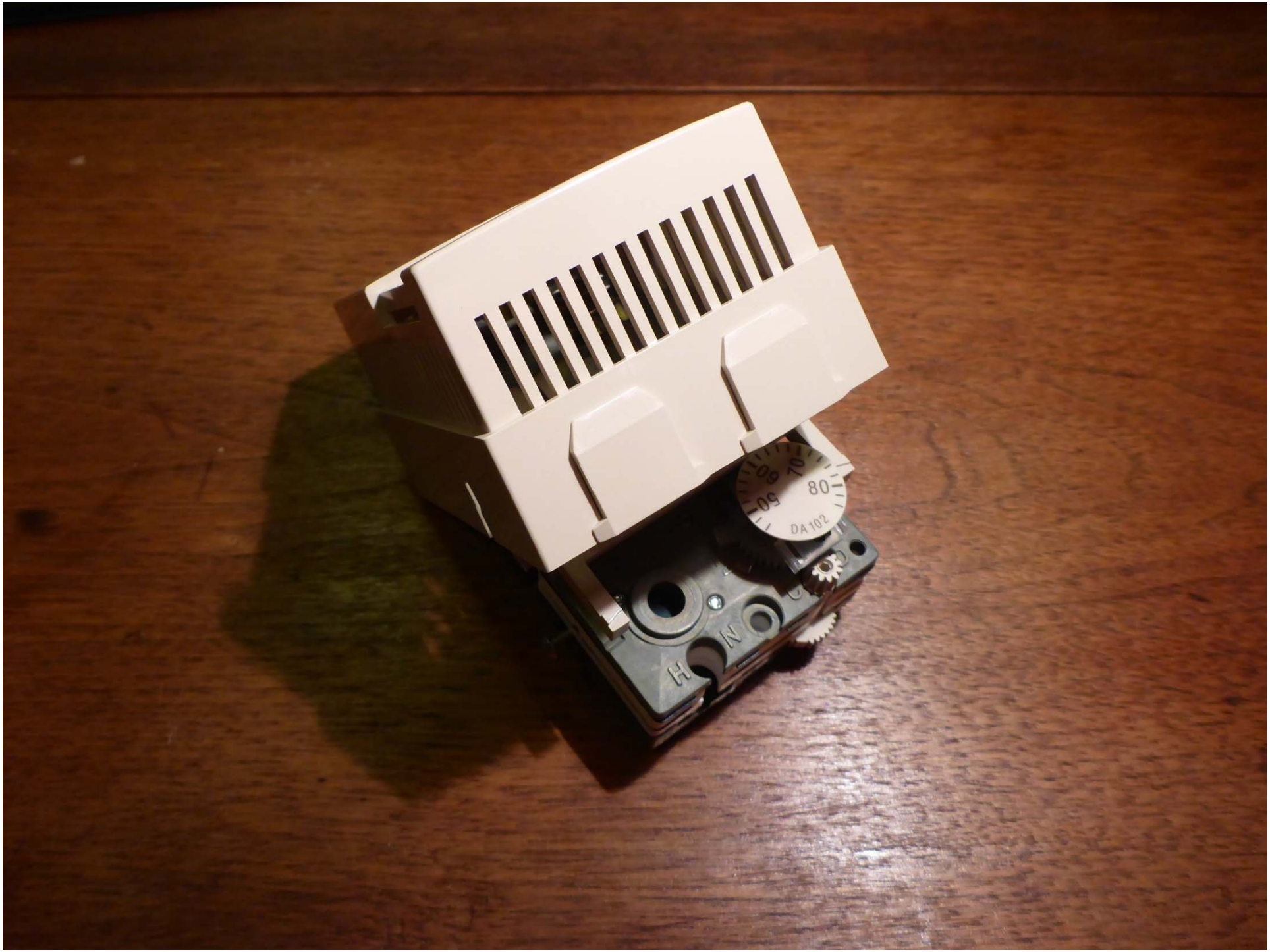
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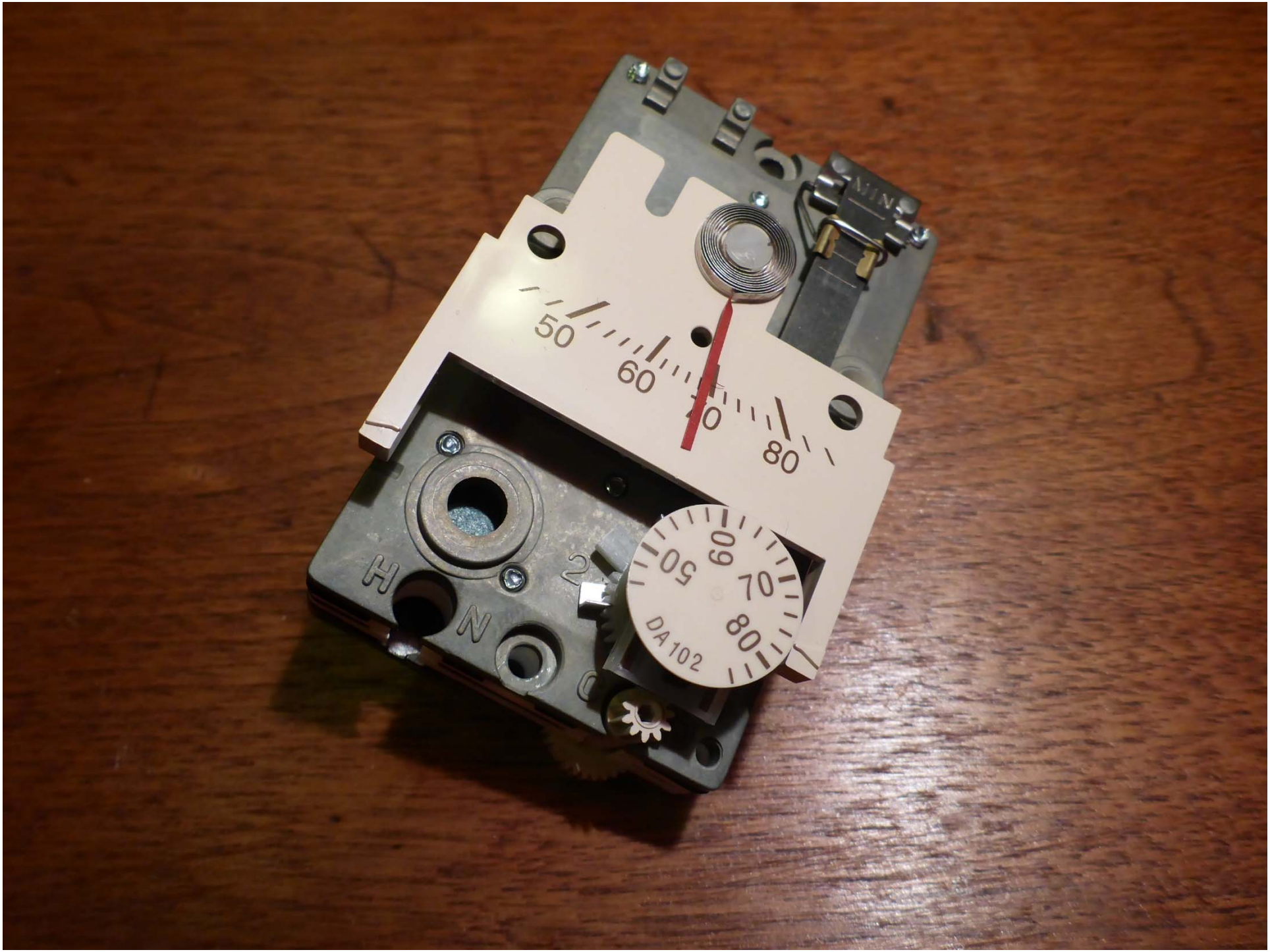
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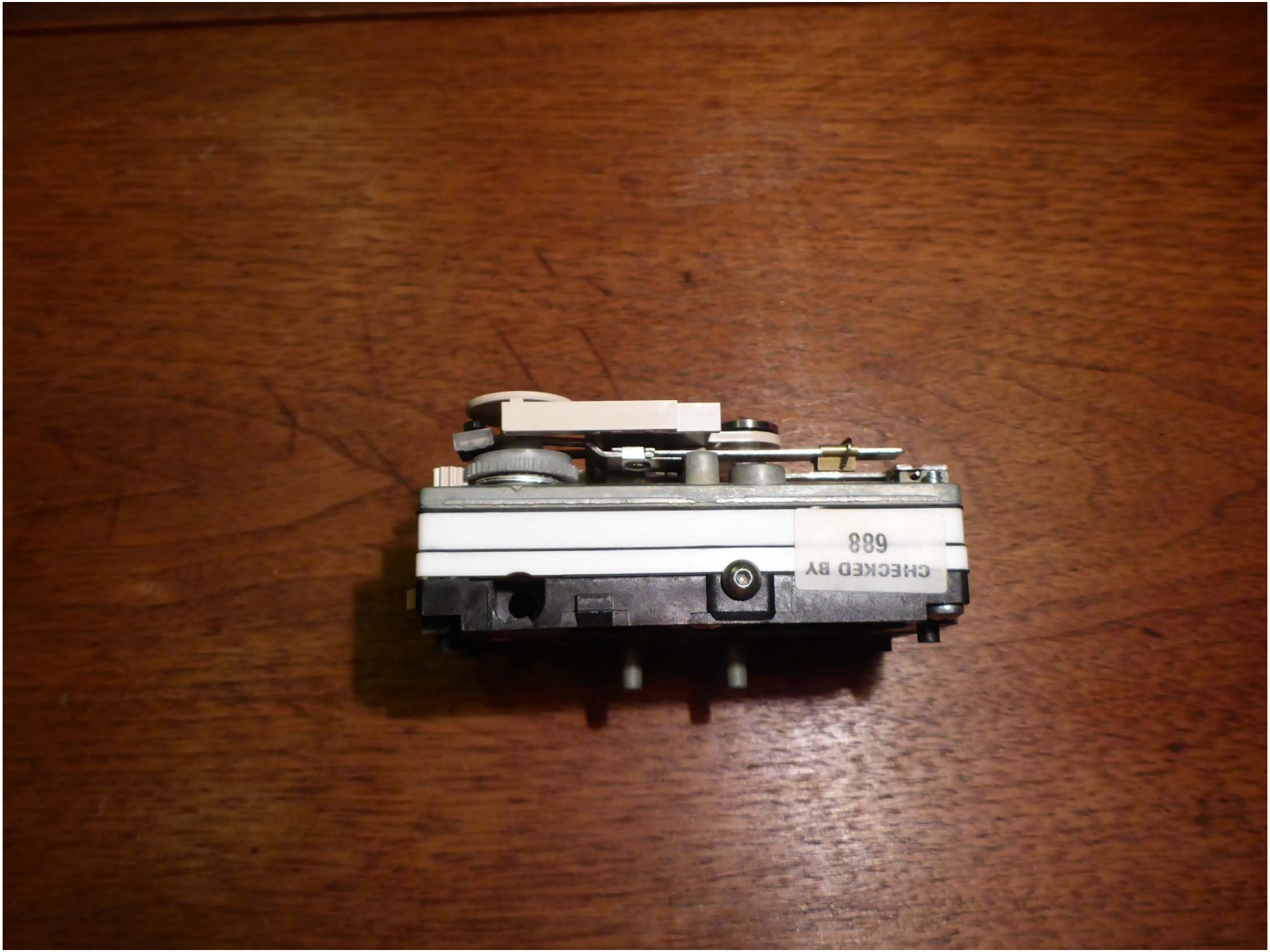
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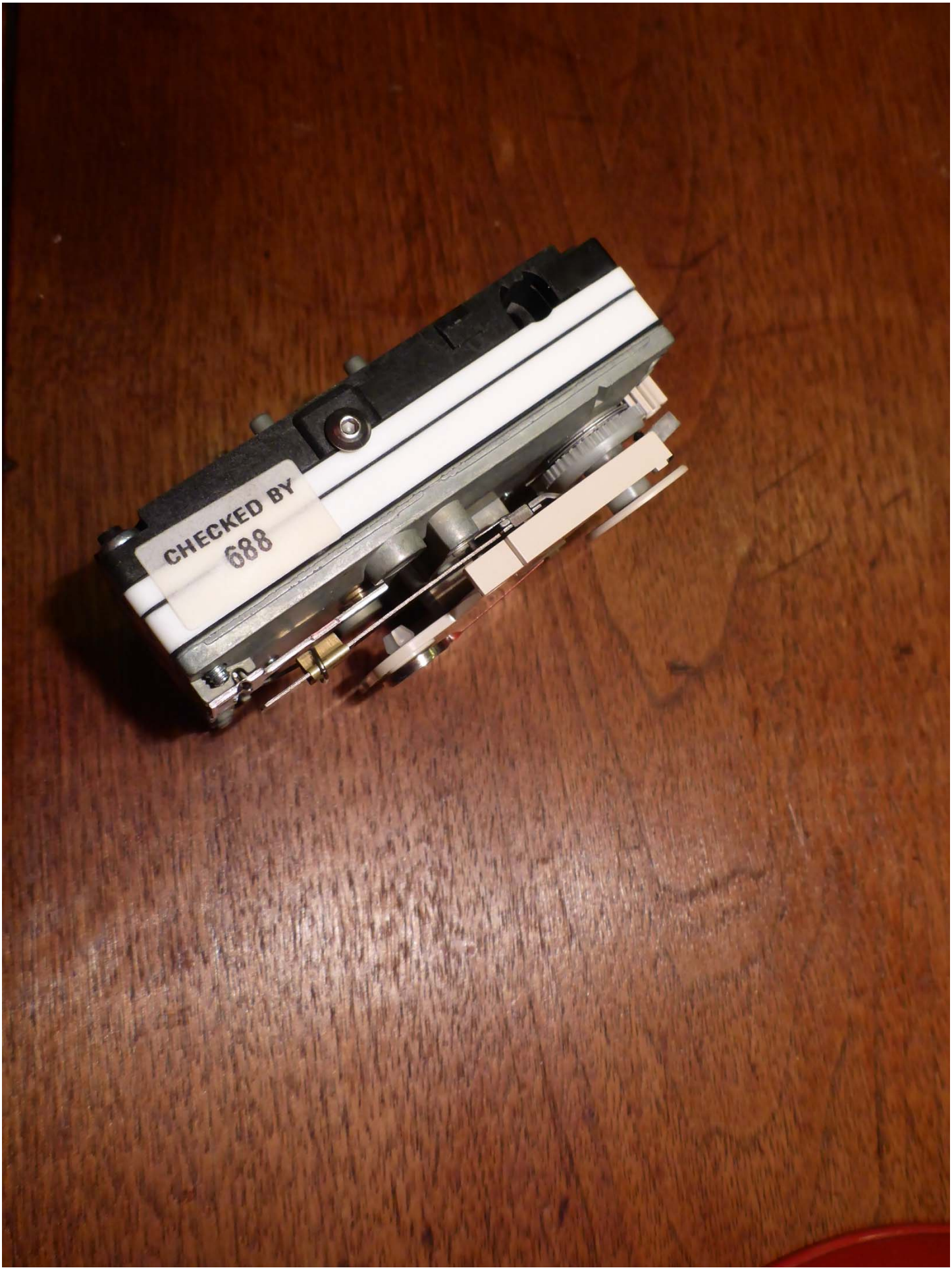
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Pneumatic vs. Electric/Electronic/Direct Digital Controls

Electric Actuators vs. Pneumatic Actuators

Electric Actuation

1. Complex
2. Use small, low power motors to allow wiring without conduit
3. Slow because of gear trains required by small motors
4. Many moving parts; gears, clutches end switches etc.
5. Consume power continuously if they are holding against a spring
6. Mechanical devices
7. No air system required (but power distribution panels required for zones to comply with NEC article 725 requirements for the energy limited required for wiring with out conduit

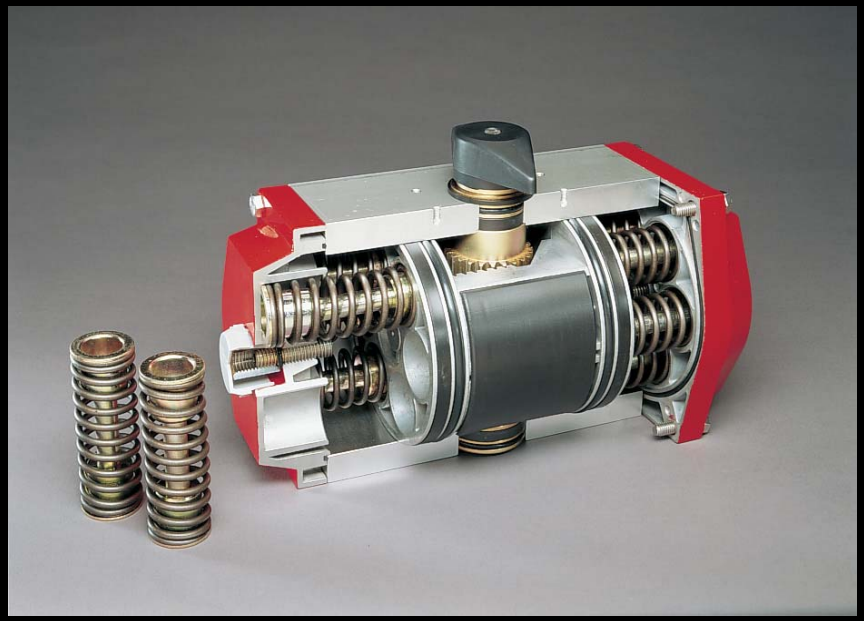
Pneumatic Actuation

1. Simple
2. Can generate large forces
3. Can move very quickly
4. Very few moving parts and moving parts are simple
5. Only consume air (energy) when they move
6. Mechanical devices
7. Require a separate air system and signal convertors when applied when with DDC technology

Electric Actuators vs. Pneumatic Actuators

Electric Actuation

Pneumatic Actuation



One Pipe vs. Two Pipe Pneumatic Thermostats

One Pipe Thermostats

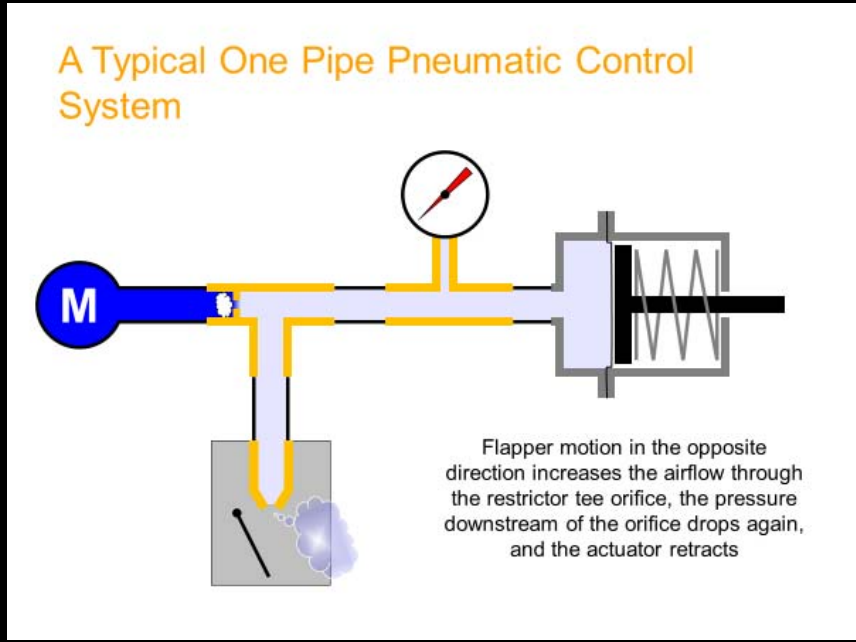
1. Inexpensive and simple
2. High air consumption
3. Sensitive to leaks
4. Restrictor tees that can:
    1. Plug
    2. Require periodic replacement
    3. Are difficult to find
5. Branch line length to the sensor can impact accuracy
6. Branch line length impacts lags
7. Mechanical devices
8. Operate on very small force differentials
9. Pivot points, linkages and diaphragms that can wear

Two Pipe Thermostats

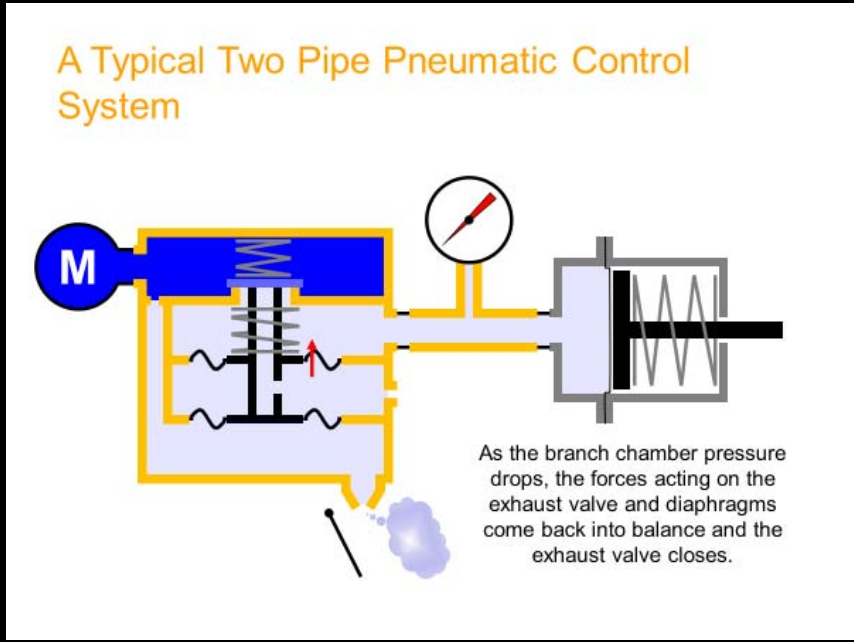
1. More expensive and complex
2. Lower air consumption
3. Tolerate leaks
4. No restrictor tees
5. Branch line length has no accuracy impact
6. Branch line length impacts lags
7. Mechanical devices
8. Operate on very small force differentials
9. Pivot points, linkages and diaphragms that can wear

One Pipe vs. Two Pipe Pneumatic Thermostats

One Pipe Thermostats



Two Pipe Thermostats



Pneumatic Controls vs. Pneumatic Actuation

Pneumatic Controls

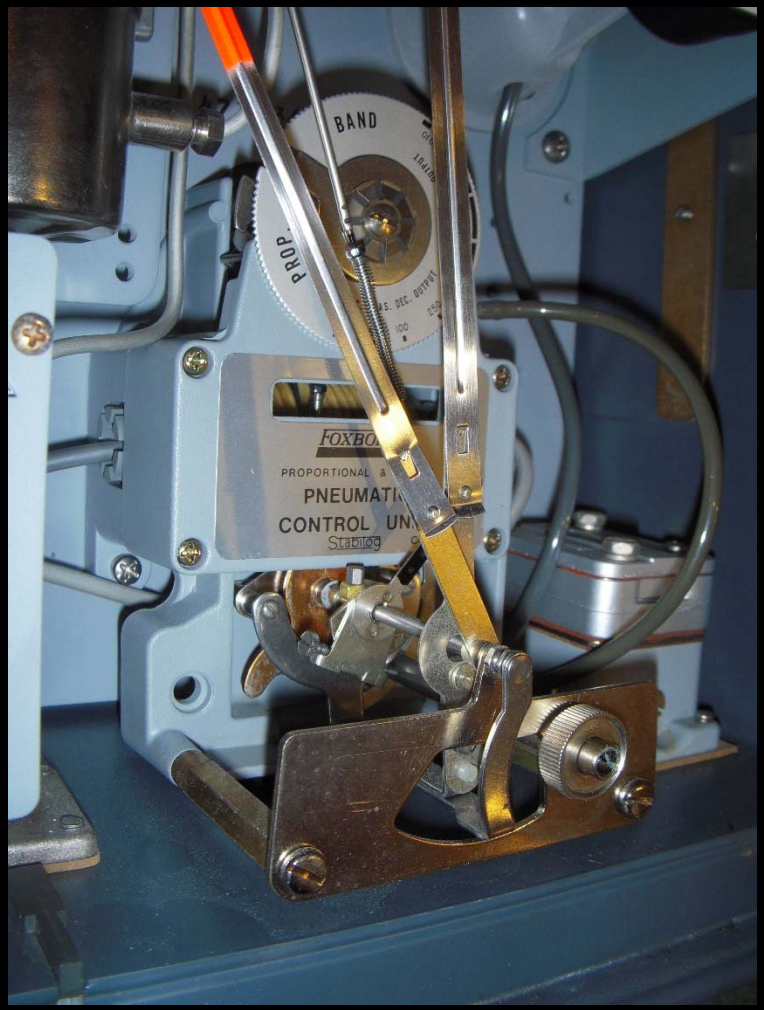
1. Complex
2. Operate on very small force differentials
3. Potentially slow reaction times due to orifices
4. Pivot points, linkages and diaphragms that can wear
5. Consume air continuously due to pilot valves and bleed orifices
6. Dirty air leads to system wide failures
7. Mechanical devices

Pneumatic Actuation

1. Simple
2. Can generate large forces
3. Can move very quickly
4. Very few moving parts and moving parts are simple
5. Only consume air (energy) when they move
6. Tolerate dirty air
7. Mechanical devices
8. Require a separate air system and signal convertors when applied when with DDC technology

Pneumatic Controls vs. Pneumatic Actuation

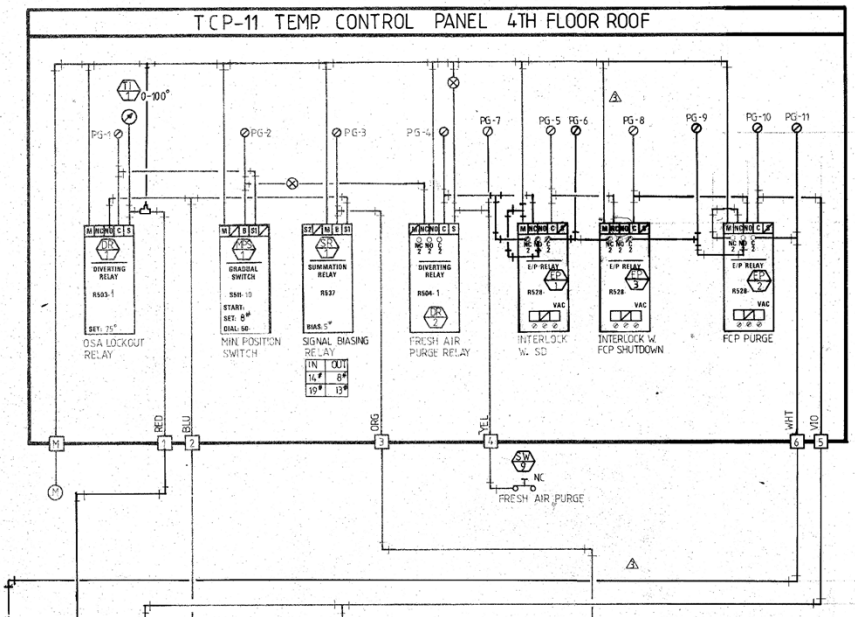
Pneumatic Controls

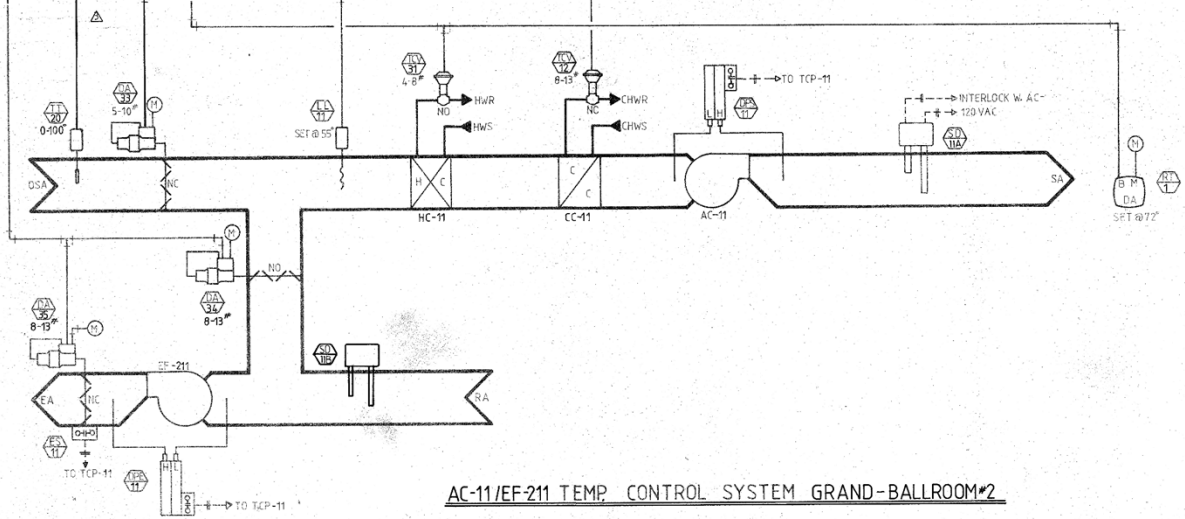


Pneumatic Actuation

Pneumatic Control Diagrams vs. Logic Diagrams

TCP-11 TEMP. CONTROL PANEL 4TH FLOOR ROOF





AC-11/EF-211 TEMP. CONTROL SYSTEM GRAND-BALLROOM#2

EQUIPMENT SCHEDULE

TCP-11

TAG	QTY	CODE-NO	DESCRIPTION	REMARKS
TI-1	1	A251	Temperature Indicator	0-100°F
PG-11	11	A201-01	Pressure Gauge	0-30#
DR-1	1	R503-1	Diverting Relay	
DR-2	1	R504-1	Diverting Relay	
MPS-1	1	S511-10	Minimum Position Switch	
SR-1	1	R537	Summation Relay	
EP-1,2,3	3	R528-110	Electric Pneumatic Relay	110 VAC
R-1/15	3	RH2B-L	2 PDT Relay	110 VAC
TCP-11	1	24X24X8	Temperature Control Panel	
ASK-11	1	WCM-50	Remote Alarm Indicator Switch	
R-4	1	RH3B-L	RELAY 3PDT	110VAC
R-3	1	RH4B-L	" 4PDT	"

SYSTEM START-UP:

SYSTEM IS MANUALLY STARTED THROUGH RELAY R-5, INTERLOCKED WITH THE SUPPLY AIR SMOKE DETECTOR. EXHAUST FAN STARTS WHEN ENDSWITCH CONTACTS CLOSE AND SUPPLY FAN IS RUNNING.

SMOKE CONTROL AND FIREMAN'S OVERRIDE:

UPON SENSING SMOKE IN THE SUPPLY AIR, SUPPLY AIR SMOKE DETECTOR DE-ENERGIZES RELAY R-5. R5-1 CONTACTS OPEN TO DE-ENERGIZE THE SUPPLY FAN. R5-2 CONTACTS OPEN TO DE-ENERGIZE THE ELECTRIC PNEUMATIC RELAY EP-1, WHICH IN TURN CLOSES THE OSA & RA DAMPERS AND OPENS THE EXHAUST AIR DAMPERS. THE EXHAUST FAN REMAINS RUNNING. UPON SENSING SMOKE IN THE RETURN AIR, RETURN AIR SMOKE DETECTOR ENERGIZES RELAY R-1. R1-1 CONTACTS CLOSE TO ENERGIZE THE ELECTRIC PNEUMATIC RELAY EP-2, WHICH IN TURN OPENS THE EXHAUST AIR AND OSA DAMPER 100% AND CLOSES THE RETURN AIR DAMPER. THE SUPPLY AND EXHAUST FAN REMAIN RUNNING. IF THE SUPPLY FAN IS OFF, IT REMAINS OFF. WHEN RELAY R-3 IS DE-ENERGIZED BY THE FCP, R3-1 CONTACTS OPEN TO DE-ENERGIZE THE SUPPLY FAN. R3-2 CONTACTS OPEN TO DE-ENERGIZE THE EXHAUST FAN. R3-3 CONTACTS OPEN TO DE-ENERGIZE THE ELECTRIC PNEUMATIC RELAY EP-1, WHICH IN TURN CLOSES THE OSA AND RA DAMPER AND OPENS THE RETURN AIR DAMPER. R3-4 CONTACTS OPEN TO DE-ENERGIZE EP-2. WHEN RELAY R-4 IS ENERGIZED BY THE FCP, R4-1 CONTACTS CLOSE TO ENERGIZE THE SUPPLY FAN. R4-2 CONTACTS CLOSE TO ENERGIZE THE EXHAUST FAN AND R4-3 CONTACTS CLOSE TO ENERGIZE THE ELECTRIC PNEUMATIC RELAY EP-2, WHICH IN TURN OPENS OSA AND EA DAMPERS AND CLOSES THE RA DAMPERS.

DIFFERENTIAL PRESSURE SWITCHES DPS-11 AND DPE-11, LOCATED ACROSS SUPPLY AND EXHAUST FANS, INDICATE THAT THE FANS ARE RUNNING AT THE FIREMAN'S CONTROL PANEL.

SUPPLY AIR TEMPERATURE CONTROL:

ROOM THERMOSTAT RT-1, LOCATED IN ITS CONDITIONED AREA, MODULATES THE HEATING CONTROL VALVE TCV-31 TO MAINTAIN ROOM TEMPERATURE. BRANCH PRESSURE FROM RT-1 IS ALSO FED INTO OSA LOCKOUT RELAY DR-1 AND SIGNAL BIASING RELAY SR-1. BRANCH PRESSURE FROM OSA LOCKOUT RELAY DR-1 MODULATES THE OUTSIDE AIR, RETURN AIR AND EXHAUST AIR DAMPERS. WHEN THE OUTSIDE AIR TEMPERATURE EXCEEDS DR-1 SETPOINT (75°F), AS SENSED BY TEMPERATURE TRANSMITTER TT-20, BRANCH PRESSURE FROM DR-1 IS VENTED, OUTSIDE AIR DAMPER TURN TO THEIR MINIMUM POSITION AND RETURN AIR DAMPER OPENS.

BRANCH PRESSURE FROM SIGNAL BIASING RELAY MODULATE THE COOLING CONTROL VALVE TCV-12 TO MAINTAIN RT-1 SETPOINT.

LOW LIMIT CONTROLLER LL-11, LOCATED IN THE MIXED AIR, OVERRIDES RT-1 SIGNAL, WHEN MIXED AIR TEMPERATURE DROPS BELOW LL-11 SETPOINT (55°F).

FRESH AIR PURGE:

WHEN SWITCH SW-9 (N.C.) IS ACTIVATED, FRESH AIR PURGE RELAY DR-2 IS ACTIVATED. MAIN AIR CONNECTED TO THE N.O. PORT IS SWITCHED TO THE N.C. PORT OF DR-4, WHICH OPENS THE OUTSIDE AND EXHAUST AIR DAMPERS AND CLOSES THE RETURN AIR DAMPER LOUV.

CONTRACTOR A & A MECH.

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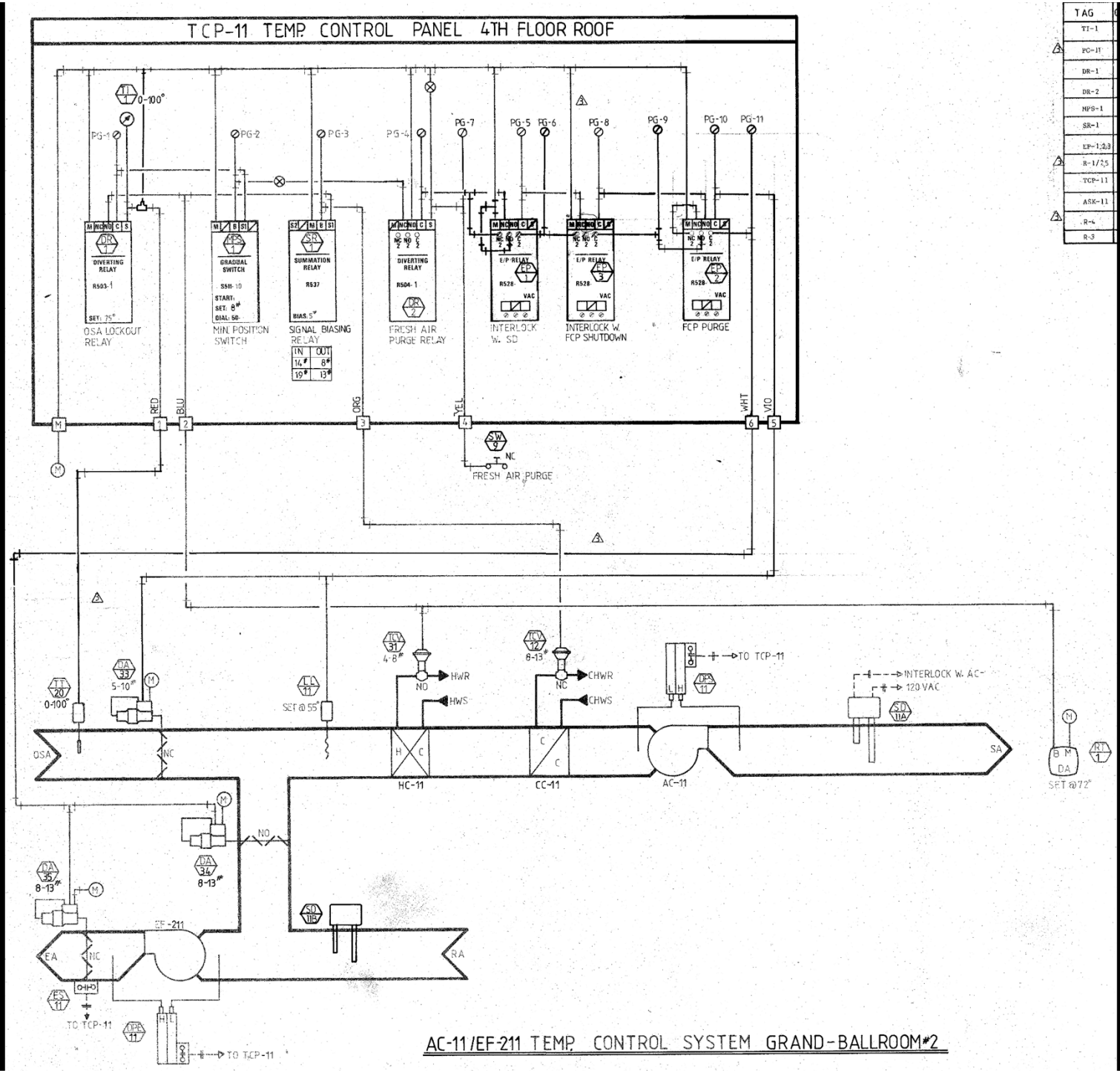
ENERGY LOGICS
2949 WHIPPLE ROAD
(415) 427-5980 CALIFORNIA 94587

REVISIONS
1-3-85KK
1-21-86 "AS BUILT"
AC-11/EF 211

DRAWN M.NOPPANU
CHECKED TCR
DATE 1-28-86
JOB NO. 84-5137

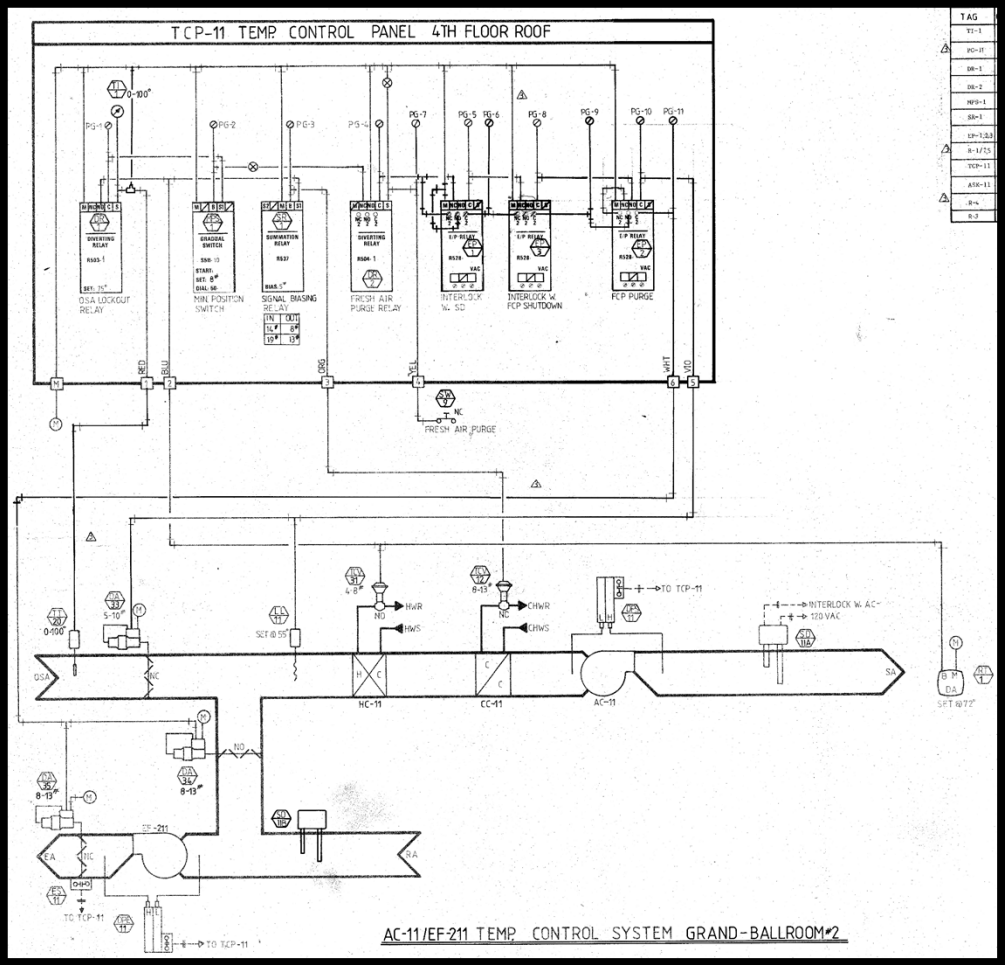
SHEET 15 OF 35



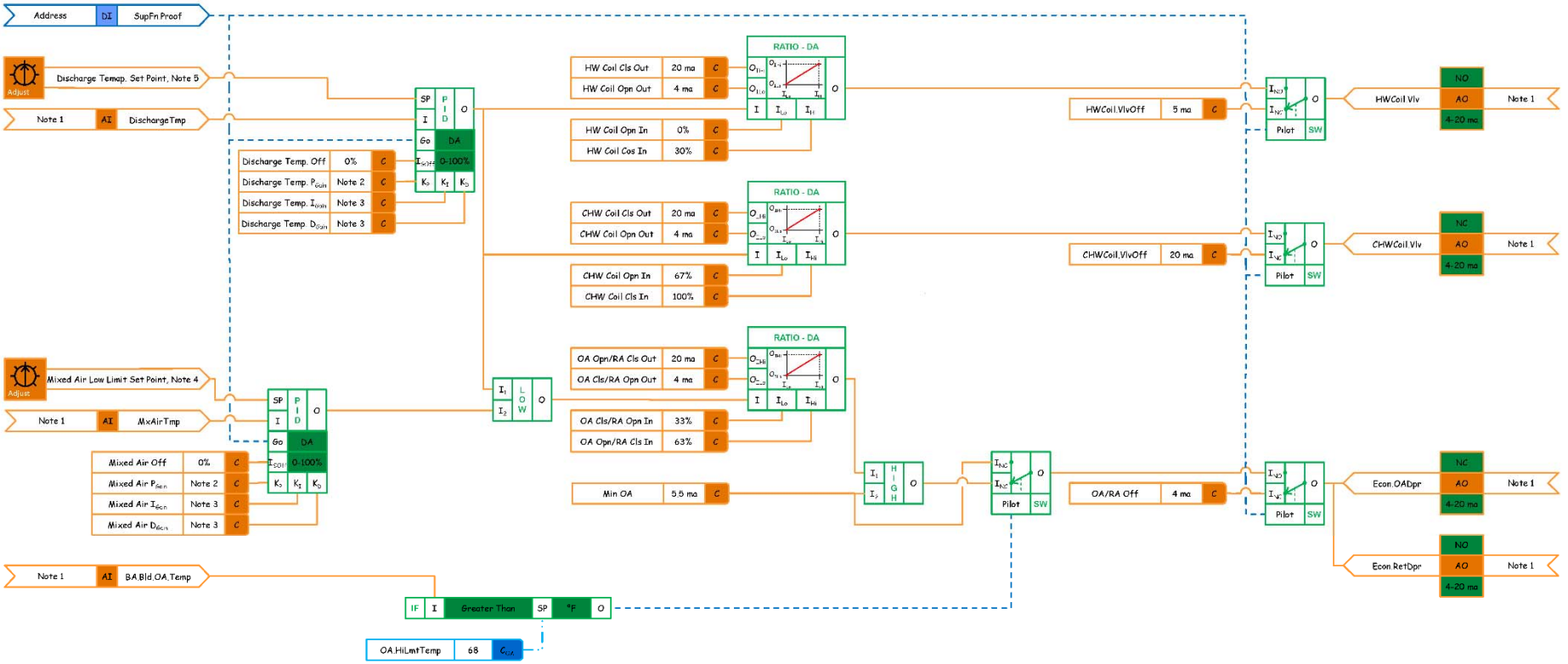
AC-11/EF-211 TEMP. CONTROL SYSTEM GRAND-BALLROOM#2

Pneumatic Control Diagrams

- Hardware object oriented
- Different hardware elements for different functions
  - Sensors
  - Actuators
  - Controllers
  - Relays
- Logic established by the way the various ports on the hardware objects are interconnected



DDC Logic Diagrams

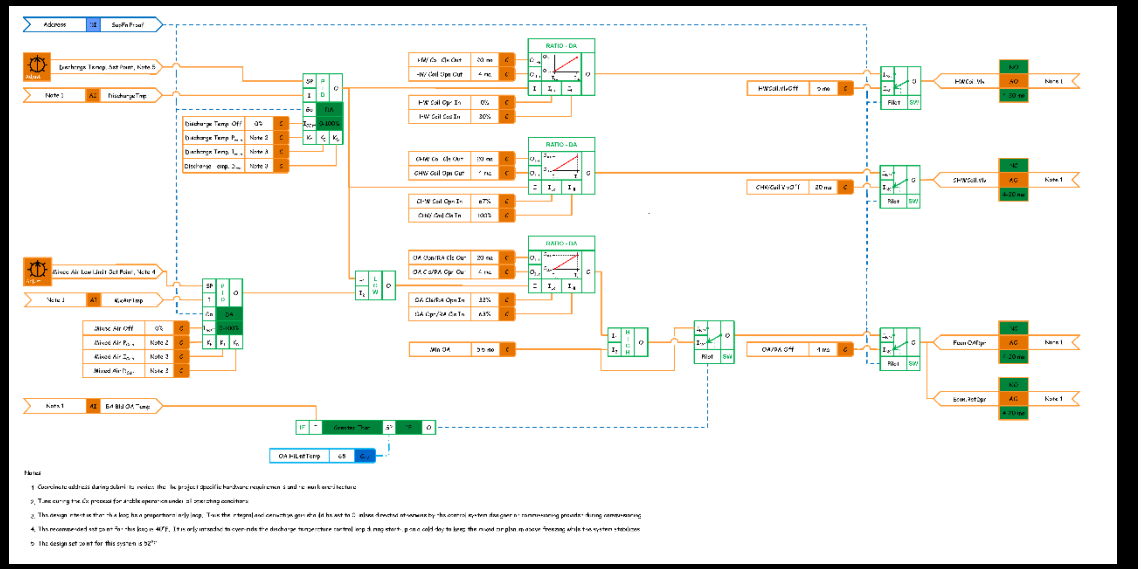


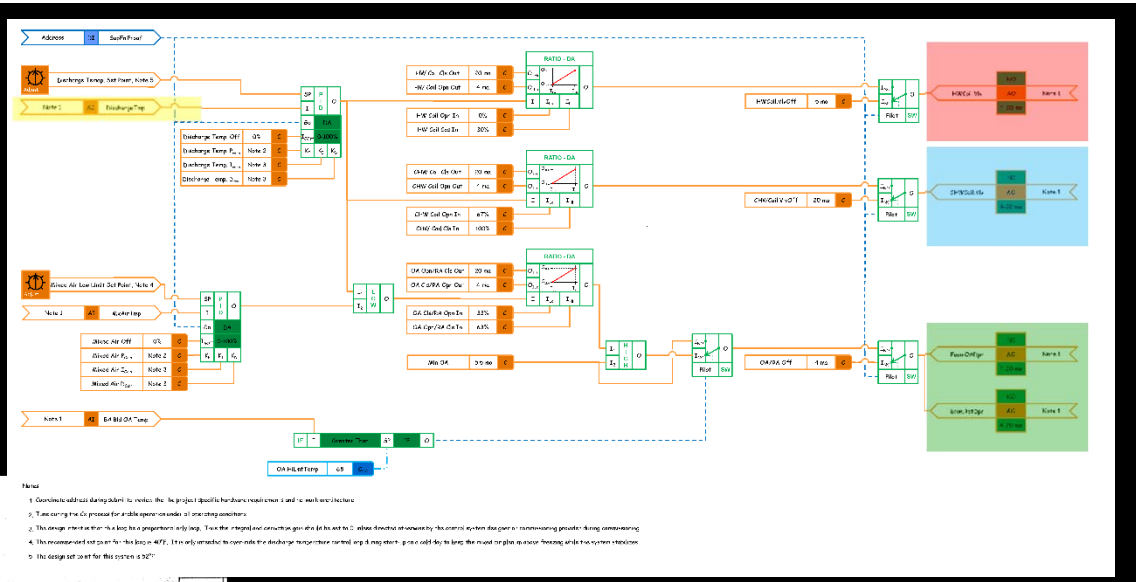
Notes

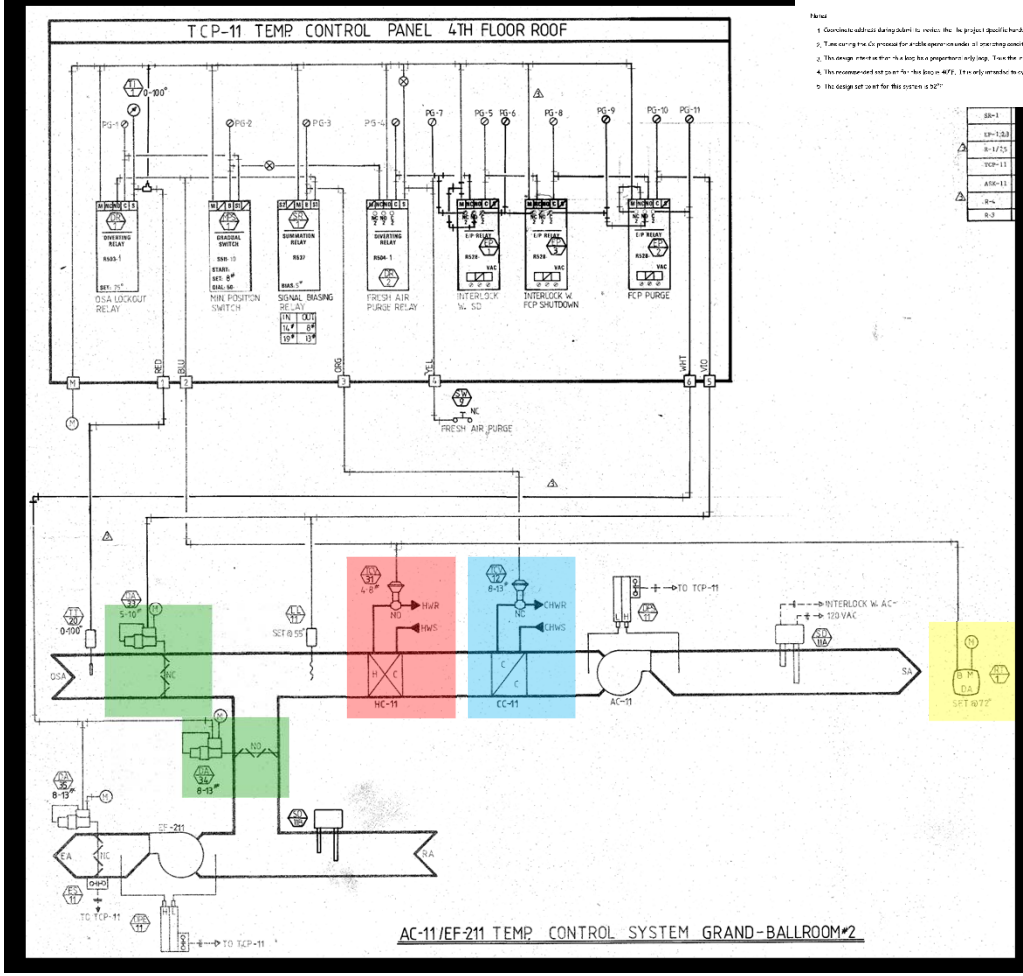
1. Coordinate address during submittal review the the project specific hardware requirements and network architecture.
2. Tune during the Cx process for stable operation under all operating conditions
3. The design intent is that this loop be a proportional only loop. Thus the integral and derivative gain should be set to 0 unless directed otherwise by the control system designer or commissioning provider during commissioning
4. The recommended set point for this loop is 40°F. It is only intended to over-ride the discharge temperature control loop during start-up on a cold day to keep the mixed air plenum above freezing while the system stabilizes.
5. The design set point for this system is 52°F

DDC Logic Diagrams

- *Software object* oriented
- Different *software* elements for different functions
  - Sensors
  - Actuators
  - Controllers
  - Relays
- Logic established by the way the various ports on the *software objects* are interconnected





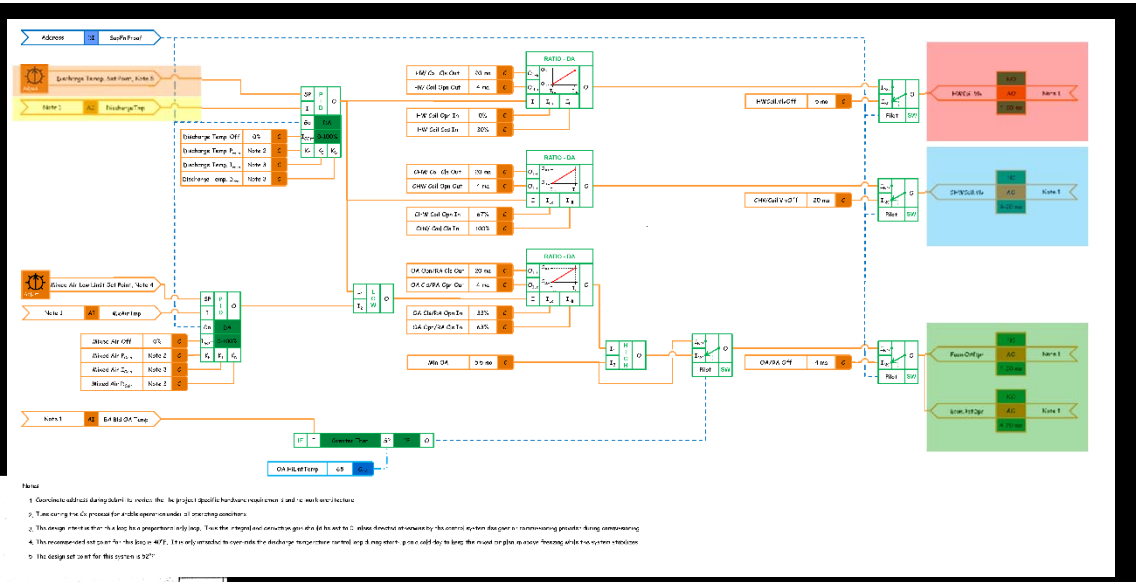


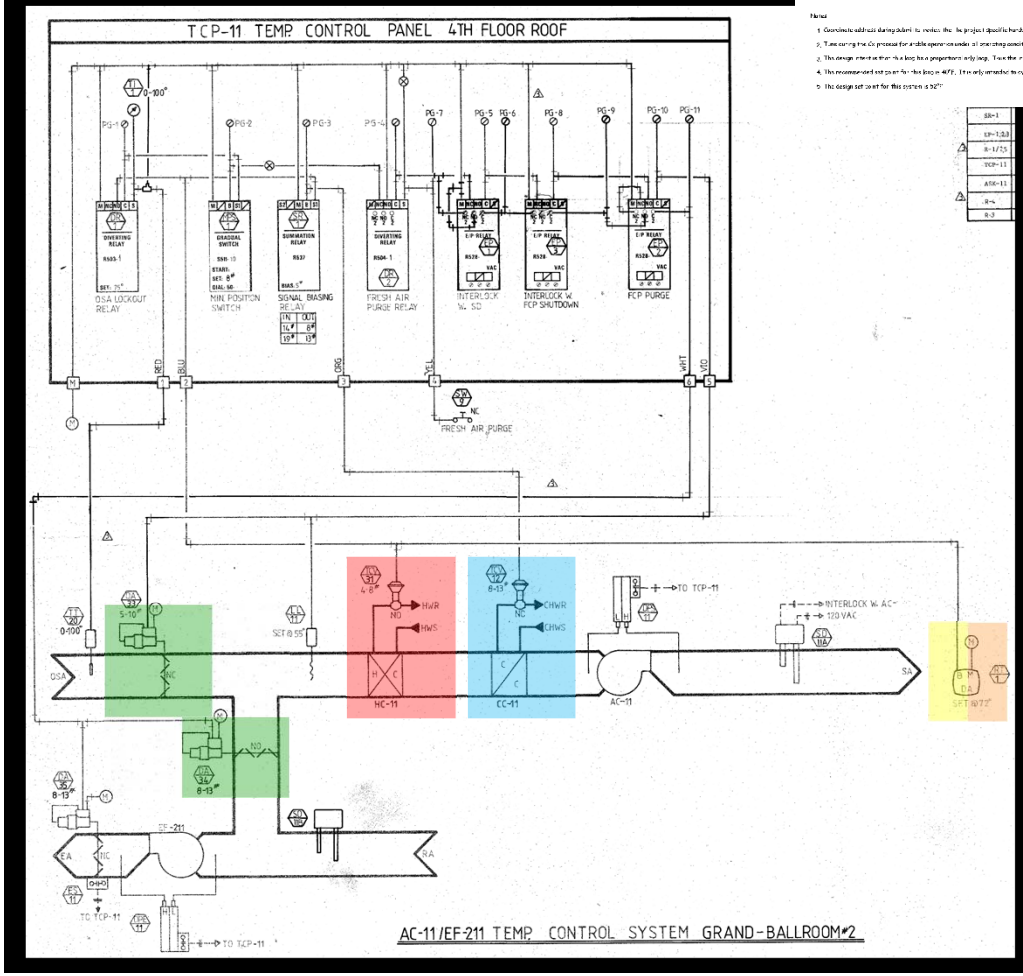
Economizer Dampers

Chilled Water Valve

Hot Water Valve

Controlling Sensor



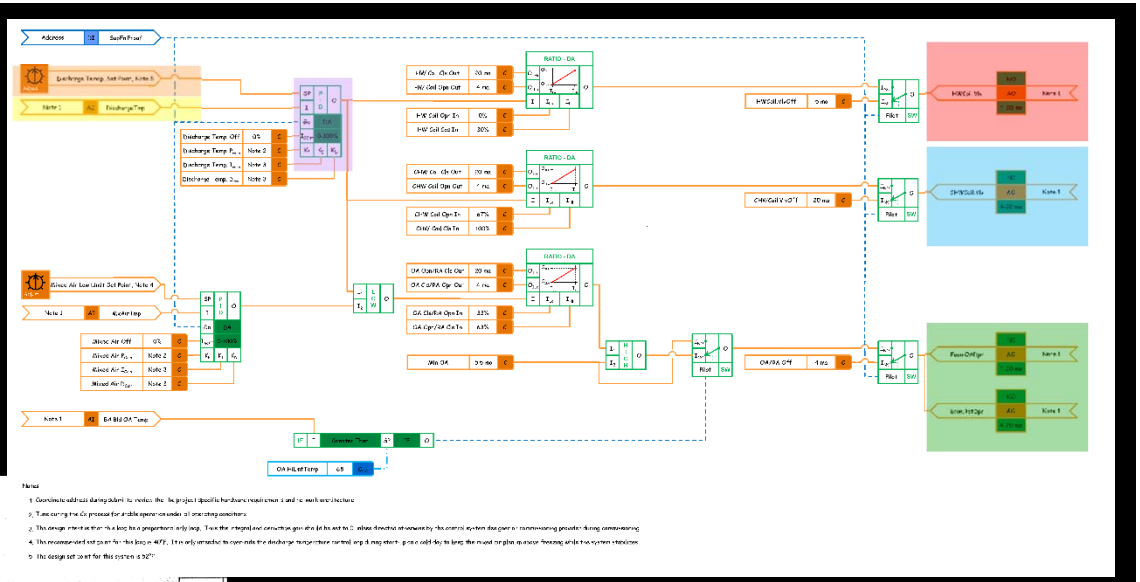


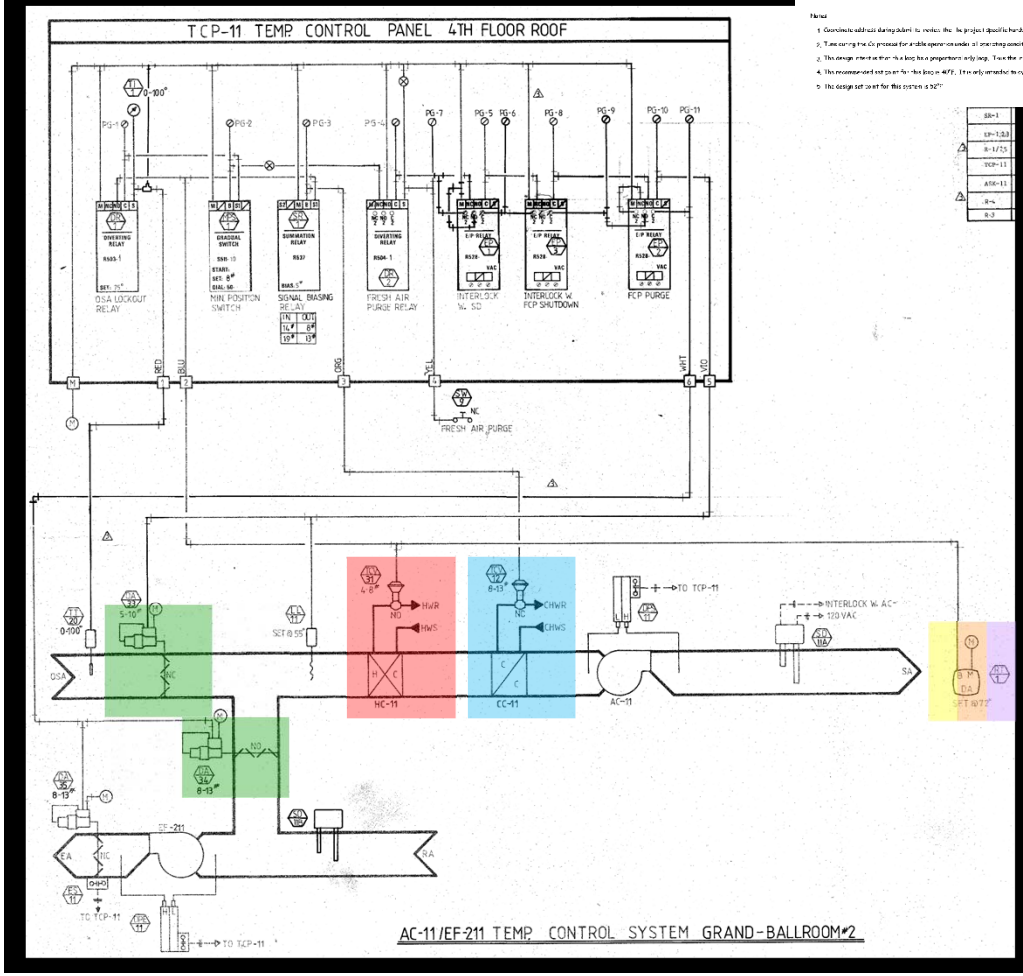
Economizer Dampers

Chilled Water Valve

Hot Water Valve

Controlling Sensor, Set Point



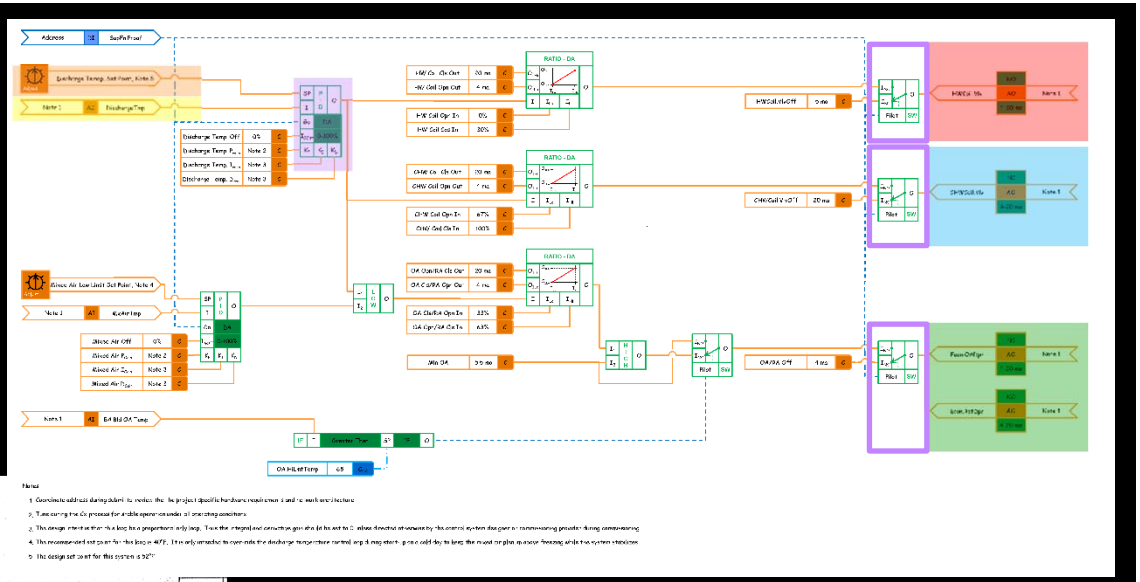


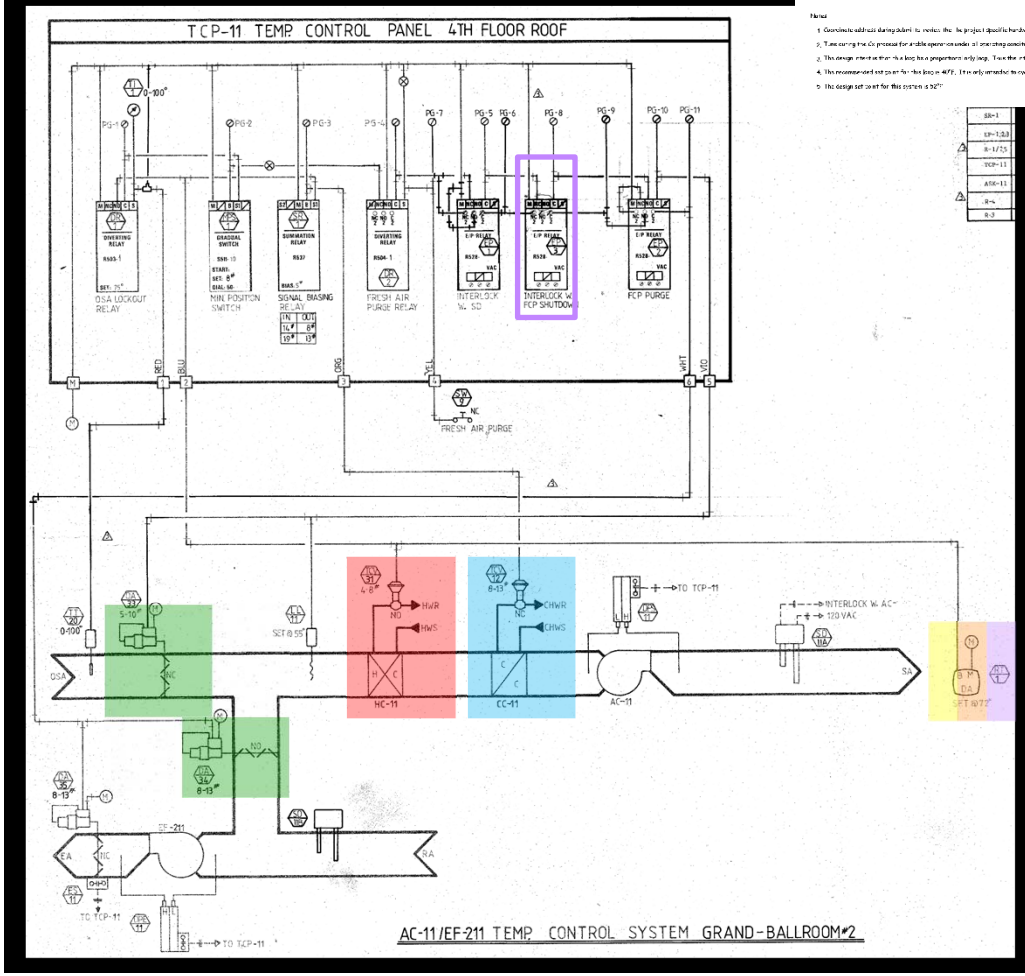
Economizer Dampers

Chilled Water Valve

Hot Water Valve

Controlling Sensor, Set Point, and Control Logic





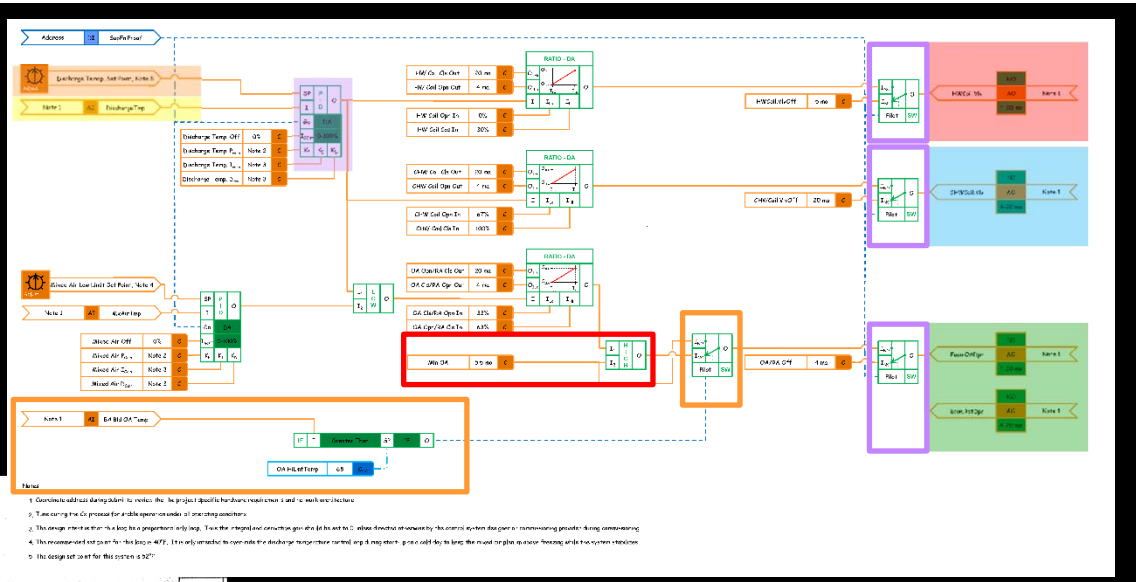
Economizer Dampers

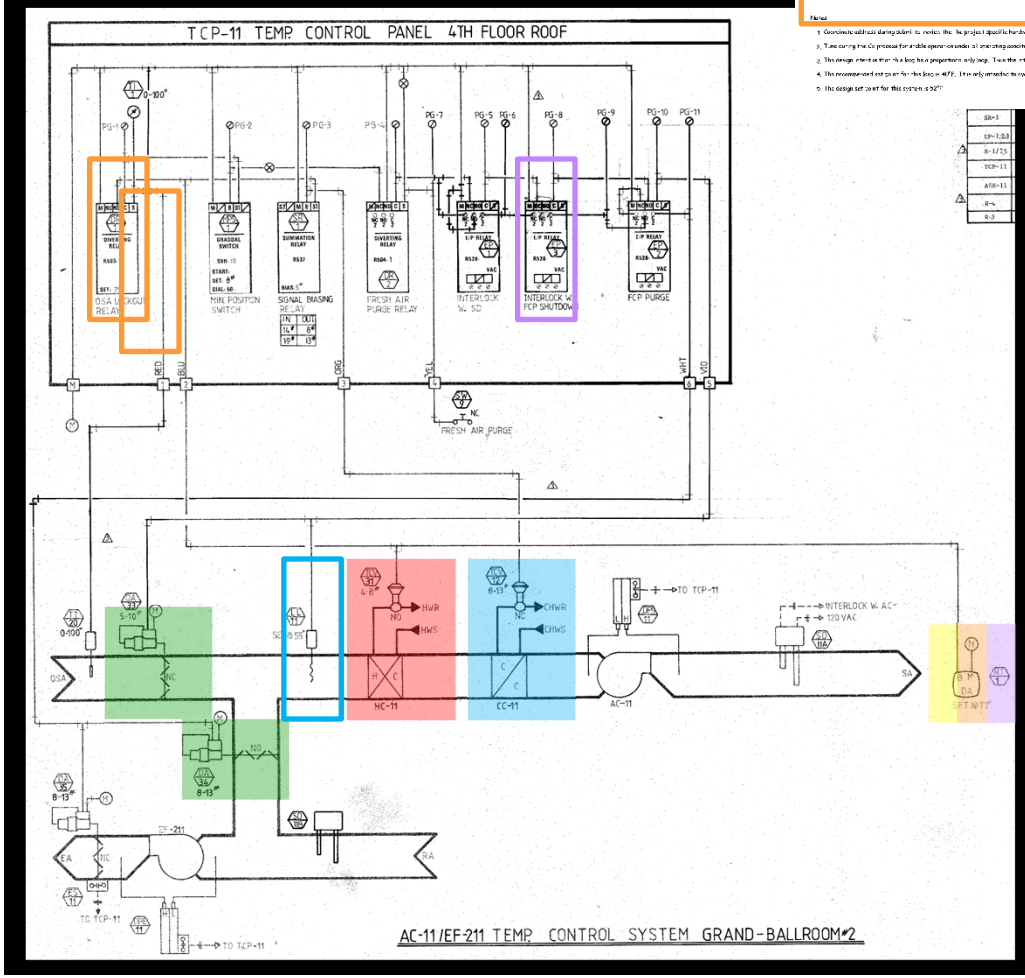
Chilled Water Valve

Hot Water Valve

Controlling Sensor, Set Point, and Control Logic

Fan Operation Interlock





Economizer Dampers

Chilled Water Valve

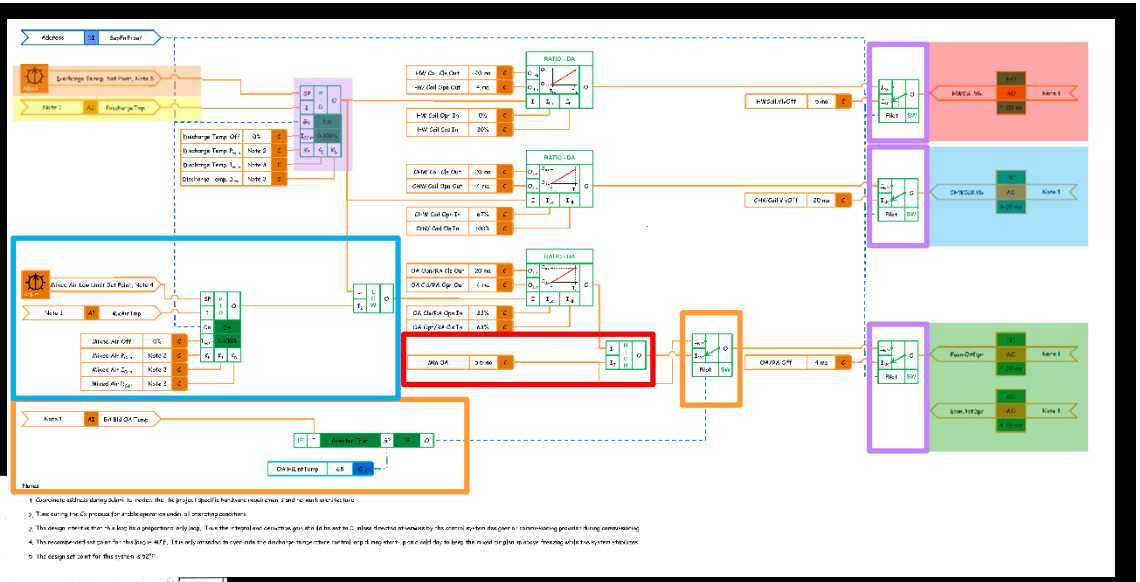
Hot Water Valve

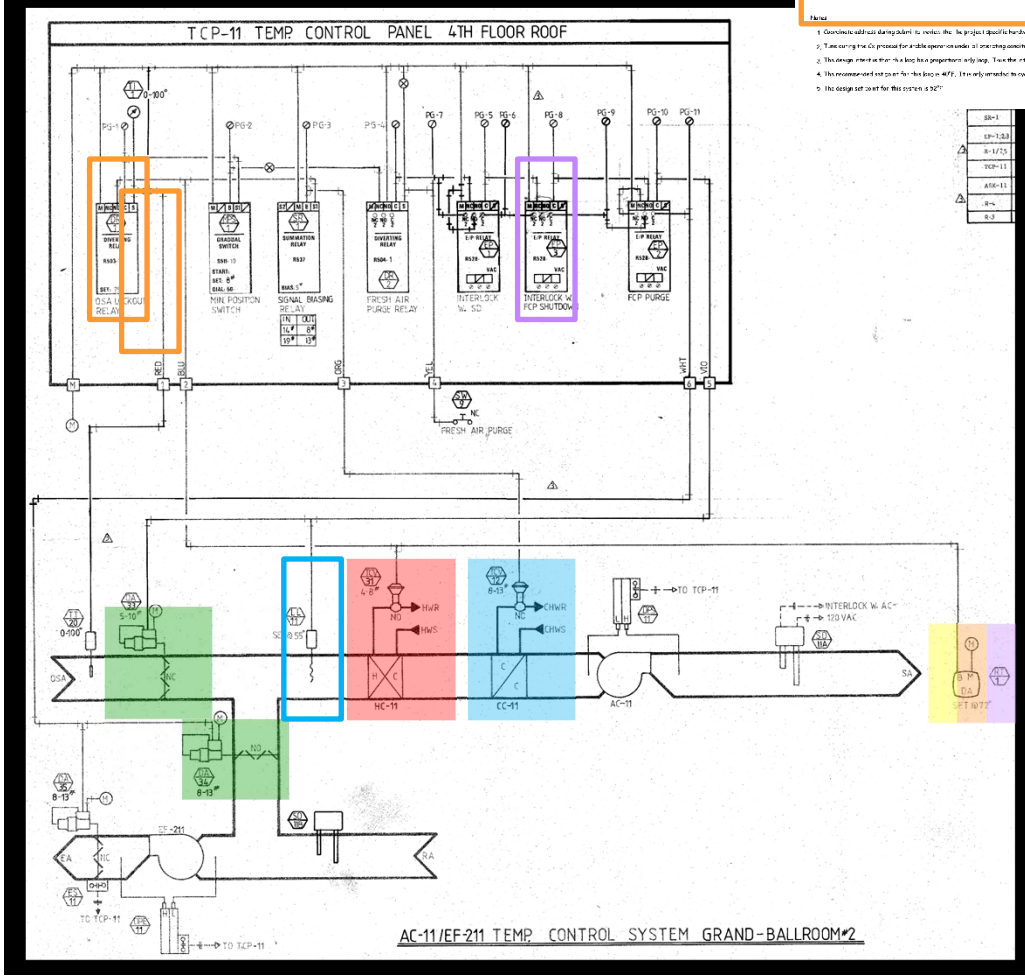
Controlling Sensor, Set Point, and Control Logic

Fan Operation Interlock

Outdoor Air High Limit

Minimum Outdoor Air Setting





Economizer Dampers

Chilled Water Valve

Hot Water Valve

Controlling Sensor, Set Point, and Control Logic

Fan Operation Interlock

Outdoor Air High Limit

Minimum Outdoor Air Setting

Mixed Air Low Limit