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FLUERICS

TERMINOLOGY AND SYMBOLS

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DEPARTMENT OF DEFENSE
Washington, D.C. 20301

Fluerics, Terminology and Symbols

MIL-STD-1306A

1. This Military Standard is approved for use by all Departments and Agencies of the Department of Defense.

2. This standard was prepared by the Government Fluidics Coordination Group comprised of Army, Navy and Air Force members and represents a coordinated effort by the military departments.

3. Recommended corrections, additions, or deletions should be addressed to Commander, Naval Air Systems Command (AIR-52022), Washington, D.C. 20360.

FOREWORD

The purpose of this standard is to provide uniformity of expression in the relatively new field of FLUERICS, within the area of fluidics. Terminology and symbolic representation are all-important in such an endeavor. When more than one group is contributing, considerable time and effort may be saved if a common reference base were to be established. Toward that end the terminology and symbolic representations contained herein have been prepared.

The material presented is based on information obtained from the Government Fluidics Coordination Group (GFCG), the Society of Automotive Engineers (SAE), and the National Fluid Power Association (NFPA). By unencumbered permission of the NFPA, the section on graphical symbols is reproduced from a standard prepared under assignment to the NFPA through USA Standards Institute Committee B93, in cooperation with the GFCG and the SAE.

It is recommended that all current and future work be documented and reported in the International System of Units (SI). Brief tables of these units are presented in Section 5. For convenience the United States Customary Units have also been included. For information on the International Metric System, see the "ISO Recommendation R1000 Rules for the Use of Units of the International System of Units and a Selection of the Decimal Multiples and Sub-multiples of the SI Units" which is available from the American National Standards Institute, 1430 Broadway, New York, New York 10018. Other valuable references are the current edition of "The International System of Units"; Editors, Chester Page and Paul Vigourex. (NBS Special Publication 330) which is for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 and "Metric Practice Guide", ASTM Designation: E380-70 which is available from American Society for Testing and Materials, 1916 Race St., Philadelphia, Pa. 19103.

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1. SCOPE

1.1 This Standard establishes uniform terminology and symbols for use in the field of FLUERICS.

2. REFERENCED DOCUMENTS

2.1 Not applicable.

3. TERMINOLOGY

3.1 General terms.

Active	The general class of devices which control power from a separate supply.
Analog	The general class of components, or circuits having one or more outputs which vary continuously with input.
Circuit	An array of interconnected components and elements which performs a function; for example, an integrator, counter, or operational amplifier.
Characteristics	The relationships that exist among various port pressures and flows during the prescribed operation of an element.
Digital	The general class of devices, or circuits that operate using discrete signal levels.
Element	The general class of devices in their simplest form, used to make up flueric components and circuits; for example, resistors, capacitors, AND gates, and OR-NOR logic gates.
Flueric	An adjective applied to fluidic components and systems which perform sensing, logic, amplification, and control functions, but which use no moving mechanical elements to perform the desired function.
Fluerics	The area within the field of fluidics, in which fluid components and systems perform sensing, logic, amplification, and control functions without the use of moving mechanical parts.

Fluidics — The general field of fluid devices and systems and the associated peripheral equipment used to perform sensing, logic, amplification, and control functions.

Passive — The general class of devices which operate on the signal power alone.

3.2 Amplifiers.

3.2.1 General.

Amplifier — An active flueric component which provides a variation in output signal greater than the impressed control signal variation. The polarity of the output signal may be either positive or negative relative to the control signal. The level of the control signal may be greater or less than the output level.

Closed Amplifier — A flueric amplifier which has no communication with the local ambient pressure in the interaction region. (See Figure 1)

Flow Amplifier — An amplifier designed primarily for amplifying flow signals.

Power Amplifier — An amplifier designed primarily to provide maximum power gain.

Pressure Amplifier — An amplifier designed primarily to amplify pressure signals.

Vented Amplifier — A flueric amplifier which utilizes vents to establish the ambient pressure in the interaction region. (See Figure 2)

3.2.2 Amplifier types.

Boundary Layer Amplifier — An amplifier which utilizes the separation-point control of a power stream from a curved, or plane surface, to modulate the output. (See Figure 3)

Focused-Jet Amplifier — An amplifier that may be either planar or axisymmetric. The supply flow enters the device from more than one location, but it is all focused toward the receiver unless control flow is applied. The control flow forces the power flow away from the receiver and into the vent. (See Figure 8)

Induction Amplifier — An induction amplifier is similar to other amplifiers except that the control signal is used to suck, by entraining, the power jet causing the device to switch rather than affecting a switch by pushing the power jet. (See Figure 9)

Impact Modulator — A flueric amplifier in which the impact-plane position of two opposing streams is controlled to alter the output. (See Figure 4)

Jet-Deflection Amplifier — An analog amplifier which uses a control jet to deflect a fluid power jet for the functional operating principle. (See Figures 1 and 2)

Turbulence Amplifier — A flueric component that operates in the transition region between laminar and turbulent stability. The power jet can make the transition when influenced by a secondary jet, an acoustic signal, or a physical interruption of the power jet, thus changing the state of the output. (See Figure 5)

Vortex Amplifier — A flueric amplifier which utilizes the pressure drop across a controlled vortex for the modulating principle. (See Figure 6)

Wall Attachment Amplifier — A digital amplifier which uses jet attachment to a wall (the Coanda effect) for the basic operating principle. (See Figure 7)

3.3 Logic elements.

Logic Elements — The general category of digital components which provide logic functions; for example, AND, OR, NOR, and NAND. They can gate or inhibit signal transmission with the application, removal or other combinations of input signals.

Flip-Flop — A bistable flueric component (reset-set) which changes state with the proper reset-set input of sufficient amplitude and width. It exhibits "memory" (remains in a particular state) once it has switched, without requiring a continual input signal.

3.4 Sensor.

Sensor — A flueric component which senses a basic quantity such as rate, position, acceleration, pressure, or temperature, and converts it into an equivalent fluid quantity.

3.5 Transducer.

Transducer — A device which converts signals from one medium to an equivalent signal in a second medium.

3.6 Actuator.

Actuator — A component which converts a fluid signal into an equivalent mechanical output.

3.7 Circuit elements.

Resistor — A passive flueric element which, because of viscous losses, produces a pressure drop as a function of the flow through it and has a transfer function of essentially real components; for example, negligible phase shift, over the frequency range of interest. Fluid resistance, R, is (for average value) the ratio of pressure drop (ΔP) to volume flow rate:

$$R = \frac{\Delta P}{Q} \qquad \frac{N\text{-}s}{m^5} \qquad \frac{lbf\text{-}s}{ft^5}$$

for incremental fluid resistance:

$$R = \frac{dP}{dQ} \qquad \frac{N\text{-}s}{m^5} \qquad \frac{lbf\text{-}s}{ft^5}$$

Capacitor

A passive flueric element which, because of fluid compressibility, produces a pressure across the device which lags net flow into it by essentially 90 degrees. Fluid capacitance, C, is the ratio of integrated volume flow rate to change in pressure.

$$\text{for gases } C = \frac{\int Q\,dt}{\Delta P} = \frac{V}{\beta} \quad \frac{m^5}{N} \quad \frac{ft^5}{lbf}$$

where V is volume and β is the bulk modulus. For gas the adiabatic capacitance is given by

$$C = \frac{V}{k\bar{p}}$$ where k is the ratio of

specific heats and $\bar{p}$ is the average pressure.

In general

$$\mathcal{L}\{\Delta P\} = \frac{1}{Cs}\mathcal{L}\{\Delta Q\}$$

where ΔP represents a small change in pressure and ΔQ represents a small change in net volume flow rate.
(s = Laplace operator)

Inductor

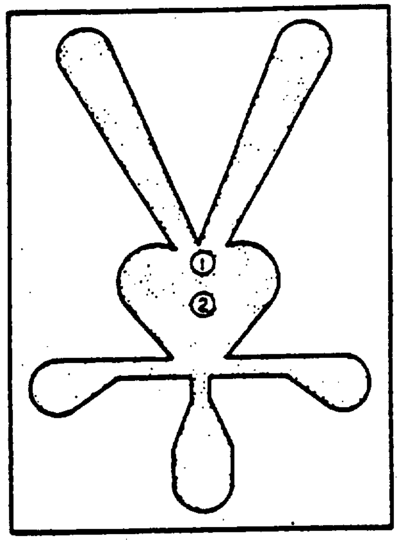
A passive flueric element which, because of fluid inertance, has a pressure drop across it which leads flow through it by essentially 90 degrees. Fluid inductance, L, is the ratio of pressure change (ΔP) to rate of change of volume flow rate.

$$L = \frac{\Delta P}{dQ/dt} \quad \text{units} \quad \frac{N\text{-}s^2}{m^5}.$$ For a duct

$$= \frac{\rho y}{A} \quad \text{units} \quad kg/m^4$$

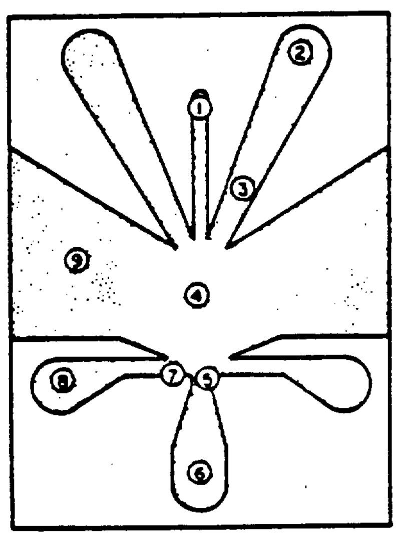
where y = channel length and A = channel cross sectional area. The two sets of units are consistent.

In general $\mathcal{L}\{\Delta P\} = Ls\ \mathcal{L}\{\Delta Q\}$ where ΔP represents a small change in pressure drop along a channel and ΔQ represents a small change in volume flow rate.



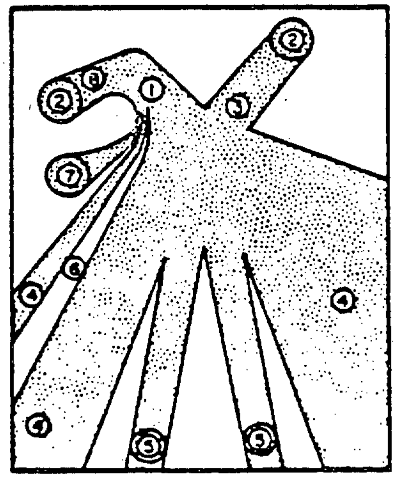
1 Splitter
2 Interaction Region

Figure 1. Closed Jet-Deflection Amplifier
(or Closed Jet-Interaction Amplifier)



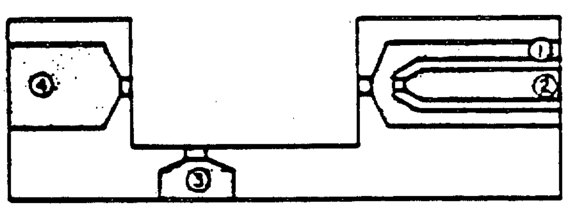
1 Center Vent (Center Output)
2 Output Port
3 Receiver
4 Interaction Region
5 Power Nozzle
6 Supply Port
7 Control Nozzle
8 Control Port
9 Vent

Figure 2. Vented Jet-Deflection Amplifier
(or Vented Jet-Interaction Amplifier)



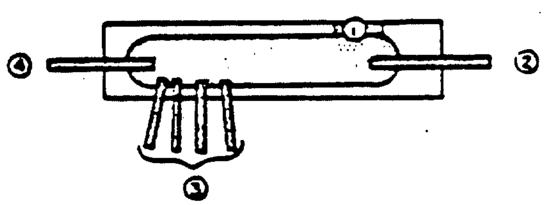
1 Interaction Region
2 Supply Port
3 Passive Leg
4 Vent
5 Output Port
6 Splitter
7 Control Port
8 Active Leg

Figure 3. Boundary Layer Amplifier
(or Separation Point Control Amplifier)



1 Outlet, or Collector Chamber
2 Supply P2
3 Control
4 Supply P1

Figure 4. Impact Modulator



1 Vent
2 Output
3 Inputs
4 Supply

Figure 5. Turbulence Amplifier

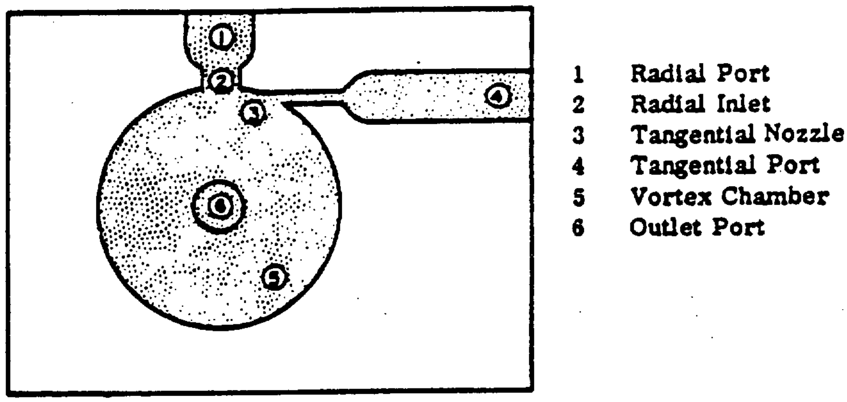


Figure 6. Vortex Amplifier

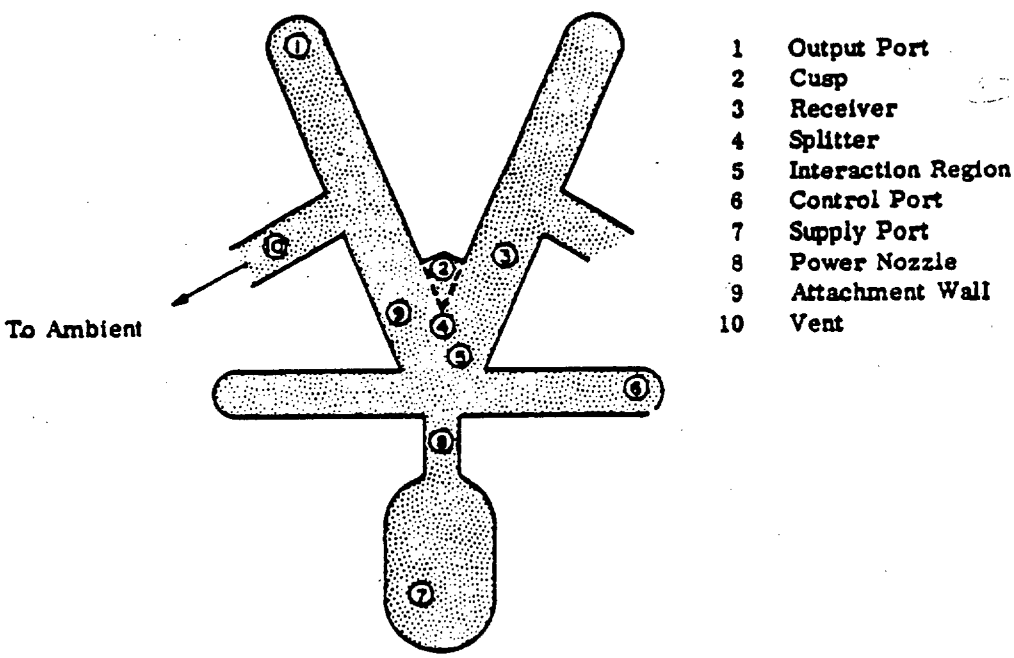
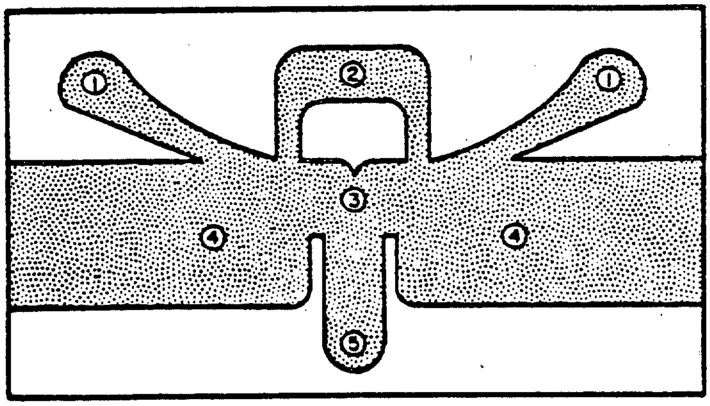
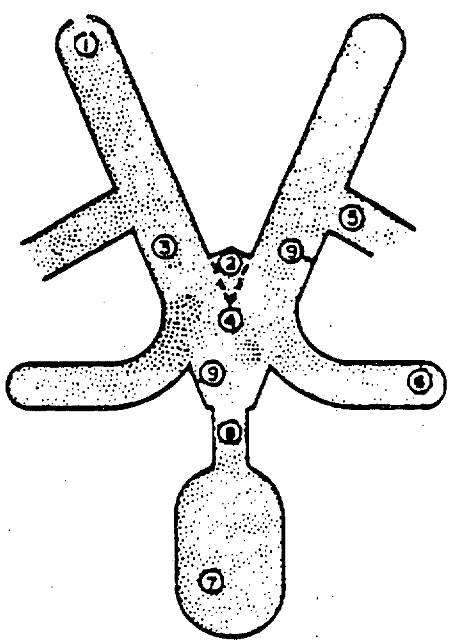


Figure 7. Wall Attachment Amplifier



1 Supply Ports
2 Control Port
3 Receiver
4 Vents
5 Output Port

Figure 8. Focused-Jet Amplifier



1 Output Port
2 Cusp
3 Receiver
4 Splitter
5 Vent
6 Control Port
7 Supply Port
8 Power Nozzle
9 Attachment Wall

Figure 9. Induction Control Amplifier

4. PARAMETERS

SYMBOL	PARAMETER	DEFINITION
σ	Aspect Ratio, Nozzle	Ratio of nozzle depth (h) to nozzle width (b).
-	Bias Level	Mean level or value of a differential signal.
-	Bias Signal	Magnitude of an auxiliary input signal used to drive the output signal of a fluidic element or sensor to zero under quiescent conditions.
D_r	Dynamic Range	The ratio of the input signal causing maximum output to the smallest input detectable above noise at the output.
-	Fanout	The maximum number of digital components that can be driven simultaneously by a single component; all components are to be similar and operated under identical conditions. In effect, this is a whole number less than or equal to the ratio of output flow to input flow at switching pressure. In the case of a driving element with multiple, logically different output signals, such as the AND-NAND shown in fig. 23, only one of these logically distinct output signals may be considered as the driving signal. Fanout value is stated to be essentially for steady-state operation unless the corresponding frequency is also given.
-	Flow Recovery, Output	The maximum output volume-flow rate, divided by the supply volume-flow rate.
-	Frequency Response	Frequency response is fully described by a gain/phase plot. An indication of frequency response is the frequency at which the output signal lags the control signal by 45 degrees for a specified load and control amplitude.
G_f	Gain, Flow (analog)	Average gain; the slope of a straight line drawn through an input volume flow rate versus output volume flow rate curve, so that deviations from the measured curve up to the maximum output level are minimized. Deviations should be based on net area. If other than maximum output level is used for the average gain definition, the range

SYMBOL	PARAMETER	DEFINITION
		should be noted. Measured curve is to be for either low output pressure recovery (resulting from instrumentation), or a value which provides maximum flow gain.
G_f	Gain, Flow (digital)	Ratio of output volume flow rate change to input volume flow rate change (from quiescent) required for switching to occur.
G_{f_i}	Gain, Flow (incremental, analog)	The slope of the output flow versus the input flow curve at the operating point of interest.
G	Gain, Power (analog)	Average power gain; ratio of the change in output power to change in input power; average value over operating range up to maximum output level unless range is stated.
G	Gain, Power (digital)	Ratio of the change in output power to the change in input power (from quiescent), for switching to occur.
G_i	Gain, Power (incremental, analog)	The slope at the operating point of an input-output power curve.
G_p	Gain, Pressure (analog)	Average gain; the slope of a straight line drawn through a measured input pressure versus output pressure curve so that deviations from the measured curve up to the maximum output level are minimized. Deviations should be based on net area. If other than the maximum output level is used for the average gain definition, the range used should be noted. Gage pressure values should be used. Measured curve is to be for either zero output flow, or a value which provides maximum pressure gain. (See Figure 10)
G_{p_i}	Gain, Pressure (incremental, analog)	Incremental gain; the slope of the measured input pressure versus output pressure curve at the operating point of interest. (See Figure 10)

SYMBOL	PARAMETER	DEFINITION
G_p	Gain, Pressure (digital)	Ratio of measured output pressure change to input pressure change (from quiescent) required for switching to occur. All control ports except the one under consideration should be maintained at the quiescent pressure level. Output flow should be zero, or a value which results in maximum pressure gain. If gain value is for other than steady-state conditions, the test frequency should be stated.
-	Hysteresis, Analog Amplifier	Total width of hysteresis loop expressed as a percent of peak-to-peak saturation input signal. Measurements must be at frequencies below those where dynamic effects become significant. (See Figure 11) Measurements to be made at the widest point on the curve.
-	Hysteresis, Digital Amplifier	Width of the hysteresis loop as measured on an input-output curve and expressed as a percentage of the supply conditions; for example, flow hysteresis is the hysteresis-loop width (measured on an input-output flow curve), divided by the supply flow. (See Figure 12)
Z_i	Impedance, Input	The ratio of pressure change to volume flow change, measured at an input port. Numerical value may depend on operating point, since input pressure-flow curve may not be linear. For active elements, the power source should be connected for measurements.
Z_o	Impedance, Output	The ratio of pressure change to volume flow change, measured at an output port. Numerical value may depend on operating point, since output pressure-flow curve may not be linear.
-	Linearity, Output	Deviation of the measured curve from the straight-line average gain approximation: the ratio of the peak-to-peak output range (range should be stated if other than maximum output level) expressed as a percentage. (See Figure 13)

SYMBOL	PARAMETER	DEFINITION
g_o	Mass Conversion Factor	The need for this parameter is brought about by the practice, common to English language text books on engineering thermodynamics, of assigning the value of 1/32.17 to the constant of proportionality, k, in Newton's Second Law of Motion, F = kma. This is done so that weight and mass are numerically equal under conditions of standard gravity. For more utility, 32.17 (1/k) is used and is named g_o. Thus: $$\text{weight} = (\text{mass})\ (g)/g_o;\ g_o = 32.17\ \frac{\text{ft-lbm}}{\text{lbf-s}^2}$$
N_{PR}	Prandtl Number	A dimensionless ratio $= \frac{\nu \rho C}{k} = \frac{C_p \mu}{k}$ μ = absolute viscosity ν = kinematic viscosity k = thermal conductivity ρ = mass density C_p = specific heat constant pressure C = specific heat capacity which frequently appears in heat transfer calculations.
-	Pressure Recovery Output	The difference between the maximum output pressure and the local vent pressure divided by the difference between the supply pressure and the pressure in the interaction region. For closed amplifiers, the control port pressure should be used as the reference pressure.
-	Response Time	The time delay between the application of an input step signal and the resulting output signal. The time measurement for the step signals are to be made at 63 percent of the final value point. (See Figure 14)
N_R	Reynolds Number	Ratio of inertial-to-viscous forces: $$N_R = \frac{ud_h}{\nu}$$

SYMBOL	PARAMETER	DEFINITION
		Where d_h = hydraulic diameter, u = velocity of the fluid, and ν = kinematic viscosity.
-	Saturation	The maximum output value regardless of input magnitude. (See Figure 15)
S/N	Signal-to-Noise Ratio (analog amplifier)	Ratio of maximum (saturation value) output signal amplitude to maximum noise amplitude (at output). Signal and noise data should be RMS values.
S/N	Signal-to-Noise Ratio (digital amplifier)	Ratio of the amplitude of the output signal to the peak-to-peak maximum noise signal. Maximum noise signal is to be measured when the port is active and inactive. The greater value of the two is used in calculating the S/N ratio.
N_{SK}	Stokes Number	The ratio of the inductive reactance to the resistance of a component times the factor $(16f/\Pi)$. For a circular line $N_{SK} = \frac{2\Pi f d^2}{\nu}$ where d is the diameter.
N_S	Strouhal Number	The Strouhal number relates a frequency, a characteristic length, and the mean velocity of the fluid; $N_S = \frac{fl}{\bar{u}}$ where f is the frequency, l is the characteristic length (for example, the diameter of a cylindrical body whose axis is normal to $\bar{u}$), and $\bar{u}$ is the fluid velocity.
-	Transport Delay	The time from the initiation of an input signal until the first discernible change in the output caused by this input signal. (See Figure 14)

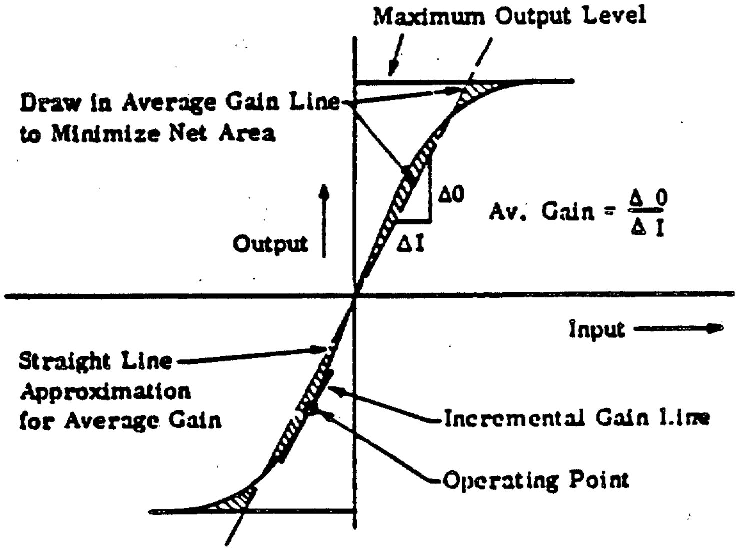


Figure 10. Pressure Gain

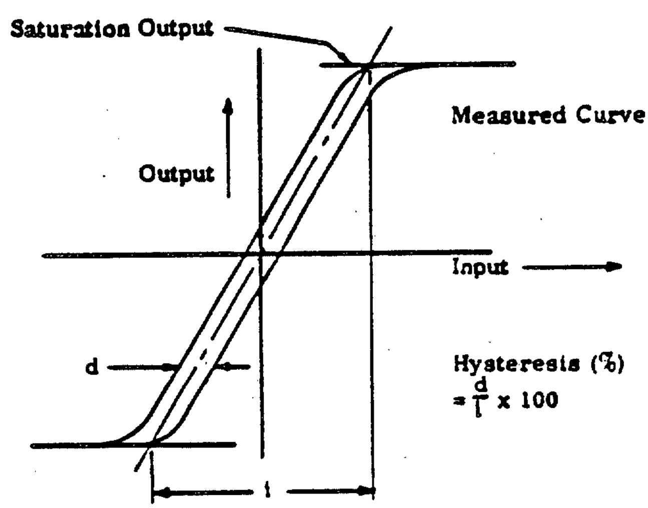


Figure 11. Analog Amplifier Hysteresis

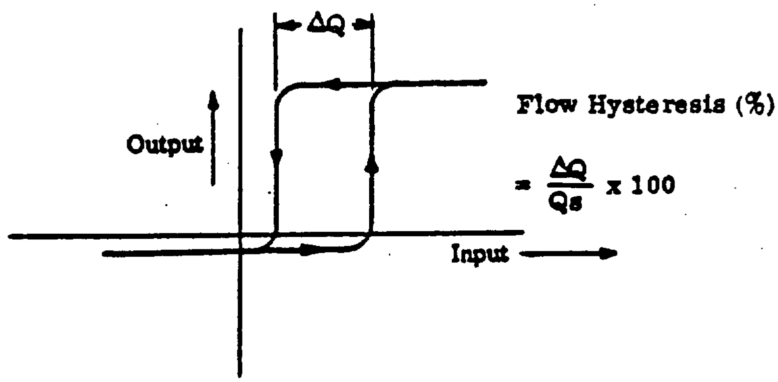


Figure 12. Digital Amplifier Hysteresis

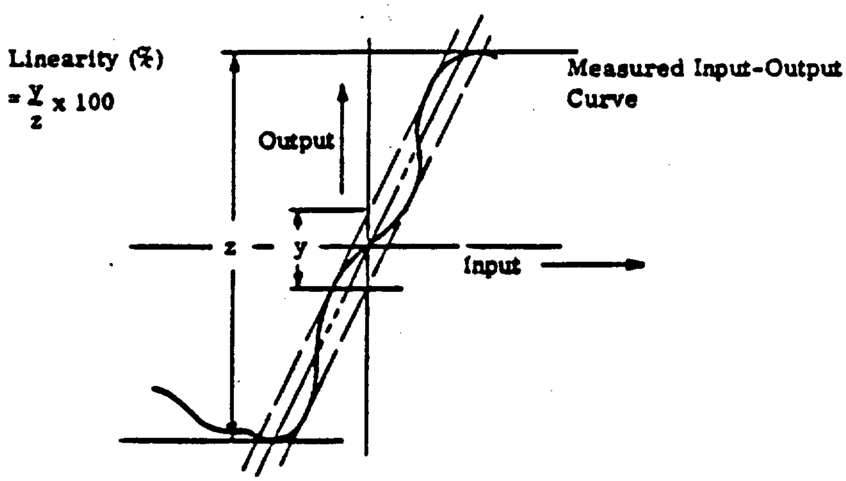


Figure 13. Output Linearity

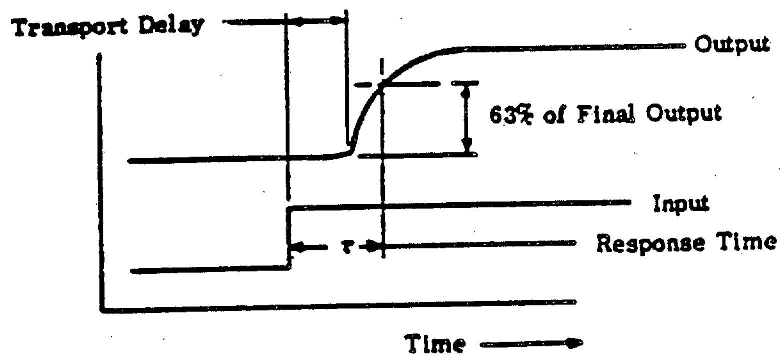


Figure 14. Response Time and Transport Delay

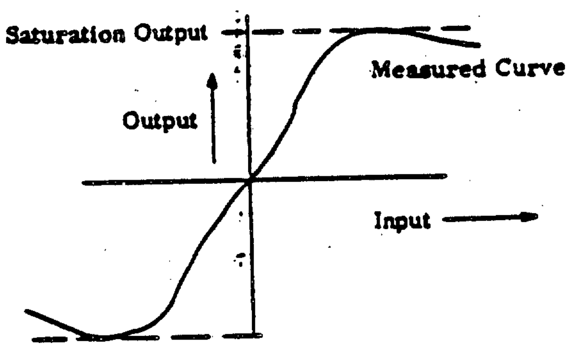


Figure 15. Saturation

5. SYMBOLS AND UNITS

Symbols and units (both SI and United States Customary) for the basic quantities are listed in Table I. Conversion factors for the basic quantities are listed in Table II.

TABLE I

SYMBOLS AND UNITS FOR BASIC QUANTITIES

Quantity	Symbol	SI units	U.S. Customary Units
Acceleration, linear	a	m/s^2	ft/sec^2
Acceleration, angular	α	rad/s^2	rad/sec^2
Acceleration, gravitational	g	m/s^2	ft/sec^2
Angle	.....	radians, rad	degrees, deg
Area	A	m^2	ft^2
Bulk modulus	β	N/m^2	lbf/ft^2
Efficiency	η	dimensionless	
Energy	E	newton-meter, N-m, or joule, J	ft-lbf
Flow gain, average	G_f	dimensionless	
Flow gain, incremental	G_{fi}	dimensionless	
Force	F	newton, N	pound-force, lbf
Frequency	f	hertz, Hz	cycles/sec, cps
Gas constant	R	N-m/kg-°K	$\frac{ft\text{-}lbf}{lbm\text{-}^{\circ}R}$
Laplace Operator	s	1/s	1/sec
Length	l	meter, m	foot, ft
Mach number	N_M	dimensionless	
Mass	m	kilogram, kg	pound-mass, lbm
Mass conversion factor	g_o	.....	$\frac{ft\text{-}lbm}{lbf\text{-}sec^2}$

TABLE I (continued)

Quantity	Symbol	SI units	U.S. Customary Units
Mass density	ρ	kg/m³	lbm/ft³
Mass flow rate	$\dot{m}$	kg/s	lbm/sec
Nozzle aspect ratio	σ	dimensionless	
Nozzle width	b	m	ft
Power	W	N-m/s, watt	ft-lbf/sec, watt
Power gain, average	G	dimensionless	
Power gain, incremental	G_i	dimensionless	
Prandtl number	N_{PR}	dimensionless	
Pressure, dynamic	P_d	N/m²	lbf/ft²
Pressure gain, average	G_p	dimensionless	
Pressure gain, incremental	G_{pi}	dimensionless	
Pressure, static	P_{st}	N/m²	lbf/ft²
Pressure, total	P_t	N/m²	lbf/ft²
Reynolds number	N_R	dimensionless	
Signal-to-noise ratio	S/N	dimensionless	
Specific heat, constant pressure	C_p	J/kg - °K	btu/lbm - °R
Specific heat, constant volume	C_v	J/kg - °K	btu/lbm - °R
Specific heat ratio	$k = C_p/C_v$	dimensionless	
Strouhal number	N_S	dimensionless	

TABLE I (continued)

Quantity	Symbol	SI units	U.S. Customary Units
Temperature, static	T	degrees Kelvin, °K	degrees Rankine, °R
Temperature, total	T_o	degrees Kelvin, °K	degrees Rankine, °R
Time	t	second, s	second, sec
Velocity, acoustic (speed of sound)	u_c	m/s	ft/sec
Velocity, angular	ω	rad/s	rad/sec
Velocity, general	u	m/s	ft/sec
Velocity, mean	$\bar{u}$	m/s	ft/sec
Viscosity, absolute	μ	N-s/m^2	lbf-sec/ft^2
Viscosity, kinematic	ν	m^2/s	ft^2/sec
Volume	V	m^3	ft^3
Volume-flow rate	Q	m^3/s	ft^3/sec
Weight density	γ	N/m^3	lbf/ft^3
Weight-flow rate	w	N/s	lbf/sec
General Subscripts			
Control	c	.....	.....
Control, differential	cd	.....	.....
Control, quiescent	co	.....	.....
Output	o	.....	.....
Output, differential	od	.....	.....
Supply	s	.....	.....

TABLE II

CONVERSION FACTORS FOR BASIC QUANTITIES

Quantity	to convert from	to	Multiply by
Acceleration	ft/sec^2	m/s^2	3.048 000*E-01a/
Angle	degrees	radians	1.745 329 E-02
Area	ft^2	m^2	9.290 304*E-02
Energy	ft-lbf	Joule, J	1.355 818 E+00
Force	pound-force, lbf	Newton, N	4.488 222 E+00
Frequency	cps	Hz	1.000 000*E+00
Length	foot, ft	meter, m	3.048 000*E-01
Liquid bulk modulus	lbf/ft^2	N/m^2	4.788 026 E+01
Mass	pound-mass, lbm	kg	4.535 924 E-01
Mass density	lbm/ft^3	kg/m^3	1.601 846 E+01
Mass flow rate	lbm/sec	kg/s	4.535 924 E-01
Power	ft-lbf/sec	watt, W	1.355 818 E+00
Power	N-m/s	watt, W	1.000 000*E+00
Pressure	lbf/ft^2	N/m^2	4.788 026 E+01
Specific heat b/	btu/lbm-°R	J/kg-°K	4.184 000 E+03
Temperature	°R	°K	5.555 555 E-01
Velocity	ft/sec	m/s	3.048 000*E-01
Viscosity, absolute	lbf-sec/ft^2	N-s/m^2	4.788 026 E+01
Viscosity, kinematic	ft^2/sec	m^2/s	9.290 304*E-02
Volume	ft^3	m^3	2.831 685 E-02
Volume flow rate	ft^3/sec	m^3/s	2.831 685 E-02
Weight density	lbf/ft^3	N/m^3	1.585 000 E+02
Weight flow rate	lbf/sec	N/s	4.488 222 E+00

a/ This notation indicates the power of 10 by which the number must be multiplied to obtain the correct value; i.e., 3.048 000 E-01 = 0.3048000

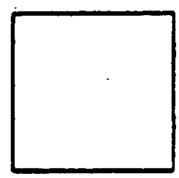
b/ The btu's referred to are thermochemical.

* An asterisk after the sixth decimal place indicates that the conversion factor is exact and all subsequent digits are zero.

6. GRAPHICAL SYMBOLS

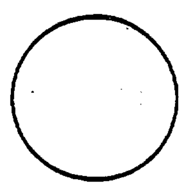
6.1 Types of symbols - Two types of graphical symbols are used in drawings and schematics in order to define either (1) the function, or (2) the operating principle of the device employed to perform that function.

6.1.1 Functional symbol - Depicts a flueric function which may be performed by a single element or a combination of elements. The symbols are enclosed within square envelopes:



Functional Symbol

6.1.2 Operating principle symbol - Depicts the fluid phenomena occuring in the interaction region of a flueric element. The symbols are enclosed within circular envelopes:

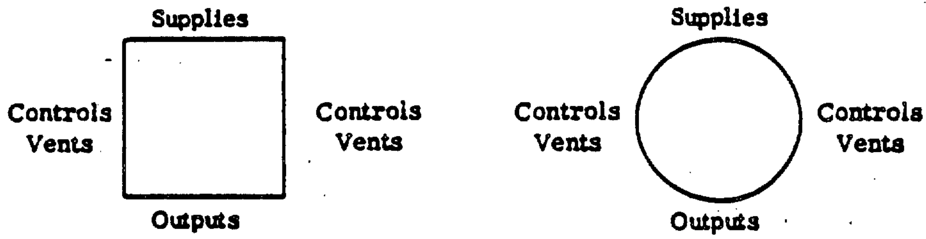


Operating Principle Symbol

The difference in envelopes is intended to emphasize the difference in purpose of the symbols. Where an operating principle symbol is not shown; for example, Schmitt Trigger, it indicates that (1) at present no single operating principle can perform the flueric function or (2) a combination of operating principles is required to perform the function.

6.2 General conventions.

Relative port locations for the symbols are arranged as follows:



Unused control ports which are left open to natural or artificial atmospheric conditions should be so indicated.
All symbols may be oriented in 90-degree increments from the position shown.

Specific ports are identified by the following nomenclature:

Supply port - S

Control port - C

Output port - O

The nomenclature shown on the graphical symbols need not be used on schematic diagrams. It is primarily intended to correlate the function of each port with the truth table.

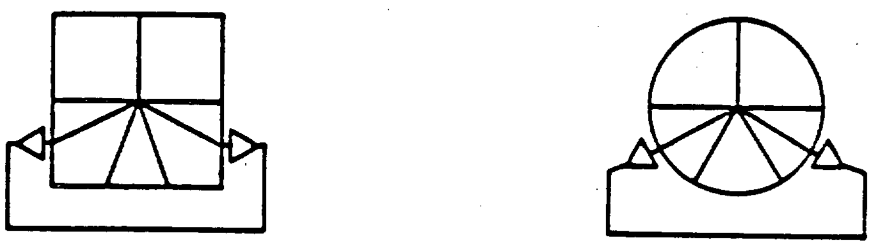
An inverted triangle, ∇, denotes a supply source connected to the supply port (active device).

Liquid supply ports are denoted by ▼, and gaseous supply ports by ∇.

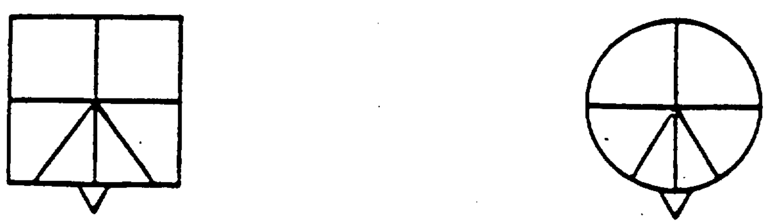
A triangle whose face is flush with the symbol envelope indicates vent connections.

When the vent port is threaded or otherwise adapted for the connection of transmission lines the triangle should be separated from the element envelope by a short line segment.

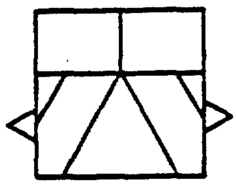
The part of the device which is vented can be indicated by a line from the vent triangle to the pertinent part of the device. As an example, the figure below shows a vented interaction region on a flip-flop with vents connected to each other by a connection external to the amplifier,

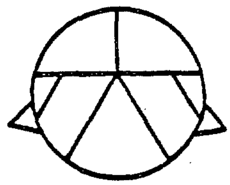


and a center vented amplifier,

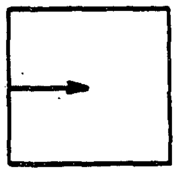


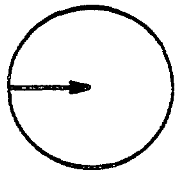
or an amplifier with vented controls.





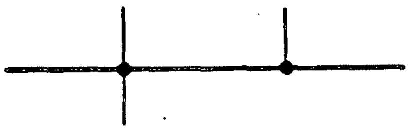
An arrowhead on the control line inside the symbol envelope indicates continual flow is required to maintain state (no memory, no hysteresis):





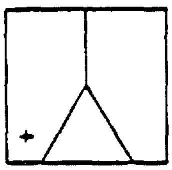
Indicates no memory

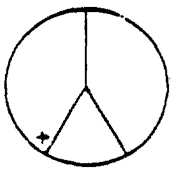
Interconnecting fluid lines are shown with a dot at the point of interconnection:



Crossing fluid lines are shown without dots:

A small + on the output of a bistable device indicates the initial or start up flow condition provided the initial condition is caused by an internal function rather than an applied bias.

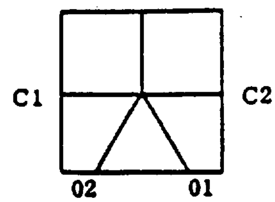




6.3 Bistable flueric devices.

Figure 16. Flip-Flop

Functional Symbol

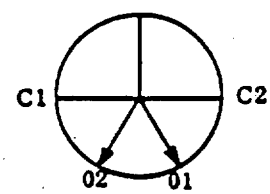


Truth Chart

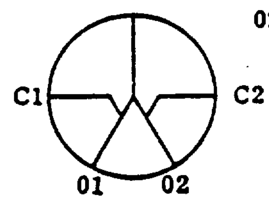
C1	C2	01	02
1	0	1	0
0	0	*	*
0	1	0	1
1	1	Not Valid	

*The existing output state for these input conditions depends on the previously applied input signal. If C1 had been the last input signal applied then 01 would be on and 02 off. If C2 had been applied last, then 02 would be on and 01 off.

Operating Principle Symbols



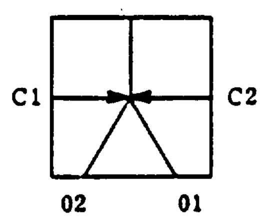
Wall Attachment



Induction

Figure 17. Digital Amplifier

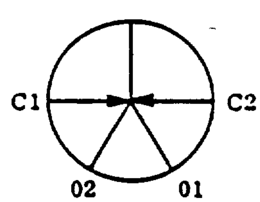
Functional Symbol



Truth Chart

C1	C2	01	02
1	0	1	0
0	1	0	1
0	0	Undefined	
1	1	Undefined	

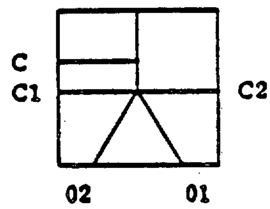
Operating Principle Symbol



Jet Interaction (or Jet Deflection)

Figure 18. Binary Counter (SRT Flip-Flop)

Functional Symbol

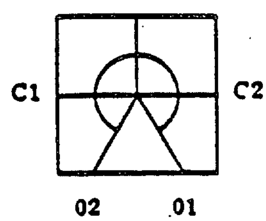


Truth Chart

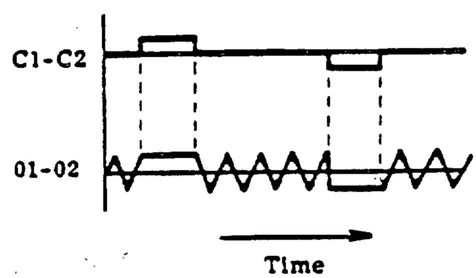
C	C1	C2	01	02
0	1	0	1	0
0	0	0	1	0
0	0	1	0	1
0	0	0	0	1
1	0	0	1	0
0	0	0	1	0
1	0	0	0	1
0	0	0	0	1

Figure 19. Multivibrator

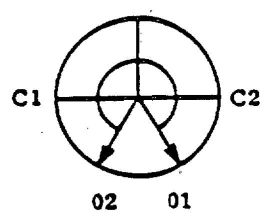
Functional Symbol



Function Description



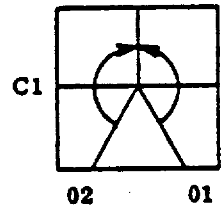
Operating Principle Symbol



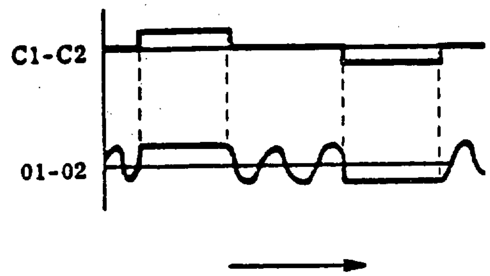
Wall attachment

Figure 20. Oscillator

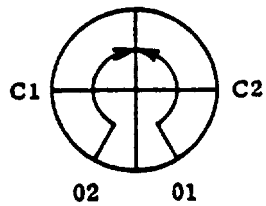
Functional Symbol



Function Description



Operating Principle Symbol



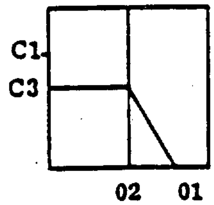
Jet Interaction

6.4 Monostable Flueric Devices.

Figure 21. OR - NOR

(Only one input defines a NOT element.)

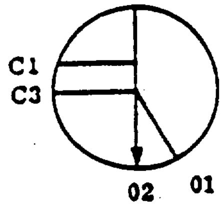
Functional Symbol



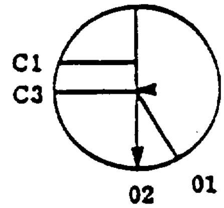
Truth Chart

C1	C3	01	02
0	0	0	1
1	0	1	0
0	1	1	0
1	1	1	0

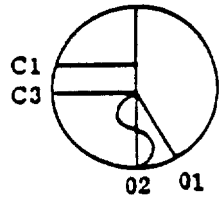
Operating Principle Symbols



Wall Attachment



Wall Attachment
(Internal Fluid Bias)



Turbulence

Figure 21. OR - NOR (Continued)

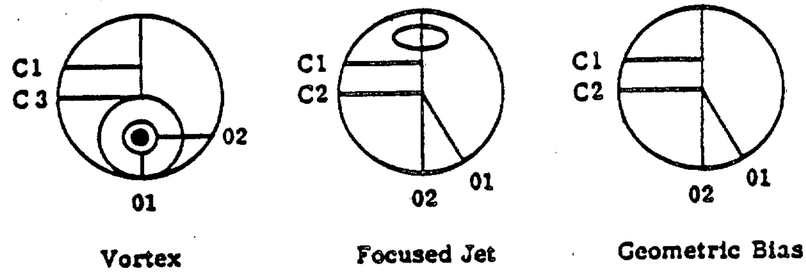
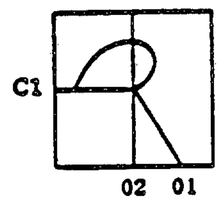


Figure 22. One-Shot

Functional Symbol



Function Description

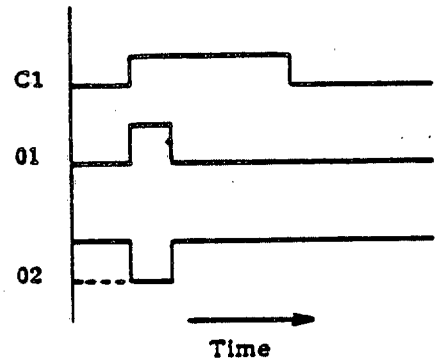
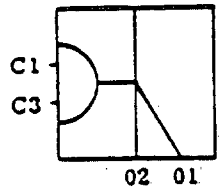


Figure 23. AND - NAND

Functional Symbol

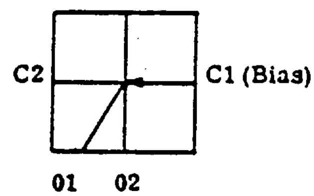


Truth Chart

C1	C3	01	02
0	0	0	1
1	0	0	1
0	1	0	1
1	1	1	0

Figure 24. Schmitt Trigger

Functional Symbol

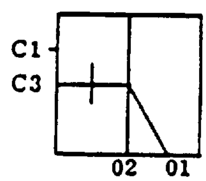


Truth Chart

	01	02
C1 > C2	1	0
C1 < C2	0	1
C1 = C2	Undefined	

Figure 25. Exclusive OR (Active Only)

Functional Symbol



Truth Chart

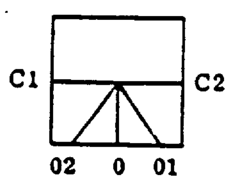
C1	C3	01	02
0	0	0	1
1	0	1	0
0	1	1	0
1	1	0	1

Operating Principle Symbol — See "Passive Digital Device" Section.

6.5 Passive Digital Devices.

Figure 26. 2/3 AND (Passive AND - Exclusive OR)

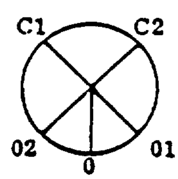
Functional Symbol



Truth Chart

C1	C2	01	02	0
0	0	0	0	0
1	0	1	0	0
0	1	0	1	0
1	1	0	0	1

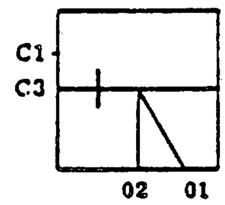
Operating Principle Symbol



Jet Interaction

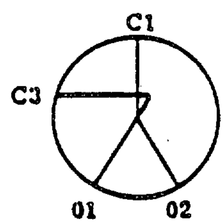
Figure 27. Exclusive OR

Functional Symbol



Truth Chart			
C1	C3	01	02
1	0	1	0
0	1	1	0
1	1	0	1
0	0	0	0

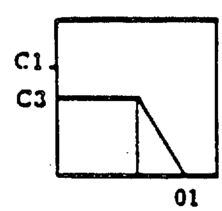
Operating Principle Symbol



Jet Interaction

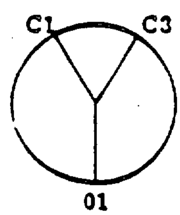
Figure 28. Passive OR

Functional Symbol



Truth Chart		
C1	C3	01
0	0	0
1	0	1
0	1	1
1	1	1

Operating Principle Symbol



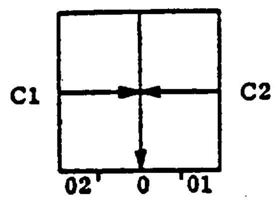
Jet Interaction
(Passive)

6.6 Proportional Flueric Devices.

Figure 29. Analog Amplifier

Function Descriptions

Functional Symbol



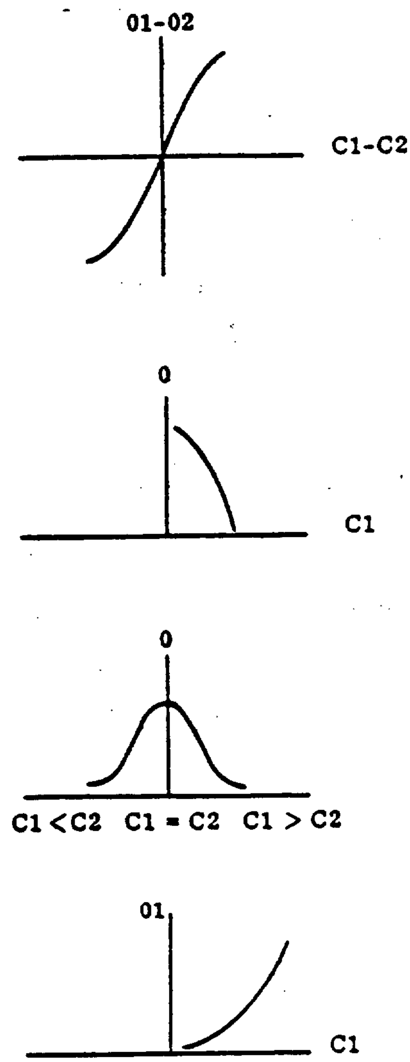


Figure 29. (Continued)

Operating Principle Symbols

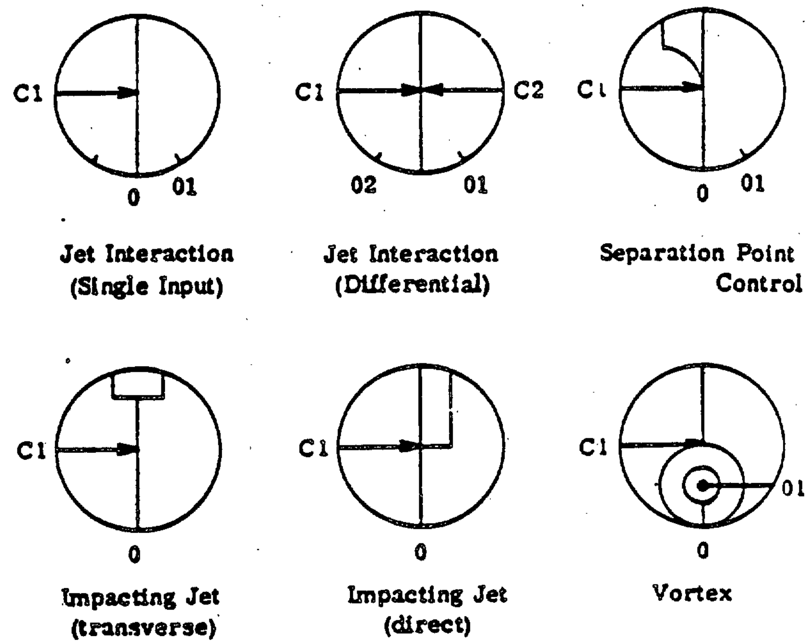


Figure 30. Pure Flueric Throttling Valve

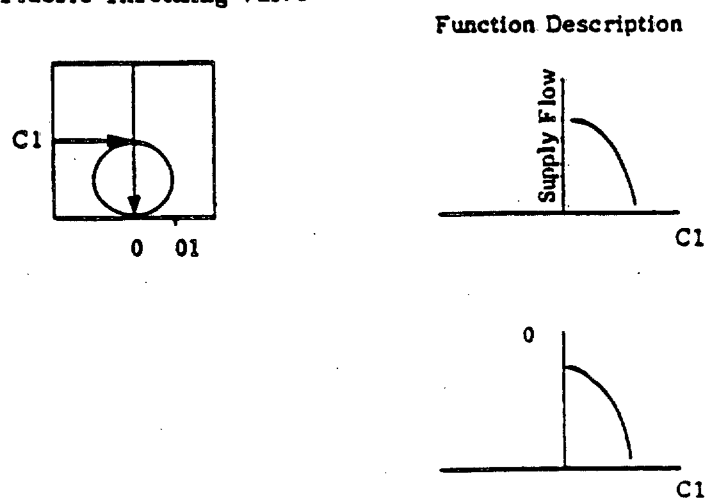
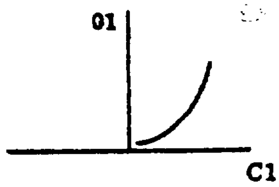
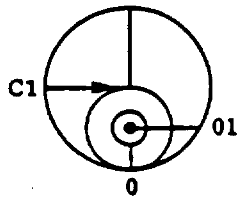


Figure 30. (Continued)



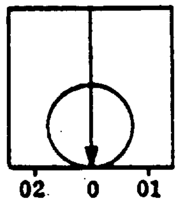
Operating Principle Symbol



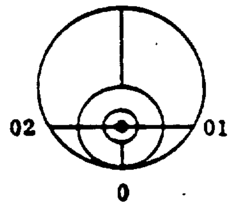
Vortex

Figure 31. Rate Sensor

Functional Symbol



Operating Principle Symbol



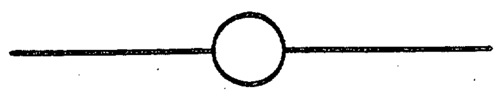
6.7 Impedance Symbols:

Resistance, general

Resistance, linear

Resistance, non-linear

Capacitance



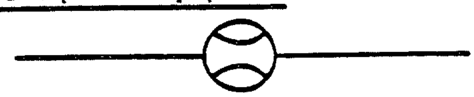
Inductance

Diode (free ← flow)

Note: An inclined arrow,  , through any of the impedance symbols denotes variable case.

6.8 Symbols For Instrumentation And Other Peripheral Equipment.

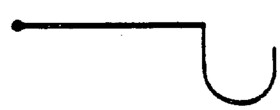
Flow rate



Pressure gage

Pressure gage, differential

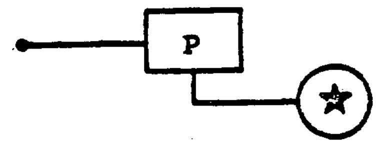
Manometer



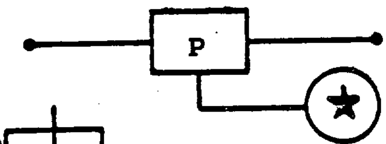
Electrical readout; meter or instrument

Temperature

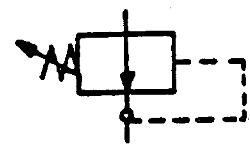
Pressure transducer*



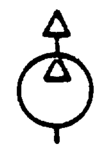
Pressure transducer, differential*



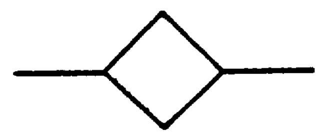
Pressure regulator



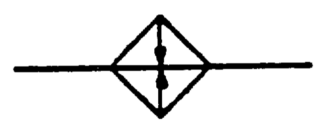
Vacuum



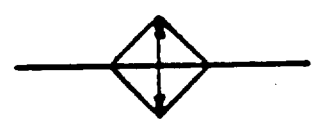
Fluid conditioner, general



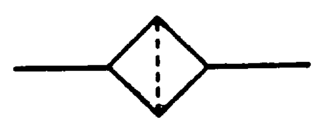
Heater



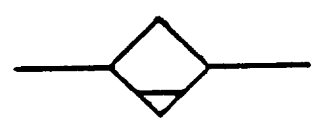
Cooler



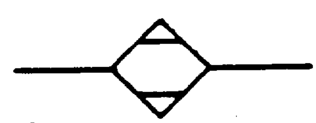
Filter



Separator



Dessicator



*Flow transducers are the same with "Q" instead of "P"

7. GENERAL REQUIREMENTS

7.1 Not applicable.

8. DETAIL REQUIREMENTS

8.1 Not applicable.

Copies of Specifications, Standards, drawings and publications required by contractors in connection with specific procurement functions should be obtained from the procuring agency or as directed by the contracting officer.

Custodians:
Army - AV
Navy - AS
Air Force - 11

Preparing Activity:

Navy - AS

Project No. 1650-0181

(TO DETACH THIS FORM, CUT ALONG THIS LINE.)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

(See Instructions – Reverse Side)

1. DOCUMENT NUMBER	2. DOCUMENT TITLE

3a. NAME OF SUBMITTING ORGANIZATION	4. TYPE OF ORGANIZATION *(Mark one)*
	☐ VENDOR ☐ USER ☐ MANUFACTURER ☐ OTHER *(Specify)*: ______
b. ADDRESS *(Street, City, State, ZIP Code)*	

5. PROBLEM AREAS

a. Paragraph Number and Wording:

b. Recommended Wo-ding:

c. Reason/Rationale for Recommendation:

6. REMARKS

7a. NAME OF SUBMITTER *(Last, First, MI)* – Optional	b. WORK TELEPHONE NUMBER *(Include Area Code)* – Optional
c. MAILING ADDRESS *(Street, City, State, ZIP Code)* – Optional	8. DATE OF SUBMISSION *(YYMMDD)*

DD FORM 1426, 82 MAR

PREVIOUS EDITION IS OBSOLETE.