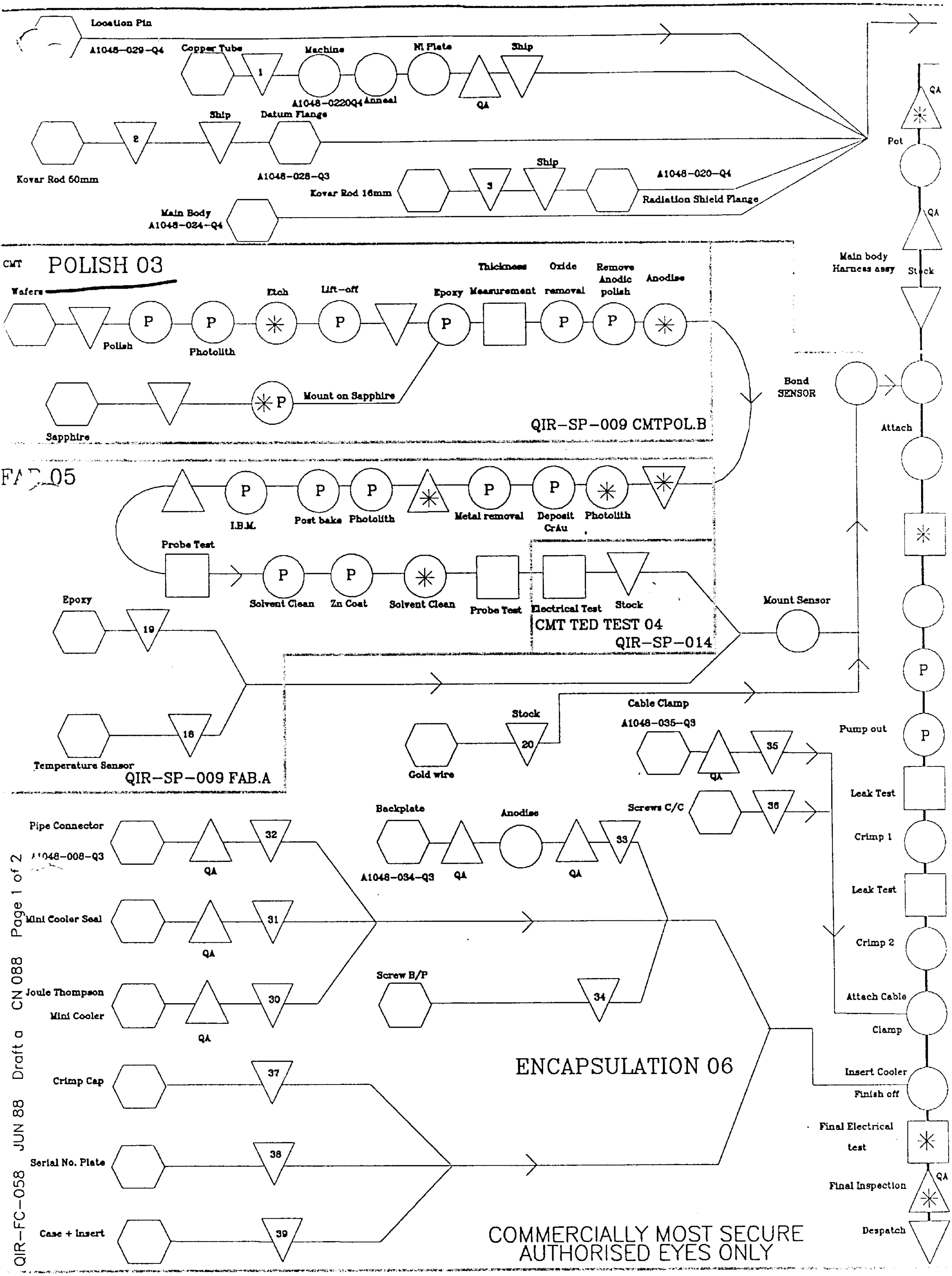

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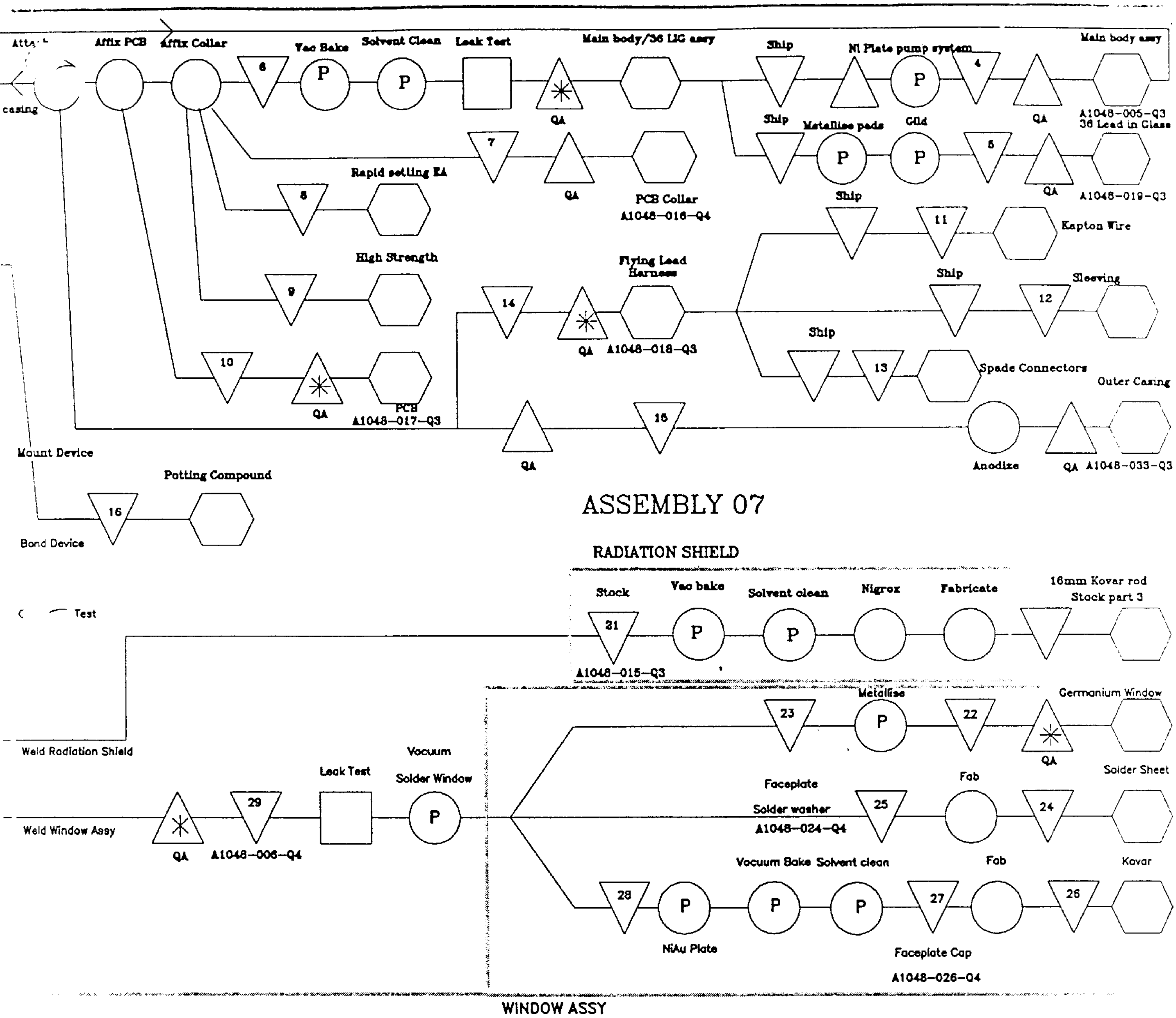

SYMBOL	FUNCTION
⬡	Parts/Material Procurement
□	TEST
○	OPERATION
△	INSPECTION
▽	STOCK OR SHIPMENT
✳	DENOTES CRITICAL
P	DENOTES PROPRIETARY

INFRA–RED DETECTOR CONFIGURATION FLOW CHART

(HRC Dewar)

GEC Hirst Research Centre

QIR–FC–058 JUN 88 Draft a CN 088 Page 2 of 2

JOULE-THOMSON MINICOOLERS

Principal of Operation

The Joule-Thompson minicooler is designed to be a close fit into the precision bore tube of the vacuum encapsulation (dewar) and to provide cryogenic cooling for the I.R. detector situated on the heat sink of the dewar.

The minicooler is basically a finned tube counter flow heat exchanger wound on a former tube.High pressure gas (max 40MPa)flows through the heat exchanger tube to the expansion nozzle where it expands isenthalpically to around atmospheric pressure.The expansion causes a reduction in the gas temperature,the cold low pressure gas is then constrained to flow back over the outside of the heat exchanger to be exhausted to atmosphere.

The action given above removes heat from the walls of the precision bore tube,thus cooling the detector,and also precools the incoming gas.The cumulative cooling effect rapidly reduces the temperature of the incoming gas to a point where the isenthalpic expansion causes a change of phase and a mixture of gas and liquid sprays out of the expansion nozzle.The liquid collected between the cooler and the dewar heat sink continually boils off removing conducted and radiant heat from the .I.R. detector.The change from the liquid to the gas phase occures at a constant temperature for a given vapour pressure over the liquid,for air this temperature is 79k at one atmosphere and for nitrogen it is 77k at one atmosphere.

The minicooler used by this department work on the above principal but with the addition of a gas reulation mechanism which senses the presence of the liquified gas and reduces the incoming gas flow,and thus the amount of liquid produced,to balance the conductive and radiant heat load of the detector.i(SEE FIGS 2 /3)

CLEANLINESS AND COMPATIBILITY OF GASES AND FITTINGS

Because of the small size of the orifice (0.1mm) and the regulation mechanism it is essential that contaminants do not reach the cooler.There are two main sources of contamination:-

1)Particles from a dirty pipe or valve and also from the gas supply if a point of use filter is not used.

2)Contaminated gas supply ie.containing water,hydrocarbons (oil) and carbon dioxide.

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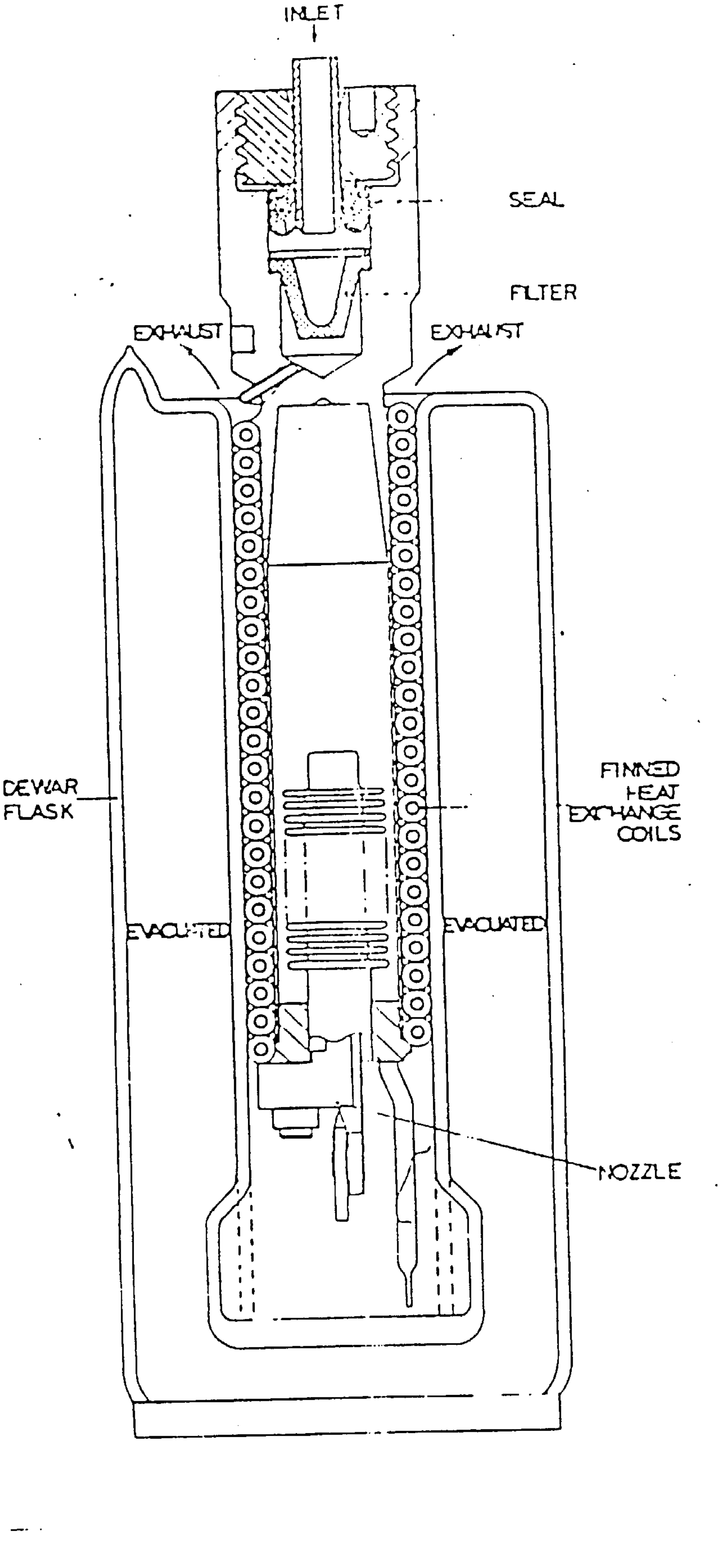

INLET
SEAL
FILTER
EXHAUST
EXHAUST
DEWAR FLASK
FINNED HEAT EXCHANGE COILS
EVACUATED
EVACUATED
NOZZLE

FIGURE 1

The gas must therefore be precleaned by the supplier,eg. white spot nitrogen,or by a gas cleaning plant when useing a compressor. The standard laid down for service requirements for minicoolers is given in AvP 32 chapter 410.All components and pipework associated with the use of minicoolers will arrive from the supplier cleaned to this standard and MUST be maintained at this standard if the coolers are to function reliably.

SYSTEM HANDLING

To preserve the integrity of a pure gas system it is essential that the following rules be observed:-

1)Observe the safety instructions for high pressure gas systems,a copy of which is available in the laboratory.

2)Ensure that servicing equipment,tools,operators hands and work area are clean.

3)The complete system is compatible to Pure Air standards.

4)On shutting down a system that a small pressure is trapped in the system to prevent contamination by back diffusion.

4)All disconnected components are efficiently blanked to prevent the ingress of contaminants.

5)Minicooler handling instructions are observed.

6)Do not contaminate a pure gas system by blowing through it by mouth or an ordinary compressed air line.ONLY USE PURE GAS.

7)The permitted gases are AIR,NITROGEN and ARGON.

8)Do not leave pipework exposed to atmosphere.

9)Always use a POINT OF USE FILTER.

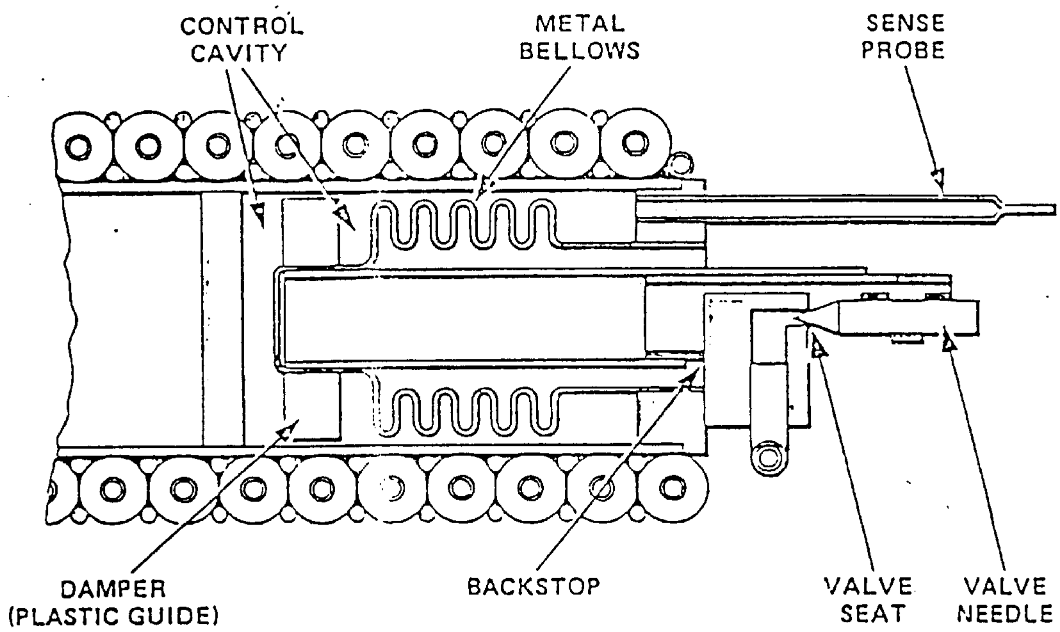
10)Always use WHITE SPOT gases if bottled gas is to be used.

COOLER HANDLING INSTRUCTIONS

1)The cooler should be handled as little as possible and then ONLY BY COOLER HEAD ie. the end conected to the pipework.

2)When not in use store in the transit tube in Silica Gel cabinet.

3)Do not touch the needle assembly or sense probe.



STANDARD SELF REGULATING
MINICOOLER

FIGURE 2

4)When inserting or withdrawing a cooler from a dewar the cooler MUST be turned CLOCKWISE as veiwed along the axis of the cooler from the head end.

5)Do not remove the cooler from the dewar when cold.

6)Do not attempt to clean the needle assembly area.

A.P.POPLE 23-2-1984.

and in the cells of a battery during electrolysis". In this paper Joule concludes as a result of his experiments that "when a current of voltaic electricity is propagated along a metallic conductor, the heat evolved in a given time is proportional to the resistence of the conductor multiplied by the square of the electric intensity". In modern terminology the law would be stated thus: The heat evolved in a circuit in a given time when an electric current flows through it is proportional to the square of the current and the resistance of the circuit.

Since the heat evolved is proportional to the square of the current it is independent of current direction.

The law may be derived theoretically using Ohm's law. Consider a circuit through which a current of I amperes flows, the potential difference across the circuit being V volts. Then, by definition of V, the rate at which energy is dissipated in the circuit per second is $VI \times 10^7$ ergs. In a time t therefore the energy dissipated is $VIt \times 10^7$ ergs.

But, by Ohms law $V = IR$, where R is the resistance of the circuit.

$\therefore$ Energy dissipated $= I^2Rt \times 10^7$ ergs.

$\therefore$ Heat produced, $H = \dfrac{I^2Rt \times 10^7}{J}$ calories.

where J is the mechanical equivalent of heat $=$ $4{\cdot}18 \times 10^7$ ergs/calorie.

$\therefore H = \dfrac{I^2Rt}{4{\cdot}18}$

This can be regarded as the mathematical statement of Joule's law.

See also: Ohm's law.

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R.C. GLASS

JOULE–THOMSON EFFECT. The Joule–Thomson effect is the change in temperature experienced by a stream of gas when its pressure decreases in a prescribed manner. The pressure drop takes place in a valve, capillary, porous plug or other throttling device. In the original experiment in 1862 Joule and Thomson used a porous plug. No heat is allowed to enter or leave the stream of gas. The rate of flow should be so low that turbulence and sound waves are not set up, nor is there an appreciable gain of kinetic energy. Under these conditions the net work done by unit mass of the gas is $(p_2v_2 - p_1v_1)$. That is,

$$\Delta w = p_2v_2 - p_1v_1.$$

If the internal energy of unit mass is u_1 before and u_2 after throttling,

$$\Delta u = u_2 - u_1.$$

Since there was not heat transfer, the first law of thermodynamics give us

$$u_2 - u_1 + p_2v_2 - p_1v_1 = 0$$

or

$$u_2 + p_2v_2 = u_1 + p_1v_1$$

or

$$h_2 = h_1$$

where h is the specific enthalpy.

The Joule–Thomson process, is therefore, an isenthalpic expansion.

The **integral Joule–Thomson effect** is the total change in temperature caused by a finite drop in pressure. When multiplied by the specific heat C_p at the final pressure, it is a measure of the possible cooling or heating effect of a throttling process between the two pressure levels. The **differential Joule–Thomson effect** can be expressed in terms of the specific heat and the equation of state of the gas as follows:

$$\left(\frac{\partial T}{\partial p}\right)_h = \frac{T\left(\dfrac{\partial v}{\partial T}\right)_p - v}{C_p}.$$

For a given gas the differential Joule–Thomson effect, $(\partial T/\partial p)_h$, varies with both temperature and pressure and is negative at relatively high temperatures at all pressures. At lower temperatures it is positive in the low pressure range and becomes negative at high pressures. The temperature at which the differential Joule–Thomson effect become zero for a given pressure is said to be the **inversion temperature.** Gases vary widely as to their inversion temperatures.

An enthalpy–temperature diagram such as the one for helium by Zelmanov shown in Fig. 1 is useful for demonstrating the variation of the Joule–Thomson effect with temperature and pressure. Starting with the gas at a chosen temperature and pressure and moving horizontally (constant enthalpy) to the left note the change in temperature. If the expansion begins at a point to the right of the diagonal curve, the temperature rises with falling pressure until the curve is crossed. Thereafter the temperature falls. This diagonal line drawn through the lowest point of the isothermals is the locus of inversion temperatures for helium. For the maximum cooling effect by Joule–Thomson expansion beginning at 14°K, for instance, the starting pressure should not exceed 30 atm. If the initial temperature is 10°K, then the initial pressure should not exceed 20 atm.

The Joule–Thomson effect has been extensively used in the liquefaction of gases. For this purpose it is obvious that the gas must be below its inversion temperature. Hydrogen and helium whose inversion temperatures lie far below room temperature must be suitably pre-cooled. The enthalpy of the compressed gas must be lower than that of the expanded gas at the same temperature. This deficit of enthalpy is an exact measure of the possible refrigerative effect upon expansion.

In order to take advantage of the relatively small refrigerative effect a counterflow heat exchanger is used between the precooler and the expansion valve. The heat exchanger consists of two lengthy conduits

Encyclopaedic Dictionary of Physics
Pergamon 1961

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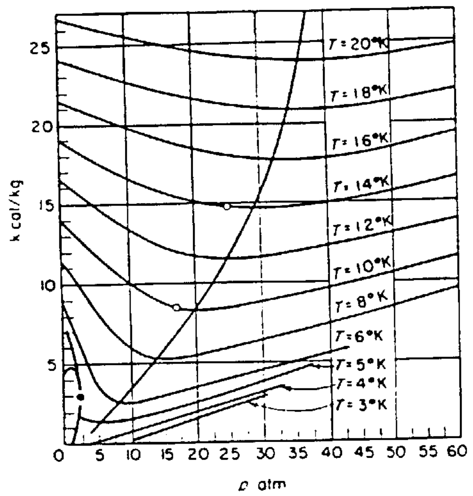
in good thermal contact with each other. The slightly cooler expanded gas from the valve absorbs heat from the incoming compressed stream causing the latter to arrive at the valve at a progressively lower temperature until the condensing point of the gas is finally reached.



Variation of enthalpy with pressure at several temperatures.

The fraction of the gas liquefied is a function of the difference in specific enthalpy at the pre-cooler temperature between high and low pressure, the latent heat of the liquid and the efficiency of the heat exchanger. The fraction actually liquefied, ε, is given by the equation

$$\varepsilon = \frac{h_2 - h_1}{h_2 - h_3}.$$

The specific enthalpy of the compressed gas entering the heat exchanger is designated by h_1, that of the expanded gas leaving by h_2 and the enthalpy of the liquid phase by h_3.

S. C. Collins

JOULE-THOMSON VALVE. A throttling device for the isenthalpic expansion of the working fluid in refrigerators using the Joule–Thomson effect. A common form of valve has a circular orifice partially closed by a fine adjustable needle.

See also: Joule–Thomson effect.

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Daunt J. G. *Handbuch der Physik—Low Temperature Physics* Vol. 1, Berlin: Springer.

J. A. Hulbert

JOULE (UNIT). The absolute Joule is defined as a unit of mechanical energy, equal to 10^7 ergs.

The international Joule is defined as the work done per second in a resistance carrying a current of one international ampere, the potential difference across the resistance being one international ohm.

One International Joule = 1·00019 absolute Joules.

See also: Mechanical equivalent of heat. Various articles beginning "Units".

JOVIGNOT TEST. The Jovignot test is used to determine the ductility of metal sheet. The circular plate to be tested is clamped at the edges and subjected to fluid pressure on one side. The sheet deforms into a segment of a sphere and eventually ruptures. The cupping coefficient is equivalent to the average increase in surface area when fracture occurs per unit area of sheet that is free to bulge.

S. F. Pugh

JULIAN DATE. For scientific and chronological purposes, the expression of dates by reference to year, month and day is a clumsy expedient, and the interval between two dates involves unnecessarily awkward calculations. The Renaissance scholar Joseph Justus Scaliger suggested in 1582 a system of reckoning by successive days, independently of various calendars and chronological epochs, by which all dates were to be referred to an arbitrary "zero" date, January 1, 4713 B.C., which he chose in connexion with his work on early chronology. The date thus reckoned is known as the Julian date, so named by its founder in honour of his father, Julius Scaliger, and having absolutely no connexion with the Julian Calendar. Julian days are used to express the times of most astronomical observations; they are reckoned from noon, and parts of a day are expressed in decimals to the necessary degree of precision. On January 1, 1960, the Julian date was 2,435,934.

JUMP FREQUENCY OF ATOMS. The quantity K, appearing in the formula for the diffusion coefficient D for atoms in a solid, derived by considering the solid as consisting of layers of atoms:

$$D = K\delta^2 \qquad (1)$$

where δ is the distance between layers. $K\,\mathrm{d}t$ is the probability that a given atom in a layer A shall move into the adjacent layer B during the time $\mathrm{d}t$. K is a frequency analogous to the velocity constant of a unimolecular chemical reaction; the velocity for such reactions is approximately given by the semi-empirical formula:

$$K = \nu e^{-h_1/kt}$$

and it can be shown that this relation also holds for K calculated from (1). K is of the order of 10^{13}.

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JUNCTION, HYBRID. A hybrid junction is a type of four-terminal microwave bridge circuit. It is named after the well known hybrid coil, or transformer, used for duplex telephone communication. Its performance as a circuit is closely analogous to that

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MULTI-FUNCTION VIDEO LINE BUFFER

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Preliminary Information

MULTI-FUNCTION VIDEO LINE BUFFER

Features

- Stores 1024 Words of 10 bits
- One Line and Two Line Configurations
- Programmable Line Lengths: 64, 128, 256, 512, 1024
- Intermediate Line Lengths by Truncation
- Delay Line and Sequential Access Modes
- Three 10 bit Parallel Data Ports: Input, Input/Output, and Output
- Cascadable to Increase Word Width, Line Length, and Number of Lines Stored
- Internal Address Generation
- 50 ns Cycle Time
- TTL Compatible I/O
- Fully Static Low Power CMOS/SOS Implementation

Applications

- Tapped Two Line Delay for 3 x 3 Filters
- Row to Column Scan Conversion for Separated 2D Filters
- Sequential Access Memory
- Support Chip for 1D/2D Convolver and Rank Order Filter

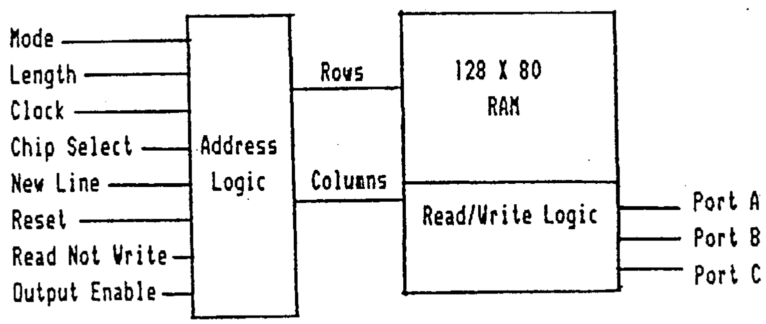
Description

The Multi-Function Video Line Buffer can be used as a tapped line delay or as a two dimensional sequential access memory. In the delay mode, one input port and two output ports provide a total delay of up to 1024 pixels, with a tap at half the length. In the sequential access mode, there is one X (row) port and there are two Y (column) ports. Image rows written to the X port may be read from the Y port as columns, and columns written to the Y port may be read from the X port as rows.

In all modes, the line length may be programmed to 64, 128, 256, 512, and 1024 pixels. Intermediate line lengths may be obtained by truncation on four word boundaries. Line lengths of 512 and less provide two lines of storage.

The Mode input selects Delay, X to Y or Y to X configurations and the Length input programs the natural line length. Reset initialises the pointer to the first pixel of the first line. Each pixel access is synchronous with Clock, which is enabled by Chip Select; Read Not Write determines the data direction. New Line steps the pointer to the first pixel of the next line, to facilitate truncation if required. Output Enable controls bus access from the output ports.

The two Y ports access two pixels per cycle, providing twice the peak data rate of the X port. This allows a full 20 M samples per second subsystem throughput in separated 2D Rank Order Filter applications.



This product is in development; specifications are subject to change.

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