TM-860A
1670.000

CCI Report No. 390-102

Magnet Test Facility

Quench Circuit

Prepared Under Fermilab Subcontract No. 94199
By Cryogenic Consultants, Inc.
Allentown, Pa.

For

Fermi National Accelerator Laboratory, Batavia, Illinois

December 20, 1978

MAGNET TEST FACILITY

QUENCH CIRCUIT

The Magnet Test Facility quench system was described originally in CCI Report No. 370-101, 8 November 1977. The report covered the various processes taking place and the concept of a quench circuit. It was based on input supplied by Fermilab on the then latest magnet design. Line sizes were selected based on a particular layout and anticipated flow rates and pressure drops. Later the design was updated, based on larger liquid inventories and the presence of an internal heater on newer magnets.

In brief, the warm quench system is a large buffer volume designed to temporarily store the large volumes of gas generated by a magnet quench. This system accepts the generated fluid, absorbs the fluid refrigeration and slowly meters the generated gas back to compressor suction at a controlled rate. This provides a method for capturing the helium which is normally vented to the atmosphere.

Figure 390-102-1 shows a single magnet tie-in. The system consists of a 4" foam-insulated manifold tied to each of six magnet stand quench lines. The foam insulation prevents personnel injury and exposure to "liquid air rain" when the magnet inventory is ejected into the quench circuit. The 4" line receives magnet fluid from the quench line of the magnet. The magnet is relieved by a yet to be selected relief device, which can be triggered open on a signal which normally precedes a quench.

A portion of the liquid helium contained in the magnet is vaporized by a magnet quench. The gas generated causes pressure to rise, providing a driving force for ejection of the liquid out of the 1Ø lead box. This fluid proceeds through CV119, through the triggered relief device SV157-1, into the 4" quench line manifold. The gas proceeds to the two 1000 gallon propane tanks where it is mixed with gas already in the tank. The cold gas is dumped into the center of the warm tank, providing thorough mixing. The line enters the carbon steel tank through a 27" thermal isolator, thereby preventing localized embrittlement of the carbon steel shell. The combination of heat of compression of the compressing gas, the specific heat of the metal pipe and tanks (in excess of 4000#), allows only a 9° temperature drop for each full quench of 30 liters. The gas is then routed back to compressor suction through PRV158. Should valve MV181 be closed or if the quench tank pressure is not sufficiently reduced by the time a subsequent quench occurs, SV156 protects the tanks at 35 psi -- although for other reasons the tanks and system are good for in excess of 250 psi. The relief assembly shown in the dotted box, SV157-1, is currently envisioned to contain three devices, SV126 (1) which acts as a low pressure ultimate relief in parallel with SV200 (mounted on the magnet at a slightly higher pressure), EV201 (2) the triggered relief device, and MV181 (3), which will allow EV201 to be isolated for warmup prior to a subsequent quench.

This combination of devices allows the magnet system to be fully protected, regardless of a single or multiple operator error. As an

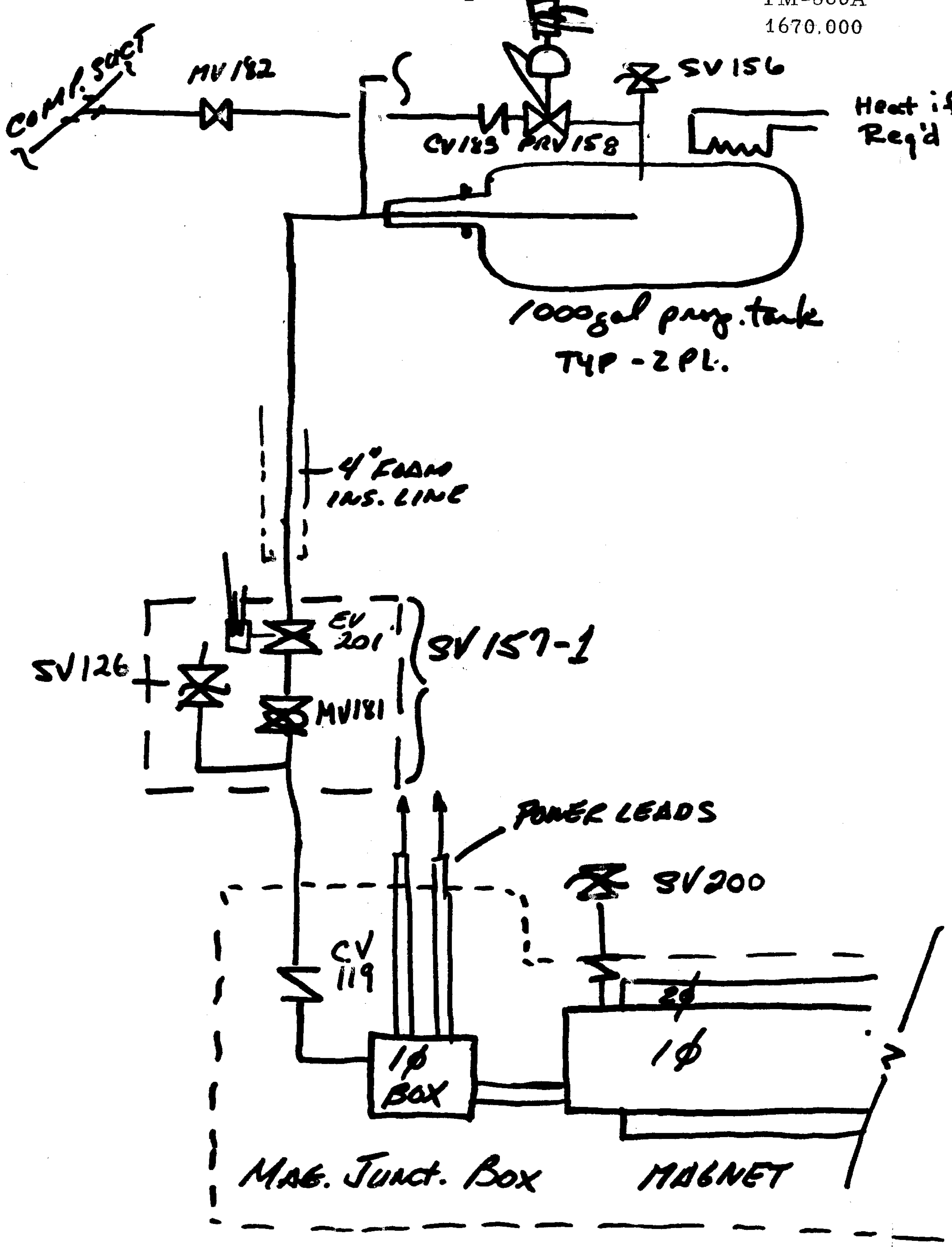

FIGURE 390-102-1

additional measure I would suggest that MV181 be an extended stem, spring-loaded to open ball valve. This would require the valve to be held closed manually for the warmup process. Release of the handle would open the valve, thus replacing EV201 into the system.

PRV158 is a regulator/stop valve combination. The valve is a downstream pressure regulator which will be set slightly above compressor suction. As pressure builds in the quench tanks, the regulator will meter gas to suction to provide the required-to-maintain constant system inventory. This device is equipped with a check valve (CV183) to prevent backflow, and an electrical solenoid which allows the PRV to be overridden (i.e., closed) from a switch in the Control Room.

Once installed the tanks must be monitored for shell temperature and interlocked with PRV158. to prevent cooling of the tanks below shell embrittlement temperature. MV182 is a line block valve in series with PRV158 to allow isolation of the quench system from the refrigerator.

If, during normal operation, it is found that these tanks run cold, a small amount of heat from strip heaters can be added to the shell of the vessels to provide the required heat.

Use of this system will provide a real savings in helium to the Laboratory. The need for purification of raw tube trailer gas should also be diminished.

PROCEDURE FOR INSTALLATION OF MV182 INTO LOW PRESSURE HELIUM HEADER

1. Drop system pressure as low as possible.
2. Provide a positive purge of helium through CV227.
3. The bolts to the spool in the ball valve flanges, which replaced a ball valve on the low pressure line, should be loosened, one bolt removed, and a piece of .060 sheet metal inserted to act as a blind. (See Figure 1.)
4. Retighten the bolts.
5. Cut 1-1/2" line as required.
6. Install Tee/ball valve spool.
7. Weld runs of Tee.
8. Close new ball valve MV182.
9. Increase purge temporarily to sweep purge line.
10. Remove sheet metal block from spool.
11. Retighten bolts on spool.
12. Snoop line for leaks.
13. Remove handle on MV182 to prevent tampering.

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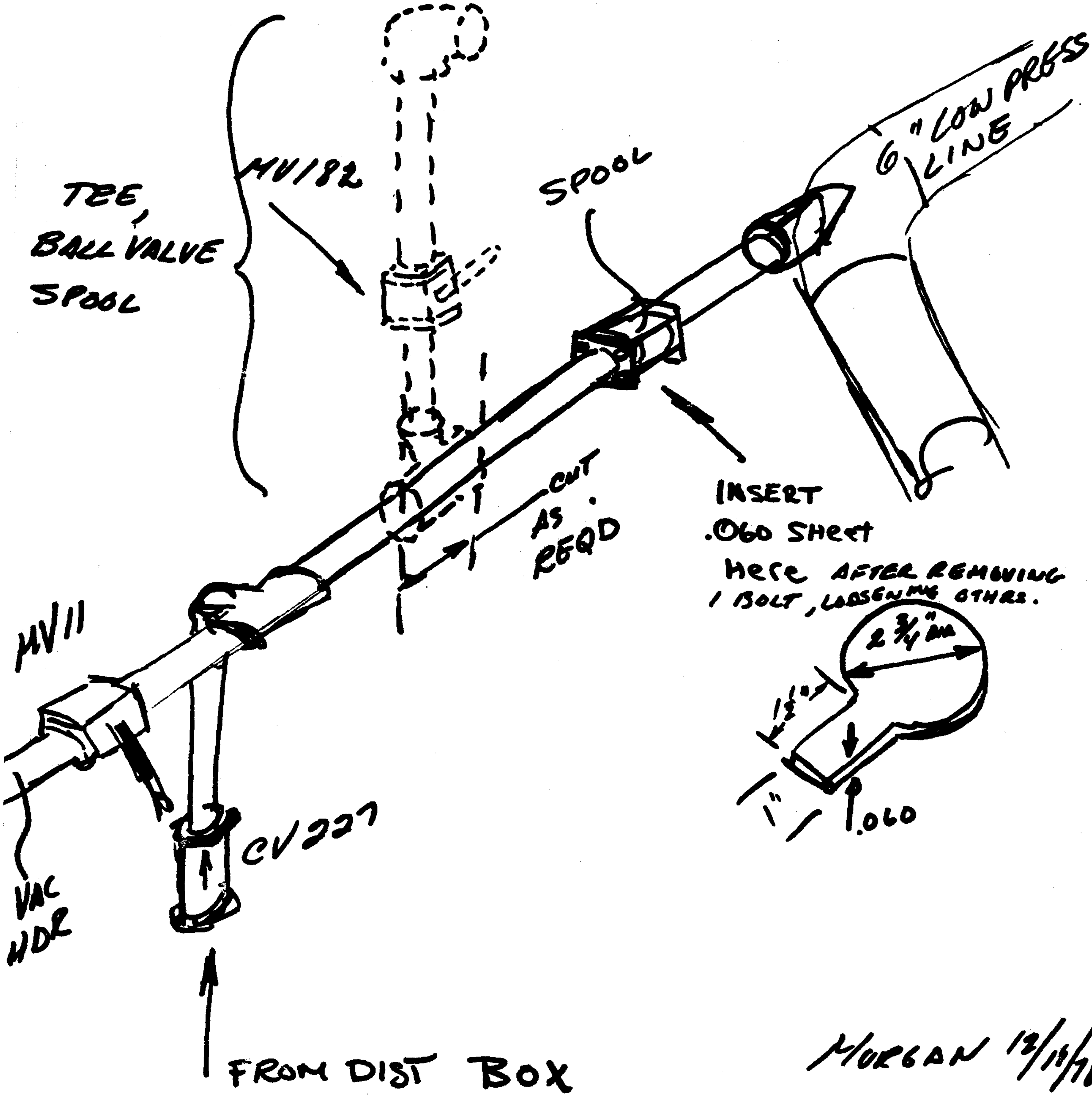
FIG 1.
QUENCH CKT. MTF, TIE IN



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TM-860B
1670.000

CCI Report No. 390-104

MAGNET TEST FACILITY

MAGNET PROTECTION, QUENCH CIRCUIT TIE-IN

Prepared Under Fermilab Subcontract No. 94199
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Allentown, Pa.

For

Fermi National Accelerator Laboratory, Batavia, Illinois

January 8, 1979

MAGNET TEST FACILITY

TM-860B
1670.000

MAGNET PROTECTION, QUENCH CIRCUIT TIE-IN

The quench circuit outlined in CCI Report #370-101 was designed to be used with a pilot-operated relief device. The pilot envisioned for use was to be a self-actuated safety device such as those used on Anderson-Greenwood relief valves. In addition, a trigger was also to be provided to allow for manual or automatic trip of the device (see Figure 1). Since this valve was to be the only relief device for the magnet, it should be a self-actuated device, reliant on no other system for its actuation. In addition, the valve cannot be in anyway isolatable from the system.

As designed, the quench circuit ejects liquid from the 1Ø region of the magnet through the lead box and relief valve into a large volume. The cold gas absorbs heat from the environment and is subsequently reinjected into the main process stream.

The system should be able to recover from a full quench in 6-10 minutes.

Due to cost prohibitions, the Anderson-Greenwood device has been eliminated from present thinking. In its place, various devices, including Ross valves and in-house designed units, are now being considered. The devices would be triggered, but are not safety valves in the true sense. In addition, they are typically put in series with a manual valve which will allow positive shutoff of the gas stream should the triggered device fail to reseat after opening.

An acceptable circuit for the magnet is shown in Figure 2. Relief valve 1 will vent to atmosphere, relief valve 2 will also vent to atmosphere. The Ross valve will vent to the quench tank where the gas will be recovered.

The settings of the relief devices 1 and 2 will vary, depending on pressure values determined during tests. Relief valve 1 can be set close to what the current reliefs are, assuming that back pressure through the Ross valve is not high enough to cause it to relieve.

If relief valve 1 is tied into the quench system, back pressure will cause the relief pressure to vary with back pressure. This is unacceptable from a safety standpoint.

The setting on relief valve 2 will be unknown until tests determine what value it rises to during a quench. During previous tests, magnet pressures rose to 90-100 psi during a quench, even with the Ross valve open.

If that is still the case with the Ross valve in the new position on the lead box, the use of a relief at this point is either useless or will defeat the purpose of the quench circuit. (Useless if it must be set above 90 psi; defeat the purpose of recovering the fluid if it vents during each quench.)

Magnet protection must be tamper-proof and not reliant on operator interaction. The use of a pilot-operated relief valve with the trigger, as shown in Figure 1, is still the simplest, most effective and safest alternative. I would recommend that that system be reevaluated.

SCHEMATIC REPRESENTATION
AGCO RELIEF VALVE (PILOT OPERATED)

PRESSURE P SUPPLIES SEATING FORCE FOR SEAT SEAL C BY APPLYING FORCE BY VIRTUE OF PISTON B. {PISTON B AREA IS > SEAT C DIA}

IF PRESSURE P RISES ABOVE VALUE SET ON PILOT VALVE, PILOT OPENS VENTING VOLUME A, OPENING VALVE. SOLENOID TRIGGER MAY BE ACTUATED IN ADVANCE IF NEC. BUT NEVER DEFEATS PILOT ACTION.

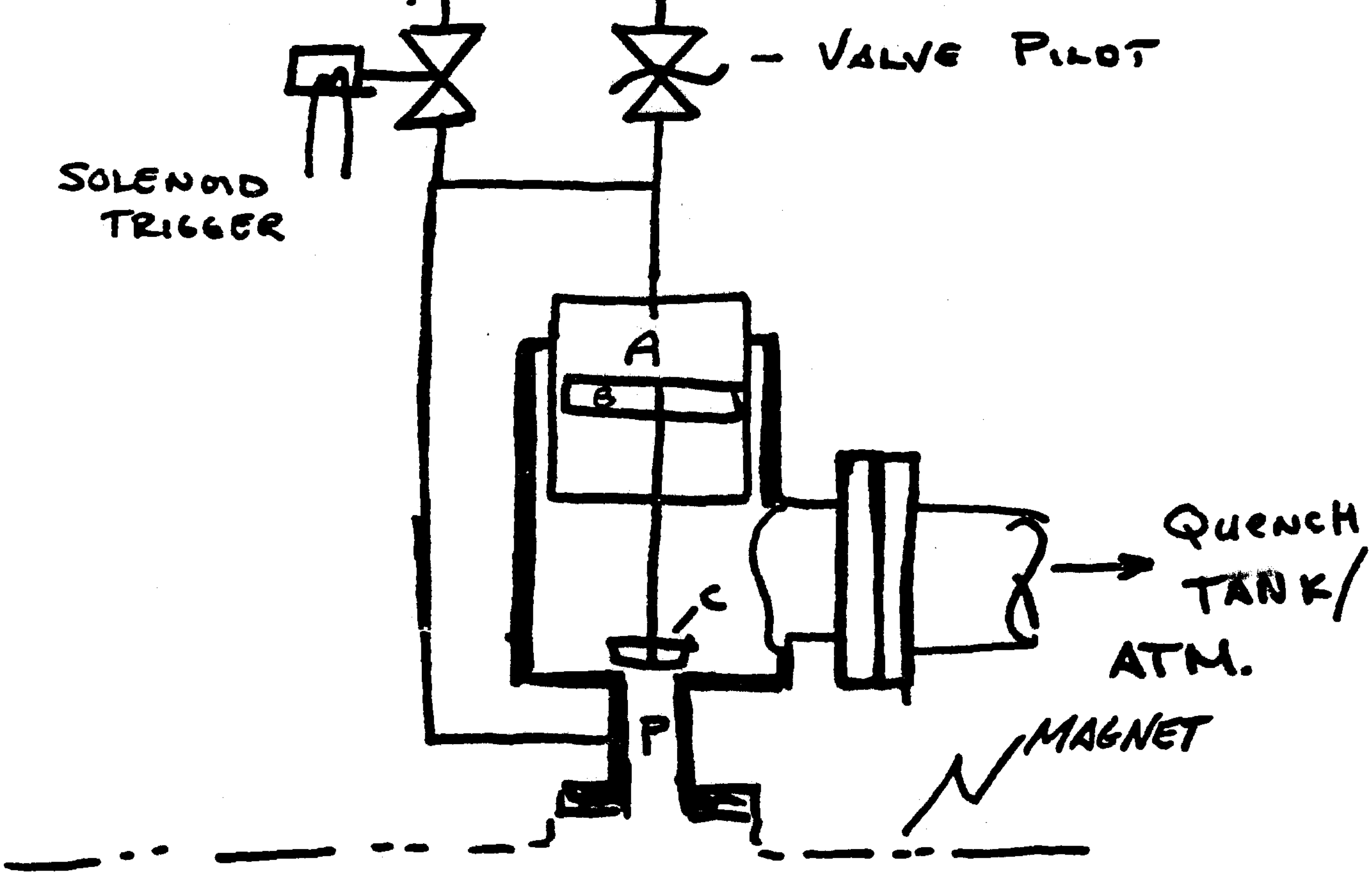

fig. 1

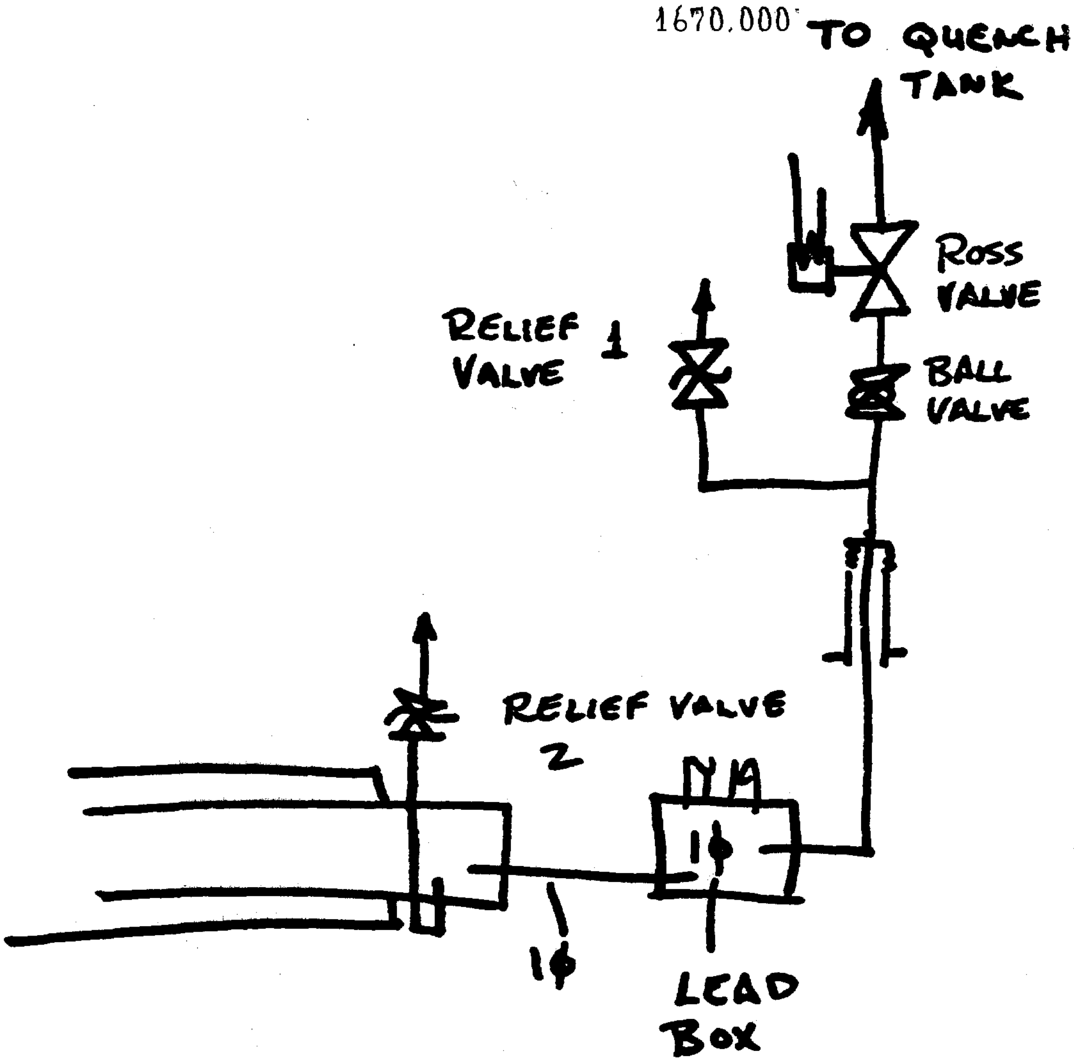
TO QUENCH
TANK
ROSS
VALVE
RELIEF 1
VALVE
BALL
VALVE
RELIEF VALVE
2
1φ
1φ
LEAD
BOX

Fig 2